 THE VASCULAR FLORA OF THE HUMMINGBIRD SPRINGS WILDERNESS, MARICOPA COUNTY, ARIZONA

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ABSTRACT

The goal of this study was to inventory the vascular plants of the Hummingbird Springs Wilderness (HSW), an area covering 31,000 acres of the Sonoran Desert and located about 60 miles west of Phoenix, Arizona. In order to obtain an accurate biodiversity assessment, plants were collected in the field from January 2006 to December 2007, in a variety of vegetation zones (defined by different parameters such as elevation, aspect, or soil) in all seasons. In addition, samples of the seed bank were collected from several locations, and grown in conditions similar to a wet year in the field. A total of 270 species were collected belonging to 64 families, including 199 genera. Five families accounted for 46% of the collection: Asteraceae (38 genera, 49 species), Poaceae (20 genera and 31 species), Fabaceae (13 genera and 19 species), Boraginaceae (six genera and 13 species) and Euphorbiaceae (five genera and 12 species). Thirty-six species were collected from the greenhouse, including six species that were not collected in the field but are now presumed to grow in HSW. The flora of the Hummingbird Springs Wilderness provides a plant community snapshot that can be used in the future by a variety of researchers and government agencies.

INTRODUCTION

At a time when biodiversity is threatened by habitat loss, invasive species, and human impacts, lands designated as wilderness are important as a refugia for species, and may be examples of less disturbed ecosystems. With the passing of the 1990 Arizona Desert Wilderness Act, over two million acres of desert terrain were set aside throughout the state, increasing the total acreage of protected land to 4.8 million acres (Warren 2002). The passage of the act created nineteen areas managed by the Bureau of Land Management (BLM), including Hummingbird Springs Wilderness (HSW).

Although there have been many floras completed in Arizona, there have been no plant checklists or floristic studies done within twenty-five miles of the Wilderness (Moore and Cole 2004). In fact, most localities in western Arizona are sparsely documented botanically compared to the rest of the state. Prior to the creation of this flora, less than 40 plant species had been collected in the Hummingbird Springs Wilderness and nearby areas, with the most recent collection in 1996 by BLM botanist John Anderson (SEINet 2008). Floras completed nearest to HSW include the White Tank Mountains Regional Park and the Buckeye Hills.
Recreational Area. A flora is in progress at the Eagletail Mountains Wilderness.

STUDY AREA

Overview — Hummingbird Springs Wilderness is located about 60 miles west of Phoenix in the Sonoran Desert, and about 11 miles north of Interstate 10 and the town of Tonopah. Nearby ranges include the Harquahala Mountains to the northwest, and the Eagletail Mountains to the southwest. The Wilderness boundary outlines over 31,000 acres and is accessible from the north and south by gravel roads. The topography varies greatly, containing 8 miles of the Big Horn Mountain Range with the peak elevation at Sugarloaf Mountain (3,418 ft) and the low valleys at 1,550 ft.

Seasonal water sources throughout the Wilderness include Hummingbird Springs, livestock tanks and washes. Several wells have been built in the past and still exist today for a variety of purposes. Within three miles of Sugarloaf Mountain is a large mine owned by the federal government, nicknamed the Belmont Pit. It actively mines gold, copper, silver, and lead (USBM 1994). Arizona had an extensive mining boom that started in the 1870s, and several inactive mines dot the area around the Wilderness (Trimble 2004).

Geology and Soils — The HSW contains six different geological units defined by geological age and type, ranging in age from the middle Pleistocene Epoch (0.78 to 0.13 Mya) to the early Proterozoic Eon (1650-1800 Mya). Volcanic rocks, granitoid rocks and older surficial deposits dominate the landscape of HSW. Other minor layers consist of sedimentary rocks, metamorphic rocks such as gneiss, and granitoid rocks such as granite, quartz diorite and gabbro (Reynolds 1988).

Two soil associations are dominant in Hummingbird Springs Wilderness. The first is the Gunsight-Rillito-Pinal Association (HA4) that includes well-drained, limey, gravelly soils on alluvial surfaces and valley slopes. Calcareous mixed alluvium resulting from volcanic rocks, schist, limestone, and granite formed the soils of HA4. Shallow depth and low water capacity in the Pinal soils restrict plant growth (Hendricks 1986). The second soil association, Lithic Camborthids-Rock Outcrop-Lithic Haplargids (HA6), consists of gravelled and cobbled shallow sloping soils, and rock outcrops on hills and low mountains. Because of the steep and rocky terrain, livestock grazing on this soil association is minimal. Weathered materials from granitic rocks, schists, basalt, volcanic tuffs and conglomerates, sandstone and some shale formed the soils of HA6 (Hendricks 1986).

Climate — The weather in central Arizona was dry and hot during the period of collection for this flora, which was conducted from the January 2006 to December 2007. The longest drought ever recorded in Arizona occurred from October 18, 2005 to March 11, 2006 lasting 143 days (Giblin 2006). HSW has a similar climate to that of the city of Phoenix, with the Wilderness climate being drier and less predictable from year to year. The average temperatures range from 106.5 °F in July to 36.4 °F in December, with recorded extremes of 121 °F and 14 °F (WRCC 2008). Precipitation averages from 1.18 inches (3 cm) in August to 0.03 inches (0.1 cm) in May with recorded extremes of 4.84 inches (12.3 cm) and 0.00 inches (0 cm) (WRCC 2008). In the town of Tonopah, 11 miles south of HSW,
temperatures reached a record high mean of 92.5 °F in the summer of 2006 (June, July, August) compared to the summer average of 89 °F. In the winter (December, January, February) of 2006, precipitation hit a record low of 1.05 inches (2.7 cm), compared to the winter average of 2.98 inches (7.6 cm) in Tonopah (WRCC 2008).

**Fauna**—The Sonoran Desert is home to a diversity of mammals, reptiles, birds and insects. Those noted while plant collecting include mule deer, jackrabbits, roadrunners, tarantulas, desert tortoises, rattlesnakes, and various other birds and lizards. Many other species typical of the Sonoran Desert are most likely present, including javelina, coyote and vultures.

Two introduced animals are also prominent in the landscape surrounding and inside the Wilderness: wild burros and cattle. About 1500 wild burros are estimated to live in Arizona. Since the land in the area is owned by the BLM, wild burro herds and the permits for cattle grazing are regulated by this agency. Although the HSW area is not managed for wild burros, a small herd (estimated at 47) has been documented in the Harquahala Mountains to the northwest. Another 100 burros do not fall into a particular herd, but roam the areas outside herd management (BLM 2008). While the Wild Horse and Burro Act of 1971 provides federal protection for wild burros, they cause problems for native wildlife and can therefore affect ecosystem health (Bleich 2005).

Cattle grazing became a large industry in Arizona in the 1880s and continues to varying degrees today (Trimble 2004). Due to the long-standing tradition of open cattle grazing, it is not surprising that when wilderness areas were created, grazing was not banned. In fact, according to the Wilderness Act of 1964, grazing levels established prior to wilderness designation must be maintained. Active sheep and cattle grazing is present in about 35% of wilderness areas in the western states, and threatens native plant and animal life (Cole and Landres 1996).

Three grazing allotments outlined by the BLM include parts of the HSW and the nearby land: Aguila, Ohaco and Echeverria. These areas are allowed a certain number of cattle per month within the assigned acreage according to the amount of forage available, measured in Animal Unit Months (AUMs) (Bedell 1992). In total, over 7000 AUMs are given for over 275,000 acres within and around HSW. The actual number of cattle present on these acres is 630, which are allowed to roam in and around the Wilderness (BLM RAS 2008).

**Vegetation**—The Sonoran Desert is a Tropical-Subtropical Desertland (Brown 1994). The Hummingbird Springs Wilderness boundary encompasses two distinct vegetation zones of the Sonoran Desert: Arizona Upland Sonoran Desertscrub (Fig. 1A), and Lower Colorado River Sonoran Desertscrub, as defined by Brown and Lowe (1980).

The HSW area primarily contains plant communities common to the Arizona Upland division of the Sonoran Desert. The landscape is a scrubland of armed leguminous trees and intervening spaces filled with perennial shrubs and cacti. The most common plant association in the HSW area is Paloverde-Cacti-Mixed Scrub, in which the dominant species are Paloverde (*Parkinsonia microphylla*), Saguaro (*Carnegiea gigantea*) and Creosote (*Larrea tridentata*). Many other species are common and can become dominant in localized areas including Triangle Leaf...
Bursage (*Ambrosia deltoidea*), White Thorn Acacia (*Acacia constricta*), Teddy Bear Cholla (*Cylindropuntia bigelovii*; Fig. 1B), and Ocotillo (*Fouquieria splendens*).

Other plant associations in the area, in this Arizona Upland division, are less common but are present in small pockets. The eastern edge of the Wilderness contains a Jojoba-Mixed Scrub community, with the dominant species being Jojoba (*Simmondsia chinensis*), but also includes many of the species mentioned above. Other areas include stands of Creosote and Crucifixion Thorn (*Canotia holacantha*), or hillsides of Brittlebush (*Encelia farinosa*). Large Ironwood trees (*Olneya tesota*) are more commonly seen in the southern portion of the wilderness, along with Saguaro and perennial shrubs.

As a person travels south, it becomes evident that the plant communities are changing, becoming less dense and adapting to an area of lower elevation and drier climate. This transition between the two divisions of the Sonoran Desert is gradual and in HSW, plant associations of the two divisions can be found overlapping throughout its center section.

Across the Wilderness, ephemeral and annual species are present after late summer monsoons or winter rains, but the recent drought created a limited estimate of these species in this study. Those that are common to the Wilderness even in dry years include grasses such as *Schismus* spp., members of Boraginaceae such as *Cryptantha* spp., and members of Euphorbiaceae such as *Chamaesyce* spp.

The southeastern portion of the HSW is sparse and contains plant communities common to the Lower Colorado River division of the Sonoran Desert (Brown 1994). Sections of desert pavement dot the area, with expanses of perennial shrubs such as Creosote and White Bursage (*Ambrosia dumosa*) throughout. The larger washes in this area house other more water dependent species, such as Paloverde, White Thorn Acacia and Ironwood.

**METHODS**

Plants were collected in the field (Fig. 2A) at least once a month throughout the floristic study (January 2006 to December 2007), with more frequent collecting during peak growing seasons or after heavy rains. A total of 29 days were spent in the field gathering plants and hiking the Wilderness. With each collection, location and elevation were recorded using a GPS, and associated species, habitat description and relative abundance were noted. With the goal of visiting every section within the Wilderness boundary, a variety of vegetation zones were surveyed in all seasons as defined by different parameters such as elevation, aspect or soil. Some areas of the Wilderness were not surveyed due to limited access and time constraints.

Specimens were identified using *Arizona Flora* (Kearney and Peebles 1960) with appropriate revisions and updates from the Flora of Arizona Project in the *Journal of Arizona-Nevada Academy of Science* and *Canotia* (www.canotia.org). Nomenclature, author names and abbreviations follow the United States Department of Agriculture’s National Plants Database (USDA 2008), with exceptions for certain species when the new treatments for Arizona were available. Experts including Elizabeth Makings and Dr. Leslie Landrum were consulted as needed for particular genera, and species identification was verified using the Arizona State University
Herbarium collections. Over 800 voucher specimens were made and are housed in the ASU Herbarium.

**Greenhouse Methods**—In the fall of 2005, when the planning of the floristic study began, Arizona experienced the driest winter ever recorded. In dry years, the ephemerals in the area are not likely to germinate. To capture the diversity of the ephemerals, samples of the seed bank were collected and grown in a greenhouse on the ASU campus. Previous studies have shown that in desert soils, the seed bank is present in the top two centimeters of the soil (Reichman 1984). Samples were collected in the field twice in 2006 and twice in 2007, at various locations in the Wilderness (Fig. 2B). Several microhabitats were sampled with an effort made to minimize the impact of soil removal. The greenhouse conditions were maintained to mimic wet seasons in the field, with frequent watering and approximate field temperatures. Each soil sample was evenly distributed over a mix of sterile soil and coarse sand in a 13 by 9 inch tray, with a total of 29 sample trays and two control trays containing only soil and coarse sand (Fig. 1C). Soil samples were between 100 and 200 cm³. Specimens grown from seed were collected, pressed and identified in the same manner as the field collections as soon as they reached reproductive maturity. The greenhouse study began in February 2006 and continued through November 2007. Voucher specimens were made of each species from each sample site and are housed at the ASU Herbarium.

**RESULTS AND DISCUSSION**

Plant collecting in and around the boundaries of HSW yielded 864 individual collections. A total of 270 species were collected belonging to 64 families, including 199 genera (Table 1). Five families accounted for 46% of the collection: Asteraceae (38 genera, 49 species), Poaceae (20 genera and 31 species), Fabaceae (13 genera and 19 species), Boraginaceae (six genera and 13 species) and Euphorbiaceae (five genera and 12 species).

**Table 1.** Taxonomic* composition of the 864 collections from HSW.

<table>
<thead>
<tr>
<th>Taxonomic Group</th>
<th>Families</th>
<th>Genera</th>
<th>Species Native</th>
<th>Species Introduced</th>
<th>Species Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pteridophyta</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Lycopsodiophyta</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pinophyta: Gnetopsida</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Magnoliophyta</td>
<td>61</td>
<td>193</td>
<td>243</td>
<td>19</td>
<td>262</td>
</tr>
<tr>
<td>Magnoliopsida</td>
<td>57</td>
<td>170</td>
<td>217</td>
<td>11</td>
<td>228</td>
</tr>
<tr>
<td>Liliopsida</td>
<td>4</td>
<td>23</td>
<td>26</td>
<td>8</td>
<td>34</td>
</tr>
<tr>
<td><strong>Column Total</strong></td>
<td><strong>64</strong></td>
<td><strong>199</strong></td>
<td><strong>251</strong></td>
<td><strong>19</strong></td>
<td><strong>270</strong></td>
</tr>
</tbody>
</table>

*Species characteristics from USDA PLANTS database (2008)
The origin of each species was determined using the USDA PLANTS database. Species are considered “native” when we presume they were present at the time of Columbus (USDA 2008). Introduced species (Table 2) reproduce spontaneously in the wild and are believed to have arrived in the U.S after the time of Columbus. Nineteen of the species collected (7%) are listed as introduced to Arizona, eight of these from Poaceae. One genus, *Cuscuta* is listed as a prohibited, restricted noxious weed in the U.S, even though it is a native species. In California, *Orobanche cooperi* is listed as a noxious weed due to its parasitic nature. All *Tamarix* species are listed as noxious weeds in several states including Nevada, but not in Arizona or California (USDA 2008).

Table 2. Introduced species collected in or around HSW.

<table>
<thead>
<tr>
<th>Species</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Amaranthus albus</em></td>
<td><em>Phalaris minor</em></td>
</tr>
<tr>
<td><em>Brassica tournefortii</em></td>
<td><em>Polygonum argyrocoleon</em></td>
</tr>
<tr>
<td><em>Bromus rubens</em></td>
<td><em>Polypleogon monspeliensis</em></td>
</tr>
<tr>
<td><em>Chenopodium murale</em></td>
<td><em>Schismus arabicus</em></td>
</tr>
<tr>
<td><em>Cynodon dactylon</em></td>
<td><em>Schismus barbatis</em></td>
</tr>
<tr>
<td><em>Echinochloa crus-galli</em></td>
<td><em>Sisymbrium altissimum</em></td>
</tr>
<tr>
<td><em>Eragrostis cilianensis</em></td>
<td><em>Sisymbrium irio</em></td>
</tr>
<tr>
<td><em>Erodium cicutarium</em></td>
<td><em>Sonchus oleraceus</em></td>
</tr>
<tr>
<td><em>Gossypium hirsutum</em> (agricultural escape)</td>
<td><em>Tamarix chinensis</em></td>
</tr>
<tr>
<td><em>Malva parviflora</em></td>
<td></td>
</tr>
</tbody>
</table>

The Arizona Wildlands Invasive Plant Working Group (AWIPWG), a group made up of over 20 federal and state agencies, created a list recording invasive species, with rankings of high, medium, and low, depending on their impact and ability to invade plant communities. Species that are of high concern are *Bromus rubens* and *Tamarix* spp. due to their severe ecological impact, wide distribution, and high rates of dispersal and establishment. Species of medium concern that have substantial ecological impacts, moderate rates of dispersal often enhanced by disturbance, and a generally limited distribution are: *Brassica tournefortii, Cynodon dactylon, Erodium cicutarium, Schismus* spp. and *Sonchus oleraceus* (AWIPWG 2008).

Invasive plants reported in Sonoran Desert wildernesses such as *Bromus rubens* and *Brassica tournefortii* can affect fire regimes. Others, like *Tamarix* spp., alter hydrology (Marler 2000). According to a recent study, invasive species are not in the top ten priorities for wilderness management for 90% of managers surveyed in the southwest. About 40% of respondents did not even have any information about invasive species in their wilderness areas (Marler 2000). HSW was included on the list of participating wilderness areas in the survey. Thus, this is the first report of invasive species within the HSW.

In comparison to other published floras in the Sonoran Desert, the flora of HSW has an average to low percent of invasive species (7%), most likely due to its
distance from major cities or lack of water sources. Other invasive species percentages include 10% at Phoenix South Mountain Park (Daniel and Butterwick 1992), 11% at Sierra Estrella Mountains Regional Park (Sundell 1974), 6.7% at White Tank Mountains Regional Park (Keil 1973), and 8% at McDowell Mountain Regional Park (Lane 1981).

In addition to collecting plants within the HSW, plants were collected in the surrounding areas when opportunities presented themselves. These collections added a few species to the total found and are considered to probably grow within the HSW. One species that was found in abundance outside the Wilderness but not found within is *Castela emoryi*. It is included in the flora list as a probable species.

This study adds no new or threatened species to the flora of Arizona but there are a few notable collections. One species, *Glinus radiatus* (spreading sweetjuice, Molluginaceae; Fig. 1D) has only been collected a few times in the state in places over 50 miles from HSW in areas near McDowell Mountain Park, Nogales and Cabreza Prieta Game Range (SEINet 2008). It is usually found at the bottom of drying ponds or tanks, and flowers during late summer. In HSW it was found in Dead Horse Tank, a large dry cow tank, in May 2007. This collection may represent an extension of its range.

Another interesting collection was of *Gossypium hirsutum* (upland cotton, Malvaceae), found in October 2006, in a roadside wash. Cotton is grown in fields south of the Wilderness near Tonopah and seems to have migrated via wind or by vehicle to the vicinity of HSW. This agricultural escape has not been seen in other floras and *Gossypium hirsutum* has only been collected in the wild twice in Arizona (SEINet 2008). Cotton has been an important crop in Arizona since 1916, and in 2007 about 190,000 acres were grown. Over 40 strains of cotton are in use across Arizona, but most of these are varieties of *Gossypium hirsutum* (CALSMART 2008).

Previous plant collections in HSW and the surrounding area are sparse. In comparing the species previously collected with the more complete checklist created as a result of this study, it was found that nearly all the species were recollected. Those that were not found in the present study are: *Gaillardia arizonica* (Asteraceae), *Rafinesquia californica* (Asteraceae), *Astragalus nuttallianus* (Fabaceae), *Calliandra eriophylla* (Fabaceae), and *Prunus fasciculata* (Rosaceae). These plants may still be present in HSW but perhaps were not found due to variations in climate, collection locations, or accessibility. For example, *R. californica* is most likely present but was not found due to the drier than average climate conditions. Another possibility is that these species are locally uncommon or no longer occur in the area.

Two areas thought to be similar to the HSW are the Kofa National Wildlife Refuge (KNWR), which is located to the southwest of HSW and has a high elevation of 4,877 ft, and the Sierra Estrella Mountain Range (SEMR), located to the southeast with a high elevation of 4,511 ft. These two places are also in the Sonoran Desert and have similar climate conditions although their elevation is higher than that of HSW. Twenty-seven species that have been collected during this study, in the HSW vicinity, have not been found in either the Kofa or Sierra Estrella regions (Russo 1987, SEINet 2008, Sundell 1974). These species are listed in Appendix A.
and represent those species that are perhaps difficult to find, rare or uncommon or are outside of their usual range. For example, one of these species, *Echinomastus johnsonii*, is typically found in the Mojave Desert and is therefore uncommon in the Sonoran Desert.

Of the 186 species found in both the KNWR and the SEMR, 37 were not found in HSW (Russo 1987, SEINet 2008, Sundell 1974). These plants are likely to be found in the HSW area, and are predicted to be part of the HSW flora (Appendix A). Future collectors are urged to search for them.

This flora study aimed to collect in all habitats across the HSW area, but inevitably, not every inch of the Wilderness can be explored. The western area of the Wilderness is difficult to access, as are the jagged peaks in the southeastern portion. Also, the drought during the study greatly restricted the diversity of winter and spring ephemerals. Continuing collection of this area and those places nearby will create a more complete picture of the flora.

**Greenhouse Results and Discussion**—The soil samples collected from HSW contained enough viable seeds to produce 374 greenhouse collections with a total of 36 species plus two species that are unlikely to have come from the field: *Oxalis corniculata* and *Nicotiana benthamniana*. The first is a greenhouse weed and the second escaped from another study in the greenhouse.

Only one out of the seven soil locations was free of any invasive species. A little over 25% (11) of the species collected are invasive species. Six species were not collected in the field but are now presumed to grow in HSW. Appendix B contains a complete list of greenhouse species.

The greenhouse study was carried out in order to add a few more species to the flora list that may not be collected in a drought year. It was a small study and only one type of climate regime was implemented. In order to germinate more species, many more soil samples should be taken, using various treatments to generate the largest amount of species. One species, *Sonchus oleraceus*, was originally present in only one tray until it spread profusely to every other tray in the room. In future studies, great care should be taken to avoid contamination by collecting specimens before mature seeds are produced. Another species, *Oxalis corniculata*, most likely does not occur in the HSW area, though it was present in every sample tray. It is a common greenhouse weed and spreads quickly. Towards the end of the study, *Sonchus* and *Oxalis* were weeded out in order to stop their continuing germination cycle. The two control trays containing sterile soil had only these two problematic species, illustrating that they originated from the greenhouse and not from the soil samples.
CATALOG OF THE VASCULAR FLORA OF THE HUMMINGBIRD SPRINGS WILDERNESS

Taxa are arranged alphabetically by family, genus and then by species. Nomenclature, author names and abbreviations follow the USDA PLANTS Database (2008), with exceptions for certain species when the new treatments for Arizona were available in the Journal of Arizona-Nevada Academy of Science and in Canotia. This database also provided common names and the origin of each species. Parts of the checklist are described below:

A. Plants that are considered non-native in North America, are listed as “INTRODUCED” after the authority. Plants are called native if they are presumed to have been present before the time of Columbus.
B. Common names are given as listed in USDA PLANTS Database (2008).
C. General habitat is given along with collection localities (see Fig. 2C) to indicate where the species is most likely to be found. Collection localities are variable in size and sometimes cover several hectares.
D. Collection numbers are from the field unless preceded by “G” which indicates they are collections from the greenhouse study. The primary collector for all collections is the author and all are deposited at the Arizona State University Herbarium.
E. The abundance determinations are based on field observations taken over the duration of the study (January 2006 to December 2007) and is rated subjectively using terms and definitions adapted from Palmer et al. (1995) are as follows: Abundant = dominant or co-dominant in one or more common habitats; Frequent = easily found in one or more common habitats, but not dominant; Occasional = widely scattered but not difficult to find; Infrequent = difficult to find with few individuals or colonies, found in several locations; Rare = very difficult to find, limited to one/few locations or uncommon habitats; Absent = found only in a previous survey from the same or similar sites.

Acanthaceae

Agavaceae

Amaranthaceae

Anacardiaceae

Apiceae

Aristolochiaceae


Asclepiadaceae


Asteraceae

Baccharis sarothroides A. Gray. Desert broom. Rocky slopes, gravel parking lot, large wash. Frequent. MT, DHT, OCW: 29, 365, 432, 727, G266.
Gutierrezia serotina Greene. Late snakeweed. Dusty roadside. Rare. AG: 776.


Monophtilon bellioides (A. Gray) H. M. Hall. Mojave desertstar. Flat dry rocky area, wash.


Senecio flaccidus Less. var. monoensis (Greene) B. L. Turner & T. M. Barkley. Smooth threadleaf ragwort. Large gravel wash. Infrequent. EER: 716.


Trichoptilium incisum (A. Gray) A. Gray. Yellow dome. Low desert hills, washes. Rare. SPR: 1.


Berberidaceae


Bignoniaceae

Chilopsis linearis (Cav.) Sweet. Desert willow. Large gravel wash. Rare. EER: 717.

Boraginaceae


Amsinckia tessellata A. Gray. Bristly fiddleneck. Large open gravel wash. Rare. EER: 590.

Cryptantha engustifolia (Torr.) Greene. Panamint cryptantha. Large open gravel wash. Rare. EER: 574b.


DHT, SPR, EER: 72, 512, 670, 848.


Pectocarya sp. DC. ex Meisn. Comseed. Flat wash. MT: 54.


Brassicaceae

Arabis sp. L. Rockcress. SM: 821b.


Brassica tournefortii Gouan INTRODUCED. Asian mustard. Large gravel wash, rocky area.

Occasional. SPR, EER: 183, 484, 676, G46, 79d, G365, G366.

Descurainia pinnata (Walter) Britton. Western tansy mustard. Large wash. Rare. SPR: 556, 626, G104.


Sisymbrium irio L. INTRODUCED. London rocket. Low desert hills, dry tank bed, large wash.


Cactaceae


Campanulaceae

Caryophyllaceae

Celastraceae

Chenopodiaceae


Chenopodium murale L. INTRODUCED. Nettleleaf goosefoot. Flat dry rocky area. Infrequent. SPR: 661.


Crossosomataceae

Cucurbitaceae

Cuscutaceae
Cuscuta umbellata Kunth. Flatglobe dodder. Gravel roadside. Rare. MT: 862.

Ephedraceae


Euphorbiaceae


**Fabaceae**


Hoffmannseggia glauca (Ortega) Eifert. Indian rushpea. Flat dusty area, roadside. Rare. AG: 599, 775.


Lotus rigidus (Benth.) Greene. Coastal bird's foot trefoil. Large rocky wash. Rare. SM, OCW: 516, 720.


Olneya tesota A. Gray. Desert ironwood. Gravel road, large gravel wash. Abundant. MT, SPR, OCW: 175, 204, 737.

Parkinsonia florida (Benth. ex A. Gray) S. Watson. Blue paloverde. Roadside, recently flooded, large gravel wash. Abundant. EER, SPR, OCW: 284, 320, 739.


Fagaceae
Quercus turbinella Greene. Sonoran scrub oak. Large rocky wash. Rare. SM: 520, 798.

Fouquieriaceae

Gentianaceae

Geraniaceae


Hydrophyllaceae


Krameriaceae


Lamiaceae


Liliaceae
Loasaceae

Malpighiaceae

Malvaceae
Gossypium hirsutum L. AGRICULTURAL ESCAPE. Upland cotton. Large wash. Rare. EER: 382.

Martyniaceae

Molluginaceae
Glinus radiatus (Ruiz. & Pav.) Rohrb. Spreading sweetjuice. Dusty dry tank bed. Rare. DHT: 713.

Nyctaginaceae
Mirabilis sp. L. Four o'clock. Small wash near road, rocky ridgeline. SM, SPR: 98, 324.

Oleaceae
Forestiera shrevei Standl. Desert olive. Large rocky wash, north slope. Rare. SM: 465, 469, 523, 641.

Onagraceae
Camissonia brevipes (A. Gray) P. H. Raven. Yellow cups. Large gravel wash. Rare. EER: 856.

Orobanchaceae

Papaveraceae
Argemone gracilenta Greene. Sonoran prickly poppy. Flat open dusty area. Rare. AG: 600.
Plantaginaceae


Plantago patagonica Jacq. Woolly plantain. Gravel roadside, dry tank bed, south rocky slope. Frequent. EER, MT, SM, DHT, SPR: 53a, 57a, 78a, 126, 554a, 645, G313, G314, G320, G64.

Poaceae


Bouteloua barbata Lag. Sixweeks grama. Large wash, gravel roadside, wet area near tank. Frequent. SM, SPR, MT, OCW: 8, 81, 260, 289, 734.


Digitaria californica (Benth.) Henr. Arizona cottontop. Rocky bank of large wash. Occasional. MT, SM: 408, 792.

Echinochloa crus-galli (L.) P. Beauv. INTRODUCED. Barnyard grass. Roadside, recently flooded. Rare. EER: 287.


Leptochloa panicea (Retz.) Ohwi. Mucronate sprangletop. Large wash. Rare. EER: 306.

Leptochloa viscida (Scribn.) Beal. Sticky sprangletop. Disturbed muddy area. Rare. DHT: 366.


Muhlenbergia microsperma (DC.) Trin. Littleseed muhly. Large gravel wash, north rocky slope. Frequent. MT, SM: 3, 111, 421, 527, 625, 703, G42.


Phalaris minor Retz. INTRODUCED. Littleseed canary grass. Large gravel wash. Rare. SPR: 190.


Polypogon monspeliensis (L.) Desf. INTRODUCED. Annual rabbit's foot grass. Dry tank bed, large gravel wash. Occasional. DHT, SPR: 117, 212.


Polemoniaceae


Polygonaceae


Eriogonum fasciculatum Benth. Eastern Mojave buckwheat. Rocky slopes, gravel parking lot, large gravel wash. Frequent. MT, SPR, OCW: 30, 211, 401a, 749.


Portulacaceae


Primulaceae

Androsace occidentalis Pursh. Western rock jasmine. Rocky area, near small wash. Rare. SM: 510.

Pteridaceae


Ranunculaceae

**Rhamnaceae**


**Rubiacene**


**Salicaceae**


**Scrophulariaceae**


**Selaginellaceae**


**Simaroubaceae**


**Simmondsiaceae**


**Solanaceae**


Tamaricaceae
*Tamarix chinensis* Lour. INTRODUCED. Five-stamen tamarisk. Large gravel wash. Rare. SPR: 156, 231.

Typhaceae
*Typha domingensis* Pers. Southern cattail. Large gravel wash. Rare. SPR: 221.

Ulmaceae

Urticaceae

Verbenaceae

Viscaceae

Zygophyllaceae
Vascular Flora of Hummingbird Springs. Figure 1. (A) Large wash in Hummbird Springs Wilderness representing Arizona Upland Sonoran Desertscrub with Paloverde, White Thorn Acacia and Creosote; (B) Large stand of Teddy Bear Cholla (*Cylindropuntia bigelovii*) with the Big Horn Mountains in the background; (C) Seedlings in Greenhouse Study; (D) *Glinus radiatus* in May 2007 at Dead Horse Tank.

Vascular Flora of Hummingbird Springs. Figure 2. (A) Field Collection Points. The size of the circle is relative to the number of collections at that point; (B) Soil Sample Collections Sites for greenhouse study. Minor roads and major streams (Tiger Wash on the left and Jackrabbit Wash on the right) are also shown; (C) General Collection Localities in Hummingbird Springs Wilderness. Abbreviations used: OCW = Old Camp Well, EER = Eagle Eye Road area (where it crosses Tiger Wash and Pump Mine Wash), MT = Microwave tower, SM = Sugarloaf Mountain, SPR = Hummingbird Springs, AG = Aguila Road area.
ACKNOWLEDGEMENTS

I would like to thank my advisors and co-chairs Dr. Les Landrum and Dr. Marty Wojciechowski and committee member Elizabeth Makings for guidance, wisdom and support through this process. Thank you to the many people who helped collect plants in the field and edit drafts including Frank Farruggia, Jennifer Riddell and my sister Christina Lund. I hope this flora will be useful to researchers and fellow botanists in the future and that more people come to love the Hummingbird Springs Wilderness as I have.

LITERATURE CITED


**APPENDIX A: COMPARISONS BETWEEN FLORAS**

Species found in the Kofa National Wildlife Refuge and in the Sierra Estrella Mountains, but not found in Hummingbird Springs Wilderness.

<table>
<thead>
<tr>
<th>Family</th>
<th>Species Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Asclepiadaceae</strong></td>
<td><em>Asclepias albicans</em> S. Watson</td>
</tr>
<tr>
<td><strong>Asteraceae</strong></td>
<td><em>Brickellia atractyloides</em> A. Gray, <em>Chaenactis carphoclinia</em> A. Gray, <em>Malacothrix sonorae</em> W. S. Davis &amp; P. H. Raven</td>
</tr>
<tr>
<td><strong>Boraginaceae</strong></td>
<td><em>Cryptantha decipiens</em> (M. E. Jones) A. Heller</td>
</tr>
<tr>
<td><strong>Cactaceae</strong></td>
<td><em>Peniocereus greggii</em> (Engelm.) Britton &amp; Rose</td>
</tr>
<tr>
<td><strong>Euphorbiaceae</strong></td>
<td><em>Bernardia myricifolia</em> (Scheele) S. Watson</td>
</tr>
<tr>
<td><strong>Fabaceae</strong></td>
<td><em>Astragalus nuttallianus</em> D. C., <em>Lupinus arizonicus</em> (S. Watson) S. Watson</td>
</tr>
<tr>
<td><strong>Grossulariaceae</strong></td>
<td><em>Ribes quercetorum</em> Greene</td>
</tr>
<tr>
<td><strong>Hydrophyllaceae</strong></td>
<td><em>Phacelia cryptantha</em> Greene, <em>Phacelia rotundifolia</em> Torr. ex. Watson</td>
</tr>
<tr>
<td><strong>Lamiaceae</strong></td>
<td><em>Hedeoma nana</em> (Torr.) Briq</td>
</tr>
<tr>
<td><strong>Loasaceae</strong></td>
<td><em>Mentzelia involucrata</em> S. Watson, <em>Mentzelia affinis</em> Greene</td>
</tr>
<tr>
<td><strong>Papaveraceae</strong></td>
<td><em>Eschscholzia minutiflora</em> S. Watson</td>
</tr>
<tr>
<td><strong>Polygonaceae</strong></td>
<td><em>Eriogonum thomasii</em> Torr.</td>
</tr>
<tr>
<td><strong>Pteridaceae</strong></td>
<td><em>Astrolepis sinuata</em> (Lag. ex. S. W.) Benham &amp; Windham, <em>Cheilanthes villosa</em> Davenport ex. Mason</td>
</tr>
<tr>
<td><strong>Ranunculaceae</strong></td>
<td><em>Delphinium parishii</em> A. Gray</td>
</tr>
<tr>
<td><strong>Resedaceae</strong></td>
<td><em>Oligomeris linifolia</em> (Vahl) J. F. Macbr.</td>
</tr>
<tr>
<td><strong>Scrophulariaceae</strong></td>
<td><em>Mimulus guttatus</em> D. C.</td>
</tr>
<tr>
<td><strong>Solanaceae</strong></td>
<td><em>Lycium andersonii</em> A. Gray</td>
</tr>
<tr>
<td><strong>Sterculiaceae</strong></td>
<td><em>Ayenia filiformis</em> S. Watson</td>
</tr>
</tbody>
</table>

* indicates this species has been collected in greenhouse from seed bank samples only.
**indicates this species is not likely part of the flora, but is a greenhouse weed.
Species that are in Hummingbird Springs Wilderness, but have not been found in the Kofa National Wildlife Refuge or in the Sierra Estrella Mountains.

**Apiaceae**
Yabea microcarpa (Hook. & Arn.) Koso-Pol.

**Asteraceae**
Machaeranthera tagetina Greene
Gutierrezia serotina Greene
Brickellia frutescens A. Gray
Lasthenia californica DC. ex Lindl.
Senecio flaccidus var. monoensis (Greene) B. L. Turner & T. M. Barkley

**Brassicaceae**
Sisymbrium altissimum L.

**Cactaceae**
Echinomastus johnsonii (Parry ex Engelm.) E. M. Baxter

**Euphorbiaceae**
Chamaesyce micromera (Boiss. Ex Engelm.) Woot. & Standl.

**Fabaceae**
Desmodium procumbens (Mill.) Hitchc.
Hoffmannsseggia glauca (Ortega) Eifert
Lotus humistratus Greene
Vicia ludoviciana Nutt. ssp. ludoviciana

**Malvaceae**
Gossypium hirsutum L.

**Molluginaceae**
Glinus radiates (Ruiz & Pav.) Rohrb.

**Onagraceae**
Epilobium ciliatum Raf.*

**Oxalidaceae**
Oxalis corniculata L.**

**Papaveraceae**
Eschscholzia glyptosperma Greene

**Poaceae**
Muhlenbergia appressa C. O. Goodding
Eragrostis cilianensis (All.) Vign. ex Janchen
Pleuraphis mutica Buckley
Vulpia microstachys (Nutt.) Munro

**Polemoniaceae**
Gilia minor A. D. Grant & V. E. Grant

**Primulaceae**
Androsace occidentalis Pursh

**Rubiaceae**
Galium aparine L.

**Simmaroubaceae**
Castela emoryi (A. Gray) Moran & Felger

**Solanaceae**
Lycium cooperi A. Gray

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### APPENDIX B: Species Collected in the Greenhouse Study

Table listing species collected in the greenhouse study, germinated from soil samples. Months given indicate when the species was in flower or fruit (I = introduced, N = native).

<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>Month Collected</th>
<th>Number of Collections</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaranthaceae</td>
<td><em>Amaranthus albus</em> L.</td>
<td>Mar, Apr, May, Jun, Jul, Sept</td>
<td>10</td>
<td>I</td>
</tr>
<tr>
<td>Apiaceae</td>
<td><em>Daucus pusillus</em> Michx.</td>
<td>Apr, May</td>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td>Asteraceae</td>
<td><em>Baccharis sarothroides</em> A. Gray</td>
<td>Jan</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Filago arizonica</em> A. Gray</td>
<td>Mar, May, Jun</td>
<td>5</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Filago californica</em> Nutt.</td>
<td>Aug</td>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Laennecia coulteri</em> (A. Gray) G. L. Nesom *</td>
<td>Dec</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Sonchus oleraceus</em> L.</td>
<td>Jan, Feb, Mar, May, Aug, Sept, Oct, Nov, Dec</td>
<td>61</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td><em>Symphyotrichum divaricatum</em> (Nutt.) G. L. Nesom *</td>
<td>Oct</td>
<td>11</td>
<td>N</td>
</tr>
<tr>
<td>Boraginaceae</td>
<td><em>Amsinckia menziesii</em> (Lehm.) A. Nelson and J. F. Macbr.</td>
<td>Feb, Mar</td>
<td>6</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Cryptantha barbigera</em> (A. Gray) Greene</td>
<td>Mar</td>
<td>4</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Harpagonella palmeri</em> A. Gray</td>
<td>Apr</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Pectocarya platycarpa</em> (Munz. &amp; I. M. Johnst.) Munz. &amp; I. M. Johnst.</td>
<td>Mar, Apr</td>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Pectocarya recurvata</em> I. M. Johnst.</td>
<td>Feb, Mar, Apr, May</td>
<td>12</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Plagiobothrys arizonicus</em> (A. Gray) Greene ex. A. Gray</td>
<td>May</td>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td>Brassicaceae</td>
<td><em>Brassica tournefortii</em> Gouan</td>
<td>Apr, May, Jun</td>
<td>5</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td><em>Guillenia lasiophylla</em> (Hook. &amp; Arn.) Greene</td>
<td>May</td>
<td>5</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Lepidium lasiocarpum</em> Nutt.</td>
<td>Jan, Feb, Mar, Apr, Jun</td>
<td>21</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Sisymbrium altissimum</em> L.*</td>
<td>Jun</td>
<td>1</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td><em>Sisymbrium irio</em> L.</td>
<td>Apr, Jun</td>
<td>8</td>
<td>I</td>
</tr>
<tr>
<td>Caryophyllaceae</td>
<td><em>Silene antirrhina</em> L.</td>
<td>May</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>Fabaceae</td>
<td><em>Lotus humistratus</em> Greene</td>
<td>May</td>
<td>1</td>
<td>N</td>
</tr>
</tbody>
</table>

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** indicates this species is not likely part of the flora, but is a greenhouse weed.
<table>
<thead>
<tr>
<th>Family</th>
<th>Species</th>
<th>Month Collected</th>
<th>Number of Collections</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geraniaceae</td>
<td><em>Erodium cicutarium</em> (L.) L’Her. ex Aiton</td>
<td>Feb, May, Jun</td>
<td>9</td>
<td>I</td>
</tr>
<tr>
<td>Onagraceae</td>
<td><em>Epilobium ciliatum</em> Raf.</td>
<td>Jun</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td>Oxalidaceae</td>
<td><em>Oxalis corniculata</em> L.**</td>
<td>Jan, Feb, Apr, May, Jun, July, Aug, Sept, Oct, Nov</td>
<td>34</td>
<td>I</td>
</tr>
<tr>
<td>Plantaginaceae</td>
<td><em>Plantago ovata</em> Forssk.</td>
<td>May</td>
<td>3</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Plantago patagonica</em> Jacq.</td>
<td>May, Apr</td>
<td>11</td>
<td>N</td>
</tr>
<tr>
<td>Poaceae</td>
<td><em>Bromus arizonicus</em> (Shear) Stebbins*</td>
<td>Mar</td>
<td>1</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Bromus rubens</em> L.</td>
<td>Feb, Apr, May, Jun, Jul</td>
<td>19</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td><em>Muhlenbergia microsperma</em> (DC.) Trin.</td>
<td>Mar, Apr</td>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Poa bigelovii</em> Vasey &amp; Scribn.</td>
<td>Mar, Apr, May, Jun</td>
<td>11</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td><em>Schismus arabis</em> Nees</td>
<td>Jan, Apr, May, Dec</td>
<td>16</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td><em>Schismus barbatus</em> (Loefl. ex L.) Thell.</td>
<td>Feb, Jun, Oct</td>
<td>5</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td><em>Vulpia octoflora</em> (Walter) Rydb.</td>
<td>Feb, Mar, Apr, May, Jun</td>
<td>60</td>
<td>N</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td><em>Eriogonum deflexum</em> Torr.</td>
<td>May, Jun</td>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td><em>Veronica peregrina</em> L. *</td>
<td>Apr</td>
<td>2</td>
<td>N</td>
</tr>
<tr>
<td>Solanaceae</td>
<td><em>Nicotiana benthamiana</em> Domin. variety**</td>
<td>Oct</td>
<td>1</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td><em>Nicotiana obtusifolia</em> A. Gray</td>
<td>Jul, Aug</td>
<td>3</td>
<td>N</td>
</tr>
<tr>
<td>Urticaceae</td>
<td><em>Parietaria hespera</em> Hinton</td>
<td>Mar</td>
<td>3</td>
<td>N</td>
</tr>
</tbody>
</table>

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