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Taxonomic Paper

Bee species checklist of the San Francisco Peaks, Arizona

Lindsie M McCabe‡, Paige R Chesshire‡, David R Smith§, Atticus Wolf‡, Jason Gibbs|, Terry L Griswold¶, Karen W Wright#, Neil S Cobb‡

‡ Department of Biological Sciences, Northern Arizona University, Flagstaff, United States of America
§ U.S. Fish and Wildlife Service, Southwest Forest Science Complex, Flagstaff, United States of America
| Department of Entomology, University of Manitoba, Winnipeg, Canada
¶ USDA-ARS, Pollinating Insects Research Unit, Logan, United States of America
# Department of Entomology, Texas A&M, College Station, United States of America

Corresponding author: Lindsie M McCabe (lma243@nau.edu)

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Abstract

Background

Here we present a checklist of the bee species found on the C. Hart Merriam elevation gradient along the San Francisco Peaks in northern Arizona. Elevational gradients can serve as natural proxies for climate change, replacing time with space as they span multiple vegetation zones over a short geographic distance. Describing the distribution of bee species along this elevation gradient will help predict how bee communities might respond to changing climate. To address this, we initiated an inventory associated with ecological studies on pollinators that documented bees on the San Francisco Peaks. Sample sites spanned six life zones (vegetation zones) on the San Francisco Peaks from 2009 to 2019. We also include occurrence data from other studies, gathered by querying the Symbiota Collection of Arthropods Network (SCAN) portal covering the San Francisco Peaks region (hereafter referred to as “the Peaks”).

New information

Our checklist reports 359 bee species and morphospecies spanning five families and 46 genera that have been collected in the Peaks region. Prior to our concerted sampling effort there were records for 155 bee species, yet there has not been a complete list of bee species inhabiting the Peaks published to date. Over a 10-year period, we documented an additional 204 bee species inhabiting the Peaks. Our study documents range expansions to northern Arizona for 15 species. The majority of these are range expansions from either southern Arizona, southern Utah, or the Rocky Mountain region of Colorado. Nine species are new records for Arizona, four of which are the southernmost record for that species. An additional 15 species are likely undescribed.

Keywords

Northern Arizona, Southwestern, United States, Bee Diversity, Faunistics, Elevation Gradient, Anthophila

Introduction

The North American Southwest has one of the highest biodiversity of bee species worldwide (Michener 1979), with Arizona in particular harboring over 1,500 bees spanning six different families (SCAN 2019). This is largely due to the wide habitat diversity within such a short geographic distance, ranging from desert ecosystems to high-elevation mountain environments. The elevational gradients that characterize “Sky Islands” (i.e. isolated mountain tops) are key biodiversity hotspots in the Southwest (Bowers and McLaughlin 1996). Due to the isolated nature of sky islands, the biota of these unique geographic areas is acutely susceptible to climate change.

In northern Arizona, the San Francisco Peaks region (hereafter referred to as “the Peaks”) is one of the northern most sky islands and is characterized by the C. Hart Merriam elevational gradient, ranging from 785 to 3,850 meters (Merriam 1890). This range of life zones includes habitats of low-elevation desert ecosystems, high-elevation forest types, and environments above-tree-line. This variation is created by a steep gradient of temperature and precipitation. Elevational gradients are attractive for studies of global climate change by exchanging time for space and are useful in a comparative sense for understanding latitudinal patterns (Blois et al. 2013). Despite inherent constraints in using elevational gradients as proxies for latitudinal gradients or climate change, they remain a focus of research interests in understanding ecological patterns and processes and are a high priority for conservation.

There have been multiple checklists published within the last year summarizing the bee species found in various regions of North America, including areas in the southern and western US (Messinger and Griswold 2002, Carril et al. 2018, Parys et al. 2018, Stephenson et al. 2018, Delphia et al. 2019, Meiners et al. 2019). However, there are no

published checklists for northern Arizona. This is the first checklist published for the Peaks and is of special interest because it includes distributions of native bees along an elevational gradient with diverse habitats. More localized studies are necessary in order to obtain baseline knowledge on distributions and species richness of North American bee communities (Jamieson et al. 2019). If species trends and distributions are known regionally, we can better predict how native bee ranges and population statuses may be affected with changing climate.

Materials and methods

Study site and collection methods

Research was conducted on the San Francisco Peaks in northern Arizona (Fig. 1). A total of fifty-eight sites were established across six distinct life zones (Table 1). The Peaks is the northern most mountain habitat in Arizona, consisting of a range of habitats from desert to alpine environments. Our study area consisted of six vegetation zones classified by the dominant vegetation type: desert shrub, desert grassland, pinyon-juniper forest, ponderosa pine forest, mixed conifer forest (dominated by aspens), and spruce-fir forest. We conducted three complementary studies 1) cup sampling from 2009–2012, 2) cup sampling from 2013–2016 and 3) flower sampling from 2016–2018. We also did qualitative (non-standardized) sampling along the Peaks in 2019. We created a reference collection of all bee species collected during the study.

Table 1.

List of all 58 NAU sites including latitude, longitude, years sampled and life zone.

Lifezone	Site	Years Sampled	lat	lon
desert shrub	DS1	2009 - 2012	35.6927	-111.4260
desert grassland	DG1	2009 - 2012	35.5810	-111.6560
pinyon-juniper	PJ1	2016 - 2018	35.4641	-111.5915
pinyon-juniper	PJ2	2016 - 2018	35.4737	-111.5932
pinyon-juniper	PJ3	2016 - 2018	35.4762	-111.6031
pinyon-juniper	PJ4	2016 - 2018	35.4862	-111.5998
pinyon-juniper	PJ5	2016	35.4875	-111.6101
pinyon-juniper	PJ6	2016 - 2018	35.4947	-111.6178
pinyon-juniper	PJ7	2016	35.5138	-111.6237
pinyon-juniper	PJ8	2009 - 2012 & 2016-2018	35.3539	-111.7306
ponderosa pine	PP1A	2013 - 2015	35.3511	-111.7992
ponderosa pine	PP2A	2013 - 2015	35.3453	-111.8041

Lifezone	Site	Years Sampled	lat	lon
ponderosa pine	PP3A	2013 - 2015	35.3474	-111.8147
ponderosa pine	PP1	2015 - 2018	35.3857	-111.7367
ponderosa pine	PP2	2015 - 2018	35.4163	-111.6714
ponderosa pine	PP3	2015 - 2018	35.3876	-111.6874
ponderosa pine	PP4	2016 - 2018	35.4270	-111.6963
ponderosa pine	PP5	2009 - 2012 & 2016 - 2019	35.3539	-111.7306
ponderosa pine	PP6	2016 - 2018	35.3889	-111.7251
ponderosa pine	PP7	2016 - 2018	35.3979	-111.7233
ponderosa pine	PP8	2016 - 2018	35.3879	-111.6869
ponderosa pine	PP1F	2013 - 2015	35.3861	-111.7365
ponderosa pine	PP2F	2013 - 2015	35.3897	-111.7245
ponderosa pine	PP3F	2013 - 2015	35.3879	-111.6861
ponderosa pine	Ken1A	2015	35.4263	-111.8199
ponderosa pine	Ken1B	2015	35.4290	-111.8221
ponderosa pine	Ken1C	2015	35.4317	-111.8240
mixed conifer	MC1	2013 - 2019	35.3285	-111.7380
mixed conifer	MC2	2009 - 2018	35.3539	-111.7306
mixed conifer	MC3	2013 - 2018	35.3290	-111.7390
mixed conifer	MC4	2016 - 2018	35.3543	-111.7320
mixed conifer	MC5	2016 - 2019	35.3803	-111.6858
mixed conifer	MC6	2016 - 2018	35.3757	-111.7321
mixed conifer	MC7	2016	35.3790	-111.6942
mixed conifer	MC8	2016	35.3799	-111.6889
mixed conifer	MC1F	2013 - 2015	35.3751	-111.7331
mixed conifer	MC2F	2013 - 2015	35.3798	-111.6847
mixed conifer	MC3F	2013 - 2015	35.3795	-111.6937
mixed conifer	Ken2A	2015	35.4225	-111.8278
mixed conifer	Ken2B	2015	35.4252	-111.8313
mixed conifer	Ken2C	2015	35.4243	-111.8338
spruce-fir	SF1A	2013 - 2015	35.3403	-111.6475

Lifezone	Site	Years Sampled	lat	lon
spruce-fir	SF2A	2013 - 2015	35.3386	-111.6506
spruce-fir	SF3A	2013 - 2015	35.3392	-111.6509
spruce-fir	SF1	2015 - 2018	35.3585	-111.7080
spruce-fir	SF2	2015 - 2018	35.3387	-111.6511
spruce-fir	SF3	2015 - 2019	35.3322	-111.6561
spruce-fir	SF4	2016 - 2018	35.3602	-111.7189
spruce-fir	SF5	2016 - 2018	35.3589	-111.7181
spruce-fir	SF6	2016 - 2019	35.3568	-111.7173
spruce-fir	SF7	2016	35.3469	-111.7035
spruce-fir	SF8	2016	35.3463	-111.7066
spruce-fir	SF1F	2013 - 2015	35.3423	-111.6436
spruce-fir	SF2F	2013 - 2015	35.3405	-111.6490
spruce-fir	SF3F	2013 - 2015	35.3373	-111.6529
spruce-fir	Ken3A	2015	35.4149	-111.8361
spruce-fir	Ken3B	2015	35.4167	-111.8389
spruce-fir	Ken3C	2015	35.4194	-111.8396

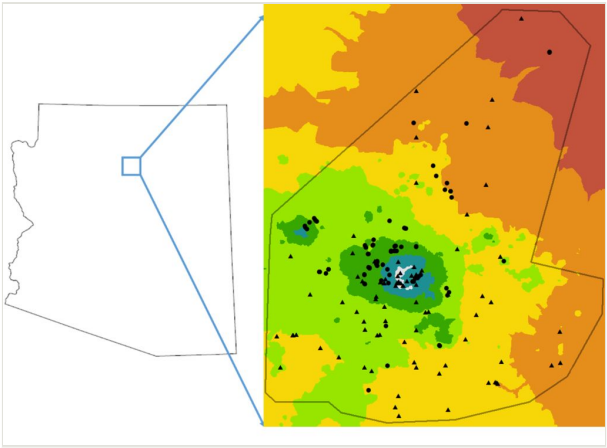

Figure 1. doi

Map of collection instances on the San Francisco Peaks with life zones coded by color (dark red = desert shrub, orange = desert grassland, yellow = pinyon-juniper, green = ponderosa pine, dark green = mixed conifer, blue = spruce-fir and white = alpine). Black dots indicate our 58 survey plots from 2009–2019. Black triangles represent any unique collection instance gathered through SCAN, GBIF & iDigBio.

Cup Sampling: 2009–2012 *(Sites: DS1, DG1, PJ8, PP5, MC2)*: Pollinators were sampled from 2009-2012 at five life zones ranging from desert shrub to mixed conifer, with one site established at each life zone. At each site we placed one pollinator cup array, which consisted of 30 pollinator cups (i.e. elevated pan traps). Each cup was filled with 50/50 water/propylene glycol about 2/3 of the way full. The pollinator cups were 12 oz. plastic stadium cups (10 white, 10 fluorescent yellow and 10 fluorescent blue). White, yellow and blue colors accounted for all of the major flora colors in this area (Campbell and Hanula 2007). The outside diameter of the cup opening was 8 cm, and the cups were 10.7 cm deep (McCabe et al. 2019b, Smith et al. 2014). Cups were suspended 30 cm above the ground in specially built holders made of polyvinyl chloride (PVC) pipes (Smith et al. 2014) to approximate the height of most flowering plants (Cane et al. 2000). Traps were placed in three rows of 10 (where each row was a single color), 10-m apart. Each cup within the row was placed 3-m apart. Traps were set once per month for 7 to 8 days. Cups did not become filled to the top with specimens throughout this time frame, so bees were consistently collected for the full 7 to 8 days. The two lower elevation sites, desert shrub and desert grassland, were sampled from April through October as freezing temperatures abated earlier at these sites than at higher elevations. Traps were set from May through October at the higher elevation sites (pinyon-juniper, ponderosa pine, and mixed conifer).

Cup Sampling: 2013–2014 *(Sites: PP1A-PP3A, PP1F-PP3F, MC1-MC3, MC1F-MC3F, SF1A-SF3A, SF1F-SF3F)*: Bees were sampled using pollinator cups at three life zones on the Peaks: ponderosa pine, mixed conifer and spruce-fir. We sampled at three unique sites at each life zone and set up pollinator arrays in two distinct locations per site: one array was placed in a meadow habitat and one was placed in a forest habitat. An array consisted of nine pollinator cups (three rows, each row with three cups of the same color). Details on our method of pollinator cup trapping is described above. Each year pollinator cups were set up during two seasons: dry pre-monsoon (June) and monsoon (August). During the monsoon season of 2013, 50% of the pre-monsoon cups were lost to animal damage at our Peaks sites at the spruce-fir elevation.

Cup Sampling: 2015 (*PP1-PP3, PP1A-PP3A, PP1F-PP3F, MC1-MC3, MC1F-MC3F, SF1-SF3, SF1A-SF3A, SF1F-SF3F)*: Cup sampling methods were identical to those used in 2013-2014, however we added an additional three sites at both ponderosa pine and spruce-fir (PP1-PP3, SF1-SF3). In addition, we established pollinator cup arrays on Kendrick Mountain, a neighboring mountain within the Peaks region, where we sampled at three life zones: ponderosa pine, mixed conifer, and spruce-fir, with three sites at each life zone *(KEN1A-KEN3A, KEN1B-KEN3B, KEN1C-KEN3C)*. Cup sampling methods and array design were identical to that used for the cup sampling on the Peaks. Each year, for both mountains, pollinator cups were set up during two seasons: dry pre-monsoon (June) and monsoon (August).

Cup Sampling: 2016 *(PJ1-PJ8, PP1-PP8, MC1-MC8, SF1-SF8)*: Cup sampling methods were identical to those used in 2013-2015, however there were differences in the sampling sites. Some sites were reused from previous years (PJ8, PP1-PP3, MC1-MC3, SF1-SF3). An additional five sites were established at each of the three higher life zones (PP4-PP8,

MC4-MC8, SF4-SF8), and seven new sites were established at the pinyon juniper ife zone (PJ1-PJ7). This led to a total of 32 sites, with eight sites per life zone.

Flower Sampling: 2016–2018 *(Sites: PJ1-PJ8, PP1-PP8, MC1-MC8, SF1-SF8)*: In 2016, transect plots were established at four life zones: pinyon-juniper, ponderosa pine, mixed conifer, and spruce-fir. Eight sites were established at each life zone that were at least 1 km apart, with each site containing three 60-meter × 1-meter transects. Five sites were re-used from previous sampling years (PJ8, PP5, MC1, MC2, and MC3). Using modified hand vacuums (Lance et al. 2017), insects were collected directly from flowers for 15 minutes at each transect. Sampling periods occurred every two weeks from June to August. In 2017 and 2018, the transects established at each site were expanded to 60-meter × 2-meter plots, and insects were collected from flowers for 30 minutes at each transect.

Flower Sampling: 2019: Qualitative sampling was done in 2019. Bees were collected off of flowering plants using sweep nets near the base of Mount Eldon (considered ponderosa pine life zone) as well as near Snowbowl Ski Resort (considered mixed conifer and spruce-fir life zones). A few additional specimens were collected at sites used in previous years (PP5, MC1, MC5, SF3, SF6). Latitude and longitude decimal points for all 2019 sampling locations are provided (Suppl. material 1).

A total of 6,324 cups and 128 flower sampling hours were used in this data set.

Species identification

All bees collected in samples were curated and initially identified in the Northern Arizona University (NAU) pollinator ecology lab. Bees were identified using DiscoverLife.org and published identification guides. Classification for species of *Andrena* and *Melissodes* followed LaBerge (1969), LaBerge (1986), LaBerge (1967)with modifications from Karen Wright's work, and all other species followed the classification of Michener (2000). Genus-level identifications were done using the Bee Genera IDnature guide from DiscoverLife.org (Ascher and Pickering 2011) and The Bee Genera of North and Central America (Michener et al. 1994). Species-level identification was done using published literature (Sandhouse 1924, Michener 1938, Michener 1939, Michener 1947, Hurd and Linsley 1951, Timberlake 1952, Stephen 1954, Timberlake 1954, Hurd and Michener 1955, Snelling 1966, LaBerge 1967, LaBerge 1969, Roberts 1972, Daly 1973, McGinley 1986, LaBerge 1986, Michener et al. 1994, Michener 2000, Sipes 2002, Rightmyer 2008, Gibbs 2010, Rightmyer et al. 2010, Sheffield et al. 2011, Koch 2012, De Silva and Packer 2012, Gonzalez and Griswold 2013, Robertson et al. 2014, Williams et al. 2014) and confirmed by Terry Griswold, Harold Ikerd (Andrenidae), Jason Gibbs (*Lasioglossum*) and Karen Wright (*Melissodes)*. Vouchers were deposited in the Colorado Plateau Museum of Arthropod Biodiversity, ARS Pollinating Insect Research Unit, Wallis Roughley Museum of Entomology, and Texas A&M University Insect Collection.

For those genera or subgenera where taxonomic information was lacking, we classified bees with similar morphological distinctions into morphospecies. Each morphospecies is classified by the genus (and subgenus if determined) followed by a unique three-digit

number. Male and female specimens of the same morphospecies were combined. Species that were morphologically different were treated as unique morphospecies. All morphospecies listed are all potentially undescribed taxa.

We established a reference collection of bee species that is currently stored in the Colorado Plateau Museum of Arthropod Biodiversity at NAU. All specimens were digitally cataloged in the Symbiota Collections of Arthropods Network (SCAN) online data portal. Identification of the 65 species that were not collected by the NAU lab and confirmed by NAU, the Logan Bee Lab, Jason Gibbs or Karen Wright need further consideration, especially in instances/localities where they have not been collected for 20+ years. These 65 taxa are noted with the year that they were last collected on the Peaks. Further, one-third of these taxa (20 species) were not assigned to a life zone due to a lack of precision in the latitude and longitude coordinates. These 20 species were removed from further analysis (Suppl. material 2). There were additional 68 species that had records with imprecise latitude and longitude removed, however we could still assign life zone designations to these 68 species because there were other sampling instances where the localities were accurate (Suppl. material 2).

Range

To determine species ranges, we used occurrence records from four main databases: SCAN, iDigBio (Integrated Digitized Biocollections), GBIF (Global Biodiversity Information Facility), and DiscoverLife. Species were deemed a new record for Arizona if there were not any previous records documented within the Arizona state boundaries on any of the four data portals mentioned above. We examined published literature to verify that these species were not previously recorded within the Arizona state boundary (Sandhouse 1924, Michener 1939, Sandhouse 1941, Timberlake 1969, LaBerge 1973, Roberts 1973, Krombein et al. 1979). Species were deemed a new record in northern Arizona if there were no records north of the Phoenix metropolitan area. We provide a KML map that defines our study area on the Peaks that is outlined in black (Fig. 1). We also provide a Darwin Core Archive (DwC) file of all records from our study area (Suppl. material 3).

Species were assigned "notes" if 1) they had not been recorded in our study range prior to our 10-year NAU study or 2) they were not collected in our 10-year NAU study but were collected in previous years from other sampling events (followed by the year that the species was last collected). Records obtained through SCAN, GBIF and iDigBio databases provided this information.

Andrenidae (n = 72)

***Andrena* (*Andrena*) *coconina* LaBerge, 1980**

Notes: Last collected on the Peaks in 1952

***Andrena* (*Andrena*) *frigida* Smith, 1853**

Notes: Last collected on the Peaks in 1986

***Andrena* (*Belandrena*) 001**

***Andrena* (*Callandrena sensu lato*) *helianthi* (Robertson, 1891)**

***Andrena* (*Callandrena sensu lato*) *pecosana* Cockerell, 1913**

***Andrena* (*Callandrena sensu lato*) *sonorensis* LaBerge, 1967**

Notes: Last collected on the Peaks in 1976

***Andrena* (*Callandrena*) *auripes* LaBerge, 1967**

***Andrena* (*Callandrena*) *micheneriana* LaBerge, 1978**

***Andrena* (*Callandrena*) *perpunctata* LaBerge, 1967**

***Andrena* (*Callandrena*) *simulata* Smith, 1879**

***Andrena* (*Callandrena*) *tegularis* LaBerge, 1967**

***Andrena* (*Cnemidandrena*) *apacheorum* Cockerell, 1897**

***Andrena* (*Cnemidandrena*) *costillensis* Cockerell, 1914**

***Andrena* (*Cnemidandrena*) *nubecula* Smith, 1853**

***Andrena* (*Diandrena*) 001 Fabricius, 1775**

***Andrena* (*Euandrena*) *algida* Smith, 1853**

Andrena (*Holandrena*) *cressonii* (Robertson, 1891)

Distribution: Our record is the first documentation of this species in northern Arizona. Species occurs in neighboring areas.

Andrena (*Holandrena*) *moquiorum* Viereck & Cockerell, 1914

Notes: Last collected on the Peaks in 1902

Andrena (*Melandrena*) *commoda* Smith, 1879

Andrena (*Melandrena*) *crinita* Bouseman & LaBerge, 1979

Andrena (*Melandrena*) *platyrhina* Cockerell, 1930

Andrena (*Plastandrena*) *argemonis* Cockerell, 1896

Andrena (*Plastandrena*) *crataegi* Robertson, 1893

Andrena (*Plastandrena*) *prunorum* Cockerell, 1896

Andrena (*Simandrena*) *angustitarsata* (Viereck, 1904)

Andrena (*Thysandrena*) *medionitens* Cockerell, 1902

Andrena (*Thysandrena*) *w-scripta* Viereck 1904

Andrena (*Trachandrena*) *amphibola* (Viereck, 1904)

Distribution: Our records are the first documentation of this species in Arizona and the southernmost extension of its range. Species occurs in neighboring areas.

Andrena (*Trachandrena*) *cyanophila* Cockerell, 1906

Andrena (*Trachandrena*) *mariae* (Robertson, 1891)

Distribution: Our record is the first documentation of this species in Arizona. Species occurs in neighboring areas.

Andrena (*Trachandrena*) *miranda* Smith, 1879

Andrena (*Trachandrena*) *striatifrons* (Cockerell, 1897)

***Andrena* (*Trachandrena*) 001 Robertson, 1902**

***Andrena* 001 Fabricius, 1775**

***Andrena* 003 Fabricius, 1775**

***Andrena* 004 Fabricius, 1775**

***Andrena* 005 Fabricius, 1775**

***Andrena* 006 Fabricius, 1775**

***Calliopsis* (*Calliopsima*) *chlorops* Cockerell, 1899**

***Calliopsis* (*Calliopsima*) *rozeni* Shinn, 1965**

Notes: Last collected on the Peaks in 1951

***Calliopsis* (*Calliopsis*) *teucrii* Cockerell, 1899**

Notes: Last collected on the Peaks in 1961

***Calliopsis* (*Hypomacrotera*) *callops* (Cockerell and Porter, 1899)**

***Calliopsis* (*Nomadopsis*) *puellae* (Cockerell, 1933)**

***Calliopsis* (*Nomadopsis*) *timberlakei* (Rozen, 1958)**

***Calliopsis* (*Nomadopsis*) *zebrata* (Cresson, 1878)**

***Calliopsis* 001 Smith, 1899**

***Macrotera* (*Macroteropsis*) *latior* (Cockerell, 1896)**

***Perdita* (*Epimacrotera*) *giliae* Timberlake, 1954**

Notes: Last collected on the Peaks in 1964

***Perdita* (*Perdita*) *gutierreziae* Cockerell, 1896**

Notes: Last collected on the Peaks in 1965

***Perdita* (*Perdita*) *sphaeralceae* Cockerell, 1896**

Notes: Last collected on the Peaks in 1967

***Perdita* (*Perdita*) *zebrata* Cresson, 1878**

Notes: Last collected on the Peaks in 1952

***Perdita* 001 Smith, 1853**

***Perdita* 002 Smith, 1853**

***Perdita* 003 Smith, 1853**

***Perdita* 004 Smith, 1853**

***Perdita* 005 Smith, 1853**

***Perdita* 006 Smith, 1853**

***Perdita* 007 Smith, 1853**

***Perdita* 008 Smith, 1853**

***Perdita* 009 Smith, 1853**

***Perdita* 010 Smith, 1853**

***Protandrena* (*Heterosarus*) *neomexicanus* Cockerell, 1906**

Notes: Last collected on the Peaks in 1958

***Protandrena* (*Heterosarus*) 001 Robertson, 1904**

***Protandrena* (*Heterosarus*) 002 Robertson, 1904**

***Protandrena* (*Heterosarus*) 003 Robertson, 1904**

***Protandrena* (*Heterosarus*) 004 Robertson, 1904**

***Protandrena* (*Heterosarus*) 005 Robertson, 1904**

***Protandrena* (*Pterosarus*) *albitarsis* (Cresson, 1872)**

Notes: Last collected on the Peaks in 1934

***Protandrena* (*Pterosarus*) *atricornis* (Cresson, 1878)**

Notes: Last collected on the Peaks in 1934

***Protandrena* (*Pterosarus*) *boylei* (Cockerell, 1896)**

Notes: Last collected on the Peaks in 1934

***Protandrena* (*Pterosarus*) *illustris* (Timberlake, 1967)**

Notes: Last collected on the Peaks in 1934

***Protandrena* (*Pterosarus*) *porterae* (Cockerell, 1900)**

Notes: Last collected on the Peaks in 1934

Apidae (n = 95)

***Anthophora* (*Anthophoroides*) *californica* (Cresson, 1869)**

***Anthophora* (*Anthophoroides*) *marginata* (Smith, 1854)**

Notes: Last collected on the Peaks in 1950

***Anthophora* (*Clisodon*) *terminalis* (Cresson, 1869)**

***Anthophora* (*Lophanthophora*) *affabilis* Cresson, 1878**

***Anthophora* (*Lophanthophora*) *coptognatha* Timberlake, 1951**

***Anthophora* (*Lophanthophora*) *porterae* Cockerell, 1900**

***Anthophora* (*Lophanthophora*) *ursina* Cresson, 1869**

***Anthophora* (*Micranthophora*) *exigua* Cresson, 1879**

***Anthophora* (*Micranthophora*) *mortuaria* Timberlake, 1937**

***Anthophora* (*Micranthophora*) *petrophila* Cockerell, 1905**

***Anthophora* (*Mystacanthophora*) *montana* (Cresson, 1869)**

***Anthophora* (*Mystacanthophora*) *urbana* (Cresson, 1878)**

***Anthophora* (*Pyganthophora*) *lesquerellae* (Cockerell, 1896)**

***Anthophora* (*Pyganthophora*) *vannigera* Timberlake, 1951**

***Apis* (*Apis*) *mellifera* Linnaeus, 1758**

***Bombus* (*Bombias*) *nevadensis* Cresson, 1874**

***Bombus* (*Bombus*) *occidentalis* Greene, 1858**

***Bombus* (*Cullumanobombus*) *morrisoni* Cresson, 1878**

***Bombus* (*Cullumanobombus*) *rufocinctus* (Cresson, 1863)**

***Bombus* (*Psithyrus*) *insularis* (Smith, 1861)**

***Bombus* (*Psithyrus*) *variabilis* (Cresson, 1872)**

Notes: Last collected on the Peaks in 1934

***Bombus* (*Pyrobombus*) *bifarius* Cresson, 1878**

***Bombus* (*Pyrobombus*) *centralis* Cresson, 1864**

***Bombus* (*Pyrobombus*) *flavifrons* Cresson, 1863**

***Bombus* (*Pyrobombus*) *huntii* Greene, 1860**

***Bombus* (*Pyrobombus*) *melanopygus* Nylander, 1848**

***Bombus* (*Pyrobombus*) *sylvicola* Kirby, 1837**

Distribution: Our record is the first documentation of this species in northern Arizona. Species occurs in neighboring areas.

***Bombus* (*Subterraneobombus*) *appositus* Cresson, 1878**

***Bombus* (*Thoracobombus*) *californicus* Smith 1854**

***Bombus* (*Thoracobombus*) *fervidus* (Fabricius, 1798)**

***Centris* (*Paracentris*) *rhodopus* Cockerell, 1897**

Notes: Last collected on the Peaks in 1936

***Ceratina* (*Ceratinula*) *arizonensis* Cockerell, 1898**

***Ceratina* (*Zadontomerus*) *apacheorum* Daly, 1973**

***Ceratina* (*Zadontomerus*) *nanula* Cockerell, 1897**

***Ceratina* (*Zadontomerus*) *neomexicana* Cockerell, 1901**

***Ceratina* (*Zadontomerus*) *pacifica* H.S. Smith, 1907**

***Ceratina* 001 Latreille, 1802**

***Diadasia* (*Coquillettapis*) *australis* (Cresson, 1878)**

***Diadasia* (*Coquillettapis*) *diminuta* (Cresson, 1878)**

***Diadasia* (*Coquillettapis*) *enavata* (Patton)**

***Diadasia* (*Coquillettapis*) *rinconis* Cockerell, 1897**

***Diadasia* (*Dasiapis*) *ochracea* (Cockerell, 1903)**

***Epeolus compactus* Cresson, 1878**

***Epeolus flavofasciatus* (Smith, 1879)**

Notes: Last collected on the Peaks in 1961

***Epeolus interruptus* Robertson, 1900**

Epeolus pusillus Cresson, 1864

Ericrocis lata (Cresson, 1878)

Notes: Last collected on the Peaks in 1936

Eucera (*Synhalonia*) *fulvitarsis* subsp. *annae* (Cresson, 1878)

Distribution: Our records are the first documentation of this species in Arizona. Species occurs in neighboring areas.

Eucera (*Synhalonia*) *lutziana* (Cockerell, 1933)

Distribution: Our records are the first documentation of this species in Arizona and the southernmost extension of its range. Species occurs in neighboring areas.

Eucera (*Synhalonia*) *primiveris* (Timberlake, 1969)

Eucera (*Synhalonia*) *speciosa* (Cresson, 1878)

Distribution: Our records are the first documentation of this species in Arizona and the southernmost extension of its range. Species occurs in neighboring areas.

Eucera (*Synhalonia*) *territella* (Cockerell, 1905)

Eucera (*Synhalonia*) 001 Patton

Eucera (*Tetraloniella*) *crenulaticornis* (Cockerell, 1898)

Eucera (*Tetraloniella*) *lippiae* (Cockerell, 1904)

Notes: Last collected on the Peaks in 1934

Eucera (*Tetraloniella*) *ochraea* (LaBerge, 2001)

Notes: Last collected on the Peaks in 1952

Eucera 001 Scopoli, 1770

Eucera 002 Scopoli, 1770

Eucera 003 Scopoli, 1770

***Exomalopsis* (*Stilbomalopsis*) *solani* Cockerell, 1896**

***Exomalopsis* (*Stilbomalopsis*) *solidaginis* Cockerell, 1898**

***Holcopasites stevensi* (Crawford, 1915)**

***Melecta* (*Melecta*) *bohartorum* Linsley, 1939**

***Melecta* (*Melecta*) *pacifica* (Cresson, 1878)**

***Melissodes* (*Callimelissodes*) *glenwoodensis* Cockerell, 1905**

***Melissodes* (*Eumelissodes*) *confusus* Cresson, 1878**

***Melissodes* (*Eumelissodes*) *druriellus* (Kirby, 1802)**

***Melissodes* (*Eumelissodes*) *fasciatellus* LaBerge, 1961**

***Melissodes* (*Eumelissodes*) *montanus* (Cresson, 1878)**

***Melissodes* (*Eumelissodes*) *pallidisignatus* Cockerell, 1905**

***Melissodes* (*Eumelissodes*) *perpolitus* LaBerge, 1961**

***Melissodes* (*Eumelissodes*) *saponellus* Cockerell, 1908**

Distribution: Our records are the first documentation of this species in northern Arizona. Species occurs in neighboring areas.

***Melissodes* (*Eumelissodes*) *semilupinus* Cockerell,1905**

***Melissodes* (*Eumelissodes*) *tristis* Cockerell, 1894**

***Melissodes* (*Eumelissodes*) *verbesinarum* Cockerell, 1905**

***Melissodes* (*Heliomelissodes*) *rivalis* Cresson, 1872**

***Melissodes* (*Melissodes*) *communis* Cresson, 1878**

***Melissodes* (*Melissodes*) *gilensis* Cockerell, 1896**

***Melissodes* (*Callimelissodes*) *coloradensis* Cresson, 1878**

Notes: Last collected on the Peaks in 1938

***Melissodes* (*Callimelissodes*) *compositus* Tucker, 1909**

Notes: Last collected on the Peaks in 1950

***Melissodes* (*Eumelissodes*) *agilis* Cresson, 1878**

Notes: Last collected on the Peaks in 1966

***Melissodes* (*Eumelissodes*) *bimatris* LaBerge, 1961**

Notes: Last collected on the Peaks in 2002

***Melissodes* (*Eumelissodes*) *coreopsis* Robertson, 1905**

Notes: Last collected on the Peaks in 1934

***Melissodes* (*Eumelissodes*) *grindeliae* Cockerell, 1898**

Notes: Last collected on the Peaks in 1964

***Melissodes* (*Eumelissodes*) *menuachus* Cresson, 1868**

Notes: Last collected on the Peaks in 1939

***Melissodes* (*Melissodes*) *paroselae* Cockerell,1905**

Notes: Last collected on the Peaks in 1936

***Nomada texana* (Cresson, 1872)**

Notes: Last collected on the Peaks in 1952

***Nomada utahensis* Moalif, 1988**

Notes: Last collected on the Peaks in 1951

***Nomada zebrata* Cresson, 1878**

Notes: Last collected on the Peaks in 1955

***Svastra* (*Epimelissodes*) *obliqua* (Say, 1837)**

***Triepeolus* 001 Robertson, 1901**

***Triepeolus* 003 Robertson, 1901**

***Triepeolus rhododontus* Cockerell, 1921**

***Xeromelecta* (*Melectomorpha*) *californica* (Cresson, 1878)**

***Xylocopa* (*Xylocopoides*) *californica* Cresson, 1864**

Colletidae (n = 21)

***Colletes bryanti* Timberlake, 1951**

***Colletes compactus* Cresson, 1868**

***Colletes eulophi* Robertson, 1891**

Notes: Last collected on the Peaks in 1952

***Colletes gilensis* Cockerell, 1897**

***Colletes kincaidii* Cockerell, 1898**

***Colletes paniscus* subsp. *paniscus* Viereck, 1903**

***Colletes scopiventer* Swenk, 1908**

***Colletes simulans* Cresson, 1868**

Notes: Last collected on the Peaks in 1939

***Colletes wickhami* Timberlake, 1943**

***Colletes wootoni* Cockerell, 1897**

Notes: Last collected on the Peaks in 1950

***Colletes* 001 Latreille, 1802**

***Colletes* 002 Latreille, 1802**

***Colletes* 003 Latreille, 1802**

***Colletes* 004 Latreille, 1802**

***Colletes* 005 Latreille, 1802**

***Hylaeus* (*Hylaeus*) *annulatus* (Linnaeus, 1758)**

***Hylaeus* (*Hylaeus*) *rudbeckiae* (Cockerell and Casad, 1895)**

***Hylaeus* (*Paraprosopis*) *cookii* (Metz, 1911)**

***Hylaeus* (*Paraprosopis*) *wootoni* (Cockerell, 1896)**

***Hylaeus* (*Prosopis*) *episcopalis* subsp. *episcopalis* (Cockerell, 1896)**

***Hylaeus* (*Prosopis*) *insolitus* Snelling, 1966**

Notes: Last collected on the Peaks in 1950

Halictidae (n = 45)

***Agapostemon* (*Agapostemon*) *angelicus* Cockerell, 1924**

***Agapostemon* (*Agapostemon*) *melliventris* (Cresson, 1874)**

***Agapostemon* (*Agapostemon*) *texanus* Cresson, 1872**

***Dieunomia* (*Dieunomia*) *apacha* Cresson, 1868**

***Dieunomia* (*Epinomia*) *micheneri* (Cross, 1958)**

***Dieunomia* (*Epinomia*) *nevadensis* (Cresson, 1874)**

***Halictus* (*Nealictus*) *farinosus* (Smith, 1853)**

***Halictus* (*Odontalictus*) *ligatus* (Say, 1837)**

***Halictus* (*Seladonia*) *confusus* (Smith, 1853)**

Distribution: Our record is the first documentation of this species in Arizona. Species occurs in neighboring areas.

***Halictus* (*Seladonia*) *tripartitus* (Cockerell, 1895)**

Lasioglossum* (*Dialictus*) aff. *comulum

***Lasioglossum* (*Dialictus*) *hudsoniellum* (Cockerell, 1919)**

***Lasioglossum* (*Dialictus*) *hyalinum* (Crawford, 1907)**

***Lasioglossum* (*Dialictus*) *microlepoides* (Ellis, 1914)**

***Lasioglossum* (*Dialictus*) *obnubilum* (Sandhouse, 1924)**

***Lasioglossum* (*Dialictus*) *occidentale* (Crawford, 1902)**

***Lasioglossum* (*Dialictus*) *pallidellum* (Ellis, 1914)**

Lasioglossum* (*Dialictus*) cf. *perdifficile

Lasioglossum* (*Dialictus*) aff. *perparvum

***Lasioglossum* (*Dialictus*) *ruidosense* species-group**

***Lasioglossum* (*Dialictus*) *semicaeruleum* (Cockerell, 1895)**

***Lasioglossum* (*Dialictus*) new *tegulare* species-group**

Lasioglossum* (*Dialictus*) cf. *viridatulum

***Lasioglossum* (*Dialictus*) 001**

***Lasioglossum* (*Dialictus*) 002**

***Lasioglossum* (*Dialictus*) 003**

***Lasioglossum* (*Dialictus*) 004**

***Lasioglossum* (*Dialictus*) 005**

***Lasioglossum* (*Dialictus*) 006**

***Lasioglossum* (*Dialictus*) 007**

***Lasioglossum* 008 Curtis, 1833**

***Lasioglossum* (*Hemihalictus*) *ruficorne* (Crawford, 1907)**

***Lasioglossum* (*Lasioglossum*) *desertum* (Smith, 1879)**

***Lasioglossum* (*Lasioglossum*) *egregium* (Vachal, 1904)**

***Lasioglossum* (*Lasioglossum*) *sisymbrii* (Cockerell, 1895)**

***Lasioglossum* (*Lasioglossum*) *trizonatum* (Cresson, 1874)**

***Lasioglossum* (*Sphecodogastra*) *boreale* (Svensson, Ebmer and Sakagami, 1977)**

***Nomia* (*Acunomia*) *foxii* Dalla Torre, 1896**

Notes: Last collected on the Peaks in 1952

***Nomia* (*Acunomia*) *tetrazonata* Cockerell, 1910**

Notes: Last collected on the Peaks in 1936

***Protodufourea eickworti* Bohart and Griswold, 1997**

***Sphecodes pecosensis* (Cockerell, 1904)**

***Sphecodes* 001 Latreille, 1804**

***Sphecodes* 002 Latreille, 1804**

***Sphecodes* 003 Latreille, 1804**

***Sphecodes* 004 Latreille, 1804**

Megachilidae (n = 126)

***Anthidiellum* (*Loyolanthidium*) *notatum* Latreille, 1809**

Notes: Last collected on the Peaks in 1986

***Anthidium* (*Anthidium*) *atripes* Cresson, 1879**

***Anthidium* (*Anthidium*) *clypeodentatum* Swenk, 1914**

***Anthidium* (*Anthidium*) *cockerelli* Schwarz, 1928**

***Anthidium* (*Anthidium*) *dammersi* Cockerell, 1937**

***Anthidium* (*Anthidium*) *duomarginatum* Gonzalez and Griswold, 2013**

***Anthidium* (*Anthidium*) *emarginatum* (Say, 1824)**

***Anthidium* (*Anthidium*) *illustre* (Cresson, 1879)**

***Anthidium* (*Anthidium*) *maculifrons* Smith, 1854**

***Anthidium* (*Anthidium*) *maculosum* Cresson, 1878**

***Anthidium* (*Anthidium*) *mormonum* Cresson, 1878**

***Anthidium* (*Anthidium*) *palmarum* Cockerell, 1904**

***Anthidium* (*Anthidium*) *porterae* Cockerell, 1900**

***Anthidium* (*Anthidium*) *schwarzi* Gonzalez and Griswold, 2013**

***Ashmeadiella* (*Arogochila*) *timberlakei* Michener, 1936**

Distribution: Our records are the first documentation of this species in Arizona. Species occurs in neighboring areas.

***Ashmeadiella* (*Ashmeadiella*) *aridula* Cockerell, 1910**

***Ashmeadiella* (*Ashmeadiella*) *bucconis* (Say, 1837)**

***Ashmeadiella* (*Ashmeadiella*) *cactorum* subsp. *basalis* (Cockerell, 1897)**

***Ashmeadiella* (*Ashmeadiella*) *californica* (Ashmead, 1897)**

***Ashmeadiella* (*Ashmeadiella*) *gillettei* Titus, 1904**

***Ashmeadiella* (*Ashmeadiella*) *meliloti* (Cockerell, 1897)**

***Ashmeadiella* (*Ashmeadiella*) *opuntiae* (Cockerell, 1897)**

***Ashmeadiella* (*Ashmeadiella*) *sonora* Michener, 1939**

***Ashmeadiella* (*Ashmeadiella*) *vandykiella* Michener, 1949**

Distribution: Our record is the first documentation of this species in northern Arizona. Species occurs in neighboring areas.

***Ashmeadiella* 002 Michener, 1939**

***Atoposmia* (*Eremosmia*) *enceliae* (Cockerell, 1935)**

***Coelioxys* (*Boreocoelioxys*) *moestus* Cresson, 1864**

***Coelioxys* (*Boreocoelioxys*) *octodentatus* Say, 1824**

Notes: Last collected on the Peaks in 1950

***Coelioxys* (*Boreocoelioxys*) *porterae* Cockerell, 1900**

Notes: Last collected on the Peaks in 1971

***Coelioxys* (*Boreocoelioxys*) *rufitarsis* Smith, 1854**

***Coelioxys* (*Coelioxys*) *sodalis* Cresson, 1878**

Notes: Last collected on the Peaks in 1971

***Coelioxys* (*Cyrtocoelioxys*) *gilensis* Cockerell, 1898**

***Coelioxys* (*Synocoelioxys*) *apacheorum* Cockerell, 1900**

Notes: Last collected on the Peaks in 1961

***Coelioxys* (*Synocoelioxys*) *erysimi* Cockerell, 1912**

Notes: Last collected on the Peaks in 1971

***Coelioxys* 001 Latrielle, 1809**

***Coelioxys* 002 Latrielle, 1809**

***Coelioxys* 003 Latrielle, 1809**

***Dianthidium* (*Adanthidium*) *arizonicum* (Rohwer, 1916)**

Notes: Last collected on the Peaks in 1967

***Dianthidium* (*Adanthidium*) *texanum* (Cresson, 1878)**

***Dianthidium* (*Dianthidium*) *concinnum* (Cresson, 1872)**

***Dianthidium* (*Dianthidium*) *cressonii* (Dalla Torre, 1896)**

***Dianthidium* (*Dianthidium*) *curvatum* (Smith, 1854)**

***Dianthidium* (*Dianthidium*) *desertorum* Timberlake, 1943**

***Dianthidium* (*Dianthidium*) *heterulkei* subsp. *fraternum* Schwarz, 1940**

***Dianthidium* (*Dianthidium*) *parvum* subsp. *parvum* (Cresson, 1878)**

***Dianthidium* (*Dianthidium*) *platyurum* Cockerell, 1923**

***Dianthidium* (*Dianthidium*) *pudicum* (Cresson, 1879)**

***Dianthidium* (*Dianthidium*) *singulare* (Cresson, 1879)**

***Dianthidium* (*Dianthidium*) *subparvum* Swenk, 1914**

***Dianthidium* (*Dianthidium*) *ulkei* (Cresson, 1878)**

***Heriades* (*Neotrypetes*) *cressoni* Michener, 1938**

***Heriades* (*Neotrypetes*) *gracilior* Cockerell, 1897**

***Heriades* (*Neotrypetes*) *micropthalma* Michener, 1954**

Notes: Last collected on the Peaks in 1934

***Heriades* (*Neotrypetes*) *texana* Michener, 1938**

Notes: Last collected on the Peaks in 1947

***Heriades* (*Neotrypetes*) *timberlakei* Michener, 1938**

***Heriades* 002 Spinola, 1808**

***Hoplitis* (*Alcidamea*) *grinnelli* (Cockerell, 1910)**

Notes: Last collected on the Peaks in 1986

***Hoplitis* (*Alcidamea*) *paroselae* Michener, 1947**

***Hoplitis* (*Alcidamea*) *truncata* subsp. *mescalerium* (Cresson, 1878)**

Notes: Last collected on the Peaks in 1961

***Hoplitis* (*Proteriades*) *zuni* (Parker, 1977)**

Distribution: Our records are the first documentation of this species in northern Arizona. Species occurs in neighboring areas.

***Hoplitis* 001 Klug, 1916**

***Lithurgopsis apicalis* (Cresson, 1875)**

***Lithurgopsis planifrons* (Friese, 1908)**

***Megachile* (*Argyropile*) *sabinensis* Mitchell, 1934**

***Megachile* (*Chelostomoides*) *angelarum* (Cockerell, 1902)**

***Megachile* (*Chelostomoides*) *chilopsidis* (Cockerell, 1900)**

***Megachile* (*Chelostomoides*) *lobatifrons* (Cockerell, 1924)**

***Megachile* (*Chelostomoides*) *subexilis* (Cockerell, 1908)**

***Megachile* (*Litomegachile*) *brevis* Say, 1837**

Notes: Last collected on the Peaks in 1967

***Megachile* (*Litomegachile*) *lippiae* Cockerell, 1900**

***Megachile* (*Litomegachile*) *onobrychidis* Cockerell, 1908**

***Megachile* (*Litomegachile*) *snowi* Mitchell, 1927**

Notes: Last collected on the Peaks in 1950

***Megachile* (*Litomegachile*) *texana* Cresson, 1878**

Notes: Last collected on the Peaks in 1950

***Megachile* (*Megachile*) *lapponica* Thomson 1872**

Distribution: Our records are the first documentation of this species in Arizona and the southernmost extension of its range. Species occurs in neighboring areas.

***Megachile* (*Megachile*) *montivaga* (Cresson, 1878)**

***Megachile* (*Megachile*) *relativa* Cresson, 1878**

***Megachile* (*Megachiloides*) *manifesta* Cresson, 1878**

Notes: Last collected on the Peaks in 1951

***Megachile* (*Megachiloides*) *mucorosa* Cockerell, 1908**

***Megachile* (*Megachiloides*) *sublaurita* Mitchell, 1927**

***Megachile* (*Phaenosarus*) *agustini* Cockerell, 1905**

***Megachile* (*Phaenosarus*) *fortis* Cresson, 1872**

***Megachile* (*Pseudocentron*) *sidalceae* Cockerell, 1897**

***Megachile* (*Sayapis*) *fidelis* Cresson, 1878**

***Megachile* (*Sayapis*) *inimica* subsp. *sayi* Cresson, 1872**

***Megachile* (*Sayapis*) *mellitarsis* Cresson, 1878**

***Megachile* (*Sayapis*) *policaris* Say, 1831**

***Megachile* (*Sayapis*) *pugnata* subsp. *pomonae* Say, 1837**

***Megachile* (*Xanthosarus*) *comata* Cresson, 1872**

***Megachile* (*Xanthosarus*) *frigida* Smith, 1853**

***Megachile* (*Xanthosarus*) *latimanus* (Say, 1823)**

Distribution: Our records are the first documentation of this species in northern Arizona. Species occurs in neighboring areas.

***Megachile* (*Xanthosarus*) *melanophaea* Smith, 1853**

***Megachile* (*Xanthosarus*) *mucida* Cresson, 1878**

***Megachile* (*Xanthosarus*) *perihirta* Cockerell, 1898**

Notes: Last collected on the Peaks in 1990

***Megachile* 001 Latreille**

***Megachile* 002 Latreille**

***Osmia* (*Cephalosmia*) *montana* Cresson, 1864**

***Osmia* (*Cephalosmia*) *subaustralis* Cockerell, 1900**

***Osmia* (*Helicosmia*) *coloradensis* Cresson, 1878**

***Osmia* (*Cephalosmia*) 001 Sladen, 1916**

***Osmia* (*Cephalosmia*) 002 Sladen, 1916**

***Osmia* (*Helicosmia*) *texana* Cresson, 1872**

***Osmia* (*Melanosmia*) *albolateralis* Cockerell, 1906**

Notes: Last collected on the Peaks in 1971

***Osmia* (*Melanosmia*) *brevis* Cresson, 1864**

***Osmia* (*Melanosmia*) *bucephala* (Cresson, 1864)**

Distribution: Our records are the first documentation of this species in Arizona. Species occurs in neighboring areas.

***Osmia* (*Melanosmia*) *densa* Cresson, 1864**

Notes: Last collected on the Peaks in 1971

***Osmia* (*Melanosmia*) *juxta* Cresson, 1864**

***Osmia* (*Melanosmia*) *liogastra* Cockerell, 1933**

***Osmia* (*Melanosmia*) *pentstemonis* Cockerell, 1906**

Notes: Last collected on the Peaks in 1950

Osmia* (*Melanosmia*) aff. *pentstemonis

***Osmia* (*Melanosmia*) *simillima* (Smith, 1853)**

***Osmia* (*Melanosmia*) *unca* Michener, 1937**

Notes: Last collected on the Peaks in 1964

***Osmia* (*Melanosmia*) 001 Schmiedeknecht, 1885**

***Osmia* (*Melanosmia*) 002 Schmiedeknecht, 1885**

***Osmia* (*Osmia*) *lignaria* (Say, 1837)**

Notes: Last collected on the Peaks in 1971

***Osmia* 002 Panzer, 1806**

***Osmia* 003 Panzer, 1806**

***Osmia* 005 Panzer, 1806**

***Osmia* 006 Panzer, 1806**

***Osmia* 007 Panzer, 1806**

***Osmia* 009 Panzer, 1806**

***Osmia* 010 Panzer, 1806**

***Osmia* 011 Panzer, 1806**

***Osmia* 012 Panzer, 1806**

***Paranthidium* (*Paranthidium*) *jugatorium* (Say, 1824)**

***Stelis* (*Dolichostelis*) *rudbeckiarum* (Cockerell, 1904)**

***Stelis* (*Stelis*) *elegans* (Cresson, 1864)**

Discussion

Prior to the start of our study, past collection events had documented 155 bees on the Peaks between 1908 and 2009. Records that were not identified to species, outside of our collection, were not considered in our checklist. Two collection events in particular significantly advanced the known number of bee species on the San Francisco Peaks (Fig. 2). In 1934, the American Museum of Natural History (Collector E. L. Bell) added 38 new bee species records to the Peaks and in 1950-1952, the University of Kansas (multiple collectors) added 45 new species records. However, of these 155 previously documented records, 68 of them have not been documented since 1971 and 49 of these 68 species were rare and only had one previously documented record. *Perdita zebrata and Coelioxys porterae* are of note because they were not collected in our 10-year study but were collected in high abundance in previous years. *P. zebrata had* 150+ records documented in the pinyon-juniper life zone but has not been recorded on the Peaks since 1971. *C. porterae* had 100+ records documented throughout the Peaks since 1952 but was not collected in our 10-year study.

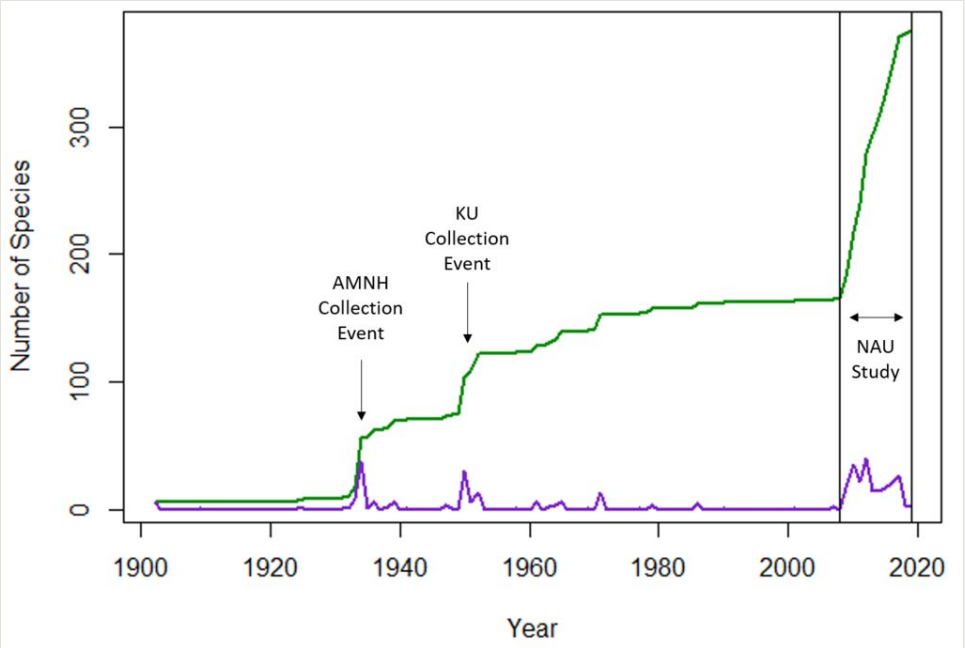

Figure 2. doi

Collection events of new species documentation on the San Francisco Peaks. The purple line represents the number of new species records, and the green line shows the cumulative addition of species to the San Francisco Peaks area.

Our study that began in 2009 was a collaborative inventory project with Northern Arizona University and United States Fish and Wildlife Service and was started with the intention of documenting all bee species inhabiting the Peaks region. Over a 10-year period, we documented an additional 204 bee species inhabiting the Peaks, leading to a total of 359 bee species recorded on this checklist (7,952 specimens Table 2). The ponderosa pine life zone is the most diverse, with a total of 177 species inhabiting that vegetation zone (Fig. 3). However, collection effort in the desert shrub and desert grassland life zones was disproportionately lower than that of the four higher life zones. Desert shrub and desert grassland were only sampled in 2009-2012. Further, only pollinator cups were used at desert shrub and desert grassland, whereas bug vacuums became the primary method of sampling at the pinyon-juniper, ponderosa pine, mixed conifer, and spruce-fir life zones from 2016-2019. These two components could potentially lead to a higher abundance of specimens collected at those four higher life zones.

Table 2.

Comprehensive list of bee species collected in the San Francisco Peaks region. Each life zone is denoted (DS = desert shrub, DG = desert grassland, PJ = pinyon-juniper, PP = ponderosa pine, MC = mixed conifer, SF = spruce-fir). Notations in the "NAU" column are species that were recorded in the NAU inventory study from 2009–2019. Notations in the "other" (O) column were species recorded to occur on the San Francisco Peaks by other institutions. Notations also designate whether species were collected from cup (C) sampling or flower (F) sampling. Further, rare (R) species (only one specimen collected) are marked with a "*" and abundant (A) species (>100 specimens collected) are marked with an "x".

Family	Genus	Species/ Morphospecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Andrenidae	*Andrena*	*algida*			1			1		1		1	1		
Andrenidae	*Andrena*	*amphibola*						1		1		1			
Andrenidae	*Andrena*	*angustitarsata*						1		1		1			
Andrenidae	*Andrena*	*apacheorum*					1	1		1	1	1			
Andrenidae	*Andrena*	*argemonis*					1	1		1	1	1			
Andrenidae	*Andrena*	*auripes*						1		1		1		*	
Andrenidae	*Andrena*	*coconina*									1			*	
Andrenidae	*Andrena*	*commoda*					1	1		1	1	1			
Andrenidae	*Andrena*	*costillensis*						1		1		1			
Andrenidae	*Andrena*	*crataegi*						1		1		1			
Andrenidae	*Andrena*	*cressonii*						1		1		1		*	
Andrenidae	*Andrena*	*crinita*						1		1		1			
Andrenidae	*Andrena*	*cyanophila*			1		1	1	1	1		1	1		x
Andrenidae	*Andrena*	*frigida*					1				1			*	
Andrenidae	*Andrena*	*helianthi*					1			1	1		1		
Andrenidae	*Andrena*	*mariae*						1		1		1		*	
Andrenidae	*Andrena*	*medionitens*						1		1	1	1	1		
Andrenidae	*Andrena*	*micheneriana*			1		1			1		1			
Andrenidae	*Andrena*	*miranda*					1	1		1		1	1		
Andrenidae	*Andrena*	*moquiorum*									1			*	
Andrenidae	*Andrena*	*nubecula*				1	1	1	1	1		1	1		
Andrenidae	*Andrena*	*pecosana*					1			1	1	1		*	
Andrenidae	*Andrena*	*perpunctata*					1	1		1		1		*	

Family	Genus	Species/ Morphospsecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Andrenidae	*Andrena*	*platyrhina*					1			1		1		*	
Andrenidae	*Andrena*	*prunorum*			1	1	1			1		1	1		
Andrenidae	*Andrena*	*simulata*		1						1	1	1			
Andrenidae	*Andrena*	*sonorensis*					1				1			*	
Andrenidae	*Andrena*	*striatifrons*						1		1	1	1		*	
Andrenidae	*Andrena*	*tegularis*							1	1			1	*	
Andrenidae	*Andrena*	*w-scripta*		1				1		1		1			
Andrenidae	*Andrena*	001						1		1		1		*	
Andrenidae	*Andrena*	003						1		1		1		*	
Andrenidae	*Andrena*	004						1		1		1			
Andrenidae	*Andrena*	005						1		1		1		*	
Andrenidae	*Andrena*	006						1		1			1	*	
Andrenidae	*Andrena*	(*Belandrena*) 001			1		1			1		1			
Andrenidae	*Andrena*	(*Diandrena*) 001					1			1		1		*	
Andrenidae	*Andrena*	(*Trachandrena*) 001					1	1		1		1			
Andrenidae	*Calliopsis*	*callops*						1		1		1		*	
Andrenidae	*Calliopsis*	*chlorops*		1	1	1				1	1	1			
Andrenidae	*Calliopsis*	*puellae*		1						1		1			
Andrenidae	*Calliopsis*	*rozeni*									1			*	
Andrenidae	*Calliopsis*	*teucrii*					1				1				
Andrenidae	*Calliopsis*	*timberlakei*			1	1				1		1			
Andrenidae	*Calliopsis*	*zebrata*					1			1	1	1			
Andrenidae	*Calliopsis*	001						1		1		1		*	
Andrenidae	*Macrotera*	*latior*			1	1	1			1	1	1			
Andrenidae	*Perdita*	*giliae*					1				1			*	
Andrenidae	*Perdita*	*gutierreziae*				1					1			*	
Andrenidae	*Perdita*	*sphaeralceae*				1					1				
Andrenidae	*Perdita*	*zebrata*				1					1				x
Andrenidae	*Perdita*	001		1					1	1		1		*	

Family	Genus	Species/ Morphospsecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Andrenidae	*Perdita*	002		1						1		1			
Andrenidae	*Perdita*	003		1	1					1		1			
Andrenidae	*Perdita*	004						1		1		1			
Andrenidae	*Perdita*	005			1					1		1			
Andrenidae	*Perdita*	006			1					1		1			
Andrenidae	*Perdita*	007		1	1					1		1			
Andrenidae	*Perdita*	008		1	1					1		1			
Andrenidae	*Perdita*	009		1						1		1			
Andrenidae	*Perdita*	010		1						1		1			
Andrenidae	*Protandrena*	*albitarsis*									1			*	
Andrenidae	*Protandrena*	*atricornis*							1		1				
Andrenidae	*Protandrena*	*boylei*				1					1			*	
Andrenidae	*Protandrena*	*illustris*									1			*	
Andrenidae	*Protandrena*	*neomexicanus*									1				
Andrenidae	*Protandrena*	*porterae*				1					1			*	
Andrenidae	*Protandrena*	(*Heterosarus*) 001						1		1		1	1		
Andrenidae	*Protandrena*	(*Heterosarus*) 002						1		1		1	1		
Andrenidae	*Protandrena*	(*Heterosarus*) 003						1	1	1			1		
Andrenidae	*Protandrena*	(*Heterosarus*) 004					1	1		1		1	1		
Andrenidae	*Protandrena*	(*Heterosarus*) 005						1		1		1		*	
Apidae	*Anthophora*	*affabilis*		1	1	1	1	1		1		1			
Apidae	*Anthophora*	*californica*						1		1	1	1			
Apidae	*Anthophora*	*coptognatha*		1	1					1		1			
Apidae	*Anthophora*	*exigua*		1	1			1		1		1			
Apidae	*Anthophora*	*lesquerellae*		1		1				1		1			
Apidae	*Anthophora*	*marginata*					1				1				

Family	Genus	Species/ Morphospsecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Apidae	*Anthophora*	*montana*		1	1	1	1	1	1	1	1	1	1		x
Apidae	*Anthophora*	*mortuaria*			1					1		1		*	
Apidae	*Anthophora*	*petrophila*		1	1	1				1		1			
Apidae	*Anthophora*	*porterae*		1	1		1			1		1			
Apidae	*Anthophora*	*terminalis*			1	1	1	1	1	1	1	1	1		x
Apidae	*Anthophora*	*urbana*		1			1	1		1	1	1	1		
Apidae	*Anthophora*	*ursina*					1	1		1		1			
Apidae	*Anthophora*	*vannigera*			1			1		1		1			
Apidae	*Apis*	*mellifera*		1			1	1		1	1	1	1		
Apidae	*Bombus*	*appositus*					1	1		1		1			
Apidae	*Bombus*	*bifarius*					1	1		1	1	1			
Apidae	*Bombus*	*californicus*					1			1		1			
Apidae	*Bombus*	*centralis*					1	1	1	1	1	1	1		
Apidae	*Bombus*	*fervidus*					1	1	1	1	1	1	1		
Apidae	*Bombus*	*flavifrons*						1		1		1			
Apidae	*Bombus*	*huntii*					1	1	1	1	1	1	1		x
Apidae	*Bombus*	*insularis*					1		1	1	1	1	1		
Apidae	*Bombus*	*melanopygus*					1	1		1		1			
Apidae	*Bombus*	*morrisoni*			1	1	1	1	1	1	1	1			
Apidae	*Bombus*	*nevadensis*			1		1	1	1	1	1	1	1		
Apidae	*Bombus*	*occidentalis*					1	1	1	1	1	1	1		x
Apidae	*Bombus*	*rufocinctus*					1		1	1	1	1			
Apidae	*Bombus*	*sylvicola*					1			1		1		*	
Apidae	*Bombus*	*variabilis*							1		1			*	
Apidae	*Centris*	*rhodopus*				1					1				
Apidae	*Ceratina*	*apacheorum*					1			1		1			
Apidae	*Ceratina*	*arizonensis*							1	1		1		*	
Apidae	*Ceratina*	*nanula*				1	1	1	1	1		1	1		
Apidae	*Ceratina*	*neomexicana*					1	1	1	1	1	1			
Apidae	*Ceratina*	*pacifica*				1		1	1	1		1	1		

Family	Genus	Species/ Morphospecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Apidae	*Ceratina*	001						1		1		1			
Apidae	*Diadasia*	*australis*		1	1	1	1			1		1			
Apidae	*Diadasia*	*diminuta*		1	1	1	1	1	1	1	1	1	1		x
Apidae	*Diadasia*	*enavata*			1		1		1	1		1			
Apidae	*Diadasia*	*ochracea*		1	1	1	1			1	1	1	1		x
Apidae	*Diadasia*	*rinconis*				1	1	1		1		1	1		x
Apidae	*Epeolus*	*compactus*			1					1	1	1			
Apidae	*Epeolus*	*flavofasciatus*					1				1			*	
Apidae	*Epeolus*	*interruptus*					1				1			*	
Apidae	*Epeolus*	*pusillus*					1			1			1	*	
Apidae	*Ericrocis*	*lata*					1				1			*	
Apidae	*Eucera*	*crenulaticornis*					1				1				
Apidae	*Eucera*	*fulvitarsis*	*annae*		1	1				1		1			
Apidae	*Eucera*	*lippiae*					1				1				
Apidae	*Eucera*	*lutziana*		1						1		1			
Apidae	*Eucera*	*ochraea*				1					1			*	
Apidae	*Eucera*	*primiveris*		1	1	1				1		1			
Apidae	*Eucera*	*speciosa*				1				1		1		*	
Apidae	*Eucera*	*territella*			1		1			1		1			
Apidae	*Eucera*	*Eucera* 001					1		1	1		1	1		
Apidae	*Eucera*	*Eucera* 002						1		1		1	1		
Apidae	*Eucera*	*Eucera* 003							1	1			1	*	
Apidae	*Eucera*	(*Synhalonia*) 001					1			1			1		
Apidae	*Exomalopsis*	*solani*		1						1		1			
Apidae	*Exomalopsis*	*solidaginis*					1			1		1		*	
Apidae	*Holcopasites*	*stevensi*				1				1		1		*	
Apidae	*Melecta*	*bohartorum*						1		1		1		*	
Apidae	*Melecta*	*pacifica*		1				1		1		1			
Apidae	*Melissodes*	*agilis*					1				1				
Apidae	*Melissodes*	*bimatris*				1					1			*	

Family	Genus	Species/ Morphospecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Apidae	*Melissodes*	*coloradensis*									1				
Apidae	*Melissodes*	*communis*				1				1		1		*	
Apidae	*Melissodes*	*compositus*				1					1			*	
Apidae	*Melissodes*	*confusus*					1	1	1	1	1	1	1		
Apidae	*Melissodes*	*coreopsis*					1				1			*	
Apidae	*Melissodes*	*druriellus*					1			1	1	1		*	
Apidae	*Melissodes*	*fasciatellus*		1				1		1			1		
Apidae	*Melissodes*	*gilensis*					1	1	1	1	1	1			
Apidae	*Melissodes*	*glenwoodensis*			1		1			1		1			
Apidae	*Melissodes*	*grindeliae*					1	1	1		1				
Apidae	*Melissodes*	*menuachus*									1				
Apidae	*Melissodes*	*montanus*					1	1		1	1	1	1		
Apidae	*Melissodes*	*pallidisignatus*		1						1	1	1			
Apidae	*Melissodes*	*paroselae*					1				1				
Apidae	*Melissodes*	*perpolitus*				1	1	1		1		1	1		
Apidae	*Melissodes*	*rivalis*					1			1	1	1			
Apidae	*Melissodes*	*saponellus*		1						1		1			
Apidae	*Melissodes*	*semilupinus*		1						1		1		*	
Apidae	*Melissodes*	*tristis*		1	1	1	1	1	1	1	1	1	1		x
Apidae	*Melissodes*	*verbesinarum*				1				1		1			
Apidae	*Nomada*	*texana*									1				
Apidae	*Nomada*	*utahensis*					1		1		1				
Apidae	*Nomada*	*zebrata*					1				1				
Apidae	*Svastra*	*obliqua*		1						1		1		*	
Apidae	*Triepeolus*	*rhododontus*		1			1			1		1			
Apidae	*Triepeolus*	001		1						1		1			
Apidae	*Triepeolus*	003		1						1		1			
Apidae	*Xeromelecta*	*californica*		1			1	1		1	1	1			
Apidae	*Xylocopa*	*californica*					1			1			1		
Colletidae	*Colletes*	*bryanti*			1					1		1		*	

Family	Genus	Species/ Morphospecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Colletidae	*Colletes*	*compactus*					1			1		1			
Colletidae	*Colletes*	*eulophi*									1				
Colletidae	*Colletes*	*gilensis*					1	1	1	1	1	1	1		
Colletidae	*Colletes*	*kincaidii*					1	1		1	1	1			
Colletidae	*Colletes*	*paniscus*	*paniscus*				1				1				
Colletidae	*Colletes*	*scopiventer*		1	1					1		1			
Colletidae	*Colletes*	*simulans*									1			*	
Colletidae	*Colletes*	*wickhami*		1						1		1			
Colletidae	*Colletes*	*wootoni*					1	1	1		1				
Colletidae	*Colletes*	001						1		1			1		
Colletidae	*Colletes*	002						1		1			1	*	
Colletidae	*Colletes*	003					1			1			1	*	
Colletidae	*Colletes*	004			1					1		1		*	
Colletidae	*Colletes*	005			1					1		1		*	
Colletidae	*Hylaeus*	*annulatus*			1		1	1	1	1	1	1	1		x
Colletidae	*Hylaeus*	*cookii*				1		1	1	1		1	1		
Colletidae	*Hylaeus*	*episcopalis*	*episcopalis*				1	1		1	1	1		*	
Colletidae	*Hylaeus*	*insolitus*					1				1			*	
Colletidae	*Hylaeus*	*rudbeckiae*					1		1	1		1			
Colletidae	*Hylaeus*	*wootoni*					1			1	1	1			
Halictidae	*Agapostemon*	*angelicus*		1	1	1	1	1	1	1	1	1	1		x
Halictidae	*Agapostemon*	*melliventris*		1	1	1				1	1	1			
Halictidae	*Agapostemon*	*texanus*		1	1	1	1	1	1	1	1	1			x
Halictidae	*Dieunomia*	*apacha*									1			*	
Halictidae	*Dieunomia*	*micheneri*				1				1		1			
Halictidae	*Dieunomia*	*nevadensis*		1						1		1		*	
Halictidae	*Halictus*	*confusus*							1	1		1		*	
Halictidae	*Halictus*	*farinosus*		1						1		1		*	
Halictidae	*Halictus*	*ligatus*			1	1	1	1		1	1	1			
Halictidae	*Halictus*	*tripartitus*		1		1	1		1	1	1	1	1		

Family	Genus	Species/ Morphospecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Halictidae	*Lasioglossum*	*boreale*						1	1	1		1			
Halictidae	*Lasioglossum*	aff. *comulum*			1		1	1		1		1	1		
Halictidae	*Lasioglossum*	*desertum*			1	1	1	1	1	1	1	1	1		x
Halictidae	*Lasioglossum*	*egregium*		1			1	1	1	1	1	1			
Halictidae	*Lasioglossum*	*hudsoniellum*			1	1		1		1		1			
Halictidae	*Lasioglossum*	*hyalinum*			1					1		1			
Halictidae	*Lasioglossum*	*microlepoides*			1			1		1		1			
Halictidae	*Lasioglossum*	*obnubilum*			1					1		1			
Halictidae	*Lasioglossum*	*occidentale*			1					1		1			
Halictidae	*Lasioglossum*	*pallidellum*			1					1		1			
Halictidae	*Lasioglossum*	cf. *perdifficile*						1		1		1			
Halictidae	*Lasioglossum*	aff. *perparvum*			1		1	1		1		1			
Halictidae	*Lasioglossum*	*ruidosense* species-group					1	1	1	1		1			
Halictidae	*Lasioglossum*	*ruficorne*			1		1	1	1	1		1			
Halictidae	*Lasioglossum*	*semicaeruleum*			1	1	1	1		1		1			
Halictidae	*Lasioglossum*	*sisymbrii*		1	1	1	1	1	1	1	1	1	1		x
Halictidae	*Lasioglossum*	new *tegulare* species-group			1					1		1			
Halictidae	*Lasioglossum*	*trizonatum*					1	1		1	1	1	1		
Halictidae	*Lasioglossum*	cf. *viridatulum*			1			1		1		1			
Halictidae	*Lasioglossum*	001			1		1			1		1			
Halictidae	*Lasioglossum*	002			1					1		1			
Halictidae	*Lasioglossum*	003			1	1				1		1			
Halictidae	*Lasioglossum*	004			1	1	1	1	1	1		1	1		
Halictidae	*Lasioglossum*	005			1		1	1	1	1		1			
Halictidae	*Lasioglossum*	006						1	1	1		1	1		
Halictidae	*Lasioglossum*	007					1	1		1		1			
Halictidae	*Lasioglossum*	008						1		1			1		
Halictidae	*Nomia*	*foxii*				1	1				1				
Halictidae	*Nomia*	*tetrazonata*					1				1			*	

Family	Genus	Species/ Morphospsecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Halictidae	*Protodufourea*	*eickworti*							1	1		1		*	
Halictidae	*Sphecodes*	*pecosensis*		1				1		1		1			
Halictidae	*Sphecodes*	001					1	1		1		1			
Halictidae	*Sphecodes*	002			1					1		1			
Halictidae	*Sphecodes*	003					1			1		1		*	
Halictidae	*Sphecodes*	004						1		1			1	*	
Megachilidae	*Anthidiellum*	*notatum*									1				
Megachilidae	*Anthidium*	*atripes*		1	1					1		1			
Megachilidae	*Anthidium*	*clypeodentatum*					1	1		1	1	1	1		
Megachilidae	*Anthidium*	*cockerelli*		1			1			1		1			
Megachilidae	*Anthidium*	*dammersi*			1					1		1			
Megachilidae	*Anthidium*	*duomarginatum*			1		1			1	1	1			
Megachilidae	*Anthidium*	*emarginatum*					1			1	1	1			
Megachilidae	*Anthidium*	*illustre*				1	1			1	1	1			
Megachilidae	*Anthidium*	*maculifrons*					1				1			*	
Megachilidae	*Anthidium*	*maculosum*				1	1	1		1	1	1			
Megachilidae	*Anthidium*	*mormonum*					1	1		1	1	1			
Megachilidae	*Anthidium*	*palmarum*		1		1				1		1		*	
Megachilidae	*Anthidium*	*porterae*			1	1	1			1	1	1			
Megachilidae	*Anthidium*	*schwarzi*		1						1		1		*	
Megachilidae	*Ashmeadiella*	*aridula*				1				1		1			
Megachilidae	*Ashmeadiella*	*bucconis*				1		1		1		1		*	
Megachilidae	*Ashmeadiella*	*cactorum*	*basalis*	1						1		1			x
Megachilidae	*Ashmeadiella*	*californica*			1		1	1		1	1	1			
Megachilidae	*Ashmeadiella*	*gillettei*		1		1	1	1	1	1		1	1		
Megachilidae	*Ashmeadiella*	*meliloti*		1	1	1	1	1		1		1			
Megachilidae	*Ashmeadiella*	*opuntiae*		1		1	1			1		1			
Megachilidae	*Ashmeadiella*	*sonora*			1	1	1			1		1	1		
Megachilidae	*Ashmeadiella*	*timberlakei*				1	1			1		1			
Megachilidae	*Ashmeadiella*	*vandykiella*		1						1		1		*	

Family	Genus	Species/ Morphospsecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Megachilidae	*Ashmeadiella*	002			1	1				1		1			
Megachilidae	*Atoposmia*	*enceliae*		1						1		1		*	
Megachilidae	*Coelioxys*	*apacheorum*					1				1				
Megachilidae	*Coelioxys*	*erysimi*					1				1			*	
Megachilidae	*Coelioxys*	*gilensis*					1			1	1	1			
Megachilidae	*Coelioxys*	*moestus*					1	1		1	1	1			
Megachilidae	*Coelioxys*	*octodentatus*									1				
Megachilidae	*Coelioxys*	*porterae*					1	1			1				
Megachilidae	*Coelioxys*	*rufitarsis*					1	1		1	1	1			
Megachilidae	*Coelioxys*	*sodalis*					1				1				
Megachilidae	*Coelioxys*	001				1				1		1		*	
Megachilidae	*Coelioxys*	002			1					1		1		*	
Megachilidae	*Coelioxys*	003			1					1		1		*	
Megachilidae	*Dianthidium*	*arizonicum*				1					1			*	
Megachilidae	*Dianthidium*	*concinnum*		1	1	1		1		1		1			
Megachilidae	*Dianthidium*	*cressonii*				1	1	1		1	1	1			
Megachilidae	*Dianthidium*	*curvatum*					1			1		1			
Megachilidae	*Dianthidium*	*desertorum*					1			1		1		*	
Megachilidae	*Dianthidium*	*heterulkei*	*fraternum*			1	1			1	1	1			
Megachilidae	*Dianthidium*	*parvum*	*parvum*	1		1	1			1		1			
Megachilidae	*Dianthidium*	*platyurum*				1				1		1			
Megachilidae	*Dianthidium*	*pudicum*				1	1			1		1			
Megachilidae	*Dianthidium*	*singulare*				1	1			1		1			
Megachilidae	*Dianthidium*	*subparvum*				1	1			1		1			
Megachilidae	*Dianthidium*	*texanum*				1				1		1			
Megachilidae	*Dianthidium*	*ulkei*		1		1	1	1		1		1			
Megachilidae	*Heriades*	*cressoni*				1	1			1	1	1			
Megachilidae	*Heriades*	*gracilior*		1		1				1		1			
Megachilidae	*Heriades*	*micropthalma*									1				
Megachilidae	*Heriades*	*texana*									1			*	

Family	Genus	Species/ Morphospecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Megachilidae	*Heriades*	*timberlakei*			1	1				1		1			
Megachilidae	*Heriades*	002						1		1		1			
Megachilidae	*Hoplitis*	*grinnelli*									1				
Megachilidae	*Hoplitis*	*paroselae*		1						1		1		*	
Megachilidae	*Hoplitis*	*truncata*	*mescalerium*				1				1				
Megachilidae	*Hoplitis*	*zuni*				1				1		1			
Megachilidae	*Hoplitis*	001		1						1		1		*	
Megachilidae	*Lithurgopsis*	*apicalis*		1		1	1			1	1	1			
Megachilidae	*Lithurgopsis*	*planifrons*				1	1			1					
Megachilidae	*Megachile*	*agustini*									1			*	
Megachilidae	*Megachile*	*angelarum*							1	1	1	1	1		
Megachilidae	*Megachile*	*brevis*									1				
Megachilidae	*Megachile*	*chilopsidis*				1				1		1		*	
Megachilidae	*Megachile*	*comata*			1		1	1	1	1	1	1	1		
Megachilidae	*Megachile*	*fidelis*					1	1	1	1	1	1			
Megachilidae	*Megachile*	*fortis*							1	1	1	1			
Megachilidae	*Megachile*	*frigida*					1	1	1	1	1	1	1		
Megachilidae	*Megachile*	*inimica*	*sayi*				1	1		1	1	1			
Megachilidae	*Megachile*	*lapponica*						1		1		1			
Megachilidae	*Megachile*	*latimanus*							1	1		1			
Megachilidae	*Megachile*	*lippiae*		1						1	1	1			
Megachilidae	*Megachile*	*lobatifrons*		1						1		1		*	
Megachilidae	*Megachile*	*manifesta*									1			*	
Megachilidae	*Megachile*	*melanophaea*						1		1	1	1			
Megachilidae	*Megachile*	*mellitarsis*				1	1	1	1	1	1	1	1		
Megachilidae	*Megachile*	*montivaga*		1		1	1	1		1	1	1			
Megachilidae	*Megachile*	*mucida*					1				1			*	
Megachilidae	*Megachile*	*mucorosa*			1					1		1			
Megachilidae	*Megachile*	*onobrychidis*			1	1				1		1			
Megachilidae	*Megachile*	*perihirta*					1				1				

Family	Genus	Species/ Morphospecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Megachilidae	*Megachile*	*policaris*		1						1	1	1			
Megachilidae	*Megachile*	*pugnata*	*pomonae*				1	1		1	1	1			
Megachilidae	*Megachile*	*relativa*		1	1		1	1	1	1	1	1	1		
Megachilidae	*Megachile*	*sabinensis*		1						1		1			
Megachilidae	*Megachile*	*sidalceae*		1						1		1		*	
Megachilidae	*Megachile*	*snowi*					1	1			1				
Megachilidae	*Megachile*	*subexilis*					1	1		1	1	1			
Megachilidae	*Megachile*	*sublaurita*		1	1	1	1			1	1	1			
Megachilidae	*Megachile*	*texana*									1				
Megachilidae	*Megachile*	001					1			1		1		*	
Megachilidae	*Megachile*	002						1		1		1		*	
Megachilidae	*Osmia*	*albolateralis*					1				1				
Megachilidae	*Osmia*	*brevis*					1	1		1			1		
Megachilidae	*Osmia*	*bucephala*					1	1	1	1		1			
Megachilidae	*Osmia*	*coloradensis*		1			1	1		1	1	1	1		
Megachilidae	*Osmia*	*densa*					1				1				
Megachilidae	*Osmia*	*juxta*					1	1	1	1		1	1		
Megachilidae	*Osmia*	*lignaria*					1				1				
Megachilidae	*Osmia*	*liogastra*		1						1		1		*	
Megachilidae	*Osmia*	*montana*							1	1		1		*	
Megachilidae	*Osmia*	*pentstemonis*					1				1				
Megachilidae	*Osmia*	aff. *pentstemonis*							1	1		1	1		
Megachilidae	*Osmia*	*simillima*					1	1	1	1	1	1	1		
Megachilidae	*Osmia*	*subaustralis*							1	1	1	1			
Megachilidae	*Osmia*	*texana*			1		1	1	1	1	1	1			
Megachilidae	*Osmia*	*unca*					1				1			*	
Megachilidae	*Osmia*	002						1	1	1		1			
Megachilidae	*Osmia*	003						1		1		1		*	
Megachilidae	*Osmia*	005					1		1	1		1			
Megachilidae	*Osmia*	006							1	1		1		*	

Family	Genus	Species/ Morphospecies	Sub-species	DS	DG	PJ	PP	MC	SF	NAU	O	C	F	R	A
Megachilidae	*Osmia*	007							1	1		1		*	
Megachilidae	*Osmia*	009						1	1	1		1			
Megachilidae	*Osmia*	010						1	1	1		1			
Megachilidae	*Osmia*	011						1		1		1		*	
Megachilidae	*Osmia*	012					1		1	1			1		
Megachilidae	*Osmia*	(*Cephalosmia*) 001						1		1		1			
Megachilidae	*Osmia*	(*Cephalosmia*) 002							1	1		1		*	
Megachilidae	*Osmia*	(*Melanosmia*) 001						1		1			1	*	
Megachilidae	*Osmia*	(*Melanosmia*) 002					1			1		1		*	
Megachilidae	*Paranthidium*	*jugatorium*		1		1	1	1		1	1	1	1		
Megachilidae	*Stelis*	*elegans*					1			1			1	*	
Megachilidae	*Stelis*	*rudbeckiarum*					1			1	1	1			

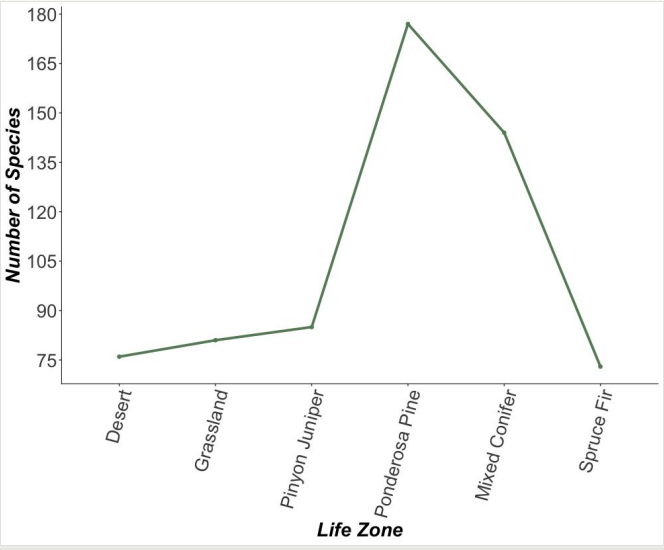

Figure 3. doi

Number of bee species found at each life zone (n=339 species for which we had accurate locality data to assign life zone designations).

Abundances varied between families but generally followed species richness trends. However, 68 species of the 204 newly documented species were singletons and 16 species were highly abundant (averaging over 50 specimens per year) with *Lasioglossum desertum* being the most abundant species on the Peaks. There were other notable species that were also relatively abundant in specific life zones, such as *Bombus occidentalis*, which averaged 25 specimens per year in all life zones above ponderosa pine. Of the 204 newly documented species, 15 of these exhibited a range expansion.

All bee families were represented at each one of the life zones (Fig. 4). Megachilids were the most diverse family and they had the highest species richness at ponderosa pine (56% of total megachilid species). This high diversity of megachilids may be explained by an abundance of dead-and-down wood required for nesting by many Megachilini and Osmiini (Sheffield et al. 2011, Cane et al. 2014) which may be restricted to higher environments (McCabe et al. 2019a). Thirty-eight percent of all bee species collected in ponderosa pine are megachilids, further supporting the idea that the woody ponderosa environment is favorable for this diverse bee family (Fig. 5). However, it is also possible that megachilid species may be more common at ponderosa pine simply due to the sheer number of Megachildae inhabiting the Peaks. Apidae is the second most diverse family on our elevation gradient and contributed to a large portion of the species at each life zone. Combined, Megachilidae and Apidae comprise about 60% of the species on the Peaks.

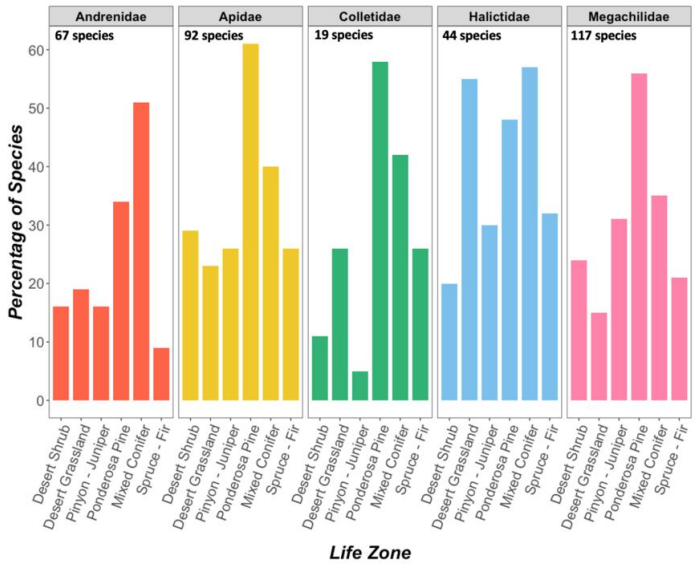

Figure 4. doi

Percentage of species in a family found at each life zone (n=339 species for which we had accurate locality data to assign life zone designations). Numbers for each family sum higher than 100% because of species that occurred in more than one life zone.

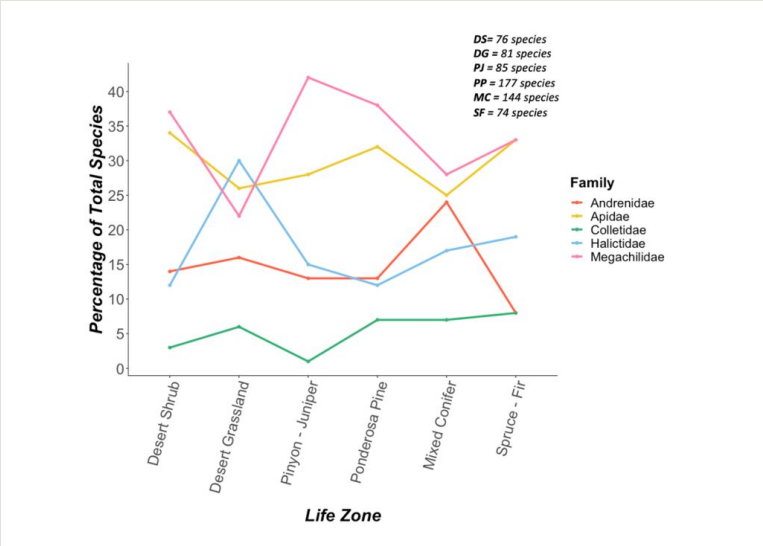

Figure 5. doi

Percent of total species organized by family for each life zone (n=339 species for which we had accurate locality data to assign life zone designations). DS = desert shrub, DG = desert grassland, PJ = pinyon-juniper, PP = ponderosa pine, MC = mixed conifer, SF = spruce-fir. Numbers for each life zone sum to 100%.

In general, the percentage of species composed by a particular family at each life zone seemed to positively correlate with the overall diversity of that family found on the Peaks. For example, Megachilidae was the most dominant family at each life zone (except for desert grassland), and they were also the most species rich family in the Peaks region. An exception is at the mixed conifer life zone where Andrenidae was the most dominant family (comprised 24% of all species). Further, all but one of our reported *Andrena* species were found to inhabit mixed conifer, and 41% of Andrenidae *only* occurred at mixed conifer. Andrenids are typically ground nesters that prefer the sandy soils found at lower elevations (Michener 2000) and such high species richness of Andrenidae at mixed conifer was unanticipated. The highest diversity of halictids (24 species) is seen at desert grassland and there is little diversity in Halictidae at the higher elevations. This trend is consistent with the idea that lower elevation habitats may provide greater nesting resources for halictids due to the warm, dry environment (Michener 2000, Devoto et al. 2005). Colletidae represented a relatively small subset of bees on the Peaks (5%) but do have representative species at every life zone.

Our results indicate a high degree of habitat specialization along the elevational gradient of the Peaks, with 49% of the total bee species found in only one life zone (177 species) (Fig. 6). Conversely, only six species (< 1% of the total bee species included in the analysis) have ranges that encompass all six of the life zones included in our study: *Anthophora montana, Diadasia diminuta, Melissodes tristis, Agapostemon angelicus, Agapostemon texanus*, and *Lasioglossum sisymbri*. These six species only come from two families

(Apidae and Halictidae) and all six are ground nesters. Evidence suggests that with changing climate or other anthropogenic disturbances, higher species loss may occur with species that encompass smaller geographic ranges or specialized habitats (Sánchez-Bayo and Wyckhuys 2019). Bees inhabiting higher elevations may be acutely susceptible to climate change; warming temperatures may cause bees to contract upwards in elevation (Hickling et al. 2006). If broad-scale tree reductions continue as predicted (Allen et al. 2015) most megachilids could lose nesting resources. Taxa that reach their highest diversity at higher elevations (e.g. Apidae) are also likely susceptible to climate change. Additionally, lower elevation habitats will get increasingly warmer and are likely to experience more drought events. This could potentially limit the already scarce floral resources available in these desert environments. It is therefore important to document ranges and habitat requirements of the bee species found on the Peaks to predict future shifts in local distribution.

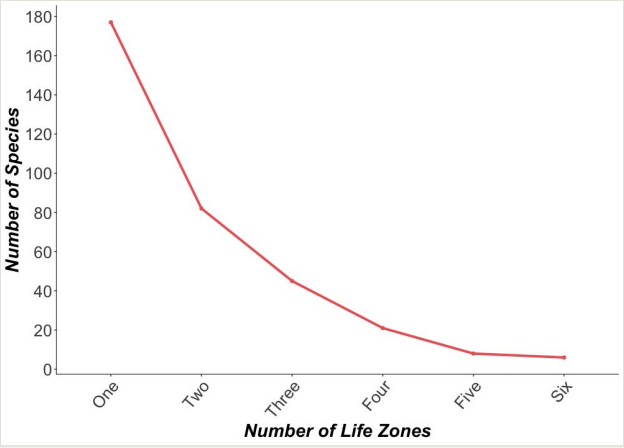

Figure 6. doi

Number of species found to inhabit increasing numbers of life zones. Nearly 50% of total bee species were found in only one life zone (n=339 species for which we had accurate locality data to assign life zone designations).

Insect species richness and abundance is reported to be declining globally, pointing to the importance of regularly monitoring populations worldwide (Biesmeijer et al. 2006, Cameron et al. 2011, Bartomeus et al. 2013, Jacobson et al. 2018). However, of the 73 studies summarized by Sánchez-Bayo and Wyckhuys (2019) that indicate a global decline of insects, the majority of the studies that reported bee declines focused mostly on bumble bees. This likened itself to a lack of world records for other native bee species, which this checklist can provide. Ranges for the vast majority of native bee species are still relatively unknown (Bartomeus et al. 2013). Only one species from our checklist, *Bombus occidentalis*, has published accounts showing population trends (Cameron et al. 2011). Checklists like ours and others (Carril et al. 2018, Parys et al. 2018, Delphia et al. 2019, Stephenson et al. 2018) could serve as important reference points to assess future responses of bees to global change.

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Author contributions

McCabe, Chesshire, Smith, and Cobb conceived the ideas and designed the methodology. McCabe, Chesshire, Smith, and Wolf collected and processed the bees. McCabe, Chesshire, and Smith conducted the initial identification of the bee species. McCabe, Chesshire, and Wolf reviewed online database and published records for range expansions and new species of the peaks. Gibbs, Griswold, and Wright identified bee species. All authors contributed to the writing of the manuscript.

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Supplementary materials

Suppl. material 1: Localities for 2019 qualitative sampling doi

Authors: McCabe et al
Data type: decimal latitude/longitude localities
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Suppl. material 2: Occurrence Records removed from analysis doi

Authors: McCabe et al
Data type: occurrences
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Suppl. material 3: DwC archive file of the bee records on the San Fransico Peaks doi

Authors: McCabe et al
Data type: occurrences
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