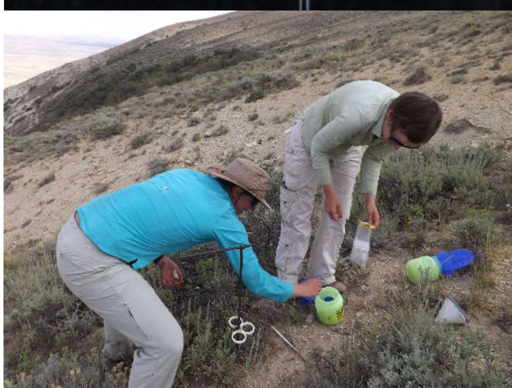
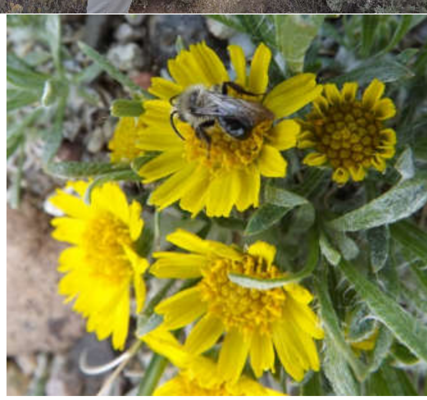
Baseline Research for Long-term Effects of Wind Farms on Insects, Plants, Birds and Bats in Wyoming

Final Report








By

Sarah DePaolo and Michael E. Dillon

Department of Zoology and Physiology, University of Wyoming, Laramie

Lusha Tronstad, Ian Abernethy, and Mark Andersen

Wyoming Natural Diversity Database, University of Wyoming, Laramie

Abstract

The United States is aiming to meet a portion of increasing energy demands with renewable energy sources. The perceived low ecological impact of wind energy has made it an attractive renewable resource, leading to the rapid construction of wind farms throughout the US. However, turbines are now known to be an important cause of mortality for bats and birds, and wind farms may affect other elements of local ecological communities. Unfortunately, we have little data on the potential local ecological impacts of wind energy development. Our long-term goal is to understand potential impacts of wind farm developments on pollinating insects, the flowering plants that rely on those pollinators, and the birds and bats that eat insects. Our approach is to collect baseline data on these plants and animals before construction of wind farms in southern Wyoming (phase I, funded by BLM) and return to characterize communities after wind farms are operational (phase II, not funded). Here we report the results from phase I.

We performed a series of pollinator and flowering plant surveys at 252 plots three times during both 2013 and 2014. We recorded 126 flowering plant species. We assessed pollen-limitation in four common insect-pollinated plants that bloom in early or late summer, and that rely on specialist or generalist pollinators. We hand-pollinated a subset of flowers from each species. We excluded pollinators from another subset of each flower species to test selfing capabilities. We allowed a final subset to be pollinated by existing animal pollinators. Once each flower had senesced, we counted and weighed seeds to estimate pollen-limitation and selfing capability. We found that late-blooming flowers were most pollen-limited. All four study species demonstrated little to no selfing capability, indicating that flower populations may decline if phenologically mismatched from their insect pollinators or if those pollinators decline.

We collected 12 orders of insects including 33 genera of bees. We collect 0.83 insects per hour and Hymenoptera (bees and wasps) were the most abundant group of invertebrates collected. We collected the most insects at Chokecherry and the fewest insects at Quaking Aspen and its control site. Topographic position and site were the best predictors of bee abundance and diversity.

Suggested citation: DePaolo, S., D.E. Dillon, L.M. Tronstad, I.M. Abernethy and M.D. Andersen. Baseline research for long-term effects of wind farms on insects, plants, birds, and bats in Wyoming: Final Report. 2016. Report prepared for the Wyoming Bureau of Land Management by the Department of Zoology and Physiology, and Wyoming Natural Diversity Database at the University of Wyoming.

Introduction

Wind energy is a growing alternative energy source in the United States and abroad, and Wyoming has exceptional wind resources (BLM 2011; Department of Energy 2008). In Wyoming, 43% of federally-owned land is considered fair to excellent for wind energy development (BLM 2011). With over 7 million hectares of Wyoming lands administered by the BLM, land conversion for the development of wind energy may have far-reaching consequences for both ecosystem health and access to and use of public lands (BLM 2011). Current proposals for wind energy developments in Wyoming estimate that wind farms operating on 61,107 hectares of BLM land will produce 4,500 megawatts of electricity, enough to power over one million homes (BLM 2012; Jakle et al. 2011).

Although wind power may be a renewable resource, construction and operation of wind turbines may have substantial environmental impacts (Elzay et al. in press). Recent work suggests that bird and bat mortality are elevated around wind turbines (Barclay et al. 2007; Kunz et al. 2010). Birds collide with the blades and rotors, and bats are killed by barotrauma due to changes in pressure around the operating blades or by collisions with blades (Long 2011; Horn et al. 2008; Baerwald et al. 2008). Despite the growing awareness of impacts of wind farms on birds and bats, the potential impacts of wind farms on insects and plants are still poorly understood (Rydell et al. 2010; Jakle et al. 2011; Elzay et al. in press).

The presence of wind farms may strongly effect insect pollinator communities with potentially cascading ecosystem effects. Insects represent 80% of the world's species, dominate terrestrial ecosystems, and provide critical ecosystem services such as food for animals and pollination (Grimaldi and Engel 2005; Willmer 2011). Insect pollinators are vital for ecosystem health and functioning, both in their native environments and in agricultural systems (Losey and Vaughan 2006; Willmer 2011). Large numbers of insects may be killed by wind turbines, given that residue from insect carcasses on turbine blades creates drag that can decrease efficiency between 25-50% (Corten and Veldkamp 2001). Turbine color and the heat generated during operation may attract insects and, in turn, bats and birds that feed on insects (Rydell et al. 2010; Long 2011; Long et al. 2011; Horn et al. 2010; Kunz et al. 2010). Indeed, the majority of bats and birds killed by wind turbines are insectivorous species (Erickson et al. 2002).

To study the potential impacts of wind farm development on insect pollinators and flowering plants as well as birds and bats, the BLM funded phase I of a two phase before-after-control-impact study at four proposed wind farm developments. In phase I, our objective was to estimate the diversity and abundance of birds, bats, pollinating insects, and flowering plants at proposed wind farm sites prior to development. Our specific questions were 1) Are flowering plants pollen-limited? 2) Does pollinator abundance and diversity change with topographic position and slope aspect of the landscape? 3) Can landscape characteristics predict biodiversity hot spots? 4) How similar are the bird and bat assemblages among wind farms sites? Our results will inform managers about the biodiversity and abundance of animals and plants on the landscape to help make decisions about turbine siting at local scales.

Methods

Study Area

The study area spanned south central Wyoming from Rawlins to Rock Springs. The study area was composed of semiarid, high elevation sagebrush steppe with warm summers (May – August average temperature, high = 24.4 ºC and low = 6.9ºC) and cold winters (November – March average temperature, high = 2.2 ºC and low = -9.1ºC). The landscape was dominated by shrubs including *Artemisia tridentata, Ericameria nauseosa, Sarcobatus vermiculatus,* and *Gutierrezia sarothrae.* Common flowering plants included *Penstemmon spp, Opuntia polyacantha, Erigeron* spp., *Eriogonum* spp., *Delphinium* spp., and *Allium* spp. We sampled in four proposed wind farm developments: Chokecherry, Sierra Madre, White Mountain, and Quaking Aspen. We also sampled at three paired control sites (Figure 1). The paired control sites were chosen for their geographic proximity to wind farm developments and shared landscape characteristics. Unfortunately, due to the particular geography of the Chokecherry wind farm development, we were unable to find a geographically similar site nearby. Hereafter, we refer to proposed wind farms or their paired controls as sites.

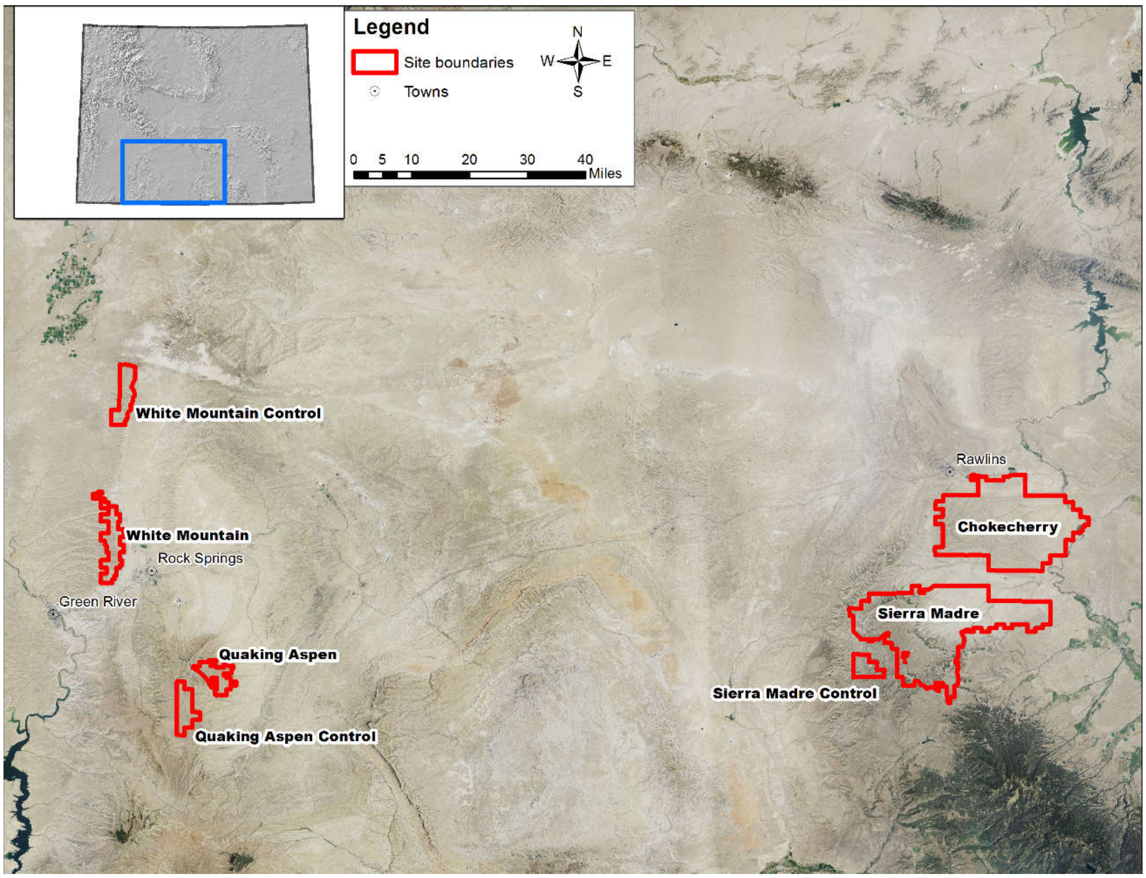


Figure 1. Map showing the locations of proposed wind farm development sites and paired controls in southern Wyoming (see inset map).

Sampling plots

We established a sampling scheme to develop spatially explicit models to predict insect and flowering plant abundance and diversity across the landscape. To account for variation in soil moisture, exposure to sun and wind, and snow pack, we determined topographic position (rim, mid-slope, and valley) and slope aspect (North, South, East, and West) for every 30 x 30 m pixel at each site using ArcGIS. We classified each pixel into 1 of 12 strata (3 topographic positions x 4 slope aspects; Table 1; see Appendix A for plot selection methods). We sampled 36 plots per site, totaling 252 plots in June, July, and August of each year to estimate flowering plant and pollinator abundance and diversity.

Table 1. We sampled twelve strata at each site that represented slope aspect (cardinal directions) and topographic position. We sampled three plots per strata per site.

	North	**South**	**East**	**West**
Rim	3 plots/site	3 plots/site	3 plots/site	3 plots/site
Mid-slope	3 plots/site	3 plots/site	3 plots/site	3 plots/site
Valley	3 plots/site	3 plots/site	3 plots/site	3 plots/site

Flowering plant sampling

We recorded the abundance and diversity of entomophilous flowering plants (plants that primarily rely on insects for pollination services) within five 1-m² quadrats per plot, haphazardly placed within 15 m of the pollinator sampling array (see below). We recorded the total number of open flowers by species in each quadrat three times per summer. Plants were identified in the field or from voucher specimens in consultation with Joy Handley and Bonnie Heidel (botanists at WYNDD). We measured total flower area by recording the diameter of five representative flowers per species. We averaged the five estimates to obtain an average floral area per species.

Seed set experiment

We measured seed set of four species of insect pollinated plants. *Allium textile,* prairie onion, blooms in mid-May with 10-30 small white cup-shaped flowers in an umbel shape (Figure 2; Williams and Free 1974). Native sweat bees (family Halictidae) are *Allium's* most common pollinator (Choi and Cota-Sanchez 2010). *Allium textile* typically produces seeds between mid to late June (Ernst 1979).

Opuntia polyacantha, plain's prickly pear, is a perennial and a member of the Cactaceae family that grows throughout much of North, Central, and South America (Figure 2; Osborn et al. 1988). *Opuntia polyacantha* has four to six cm diameter bowl-shaped flowers with large yellow or red flowers that bloom in the mid-to-late summer in this area. Several species of bees visit *Opuntia* spp. flowers, including: *Diadasia* spp*., Lithurge* spp*.,* and *Agopostemon* spp. (McFarland et al. 1989). *Diadasia and Lithurge* spp. appear to be oligolegtic (specialized mutualists) with *Opuntia* (Grant et al. 1979; Grant and Hurd 1979).

Delphinium nutallianum and *D. bicolor* are blue zygomorphic (having only one plane of symmetry) perennials with deep corollas (Figure 2; 9-28 mm; Simon et al. 2001) that require long-tongued, large-bodied pollinators for effective pollination (Hewitt 1980; Bosch and Waser 1999a; Williams and Waser 1999). Many *Delphinium* species are self-compatible but have elevated seed-set when visited by pollinators (Bauer 1983). *Delphinium nuttallianum* blooms immediately after snow melt, synchronously with early-emerging queen *Bombus spp.* (Bosch and Waser 1999b). *Delphinium bicolor* blooms later in the season, from mid-June to early July in southern Wyoming, and relies heavily on later-emerging *Bombus spp.* and hummingbirds for pollination (Schulke and Waser 2001).

For each flower species during its peak bloom time, we tagged (paper clips with waterproof paper labels) 30 plants with nascent (newly opened) flowers. To ensure plants were not related, we chose plants that were separated by at least 50 meters. Ten plants from each species were assigned to each of three treatment groups (hand-pollinated, pollinators excluded, and ambient pollinated). We excluded pollinators from flowers with fine bridal veil cloth (1 mm² mesh). For *A. textile*, and both *Dephinium* spp., we sewed bridal veil cloth to 30 cm x 1.27 cm garden stake tripods. For *O. polyacantha*, we placed three 30 cm x 1.27 cm garden stakes around the cladode (paddle or stem of the cactus) and flower, and then used safety pins to secure the mesh around the tripod and over the top of the tripod, covering the flower. Ambient pollinated flowers were left undisturbed, but their senescence was tracked. We hand-pollinated flowers by collecting pollen on a trimmed cotton swab from a donor plant at least 50 m from a given experimental plant. Following Fyfe and Bailey (1951), donor pollen was transferred to experimental flowers by gently brushing the swab across the stamen at least 10 times. Once flowers senesced, we monitored seed development and collected seeds and fruits from each experimental flower and dried them. After a two week drying period, we counted and weighed the seeds using an analytic scale (Acculab® ± 0.1 mg).

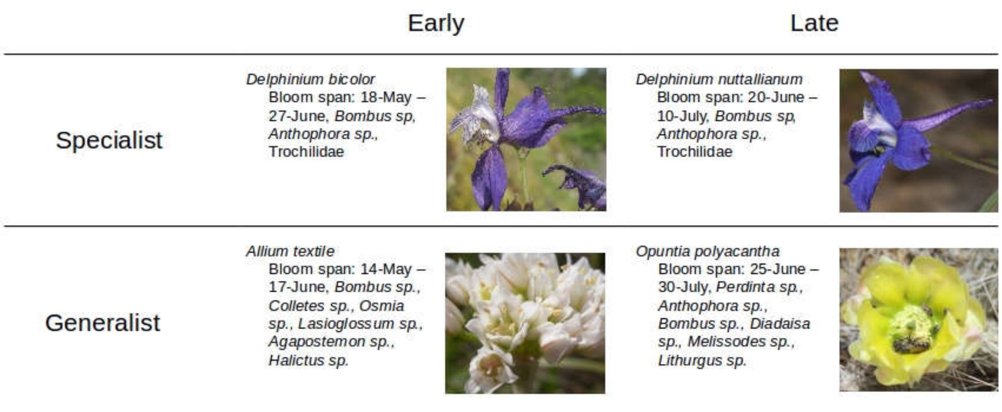


Figure 2. The phenology of flowering for each species listed per literature review and DePaolo field notes in 2013 and 2014. The target pollinators of each species are included.

Insect pollinator sampling and processing

We collected insect pollinators using bee cups (Droege et al. 2010) and vane traps (Stephen and Rao 2005; Wilson 2008; Roulston et al. 2007; Figure 2), which provided a standardized approach to characterizing insect pollinator communities (Lebuhn et al. 2013). We used 5 ounce polystyrene vials that we painted white (Royal Exterior Latex Flat House Paint, Ace Hardware Corp., Oak Brooks, Illinois), florescent yellow (Guerra Paint & Pigment Corp., New York, New York), and florescent blue (Guerra Paint & Pigment Corp., New York, New York; Figure 3a). We filled bee cups with soapy water, and placed one cup of each color in cup holders (2" PVC rings) attached to a 4 foot rebar stake (Figure 3a). Pollinators are strongly attracted to these colors and fall into the low surface tension soapy water for later processing. We hung the vane traps above bee cups on the same rebar stake with wire and zip ties. Vane traps have a blue funnel screw top with two blue cross vanes (13 cm width x 24 cm height) attached to a fluorescent yellow jar (15 cm diameter x 15 cm height; Figure 3b). Pollinators are attracted to the fluorescent colors of the vane traps and fall into the jar when they collide with the cross vanes. The funnel prevents escape so specimens can be collected without any fluid present. We placed a single collecting stake (with 3 bee cups and 1 vane trap) in each plot for 24 hours during each visit on warm days that were partly cloudy to sunny. After 24 hours, the contents of the bee cups were filtered through paper coffee filters and placed in Whirl-paks® (Nasco). Because vane traps often contained live specimens, we first emptied the specimens into cyanide kill tubes and transferred specimens into air-filled Whirl-paks® to prevent crushing. Specimens were transported to the laboratory in coolers with dry ice.

Upon arrival to the laboratory, we pinned vane trap specimens. The bee cup specimens were thawed in warm water, washed in soapy water, rinsed, and dried using forced air before pinning. Pinned insects were databased and labeled with collection information and unique bar codes. We identified all insect specimens to order, and bees to genus or species depending on available keys (Michener 2000; Michener et al. 1994; Ascher and Pickering 2014).

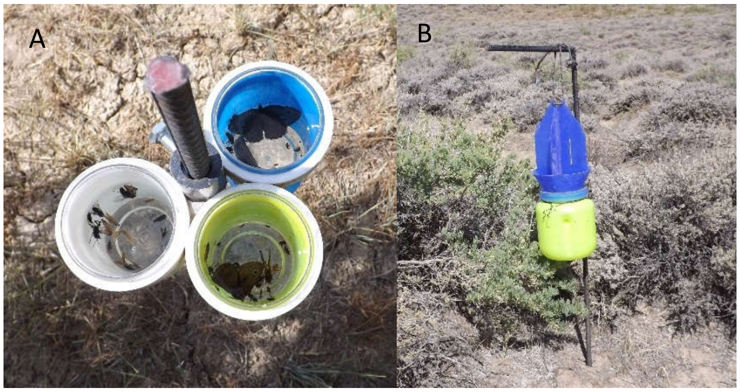


Figure 3. A.) Bee cups and B.) vane traps were hung from rebar stakes.

Modeling bee abundance and diversity

Using our replicate plot design, we asked whether slope aspect, topographic position, or site could explain differences among sampling plots in bee abundance and richness using generalized linear models. To do so, we compared all possible full-factorial models using information criteria model selection (Burnham and Anderson, 2002) implemented with the MuMIn package (Barton, 2016) in R (R Core Team, 2016). Briefly, we selected the best models based on second-order Akaike Information Criterion (AICc) and on Akaike weights (w_i, the probability that the given model would be the best model given repeated sampling; Burnham and Anderson, 2002).

Acoustic estimation of bat diversity

We sampled diversity of bats with passive acoustic and ultrasonic monitoring devices in 2013 (Wildlife Acoustics Song Meter SM2BAT+[2] full-spectrum recording equipment; Figure 4). Units were programed to begin recording one half hour before civil sunset and to stop recording one half hour after civil sunrise. On each recorder, an ultrasonic microphone (SMX-US, for bats) attached to the recording device was zip-tied to a eight foot painter's pole between 1 m and 2 m above the ground (Figure 4). We placed the recording devices in sites with low-wind, and with low-visibility from public roads to prevent disturbance during recordings. We recorded for three consecutive days at a single location at each site during each seasonal sampling trip. All calls were analyzed using the Sonobatch automated call analysis algorithm in the SonoBat 3 Wyoming Species Package (www.sonobat.com, Arcata, CA; Szewczak 2011). We used an acceptable call quality threshold of 0.70 and a discriminate probability threshold of 0.80.

Figure 4. Songmeter deployed to record bat calls.

Point count estimates of bird abundance and diversity

Point count methods followed the Integrated Monitoring in Bird Conservation Regions land bird monitoring program (Hanni et al. 2014). Point count grids were established in a stratified random fashion in a Geographic Information System (GIS). First, we randomly placed three points within each GAP land-cover category polygon within each study area boundary (Davidson et al. 2009). We then centered a north-south oriented 16-point grid with points spaced at 250 m intervals on each randomly placed point. We then selected a number of transects that could logistically be surveyed in 2013 and 2014. Each point count survey consisted of a 16 point grid with point count stations spaced at 250 m. At each point, a six-minute point count was conducted. We attempted to complete all 16 points during each point count survey but were unable to in some cases due to time or weather limitations. Point count surveys began approximately one half hour before local sunrise and ended no later than five hours after local sunrise. For every bird detected during the six-minute point count, we recorded species, sex, horizontal distance to the bird, minute of the point count during which the bird was detected, type of detection (i.e. call, song, visual), and whether or not the observer was able to visually identify the bird. We measured the distance to each detected bird using a laser range finder. If it was not possible to measure the distance to a bird, we estimated the distance to an object near the bird. We also recorded any bird species not previously detected during a point count while traveling between points within a transect. At the start and end of each survey, we recorded time, ambient temperature, cloud cover, precipitation and wind speed. Before beginning each six-minute count, we collected ocular vegetation data within a 50m radius of the point. Vegetation data included dominant habitat type, relative abundance, percent cover and mean height of trees and shrubs by species, grass height, and ground cover types. These vegetation data were recorded quietly before beginning each point count to allow birds time to return to their normal habits prior to beginning each count.

Results

Flowers

We counted 113,709 individual flowers on 126 species of flowering plants (see Appendix B for a complete list of plant species by site). The most abundant flowers across all sites were: *Eriogonum microthecum* (slender buckwheat), *Gutierrezia sarothrae* (snakeweed), *Eriofonum umbellatum* (sulphurflower buckwheat), *Alyssum simplex* (wild alyssum), and *Trifolium gymnocarpon* (hollyleaf clover; Table 2). To some extent, differences in flower counts among species were driven by differences in flower size. For example, snakeweed can have hundreds of small flowers on a single plant, and some forbs like *Phlox multiflora* often had more than 50 flowers on a single plant (Figure 5a). At the other extreme, plants such as *Calochortus nutallii* (sego lily) only have one flower per plant (Figure 5b). The most common flowers at each site can be found on Table 3. We did not find any Sensitive, Threatened or Endangered flower species in any of the sites (BLM Sensitive Species, 2013, available at:

Figure 5. A.) *Phlox multiflora* and B.) *Calochortus nutallii.*

http://www.blm.gov/wy/st/en/programs/pcp/species/sensitive/BLMWYsens-species.html).

Species richness and abundance of flowers both varied strongly among wind farm sites (Table 3). Plant species richness was highest at Sierra Madre (74) and its paired control site (54) and lowest at White Mountain (25). Across all sites, floral abundance varied little with topographic position and slope aspect; however, north-facing mid-slope sites and western valley sites had the most flowers counted (Figure 5a), in part because of the preponderance of small-flowered species. Species richness varied little with relative elevation and slope aspect, other than lower species richness on western rims (Figure 5b). Within sites, patterns of variation in flower abundance and plant species richness with slope aspect and relative elevation were more pronounced (Appendices C, D, E).

Table 2. Ten most common species based on total number of flowers counted.

Common name	Scientific name	Number of flowers	Area of a single flower (cm^2)
Slender buckwheat	*Eriogonum microthecum*	34371	0.07
Snakeweed	*Gutierrezia sarothrae*	20553	0.50
Wild alyssum	*Alyssum simplex*	11244	0.79
Western tansymustard	*Descurainia pinnata*	4939	1.33
Chamisa	*Ericameria nauseosa*	4669	0.03
Maiden blue-eyed Mary	*Collinsia parviflora*	3964	0.64
Sulphurflower buckwheat	*Eriogonum umbellatum*	2768	4.91
Hollyleaf clover	*Trifolium gymnocarpon*	2725	0.07
Sagebrush bluebells	*Mertensia oblongifolia*	2629	1.54
Long-leaf phlox	*Phlox multiflora*	2345	1.77

Table 3. Total number of flowers and species recorded at individual sites, with the five most abundant species by flower abundance listed for each site.

Wind farm site	Total flowers	Total species
Chokecherry	18019	40
Alyssum simplex, Descurainia pinnata, Lappula occidentalis, Mertensia oblongifolia, Eremogone hookeri		
Quaking Aspen	22898	30
Eriogonum microthecum, Gutierrezia sarothrae, Phlox multiflora, Antennaria rosea, Eriogonum jamesii		
Quaking Aspen Control	5164	32
Gutierrezia sarothrae, Eriogonum microthecum, Eriogonum umbellatum, Ericameria nauseosa, Erigeron compositus		
Sierra Madre	16176	74
Trifolium gymnocarpon, Collinsia parviflora, Mertensia oblongifolia, Linanthus pungens, Phlox hoodii		
Sierra Madre Control	13954	54
Gutierrezia sarothrae, Collinsia parviflora, Phlox multiflora, Eriogonum umbellatum, Phlox longifolia		
White Mountain	22614	25
Eriogonum microthecum, Gutierrezia sarothrae, Stenotus acaulis, Eriogonum jamesii, Ericameria nauseosa		
White Mountain Control	14913	38
Eriogonum microthecum, Ericameria nauseosa, Gutierrezia sarothrae, Stenotus acaulis, Eriogonum jamesii		

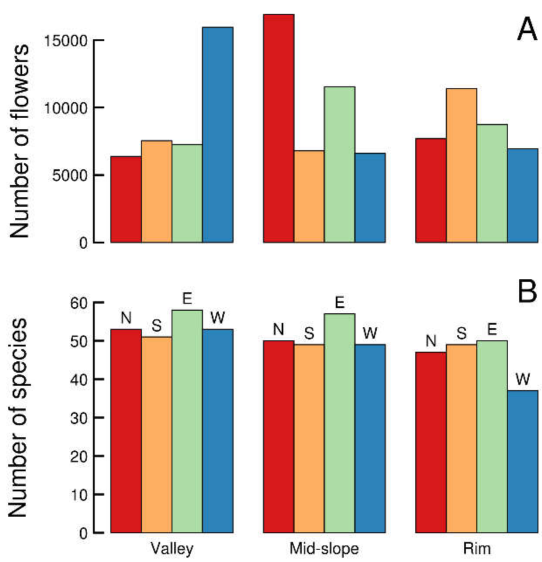


Figure 5. A.) Number and B.) species richness of flowers along each strata.

Seed-set experiment

With the exception of *O. polyacantha*, plants set few to no seeds in the absence of pollinators. No bagged flowers of either *A. textile* or *D. bicolor* produced seeds and only one bagged *D. nuttallianum* flower produced a seed. Four of eight *O. polyacantha* flowers produced seeds when bagged, indicating some ability to set seed without pollinator visits. However, bagged *O. polyacantha* flowers produced significantly fewer seeds than either hand-pollinated or open treatments even when the two outliers in the hand treatment were removed (Z tests, all P < 0.001; Figure 7). *Delphinium nuttallianum* flowers produced significantly fewer seeds when bagged as compared to open and hand-pollinated flowers (Z test, P < 0.001; Table 4).

Table 4. The number of seeds produced per flower varied among treatment groups for the four plant species. Values are means ± standard deviation with sample sizes in parentheses indicating number of flowers. Differences in seed number among treatment groups was assessed by Poisson generalized linear model with model *P*-values from chi square tests of deviance. Letters indicate significant differences calculated with z-scores (*P*<0.05). Plants in the bagged treatments for *D. bicolor* and *A. textile* did not produce any seeds, so were excluded from analyses (P-values for these species refer to the comparison between open and hand-pollinated treatments).

	Bagged	Open	Hand-pollinated	Deviance	*P*
D. bicolor	0 (10)	20.0 ± 12.0 (6)	18.1± 4.6 (8)	0.634	0.426
D. nuttallianum	0.1 ± 0.3 (9)a	17.5 ± 6.8 (11)b	18.0 ± 6.8 (9)b	251.8	**<0.001**
A. textile	0 (9)	4.0 ± 3.0 (9)	4.1 ± 4.4 (7)	0.020	0.888
O. polyacantha	2.0 ± 3.8 (8)a	18.8 ± 17.8 (8)b	44.9 ± 16.3 (9)c	410.8	**<0.001**

Pollen limitation would be indicated by reduced seed production in the open treatment relative to the hand-pollinated treatment. Neither species of *Delphinium* nor *A. textile* had reduced seed production from open flowers relative to hand-pollinated flowers (Table 4). However, *O. polyacantha* flowers that were hand-pollinated produced more than twice as many seeds as open flowers (Z test, P < 0.001; Table 4, Figure 7), providing strong evidence for pollen limitation in this species. In addition to seed number, we also measured seed mass as an indicator of seed quality (Westoby et al. 2002). All four plants showed the same general pattern: seeds from a flower that produced one or a few seeds tended to be much heavier than seeds produced in larger numbers (Figure 8), a common pattern within and among plant species (Gross 1984). We therefore analyzed seed mass data with and without these outliers. After removing flowers that produced a single seed, hand-pollinated *O. polyacantha* flowers produced significantly heavier seeds than open flowers (Table 5, Figure 8). Similarly, hand-pollinated *D. nuttallianum* flowers produced heavier seeds than open flowers (*F*-test, *P* = 0.008; Table 5; Figure 8). Seed mass did not vary significantly between treatments for *A. textile*, but open *D. bicolor* flowers produced heavier seeds than did hand-pollinated flowers, and this pattern held after removing the flower that produced a single seed (Table 5, Figure 8).

Table 5. Average seed mass varied strongly among treatment groups. Values are means ± standard deviation with sample sizes in parentheses indicating number of flowers. Differences in average seed mass among treatment groups was assessed by Gaussian generalized linear model with model *P*-values from *F*-tests. Letters indicate significant differences. If flowers produced only 1 seed, that seed was much larger than seeds from flowers that produced multiple seeds. Therefore values and analyses when single seeds were excluded are also shown where relevant.

	Bagged	Open	Hand-pollinated	*F* (df)	*P*
D. bicolor	--	0.54 ± 0.37 (6)[a]	0.22 ± 0.14 (8)[b]	10.8 (1,10)[1]	**0.008**
D. bicolor (without single seeds)	--	0.39 ± 0.10 (5)	0.22 ± 0.14 (8)	3.4 (1,10)[1]	0.093
D. nuttallianum	9.2 (1)*	1.1 ± 0.4 (11)[a]	1.9 ± 0.4 (9)[b]	8.9 (1,17)	**0.008**
A. textile	--	2.8 ± 1.4 (7)	1.6 ± 1.4 (4)	0.3 (1,8)[2]	0.613
O. polyacantha	37.7 ± 17.9 (4)[a]	20.0 ± 6.0 (7)[b]	20.7 ± 3.8 (9)[b]	6.5 (2,5)	**0.010**
O. polyacantha (without single seeds)	24.6 ± 6.0 (2)[3]	17.6 ± 3.1 (5)[a]	20.7 ± 3.8 (9)[b]	5.7 (1,11)	**0.036**

* Mass of the single seed produced in this treatment was not included in analysis.
[1] From model including interaction between seed number and treatment.
[2] Accounting for a significant decline in seed mass with more seeds produced.
[3] Excluded from analysis due to small sample size.

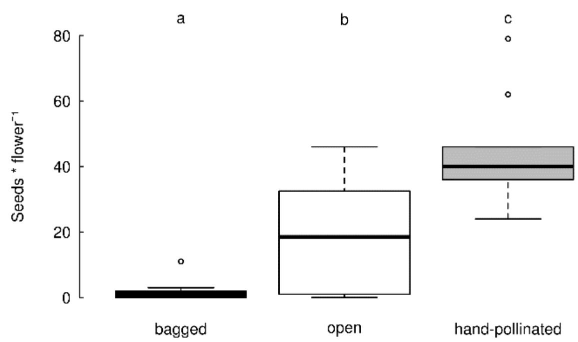


Figure 7. Seed production in *O. polyacantha* varied significantly among treatments. Bagged flowers produced few seeds, suggesting limited selfing ability. Hand-pollinated flowers produced more seeds than open flowers, suggesting pollen limitation.

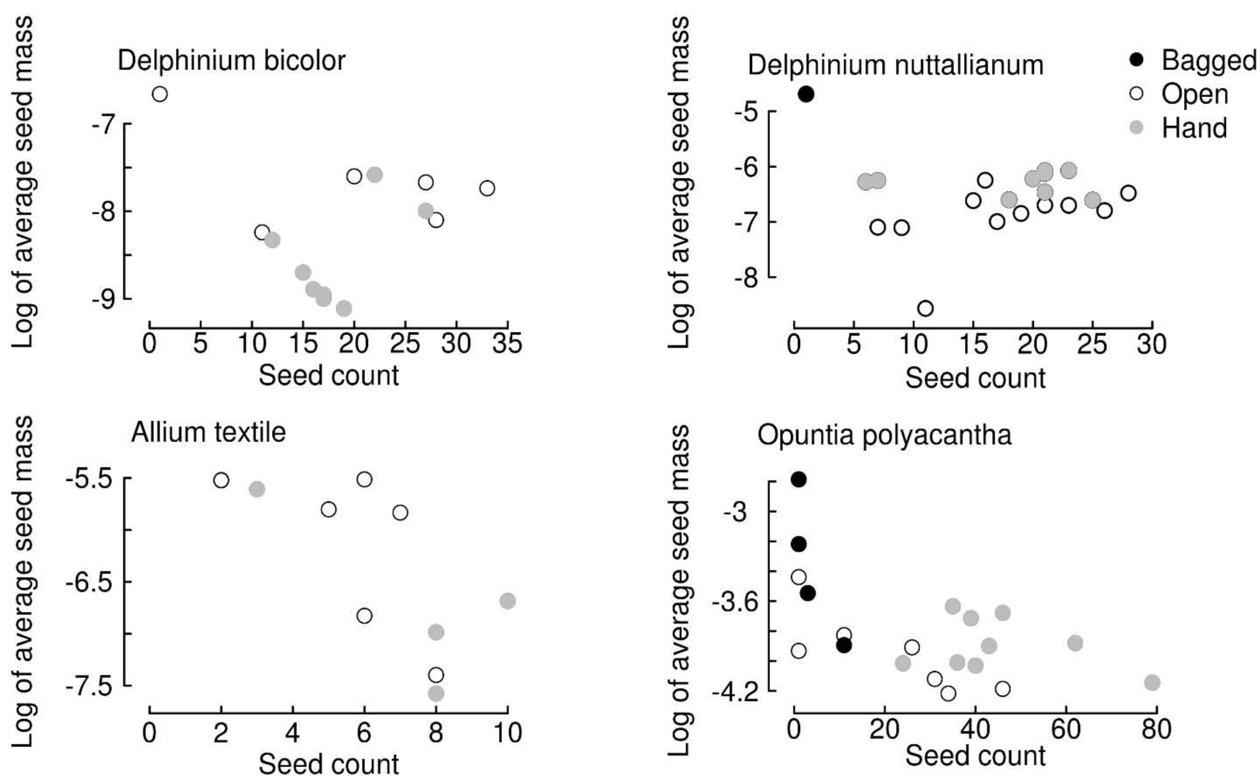


Figure 8. Pollination treatments altered the seed size/seed number trade-off. Flowers that set one or a few seeds (primarily in bagged or open treatments) tended to set large seeds. If flowers set more than a few seeds, those seeds either did not differ in size (*A. textile*), were larger (*O. polyacantha* and *D. nuttalianum*) or were smaller (*D. bicolor*) for hand-pollinated flowers relative to open flowers.

Insects

Traps were deployed for 36,000 total hours of vane trap and bee cup sampling which yielded 29,378 invertebrate specimens from Araneae (spiders), Coleoptera (beetles), Diptera (flies), Hemiptera (true bugs), Hymenoptera (bees and wasps), Lepidoptera (butterflies and moths), Neuroptera (lacewings and relatives), Orthoptera (grasshoppers and crickets), Raphidioptera (snakeflies), Thysanoptera (thrips), and Trichoptera (caddisflies; see Appendix G for abundance of insect orders by sites). Overall, collections yielded an average of 0.83 insects per hour. The Hymenoptera (11,223 total specimens), Diptera (9,481), and Coleoptera (6,058) dominated collections (Appendix G). Insect abundance was highest at Chokecherry (5,486 total specimens), followed by Sierra Madre Control (5,095 specimens) and White Mountain Control (4,688 specimens) with Quaking Aspen Control having the lowest insect abundance (2,975 specimens; see Appendix G).

Insect abundance was highest in valley plots, intermediate in mid-slope plots, and lowest in rim plots (Figure 9). This difference may relate to wind exposure. Insects may avoid high winds on rims in favor of mid-slope and valley locations where wind is less severe. Alternatively, high wind speeds on rims may prevent insects from being collected by vane traps and bee cups. At mid-slope sites, abundance was greatest on east and south-facing slopes and lowest on north-facing slopes. North-facing slopes also had the lowest insect abundance in valleys where east slopes had the highest abundance (Figure 9).

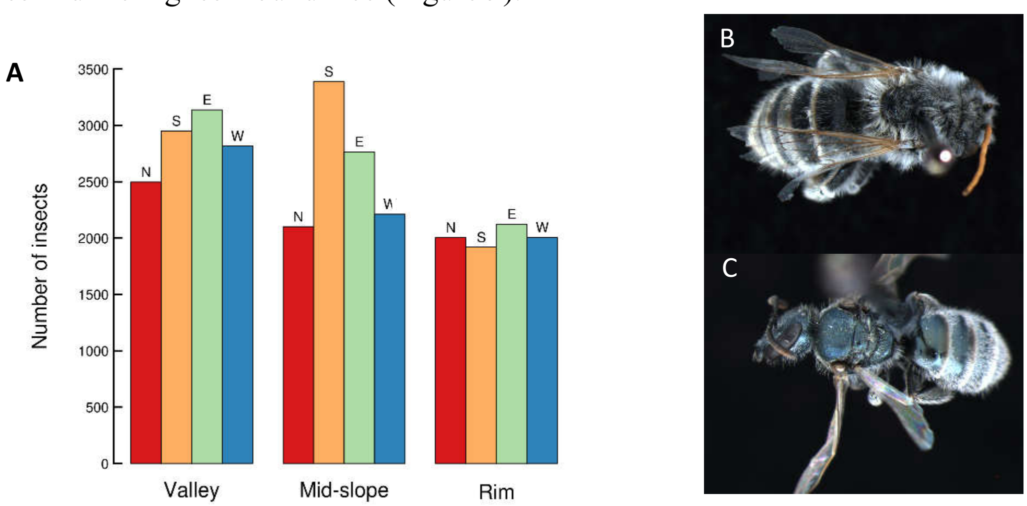


Figure 9. A.) Insect abundance across all sites by slope aspect and topographic position. B.) *Melisodes* and C.) *Lassioglossum* were some of the most abundant bees across sites.

We identified 33 different bee genera from diverse families including Apidae (bumblebees and relatives), Halictidae (sweat bees), Megachilidae (mason and leafcutter bees), Colletidae (polyester bees), and Andrenidae (mining bees). Among the Apidae, bumble bees (genus *Bombus*) and long-horned bees (*Eucera* and *Melisodes*) dominated collections (Appendix H). Bumble bees, leaf-cutter bees (*Osmia)*, and sweat bees (*Lassioglossum*) were abundant at all sites (Figure 9b, c).

Modeling bee abundance and diversity

The best-fit model for bee abundance included only site, but the next best model had a small Δ_i and large w_i, indicating the importance of topographic position (Table 6). This second best model that included site and topographic position explained 32% of the variation in bee abundance and found significant variation among sites (ANOVA, $F_{6,242}$=18.7, P<0.001), but not across slope aspects ($F_{2,242}$=1.85, P=0.159; Figure 10). Bee abundance was highest at Choke Cherry, intermediate at Sierra Madre Control, White Mountain, and White Mountain Control, and lowest at both Quaking Aspen sites and at Sierra Madre (Tukey HSD, all P<0.078; Figure 10a). Bee abundance tended to decline from valley to mid-slope to rim sites, regardless of which slope aspect was being sampled (Figure 10b, c).

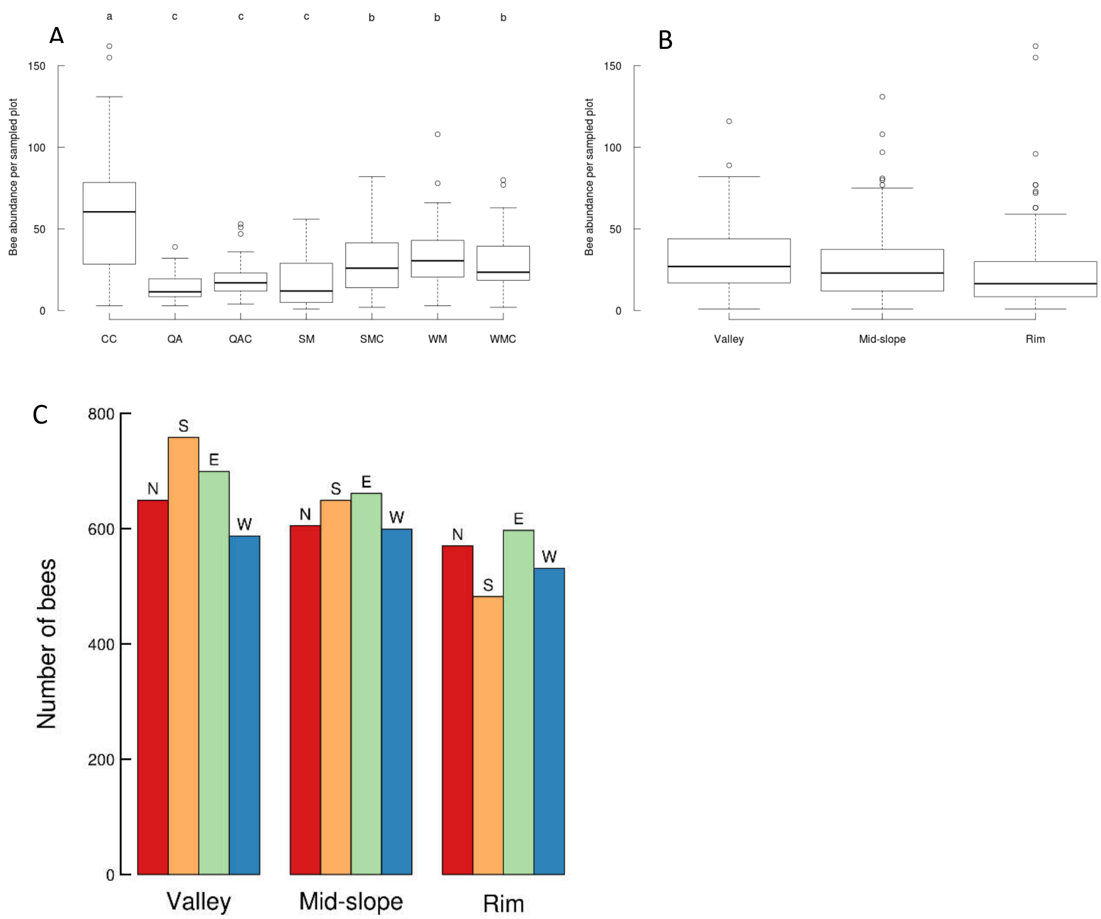


Figure 10. A.) Variation in bee abundance among sampling sites (CC= Choke Cherry, QA = Quaking Aspen, QAC = Quaking Aspen Control, SM = Sierra Madre, SMC = Sierra Madre Control, WM = White Mountain, WMC = White Mountain Control). Variation in bee abundance with B.) topographic position C.) and all strata (topographic position and slope aspect) with data from the seven sites combined. Letters indicate outcomes of post-hoc comparisons among sites.

Table 6. Top models explaining variation in bee abundance among sites, relative elevation, and slope aspect. Only models with w_i > 0.01 are shown.

model	AICc	Δ_i	w_i
site	2264.6	0	0.524
site + topographic position	2265.1	0.50	0.408
site + slope aspect	2269.8	5.26	0.038
site + topographic position + slope aspect	2270.4	5.82	0.029

For richness of bee genera, the best fit model included site and topographic position (Table 7). Slope aspect was included in the second-best model, but the relatively large Δ_i and low w_i suggested little importance of slope aspect in determining richness of bee genera. The best-fit model which included site and topographic position explained 26% of the variation in bee genera richness and found significant variation in richness among sites (ANOVA, $F_{6,242}$=12.4, P<0.001) and topographic position ($F_{2,242}$= 4.60, P=0.019). Chokecherry had the most bee genera on average, and Quaking Aspen the least, with all other sites falling somewhere in between (Tukey HSD, all P<0.065; Figure 11a). Rim sites had significantly fewer genera than did valley sites, with mid-slope sites having intermediate richness (Figure 11b).

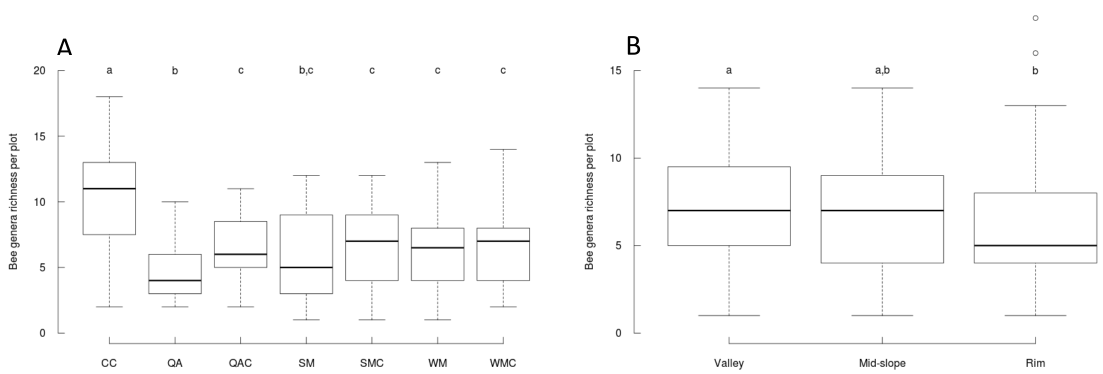


Figure 11. A.) Richness of bee genera varied among sites (CC= Choke Cherry, QA = Quaking Aspen, QAC = Quaking Aspen Control, SM = Sierra Madre, SMC = Sierra Madre Control, WM = White Mountain, WMC = White Mountain Control). B.) Richness of bee genera tended to decline with topographic position. Letters indicate outcomes of post-hoc comparisons.

Table 7. Comparison of models for richness of bee genera among sites, relative elevation, and slope aspect. Only models with w_i > 0.01 are shown.

model	AICc	Δ_i	w_i
site + topographic position	1259.7	0	0.740
site + topographic position + slope aspect	1262.4	2.75	0.187
site	1264.7	5.05	0.059
site + slope aspect	1267.6	7.92	0.014

Birds and bats

We conducted a total of 250 individual point counts on 17 point count grids in 2013. During these point counts, we detected a total of 2,465 birds representing 57 different bird species (Appendix I and J for complete list of bird species). In 2014, we conducted a total of 280 individual point counts on 21 point count grids. During these point counts we observed 1,941 birds representing 64 species. Estimates of occupancy and density can be found at the Rocky Mountain Bird Observatory's Avian Data Center (http://rmbo.org/v3/avian/ExploretheData.aspx).

In 2013, we conducted a total of 26 nights of acoustic recording at the seven sites across the season. From a total of 783 recordings of echolocation calls, 121 were identifiable, representing five species (Table 8). In 2014, we were unable to obtain any acoustic recordings due to equipment malfunctions. Bat activity was variable across sites but was very low in general. The majority of acoustic recordings were made at one location within the Sierra Madre site and one at the White Mountain Control site. This suggests that while much of the area surveyed during this study may not support high levels of bat activity, specific landscape features such as rock outcrops, aspen stands, and water bodies may concentrate bats as they roost, obtain water, or forage over standing water. To minimize impacts to local bat populations, it is important to identify these features within each site and place wind turbines accordingly. We only had four total detections for the two bat species (hoary bat and silver-haired bat) that are most frequently killed at wind energy development sites in the western United States. This may indicate that our study areas do not support large populations of these species during the summer. However, given that the majority of mortality events occur during the late summer and fall when these species are migrating to wintering grounds (Arnett 2008), it would of great importance evaluate activity of these species during this time. Furthermore, deductive models of bat migratory and stopover habitat predict that portions of all of the sites in the study area have a high probability of use during the fall (Abernethy et al. 2015).

Table 8. Number of acoustic recordings for bat species at each site.

Common Name	Scientific Name	Choke Cherry	Quaking Aspen	Quaking Aspen Control	Sierra Madre	Sierra Madre Control	White Mountain	White Mountain Control
Hoary Bat	*Lasiurus cinereus*	0	2	0	0	0	0	0
Western Small-footed Myotis	*Myotis ciliolabrum*	1	3	3	26	0	0	65
Long-eared Myotis	*Myotis evotis*	0	4	0	4	0	0	1
Little Brown Myotis	*Myotis lucifugus*	1	0	0	9	0	0	0
Silver-haired Bat	*Lasionycteris noctivagans*	0	0	0	0	0	0	2

Conclusion and future goals

We found diverse and robust flowering plant and pollinator communities throughout our sampling sites. We recorded 126 species of flowering plants that feed diverse taxa throughout the high elevation sagebrush steppe, including pronghorn, horned lizards, pygmy rabbits, and sage grouse. Our seed-set experiment indicated that late blooming flowering plants experienced pollen-limitation and may experience population declines should pollinators decline. We also recorded diverse orders of insects including 33 genera of bees that provide pollination services to many of the flowering plant species we recorded. Our surveys for birds indicated that a diversity of species live at these sites. We recorded five bat species, but the lack of surface water and roosting sites at most locations may limit resident populations. Sagebrush ecosystems in southern Wyoming are home to an astonishing biodiversity. With the baseline data we have collected at the four proposed wind farm sites and their controls, we have excellent before data to compare if any of these areas are developed and a future project is funded.

Literature cited

Abernethy, I. M., Andersen, M. D., and Keinath, D. A. 2015. Bats of Wyoming: distribution and migration year 4 report. Prepared for the USDI Bureau of Land Management by the Wyoming Natural Diversity Database, University of Wyoming, Laramie, Wyoming.

Arnett, E. B., Brown, W. K., Erickson, W. P., Fiedler, J. K., Hamilton, B. L., Henry, T. H., Jain, A., Johnson, G. D., Kerns, J., Koford, R. R., Nicholson, C. P., O'Connell, T. J., Piorkowski, M. D., and Tankersley, R. D., Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America, Journal of Wildlife Management 72, 61-78.

Ascher, J. S. and J. Pickering. 2014. Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila). Available at: http://www.discoverlife.org/mp/20q?guide=Apoidea_species

Baerwald, E. F., G. H. D'Amours, B. J. Klug and R. M. R. Barclay. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology 18:R695–R696.

Barton, K. 2016. MuMIn: Multi-Model Inference. R package version 1.15.6. https://CRAN.R-project.org/package=MuMIn.

Bureau of Land Management. 2011, Renewable Energy. Available at: http://www.blm.gov/wy/st/en/programs/energy/renewable.html Accessed 12 March 2014.

Bureau of Land Management, 2012. 2012 Annual Report. Available at: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/annualreports.Par.74106.File.dat/2012annrpt.pdf Accessed 12 March 2014.

Burnham, K.P., Anderson, D.R., 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach. Springer.

Davidson, A., J. Aycrigg, E. Grossmann, J. Kagan, S. Lennartz, S. McDonough, T. Miewald, J. Ohmann, A. Radel and T. Sajwaj. 2009. Digital Land Cover Map for the Northwestern United States. Northwest Gap Analysis Project, USGS GAP Analysis Program, Moscow, Idaho.

Department of Energy. 2008. 20% Wind Energy by 2030: Increasing wind energy's contribution to U.S electricity supply. Oak Ridge Tennessee: Department of Energy, Office of Scientific and Technical Information. Available at: http://www.nrel.gov/docs/fy08osti/41869.pdf Accessed 12 March 2014.

Droege, S., V. J. Tepedino, G. Lebuhn, W. Link, R. L. Minckley, Q. Chen and C. Conrad. 2010. Spatial patterns of bee captures in North American bowl trapping surveys. Insect Conservation and Diversity 3:15–23.

Elzay, S., Tronstad, L, and M.E. Dillon. In press. Chapter 5: Terrestrial invertebrates In: Wildlife and wind farms: conflicts and solutions, Volume 1 Onshore. Pelagic Press.

Erickson W., G. Johns, D. Young, D. Strickland, R. Good, M. Bourassa, K. Bay, K. Semka. 2002. Synthesis and Comparison of Baseline Avian and Bat Use, Raptor Nesting and Mortality Information from Proposed and Existing Wind Developments. West, Inc. Available at: http://www.bpa.gov/Power/pgc/wind/Avian_and_Bat_Study_12-2002.pdf. Accessed 12 Mar 2014.

Grimaldi, D. and M. S. Engel. 2005. Evolution of the Insects. Cambridge University Press.

Grundel, R., K. J. Frohnapple, R. P. Jean and N. B. Pavlovic. 2011. Effectiveness of bowl trapping and netting for inventory of a bee community. Environmental Entomology 40:374–380.

Grundel, R., R. P. Jean, K. J. Frohnapple, G. A. Glowacki, P. E. Scott and N. B. Pavlovic. 2010. Floral and nesting resources, habitat structure, and fire influence bee distribution across an open-forest gradient. Ecological applications 20:1678–1692.

Hanni, D. J., C. M. White, N. J. VanLanen, J. J. Birek, J. M. Berven and M. A. McLaren. 2013. Integrated Monitoring of Bird Conservation Regions (IMBCR): Field protocol for spatially-balanced sampling of land bird populations. Rocky Mountain Bird Observatory, Brighton, Colorado, USA

Horn, J., E. Arnett, T. Kunz. 2010. Behavioral responses of bats to operating wind turbines. The Journal of Wildlife Management 72: 123-132.

Jakle, A., Geiger, M. E., McDonough, C. J., & Lovato, J. M. (2011). Commercial Wind Energy Development in Wyoming: A Guide for Landowners. Haub School & Ruckelshaus Institute of Environment and Natural Resources, School of Energy Resources, University of Wyoming Cooperative Extension Service.

Kunz, T., E. Arnett, B. Cooper, W. Erickson, R. Larkin, T. Mabee, M. Morrision, M.D. Strickland and J. Szewczak. 2010. Assessing impacts of wind-energy development on norcturnally active birds and bats: a guidance document. The Journal of Wildlife Management 71: 2449-2486.

Lebuhn, G., S. Droege, E. F. Connor, B. Gemmill-Herren, S. G. Potts, R. L. Minckley, T. Griswold, R. Jean, E. Kula, D. W. Roubik, J. Cane, K. W. Wright, G. Frankie and F. Parker. 2013. Detecting insect pollinator declines on regional and global scales. Conservation Biology 27:113–120.

Long, C. 2011. Wind Turbines, insects and wildlife interaction. Antenna 35:90-95

Long, C., J.A. Flint and P.A. Lepper. 2011. Insect attraction to wind turbines: does color play a role? European Journal of Wildlife Research 57:323-331.

Losey, J. E. and M. Vaughan. 2006. The economic value of ecological services provided by insects. BioScience 56:311–323.

Luebehusen, E. 2013. United States Drought Monitor. United States Department of Agriculture. Available at: http://droughtmonitor.unl.edu/MapsAndData/MapArchive.aspx

Michener, C. D. 2000. The Bees of the World. Johns Hopkins University Press.

Michener, C.D, R. McGinley, B. Danforth. 1994. The Bee Genera of North and Central American (Hymenoptera: Apoidea). Smithsonian Institutional Press.

R Development Core Team (2008). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at http://www.R-project.org.

T. H., S. A. Smith and A. L. Brewster. 2007. A comparison of pan trap and intensive net sampling techniques for documenting a bee (Hymenoptera: Apiformes) fauna. Journal of the Kansas Entomological Society 80:179–181.

Rydell, J., Bach, L., Dubourg-Savage, M.-J., Green, M., Rodrigues, L. and Hedenström, A. 2010. Mortality of bats at wind turbines links to nocturnal insect migration? European Journal of Wildlife Research *56*:823–827.

Szewczak, J.M. 2011. SonoBat: Wyoming species package. Arcata, California.

Stephen, W. P. and S. Rao. 2005. Unscented color traps for non-Apis bees (Hymenoptera: Apiformes). Journal of the Kansas Entomological Society 78:373–380.

Underwood, A. J. 1994. On beyond BACI: sampling designs that might reliably detect environmental disturbances. Ecological Applications 4:3–15.

U.S. Fish and Wildlife Service, Mountain-Prairie Region, Wyoming Ecological Services. 2013.. Chokecherry and Sierra Madre Wind Energy Project. Available at: http://www.fws.gov/mountain-prairie/wind/ChokecherrySierraMadre/CCSMFactSheet1.pdf
Westphal, C., R. Bommarco, G. Carré, E. Lamborn, N. Morison, T. Petanidou, S. G. Potts, S. P. Roberts, H. Szentgyörgyi and T. Tscheulin. 2008. Measuring bee diversity in different European habitats and biogeographical regions. Ecological Monographs 78:653–671.
Willmer, P. 2011. Pollination and Floral Ecology. Princeton University Press.
Wilson, J. S., T. Griswold and O. J. Messinger. 2008. Sampling bee communities (Hymenoptera: Apiformes) in a desert landscape: are pan traps sufficient? Journal of the Kansas Entomological Society 81:288–300.

Appendix A. Plot selection methods using ArcGIS.

Overview:

Four wind farm locations were sampled prior to development (Chokecherry, Sierra Madre, White Mountain, and Quaking Aspen). At each development site (i.e., "wind farm"), 36 locations were sampled in 2013-2014. Additionally, each of the latter two sites had dedicated control sites, and a single control site was selected and sampled for the Chokecherry and Sierra Madre sites. At each control site, another 36 locations were sampled. Control sites were chosen opportunistically, based on access and similarity to the development sites in terms of major landforms, vegetation, etc. All sites were stratified, with 4 aspect categories X 3 dissection categories = 12 total strata, each of which had 3 sample locations.

Protocols for selecting sample points:

1. Start a new map document, *N:\WyomingInverts\Projects\Current Projects\Pollinators&WindFarms\GIS**SITE_SELECTION.mxd***, and add the relevant layers.
2. Merge the wind farm project area boundaries (from *N:\WyomingInverts\Projects\Current Projects\Pollinators&WindFarms\Maps\RockSpringsFieldOfficeMaps*) into a single shapefile, *N:\WyomingInverts\Projects\Current Projects\Pollinators&WindFarms\GIS**SITE_BOUNDARIES.shp***.
3. Add the statewide public lands (single part) layer: *K:\LIBRARY\OWNERSHIP**StatewidePublicLandsSinglePart.shp*** ("SPLSP") and the plss section layer (*M:\working_spatial_data\town_range_section(plss100k)**plss_wylam.shp***).
4. Digitize the selected control site boundaries using the plss layer from above as a snap layer, adding these to the SITE_BOUNDARIES shapefile.
5. Clip the SPLSP layer to the site boundaries layer, writing the output as *N:\WyomingInverts\Projects\Current Projects\Pollinators&WindFarms\GIS**publicSectionsWithinSiteBoundaries.shp***
6. For White Mountain and Quaking Aspen, add in lands owned by the Rock Springs Grazing Association, as these are also possible survey targets.
7. Remove any sections that do not have clear access within approx. 2 miles of a road that is known to be accessible.
8. Generate a unique ID field in the public sections shapefile as "PUBLIC_" & [FID].
9. Give each sample site an ID.

Wind Farm	**Wind Farm ID**	**Control ID**
White Mountain	WM	WMC
Quaking Aspen	QA	QAC
Sierra Madre	SM	SMC
Chokecherry	CC	[None – SMC is control]

10. Add the 10-cell window dissection and aspect layers from K:\LIBRARY\MODEL_VARIABLE_LAYERS\FILE_GEODATABASE\30m\PREDICTOR_LAYERS.gdb.
11. Set all environment parameters to match that of the 10-cell dissection layer, and use the “GenerateAspect_Classes—4_Class..” tool in the WYNDD toolbox to create a 4-category aspect layer from the original aspect layer.
12. Convert the raster centers to a point shapefile, N:\WyomingInverts\Projects\Current Projects\Pollinators&WindFarms\GIS\RASTER_CENTROIDS.shp.
13. Select only the raster centroids that fall within the public sections, and export as PotentialSamplingPoints.shp.
14. Reclassify the dissection raster into 3 categories using an equal interval classification, masking results to the public sections layer, and writing as N:\WyomingInverts\Projects\Current Projects\Pollinators&WindFarms\GIS\dissectrcls.
15. Use the GME sampling tool to add the values for the reclassified dissection and 4-category aspect, to the “PotentialSamplingPoints” shapefile, writing resulting point shapefile to N:\WyomingInverts\Projects\Current Projects\Pollinators&WindFarms\GIS\potentialSamplingPointsWithValues.shp.
16. Add the site name into this point shapefile in a siteID field.
17. Add a strataID field as a concatenation of the site ID, aspect, and dissection.

strataID	points
CC_E_M	3350
CC_E_R	1163
CC_E_V	1038
CC_N_M	5054
CC_N_R	1092
CC_N_V	1994
CC_S_M	2119
CC_S_R	1057
CC_S_V	833
CC_W_M	1577
CC_W_R	452
CC_W_V	402

strataID	points
QA_W_R	478
QA_W_V	202
QAC_E_M	2639
QAC_E_R	1714
QAC_E_V	956
QAC_N_M	3374
QAC_N_R	1841
QAC_N_V	1165
QAC_S_M	3788
QAC_S_R	2146
QAC_S_V	1584
QAC_W_M	3498

strataID	points
SM_S_V	3361
SM_W_M	6031
SM_W_R	5483
SM_W_V	2333
SMC_E_M	3268
SMC_E_R	1504
SMC_E_V	1293
SMC_N_M	3799
SMC_N_R	1520
SMC_N_V	2100
SMC_S_M	1632
SMC_S_R	907

strataID	points
WM_S_M	4755
WM_S_R	5866
WM_S_V	1251
WM_W_M	5764
WM_W_R	5529
WM_W_V	1092
WMC_E_M	959
WMC_E_R	564
WMC_E_V	289
WMC_N_M	14002
WMC_N_R	3546
WMC_N_V	2432

QA_E_M	3963
QA_E_R	5109
QA_E_V	426
QA_N_M	1743
QA_N_R	2527
QA_N_V	584
QA_S_M	6573
QA_S_R	5026
QA_S_V	739
QA_W_M	389
QAC_W_R	1785
QAC_W_V	939
SM_E_M	9186
SM_E_R	5443
SM_E_V	3994
SM_N_M	8405
SM_N_R	5317
SM_N_V	3619
SM_S_M	9905
SM_S_R	7473
SMC_S_V	1108
SMC_W_M	3343
SMC_W_R	1536
SMC_W_V	3284
WM_E_M	1810
WM_E_R	2412
WM_E_V	528
WM_N_M	11066
WM_N_R	8084
WM_N_V	2152
WMC_S_M	3770
WMC_S_R	2476
WMC_S_V	1471
WMC_W_M	7660
WMC_W_R	2685
WMC_W_V	1383

18. Use the r.sample tool in GME to select 6 points (3 primary, 3 backup) per stratum: *r.sample(in="N:\WyomingInverts\Projects\Current Projects\Pollinators&WindFarms\GIS\potentialSamplingPointsWithValues.shp", size=6, field="selected", stratified="strataID");*
19. Select where “selected” = 1, and export as N:\WyomingInverts\Projects\Current Projects\Pollinators&WindFarms\GIS\samplePoints.shp.
20. Add a random number field, to use in sorting points, to identify the priority of sampling, so that there is an order for each stratum (84 total strata). 504 points were selected, and the field “selected” was populated with 1 for these points. Use ET Geowizards to sort in ascending order on the random filed, writing to c:\temp\pollinators\samplePointsSorted.shp
21. Split using GME: *splitdataset(in="c:\temp\pollinators\samplePointsSorted.shp", uidfield="strataID", outws="C:\temp\pollinators\sortedSplit", prefix="split");*
22. Calculate the ET_ID field as FID + 1, so that we have a 1-6 ordering for points in each stratum, via a ModelBuilder model run in batch mode.
23. Merge these split files back into a single file, N:\WyomingInverts\Projects\Current Projects\Pollinators&WindFarms\GIS\samplePointsWSampleOrder.
24. Calculate a new field, SampleID, to hold a concatenation of strataID and the ET_ID field. This gives us an ID for each point that tells us what order to sample in.

Appendix B. Number of flowers counted of each plant species (listed alphabetically) at each site. Numbers in parenthesis after site names indicate total number of species documented for that site. Numbers in parentheses after plant species indicate the flower abundance rank of that plant across all sites (1 being most abundant). Numbers in parentheses after each flower count indicate the abundance rank of that species in that site (column). Bold species names and bold flower counts indicate, respectively, the 10 most abundant flowers across all sites and within each site.

Species (overall abundance rank)	Chokecherry (40)	Quaking Aspen (30)	Quaking Aspen Control (32)	Sierra Madre (74)	Sierra Madre Control (54)	White Mountain (25)	White Mountain Control (38)
Achillea millefolium (38)	-	-	**111 (9)**	5 (58)	97 (23)	-	-
Agroseris sp (30)	10 (25)	-	-	124 (23)	191 (15)	-	-
Allium sp (37)	-	-	-	-	246 (12)	-	-
Allium textile (35)	**224 (6)**	-	-	2 (66)	-	**39 (8)**	-
***Alyssum simplex* (3)**	**10742 (1)**	-	-	410 (12)	85 (24)	-	7 (28)
Amelanchier alnifolia (90)	-	-	15 (19)	-	-	-	-
Amsinckia menziesii (54)	-	-	-	-	-	-	102 (12)
Androsace septentrionalis (20)	6 (30)	-	11 (20)	**826 (7)**	-	-	-
Antennaria rosea (21)	-	**433 (3)**	**90 (10)**	133 (21)	-	-	-
Apocynum cannabinum (80)	-	-	-	-	-	-	21 (20)
Arenaria congesta (32)	-	**262 (8)**	-	35 (39)	-	-	-
Arenaria hookeri (15)	**471 (5)**	**386 (5)**	2 (29)	160 (18)	-	3 (22)	**214 (9)**
Arnica cordifolia (73)	-	-	-	29 (42)	-	-	-
Astragalus convallarius (49)	1 (38)	-	5 (23)	88 (27)	-	6 (20)	22 (19)
Astragalus lentiginosus var. *salinus* (92)	-	-	-	-	-	-	12 (25)
Astragalus pectinatus (44)	22 (18)	-	-	135 (20)	2 (50)	-	6 (29)
Astragalus purshii (106)	-	-	-	3 (64)	-	-	-
Astragalus sericoleucus (26)	-	-	-	127 (22)	**329 (9)**	-	-
Astragalus sp (74)	-	-	-	2 (67)	27 (33)	-	-
Atriplex gardneri (42)	**166 (7)**	-	-	-	-	-	-
Balsamorhiza sagittata (51)	-	-	-	-	108 (19)	-	-
Calochortus nuttallii (79)	-	-	-	2 (68)	22 (37)	-	-
Castilleja angustifolia (110)	-	-	1 (30)	1 (71)	-	-	-
Castilleja angustifolia var *dubia* (103)	-	-	4 (24)	-	-	-	-
Castilleja flava (60)	-	38 (16)	4 (25)	-	7 (44)	9 (17)	-
Castilleja linariifolia (33)	-	52 (13)	**199 (7)**	40 (37)	2 (51)	2 (24)	2 (35)
Castilleja sp (81)	-	-	-	21 (45)	-	-	-
Chorispora tenella (62)	-	-	-	6 (56)	44 (31)	-	6 (30)

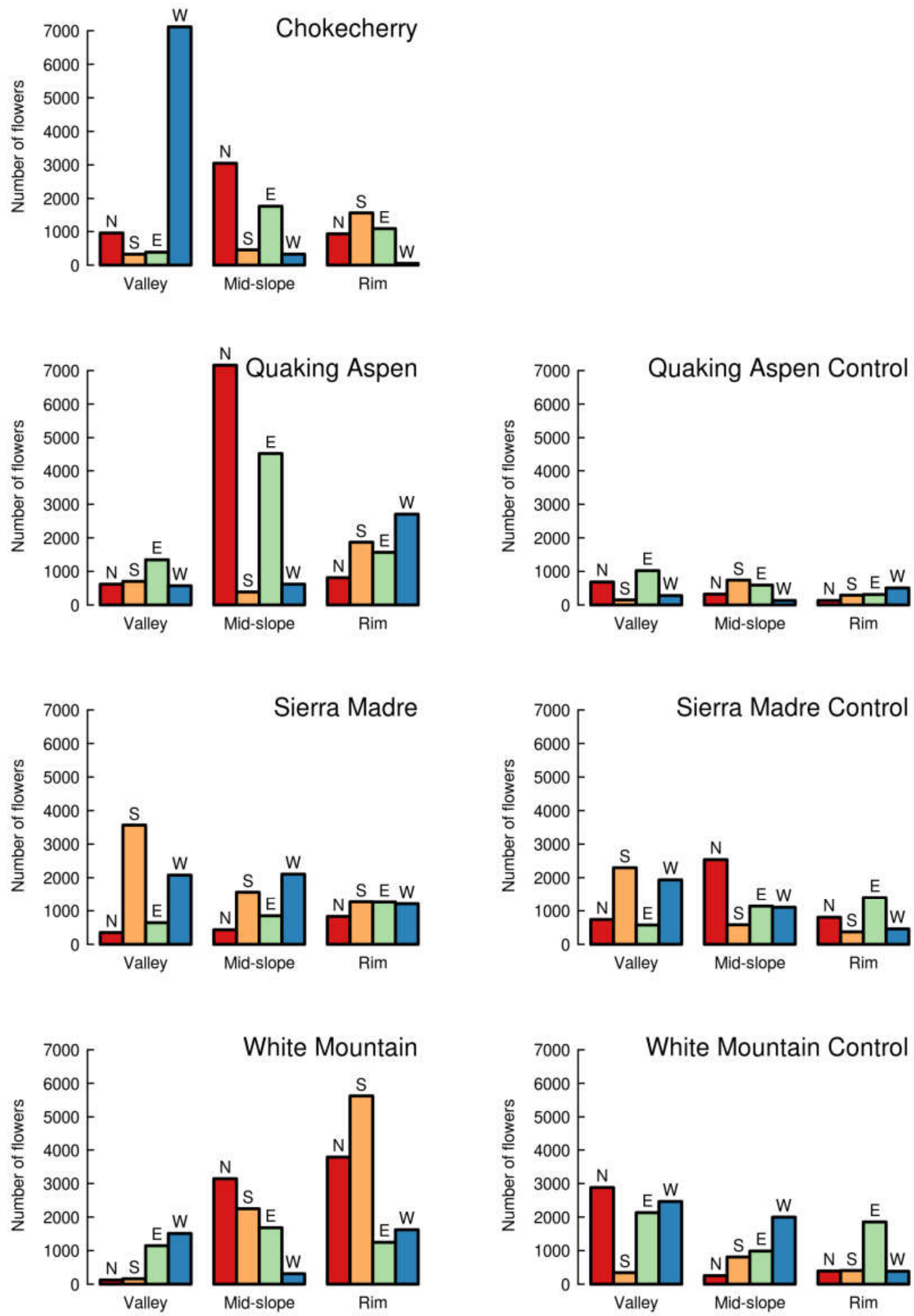
Species (overall abundance rank)	Chokecherry (40)	Quaking Aspen (30)	Quaking Aspen Control (32)	Sierra Madre (74)	Sierra Madre Control (54)	White Mountain (25)	White Mountain Control (38)
Cirsium sp (97)	-	-	6 (22)	-	1 (52)	-	-
***Collinsia parviflora* (6)**	49 (13)	-	-	**2326 (2)**	**1589 (2)**	-	-
Comandra umbellata (98)	7 (28)	-	-	-	-	-	-
Cordylanthus ramosus (91)	-	2 (27)	1 (31)	10 (53)	-	1 (25)	-
Crepis occidentalis (75)	26 (15)	-	-	-	-	-	-
Crepis runcinata (104)	-	-	-	4 (60)	-	-	-
Crepis sp (99)	-	-	-	-	-	7 (18)	-
Cryptantha cinerea (77)	-	-	-	-	-	-	25 (18)
Cryptantha flavoculata (89)	-	-	-	-	-	-	16 (21)
Cryptantha sp (65)	2 (36)	-	-	-	48 (29)	-	-
Delphinium barbeyi (78)	-	-	-	-	25 (35)	-	-
Delphinium bicolor (23)	78 (11)	3 (26)	-	7 (55)	**472 (8)**	-	-
Delphinium nuttallianum (59)	12 (23)	-	-	32 (40)	16 (41)	-	3 (33)
***Descurainia pinnata* (4)**	**4415 (2)**	16 (20)	-	-	-	17 (13)	491 (6)
Dodecatheon pulchellum (101)	-	-	-	6 (57)	-	-	-
***Ericameria nauseosa* (5)**	-	56 (12)	**342 (4)**	268 (16)	216 (14)	**377 (5)**	**3410 (2)**
Ericameria sp (53)	-	-	-	4 (61)	99 (22)	-	-
Erigeron compositus (18)	-	**201 (9)**	**262 (5)**	**596 (9)**	-	-	-
Erigeron sp (41)	47 (14)	5 (25)	4 (26)	54 (31)	78 (26)	-	5 (31)
Erigeron speciosus (61)	-	-	-	-	57 (28)	-	-
Eriogonum caespitosum (47)	20 (19)	37 (17)	-	-	-	-	71 (15)
Eriogonum jamesii (12)	**142 (9)**	**363 (6)**	38 (13)	-	108 (20)	**409 (4)**	**715 (5)**
***Eriogonum microthecum* (1)**	-	**12065 (1)**	**776 (2)**	42 (36)	-	**15448 (1)**	**6040 (1)**
Eriogonum ovalifolium (25)	-	19 (19)	-	-	-	12 (14)	**430 (7)**
Eriogonum sp (107)	-	-	-	-	-	3 (23)	-
***Eriogonum umbellatum* (7)**	52 (12)	**278 (7)**	**530 (3)**	385 (14)	**1241 (4)**	**148 (6)**	**134 (10)**
Erysimum asperum (83)	-	-	-	18 (46)	-	-	-
Erysimum inconspicuum (111)	2 (37)	-	-	-	-	-	-
Fritillaria atropurpurea (115)	-	-	-	1 (72)	-	-	-
Gentiana parryi (116)	-	-	-	-	1 (53)	-	-
Geranium sp (84)	-	-	-	-	18 (39)	-	-
Geranium viscosissimum (112)	-	-	-	2 (69)	-	-	-
***Gutierrezia sarothrae* (2)**	5 (32)	**7860 (2)**	**2109 (1)**	14 (50)	**3513 (1)**	**5452 (2)**	**1600 (3)**
Gymnosteris parvula (19)	**152 (8)**	-	-	**652 (8)**	75 (27)	-	-
Hackelia sp (117)	1 (39)	-	-	-	-	-	-

Species (overall abundance rank)	Chokecherry (40)	Quaking Aspen (30)	Quaking Aspen Control (32)	Sierra Madre (74)	Sierra Madre Control (54)	White Mountain (25)	White Mountain Control (38)
Helianthella sp (105)	-	-	-	-	4 (49)	-	-
Hieracium cynoglossoides (68)	-	-	-	-	27 (34)	-	16 (22)
Ipomopsis aggregata (72)	-	-	8 (21)	26 (43)	-	-	-
Ipomopsis spicata (69)	-	-	-	40 (38)	-	-	-
Lappula occidentalis (22)	**613 (3)**	-	-	-	-	-	-
Lappula redowskii (118)	1 (40)	-	-	-	-	-	-
Lappula sp (94)	9 (26)	-	-	-	-	-	-
Leucanthemum vulgare (48)	24 (17)	-	-	99 (26)	-	-	-
Lewisia pygmaea (113)	-	-	-	2 (70)	-	-	-
Lewisia rediviva (87)	17 (21)	-	-	-	-	-	-
Linanthus pungens (16)	**90 (10)**	-	4 (27)	**1099 (4)**	-	-	11 (26)
Linum lewisii (102)	-	-	-	-	5 (46)	-	-
Lithophragma tenellum (27)	-	2 (28)	-	393 (13)	5 (47)	-	2 (36)
Lithospermum incisum (50)	-	-	-	-	112 (18)	-	-
Lithospermum ruderale (28)	5 (33)	-	-	4 (62)	**254 (10)**	11 (16)	113 (11)
Lomatium ambiguum (45)	-	-	-	162 (17)	-	-	-
Lomatium macrocarpum (63)	-	7 (23)	-	10 (54)	29 (32)	5 (21)	2 (37)
Lupinus argenteus (11)	-	7 (24)	22 (16)	**862 (6)**	**663 (7)**	-	**352 (8)**
Lupinus caespitosus var *utahensis* (57)	-	-	-	70 (30)	-	-	-
Machaeranthera canescens (52)	-	8 (22)	33 (14)	5 (59)	46 (30)	-	15 (24)
Mahonia repens (56)	-	-	-	-	100 (21)	-	-
Mentzelia montana (85)	18 (20)	-	-	-	-	-	-
***Mertensia oblongifolia* (9)**	**509 (4)**	-	33 (15)	**1114 (3)**	**867 (5)**	**87 (7)**	69 (16)
Oenothera pallida (95)	3 (34)	-	-	-	-	-	5 (32)
Oenothera sp (108)	-	-	-	-	-	-	3 (34)
Oxytropis lambertii (82)	-	-	20 (17)	-	-	-	-
Oxytropis nana (29)	-	-	-	362 (15)	-	7 (19)	1 (38)
Penstemon eriantherus (43)	6 (31)	-	-	136 (19)	24 (36)	-	-
Penstemon humilis (66)	-	12 (21)	16 (18)	4 (63)	5 (48)	12 (15)	-
Penstemon laricifolius (119)	-	-	-	1 (73)	-	-	-
Penstemon strictus (36)	-	81 (11)	**155 (8)**	12 (51)	-	-	-
Phlox hoodii (14)	17 (22)	-	-	**1045 (5)**	182 (16)	**29 (9)**	72 (14)
Phlox longifolia (17)	-	**124 (10)**	4 (28)	50 (33)	**830 (6)**	-	56 (17)
***Phlox multiflora* (10)**	-	**431 (4)**	55 (11)	**537 (10)**	**1278 (3)**	**28 (10)**	16 (23)

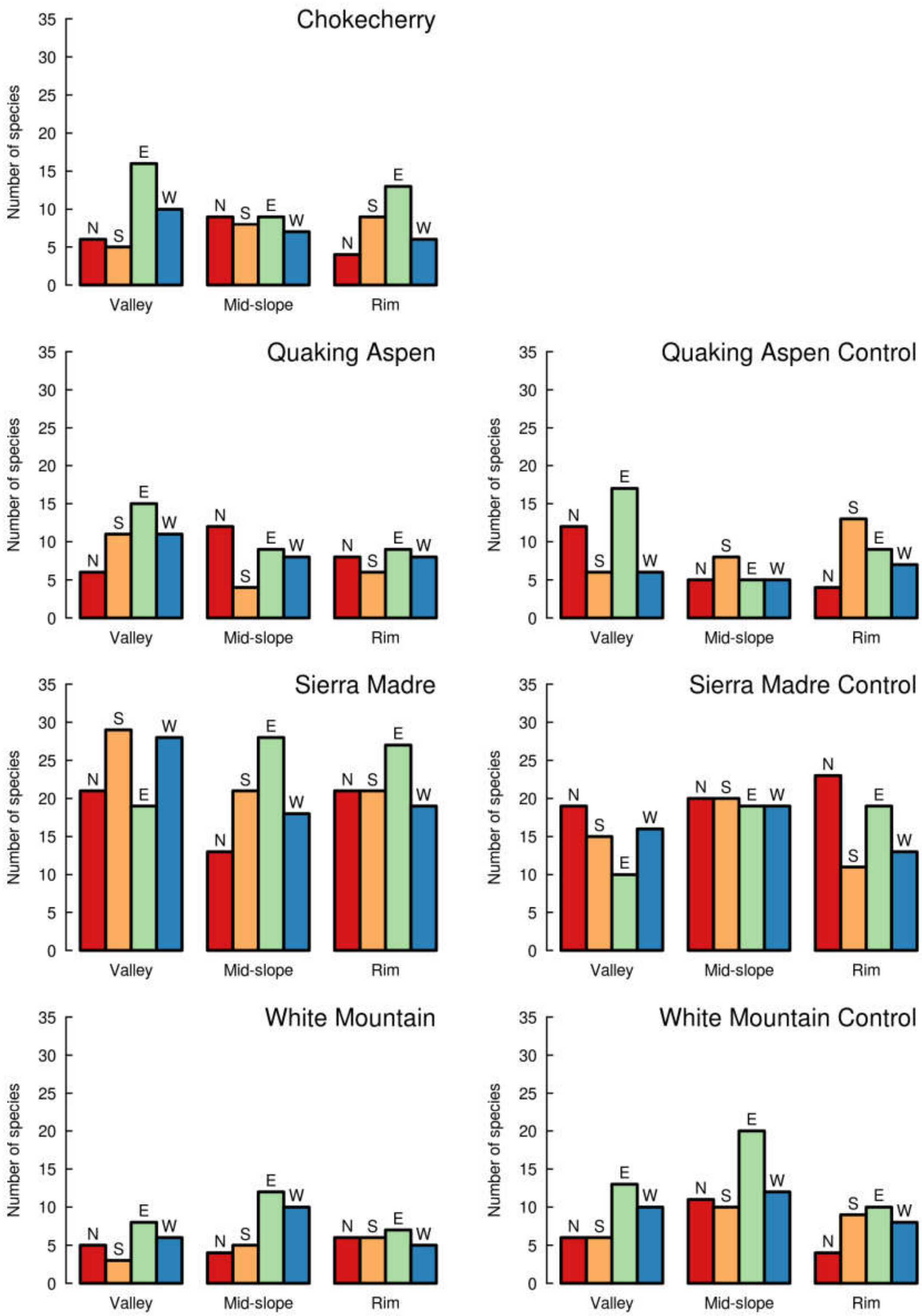
Species (overall abundance rank)	Chokecherry (40)	Quaking Aspen (30)	Quaking Aspen Control (32)	Sierra Madre (74)	Sierra Madre Control (54)	White Mountain (25)	White Mountain Control (38)
Physaria sp (109)	-	-	-	3 (65)	-	-	-
Picrothamnus desertorum (96)	8 (27)	-	-	-	-	-	-
Polygonum bistortoides (39)	-	-	-	88 (28)	17 (40)	22 (11)	75 (13)
Ranunculus acriformis (67)	-	-	-	45 (35)	-	-	-
Ranunculus glaberrimus (46)	-	-	-	72 (29)	80 (25)	-	-
Ranunculus sp (86)	-	-	-	18 (47)	-	-	-
Sedum lanceolatum (31)	-	40 (15)	**262 (6)**	11 (52)	-	-	-
Stanleya pinnata (70)	-	37 (18)	-	-	-	-	-
Stenotus acaulis (13)	12 (24)	48 (14)	41 (12)	105 (24)	1 (54)	**458 (3)**	**756 (4)**
Taraxacum officinale (76)	-	-	-	17 (48)	9 (43)	-	-
Taraxacum sp (114)	-	1 (30)	-	1 (74)	-	-	-
Townsendia hookeri (71)	3 (35)	-	-	32 (41)	-	-	-
Tragopogon sp (93)	-	-	1 (32)	-	-	-	11 (27)
***Trifolium gymnocarpon* (8)**	-	2 (29)	-	**2469 (1)**	254 (11)	-	-
Trifolium parryi (55)	-	-	-	102 (25)	-	-	-
Trifolium repens (24)	-	-	-	466 (11)	-	-	-
Vicia americana (88)	7 (29)	-	-	-	10 (42)	-	-
Viola nuttallii (58)	-	-	-	48 (34)	22 (38)	-	-
Viola praemorsa (64)	-	-	-	53 (32)	-	-	-
Viola purpurea (40)	-	-	-	16 (49)	161 (17)	22 (12)	-
Xylorhiza glabriuscula (34)	25 (16)	-	-	26 (44)	245 (13)	-	-
*Zigadenus venenosu*s (100)	-	-	-	-	7 (45)	-	-

Appendix C. Flower abundance among sites separated by landscape characteristics (topographic position and slope aspect).

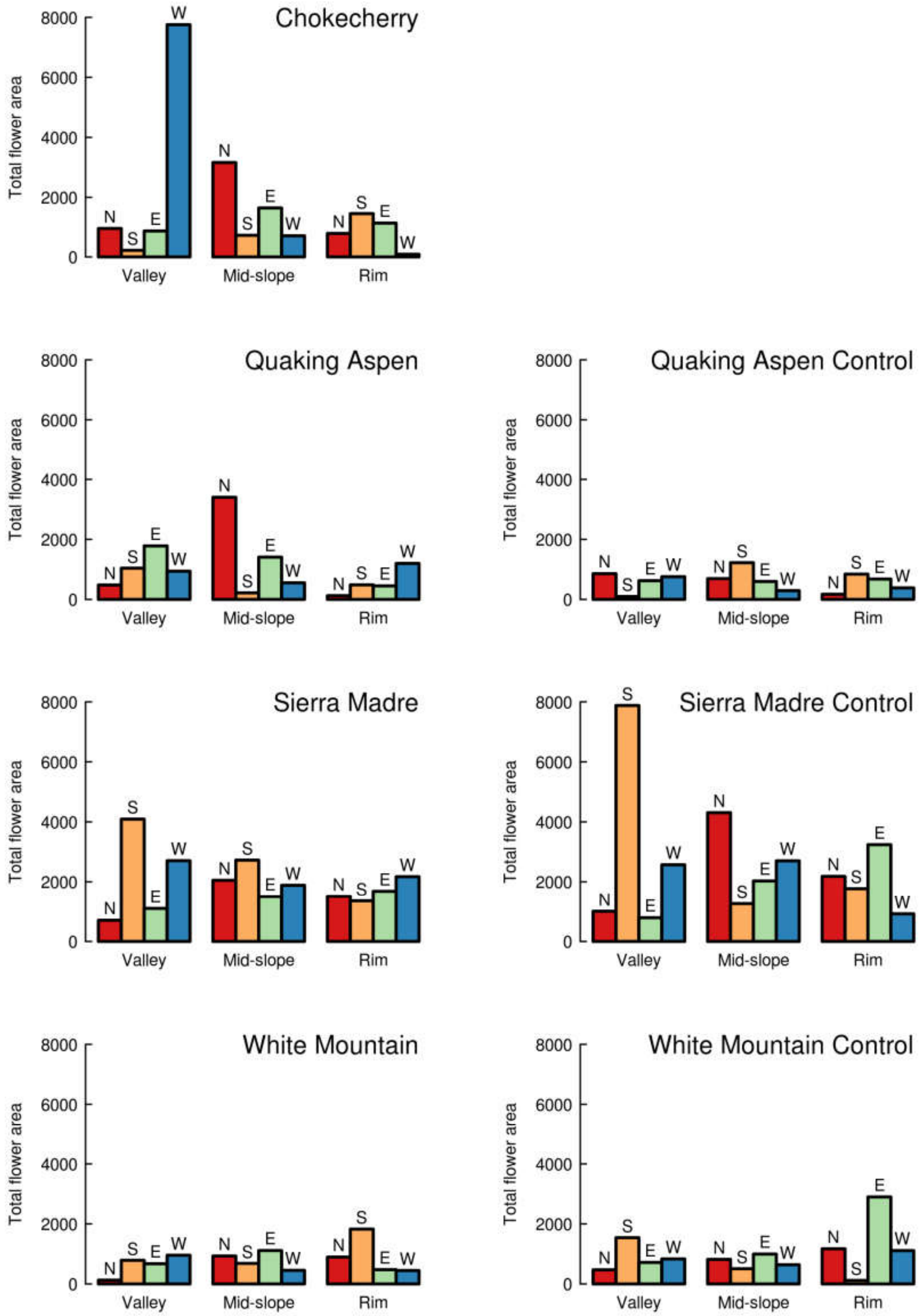
A



Appendix D. Floral species richness among sites separated by landscape characteristics (topographic position and slope aspect).



Appendix E. Flower area among sites separated by landscape characteristics (topographic position and slope aspect).



Appendix F. Total flower counts by site of the 20 most abundant flower species. Average area (mm^2) per flower and total floral area displayed (mm^2) per species during the 2013 and 2014 field season.

Species	Chokecherry	Quaking Aspen	Quaking Aspen Control	Sierra Madre	Sierra Madre Control	White Mountain	White Mountain Control	Total flowers	Average flower area (mm^2)	Total flower area (mm^2)
Eriogonum microthecum	0	12060	776	42	0	15288	6040	34206	2.2	15548
Gutierrezia sarothrae	5	7692	2109	14	3466	5452	1600	20338	6.8	2991
Alyssum simplex	10739	0	0	410	85	0	7	11241	10	1124
Descurainia pinnata	4415	16	0	0	0	17	491	4939	13.6	363
Collinsia parviflora	49	0	0	2326	1589	0	0	3964	10	396
Eriogonum umbellatum	52	278	530	385	1241	148	134	2768	2.2	1258
Trifolium gymnocarpon	0	2	0	2469	254	0	0	2725	2.6	1048
Mertensia oblongfolia	509	0	33	1114	808	87	69	2620	11.8	222
Phlox multiflora	0	431	55	537	1278	28	16	2345	15.8	148
Lupinus argenteus	0	7	22	862	663	0	352	1906	8.4	227
Eriogonum jamseii	142	363	38	0	108	409	715	1775	2.2	807
Stenotus acaulis	12	48	41	105	1	458	756	1421	24	59
Phlox hoodii	17	0	0	1045	182	29	72	1345	15.8	85
Leptodactylon pungens	90	0	4	1099	0	0	11	1204	13.8	87
Phlox longifolia	0	124	4	50	830	0	56	1064	15.8	67
Erigeron compositus	0	201	262	596	0	0	0	1059	22.8	46
Eremogone hookeri	471	173	0	160	0	3	187	994	11.2	89
Gymnosteris parvula	152	0	0	652	75	0	0	879	16.8	52
Androsace septentrionalis	6	0	11	826	0	0	0	843	17.4	48

Appendix G. Total numbers of invertebrates by order collected at all sites.

	Chokecherry	Quaking Aspen		Sierra Madre		White Mountain		Total
	Site	Site	Control	Site	Control	Site	Control	
Araneae	11	7	8	9	11	17	4	67
Coleoptera	1036	536	328	452	1779	1190	737	6058
Diptera	1175	1635	1314	1176	1045	1297	1839	9481
Hemiptera	97	41	50	50	124	62	82	506
Hymenoptera	2882	1066	1093	1257	1725	1426	1774	11223
Lepidoptera	172	129	142	128	274	168	167	1180
Neuroptera	3	1	2	4	2	0	4	16
Orthoptera	2	1	3	1	1	1	1	10
Plecoptera	0	0	0	0	1	0	0	1
Raphidioptera	0	0	0	1	4	1	1	7
Thysanoptera	103	22	35	155	127	299	76	817
Trichoptera	5	2	0	0	2	0	3	12
Total	5486	3440	2975	3233	5095	4461	4688	29378

Appendix H. The number of bees of each genera (listed alphabetically) collected with bee cups and vane traps at each site. Numbers in parenthesis after site names indicate total number of bee genera documented for that site. Numbers in parentheses after bee genera indicate the abundance rank of that genus across all sites (1 being most abundant). Numbers in parentheses after each bee abundance indicate the abundance rank of that genus at that site (column). NA indicates that the genus was not collected at a site.

	Chokecherry	**Quaking Aspen**		**Sierra Madre**		**White Mountain**	
Genera	**Site (28)**	**Site (21)**	**Control (20)**	**Site (24)**	**Control (24)**	**Site (22)**	**Control (24)**
Agapostemon (6)	519 (4)	18 (7)	69 (6)	17 (9)	34 (10)	45 (6)	107 (4)
Andrena (9)	200 (7)	10 (11)	34 (9)	36 (7)	13 (14)	33 (11)	11 (17)
Anthidium (15)	11 (17)	4 (14)	10 (14)	2 (18)	2 (21)	42 (7)	10 (18)
Anthophora (7)	485 (5)	14 (9)	64 (7)	35 (8)	44 (6)	20 (13)	37 (7)
Apis (32)	NA	NA	NA	NA	NA	NA	2 (22)
Ashmeadiella (23)	6 (19)	NA	NA	NA	2 (22)	3 (19)	6 (19)
Bombus (2)	886 (1)	318 (1)	275 (2)	202 (2)	460 (2)	169 (3)	377 (2)
Ceratina (8)	17 (16)	12 (10)	5 (16)	12 (11)	298 (3)	40 (9)	23 (11)
Colletes (14)	2 (26)	6 (13)	31 (10)	6 (14)	7 (15)	22 (12)	37 (8)
Diadasia (12)	87 (10)	3 (15)	15 (12)	8 (13)	35 (8)	13 (14)	31 (10)
Dianthidium (19)	4 (22)	3 (16)	3 (17)	2 (19)	NA	7 (18)	15 (14)
Dioxys (29)	3 (23)	NA	NA	NA	1 (23)	NA	NA
Dufourea (26)	NA	NA	NA	NA	5 (16)	NA	2 (23)
Epeolus (27)	2 (27)	NA	NA	4 (17)	NA	NA	NA
Eucera (4)	718 (2)	39 (5)	76 (5)	117 (4)	34 (11)	42 (8)	14 (16)
Habropoda (24)	6 (20)	NA	NA	5 (15)	NA	NA	3 (20)
Halictus (10)	84 (11)	18 (8)	64 (8)	16 (10)	35 (9)	92 (5)	17 (13)
Hoplitis (11)	9 (18)	24 (6)	17 (11)	51 (6)	14 (13)	40 (10)	53 (6)
Hylaeus (30)	NA	NA	3 (18)	1 (24)	NA	NA	NA
Lasioglossum (1)	559 (3)	184 (3)	354 (1)	362 (1)	627 (1)	1120 (1)	737 (1)
Lithurge (22)	3 (24)	NA	NA	NA	4 (17)	1 (21)	15 (15)
Lithurgopsis (20)	29 (13)	NA	1 (20)	NA	NA	NA	NA
Megachile (13)	97 (9)	2 (18)	10 (15)	10 (12)	28 (12)	10 (16)	22 (12)
Melecta (17)	31 (12)	8 (12)	14 (13)	5 (16)	3 (18)	9 (17)	NA
Melissodes (5)	419 (6)	57 (4)	89 (4)	67 (5)	73 (5)	134 (4)	83 (5)
Melitta (18)	6 (21)	1 (20)	NA	2 (20)	40 (7)	1 (22)	1 (24)
Nomada (31)	NA	NA	NA	NA	NA	NA	3 (21)
Osmia (3)	172 (8)	287 (2)	220 (3)	135 (3)	259 (4)	502 (2)	286 (3)
Perdita (16)	23 (15)	2 (19)	NA	2 (21)	3 (19)	12 (15)	33 (9)
Sphecodes (25)	2 (28)	3 (17)	3 (19)	2 (22)	NA	2 (20)	NA
Sphecodogastra (28)	3 (25)	NA	NA	2 (23)	1 (24)	NA	NA
Tetraloniella (21)	25 (14)	NA	NA	NA	3 (20)	NA	NA
Triepeolus (33)	NA	1 (21)	NA	NA	NA	NA	NA

Appendix I. Common name, scientific name, and number of detections for bird species detected during point count surveys in southern Wyoming in 2013.

Common Name	Scientific Name	Number Detected
American Avocet	*Recurvirostra americana*	1
American Crow	*Corvus brachyrhynchos*	13
American Goldfinch	*Spinus tristis*	1
American Kestrel	*Falco sparverius*	3
American Robin	*Turdus migratorius*	36
Barn Swallow	*Hirundo rustica*	3
Black-billed Magpie	*Pica hudsonia*	16
Black-headed Grosbeak	*Pheucticus melanocephalus*	3
Brewer's Blackbird	*Euphagus cyanocephalus*	12
Brewer's Sparrow	*Spizella breweri*	528
Broad-tailed Hummingbird	*Selasphorus platycercus*	3
Brown-headed Cowbird	*Molothrus ater*	16
Canada Goose	*Branta canadensis*	1
Clark's Nutcracker	*Nucifraga columbiana*	1
Cliff Swallow	*Petrochelidon pyrrhonota*	9
Common Nighthawk	*Chordeiles minor*	14
Common Raven	*Corvus corax*	37
Dark-eyed Junco	*Junco hyemalis*	3
Dusky Flycatcher	*Empidonax oberholseri*	26
Golden Eagle	*Aquila chrysaetos*	1
Great Horned Owl	*Bubo virginianus*	1
Green-tailed Towhee	*Pipilo chlorurus*	223
Hairy Woodpecker	*Picoides villosus*	2
Hooded Warbler	*Setophaga citrina*	1
Horned Lark	*Eremophila alpestris*	390
House Wren	*Troglodytes aedon*	24
Killdeer	*Charadrius vociferus*	4
Lazuli Bunting	*Passerina amoena*	1
Least Flycatcher	*Empidonax minimus*	2
Loggerhead Shrike	*Lanius ludovicianus*	1
MacGillivray's Warbler	*Geothlypis tolmiei*	1
Mountain Bluebird	*Sialia currucoides*	15
Mourning Dove	*Zenaida macroura*	23
Northern Flicker	*Colaptes auratus*	20
Northern Harrier	*Circus cyaneus*	5
Orange-crowned Warbler	*Oreothlypis celata*	4
Prairie Falcon	*Falco mexicanus*	1

Common Name	Scientific Name	Number Detected
Red Crossbill	*Loxia curvirostra*	1
Red-breasted Nuthatch	*Sitta canadensis*	2
Red-naped Sapsucker	*Sphyrapicus nuchalis*	2
Red-tailed Hawk	*Buteo jamaicensis*	10
Red-winged Blackbird	*Agelaius phoeniceus*	8
Rock Wren	*Salpinctes obsoletus*	54
Sagebrush Sparrow	*Artemisiospiza nevadensis*	113
Sage Thrasher	*Oreoscoptes montanus*	189
Sandhill Crane	*Grus canadensis*	1
Savannah Sparrow	*Passerculus sandwichensis*	10
Say's Phoebe	*Sayornis saya*	4
Song Sparrow	*Melospiza melodia*	7
Sora	*Porzana carolina*	3
Swainson's Hawk	*Buteo swainsoni*	2
Tree Swallow	*Tachycineta bicolor*	5
Unknown Bird	NA	82
Unknown Blackbird	NA	1
Unknown Duck	NA	1
Unknown Flycatcher	NA	3
Unknown Sparrow	NA	63
Unknown Swallow	NA	3
Unknown Warbler	NA	2
Vesper Sparrow	*Pooecetes gramineus*	356
Violet-green Swallow	*Tachycineta thalassina*	8
Warbling Vireo	*Vireo gilvus*	19
Western Bluebird	*Sialia mexicana*	1
Western Meadowlark	*Sturnella neglecta*	60
White-crowned Sparrow	*Zonotrichia leucophrys*	3
Williamson's Sapsucker	*Sphyrapicus thyroideus*	1
Wilson's Snipe	*Gallinago delicata*	2
Yellow Warbler	*Setophaga petechia*	2
Yellow-rumped Warbler	*Setophaga coronata*	2
Total		**2465**

Appendix J. Common name, scientific name, and number of detections for bird species detected during point count surveys in southern Wyoming in 2014.

Common Name	Scientific Name	Number Detected
American Crow	*Corvus brachyrhynchos*	3
American Goldfinch	*Spinus tristis*	3
American Kestrel	*Falco sparverius*	1
American Robin	*Turdus migratorius*	20
Black-billed Magpie	*Pica hudsonia*	8
Black-headed Grosbeak	*Pheucticus melanocephalus*	3
Brewer's Blackbird	*Euphagus cyanocephalus*	18
Brewer's Sparrow	*Spizella breweri*	469
Broad-tailed Hummingbird	*Selasphorus platycercus*	2
Brown-headed Cowbird	*Molothrus ater*	24
Chipping Sparrow	*Spizella passerina*	1
Cliff Swallow	*Petrochelidon pyrrhonota*	1
Common Nighthawk	*Chordeiles minor*	3
Common Raven	*Corvus corax*	12
Dusky Flycatcher	*Empidonax oberholseri*	24
Ferruginous Hawk	*Buteo regalis*	1
Gray Flycatcher	*Empidonax wrightii*	12
Greater Sage-Grouse	*Centrocercus urophasianus*	7
Green-tailed Towhee	*Pipilo chlorurus*	193
Horned Lark	*Eremophila alpestris*	337
House Wren	*Troglodytes aedon*	10
Killdeer	*Charadrius vociferus*	4
Lark Bunting	*Passerina amoena*	5
Lazuli Bunting	*Passerina amoena*	1
Lincoln's Sparrow	*Melospiza lincolnii*	1
Loggerhead Shrike	*Lanius ludovicianus*	1
MacGillivray's Warbler	*Geothlypis tolmiei*	4
Mountain Bluebird	*Sialia currucoides*	15
Mourning Dove	*Zenaida macroura*	50
No Birds	NA	659
Northern Flicker	*Colaptes auratus*	10
Northern Harrier	*Circus cyaneus*	2
Orange-crowned Warbler	*Oreothlypis celata*	7
Prairie Falcon	*Falco mexicanus*	1
Red-tailed Hawk	*Buteo jamaicensis*	7
Red-winged Blackbird	*Agelaius phoeniceus*	5
Rock Wren	*Salpinctes obsoletus*	55

Common Name	Scientific Name	Number Detected
Sagebrush Sparrow	*Artemisiospiza nevadensis*	130
Sage Thrasher	*Oreoscoptes montanus*	205
Savannah Sparrow	*Passerculus sandwichensis*	1
Say's Phoebe	*Sayornis saya*	3
Song Sparrow	*Melospiza melodia*	3
Townsend's Solitaire	*Myadestes townsendi*	1
Tree Swallow	*Tachycineta bicolor*	4
Unknown Bird	NA	28
Unknown Blackbird	NA	3
Unknown Corvid	NA	1
Unknown Duck	NA	1
Unknown Empidonax	NA	1
Unknown Finch	NA	1
Unknown Sapsucker	NA	2
Unknown Sparrow	NA	27
Unknown Swallow	NA	2
Unknown Warbler	NA	3
Vesper Sparrow	*Pooecetes gramineus*	146
Violet-green Swallow	*Tachycineta thalassina*	3
Virginia Rail	*Rallus limicola*	1
Warbling Vireo	*Vireo gilvus*	21
Western Meadowlark	*Sturnella neglecta*	19
Western Tanager	*Piranga ludoviciana*	1
Western Wood-Pewee	*Contopus sordidulus*	3
White-crowned Sparrow	*Zonotrichia leucophrys*	4
Wilson's Snipe	*Gallinago delicata*	2
Yellow Warbler	*Setophaga petechia*	5
Total		**1941**