Bee species checklist of the San Francisco Peaks, Arizona

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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.

| 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|

Table 1.
List of all 58 NAU sites including latitude, longitude, years sampled and life zone.
| 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| -111.7189 |
| 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. 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 life 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 reused 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 Ikeda (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

*Calliopsis (Calliopsima) teucrrii* Cockerell, 1899

*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

*Perdita (Perdita) gutierreziae* Cockerell, 1896

Notes: Last collected on the Peaks in 1951

Notes: Last collected on the Peaks in 1961

Notes: Last collected on the Peaks in 1964

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) fulvitas 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) bimatrix** 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) microphthalmia** 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. *mescalium* (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
**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.
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/ Morphospsecies | 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 | apachecorum | | 1 | 1 | 1 | 1 | 1 | | |
| Andrenidae | Andrena | argemonis | | 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 | | | |
| Andrenidae | Andrena | moquiorum | | 1 | * | | | | | |
| Andrenidae | Andrena | nubecula | | 1 | 1 | 1 | 1 | 1 | 1 | | |
| Andrenidae | Andrena | pecosana | | 1 | 1 | 1 | 1 | * | | |
| Andrenidae | Andrena | perpunctata | | 1 | 1 | 1 | 1 | * | | |
| Family      | Genus      | Species/ Morphospecies | Subspecies | DS | DG | PJ | PP | MC | SF | NAU | O | C | F | R | A |
|-------------|------------|------------------------|------------|----|----|----|----|----|----|-----|---|---|---|---|---|
| Andrenidae  | Andrena    | platyrhina             |            | 1  | 1  | 1  | 1  | 1  | 1  |     |   |   |   |   | * |
| Andrenidae  | Andrena    | prunorum               |            | 1  | 1  | 1  | 1  | 1  | 1  |     |   |   |   |   |   |
| Andrenidae  | Andrena    | simulata               |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Andrena    | sonorensis             |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Andrenidae  | Andrena    | striatifrons           |            | 1  | 1  | 1  | 1  |     |   |     |   |   | * |   |   |
| Andrenidae  | Andrena    | tegularis              |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   | * |
| Andrenidae  | Andrena    | w-scripta              |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Andrena    | 001                    |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Andrenidae  | Andrena    | 003                    |            | 1  | 1  | 1  | 1  |     |   |     |   |   | * |   |   |
| Andrenidae  | Andrena    | 004                    |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Andrena    | 005                    |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Andrenidae  | Andrena    | 006                    |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Andrenidae  | Andrena    | (Belandrena) 001       |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Andrena    | (Diandrena) 001       |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Andrenidae  | Andrena    | (Trachandrena) 001    |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Calliopsis | callops                |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Andrenidae  | Calliopsis | chlorops               |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Calliopsis | puellae                |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Calliopsis | rozeni                 |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Andrenidae  | Calliopsis | teucrri                |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Calliopsis | timberlakei            |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Calliopsis | zebrata                |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Perdita    | 001                    |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Andrenidae  | Perdita    | giliae                 |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Andrenidae  | Perdita    | gutierreziae           |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Andrenidae  | Perdita    | sphaeroleae            |            | 1  | 1  | 1  | 1  |     |   |     |   |   |   |   |   |
| Andrenidae  | Perdita    | zebrata                |            | 1  | 1  | 1  | 1  |     |   |     |   |   | x  |   |   |
| Andrenidae  | Perdita    | 001                    |            | 1  | 1  | 1  | 1  |     |   |     |   | * |   |   |   |
| Family     | Genus     | Species/ Morphospecies | Subspecies | DS | DG | PJ | PP | MC | SF | NAU | O | C | F | R | A |
|------------|-----------|------------------------|------------|----|----|----|----|----|----|-----|---|---|---|---|---|
| Andrenidae | Perdita   | 002                    | 1          | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Perdita   | 003                    | 1 1        | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Perdita   | 004                    |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Perdita   | 005                    | 1          | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Perdita   | 006                    | 1          | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Perdita   | 007                    | 1 1        | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Perdita   | 008                    | 1 1        | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Perdita   | 009                    | 1          | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Perdita   | 010                    | 1          | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena albitarsis |            | 1          | *  |    |    |    |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena atricornis |          | 1          | 1  |    |    |    |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena boylei  |            | 1          | 1  | 1  | * |    |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena illustris |          | 1          | 1  |    |    |    |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena neomexicanus |      | 1          |    |    |    |    |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena porterae |            | 1          | 1  |    |    |    |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena (Heterosarus) 001 |  | 1          | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena (Heterosarus) 002 |  | 1          | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena (Heterosarus) 003 |  | 1          | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena (Heterosarus) 004 |  | 1          | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Andrenidae | Protandrena (Heterosarus) 005 |  | 1          | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   | * |
| Apidae     | Anthophora affabilis  | 1 1 1 1 1 1 1 |    |    |    |    |    |     |   |   |   |   |   |
| Apidae     | Anthophora Californica | 1 1 1 1 1 |    |    |    |    |    |     |   |   |   |   |   |
| Apidae     | Anthophora coptognatha | 1 1 |    |    |    |    |    |     |   |   |   |   |   |
| Apidae     | Anthophora exigua  | 1 1 1 1 1 |    |    |    |    |    |     |   |   |   |   |   |
| Apidae     | Anthophora lesquerellae | 1 1 |    |    |    |    |    |     |   |   |   |   |   |
| Apidae     | Anthophora marginata | 1 |    |    |    |    |    |     |   |   |   |   |   |
| Family | Genus     | Species/ Morphospecies | 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  | x |
| Apidae | Anthophora | mortuaria              |             | 1  |    | 1  | 1  | 1  | 1  |     |   |   |   |   | * |
| Apidae | Anthophora | petrophila             |             | 1  | 1  |    | 1  | 1  |    |     |   |   |   |   |   |
| Apidae | Anthophora | porterae               |             | 1  | 1  | 1  | 1  | 1  | 1  |     |   |   |   |   |   |
| Apidae | Anthophora | terminalis             |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | x |
| Apidae | Anthophora | urbana                 |             | 1  |    | 1  | 1  | 1  | 1  |     |   |   |   |   |   |
| Apidae | Anthophora | ursina                 |             | 1  | 1  | 1  | 1  | 1  |    |     |   |   |   |   |   |
| Apidae | Anthophora | vannigera              |             | 1  |    | 1  | 1  | 1  | 1  |     |   |   |   |   |   |
| Apidae | Apis      | mellifera              |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |
| Apidae | Bombus    | appositus              |             | 1  | 1  |    | 1  | 1  | 1  |     |   |   |   |   |   |
| Apidae | Bombus    | bifarius               |             | 1  | 1  | 1  | 1  | 1  | 1  |     |   |   |   |   |   |
| Apidae | Bombus    | californicus           |             | 1  |    | 1  | 1  | 1  | 1  |     |   |   |   |   |   |
| Apidae | Bombus    | centralis              |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |
| Apidae | Bombus    | fervidus               |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |
| Apidae | Bombus    | flavifrons             |             | 1  |    | 1  | 1  | 1  |    |     |   |   |   |   |   |
| Apidae | Bombus    | huntii                 |             | 1  | 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  | 1  | x |
| Apidae | Bombus    | rufocinctus            |             | 1  | 1  | 1  | 1  | 1  | 1  |     |   |   |   |   |   |
| Apidae | Bombus    | sylvicola              |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |
| Apidae | Bombus    | variabilis             |             | 1  |    | 1  | 1  |    |     |   |   |   |   |   | * |
| Apidae | Centris   | rhodopus               |             | 1  |    | 1  | 1  | 1  | 1  |     |   |   |   |   |   |
| Apidae | Ceratina  | apacheorum             |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |
| Apidae | Ceratina  | arizonensis            |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |
| Apidae | Ceratina  | nanula                 |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |
| Apidae | Ceratina  | neomexicana            |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |
| Apidae | Ceratina  | pacifica               |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |
| Family     | Genus     | Species/Morphospescies | Subspecies | DS | DG | PJ | PP | MC | SF | NAU | O | C | F | R | A |
|------------|-----------|------------------------|------------|----|----|----|----|----|----|-----|---|---|---|---|---|
| Apidae     | Ceratina  | 001                    |            | 1  | 1  | 1  | 1  |     |     |     |   |   |   |   |   |
| Apidae     | Diadasia  | australis              |            | 1  | 1  | 1  | 1  |     |     |     |   |   |   |   | x |
| Apidae     | Diadasia  | diminuta               |            | 1  | 1  | 1  | 1  | 1  | 1  |     |   |   |   |   |   |
| Apidae     | Diadasia  | enavata                |            | 1  | 1  | 1  | 1  |     |     |     |   |   |   |   |   |
| Apidae     | Diadasia  | ochracea               |            | 1  | 1  | 1  | 1  | 1  | 1  |     |   |   |   |   | x |
| Apidae     | Diadasia  | rinconis               |            | 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  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Ericrocis | lata                   |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | crenulaticomis         |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | fulvitaris annae       |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | lippiae                |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | lutziana               |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | ochraea                |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | primiveris             |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | speciosa               |            | 1  | 1  | 1  |   |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | territella             |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | Eucera 001             |            | 1  | 1  | 1  | 1  |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | Eucera 002             |            | 1  | 1  | 1  | 1  |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | Eucera 003             |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Eucera    | (Synhalonia) 001       |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Exomalopsis| solani             |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Exomalopsis| solidaginis         |            | 1  | 1  | 1  |   |     |     |     |   |   |   |   |   |
| Apidae     | Holcopasites| stevensi          |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Melecta   | bohartorum             |            | 1  | 1  | 1  |   |     |     |     |   |   |   |   |   |
| Apidae     | Melecta   | pacifica               |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Melissodes| agilis                 |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Apidae     | Melissodes| bimatris               |            | 1  | 1  |     |   |     |     |     |   |   |   |   |   |
| Family | Genus       | Species/Morphospecies | Subspecies | DS | DG | PJ | PP | MC | SF | NAU | O  | C  | F  | R  | A  |
|--------|-------------|------------------------|------------|----|----|----|----|----|----|-----|----|----|----|----|----|
| Apidae | Melissodes  | coloradensis           |            |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | communis               | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | compositus             | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | confusus               | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | coreopsis              | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | druriellus             | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | fasciellus             | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | gilensis               | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | glenwoodensis          | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | grindeliae             | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | menuachus              |            |    |    |    |    |    |    |     |    |    |    |    |    |    |
| Apidae | Melissodes  | montanus               | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | pallidisignatus        | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | paroselae              | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | perpolitus             | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | rivalis                | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | saponellus             | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | semilupinus            | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | tristis                | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Melissodes  | verbesinarum           | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Nomada      | texana                 |            |    |    |    |    |    |    |     |    |    |    |    |    |    |
| Apidae | Nomada      | utahensis              | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Nomada      | zebrata                | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Svastra     | obliqua                | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Triepeolus   | rhododontus            | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Triepeolus   | 001                    | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Triepeolus   | 003                    | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Xeromelecta  | californica            | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Apidae | Xylocopa    | californica            | 1 1 1 1 1  |    |    |    |    |    |    |     |    |    |    |    |    |
| Colletidae | Colletes  | bryanti                | 1 1 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 |
| Colletidae | Colletes  | wootoni               |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Colletidae | Colletes  | 001                   |             | 1  | 1  | 1  |    |    |    |     |   |   |   |   |   |
| Colletidae | Colletes  | 002                   |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   | * |
| Colletidae | Colletes  | 003                   |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Colletidae | Colletes  | 004                   |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   | * |
| Colletidae | Colletes  | 005                   |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Colletidae | Hylaeus   | annulatus             |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | x  |   |   |   |   |   |
| Colletidae | Hylaeus   | cookii                |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Colletidae | Hylaeus   | episcopalis           | episcopalis | 1  | 1  | 1  | 1  | 1  |     |   |   |   |   |   | * |
| Colletidae | Hylaeus   | insolitus             |             | 1  |    |    |    |    |    |     |   |   |   |   | 1 |
| Colletidae | Hylaeus   | rudbeckiae            |             | 1  | 1  | 1  |    |    |    |     |   |   |   |   |   |
| Colletidae | Hylaeus   | wootoni               |             | 1  | 1  | 1  |    |    |    |     |   |   |   |   |   |
| Halictidae | Agapostemon| angelicus            |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  | 1  | x  |   |   |   |   |
| Halictidae | Agapostemon| melliventris          |             | 1  | 1  | 1  |    |    |    |     |   |   |   |   | 1 |
| Halictidae | Agapostemon| texanus               |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  |     |   |   |   |   | x |
| Halictidae | Dieunomia  | apacha                |             | 1  |    |    |    |    |    |     |   |   |   |   | 1 |
| Halictidae | Dieunomia  | micheneri             |             | 1  |    |    |    |    |    |     |   |   |   |   | 1 |
| Halictidae | Dieunomia  | nevadensis            |             | 1  |    |    |    |    |    |     |   |   |   |   | 1 |
| Halictidae | Halictus   | confusus              |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Halictidae | Halictus   | farinosus             |             | 1  |    |    |    |    |    |     |   |   |   |   | 1 |
| Halictidae | Halictus   | ligatus               |             | 1  | 1  | 1  | 1  | 1  | 1  |     |   |   |   |   | 1 |
| Halictidae | Halictus   | tripartitus           |             | 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  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | aff. comulum          |             | 1  | 1  | 1  | 1  | 1  | 1  | x   |    |   |   |   |   |
| Halictidae | Lasioglossum | desertum              |             | 1  | 1  | 1  | 1  | 1  | 1  | 1   |    |   |   |   |   |
| Halictidae | Lasioglossum | egregium              |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | hudsoniellum          |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | hyalinum              |             | 1  |    |    |    | 1  |    |     |    |   |   |   |   |
| Halictidae | Lasioglossum | microlepoides         |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | obnubilum             |             | 1  |    |    |    | 1  |    |     |    |   |   |   |   |
| Halictidae | Lasioglossum | occidentale            |             | 1  |    |    |    | 1  |    |     |    |   |   |   |   |
| Halictidae | Lasioglossum | pallidellum            |             | 1  |    |    |    | 1  |    |     |    |   |   |   |   |
| Halictidae | Lasioglossum | cf. perdiflicle       |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | aff. perparvum        |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | ruidosense            |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | sisymbrii              |             | 1  | 1  | 1  | 1  | 1  | 1  | 1   |    |   |   |   |   |
| Halictidae | Lasioglossum | new tegulare          |             | 1  |    |    |    | 1  |    |     |    |   |   |   |   |
| Halictidae | Lasioglossum | trizonatum            |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | cf. viridatulum       |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | 001                    |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | 002                    |             | 1  |    |    |    | 1  |    |     |    |   |   |   |   |
| Halictidae | Lasioglossum | 003                    |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | 004                    |             | 1  | 1  | 1  | 1  | 1  | 1  | 1   |    |   |   |   |   |
| Halictidae | Lasioglossum | 005                    |             | 1  | 1  | 1  | 1  | 1  | 1  | 1   |    |   |   |   |   |
| Halictidae | Lasioglossum | 006                    |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | 007                    |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Lasioglossum | 008                    |             | 1  |    |    |    | 1  |    |     |    |   |   |   |   |
| Halictidae | Nomia       | foxii                  |             | 1  | 1  | 1  | 1  | 1  | 1  |     |    |   |   |   |   |
| Halictidae | Nomia       | tetrazonata            |             | 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    | Protodufourea   | eickworti              |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   | *|
| Halictidae    | Sphecodes       | pecosensis             |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Halictidae    | Sphecodes       | 001                    |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Halictidae    | Sphecodes       | 002                    |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Halictidae    | Sphecodes       | 003                    |             | 1  | 1  | 1  | 1  | *  |    |     |   |   |   |   |   |
| Halictidae    | Sphecodes       | 004                    |             | 1  | 1  | 1  | 1  | *  |    |     |   |   |   |   |   |
| Megachilidae  | Anthidium       | notatum                |             | 1  |    |    |    |    |    |     |   |   |   |   |   |
| Megachilidae  | Anthidium       | atripes                |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae  | Anthidium       | clypeodentatum         |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |   |   |   |   |
| Megachilidae  | Anthidium       | cockerelli             |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae  | Anthidium       | dammersi               |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae  | Anthidium       | duomarginatum          |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae  | Anthidium       | emarginatum            |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae  | Anthidium       | illustre                |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae  | Anthidium       | maculifrons            |             | 1  | 1  | 1  | 1  | *  |    |     |   |   |   |   |   |
| Megachilidae  | Anthidium       | maculosum              |             | 1  | 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  |    |    |     |   |   |   |   |   |
| Megachilidae  | Anthidium       | schwarzi                |             | 1  | 1  | 1  | 1  | *  |    |     |   |   |   |   |   |
| Megachilidae  | Ashmeadiella    | aridula                |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae  | Ashmeadiella    | bucconis               |             | 1  | 1  | 1  | 1  | *  |    |     |   |   |   |   |   |
| Megachilidae  | Ashmeadiella    | cactorum basalis       |             | 1  | 1  | 1  | 1  | 1  |    |     |   |   |   |   |   |
| Megachilidae  | Ashmeadiella    | californica            |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |   |   |   |   |
| Megachilidae  | Ashmeadiella    | gillettei              |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |   |   |   |   |
| Megachilidae  | Ashmeadiella    | melioli                |             | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |   |   |   |   |
| Megachilidae  | Ashmeadiella    | opuntiae               |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae  | Ashmeadiella    | sonora                 |             | 1  | 1  | 1  | 1  | 1  |    |     |   |   |   |   |   |
| Megachilidae  | Ashmeadiella    | timberlakei            |             | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae  | Ashmeadiella    | vandykiiellla           |             | 1  | 1  | 1  | 1  | *  |    |     |   |   |   |   |   |
| Family        | Genus          | Species/Morphospsecies | Subspecies | 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           |            |    |    |    |    |    |    |     |   |   |   |   |   |
| Megachilidae | Coelioxys      | porterae               |            | 1  | 1  | 1  |    |    |    |     |   |   |   |   |   |
| Megachilidae | Coelioxys      | rufitarsis             |            | 1  | 1  | 1  | 1  | 1  |    |     |   |   |   |   |   |
| Megachilidae | Coelioxys      | sodalis                |            |    |    |    |    |    |    |     |   |   |   |   |   |
| Megachilidae | Coelioxys      | 001                    |            | 1  | 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    | platyrum               |            | 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  |    |     |   |   |   |   |   |
| Megachilidae | Heriades       | cressoni               |            | 1  | 1  | 1  | 1  | 1  |    |     |   |   |   |   |   |
| Megachilidae | Heriades       | gracilior              |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae | Heriades       | microphalma            |            | 1  |    |    |    |    |    |     |   |   |   |   |   |
| Megachilidae | Heriades       | texana                 |            |    |    |    |    |    |    |     |   |   |   |   |   |
| Family       | Genus                | Species/Morphospecies | Subspecies | DS | DG | PJ | PP | MC | SF | NAU | O | C | F | R | A |
|--------------|----------------------|-----------------------|------------|----|----|----|----|----|----|-----|---|---|---|---|---
| Megachilidae | Heriades             | timberlakei           |            | 1  | 1  | 1  | 1  |     |     |     |   |   |   |   |   |
| Megachilidae | Heriades             | 002                   |            |    |    |    |    |     |     |     |   |   |   |   |   |
| Megachilidae | Hoplitis             | grinnelli             |            |    |    |    |    |     |     |     |   |   |   |   | 1 |
| Megachilidae | Hoplitis             | paroselae             |            | 1  |    |    |    |     |     |     |   *|   |   |   |   |
| Megachilidae | Hoplitis             | truncata mescalerium  |            |    |    |    |    |     |     |     |   |   |   |   | 1 |
| Megachilidae | Hoplitis             | zuni                  |            | 1  |    |    |    |     |     |     |   |   |   |   | 1 |
| Megachilidae | Hoplitis             | 001                   |            | 1  |    |    |    |     |     |     |   *|   |   |   |   |
| Megachilidae | Lithurgopsis         | apicalis              |            | 1  |    |    |    |     |     |     |   |   |   |   | 1 |
| Megachilidae | Lithurgopsis         | planifrons            |            | 1  |    |    |    |     |     |     |   |   |   |   | 1 |
| Megachilidae | Megachile            | agustini              |            | 1  |    |    |    |     |     |     |   *|   |   |   |   |
| Megachilidae | Megachile            | angelarum             |            | 1  |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | brevis                |            |    |    |    |    |     |     |     |   |   |   |   | 1 |
| Megachilidae | Megachile            | chilopсидis           |            | 1  |    |    |    |     |     |     |   *|   |   |   |   |
| Megachilidae | Megachile            | comata                |            | 1  |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | fidelis               |            | 1  |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | fortis                |            |    |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | frigida               |            | 1  |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | inimica sayi          |            | 1  |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | lapponica             |            |    |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | latimanus             |            |    |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | lippiae               |            | 1  |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | lobatifrons           |            | 1  |    |    |    |     |     |     |   *|   |   |   |   |
| Megachilidae | Megachile            | manifesta             |            |    |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | melanophaea           |            |    |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | mellitarsis           |            | 1  |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | montivaga             |            | 1  |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | mucida                |            |    |    |    |    |     |     |     |   *|   |   |   |   |
| Megachilidae | Megachile            | mucorosa              |            | 1  |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | onobrychidis          |            | 1  |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Megachilidae | Megachile            | perihirta             |            |    |    |    |    |     |     |     |   | 1 | 1 | 1 | 1 |
| Family     | Genus   | Species/Morphospecies | Subspecies | DS | DG | PJ | PP | MC | SF | NAU | O | C | F | R | A |
|------------|---------|-----------------------|------------|----|----|----|----|----|----|-----|---|---|---|---|---|
| Megachilidae | Megachile | policaris            |            | 1  |    |    |    |    |    |     |   |   |   |   |   |
| Megachilidae | Megachile | pugnata pomonae      |            | 1  |    |    |    | 1  |    |     |   |   |   |   |   |
| Megachilidae | Megachile | relativa             |            | 1  | 1  | 1  | 1  | 1  | 1  | 1   |   |   |   |   |   |
| Megachilidae | Megachile | sabinensis           |            | 1  |    |    | 1  |    |    |     |   |   |   |   |   |
| Megachilidae | Megachile | sidalceae            |            | 1  |    |    |    |    | 1  | 1   |   | * |   |   |   |
| Megachilidae | Megachile | snowi                |            | 1  |    | 1  |    |    |    |     |   |   |   |   |   |
| Megachilidae | Megachile | subexilis            |            | 1  |    | 1  |    | 1  | 1   |   |   |   |   |   |
| Megachilidae | Megachile | sublaurita           |            | 1  | 1  | 1  |    | 1  |    |     |   |   |   |   |   |
| Megachilidae | Megachile | texana               |            |    |    |    |    |    |    | 1   |   |   |   |   |   |
| Megachilidae | Megachile | 001                   |            | 1  |    | 1  |    |    |    | 1   |   | * |   |   |   |
| Megachilidae | Megachile | 002                   |            | 1  |    | 1  |    | 1  |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | albolateralis        |            | 1  |    |    |    |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | brevis               |            | 1  |    | 1  |    |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | bucephala            |            | 1  | 1  | 1  |    |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | coloradensis         |            | 1  |    | 1  |    | 1  |    | 1   |   |   |   |   |   |
| Megachilidae | Osmia    | densa                |            | 1  |    |    |    |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | juxta                |            | 1  |    | 1  |    | 1  |    | 1   |   |   |   |   |   |
| Megachilidae | Osmia    | lignaria             |            | 1  |    |    |    |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | liogastra            |            | 1  |    |    |    | 1  |    | 1   |   | * |   |   |   |
| Megachilidae | Osmia    | montana              |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | pentstemonis         |            | 1  |    |    |    |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | aff. pentstemonis    |            | 1  |    | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | simillima            |            | 1  | 1  | 1  |    | 1  |    | 1   |   |   |   |   |   |
| Megachilidae | Osmia    | subaustralis         |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | texana               |            | 1  | 1  | 1  | 1  | 1   |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | unca                 |            | 1  |    |    |    | 1  |    |     |   | * |   |   |   |
| Megachilidae | Osmia    | 002                   |            | 1  | 1  | 1  |    |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | 003                   |            | 1  |    | 1  |    | 1   |    |     |   | * |   |   |   |
| Megachilidae | Osmia    | 005                   |            | 1  | 1  | 1  |    |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia    | 006                   |            | 1  | 1  | 1  |    |    |    |     |   | * |   |   |   |
| Family       | Genus          | Species/ Morphospecies | Subspecies | DS | DG | PJ | PP | MC | SF | NAU | O | C | F | R | A |
|--------------|----------------|------------------------|------------|----|----|----|----|----|----|-----|---|---|---|---|---|
| Megachilidae | Osmia          | 007                    |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   | * |
| Megachilidae | Osmia          | 009                    |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia          | 010                    |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia          | 011                    |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   | * |   |
| Megachilidae | Osmia          | 012                    |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |
| Megachilidae | Osmia          | (Cephalosmia)          | 001        |    |    |    |    | 1  | 1  |     |   |   |   |   |   |
| Megachilidae | Osmia          | (Cephalosmia)          | 002        |    |    |    |    | 1  | 1  |     |   |   |   | * |   |
| Megachilidae | Osmia          | (Melanosmia)           | 001        |    |    |    |    | 1  | 1  |     |   |   |   | * |   |
| Megachilidae | Osmia          | (Melanosmia)           | 002        |    |    |    |    | 1  | 1  |     |   |   |   | * |   |
| Megachilidae | Paranthidium   | jugatorium             |            | 1  | 1  | 1  | 1  | 1  | 1  | 1  |   |   |   |   |   |
| Megachilidae | Stelis         | elegans                |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   | * |   |
| Megachilidae | Stelis         | rudbeckiarum           |            | 1  | 1  | 1  | 1  |    |    |     |   |   |   |   |   |

**Figure 3.**
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 Megachilidae 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](image-url)  
**Figure 4.** 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.
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.

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.

![Figure 6. 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).](Image)
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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 Francisco Peaks  
doi

Authors: McCabe et al  
Data type: occurrences  
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