Summary Report: Pollinator groups in an alpine ecosystem, base of West Turkshead Peak, San Juan Mountains, southwestern Colorado

***Principal Investigator*:** Dr. Julie E. Korb
Fort Lewis College, Biology Department, 1000 Rim Drive, Durango Colorado 81301,
korb_j@fortlewis.edu, 970 382-6905
Lead Field Researcher: Esme Sienicki

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Note: Report only includes an Introduction, Methods, and Results due to limited funds for this project

Introduction: Regional stressors in combination with climate warming may alter the structure and function of plant communities in ways we cannot expect. For example, plants in cold environments may respond favorably to climate warming in the absence of regional stressors, but may not be able to tolerate the effect of multiple environmental changes. Throughout the Western U.S., we are finding evidence that long-lived plants, such as pinyon pine and aspen, can die when exposed to further stress in extreme climate years (Breshears et al. 2005, Worrall et al. 2008). Experiments provide a means to evaluate plant responses to climate change, plan for monitoring, and inform adaptive management. Thus, science-based decisions can be made to manage regional stressors, if they will increase the negative impacts of climate change on ecosystem resources.

In the Southern Rocky Mountains, desert dust deposition in winter, a consequence of land use in nearby arid regions (Neff et al. 2006), leads to rapid snowmelt (Painter et al. 2007). The effects of dust on snow have far reaching human implications related to water resources. For example, currently the Colorado River Basin provides water for more than 27 million people. Water use exceeds historical mean flows by 10%. It is expected that climate warming will reduce runoff in the Upper Colorado River Basin by 7-20% by 2050 (Painter et al. 2010). Early snowmelt due to desert dust also reduces runoff (Painter et al. 2010), but an improved understanding of plant responses to early snowmelt in high elevation watersheds is essential to determine the magnitude of the impact (Deems, personal communication). If earlier snowmelt triggers plants to grow earlier, then plants will use more water earlier in the year to support this growth. Alternatively, plants may delay growth if temperatures remain below freezing (Steltzer et al. 2009), which could minimize the reduction in runoff. Climate warming increases the likelihood that plant growth will not be delayed by cold temperatures, increasing the potential for lower water yields.

Similarly, plant responses to climate change can alter resources for pollinators. Specifically, early snowmelt and growing season warming can influence plant-pollinator interactions. A global pollination crisis along with a lack of baseline plant-pollinator data has created an urgent need for pollinator research. Specifically, Inouye and Barr (2006) noted that alpine bees are particularly susceptible to decline as their "island" habitat decreases due to warming temperatures. Kudo et al. (2008) showed that the relationship between spring ephemerals and bumble bees were most sensitive to early snowmelt due to mismatched phenology between trophic levels. Inouye et al. (2008) also saw probable evidence between the timing of bumble bee queen emergence from wintering underground and snowmelt date in western Colorado. Plant reproductive events at altered times due to climate change may result in a pollinator being unable to find pollen and nectar or failure in a flower to be pollinated (Inouye et al. 2008). Hegland et al. (2009) recommend one way to test plant-pollinator mismatches under a changing climate is to accelerate flowering time (e.g., growing season warming) to force plants to reach antithesis before their main pollinator is available to quantify how a mismatch impacts reproductive success and long-term population dynamics. Ultimately, changes in the timing of plant growth and other life history events may affect plant survival and plant composition in the alpine. It is not clear how climate change in the Southern Rockies, earlier snowmelt and warmer summer temperatures, will affect plant community composition because plants in high stress alpine communities tend to benefit from interactions with their neighbors (i.e. other species) (Calloway et al. 2002). Thus, if the abundance of one plant decreases, the abundance of other species may also decrease even though they are not directly impacted by climate change. In contrast, plants in more moderate stress environments often compete for resources with their neighbors, so that a decrease in the abundance of one species leads to an increase in the abundance of a competing species. These dynamic responses may be dependent on the balance of competitive versus facilitative plant interactions within communities. Early snowmelt increases the frost susceptibility of alpine plants making the environment more stressful and thus we would expect an increase of facilitative interactions among plants. However, warmer temperatures ameliorate cold stress to alpine plants and promote a longer growing season and

thus we would expect a more competitive plant community (Wipf et al. 2006). Brooker et al. (2008) illustrated in some cases the opposite is true where as abiotic stress increased competitive interactions also increased. This contradictory research implies that species specific responses are crucial to understand plant community species interactions under changing global conditions (Brooker et al. 2008). Our study aims to fill the current gap in plant community ecology research to address how plant communities will respond to multifactorial levels of stress in an alpine ecosystem afflicted by early snow melt and warming.

Life history traits play an important role in determining specific individual and community responses to climatic shifts (Zhang and Welker 1996). Plant species in the alpine can be broken down into two categories based on their distributional ranges: generalists and specialists. Alpine generalists have a wide distribution range from the montane to the alpine while alpine specialists have a narrow distribution range from the subalpine to the alpine (Galbreath et al. 2009). Alpine specialist's life history traits are specific to adapting to cold environments producing relatively few large flowers and seeds. In contrast alpine generalists often produce numerous small flowers and small seeds (Wilson & Martin 2011, Fried et al. 2010). Alpine specialists generally experience intra-specific competition implying their survival rates are density dependent, as density increases survival rates decrease, while alpine generalists are typically very competitive between species and thus experience inter-specific competition (Fried et al. 2010). Understanding the dynamics of generalists-specialists responses is an important indicator of climate change and can provide insight to long-term species response patterns without having multi-decadal long-term data sets. Long-term changes in plant communities could result in a positive feedback loop where an increase in plant biomass may result in taller plants that decrease snow albedo, or reflectivity, thus melting snow faster than just from dust on snow and warmer temperatures. This pattern has already been shown in Arctic systems where warmer temperatures have increased shrub growth and decreased snow pack cover through decreased snow albedo (Bret-Harte et al. 2008, Rixen et al. 2009). As a result, land and water managers in the western United States need to have a thorough understanding of how early snowmelt and warmer temperatures will affect plant community dynamics, specifically plant interactions (facilitation and competition), and how alterations to these interactions will impact plant species composition and structure and potentially snowpack duration and runoff timing.

Methods:

Study Site Selection: We chose the site for our climate change experiment from potential locations that met a set of predetermined criteria: elevation greater than 3,505 meters, slope less than thirty degrees, distance to a road less than two miles, no snowmobiles permitted, no grazing and low avalanche risk. In June, 2012 we realized we were in a sheep grazing allotment after sheep destroyed equipment and grazed our study site. The Forest Service provided us with outdated grazing allotment maps when we identifirf our study site location. The study site is located at 3,688 meters adjacent to West Grandturk on Molas Pass in the San Juan National Forest, southwestern Colorado (Figure 1). The region has an average daily temperature of 1.25°C with a maximum of 17°C in July and a minimum of -31°C in January. The area receives an average of 454 mm of precipitation a year with about 239 mm falling as snow

Experimental Design: We established ten 8 m x 12 m experimental plots at the study site on March 26, 2012 with five early snowmelt plots (hereafter referred to as advanced) and five control plots (hereafter referred to non-advanced) (Figure 2). We used black shade cloth to increase energy absorption by the snowpack, melting snow early similar to the effect of dust on snow (Steltzer et al. 2009) (Figure 2). We established plots 4 m apart at a similar slope position to decrease the effects of adjacent plots and upslope areas, respectively (Steltzer et al. 2009). We used a randomized block design

to control for spatial variation across the hillslope. All plots had ~1m of snow when the fabric was set out on the snow (anchors were used to keep the fabric in place).

Within each of the 10 experimental plots, we established four $1m^2$ subplots: two subplots with an open top warming chamber (OTC) and two subplots no OTC. Each OTC is a trapezoid fiberglass (Sun-Lite HP Fiberglass 2mm from Solar Components, Manchester, NH) unit based on the design used in the International Tundra Experiment (Walker et al. 2003) (Figure 3). Placement of the OTCs occurred when plots were 80% snow free, which we consider the day of year the plots are snowfree to minimize artifacts of the fabric on the plots once most of the plot is snowfree.

Abiotic Measurements: We used Thermochron I-button temperature data loggers (Embedded Data Systems, Lawerenceberg, KY) to quantify subnivean, soil, and air temperature in each $1m^2$ subplot. In each plot, we placed two subnivean snow temperature data loggers (one at the soil surface and one at 5 cm above the soil surface) from mid-March until snowmelt. These measurements along with regular field reconnaissance allowed us to determine the day the plots were snowfree (Wipf et al. 2006). Following snowmelt and subplot establishment, we established additional I-buttons within each 1 m^2 subplot to monitor temperature 5 cm above the soil surface, at the soil surface and at 2 cm soil depth. Loggers recorded data every 30 minutes throughout the entire growing season (snowmelt until ~mid-September). These data loggers along with information from the nearest weather station provided by CSAS allow us to quantify the number of potential frost events and growing-degree days since snowmelt. We measured soil moisture in each subplot using Hobo Micro Station Data Loggers (Onset Computer Corporation, Pocasset, MA). Soil moisture data was used to characterize average soil water (% pore filled space) and the timing and duration of dry periods when low soil water availability may adversely affect plant growth. Soil moisture along with air temperature plays a fundamental role in plant growth and development. Therefore, it is necessary to quantify how early snowmelt and a longer, warmer growing season influences soil moisture.

Phenological Observations: We quantified species composition in each of the experimental plots as soon as plants were visible to determine $1m^2$ plot locations. We recorded phenology for all species found in the $1m^2$ plots every three-four days throughout the growing season and classified each species as a generalist or specialist. Phenology was recorded as the date when a target individual entered a new vegetative or reproductive stage. Vegetative stages for species included first leaf emergence, first leaf fully expanded, first leaf color change, and entire plant color change (Steltzer et al. 2009). Reproductive stages included first flower open and first fruit fully developed.

Additional Data Collection on Pollinators: At each sampling period every three-four days throughout the growing season we recorded all pollinators, focusing specifically on bumblebees, and their abundance in one OTC and one non-OTC $1m^2$ plot for a 5 minute period. We identified all species to Order that were collected and some to the Species level. We attempted to collect all of species flying overhead and pollinating at the study site during our sampling timeframe. Some species we only saw on one occasion and we were unsuccessful in collecting a voucher specimen. We created a voucher collection from all individuals collected that is housed with the Fort Lewis College Entomology Collection, Durango, Colorado (Figure 4). Bumblebees (*Bombus* spp.), which are a major pollinating group in the alpine, were identified in the field by species through their distinctive abdominal and thoracic color patterns (Pleasants 1980). Individual bumblebees not identified in the field were collected with a net and placed in a kill jar for lab identification. When possible, we recorded the resource type bees were collecting (pollen, nectar or both). The presence or absence of a corbicular pollen load determined whether the bee was collecting pollen. Bumblebees probing flowers for nectar and a pollen load we considered to be collecting for both nectar and pollen (Pleasants 1980).

Data analysis: We used t-tests (SPSS 18.0) to quantify differences in pollinator groups between warming and no-warming treatments. We also conducted NMS analyses using PC-ORD software (version 6.10, McCune & Mefford 2006) a permutational multivariate analysis of variance (PERMANOVA)

(Anderson 2001; McArdle & Anderson 2001) to quantify pollinator community responses to warming treatments. PERMANOVA uses common ecological distance measures (Bray-Curtis for this study) to examine multivariate datasets and calculates P-values using permutations rather than tabled P-values that assume normality. We analyzed groups that were present in a minimum of 5% of the plots as recommended by McCune & Grace (2002). We used indicator-species analysis (McCune & Grace 2002), which uses species richness and associated abundance values of species, to identify species that were particularly faithful (i.e., consistent indicators) for a particular treatment.

Results:

Abiotic Measurements: There was no difference in the Julian day of plots being snowfree in advanced snowmelt versus control plots due to an unusually warm spring in 2012 (Figure 5). As a result, all further analyses only looked at differences between warming and non-warming treatments. Soil temperature did not vary significantly between non-warming and warming treatments for average day or night temperatures or maximum day or minimum night temperatures (Table 1). In contrast, mean day air temperature and maximum temperature were significantly higher in warming treatments in comparison to non-warming treatments with no significant differences between mean night air temperature and minimum night temperature in the two treatments (Table 2). Warmer day air temperatures influenced available soil moisture with warming treatments having significantly lower soil moisture (0.07m^3 water/m^3 soil) in comparison to non-warming treatments (Table 3).

Plant Phenology: There were significant differences in the Julian day of first flower emergence for the entire plant community between non-warming and warming treatments (Table 4; Figure 6). Phenological timing also resulted in significant differences in the percentage of generalists and specialists that developed seed between non-warming and warming treatments. Specifically, generalists had ~30% higher seed production in warming plots compared to specialists (Figure 7).

Pollinator Richness and Diversity: We collected and identified two new bubble bee species for San Juan County, Colorado: *Bombus nevadensis* (Figure 8) and *Bombus huntii* (Figure 9). Both species are found in adjacent counties and are not new records for Colorado. We also recorded and collected numerous solitary bees, sweat bees (Figure 10), beeflies (Figure 11), hoverflies (Figure 12), and nondescript flies. We were unable to collect and identify many of the solitary bees and therefore we grouped them for analyses. On average we encountered 2.9 different pollinator groups over a 50 minute time period in non-warming 1m^2 plots in comparison to 2.3 different pollinator groups over a 50 minute time period in warming Open Top Chambers (OTC) 1m^2 plots; there were no significant differences between the two treatments (Figure 13). In addition, there were no significant differences in Shannon Diversity Indices between non-warming (H=0.731) versus warming (H=0.583) plots for pollinator groups (Figure 13).

Pollinator Abundance: Solitary bees had the highest average abundance (6-8 visits) in 1m^2 plots followed by bumblebees (2-3 visits) and sweat bees (1-2 visits) for both non-warming and warming treatment plots over a 50 minute time period (Figure 14). Sweat bees were significantly higher in non-warming plots than warming plots; there were no significant differences for solitary bees or bumblebees (Figure 14). In contrast, bee flies (2-3 visits) and non-descript flies (1-2 visits) had higher abundance in 1m^2 warming plots than non-warming plots over a 50 minute time period with fly abundance being significantly higher in warming plots; there was no significant difference in bee fly abundance between treatments (Figure 14). Sweat bees were collecting pollen on average 90% of the time in contrast to bumblebees that were collecting both pollen and nectar 70% of the time. There was no significant difference between pollinators pollinating generalist or specialist plant species with most pollinators pollinating plants in the Asteraceae (Sunflower) Family.

On the 200 m^2 belt transect pollinator surveys over a 10 minute period, sweat bees had the highest average number of visits (10.5 visits) followed by solitary bees (7.1 visits), bee flies (3 visits),

bumblebees (1.9 visits) and non-descript flies (1.7 visits) (Figure 15). This pattern of pollinator abundance contrasts with pollinator abundance levels at the finer $1m^2$ plot scale, where solitary bees had the highest abundance. Other pollinator group abundances were similar at the two difference spatial scales (Figures 14 and 15).

Pollinator Community: Multivariate ordination analysis showed no significant differences in pollinator communities between non-warming and warming treatments with complete overlap of pollinator richness and abundance (Figure 16). Specifically, PERMANOVA analyses illustrated no significant differences in pollinator communities (F=0.96432, P=0.41) and there were no indicator species, species that are particularly faithful, for either treatment.

Future Studies: Further studies are needed to determine if pollinator responses to warming quantified in this study remains consistent over multiple years with different summer weather patterns. 2012 was an unusually warm and dry summer and having pollinator studies under normal summer weather patterns would enhance the findings from this study. In addition, adding in more pollinator sweeps on belt transects in different areas of the San Juan Mountains and at study sites with warming treatments would enhance the pollinator collection from this season and would allow us to gain a more thorough baseline of pollinators in the San Juan Mountains. While there were no significant differences in pollinator community responses to warming suggesting that pollinators might be resistant to a warming climate, we did notice a general trend of bee flies and non-descript flies having higher abundance in warming treatments in comparison to bumblebees, solitary bees and sweat bees in non-warming plots. It is important to quantify if this trend of flies in warming treatments is a true pattern that might forecast pollinator group abundance shifts in high alpine environments under warmer conditions. Generally speaking, specialist plant species in the alpine tend to be pollinated by bees where generalist species are often pollinated by flies or through wind dispersal of pollen. A shift in pollinator group abundance may result in shifts in plant species abundances as well as a decrease in alpine plant species richness and diversity resulting long-term in the homogenization of the alpine landscape with a decrease in plant specialist species and their associated pollinators. This study identified numerous research gaps that need further investigation.

Table 1: Mean and maximum day (700-1859 hours) and mean and minimum night (1900-659 hours) soil temperatures (°C) 2 cm below soil surface for non-warming and warming treatments. N=5. There were no significant differences (p≤0.05) between treatments for specific temperature measurements.

Treatment	**Max Day Soil Temp (°C)**	**Min Night Soil Temp (°C)**	**Mean Day Soil Temp (°C)**	**Mean Night Soil Temp (°C)**
Non-warming	14.00 a	1.75 a	9.37 a	8.49 a
Warming	19.88 a	1.75 a	9.84 a	9.28 a

Table 2: Mean and maximum day (700-1859 hours) and mean and minimum night (1900-659 hours) air temperatures (°C) 2 cm below soil surface for non-warming and warming treatments. N=5. Different letters indicated significance (p≤0.05) between treatments.

Treatment	**Max Day Air Temp (°C)**	**Min Night Air Temp (°C)**	**Mean Day Air Temp (°C)**	**Mean Night Air Temp (°C)**
Non-warming	19.0 a	-2 a	16.57 a	4.92 a
Warming	21.5 b	-1 a	17.99 b	5.69 a

Table 3: Average soil moisture for warming and non-warming treatments. N=5. Different letters indicated significance (p≤0.05) between treatments.

Treatment	**Soil Moisture (m^3 water/ m^3 soil)**
Non-warming	0.133075 a
Warming	0.072825 b

Table 4. PERMANOVA based on Bray–Curtis dissimilarities of untransformed first flower emergence for non-warming and warming treatments in the alpine tundra, San Juan Mountains, Colorado.

Source	***d.f.***	***SS***	***MS***	***F***	**p ***
Treatment	1	0.92145	0.92145	3.8514	0.006000
Residual	18	0.43065	0.23925		
Total	19	0.52280			

Table 5. PERMANOVA based on Bray–Curtis dissimilarities of untransformed pollinator species abundance data for non-warming and warming treatments in the alpine tundra, San Juan Mountains, Colorado.

Source	***d.f.***	***SS***	***MS***	***F***	**p ***
Treatment	1	0.23325	0.23325	0.96432	0.409800
Residual	28	6.7726	0.24188		

Total	29	7.0058

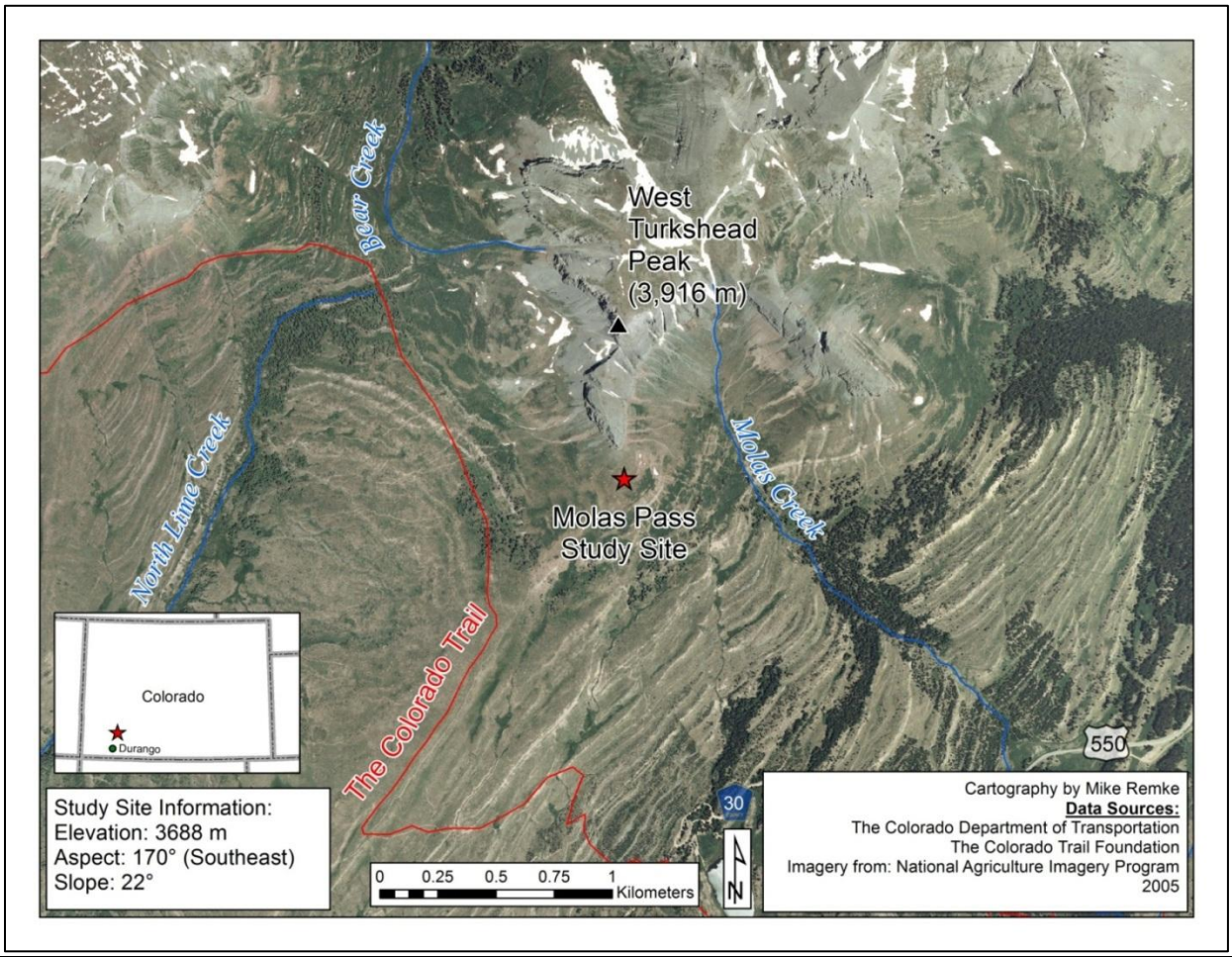

Figure 1. Map of study site location near Grand Turk, Molas Pass in the San Juan Mountains, southwestern Colorado on the San Juan National Forest.

Figure 2. Study site with black fabric to mimic the effect of dust on snowmelt (March, 2012). Three of the five early snowmelt plots can be seen.

Figure 3. Study site in peak flower in mid-July with Open Top Warming Chambers (OTC).

Figure 4. Voucher collection of pollinator specimens collected near West Turkshead Peak, Molas Pass in the San Juan Mountains, southwestern Colorado on the San Juan National Forest.

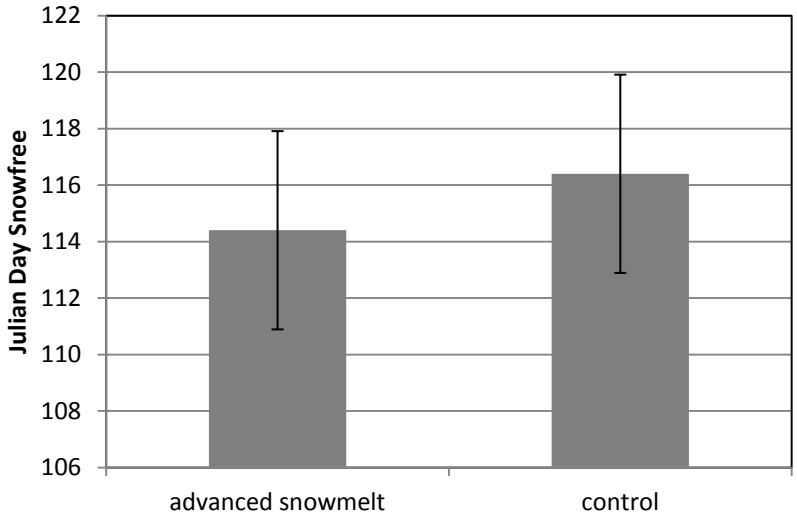

Figure 5. Julian day snowfree between advanced snowmelt plots and control no advanced snowmelt plots. There was no significant ($p \geq 0.05$) difference between treatments due to an abnormally warm spring. N=5.

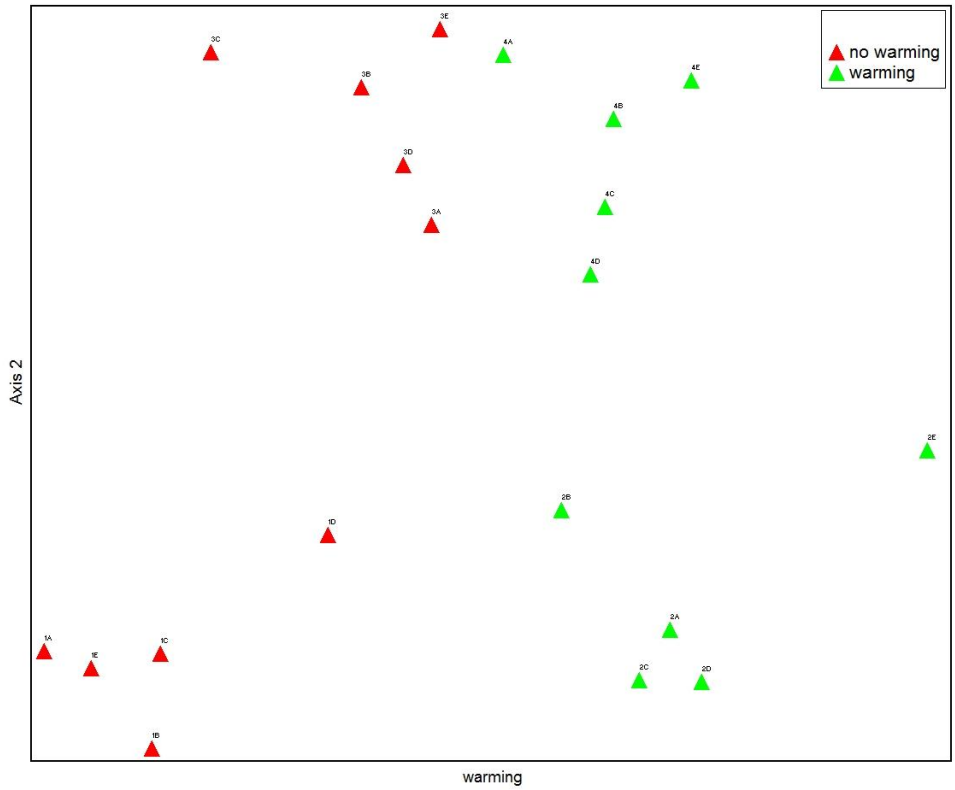

Figure 6. Non-metric multidimensional scaling ordination of untransformed first flower emergence community data for non-warming and warming treatments. Each symbol represents one treatment unit in the alpine tundra, San Juan Mountains, Colorado. N=10. The final solution had three dimensions. There is clear separation between non-warming and warming plots for first flower community emergence.

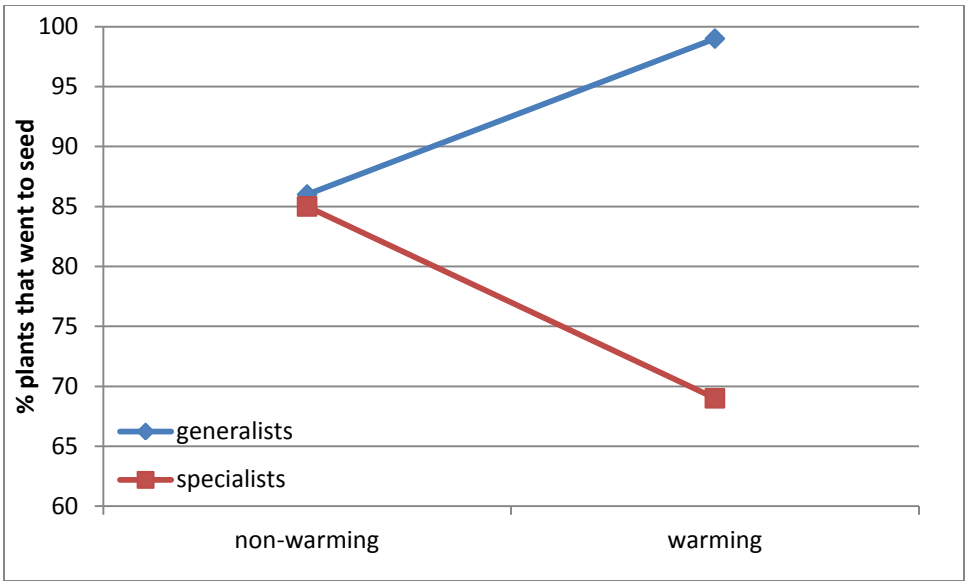

Figure 7. Percentage of generalists and specialists that went to seed in non-warming and warming $1m^2$ plots in the alpine tundra, San Juan Mountains, Colorado. N=10.

Figure 8. *Bombus nevadensis* Family Apidae. New species for San Juan County, Colorado. Present in adjacent La Plata, Archuleta and Montezuma Counties, Colorado.

Figure 9. *Bombus huntii* Family Apidae. New species for San Juan County, Colorado. Present in adjacent La Plata and Archuleta Counties, Colorado.

Figure 10. Sweat Bee, Family Halictidae. No records in San Juan County.

Figure 11. *Bombylius* major, Beefly, Family Bombyliidae. Mimics bees.

Figure 12. Hoverfly, Family Syrphidae. Mimics bees and wasps.

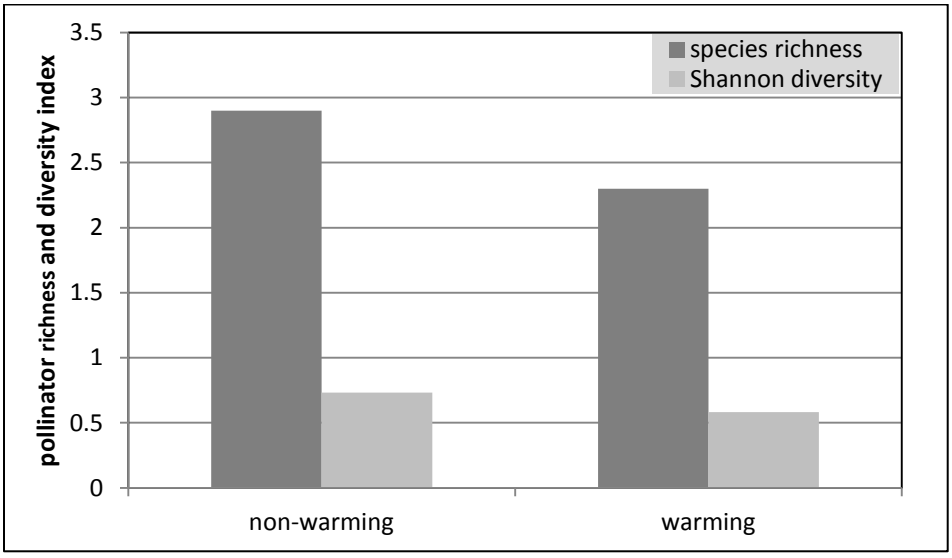

Figure 13. Pollinator species richness and Shannon Weiner Diversity for non-warming and warming $1m^2$ plots in the alpine tundra, San Juan Mountains, Colorado over a 50 minute period. N=10.

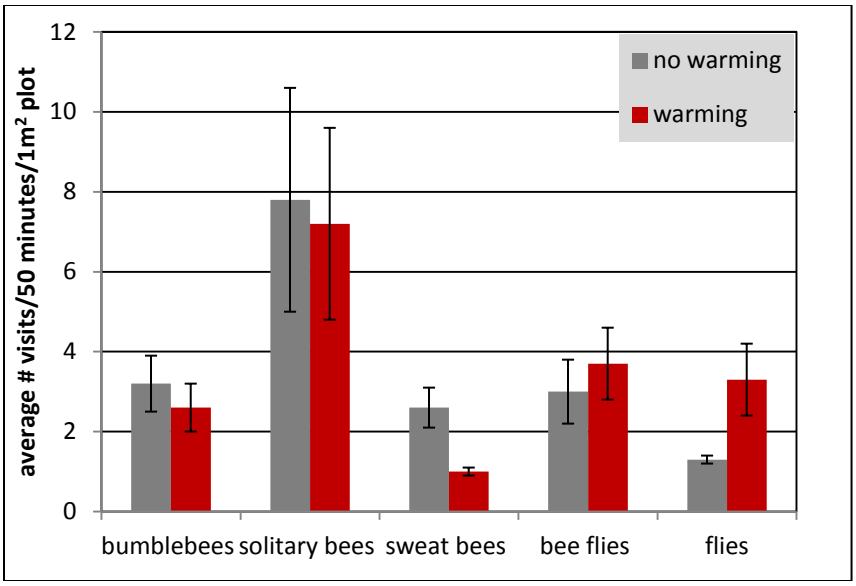

Figure 14. Pollinator average number visits/50 minutes for non-warming and warming $1m^2$ plots in the alpine tundra, San Juan Mountains, Colorado. N=18.

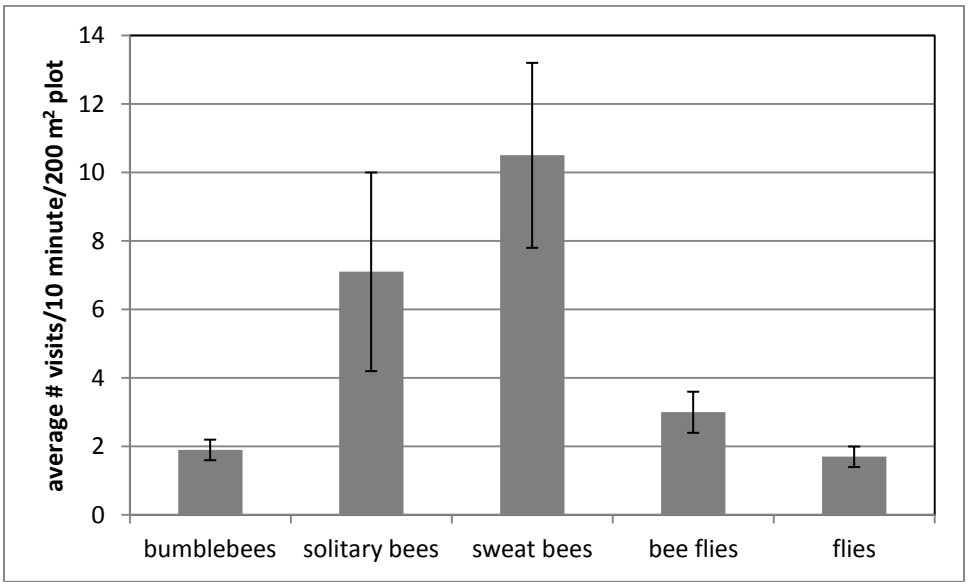

Figure 15. Pollinator average number visits/10 minute 100 m transect walk in the alpine tundra, San Juan Mountains, Colorado. N=12.

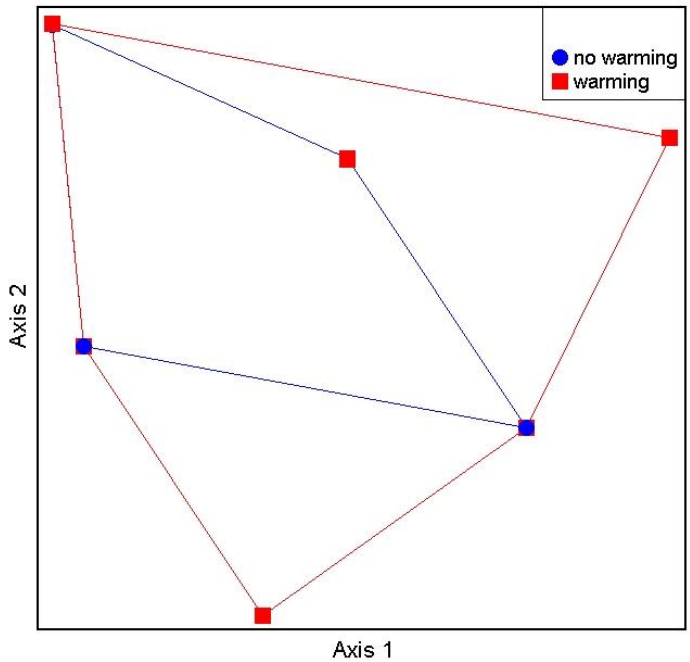

Figure 16. Non-metric multidimensional scaling ordination of untransformed pollinator species abundance data for non-warming and warming treatments. Each symbol represents one treatment unit in the alpine tundra, San Juan Mountains, Colorado. N=10. The final solution had two dimensions.

Appendix A. From: The Bees of Colorado (Hymenoptera: Apoidea: Anthophila), Virginia L. Scott, John S. Ascher Terry Griswold, and César R. Nufio, 2011. Natural History Inventory of Colorado, Number 23, University of Colorado Museum of Natural History, Boulder, Colorado. Bombini list with Colorado counties where species have been documented. The two new species not previously recorded for San Juan County are in bold in the text (*Bombus nevadensis* and *Bombus huntii*).

Bombini

Bombus (References: Byron 1980; Franklin 1913; Kearns and Thomson 2001; LaBerge and Webb 1962; Milliron 1971, 1973a, 1973b; Stephen 1957; Thorp et al. 1983; Williams 1998; Williams et al. 2008)

(Alpinobombus)

balteatus Dahlbom, 1832 – Boulder, Clear Creek, Gilpin, Grand, Gunnison, Hinsdale, Larimer, Mesa, Mineral, Park, Pitkin, San Miguel, and Summit Counties.

(**Bombias**)

(**nevadensis group**)

auricomus (Robertson, 1903) – Boulder, Larimer, and Yuma Counties. One additional record from El Paso County was located at the University of Minnesota Insect Collection (UMSP) and a Weld County record was located at the University of Wyoming Entomological Museum (ESUW) by C. Boyd (pers. comm.).

nevadensis Cresson, 1874 – Adams, Alamosa, Archuleta, Bent, Boulder, Chaffee, Conejos, Denver, Dolores, Douglas, El Paso, Elbert, Fremont, Garfield, Gilpin, Grand, Gunnison, Huerfano, Jefferson, La Plata, Larimer, Mesa, Moffat, Montrose, Park, Pueblo, Routt, Saguache, Teller, and Weld Counties.

(Bombus)

occidentalis Greene, 1858 – Boulder, Chaffee, Clear Creek, Conejos, Costilla, Delta, Denver, Dolores, Douglas, Eagle, El Paso, Fremont, Garfield, Gilpin, Grand, Gunnison, Hinsdale, Huerfano, Jackson, Jefferson, La Plata, Lake, Larimer, Mesa, Mineral, Moffat, Montezuma, 71 Montrose, Ouray, Park, Pitkin, Rio Grande, Routt, Saguache, San Miguel, Summit, and Teller Counties. Although this species used to be common in Colorado, it has become undetectable across much of its former range. It was documented in Boulder, Chaffee, Gunnison, Larimer, Mesa, Montrose, and Summit Counties in 2008 and/or 2009 (UCMC and BBSL specimens) and by a Diane Wilson photograph of a very yellow individual for Colorado, http://bugguide.net/node/view/358442 from Jefferson County on July 27, 2009. It continues to be seen on rare occasion including a recently collected worker UCMC specimen from Arvada on July 20, 2011 by D.M. Wilson.

(Cullumanobombus)

(griseocollis group)

griseocollis (DeGeer, 1773) – Adams, Baca, Bent, Boulder, Delta, Douglas, El Paso, Fremont, Jefferson, Larimer, Moffat, Morgan, Otero, Prowers, Pueblo, Saguache, Weld, and Yuma Counties.

morrisoni Cresson, 1878 – Adams, Alamosa, Archuleta, Baca, Bent, Boulder, Chaffee, Conejos, Costilla, Delta, Denver, Dolores, Douglas, El Paso, Fremont, Garfield, Huerfano, Jefferson, La Plata, Larimer, Las Animas, Lincoln, Mesa, Mineral, Moffat, Montezuma, Montrose, Morgan, Otero, Ouray, Prowers, Pueblo, Saguache, San Juan, Teller, and Weld Counties.

(robustus group)

fraternus (Smith, 1854) – Adams, Arapahoe, Baca, Bent, Boulder, Denver, Douglas, El Paso, Elbert, Fremont, Huerfano, Jefferson, Kit Carson, Larimer, Morgan, Otero, Prowers, Sedgwick, Teller, Weld, and Yuma Counties.

(rufocinctus group)
rufocinctus Cresson, 1863 – Archuleta, Boulder, Chaffee, Clear Creek, Conejos, Costilla, Custer, Delta, Denver, Dolores, Douglas, El Paso, Elbert, Fremont, Garfield, Gilpin, Grand, Gunnison, Huerfano, Jackson, Jefferson, La Plata, Lake, Larimer, Las Animas, Logan, Mesa, Mineral, Moffat, Montrose, Ouray, Park, Pitkin, Rio Blanco, Routt, Saguache, San Miguel, Summit, Teller, and Weld Counties.
(Psithyrus)
(bohemicus group)
suckleyi Greene, 1860 – Boulder, Chaffee, Clear Creek, Conejos, Eagle, Gilpin, Grand, Gunnison, Jackson, La Plata, Larimer, Mesa, Pitkin, Routt, and San Miguel Counties.
(citrinus group)
insularis (Smith, 1861) – Adams, Alamosa, Boulder, Chaffee, Conejos, Custer, El Paso, Elbert, Fremont, Garfield, Gilpin, Grand, Gunnison, Huerfano, Jackson, Jefferson, La Plata, Larimer, Mesa, Moffat, Montezuma, Montrose, Ouray, Park, Pitkin, Routt, San Juan, San Miguel, Summit, and Teller Counties.
(sylvestris group)
fernaldae (Franklin, 1911) – Archuleta, Boulder, Conejos, Gilpin, Grand, Gunnison, Jackson, Larimer, Montrose, Ouray, San Juan, San Miguel, and Teller Counties.
(**Pyrobombus**)
(**lapponicus group**)
bifarius Cresson, 1878 – Alamosa, Archuleta, Boulder, Chaffee, Clear Creek, Conejos, Costilla, Custer, Delta, Dolores, Douglas, Eagle, El Paso, Elbert, Fremont, Garfield, Gilpin, Grand, Gunnison, Hinsdale, Huerfano, Jackson, Jefferson, La Plata, Lake, Larimer, Las Animas, Logan, Mesa, Mineral, Moffat, Montezuma, Montrose, Ouray, Park, Pitkin, Rio Blanco, Rio Grande, Routt, Saguache, San Juan, San Miguel, Summit, and Teller Counties.
huntii Greene, 1860 – Adams, Alamosa, Archuleta, Boulder, Chaffee, Clear Creek, Conejos, Costilla, Delta, Denver, Dolores, Douglas, Eagle, El Paso, Elbert, Fremont, Garfield, Gilpin, Grand, Gunnison, Hinsdale, Huerfano, Jackson, Jefferson, La Plata, Larimer, Logan, Mesa, Mineral, Moffat, Montezuma, Montrose, Morgan, Otero, Ouray, Park, Pitkin, Pueblo, Rio Blanco, Rio Grande, Routt, Saguache, Teller, and Weld Counties plus the San Luis Valley.72
melanopygus Nylander, 1848 – Boulder, Clear Creek, Conejos, El Paso, Gilpin, Grand, Gunnison, Hinsdale, Huerfano, Jackson, Larimer, Mineral, Park, Pitkin, Summit, and Teller Counties.
sylvicola Kirby, 1837 – Boulder, Chaffee, Clear Creek, Conejos, Custer, Delta, Dolores, Eagle, El Paso, Garfield, Gilpin, Grand, Gunnison, Hinsdale, Huerfano, Jackson, Lake, Larimer, Mesa, Mineral, Montezuma, Park, Pitkin, Routt, Saguache, San Miguel, and Summit Counties.
(vagans group)
centralis Cresson, 1864 – Alamosa, Archuleta, Boulder, Chaffee, Clear Creek, Conejos, Costilla, Custer, Dolores, Douglas, El Paso, Elbert, Fremont, Garfield, Gilpin, Grand, Gunnison, Huerfano, Jackson, Jefferson, La Plata, Larimer, Las Animas, Mesa, Mineral, Montrose, Ouray, Park, Pitkin, Rio Blanco, Routt, Saguache, San Miguel, Summit, and Teller Counties.
flavifrons Cresson, 1863 – Alamosa, Boulder, Chaffee, Clear Creek, Conejos, Custer, Delta, Dolores, Douglas, El Paso, Elbert, Garfield, Gilpin, Grand, Gunnison, Huerfano, Jackson, La Plata, Lake, Larimer, Mesa, Mineral, Montezuma, Montrose, Ouray, Park, Pitkin, Routt, Saguache, San Juan, San Miguel, Summit, and Teller Counties.
(pratorum group)

frigidus Smith, 1854 – Boulder, Clear Creek, Eagle, Grand, Gunnison, Hinsdale, Jackson, Lake, Larimer, Park, Routt, Saguache, and Summit Counties.
mixtus Cresson, 1878 – Alamosa, Boulder, Chaffee, Clear Creek, Conejos, Eagle, Garfield, Gilpin, Grand, Gunnison, Jackson, Lake, La Plata, Larimer, Mesa, Mineral, Montrose, Ouray, Park, Pitkin, Routt, San Juan, and San Miguel Counties.
(Subterraneobombus)
appositus Cresson, 1878 – Alamosa, Archuleta, Boulder, Chaffee, Clear Creek, Conejos, Delta, Denver, Douglas, Eagle, El Paso, Elbert, Fremont, Garfield, Gilpin, Grand, Gunnison, Huerfano, Jackson, Jefferson, Larimer, Mesa, Montezuma, Montrose, Ouray, Park, Pitkin, Rio Blanco, Rio Grande, Routt, Saguache, San Miguel, and Teller Counties.
(Thoracobombus)
(pensylvanicus group)
californicus Smith, 1854 – Boulder, Chaffee, Dolores, Garfield, Gilpin, Grand, Gunnison, Jefferson, Larimer, Mesa, Moffat, Montrose, Ouray, Park, Routt, Summit, and Teller Counties.
fervidus (Fabricius, 1798) – Alamosa, Arapahoe, Boulder, Conejos, Delta, Denver, Dolores, Douglas, El Paso, Elbert, Fremont, Garfield, Gilpin, Huerfano, Jefferson, La Plata, Larimer, Las Animas, Lincoln, Mesa, Moffat, Montezuma, Montrose, Morgan, Otero, Ouray, Pueblo, Rio Blanco, Saguache, Teller, Weld, and Yuma Counties.
pensylvanicus (DeGeer, 1773) – Adams, Alamosa, Baca, Bent, Boulder, Crowley, Delta, Denver, Douglas, El Paso, Elbert, Fremont, Huerfano, Jefferson, Kiowa, Kit Carson, Larimer, Las Animas, Lincoln, Logan, Mesa, Moffat, Morgan, Otero, Phillips, Prowers, Pueblo, Sedgwick, Weld, and Yuma Counties.