Supplemental Information for:

Biotic and abiotic drivers of plant-pollinator community assembly across wildfire gradients

Joseph A. LaManna[1,2]*, Laura A. Burkle[3], R. Travis Belote[4], and Jonathan A. Myers[5]

[1] Department of Biological Sciences, Marquette University, PO Box 1881, Milwaukee, Wisconsin 53201 USA, joseph.lamanna@marquette.edu * Corresponding author

[2] Departments of Botany & Zoology, Milwaukee Public Museum, Milwaukee, Wisconsin 53233 USA

[3] Department of Ecology, Montana State University, Bozeman, Montana 59717 USA, laura.burkle@montana.edu

[4] The Wilderness Society, Bozeman, Montana 59717 USA, tbelote@tws.org

[5] Department of Biology & Tyson Research Center, Washington University in St. Louis, St. Louis, Missouri 63130 USA, jamyers@wustl.edu

Supplemental Methods

Study site

Our study took place in three sites (named Helena, Paradise, and Whitefish) within the Northern Rocky Mountains, which encompasses the Crown of the Continent and the Greater Yellowstone Ecosystem in western Montana, USA (Fig. 1; Burkle, Myers, & Belote, 2015). Historically, this region has experienced mixed-severity fire regimes (Baker, 2009; Fischer & Bradley, 1987), which favor understory and early successional plant species and a mosaic of forest successional stages (Hessburg & Agee, 2003; Perry et al., 2011). Wildfires have largely been suppressed over the past century, however, leading to denser stands and more intense and extensive wildfires in the past few decades (e.g. Miller, Safford, Crimmins, & Thode, 2009). The Helena site is characterized by low primary productivity, Paradise by intermediate productivity, and Whitefish by high productivity (Burkle et al., 2015). These three site include a variety of forested ecosystems, including ponderosa-pine dominated forests and woodlands in Helena, lodgepole-pine and Douglas-fir forests in Paradise, and western-larch, lodgepole-pine and mixed-conifer forests in Whitefish (Burkle et al., 2015). Within each site, 52–54 plots were selected that differed in the recent presence and severity of wildfire (Fig. 1), including 16–18 plots with no recent wildfire (within at least the past 60 years), 18 plots with recent (< 10 years old) mixed-severity wildfire, and 18 plots with recent high-severity wildfire (Burkle et al., 2015). Within each wildfire disturbance level in each site, plots were in one of two previous wildfire burn units or unburned units. In general, woody plants were recovering slowly, if at all, from high-severity fire in Helena and Paradise, while young trees (mostly lodgepole pine regeneration) dominated high-severity burned areas in Whitefish, indicating that the rate of forest succession and the influence of the woody overstory strata varies among these sites (Burkle et al., 2015).

Data collection

Flowering-plant community sampling – Throughout the 2014 and 2015 growing seasons, we visited each plot once per week. During each visit, we quantified floral densities, species richness, and composition by recording the number of open flowers of each species along a 25 × 2 m band transect (Fig. 1). Although there were additional plant species present at these plots (see Burkle et al., 2015 for a description of forb, grass, and tree diversity in the study sites), we focused on herbaceous and woody plant species in bloom as they represent floral resources for pollinators. Importantly, all open flowers were surveyed (i.e. not only those flowers where pollinators were present).

Pollinator community sampling – During each floral-transect visit, we also quantified the densities, species richness, and composition of pollinators by hand-netting within a 25 m diameter circular plot centered on the 25 × 2 m floral transect (Fig. 1b) for 20 minutes during sunny, calm weather and peak pollinator activity (ca. 0900 – 1630). Plots were visited in random order during these hours. We considered pollinators to be any insect visitor that was observed flying among flowers and contacting floral reproductive parts. Plots in Helena were observed 12 times in 2014 and 9 times in 2015. Plots in Paradise were observed 9 times each in 2014 and 2015. Plots in Whitefish were observed 7 times each in 2014 and 2015. Total observation time varied per plot depending mainly on growing season length, which varied among sites. Each pollinator was collected individually and identified to species later. Bees (Hymenoptera), flies (Diptera) and butterflies (Lepidoptera) were all sampled during our surveys and are included in our analyses. However, most of the pollinators sampled were Hymenoptera (Burkle, Simanonok, Durney, Myers, & Belote, 2019; Reese, Burkle, Delphia, & Griswold, 2018), and results were similar if we conducted all analyses using only Hymenoptera.

Abiotic environmental factors – We measured several abiotic environmental variables at each plot that are thought to influence pollinator and plant community composition, including wildfire disturbance severity, climate, soil chemistry, topography, and other variables associated with wildfires and pollinator nesting habitat. For each transect, we quantified the severity of recent wildfires with a wildfire severity index (dNBR) determined by remotely-sensed data (Eidenshink et al., 2007). We also obtained values of net primary productivity (NPP; Zhao, Heinsch, Nemani, & Running, 2005) and 19 climatic variables (BIOCLIM) with remotely-sensed satellite data (Wang, Hamann, Spittlehouse, & Carroll, 2016). We determined elevation, slope, and northern and eastern aspect at each plot, which we calculated based on a 30-m digital elevation model. We collected soil samples from each plot and measured the following soil-chemistry variables: pH, neutralizable acidity, percent organic material, available P, Ca, Mg, K, cation exchange capacity, percent sand, silt and clay. Finally, changes in coarse-woody debris (CWD), bare ground, stumps, and other legacies that can result from wildfires can influence plant and pollinator diversity and species composition (Harmon, 1996; Mateos, Santos, & Pujade-Villar, 2011; Moretti, De Bello, Roberts, & Potts, 2009; Tinker & Knight, 2000; Vázquez, Alvarez, Debandi, Aranibar, & Villagra, 2011; Williams et al., 2010). Thus, we measured the following variables to quantify other changes in the abiotic environment associated with wildfires and pollinator nesting habitat: number of stumps and percent ground cover represented by bare ground, leaf litter, and CWD (Grundel et al., 2010; Hopwood, 2008; Potts et al., 2005).

Statistical analyses

We calculated β-diversity among plots within each wildfire-severity level (i.e. high-severity, mixed-severity, and unburned) using mean distance-to-centroids calculated from Bray-Curtis distance that measure differences in species composition and relative abundances of species across plots (Anderson et al., 2011). The distances to the centroid of each wildfire-severity level in each site were calculated with function 'betadisp' in the R 'vegan' package (Oksanen et al., 2019; R Core Team, 2015). We then performed null-model analyses to disentangle potential wildfire effects on β-diversity via alteration of species pools and local abundance from wildfire effects on β-diversity via non-random effects on local species composition of plants and pollinators (Kraft et al., 2011; Myers et al., 2013). Individual pollinators or flowers from each wildfire severity level in each site were randomly re-distributed among plots in that wildfire severity level in that site while preserving local abundance (i.e. the total number of pollinators or flowers in each plot) and species-abundance distributions in each site × wildfire combination (Kraft et al., 2011; Myers et al., 2013). Thus, these null assemblages were the product of stochastic assembly from the observed species pool and local abundance alone, and all local-scale mechanisms that might cause additional spatial aggregation of pollinators or flowers (e.g., habitat partitioning, local interactions among species, dispersal limitation) were removed. Distance-to-centroids for simulated communities (β_{SIM}) were then compared to observed distance-to-centroid (β_{OBS}) relative to the standard deviation of β_{SIM} (σ_{SIM}) after 2,000 iterations, and a standardized effect size of the difference was calculated as: $\beta_{SES} = (\beta_{OBS} - \beta_{SIM}) / \sigma_{SIM}$. Therefore, β_{SES} represent β-diversity that remains unexplained by stochastic assembly from the species pool determined by site and wildfire-severity level (Kraft et al. 2011), and are a way to measure the influence of wildfire at the local plot-to-plot scale (as opposed to wildfire effects on the species pool itself). We tested for differences in β-diversity among wildfire-severity levels using generalized linear mixed models (GLMMs) with distance-to-centroid as the response that included site and unit nested within site as random effects. The unit of replication in these GLMMs was the distance of each plot to its wildfire-severity-level centroid in a study site (i.e. one data point per plot per wildfire-severity level per site). These distances are calculated from Bray-Curtis dissimilarities using function 'betadisper' from R package 'vegan' and are directly comparable across different sites and wildfire-severity levels (Anderson et al., 2011; Oksanen et al., 2019). We report results from both a parametric and nonparametric statistical model. For the parametric model, we used GLMMs that allowed residual variance to differ among wildfire-severity levels using function 'lme' from R package 'nlme.' For the non-parametric model, we used permutational GLMMs using function 'permanova.lmer' from R package 'predictmeans' (Luo, Ganesh, & Koolaard, 2020; Pinheiro, Bates, DebRoy, & Sarkar, 2020). Briefly, non-parametric permutational GLMMs randomly re-assign data points in a mixed-model ANOVA to different groups in each iteration (we used 9,999 iterations) and compare a distribution of null-expected F values to the observed F value. We summed pollinator and floral abundances at each plot across both years for analyses presented here. Results were qualitatively similar if we analyzed 2014 and 2015 separately except β-diversity for pollinators differed among wildfire-severity levels in 2014 and 2014-2015 combined, but not in 2015 when considered separately. However, three times as many pollinators were sampled in 2014 compared to 2015, so inferences were made with the larger dataset of 2014 and 2015 combined, and these results matched results considering only 2014.

To assess effects of wildfire on floral and pollinator species richness and total abundance at the fire-unit scale, we compared total abundances and rarefied species richness (rarefied to the minimum number of individuals across burn units after first rarefying to the minimum number of plots in each wildfire × site × unit combination) for each unit among the three wildfire-severity levels. We calculated fire-unit abundance as the total number of pollinators or flowers of all species combined across plots in a burn or unburned unit. We then tested for difference in mean fire-unit abundances and mean rarefied species richness across wildfire-severity levels with GLMMs that included site as a random effect. At the plot (local) scale, we tested for differences in local total abundance (total count of flowers or pollinators at each plot), local species richness, and local rarefied species richness among wildfire severity levels with GLMMs that included site and unit nested within site as random effects. For rarefication analyses, species richness was rarefied to the minimum number of individuals across burn units or plots. The only exception to this was for local pollinator species richness, where species richness was rarefied to the 15th percentile of total abundances across sites, because only one pollinator was detected at seven plots. However, results are similar and inferences the same if we exclude these seven plots. Six of the seven plots where only one pollinator was detected were in unburned landscapes, where pollinator abundances were much lower than in burned landscapes. Moreover, plots with only one pollinator were surveyed with equal effort as plots with many more pollinators. Therefore, we retained plots with only one pollinator because they reflect biologically-meaningful differences in pollinator abundances across wildfire-severity levels. For all analyses, we report both GLMMs that allowed residual variance to differ among wildfire-severity levels using function 'lme' from R package 'nlme' and non-parametric permutational GLMMs using function 'permanova.lmer' from R package 'predictmeans' (Luo et al., 2020; Pinheiro et al., 2020). We summed pollinator and floral abundances at each plot across both years for analyses presented here, but results were qualitatively similar if we analyzed 2014 and 2015 separately. We also visualized these patterns using nonmetric multidimensional scaling (NMDS) in program R (Oksanen et al., 2019; R Core Team, 2015).

We used variation partitioning at two scales to determine the relative importance of various ecological factors to differences in species composition among plots within each wildfire-severity level and among plots across wildfire-severity levels. This allowed us to evaluate: 1) the relative importance of species sorting along abiotic and biotic gradients within each wildfire-severity level; and 2) the relative importance of wildfire severity and biotic interactions to differences in species composition across wildfire-severity levels. Factors examined in these analyses included plant-pollinator associations (i.e. the extent to which variation in floral species composition predicts pollinator species composition, and vice versa), wildfire severity, other abiotic factors (i.e. climate, topography, and other variables associated with wildfires and pollinator nesting habitat), and spatial variables associated with dispersal limitation (geographic distance) and unmeasured environmental variables (Peres-Neto, Legendre, Dray, & Borcard, 2006). We used the 'varpart' and 'rda' functions in the R 'vegan' package (Oksanen et al., 2019; R Core Team, 2015). Prior to conducting variation partitioning analyses, we first performed a parallel analysis for our abiotic environmental data using function 'paran' of R package 'paran' (Dinno, 2018), which tests how many principal components (PCs) are different from random variation. This parallel analysis indicated retaining the first four abiotic principal components. For biotic variables, we performed a principal coordinate analysis (PCoA) on the floral and pollinator Bray-Curtis dissimilarity values (pollinator and flowering-plant β-diversity) using the 'cmdscale' function from the 'vegan' R package to compute orthogonal scores that described correlated differences in floral and pollinator species composition among plots within each study site (Borcard, Gillet, & Legendre, 2011). We used all of these floral and pollinator PCoA scores as the response matrix for floral and pollinator variation partitioning analyses respectively—this analysis is also known as a distance-based redundancy analysis (dbRDA; Borcard et al., 2011; Legendre & Legendre, 2012).

Prior to conducting variation partitioning analyses, we used forward model-selection ('forward.sel' function in the 'adespatial' R package) to reduce the number of variables used to predict variation in floral and pollinator species composition (Borcard et al., 2011; Legendre & Legendre, 2012). Forward-model selection is a standard approach recommended for variation partitioning that first tests for the overall significance of a predictor matrix and, if significant, assesses the significance of each column of the matrix to evaluate its contribution in light of other columns (Borcard et al., 2011; Legendre & Legendre, 2012). Only significant columns are retained up to the adjusted-R^2 of the overall predictor matrix (Borcard et al., 2011; Legendre & Legendre, 2012). We used this forward-selection approach to select abiotic environmental PCs and biotic variables (axes of floral and pollinator PCoAs) for use in variation partitioning analyses. Thus, we analyzed differences in pollinator and floral species composition among plots within each site or wildfire-severity level and among sites using three explanatory matrices (one with abiotic environment variables; the second with floral or pollinator variables; and the third with 2 spatial variables: longitude and latitude). Variation partitioning calculates the proportion of total variation in the response matrix explained by each explanatory matrix and the proportion of variation that is shared among explanatory matrices (Borcard et al., 2011; Legendre & Legendre, 2012; Peres-Neto et al., 2006). Here, we used the proportion of variation in pollinator or floral species composition explained by the other community alone (i.e. the extent to which variation in floral species composition not associated with the abiotic environment or geographic space predicts pollinator species composition, and vice versa) as a measure of the degree to which plant-pollinator associations drive species composition of pollinators and flowering-plants independently of the abiotic environment or geographic distance.

To complement the variation partitioning analyses and to assess whether certain pollinator species co-occurred with certain plant species across plots in each site and wildfire-severity level, we performed an analysis of co-occurrence using c-scores (Gotelli, 2000; Gotelli & Ulrich, 2010; Stone & Roberts, 1990). The c-score, a measure of co-occurrence across plots, was calculated for each pollinator-plant species pair in each site and wildfire-severity level with the following equation:

$$C_{AB} = \frac{(R_A - SS)(R_B - SS)}{R_A R_B}$$

where R_A is the number of plots occupied by species A, R_B is the number of plots occupied by species B, and *SS* is the number of plots occupied jointly by both species. Therefore, for any pollinator-plant species pair, the c-score ranges from 0 (complete positive co-occurrence, i.e. the species pair only occurs together across plots) to 1 (complete negative co-occurrence, i.e. the species pair never occurs together across plots). We also used a null-model approach to calculate the c-score expected if species occurrence was randomly distributed across plots within a site. To do this, we preserved the total number of plots occupied by each species and the species richness of each plot, and randomized occurrences of all species given those constraints (Gotelli, 2000; Gotelli & Ulrich, 2010; Oksanen et al., 2019; R Core Team, 2015). We reiterated this null-model approach 1,000 times, calculating a distribution of 1,000 null c-score values for each pollinator-plant species pair. A species pair was determined to have significant positive/negative co-occurrence if its observed c-score was less than/greater than the middle 95% of null c-score values for that species pair respectively, and this is known as the simple 95% confidence interval (CI) criterion (Gotelli & Ulrich, 2010). We then evaluated if each species pair determined to be significant with the simple 95% CI criterion remained significant using the more restrictive Bayes mean-based criterion, which corrects for multiple comparisons by accounting for the expected distribution of c-scores (from the null model) within each of 250 equally sized bins from 0 to 1 (Gotelli & Ulrich, 2010).

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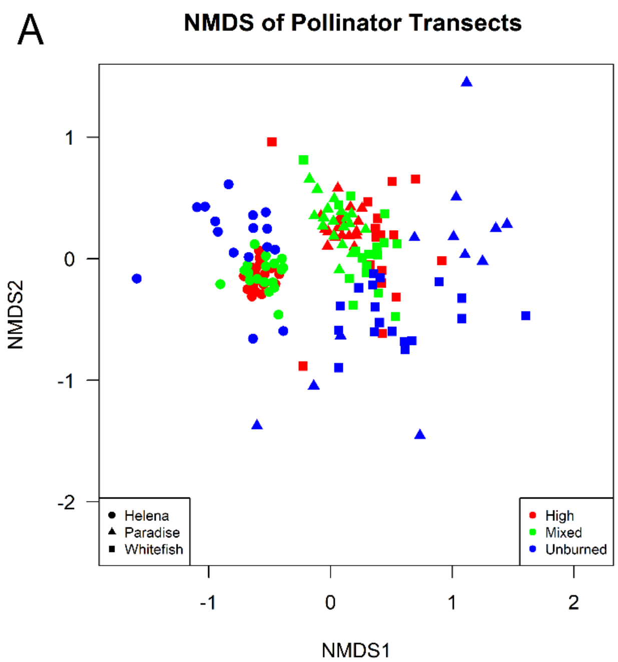
Fig. S1. Nonmetric multidimensional scaling (NMDS) for pollinator (A) and floral (B) communities in western Montana, showing the extent to which transects in each region and wildfire severity class had similar or distinct species composition (transects with more dissimilar species composition are farther from one another). The first two NMDS axes are shown for each community. The pollinator and floral regional species pools in the Helena region were most distinct from regional species pools in the Paradise and Whitefish regions, although species pools in Paradise and Whitefish also differed from one another



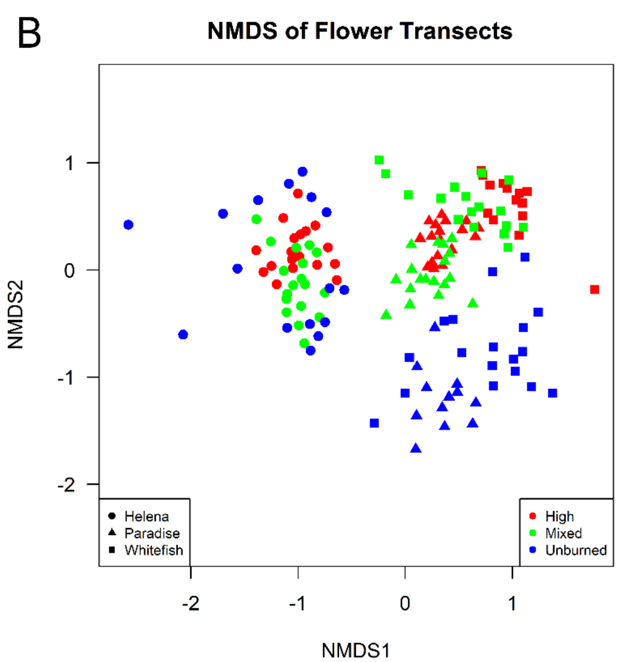


Fig. S2. Observed and standardized effect sizes for within-landscape β-diversity (multivariate distance from each site to the centroid of each burn ×region combination) for pollinator (A-F) and flowering-plant (G-L) species in each wildfire severity level in each of three regions in western Montana, USA. β-diversity standardized effect sizes (SES) or differences between observed β-diversity and the null model expectations (see text for details).

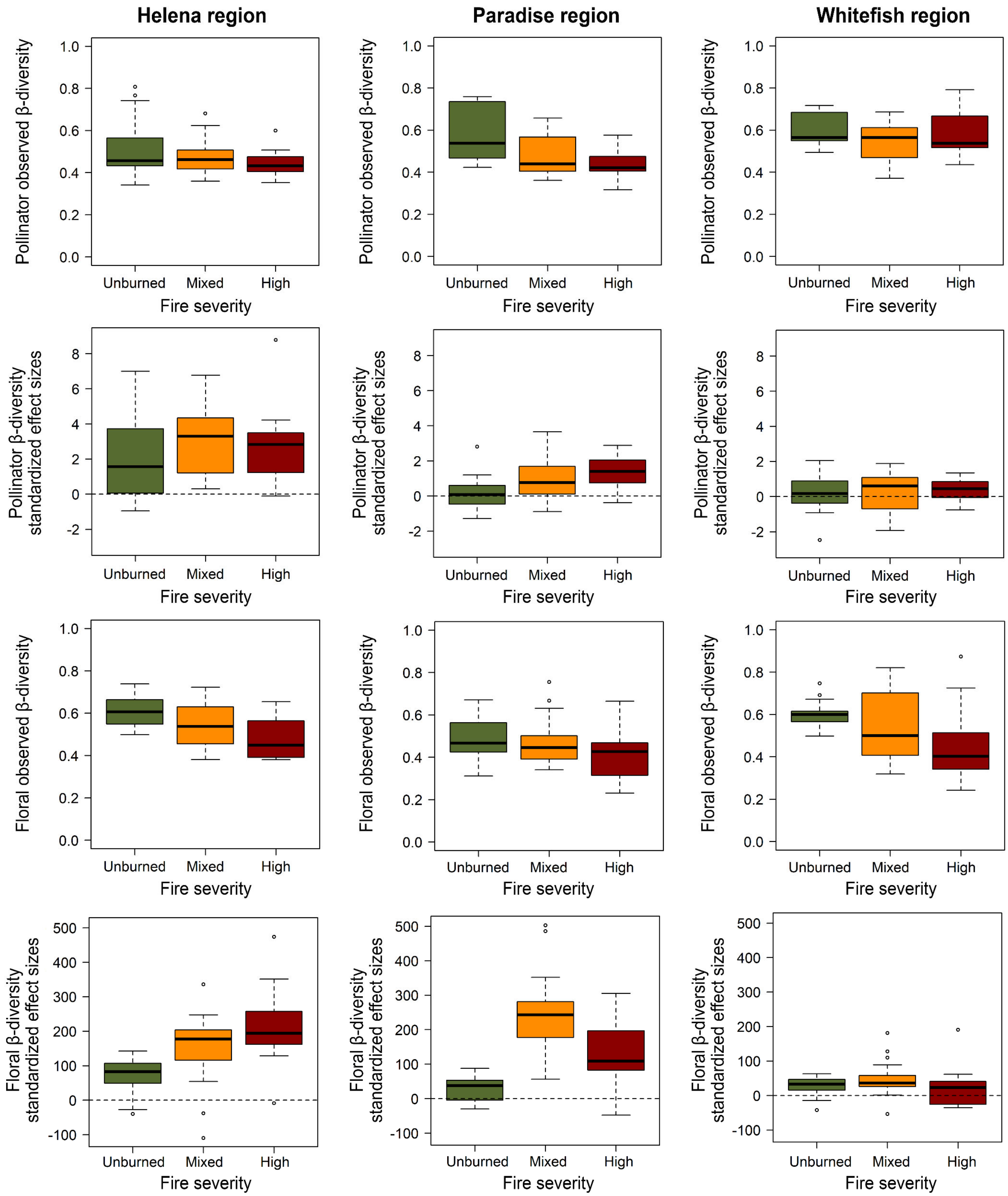


Fig. S3. The total number of pollinator (A-F) and flowering-plant (G-L) individuals and species in each wildfire severity level in each of three regions in western Montana, USA.

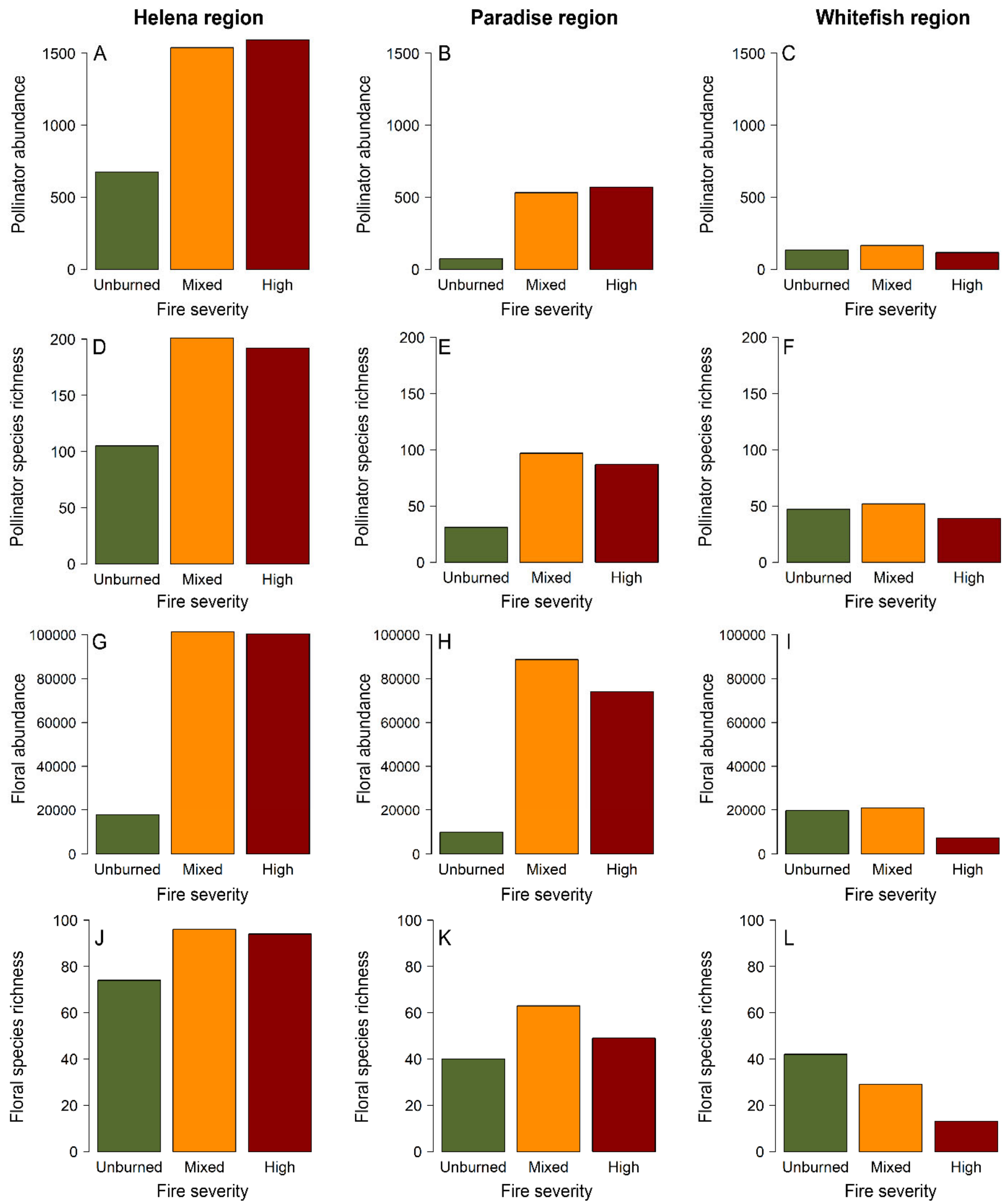


Fig. S4. Local (site-level) community size (total number of individuals) and local species richness for pollinator (A-F) and flowering-plant (G-L) species in each wildfire severity level in each of three regions in western Montana, USA.

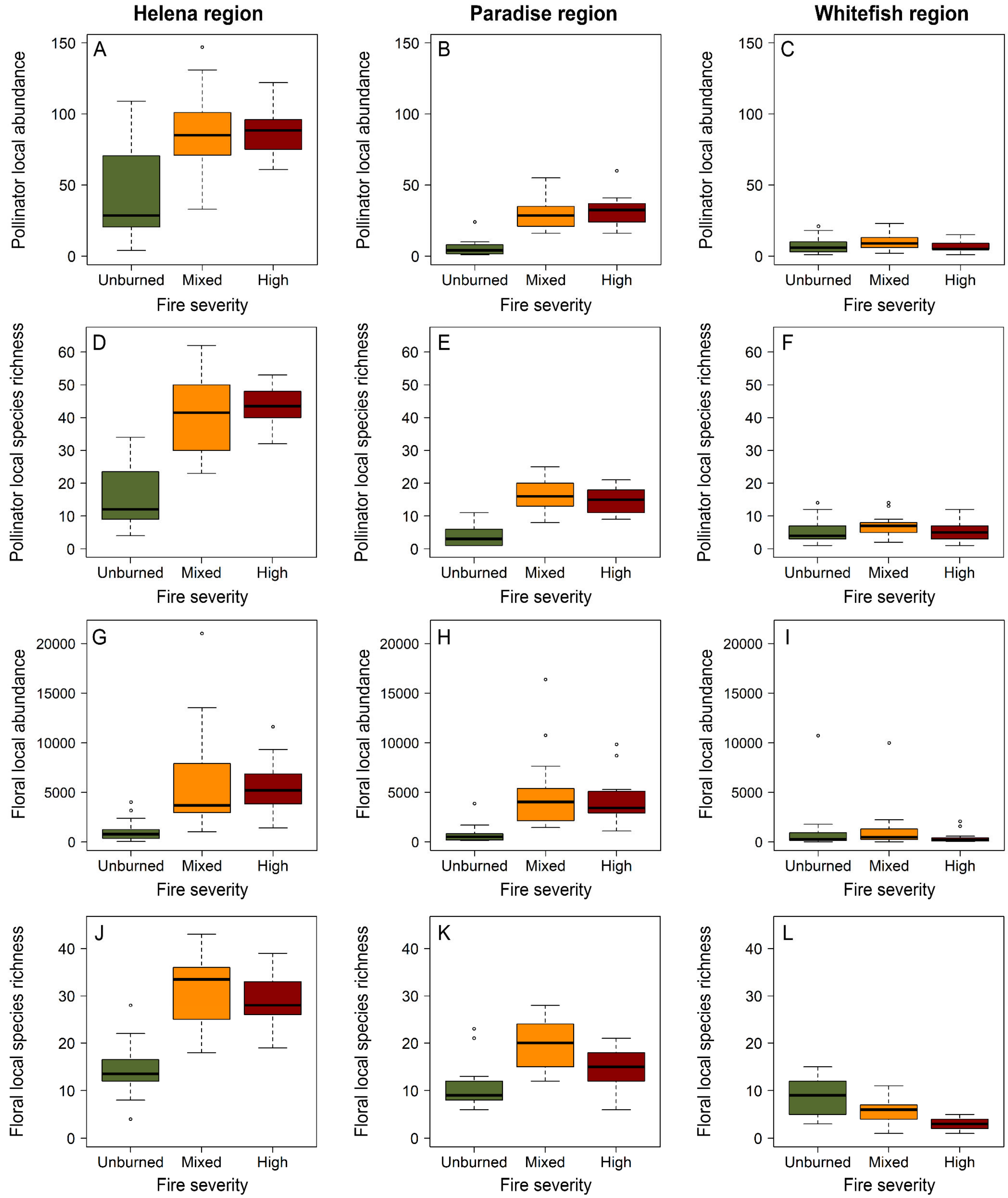


Fig. S5. β-diversity expected from the null model (multivariate distance from each plot to the centroid of each wildfire-severity level × site combination) within each wildfire-severity level for pollinator and flowering-plant communities. Distance-to-centroids are calculated from Bray-Curtis dissimilarities. Unburned plots are in green, plots with mixed-severity wildfires are in yellow, and plots with high-severity wildfire are in red. Lower-case letters indicate the results of posthoc comparisons (different letters indicate significant contrasts), and lack of lower-case letters indicates that the overall GLMM ANOVA test was insignificant ($p > 0.05$, Table S1). Random effects are included for burn unit (block) nested within site.

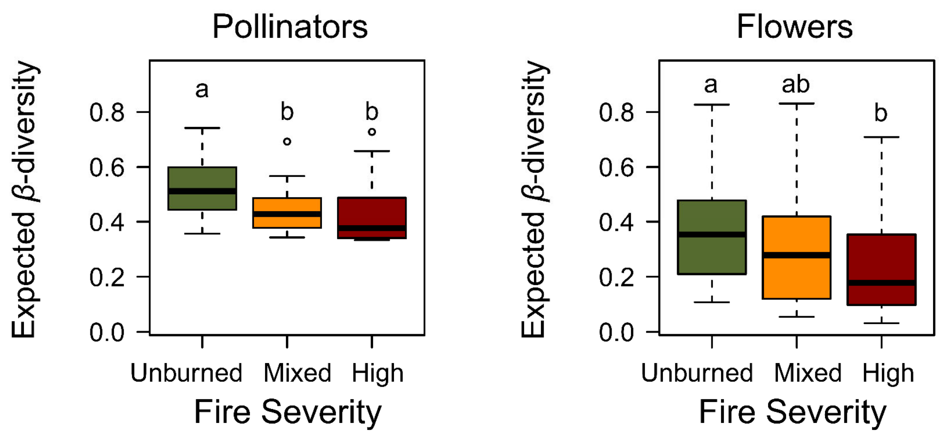


Table S1. Parametric generalized linear mixed model (GLMM) and non-parametric permutational GLMM model (GLMM PermANOVA) results, testing for differences in regional abundance (total number of individuals combined across sites in a burn or unburned unit, rarefied to the minimum number of plots per burn unit), regional species richness (rarefied to the minimum number of plots per burn unit), regional rarefied species richness (first rarefied to the minimum number of plots per burn unit, then rarefied to the minimum number of individuals across burn units), local community size (total number of individuals in each plot), local species richness, local rarefied species richness, and within-landscape β-diversity among wildfire disturbance levels for pollinators and flowering plants. β-diversity was measured as the multivariate distance from each site to the centroid of each burn ×region combination. Expected distance-to-centroid reflects β-diversity expected given the composition of the species pool (calculated using null models, see text for details), and deviation distance-to-centroid reflects β-diversity standardized effect sizes (SES) or differences between observed β-diversity and the null model expectations. Random effects are included for burn unit (block) nested within region for local analyses and a random effect of region was included in regional analyses.

Pollinators

Tests for community size & species richness	*F*	Num DF	Dem DF	*P*
Regional Abundance GLMM Mixed Var.	23.17	2	13	0.0001
Regional Abundance GLMM PermANOVA	8.27	2	13	0.006
Regional Species Richness GLMM Mixed Var.	27.17	2	13	<0.0001
Regional Species Richness GLMM PermANOVA	10.55	2	13	0.003
Regional Rarefied Species Richness GLMM Mixed Var.	1.68	2	13	0.224
Regional Rarefied Species Richness GLMM PermANOVA	2.73	2	13	0.101
Local Community Size GLMM Mixed Var.	13.098	2	13	0.001
Local Community Size GLMM PermANOVA	11.890	2	13	0.001
Local Species Richness GLMM Mixed Var.	8.345	2	13	0.005
Local Species Richness GLMM PermANOVA	8.742	2	13	0.004
Local Rarefied Richness GLMM Mixed Var.	13.631	2	13	0.001
Local Rarefied Richness GLMM PermANOVA	11.714	2	13	0.002

Tests for within-landscape β-diversity	*F*	Num DF	Dem DF	*P*
Obs distance to centroid GLMM Mixed Var.	6.490	2	13	0.011
Obs distance to centroid GLMM PermANOVA	7.680	2	13	0.005
Exp distance to centroid GLMM Mixed Var.	13.869	2	13	0.001
Exp distance to centroid GLMM PermANOVA	14.027	2	13	0.001
Dev distance to centroid GLMM Mixed Var.	4.827	2	13	0.027
Dev distance to centroid GLMM PermANOVA	3.466	2	13	0.028

Flowers

Tests for community size & species richness	*F*	Num DF	Dem DF	*P*
Regional Abundance GLMM Mixed Var.	36.52	2	13	<0.0001
Regional Abundance GLMM PermANOVA	8.52	2	13	0.006
Regional Species Richness GLMM Mixed Var.	6.24	2	13	0.013
Regional Species Richness GLMM PermANOVA	1.73	2	13	0.147
Regional Rarefied Species Richness GLMM Mixed Var.	3.12	2	13	0.078
Regional Rarefied Species Richness GLMM PermANOVA	1.18	2	13	0.291
Local Community Size GLMM Mixed Var.	10.386	2	13	0.002
Local Community Size GLMM PermANOVA	7.057	2	13	0.012
Local Species Richness GLMM Mixed Var.	2.992	2	13	0.085
Local Species Richness GLMM PermANOVA	3.536	2	13	0.046
Local Rarefied Richness GLMM Mixed Var.	0.686	2	13	0.521
Local Rarefied Richness GLMM PermANOVA	0.691	2	13	0.468

Tests for within-landscape β-diversity	*F*	Num DF	Dem DF	*P*
Obs distance to centroid GLMM Mixed Var.	11.655	2	13	0.001
Obs distance to centroid GLMM PermANOVA	11.620	2	13	0.001
Exp distance to centroid GLMM Mixed Var.	5.735	2	13	0.016
Exp distance to centroid GLMM PermANOVA	8.065	2	13	0.002
Dev distance to centroid GLMM Mixed Var.	5.089	2	13	0.023
Dev distance to centroid GLMM PermANOVA	5.728	2	13	0.021

Table S2. Proportion of variation in species composition of pollinator and flowering-plant communities (β-diversity) in western Montana explained by the abiotic environment (see Table S1), the biotic environment (the variation in pollinators explained by flowers, and vice versa), and geographic distance. Isolated effect refers to the variation in β-diversity that is uniquely (independently) explained by only one explanatory factor. Shared effect refers to variation in β-diversity explained by covariation among two or three explanatory factors. Total effect refers to variation in β-diversity explained by the sum of isolated and all shared components for a particular explanatory factor. Only the total and isolated fractions can be tested for significance. Negative values of adjusted r^2 (r_a^2) indicate near zero explanatory power. Please see text for more details on the variation partitioning that produced these results.

Unburned pollinators

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.181	8	2.24	0.001
Total effect of abiotic env.	0.139	2	4.62	0.001
Total effect of biotic env.	0.155	4	3.07	0.001
Total effect of geo. distance	0.145	2	4.82	0.001
Isolated effect of abiotic env.	0.007	2	1.16	0.137
Isolated effect of biotic env.	0.032	4	1.40	0.001
Isolated effect of geo. distance	0.015	2	1.36	0.025
Shared effect of abiotic env. & geo.distance	0.004	---	---	---
Shared effect of abiotic env. & biotic env.	-0.003	---	---	---
Shared effect of biotic env. & geo.distance	-0.005	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.131	---	---	---
Residual variation	0.819	---	---	---

Mixed-severity wildfire pollinators

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.266	10	2.88	0.001
Total effect of abiotic env.	0.136	1	9.19	0.001
Total effect of biotic env.	0.239	7	3.33	0.001
Total effect of geo. distance	0.211	2	7.97	0.001
Isolated effect of abiotic env.	0.002	1	1.14	0.210
Isolated effect of biotic env.	0.053	7	1.51	0.001
Isolated effect of geo. distance	0.019	2	1.58	0.001
Shared effect of abiotic env. & geo.distance	0.005	---	---	---
Shared effect of abiotic env. & biotic env.	-0.002	---	---	---
Shared effect of biotic env. & geo.distance	0.057	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.130	---	---	---
Residual variation	0.734	---	---	---

High-severity wildfire pollinators

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.279	10	3.02	0.001
Total effect of abiotic env.	0.223	2	8.47	0.001
Total effect of biotic env.	0.255	6	3.97	0.001
Total effect of geo. distance	0.227	2	8.61	0.001
Isolated effect of abiotic env.	0.003	2	1.10	0.219
Isolated effect of biotic env.	0.041	6	1.46	0.001
Isolated effect of geo. distance	0.005	2	1.16	0.122
Shared effect of abiotic env. & geo.distance	0.016	---	---	---
Shared effect of abiotic env. & biotic env.	0.008	---	---	---
Shared effect of biotic env. & geo.distance	0.010	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.196	---	---	---
Residual variation	0.721	---	---	---

Unburned flowers

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.200	11	2.02	0.001
Total effect of abiotic env.	0.161	3	3.88	0.001
Total effect of biotic env.	0.161	6	2.44	0.001
Total effect of geo. distance	0.154	2	5.08	0.001
Isolated effect of abiotic env.	0.011	3	1.18	0.094
Isolated effect of biotic env.	0.029	6	1.24	0.014
Isolated effect of geo. distance	0.000	2	1.00	0.477
Shared effect of abiotic env. & geo.distance	0.028	---	---	---
Shared effect of abiotic env. & biotic env.	0.006	---	---	---
Shared effect of biotic env. & geo.distance	0.010	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.116	---	---	---
Residual variation	0.800	---	---	---

Mixed-severity wildfire flowers

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.289	11	2.92	0.001
Total effect of abiotic env.	0.212	2	8.00	0.001
Total effect of biotic env.	0.244	7	3.40	0.001
Total effect of geo. distance	0.215	2	8.12	0.001
Isolated effect of abiotic env.	0.012	2	1.36	0.029
Isolated effect of biotic env.	0.050	7	1.48	0.001
Isolated effect of geo. distance	0.011	2	1.33	0.040
Shared effect of abiotic env. & geo.distance	0.022	---	---	---
Shared effect of abiotic env. & biotic env.	0.012	---	---	---
Shared effect of biotic env. & geo.distance	0.016	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.166	---	---	---
Residual variation	0.711	---	---	---

High-severity wildfire flowers

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.375	13	3.40	0.001
Total effect of abiotic env.	0.305	3	8.62	0.001
Total effect of biotic env.	0.358	8	4.62	0.001
Total effect of geo. distance	0.300	2	12.17	0.001
Isolated effect of abiotic env.	0.008	3	1.17	0.102
Isolated effect of biotic env.	0.055	8	1.51	0.001
Isolated effect of geo. distance	0.002	2	1.08	0.293
Shared effect of abiotic env. & geo.distance	0.007	---	---	---
Shared effect of abiotic env. & biotic env.	0.012	---	---	---
Shared effect of biotic env. & geo.distance	0.013	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.278	---	---	---
Residual variation	0.625	---	---	---

Helena pollinators

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.203	13	2.00	0.001
Total effect of abiotic env.	0.081	3	2.51	0.001
Total effect of biotic env.	0.171	8	2.31	0.001
Total effect of geo. distance	0.083	2	3.32	0.001
Isolated effect of abiotic env.	0.004	3	1.07	0.259
Isolated effect of biotic env.	0.102	8	1.74	0.001
Isolated effect of geo. distance	0.013	2	1.32	0.033
Shared effect of abiotic env. & geo.distance	0.016	---	---	---
Shared effect of abiotic env. & biotic env.	0.014	---	---	---
Shared effect of biotic env. & geo.distance	0.007	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.048	---	---	---
Residual variation	0.797	---	---	---

Paradise pollinators

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.277	16	2.13	0.001
Total effect of abiotic env.	0.128	1	7.89	0.001
Total effect of biotic env.	0.256	13	2.25	0.001
Total effect of geo. distance	0.143	2	4.92	0.001
Isolated effect of abiotic env.	0.001	1	1.05	0.382
Isolated effect of biotic env.	0.123	13	1.58	0.001
Isolated effect of geo. distance	0.017	2	1.38	0.024
Shared effect of abiotic env. & geo.distance	0.003	---	---	---
Shared effect of abiotic env. & biotic env.	0.010	---	---	---
Shared effect of biotic env. & geo.distance	0.010	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.114	---	---	---
Residual variation	0.723	---	---	---

Whitefish pollinators

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.068	9	1.42	0.001
Total effect of abiotic env.	0.013	1	1.70	0.003
Total effect of biotic env.	0.078	6	1.72	0.001
Total effect of geo. distance	0.027	2	1.70	0.001
Isolated effect of abiotic env.	-0.004	1	0.83	0.772
Isolated effect of biotic env.	0.044	6	1.38	0.001
Isolated effect of geo. distance	-0.008	2	0.82	0.887
Shared effect of abiotic env. & geo.distance	0.001	---	---	---
Shared effect of abiotic env. & biotic env.	0.001	---	---	---
Shared effect of biotic env. & geo.distance	0.018	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.015	---	---	---
Residual variation	0.932	---	---	---

Helena flowers

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.226	13	2.15	0.001
Total effect of abiotic env.	0.094	3	2.77	0.001
Total effect of biotic env.	0.159	8	2.20	0.001
Total effect of geo. distance	0.061	2	2.65	0.001
Isolated effect of abiotic env.	0.034	3	1.61	0.001
Isolated effect of biotic env.	0.096	8	1.71	0.001
Isolated effect of geo. distance	0.020	2	1.51	0.001
Shared effect of abiotic env. & geo.distance	0.014	---	---	---
Shared effect of abiotic env. & biotic env.	0.036	---	---	---
Shared effect of biotic env. & geo.distance	0.017	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.011	---	---	---
Residual variation	0.774	---	---	---

Paradise flowers

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.277	9	3.00	0.001
Total effect of abiotic env.	0.230	3	5.67	0.001
Total effect of biotic env.	0.207	4	4.06	0.001
Total effect of geo. distance	0.210	2	7.25	0.001
Isolated effect of abiotic env.	0.024	3	1.46	0.005
Isolated effect of biotic env.	0.029	4	1.42	0.003
Isolated effect of geo. distance	0.019	2	1.52	0.008
Shared effect of abiotic env. & geo.distance	0.028	---	---	---
Shared effect of abiotic env. & biotic env.	0.014	---	---	---
Shared effect of biotic env. & geo.distance	0.000	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.163	---	---	---
Residual variation	0.723	---	---	---

Whitefish flowers

Explanatory variables	r_a^2	df	*F*	*P*
Combined effect of abiotic env., biotic env. & geo. distance	0.248	15	2.12	0.001
Total effect of abiotic env.	0.104	2	3.94	0.001
Total effect of biotic env.	0.177	11	2.00	0.001
Total effect of geo. distance	0.123	2	4.56	0.001
Isolated effect of abiotic env.	0.034	2	1.86	0.001
Isolated effect of biotic env.	0.109	11	1.62	0.001
Isolated effect of geo. distance	0.018	2	1.47	0.017
Shared effect of abiotic env. & geo.distance	0.019	---	---	---
Shared effect of abiotic env. & biotic env.	-0.017	---	---	---
Shared effect of biotic env. & geo.distance	0.018	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.067	---	---	---
Residual variation	0.752	---	---	---

Pollinators across all sites and wildfire-severity levels

Explanatory variables	r_a^2	df	F	P
Combined effect of abiotic env., biotic env. & geo. distance	0.223	33	2.31	0.001
Total effect of abiotic env.	0.129	3	8.46	0.001
Total effect of biotic env.	0.214	28	2.46	0.001
Total effect of geo. distance	0.119	2	11.17	0.001
Isolated effect of abiotic env.	0.002	3	1.10	0.088
Isolated effect of biotic env.	0.074	28	1.50	0.001
Isolated effect of geo. distance	0.004	2	1.28	0.004
Shared effect of abiotic env. & geo.distance	0.004	---	---	---
Shared effect of abiotic env. & biotic env.	0.028	---	---	---
Shared effect of biotic env. & geo.distance	0.016	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.096	---	---	---
Residual variation	0.777	---	---	---

Flowers across all sites and wildfire-severity levels

Explanatory variables	r_a^2	df	F	P
Combined effect of abiotic env., biotic env. & geo. distance	0.252	28	2.81	0.001
Total effect of abiotic env.	0.146	4	7.47	0.001
Total effect of biotic env.	0.217	22	2.90	0.001
Total effect of geo. distance	0.116	2	10.88	0.001
Isolated effect of abiotic env.	0.022	4	1.91	0.001
Isolated effect of biotic env.	0.080	22	1.70	0.001
Isolated effect of geo. distance	0.011	2	1.95	0.001
Shared effect of abiotic env. & geo.distance	0.002	---	---	---
Shared effect of abiotic env. & biotic env.	0.035	---	---	---
Shared effect of biotic env. & geo.distance	0.014	---	---	---
Shared effect of abiotic env., biotic env. & geo. distance	0.089	---	---	---
Residual variation	0.748	---	---	---

Table S3. Importance of abiotic environmental variables (principal components) to explaining variation in species composition of pollinator and flowering-plant communities (β-diversity) in western Montana. The overall test for significance of the entire predictor matrix is in parentheses. Please see text for more details on the principal components analysis and variation partitioning that produced these results.

Unburned pollinators (F = 2.88; p = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
PC1 (Climate, soils, NPP, slope)	1	0.117	0.117	0.097	5.85	0.001
PC2 (Elevation, climate, soils, NPP)	2	0.060	0.177	0.139	3.11	0.001

Mixed-severity wildfire pollinators (F = 4.22; p = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
PC1 (Climate, soils, NPP, slope)	1	0.153	0.153	0.136	9.19	0.001

High-severity wildfire pollinators (F = 4.74; p = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
PC1 (Climate, soils, NPP, slope)	1	0.159	0.159	0.142	9.62	0.001
PC2 (Elevation, climate, soils, NPP)	2	0.094	0.253	0.223	6.31	0.001

Unburned flowers (F = 3.17; p = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
PC1 (Climate, soils, NPP, slope)	1	0.098	0.098	0.077	4.77	0.001
PC2 (Elevation, climate, soils, NPP)	2	0.093	0.191	0.153	4.93	0.001
PC3 (Fire, soils, woody debris)	3	0.026	0.217	0.161	1.40	0.024

Mixed-severity wildfire flowers (*F* = 4.57; *p* = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
PC1 (Climate, soils, NPP, slope)	1	0.146	0.146	0.130	8.74	0.001
PC2 (Elevation, climate, soils, NPP)	2	0.096	0.242	0.212	6.34	0.001

High-severity wildfire flowers (*F* = 6.72; *p* = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
PC1 (Climate, soils, NPP, slope)	1	0.192	0.192	0.176	12.09	0.001
PC2 (Elevation, climate, soils, NPP)	2	0.134	0.326	0.299	9.92	0.001
PC4 (Soils, aspect, woody debris)	3	0.020	0.345	0.305	1.48	0.035

Helena pollinators (*F* = 2.16; *p* = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
PC2 (Elevation, climate, soils, NPP)	1	0.073	0.073	0.054	3.94	0.001
PC3 (Fire, soils, woody debris)	2	0.033	0.106	0.069	1.80	0.009
PC1 (Climate, soils, NPP, slope)	3	0.030	0.135	0.081	1.64	0.017

Paradise pollinators (*F* = 2.86; *p* = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
PC3 (Fire, soils, woody debris)	1	0.146	0.146	0.128	7.89	0.001

Whitefish pollinators (*F* = 1.32; *p* = 0.004)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
PC3 (Fire, soils, woody debris)	1	0.033	0.033	0.013	1.70	0.007

Helena flowers (*F* = 2.36; *p* = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
PC3 (Fire, soils, woody debris)	1	0.059	0.059	0.040	3.11	0.001
PC1 (Climate, soils, NPP, slope)	2	0.052	0.111	0.074	2.88	0.001
PC2 (Elevation, climate, soils, NPP)	3	0.037	0.148	0.094	2.07	0.002

Paradise flowers (*F* = 4.56; *p* = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
PC3 (Fire, soils, woody debris)	1	0.175	0.175	0.157	9.75	0.001
PC1 (Climate, soils, NPP, slope)	2	0.068	0.242	0.209	4.01	0.001
PC2 (Elevation, climate, soils, NPP)	3	0.036	0.279	0.230	2.21	0.001

Whitefish flowers (*F* = 2.60; *p* = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
PC3 (Fire, soils, woody debris)	1	0.101	0.101	0.083	5.61	0.001
PC1 (Climate, soils, NPP, slope)	2	0.038	0.139	0.104	2.15	0.004

Pollinators across all sites and wildfire-severity levels (F = 6.63; p = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
PC1 (Climate, soils, NPP, slope)	1	0.084	0.084	0.078	13.70	0.001
PC2 (Elevation, climate, soils, NPP)	2	0.039	0.123	0.111	6.64	0.001
PC3 (Fire, soils, woody debris)	3	0.024	0.146	0.129	4.11	0.001

Flowers across all sites and wildfire-severity levels (F = 7.47; p = 0.001)

Principal component	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
PC1 (Climate, soils, NPP, slope)	1	0.073	0.073	0.067	11.76	0.001
PC2 (Elevation, climate, soils, NPP)	2	0.047	0.120	0.108	7.96	0.001
PC3 (Fire, soils, woody debris)	3	0.041	0.160	0.143	7.16	0.001
PC4 (Soils, aspect, woody debris)	4	0.009	0.169	0.146	1.52	0.007

Table S4. Importance of biotic environmental axes (principal coordinates based on Bray-Curtis dissimilarities) to explaining variation in species composition of pollinator and flowering-plant communities (β-diversity) in western Montana. The overall test for significance of the entire predictor matrix is in parentheses. Please see text for more details on the distance-based approach, forward-stepwise model selection, and variation partitioning that produced these results.

Unburned pollinators (*F* = 1.66; *p* = 0.001)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
Floral axis 1	1	0.098	0.098	0.078	4.78	0.001
Floral axis 2	2	0.076	0.174	0.135	3.94	0.001
Floral axis 6	3	0.031	0.204	0.148	1.62	0.003
Floral axis 7	4	0.026	0.231	0.155	1.40	0.034

Mixed-severity wildfire pollinators (*F* = 1.38; *p* = 0.001)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
Floral axis 1	1	0.143	0.143	0.126	8.51	0.001
Floral axis 2	2	0.070	0.213	0.182	4.47	0.001
Floral axis 3	3	0.031	0.245	0.199	2.04	0.001
Floral axis 12	4	0.026	0.271	0.211	1.74	0.002
Floral axis 35	5	0.025	0.296	0.222	1.69	0.004
Floral axis 52	6	0.023	0.319	0.230	1.54	0.011
Floral axis 6	7	0.022	0.341	0.239	1.52	0.013

High-severity wildfire pollinators (*F* = 1.66; *p* = 0.015)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
Floral axis 1	1	0.166	0.166	0.150	10.15	0.001
Floral axis 2	2	0.077	0.243	0.212	5.07	0.001
Floral axis 3	3	0.030	0.273	0.228	2.04	0.001
Floral axis 4	4	0.027	0.300	0.241	1.82	0.002
Floral axis 47	5	0.021	0.321	0.248	1.46	0.040
Floral axis 5	6	0.020	0.341	0.255	1.43	0.028

Unburned flowers (*F* = 1.41; *p* = 0.001)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
Pollinator axis 1	1	0.095	0.095	0.075	4.63	0.001
Pollinator axis 2	2	0.061	0.156	0.117	3.12	0.001
Pollinator axis 7	3	0.035	0.191	0.133	1.79	0.005
Pollinator axis 6	4	0.029	0.220	0.144	1.51	0.025
Pollinator axis 29	5	0.027	0.246	0.152	1.42	0.036
Pollinator axis 19	6	0.026	0.273	0.161	1.42	0.037

Mixed-severity wildfire flowers (*F* = 1.41; *p* = 0.027)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
Pollinator axis 1	1	0.147	0.147	0.130	8.79	0.001
Pollinator axis 2	2	0.085	0.232	0.201	5.52	0.001
Pollinator axis 3	3	0.028	0.260	0.214	1.83	0.006
Pollinator axis 26	4	0.024	0.283	0.224	1.60	0.012
Pollinator axis 19	5	0.021	0.305	0.231	1.44	0.037
Pollinator axis 38	6	0.021	0.326	0.238	1.43	0.038
Pollinator axis 24	7	0.020	0.346	0.244	1.40	0.049

High-severity wildfire flowers ($F = 3.41$; $p = 0.001$)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
Pollinator axis 1	1	0.191	0.191	0.175	12.02	0.001
Pollinator axis 2	2	0.129	0.320	0.293	9.51	0.001
Pollinator axis 5	3	0.036	0.356	0.317	2.77	0.001
Pollinator axis 6	4	0.025	0.381	0.329	1.91	0.003
Pollinator axis 7	5	0.021	0.402	0.338	1.65	0.010
Pollinator axis 15	6	0.018	0.420	0.345	1.47	0.024
Pollinator axis 4	7	0.018	0.439	0.351	1.44	0.042
Pollinator axis 8	8	0.018	0.456	0.358	1.46	0.045

Helena pollinators ($F = 1.45$; $p = 0.004$)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
Floral axis 1	1	0.078	0.078	0.060	4.23	0.001
Floral axis 7	2	0.043	0.121	0.085	2.38	0.001
Floral axis 3	3	0.040	0.161	0.109	2.31	0.001
Floral axis 4	4	0.033	0.194	0.126	1.95	0.002
Floral axis 13	5	0.027	0.222	0.137	1.61	0.016
Floral axis 26	6	0.027	0.249	0.149	1.63	0.006
Floral axis 2	7	0.027	0.276	0.161	1.64	0.003
Floral axis 6	8	0.025	0.301	0.171	1.53	0.019

Paradise pollinators (F = 1.56; p = 0.002)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
Floral axis 1	1	0.165	0.165	0.147	9.07	0.001
Floral axis 27	2	0.032	0.196	0.161	1.77	0.004
Floral axis 41	3	0.026	0.222	0.169	1.47	0.015
Floral axis 33	4	0.026	0.248	0.178	1.47	0.028
Floral axis 12	5	0.025	0.273	0.187	1.45	0.023
Floral axis 10	6	0.025	0.298	0.195	1.46	0.014
Floral axis 6	7	0.025	0.323	0.204	1.45	0.029
Floral axis 16	8	0.024	0.347	0.213	1.44	0.030
Floral axis 17	9	0.024	0.370	0.221	1.43	0.045
Floral axis 22	10	0.024	0.394	0.230	1.44	0.029
Floral axis 3	11	0.023	0.417	0.239	1.41	0.042
Floral axis 2	12	0.023	0.440	0.247	1.41	0.038
Floral axis 9	13	0.022	0.462	0.256	1.41	0.046

Whitefish pollinators (F = 1.36; p = 0.032)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
Floral axis 1	1	0.047	0.047	0.028	2.47	0.001
Floral axis 2	2	0.034	0.081	0.044	1.83	0.004
Floral axis 23	3	0.028	0.110	0.054	1.52	0.017
Floral axis 18	4	0.027	0.136	0.063	1.45	0.030
Floral axis 6	5	0.025	0.162	0.071	1.39	0.043
Floral axis 41	6	0.025	0.187	0.078	1.39	0.038

Helena flowers (*F* = 1.56; *p* = 0.001)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
Pollinator axis 1	1	0.079	0.079	0.061	4.29	0.001
Pollinator axis 3	2	0.044	0.123	0.087	2.46	0.001
Pollinator axis 23	3	0.036	0.160	0.107	2.08	0.001
Pollinator axis 20	4	0.030	0.190	0.121	1.77	0.006
Pollinator axis 25	5	0.026	0.216	0.131	1.52	0.034
Pollinator axis 4	6	0.026	0.242	0.140	1.51	0.036
Pollinator axis 21	7	0.025	0.267	0.150	1.50	0.031
Pollinator axis 2	8	0.024	0.291	0.159	1.47	0.035

Paradise flowers (*F* = 1.48; *p* = 0.003)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
Pollinator axis 1	1	0.184	0.184	0.166	10.34	0.001
Pollinator axis 12	2	0.039	0.222	0.187	2.23	0.003
Pollinator axis 19	3	0.026	0.248	0.197	1.55	0.018
Pollinator axis 33	4	0.026	0.274	0.207	1.52	0.029

Whitefish flowers (F = 1.49; p = 0.001)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	F	P
Pollinator axis 1	1	0.057	0.057	0.038	3.03	0.001
Pollinator axis 11	2	0.039	0.096	0.059	2.10	0.005
Pollinator axis 6	3	0.037	0.133	0.079	2.06	0.003
Pollinator axis 2	4	0.033	0.166	0.095	1.89	0.010
Pollinator axis 3	5	0.031	0.197	0.110	1.75	0.016
Pollinator axis 26	6	0.029	0.226	0.123	1.71	0.012
Pollinator axis 13	7	0.029	0.255	0.136	1.68	0.025
Pollinator axis 28	8	0.026	0.281	0.147	1.56	0.045
Pollinator axis 5	9	0.025	0.306	0.157	1.52	0.037
Pollinator axis 8	10	0.025	0.331	0.167	1.51	0.044
Pollinator axis 17	11	0.024	0.355	0.177	1.49	0.039

Pollinators across all sites and wildfire-severity levels (*F* = 1.54; *p* = 0.002)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
Floral axis 1	1	0.079	0.079	0.073	12.83	0.001
Floral axis 2	2	0.044	0.123	0.111	7.49	0.001
Floral axis 3	3	0.032	0.155	0.138	5.69	0.001
Floral axis 6	4	0.017	0.172	0.150	2.96	0.001
Floral axis 5	5	0.012	0.185	0.157	2.23	0.001
Floral axis 4	6	0.012	0.197	0.163	2.19	0.001
Floral axis 8	7	0.010	0.207	0.168	1.85	0.001
Floral axis 21	8	0.009	0.216	0.172	1.65	0.001
Floral axis 14	9	0.009	0.225	0.176	1.63	0.001
Floral axis 48	10	0.008	0.233	0.179	1.54	0.002
Floral axis 7	11	0.008	0.241	0.182	1.52	0.001
Floral axis 104	12	0.008	0.250	0.185	1.51	0.002
Floral axis 10	13	0.008	0.257	0.187	1.44	0.007
Floral axis 113	14	0.007	0.265	0.189	1.34	0.012
Floral axis 34	15	0.007	0.272	0.191	1.34	0.011
Floral axis 12	16	0.007	0.279	0.193	1.34	0.010
Floral axis 13	17	0.007	0.286	0.195	1.33	0.011
Floral axis 65	18	0.007	0.293	0.197	1.30	0.023
Floral axis 16	19	0.007	0.300	0.199	1.29	0.030
Floral axis 66	20	0.007	0.306	0.201	1.28	0.028
Floral axis 15	21	0.007	0.313	0.202	1.27	0.037
Floral axis 94	22	0.007	0.320	0.204	1.27	0.026
Floral axis 71	23	0.007	0.327	0.206	1.27	0.026
Floral axis 9	24	0.007	0.333	0.207	1.27	0.034
Floral axis 105	25	0.007	0.340	0.209	1.26	0.030
Floral axis 63	26	0.007	0.346	0.210	1.26	0.030
Floral axis 118	27	0.007	0.353	0.212	1.25	0.045
Floral axis 119	28	0.006	0.359	0.214	1.24	0.044

Flowers across all sites and wildfire-severity levels (*F* = 1.46; *p* = 0.001)

Principal coordinate	Rank	r^2	Cumulative r^2	Cumulative r_a^2	*F*	*P*
Pollinator axis 1	1	0.084	0.084	0.078	13.71	0.001
Pollinator axis 2	2	0.058	0.141	0.130	10.00	0.001
Pollinator axis 3	3	0.021	0.162	0.145	3.62	0.001
Pollinator axis 5	4	0.018	0.180	0.157	3.21	0.001
Pollinator axis 4	5	0.018	0.198	0.170	3.26	0.001
Pollinator axis 6	6	0.010	0.208	0.175	1.91	0.003
Pollinator axis 21	7	0.009	0.218	0.179	1.73	0.003
Pollinator axis 18	8	0.009	0.226	0.183	1.64	0.002
Pollinator axis 9	9	0.008	0.235	0.186	1.57	0.002
Pollinator axis 46	10	0.008	0.243	0.189	1.50	0.002
Pollinator axis 23	11	0.008	0.251	0.192	1.47	0.009
Pollinator axis 15	12	0.008	0.259	0.195	1.47	0.006
Pollinator axis 27	13	0.008	0.266	0.197	1.46	0.007
Pollinator axis 12	14	0.008	0.274	0.200	1.42	0.005
Pollinator axis 35	15	0.008	0.281	0.202	1.43	0.012
Pollinator axis 17	16	0.008	0.289	0.205	1.43	0.012
Pollinator axis 51	17	0.007	0.296	0.207	1.40	0.015
Pollinator axis 48	18	0.007	0.304	0.209	1.38	0.009
Pollinator axis 13	19	0.007	0.311	0.212	1.37	0.022
Pollinator axis 29	20	0.007	0.318	0.213	1.30	0.037
Pollinator axis 75	21	0.007	0.324	0.215	1.30	0.035
Pollinator axis 141	22	0.007	0.331	0.217	1.30	0.034

Table S5. Number and proportion (out of all possible pollinator-plant species pairs) of pollinator-plant species pairs with significant positive and negative co-occurrences across sites in each of three regions of western Montana, USA. The number (proportion) of species pairs with significant co-occurrence using the 95% confidence interval (95% CI) criterion (observed value falls outside the middle 95% of null values) and the more restrictive Bayesian mean-based criterion (Gotelli and Ulrich 2010) are shown. Also shown are the number and proportion of pollinator-plant species pairs that exhibit positive co-occurrences (i.e. aggregation) across sites in each of three regions. Positive co-occurrences indicate that a pollinator-plant species pair co-occurs more often than expected from 1,000 random redistributions of species occurrences across sites (as determined by null-model analysis, see methods), and negative co-occurrences indicate that a pollinator-plant species pair co-occurs less often than expected from 1,000 random redistributions of species occurrences across sites.

	Number (proportion) of species with positive or negative co-occurrence with the other linked trophic level		**Number (proportion) of species with positive co-occurrence with the other linked trophic level**	
	95% CI	**Bayes mean criterion**	**95% CI**	**Bayes mean criterion**
Helena pollinators	161 (61.2 %)	84 (31.9 %)	140 (53.2 %)	48 (18.3 %)
Paradise pollinators	58 (41.7 %)	56 (40.3 %)	46 (33.1 %)	44 (31.7 %)
Whitefish pollinators	16 (18.6 %)	13 (15.1 %)	15 (17.4 %)	13 (15.1 %)
Helena flowers	105 (84.0 %)	58 (46.4 %)	92 (73.6 %)	35 (28.0 %)
Paradise flowers	47 (57.3 %)	47 (57.3 %)	41 (50.0 %)	38 (46.3 %)
Whitefish flowers	25 (49.0 %)	19 (37.3 %)	21 (41.2 %)	18 (35.3 %)

	Number (proportion) of species with positive or negative co-occurrence with the other linked trophic level		**Number (proportion) of species with positive co-occurrence with the other linked trophic level**	
	95% CI	**Bayes mean criterion**	**95% CI**	**Bayes mean criterion**
Unburned pollinators	74 (48.7 %)	73 (48.0 %)	73 (48.0 %)	72 (47.4 %)
Mixed-severity pollinators	137 (55.7 %)	132 (53.7 %)	124 (50.4 %)	111 (45.1 %)
High-severity pollinators	135 (56.0 %)	129 (53.5 %)	106 (44.0 %)	106 (44.0 %)
Unburned flowers	74 (59.2 %)	72 (57.6 %)	72 (57.6 %)	67 (53.6 %)
Mixed-severity flowers	105 (72.4 %)	101 (69.7 %)	95 (65.5 %)	90 (62.1 %)
High-severity flowers	80 (62.5 %)	78 (60.9 %)	72 (56.3 %)	71 (55.5 %)

Table S6. Pollinator-plant species pairs in each region that showed positive co-occurrence (aggregation) based on the 95% confidence interval (CI) criterion. Species pairs that reached significance with the more restrictive Bayes mean-based criterion (BMC) are indicated in the last column. See methods for more details on the significance criteria for co-occurrence analyses.

Helena Region (positive co-occurrences)

Pollinator species	Flower species	BMC
Andrena lawrencei	*Balsamorhiza sagittata*	0
Andrena lawrencei	*Centaurea stoebe*	0
Andrena milwaukeensis	*Descurainia pinnata*	0
Andrena nivalis	*Astragalus tenellus*	1
Andrena nivalis	*Crepis atribarba*	1
Andrena nivalis	*Symphyotrichum ascendens*	0
Andrena nivalis	*Tragopogon dubius*	0
Andrena surda	*Stellaria longipes*	0
Andrena thaspii	*Lupinus sericeus*	0
Andrena transnigra	*Leucanthemum vulgare*	0
Anthidium clypeodentatum	*Astragalus convallarius*	1
Anthidium clypeodentatum	*Carduus nutans*	1
Anthidium clypeodentatum	*Gaillardia aristata*	1
Anthidium clypeodentatum	*Medicago lupulina*	1
Anthidium mormonum	*Melilotus officinalis*	1
Anthidium mormonum	*Tragopogon dubius*	1
Anthidium mormonum	*Lactuca serriol*	0
Anthidium mormonum	*Linaria dalmatica*	0
Anthidium mormonum	*Symphyotrichum falcatum*	0
Anthidium tenuiflorae	*Astragalus drummondii*	0
Anthidium tenuiflorae	*Astragalus flexuosus*	0
Anthidium utahense	*Astragalus alpinus*	1
Anthidium utahense	*Medicago lupulina*	1
Anthidium utahense	*Solidago missouriensis*	1
Anthidium utahense	*Symphyotrichum falcatum*	1
Anthidium utahense	*Tragopogon dubius*	1
Anthidium utahense	*Alyssum alyssoides*	0
Anthidium utahense	*Centaurea stoebe*	0
Anthidium utahense	*Linaria dalmatica*	0
Anthophora bomboides	*Sedum lanceolatum*	0
Anthophora terminalis	*Taraxacum officinale*	1
Anthophora terminalis	*Tragopogon dubius*	1
Anthophora terminalis	*Linaria dalmatica*	0
Anthophora urbana	*Centaurea stoebe*	1
Anthophora ursina	*Verbascum thapsus*	1
Anthophora ursina	*Epilobium brachycarpum*	0

Anthrax pauper	*Grindelia squarrosa*	0
Apis mellifera	*Melilotus officinalis*	1
Apis mellifera	*Centaurea stoebe*	0
Apis mellifera	*Linaria dalmatica*	0
Apis mellifera	*Sisymbrium loeselii*	0
Apis mellifera	*Symphyotrichum falcatum*	0
Ashmeadiella bucconis	*Centaurea stoebe*	1
Ashmeadiella bucconis	*Evolvulus nuttallianus*	1
Ashmeadiella bucconis	*Taraxacum officinale*	1
Ashmeadiella bucconis	*Verbascum thapsus*	1
Ashmeadiella bucconis	*Sisymbrium loeselii*	0
Ashmeadiella cactorum	*Astragalus miser*	1
Ashmeadiella cactorum	*Geum triflorum*	1
Ashmeadiella californica	*Lomatium triternatum*	1
Bombus appositus	*Alyssum alyssoides*	1
Bombus appositus	*Carduus nutans*	1
Bombus appositus	*Centaurea stoebe*	1
Bombus appositus	*Medicago lupulina*	1
Bombus appositus	*Melilotus officinalis*	1
Bombus appositus	*Sisymbrium loeselii*	1
Bombus appositus	*Solidago missouriensis*	1
Bombus appositus	*Taraxacum officinale*	1
Bombus appositus	*Tragopogon dubius*	1
Bombus appositus	*Cirsium arvense*	0
Bombus appositus	*Linaria dalmatica*	0
Bombus appositus	*Verbascum thapsus*	0
Bombus borealis	*Grindelia squarrosa*	0
Bombus centralis	*Lithospermum ruderale*	0
Bombus fervidus	*Carduus nutans*	1
Bombus fervidus	*Gaillardia aristata*	1
Bombus fervidus	*Linaria dalmatica*	1
Bombus fervidus	*Taraxacum officinale*	1
Bombus fervidus	*Tragopogon dubius*	0
Bombus huntii	*Taraxacum officinale*	1
Bombus rufocinctus	*Symphyotrichum laeve*	1
Ceratina neomexicana	*Tragopogon dubius*	0
Cercyonis oetus.charon	*Lithospermum ruderale*	0
Coelioxys alternata	*Verbascum thapsus*	1
Coelioxys alternata	*Taraxacum officinale*	0
Coelioxys porterae	*Cirsium arvense*	0
Coelioxys porterae	*Erysimum inconspicuum*	0
Coelioxys sodalis	*Ipomopsis spicata*	0
Coelioxys sodalis	*Stenotus acaulis*	0

Colletes fulgidus	*Medicago lupulina*	1
Colletes fulgidus	*Penstemon eriantherus*	1
Colletes fulgidus	*Symphyotrichum falcatum*	1
Colletes fulgidus	*Centaurea stoebe*	0
Colletes fulgidus	*Lactuca tatarica*	0
Colletes fulgidus	*Linaria dalmatica*	0
Colletes fulgidus	*Solidago missouriensis*	0
Colletes fulgidus	*Symphyotrichum ascendens*	0
Colletes fulgidus	*Symphyotrichum ericoides*	0
Colletes kincaidii	*Linaria dalmatica*	0
Colletes kincaidii	*Melilotus officinalis*	0
Colletes lutzi.lutzi	*Solidago simplex*	0
Colletes phaceliae	*Gaillardia aristata*	1
Colletes phaceliae	*Solidago missouriensis*	1
Colletes phaceliae	*Symphyotrichum falcatum*	1
Colletes phaceliae	*Taraxacum officinale*	1
Colletes phaceliae	*Linaria dalmatica*	0
Colletes phaceliae	*Tragopogon dubius*	0
Colletes phaceliae	*Verbascum thapsus*	0
Conophorus sackenii	*Erigeron caespitosus*	0
Diadasia diminuta	*Dalea purpurea*	0
Dianthidium ulkei	*Epilobium brachycarpum*	0
Dufourea maura	*Sedum lanceolatum*	1
Dufourea maura	*Antennaria microphylla*	0
Dufourea maura	*Campanula rotundifolia*	0
Dufourea trochantera	*Astragalus agrestis*	0
Eristalis Eoseristalis hirta	*Cirsium vulgare*	0
Eristalis Eoseristalis hirta	*Zigadenus venenosus*	0
Eristalis Eristalis tenax	*Grindelia squarrosa*	0
Eucera edwardsii	*Centaurea stoebe*	1
Eucera edwardsii	*Symphyotrichum ascendens*	0
Eucera edwardsii	*Symphyotrichum laeve*	0
Eucera frater	*Symphyotrichum ascendens*	0
Eucera frater	*Symphyotrichum laeve*	0
Eupeodes snowi	*Verbascum thapsus*	1
Eupeodes snowi	*Agoseris glauca*	0
Eupeodes snowi	*Taraxacum officinale*	0
Exoprosopa dorcadion	*Symphyotrichum laeve*	0
Halictus ligatus	*Alyssum alyssoides*	1
Halictus ligatus	*Crepis tectorum*	1
Halictus ligatus	*Gaillardia aristata*	1
Halictus ligatus	*Solidago missouriensis*	1
Halictus ligatus	*Tragopogon dubius*	1

Halictus ligatus	*Descurainia pinnata*	0
Halictus ligatus	*Linaria dalmatica*	0
Halictus rubicundus	*Penstemon eriantherus*	0
Halictus tripartitus	*Medicago lupulina*	1
Halictus tripartitus	*Solidago missouriensis*	1
Hellinsia paleaceus	*Leucanthemum vulgare*	0
Heriades carinatus	*Anemone multifida*	1
Heriades carinatus	*Arenaria capillaris*	1
Heriades carinatus	*Hedysarum boreale*	1
Heriades carinatus	*Lithospermum ruderale*	1
Heriades carinatus	*Arabis holboellii var. retrofracta*	0
Heriades variolosa	*Lomatium triternatum*	0
Heriades variolosa	*Oxytropis sericea*	0
Hesperia colorado	*Apocynum androsaemifolium*	0
Hoplitis fulgida fulgida	*Dalea candida*	0
Hoplitis fulgida fulgida	*Dalea purpurea*	0
Hoplitis grinnelli	*Alyssum alyssoides*	0
Hoplitis grinnelli	*Alyssum desertorum*	0
Hoplitis grinnelli	*Cirsium vulgare*	0
Hoplitis grinnelli	*Epilobium brachycarpum*	0
Hoplitis hypocrita	*Cirsium arvense*	1
Hoplitis hypocrita	*Gaillardia aristata*	1
Hoplitis hypocrita	*Linaria dalmatica*	1
Hoplitis hypocrita	*Sisymbrium loeselii*	1
Hoplitis hypocrita	*Taraxacum officinale*	1
Hoplitis hypocrita	*Tragopogon dubius*	1
Hoplitis hypocrita	*Verbascum thapsus*	1
Hoplitis hypocrita	*Alyssum desertorum*	0
Hoplitis hypocrita	*Centaurea stoebe*	0
Hoplitis hypocrita	*Symphyotrichum falcatum*	0
Hoplitis producta	*Arabis nuttallii*	0
Hoplitis truncata	*Linaria dalmatica*	1
Hylaeus coloradensis	*Astragalus miser*	0
Hylaeus rudbeckiae	*Lithospermum incisum*	1
Hylaeus Hylaeus annulatus	*Arabis holboellii*	0
Hylaeus Hylaeus leptocephalus	*Lomatium triternatum*	1
Hylaeus Hylaeus leptocephalus	*Astragalus gracilis*	0
Hylaeus Hylaeus leptocephalus	*Collomia linearis*	0
Hylaeus Hylaeus leptocephalus	*Sisymbrium loeselii*	0
Lasioglossum egregium	*Crepis atribarba*	1
Lasioglossum egregium	*Arnica angustifolia*	0
Lasioglossum egregium	*Symphyotrichum ascendens*	0
Lasioglossum Dialictus abundipunctum	*Lupinus sericeus*	0

Lasioglossum Dialictus aff. caducum	*Hedysarum boreale*	0
Lasioglossum Dialictus albipenne	*Alyssum alyssoides*	1
Lasioglossum Dialictus albipenne	*Centaurea stoebe*	1
Lasioglossum Dialictus albipenne	*Sisymbrium loeselii*	1
Lasioglossum Dialictus albipenne	*Solidago missouriensis*	1
Lasioglossum Dialictus albipenne	*Symphyotrichum falcatum*	1
Lasioglossum Dialictus albipenne	*Taraxacum officinale*	1
Lasioglossum Dialictus albipenne	*Verbascum thapsus*	1
Lasioglossum Dialictus albipenne	*Gaillardia aristata*	0
Lasioglossum Dialictus albipenne	*Linaria dalmatica*	0
Lasioglossum Dialictus albipenne	*Medicago lupulina*	0
Lasioglossum Dialictus albipenne	*Symphyotrichum laeve*	0
Lasioglossum Dialictus albipenne	*Tragopogon dubius*	0
Lasioglossum Dialictus marinense	*Cirsium arvense*	1
Lasioglossum Dialictus marinense	*Arabis nuttallii*	0
Lasioglossum Dialictus marinense	*Campanula rotundifolia*	0
Lasioglossum Dialictus marinense	*Carduus nutans*	0
Lasioglossum Dialictus marinense	*Lithospermum ruderale*	0
Lasioglossum Dialictus marinense	*Zigadenus venenosus*	0
Lasioglossum Dialictus nr. pavoninum	*Penstemon procerus*	0
Lasioglossum Dialictus occidentale	*Medicago lupulina*	0
Lasioglossum Dialictus ruidosense	*Allium cernuum*	1
Lasioglossum Dialictus ruidosense	*Centaurea stoebe*	1
Lasioglossum Dialictus ruidosense	*Tragopogon dubius*	1
Lasioglossum Dialictus ruidosense	*Linaria dalmatica*	0
Lasioglossum Dialictus sp. M7	*Leucanthemum vulgare*	0
Lasioglossum Dialictus succinipenne	*Liatris punctata*	0
Lasioglossum Dialictus succinipenne	*Medicago lupulina*	0
Lasioglossum Evylaeus sp. F1	*Helianthus annuus*	0
Lasioglossum Evylaeus sp. F2	*Lithospermum ruderale*	0
Lasioglossum Evylaeus sp. F3	*Zigadenus venenosus*	0
Megachile angelarum	*Campanula rotundifolia*	0
Megachile angelarum	*Symphyotrichum laeve*	0
Megachile apicalis	*Taraxacum officinale*	1
Megachile apicalis	*Centaurea stoebe*	0
Megachile apicalis	*Linaria dalmatica*	0
Megachile apicalis	*Melilotus officinalis*	0
Megachile apicalis	*Solidago missouriensis*	0
Megachile apicalis	*Solidago multiradiata*	0
Megachile apicalis	*Tragopogon dubius*	0
Megachile brevis	*Gutierrezia sarothrae*	0
Megachile brevis	*Symphyotrichum falcatum*	0
Megachile campanulae	*Astragalus tenellus*	0

Megachile fidelis	*Symphyotrichum laeve*	0
Megachile fidelis	*Taraxacum officinale*	0
Megachile fidelis	*Verbascum thapsus*	0
Megachile lapponica	*Astragalus gracilis*	0
Megachile lapponica	*Astragalus tenellus*	0
Megachile lapponica	*Lupinus sericeus*	0
Megachile montivaga	*Campanula rotundifolia*	0
Megachile montivaga	*Symphyotrichum ericoides*	0
Megachile pugnata	*Sisymbrium loeselii*	1
Megachile pugnata	*Descurainia incana*	0
Megachile relativa	*Medicago lupulina*	1
Megachile relativa	*Carduus nutans*	0
Melissodes confusa	*Geranium viscosissimum*	0
Melissodes microsticta	*Astragalus miser*	0
Melissodes microsticta	*Melilotus officinalis*	0
Melissodes Eumelissodes microsticta	*Centaurea stoebe*	0
Melissodes Eumelissodes microsticta	*Linaria dalmatica*	0
Melissodes Eumelissodes microsticta	*Solidago missouriensis*	0
Nomada edwardsii	*Anemone multifida*	0
Nomada sp. F2	*Astragalus drummondii*	0
Nomada sp. F7	*Crepis occidentalis*	0
Nomada sp. M6	*Cerastium arvense*	0
Osmia albolateralis	*Symphyotrichum ascendens*	0
Osmia juxta	*Centaurea stoebe*	1
Osmia juxta	*Cirsium arvense*	1
Osmia juxta	*Symphyotrichum ascendens*	1
Osmia juxta	*Tragopogon dubius*	1
Osmia juxta	*Collomia linearis*	0
Osmia juxta	*Linaria dalmatica*	0
Osmia juxta	*Sisymbrium loeselii*	0
Osmia juxta	*Solidago missouriensis*	0
Osmia montana montana	*Taraxacum officinale*	1
Osmia montana montana	*Balsamorhiza sagittata*	0
Osmia pusilla	*Linaria dalmatica*	0
Osmia pusilla	*Medicago lupulina*	0
Osmia tristella	*Zigadenus venenosus*	0
Osmia Cephalosmia californica	*Linaria dalmatica*	1
Osmia Cephalosmia californica	*Sisymbrium loeselii*	1
Osmia Cephalosmia californica	*Verbascum thapsus*	1
Osmia Cephalosmia californica	*Collomia linearis*	0
Osmia Cephalosmia californica	*Evolvulus nuttallianus*	0
Osmia Cephalosmia californica	*Taraxacum officinale*	0
Osmia Cephalosmia californica	*Tragopogon dubius*	0

Osmia Hapsidosmia iridis	*Astragalus miser*	0
Osmia Melanosmia aff. grindeliae	*Fritillaria atropurpurea*	0
Osmia Melanosmia atrocyanea	*Astragalus gilviflorus*	0
Osmia Melanosmia brevis	*Lithospermum ruderale*	1
Osmia Melanosmia bucephala	*Symphyotrichum laeve*	0
Osmia Melanosmia densa	*Anemone multifida*	0
Osmia Melanosmia grindeliae	*Gutierrezia sarothrae*	0
Osmia Melanosmia inermis	*Anemone multifida*	0
Osmia Melanosmia kincaidii	*Cirsium arvense*	0
Osmia Melanosmia longula	*Antennaria racemosa*	0
Osmia Melanosmia malina	*Cynoglossum officinale*	0
Osmia Melanosmia nigrifrons	*Oxytropis sericea*	0
Osmia Melanosmia odontogaster	*Gaura coccinea*	0
Osmia Melanosmia pentstemonis	*Gutierrezia sarothrae*	0
Osmia Melanosmia phaceliae	*Linum lewisii*	0
Osmia Melanosmia simillima	*Glycyrrhiza lepidota*	0
Osmia Melanosmia trevoris	*Carduus nutans*	0
Panurginus torchioi	*Geranium viscosissimum*	0
Paragus Pandasyopthalmus haemorrhous	*Cirsium vulgare*	0
Paragus Pandasyopthalmus haemorrhous	*Epilobium brachycarpum*	0
Paravilla sp. F1	*Agoseris glauca*	1
Paravilla sp. F2	*Helianthus annuus*	0
Phyciodes pulchella	*Crepis acuminata*	0
Phyciodes tharos	*Symphyotrichum laeve*	1
Plebejus icarioides	*Verbascum thapsus*	1
Plebejus icarioides	*Centaurea stoebe*	0
Plebejus icarioides	*Lupinus sericeus*	0
Plebejus saepiolus	*Symphyotrichum laeve*	0
Scaeva pyrastri	*Lactuca tatarica*	0
Sphaerophoria abbreviata	*Arabis nuttallii*	0
Sphaerophoria abbreviata	*Cerastium arvense*	0
Sphaerophoria contigua	*Lactuca serriol*	0
Stelis aff. permaculata	*Lactuca serriol*	0
Stelis calliphorina	*Arabis holboellii*	0
Stelis callura	*Brickellia eupatorioides*	0
Stelis callura	*Ipomopsis congesta*	0
Stelis callura	*Lomatium dissectum*	0
Stelis foederalis	*Penstemon procerus*	0
Stelis montana	*Cirsium arvense*	1
Stelis montana	*Conyza canadensis*	0
Stelis monticola	*Alyssum desertorum*	0
Stelis permaculata	*Erigeron compositus*	1
Stelis permaculata	*Anemone multifida*	0

Stelis permaculata	*Phlox hoodii*	0
Stelis sp. B	*Brickellia eupatorioides*	0
Stelis sp. B	*Ipomopsis congesta*	0
Stelis sp. B	*Pteryxia terebinthina*	0
Systoechus oreas	*Tragopogon dubius*	1
Systoechus oreas	*Verbascum thapsus*	1
Systoechus vulgaris	*Centaurea stoebe*	1
Systoechus vulgaris	*Sisymbrium loeselii*	1
Systoechus vulgaris	*Evolvulus nuttallianus*	0
Systoechus vulgaris	*Linaria dalmatica*	0
Systoechus vulgaris	*Taraxacum officinale*	0
Systoechus vulgaris	*Tragopogon dubius*	0
Thymelicus lineola	*Lesquerella ludoviciana*	0
Triepeolus paenepectoralis	*Geranium viscosissimum*	0
Villa alternata	*Sisymbrium loeselii*	1
Villa alternata	*Centaurea stoebe*	0
Villa alternata	*Linaria dalmatica*	0
Villa alternata	*Symphyotrichum falcatum*	0
Villa fulviana	*Astragalus gracilis*	0
Villa fulviana	*Astragalus tenellus*	0
Villa fulviana	*Lupinus sericeus*	0
Villa lateralis	*Centaurea stoebe*	1
Villa lateralis	*Tragopogon dubius*	1
Villa lateralis	*Linaria dalmatica*	0
Villa lateralis	*Melilotus officinalis*	0
Villa lateralis	*Symphyotrichum ascendens*	0
Villa lateralis	*Symphyotrichum falcatum*	0
Villa pretiosa	*Descurainia pinnata*	0

Paradise Region (positive co-occurrences)

Pollinator species	Flower species	BMC
Andrena crataegi	*Erigeron acris*	1
Andrena prunorum	*Fritillaria atropurpurea*	1
Andrena prunorum	*Hieracium scouleri*	1
Andrena thaspii	*Agoseris aurantiaca*	1
Apis mellifera	*Oxytropis campestris*	1
Ashmeadiella pronitens	*Astragalus convallarius*	1
Ashmeadiella pronitens	*Erigeron peregrinus*	1
Bombus bifarius	*Achillea millefolium*	1
Bombus bifarius	*Anaphalis margaritacea*	1
Bombus bifarius	*Antennaria neglecta*	1
Bombus bifarius	*Antennaria rosea*	1
Bombus bifarius	*Chamerion angustifolium*	1

Bombus bifarius	*Eurybia conspicua*	1
Bombus bifarius	*Hedysarum sulphurescens*	1
Bombus bifarius	*Lupinus argenteus*	1
Bombus bifarius	*Taraxacum officinale*	1
Bombus bifarius	*Hieracium albiflorum*	0
Bombus flavifrons	*Astragalus miser*	1
Bombus insularis	*Antennaria neglecta*	1
Bombus insularis	*Chamerion angustifolium*	1
Bombus insularis	*Eurybia conspicua*	1
Bombus insularis	*Taraxacum officinale*	1
Bombus insularis	*Achillea millefolium*	0
Bombus insularis	*Hedysarum sulphurescens*	0
Bombus insularis	*Lupinus argenteus*	0
Bombus insularis	*Lupinus sericeus*	0
Bombus mixtus	*Linnaea borealis*	0
Bombus occidentalis	*Eurybia conspicua*	1
Bombus rufocinctus	*Achillea millefolium*	1
Bombus rufocinctus	*Agoseris aurantiaca*	1
Bombus rufocinctus	*Antennaria rosea*	1
Bombus rufocinctus	*Eurybia conspicua*	1
Bombus rufocinctus	*Hedysarum sulphurescens*	1
Bombus rufocinctus	*Chamerion angustifolium*	0
Chrysotoxum fasciatum	*Calypso bulbosa*	1
Colletes fulgidus	*Erigeron peregrinus*	1
Conophorus sackenii	*Stellaria longipes*	1
Eristalis Eoseristalis hirta	*Aquilegia flavescens*	1
Eristalis Eoseristalis hirta	*Viola orbiculata*	1
Heriades cressoni	*Hieracium aurantiacum*	1
Hoplitis albifrons argentifrons	*Antennaria rosea*	1
Hoplitis albifrons argentifrons	*Campanula rotundifolia*	1
Hoplitis albifrons argentifrons	*Chamerion angustifolium*	1
Hoplitis albifrons argentifrons	*Eurybia conspicua*	1
Hoplitis albifrons argentifrons	*Hedysarum sulphurescens*	1
Hoplitis albifrons argentifrons	*Lupinus sericeus*	0
Hylaeus modestus	*Epilobium brachycarpum*	1
Hylaeus modestus	*Eurybia conspicua*	1
Hylaeus modestus	*Hedysarum sulphurescens*	1
Hylaeus wootoni	*Erigeron peregrinus*	1
Lasioglossum Dialictus ephialtum	*Maianthemum stellatum*	1
Lasioglossum Dialictus sp. F17	*Platanthera dilatata*	1
Lasioglossum egregium	*Erigeron speciosus*	1
Lasioglossum Evylaeus sp. F3	*Astragalus miser*	1
Lasioglossum Evylaeus sp. F3	*Platanthera hyperborea*	1

Lycaena heteronea	*Zigadenus elegans*	1
Megachile frigida	*Achillea millefolium*	1
Megachile frigida	*Chamerion angustifolium*	1
Megachile frigida	*Hedysarum sulphurescens*	1
Megachile frigida	*Lupinus sericeus*	0
Megachile lapponica	*Antennaria neglecta*	1
Megachile lapponica	*Antennaria rosea*	1
Megachile lapponica	*Chamerion angustifolium*	1
Megachile lapponica	*Crepis atribarba*	1
Megachile lapponica	*Eurybia conspicua*	1
Megachile lapponica	*Taraxacum officinale*	1
Megachile melanophaea	*Lupinus argenteus*	1
Megachile melanophaea	*Lupinus sericeus*	0
Megachile relativa	*Epilobium brachycarpum*	1
Megachile relativa	*Crepis atribarba*	0
Melanostoma mellinum	*Aquilegia flavescens*	1
Melanostoma mellinum	*Viola orbiculata*	1
Osmia albolateralis	*Eurybia conspicua*	1
Osmia albolateralis	*Hedysarum sulphurescens*	1
Osmia albolateralis	*Antennaria rosea*	0
Osmia juxta	*Calypso bulbosa*	1
Osmia Melanosmia aff. paradisica	*Castilleja miniata*	1
Osmia Melanosmia aff. paradisica	*Stellaria longipes*	1
Osmia Melanosmia brevis	*Tragopogon dubius*	1
Osmia Melanosmia bucephala	*Hedysarum sulphurescens*	1
Osmia Melanosmia bucephala	*Trifolium repens*	1
Osmia Melanosmia bucephala	*Lupinus argenteus*	0
Osmia Melanosmia densa	*Polygonum douglasii*	1
Osmia Melanosmia nigrifrons	*Pseudognaphalium canescens*	1
Osmia Melanosmia pentstemonis	*Agoseris aurantiaca*	1
Osmia Melanosmia pentstemonis	*Valeriana edulis*	0
Osmia Melanosmia physariae	*Fritillaria atropurpurea*	1
Osmia tristella	*Stellaria longipes*	1
Pieris marginalis	*Aquilegia flavescens*	1
Plebejus icarioides	*Potentilla glandulosa*	1
Plebejus melissa	*Astragalus miser*	0
Plebejus saepiolus	*Lupinus argenteus*	1
Plebejus saepiolus	*Platanthera hyperborea*	1
Sphaerophoria nr. asymmetrica	*Agoseris aurantiaca*	1
Stelis montana	*Solidago gigantea*	1
Thymelicus lineola	*Lupinus argenteus*	1
Thymelicus lineola	*Lupinus sericeus*	1
Thymelicus lineola	*Stellaria longipes*	1

Whitefish Region (positive co-occurrences)

Pollinator species	Flower species	BMC
Bombus bifarius	*Apocynum androsaemifolium*	1
Bombus bifarius	*Achillea millefolium*	0
Bombus bifarius	*Chamerion angustifolium*	0
Bombus centralis	*Symphyotrichum foliaceum*	1
Bombus flavifrons	*Lomatium dissectum*	1
Bombus flavifrons	*Achillea millefolium*	0
Bombus flavifrons	*Antennaria racemosa*	0
Bombus sitkensis	*Viola canadensis*	1
Bombus sitkensis	*Clintonia uniflora*	0
Bombus vagans	*Clintonia uniflora*	1
Hemipenthes morioides	*Antennaria racemosa*	1
Hemipenthes morioides	*Balsamorhiza sagittata*	1
Hemipenthes morioides	*Mentzelia dispersa*	1
Hemipenthes morioides	*Sedum lanceolatum*	1
Heriades carinatus	*Antennaria neglecta*	1
Heriades carinatus	*Trifolium pratense*	1
Hylaeus Hylaeus verticalis	*Allium cernuum*	1
Lasioglossum Dialictus nigroviride	*Achillea millefolium*	0
Megachile frigida	*Chamerion angustifolium*	1
Melanostoma mellinum	*Crepis tectorum*	1
Melanostoma mellinum	*Maianthemum stellatum*	1
Osmia albolateralis	*Hieracium scouleri*	0
Osmia tristella	*Antennaria racemosa*	1
Osmia tristella	*Erigeron glabellus*	1
Osmia tristella	*Eurybia conspicua*	1
Osmia tristella	*Mentzelia dispersa*	1
Osmia tristella	*Sedum lanceolatum*	1
Osmia tristella	*Fragaria virginiana*	0
Osmia Melanosmia aff. paradisica	*Collomia linearis*	1
Sphaerophoria novaeangliae	*Collomia linearis*	1

Table S7. Pollinator-plant species pairs in each region that showed negative co-occurrence (segregation) based on the 95% confidence interval (CI) criterion. Species pairs that reached significance with the more restrictive Bayes mean-based criterion (BMC) are indicated in the last column. See methods for more details on the significance criteria for co-occurrence analyses.

Helena Region (negative co-occurrences)

Pollinator species	Flower species	BMC
Andrena amphibola	*Balsamorhiza sagittata*	0
Andrena lawrencei	*Apocynum androsaemifolium*	1
Andrena lawrencei	*Hedysarum boreale*	0
Andrena prunorum	*Liatris punctata*	1
Anthidium mormonum	*Arenaria capillaris*	1
Anthidium mormonum	*Phlox albomarginata*	0
Anthophora urbana	*Phlox albomarginata*	0
Anthophora ursina	*Phlox albomarginata*	1
Apis mellifera	*Douglasia montana*	1
Apis mellifera	*Medicago sativa*	1
Ashmeadiella bucconis	*Arabis holboellii var. retrofracta*	1
Ashmeadiella bucconis	*Geum triflorum*	1
Ashmeadiella bucconis	*Arenaria capillaris*	0
Ashmeadiella cactorum	*Centaurea stoebe*	0
Ashmeadiella cactorum	*Heterotheca villosa*	0
Ashmeadiella cactorum	*Liatris punctata*	0
Ashmeadiella cactorum	*Linaria dalmatica*	0
Ashmeadiella cactorum	*Melilotus officinalis*	0
Ashmeadiella cactorum	*Tragopogon dubius*	0
Bombus appositus	*Erigeron caespitosus*	0
Bombus centralis	*Erigeron caespitosus*	1
Bombus centralis	*Sisymbrium loeselii*	1
Bombus centralis	*Alyssum alyssoides*	0
Bombus centralis	*Erysimum inconspicuum*	0
Bombus centralis	*Phlox hoodii*	0
Bombus fervidus	*Erigeron caespitosus*	0
Bombus insularis	*Gaillardia aristata*	1
Bombus rufocinctus	*Antennaria rosea*	1
Ceratina nanula	*Allium textile*	1
Ceratina nanula	*Antennaria neglecta*	0
Ceratina nanula	*Antennaria rosea*	0
Ceratina neomexicana	*Lithospermum incisum*	1
Ceratina neomexicana	*Erigeron caespitosus*	0
Colletes fulgidus	*Lithospermum ruderale*	1
Colletes fulgidus	*Campanula rotundifolia*	0
Colletes fulgidus	*Geum triflorum*	0

Colletes kincaidii	*Geum triflorum*	1
Colletes kincaidii	*Achillea millefolium*	0
Colletes kincaidii	*Antennaria neglecta*	0
Colletes phaceliae	*Geum triflorum*	1
Conophorus sackenii	*Liatris punctata*	1
Dianthidium subparvum	*Balsamorhiza sagittata*	1
Dianthidium ulkei	*Phlox albomarginata*	1
Dufourea trochantera	*Astragalus miser*	1
Eupeodes volucris	*Antennaria neglecta*	1
Halictus confusus	*Antennaria rosea*	1
Halictus confusus	*Arabis holboellii*	1
Halictus tripartitus	*Descurainia incana*	1
Halictus tripartitus	*Geum triflorum*	1
Hemipenthes morioides	*Achillea millefolium*	1
Hemipenthes sinuosa	*Astragalus tenellus*	1
Hemipenthes sinuosa	*Cirsium vulgare*	1
Hemipenthes sinuosa	*Allium cernuum*	0
Hemipenthes sinuosa	*Geum triflorum*	0
Hemipenthes sinuosa	*Zigadenus venenosus*	0
Heriades cressoni	*Potentilla hippiana*	1
Hesperia colorado	*Crepis tectorum*	1
Hoplitis grinnelli	*Erigeron caespitosus*	1
Hylaeus coloradensis	*Heterotheca villosa*	1
Hylaeus wootoni	*Astragalus alpinus*	1
Hylaeus wootoni	*Centaurea stoebe*	1
Hylaeus wootoni	*Medicago lupulina*	1
Hylaeus wootoni	*Penstemon eriantherus*	1
Hylaeus wootoni	*Symphyotrichum falcatum*	1
Hylaeus wootoni	*Tragopogon dubius*	1
Hylaeus wootoni	*Evolvulus nuttallianus*	0
Hylaeus wootoni	*Gaillardia aristata*	0
Hylaeus wootoni	*Melilotus officinalis*	0
Hylaeus wootoni	*Solidago missouriensis*	0
Hylaeus wootoni	*Taraxacum officinale*	0
Hylaeus wootoni	*Verbascum thapsus*	0
Lapposyrphus lapponicus	*Solidago missouriensis*	1
Lasioglossum Dialictus aff. caducum	*Tragopogon dubius*	0
Lasioglossum Dialictus albipenne	*Allium textile*	1
Lasioglossum Dialictus ebmerellum	*Achillea millefolium*	0
Lasioglossum Dialictus ruidosense	*Antennaria neglecta*	0
Lasioglossum Dialictus semicaeruleum	*Allium cernuum*	1
Megachile gemula	*Balsamorhiza sagittata*	1
Megachile melanophaea	*Symphyotrichum falcatum*	0

Megachile perihirta	*Phacelia linearis*	1
Megachile perihirta	*Phlox albomarginata*	0
Megachile pugnata	*Arabis holboellii var retrofracta*	1
Megachile relativa	*Heterotheca villosa*	1
Melissodes Eumelissodes microsticta	*Allium cernuum*	0
Melissodes microsticta	*Heterotheca villosa*	1
Nomada sp. F1	*Packera cana*	1
Nomada sp. F1	*Phacelia linearis*	1
Nomada sp. F2	*Heterotheca villosa*	1
Osmia albolateralis	*Phacelia linearis*	0
Osmia Cephalosmia californica	*Astragalus alpinus*	1
Osmia Cephalosmia californica	*Phlox albomarginata*	0
Osmia Cephalosmia californica	*Phlox hoodii*	0
Osmia Hapsidosmia iridis	*Liatris punctata*	1
Osmia Helicosmia coloradensis	*Antennaria neglecta*	1
Osmia Helicosmia coloradensis	*Phacelia linearis*	0
Osmia Helicosmia coloradensis	*Symphyotrichum ericoides*	0
Osmia juxta	*Allium textile*	1
Osmia Melanosmia brevis	*Antennaria neglecta*	1
Osmia Melanosmia brevis	*Phacelia linearis*	1
Osmia Melanosmia trevoris	*Erigeron caespitosus*	1
Osmia montana montana	*Phlox hoodii*	1
Osmia montana montana	*Allium cernuum*	0
Osmia montana montana	*Phacelia linearis*	0
Osmia tristella	*Gaillardia aristata*	1
Osmia tristella	*Heterotheca villosa*	1
Osmia tristella	*Symphyotrichum falcatum*	1
Osmia tristella	*Alyssum alyssoides*	0
Panurginus atriceps	*Heterotheca villosa*	1
Phyciodes pulchella	*Phacelia linearis*	1
Plebejus icarioides	*Geum triflorum*	1
Plebejus melissa	*Alyssum desertorum*	1
Plebejus melissa	*Alyssum alyssoides*	0
Plebejus melissa	*Gaillardia aristata*	0
Plebejus melissa	*Phlox albomarginata*	0
Systoechus oreas	*Erigeron caespitosus*	0
Systoechus vulgaris	*Phlox albomarginata*	1
Systoechus vulgaris	*Phlox hoodii*	0
Thymelicus lineola	*Evolvulus nuttallianus*	1
Villa alternata	*Arabis holboellii var. retrofracta*	1
Villa alternata	*Arenaria capillaris*	1
Villa alternata	*Hedysarum boreale*	1
Villa alternata	*Astragalus miser*	0

Villa alternata	*Campanula rotundifolia*	0
Villa alternata	*Geum triflorum*	0
Villa lateralis	*Astragalus laxmannii var robustior*	1
Villa pretiosa	*Fragaria virginiana*	1

Paradise Region (negative co-occurrences)

Pollinator species	Flower species	BMC
Andrena crataegi	*Hedysarum sulphurescens*	*1*
Andrena miranda	*Fragaria virginiana*	*0*
Andrena topazana	*Thalictrum occidentale*	*1*
Bombus appositus	*Linnaea borealis*	*1*
Bombus bifarius	*Actaea rubra*	*1*
Bombus bifarius	*Calypso bulbosa*	*1*
Bombus bifarius	*Osmorhiza berteroi*	*1*
Bombus bifarius	*Viola orbiculata*	*1*
Bombus bifarius	*Aquilegia flavescens*	*0*
Bombus bifarius	*Fragaria virginiana*	*0*
Bombus bifarius	*Geranium richardsonii*	*0*
Bombus bifarius	*Linnaea borealis*	*0*
Bombus bifarius	*Thalictrum occidentale*	*0*
Bombus centralis	*Crepis atribarba*	*1*
Bombus flavifrons	*Thalictrum occidentale*	*0*
Bombus insularis	*Aquilegia flavescens*	*1*
Bombus insularis	*Calypso bulbosa*	*1*
Bombus insularis	*Osmorhiza berteroi*	*1*
Bombus insularis	*Viola orbiculata*	*1*
Bombus insularis	*Fragaria virginiana*	*0*
Bombus insularis	*Thalictrum occidentale*	*0*
Bombus mixtus	*Anaphalis margaritacea*	*1*
Bombus mixtus	*Achillea millefolium*	*0*
Bombus mixtus	*Antennaria neglecta*	*0*
Bombus mixtus	*Antennaria rosea*	*0*
Bombus mixtus	*Chamerion angustifolium*	*0*
Bombus mixtus	*Eurybia conspicua*	*0*
Bombus mixtus	*Hedysarum sulphurescens*	*0*
Bombus occidentalis	*Fragaria virginiana*	*0*
Bombus rufocinctus	*Actaea rubra*	*1*
Bombus rufocinctus	*Aquilegia flavescens*	*1*
Bombus rufocinctus	*Calypso bulbosa*	*1*
Bombus rufocinctus	*Osmorhiza berteroi*	*1*
Bombus rufocinctus	*Viola orbiculata*	*1*
Bombus rufocinctus	*Fragaria virginiana*	*0*
Bombus rufocinctus	*Geranium richardsonii*	*0*

Bombus rufocinctus	*Linnaea borealis*	*0*
Bombus rufocinctus	*Thalictrum occidentale*	*0*
Chrysotoxum fasciatum	*Eurybia conspicua*	*1*
Chrysotoxum fasciatum	*Hedysarum sulphurescens*	*1*
Eristalis Eoseristalis hirta	*Eurybia conspicua*	*1*
Eupeodes latifasciatus	*Hieracium albiflorum*	*1*
Halictus confusus	*Fragaria virginiana*	*1*
Hoplitis albifrons argentifrons	*Aquilegia flavescens*	*1*
Hoplitis albifrons argentifrons	*Calypso bulbosa*	*1*
Hoplitis albifrons argentifrons	*Geranium richardsonii*	*1*
Hoplitis albifrons argentifrons	*Thalictrum occidentale*	*1*
Hoplitis albifrons argentifrons	*Viola orbiculata*	*1*
Hoplitis albifrons argentifrons	*Linnaea borealis*	*0*
Hoplitis fulgida fulgida	*Geranium richardsonii*	*1*
Hoplitis fulgida fulgida	*Linnaea borealis*	*1*
Hoplitis fulgida fulgida	*Fragaria virginiana*	*0*
Hylaeus modestus	*Fragaria virginiana*	*0*
Lasioglossum Dialictus marinense	*Castilleja miniata*	*1*
Lasioglossum Dialictus marinense	*Thalictrum occidentale*	*0*
Lasioglossum Dialictus nigroviride	*Viola orbiculata*	*1*
Lasioglossum Dialictus nigroviride	*Fragaria virginiana*	*0*
Lasioglossum Dialictus nigroviride	*Thalictrum occidentale*	*0*
Lasioglossum Evylaeus sp. F4	*Thalictrum occidentale*	*1*
Lasioglossum Evylaeus sp. F4	*Fragaria virginiana*	*0*
Lasioglossum Evylaeus sp. F5	*Antennaria racemosa*	*1*
Megachile frigida	*Aquilegia flavescens*	*1*
Megachile frigida	*Calypso bulbosa*	*1*
Megachile frigida	*Valeriana edulis*	*1*
Megachile frigida	*Viola orbiculata*	*1*
Megachile frigida	*Linnaea borealis*	*0*
Megachile frigida	*Thalictrum occidentale*	*0*
Megachile lapponica	*Aquilegia flavescens*	*1*
Megachile lapponica	*Calypso bulbosa*	*1*
Megachile lapponica	*Viola orbiculata*	*1*
Megachile lapponica	*Fragaria virginiana*	*0*
Megachile lapponica	*Geranium richardsonii*	*0*
Megachile lapponica	*Linnaea borealis*	*0*
Megachile lapponica	*Thalictrum occidentale*	*0*
Megachile relativa	*Linnaea borealis*	*1*
Osmia juxta	*Hieracium albiflorum*	*1*
Osmia tristella	*Eurybia conspicua*	*0*
Platycheirus modestus	*Hieracium albiflorum*	*1*
Thymelicus lineola	*Anaphalis margaritacea*	*1*

Whitefish Region (negative co-occurrences)

Pollinator species	Flower species	BMC
Bombus bifarius	*Hieracium albiflorum*	1
Bombus bifarius	*Clintonia uniflora*	0
Bombus bifarius	*Linnaea borealis*	0
Bombus sitkensis	*Chamerion angustifolium*	1
Lasioglossum Dialictus nigroviride	*Xerophyllum tenax*	0
Megachile frigida	*Calochortus apiculatus*	0
Megachile relativa	*Hieracium albiflorum*	0