ABSTRACT

The Dead Horse Mountains area of Big Bend National Park is one of the least explored areas in Texas. This is the first collective body of work to document the area's vascular flora through a major new collection of vouchered specimens and a survey of existing herbarium specimens. Field work was performed between August 2003 and September 2006. The study area covered 176,800 acres (71,548 hectares; 276 mi², 716 km²) with a 4100 ft (1250 m) range in elevation. Non-vascular specimens (bryophytes, hepatophytes, and lichens) were also collected but are not a part of the current report. A total of 1584 vascular specimens were collected during the current study, and 2212 previously collected specimens were found in various herbaria.

The total of the Dead Horse flora documented to date consists of 671 taxa at or below the species level (663 species) from 91 families and 344 genera. The current effort increased vouchered taxa by 12% and documented 55 novel species for the Dead Horse, a 10% increase over historical records. The best-represented families are the Asteraceae (12.0 % of total flora, 80 species), Poaceae (11.3 %, 75), Fabaceae (7.8 %, 52), Euphorbiaceae (5.1 %, 34), Cactaceae (5.1 %, 34), Pteridaceae (3.0 %, 20), and Boraginaceae (3.0%, 20). *Seymeria falcata* var. *falcata* was collected for the first time in the United States, in addition to eight new species records for Brewster County. One additional taxon may be undescribed or new to the United States. Twenty four non-native species have been collected in the Dead Horse; three are state-listed noxious weeds, and six are considered invasive. Eleven species endemic to Texas are found

within the study area, and 17 species are considered rare. The Dead Horse flora differs from other southwestern floras, mainly in terms of the relative importance of monocots and the co-dominance of Asteraceae and Poaceae in the overall floristic composition of the Dead Horse. This and other factors suggest connections to several peripheral floristic areas, with influences ranging from the Mogollon Rim and the Great Plains, to South Texas and southern Mexico. Using similarity index calculations to compare regional floras should become an integral part of the future of defining floristic relationships of Trans-Pecos Texas and the Chihuahuan Desert Region.

ACKNOWLEDGMENTS

Mike Powell is offered my greatest appreciation and thanks for his vision for this project, which enabled my eventual involvement; for his generous assistance, helpful guidance, and consistent support; and for the collegial respect, companionship, and friendship we have enjoyed throughout this project. I wish to also recognize and thank Billie Turner, for providing such an enjoyable work environment, and for providing so much invaluable assistance towards this final product. It is because of botanists like these that current-day floristic work can occur with the degree of ease and facility we find possible. Botanists of the next generation will remain indebted to their publications and perhaps may never see their equal in their incredible command of regional floristics, from simple identifications to an intimate understanding of wide-ranging, field-level botanical relationships. They have also done an outstanding job at curating and maintaining the Sul Ross University herbarium; the exceptional organization made my work much easier by a significant degree.

I am thankful for the support given to me by Martin Terry, in addition to his excellent command of language and his perennial good-natured outlook on life. Joe Sirotnak has been an important friend and presence in my life, and he always reminds me of the joy to be found in field work. I appreciate James Zech's encouragements to attain the highest standards possible in my work. Sul Ross State University should be recognized for continuing to support and house a vascular plant herbarium.

Thanks go to the Sul Ross Biology faculty and staff for their support, Chris Ritzi for his help with grant writing, and the department as a whole for financial support and for loaning me an excellent camera for the duration of my project. Alfred Negley, Kirby Warnock, and the Big Bend Chapter of the Texas Native Plant Society all made scholarships possible through their donations. The Texas Academy of Science awarded me a graduate research grant, and a large grant contribution came from the Big Bend Natural History Association. The Friends of Big Bend National Park group was the original funding source for this study (National Park Service Task Agreement Number J717003001A and Cooperative Agreement Number H7170030001 with Sul Ross State University), enabling the project to be considered in the first place.

The staff of Big Bend National Park have been extremely helpful, including the Science and Resource Management division, especially Betty Alex; Don Sharlow and the trail crew; the Rio District rangers, especially Mike Ryan; Steve McAllister; and Diane Herring. Texas Parks and Wildlife granted me access and permits to collect in the Black Gap WMA portion of my study area, and the staff was helpful in assembling climate and ownership data. Thanks go to Jackie Poole for her help with rare plant information and for her and Jim and Ferne Scuddy's efforts to track down, and make available to me, regional floristic publications. Many people have put their time and effort into this project: Fay Burton mounted the majority of specimens, Sharon Collyer backed me up in the field, Hillary Loring helped me feel like a more accomplished botanist, Mark Darrach assisted me on a very successful spring break expedition, Bill Dodson opened the door to the eastern side of the Dead Horse and shared his valuable experiences there, the Shackelfords allowed us access to their property in Brushy Canyon, and Richard

Worthington and James Henrickson graciously provided data based on many years of their hard work for the floristic analyses. I would like to recognize that this study stands on the shoulders of the floristic workers who have come before me, whose work enables and enriches all that comes after.

Deep appreciation goes to my parents Ann and Jeff for their unhesitating and generous support and encouragement over the years and that their ultimate desire for me is to be happy in life. Thanks go to my brother Ben for living his life the way he wants to, finding his passion, and having a great time at it—a good inspiration. Lastly, I am so thankful for the dedicated field assistance, motivational companionship, and overall, unfailing support during the study period from Mark Yuhas. This study was more enjoyable and exciting to do, and the final product is significantly more robust, because of his involvement.

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Away from the railroad, the Big Bend – sometimes called the Bloody Bend – is a hardy country, that is, one in which, through lack of water, civilization finds it difficult to gain a foothold. Although abundantly supplied with waterworks, such as scarped and canyoned streamways, it possesses a minimum of water. These great arroyos are mocking travesties which suggest that nature becomes tired of making this country before turning on the water.

– Robert T. Hill, USGS geologist, 1889

(Maxwell 1985)

"The harsh physically inhospitable arid Big Bend area either attracts and fascinates or utterly repels the visitor…if [he] lingers however, he learns that the higher mountains are a treasure…"

-- Ross A. Maxwell, first superintendent of Big Bend National Park

(Maxwell et al. 1967)

CHAPTER I

INTRODUCTION

To this day, Ross Maxwell's words ring true for those who know the Big Bend region. The Dead Horse Mountains (DH) of Big Bend National Park (BBNP) create a remote and forbidding viewscape on the West Texas park's eastern skyline. The rugged limestone escarpments offer no reliable surface water, nor infrastructure allowing quick access to the interior, leading to claims of it's being uncharted wilderness (Wood et al. 1999). These logistical challenges, in addition to rugged topography and extreme climate, have left the area one of the least botanically understood areas in Texas and the northern Chihuahuan Desert province.

The lack of attention creates a degree of floristic intrigue. The DH occur in an area of large-scale ecological overlap. In this part of the Trans-Pecos Mountains and Basins vegetational area (Fig. 1; Hatch et al. 1990), phytogeographic connections exist with other Texas floristic areas including the High Plains, Rolling Plains, Edwards Plateau, and the South Texas Plains, also known as the Tamaulipan Thornscrub region (Powell 2000). Northerly connections are evidenced by the populations of aspen, Douglas-fir, and other Rocky Mountain species growing well south of their normal distributions. Floristic links reach south to the Sierra Madre Oriental and Occidental, in addition to the greater Chihuahuan Desert of Mexico (Larke 1989). The graminoid flora even has an affinity to the Great Plains grasslands (Powell 2000; Christie 2006).

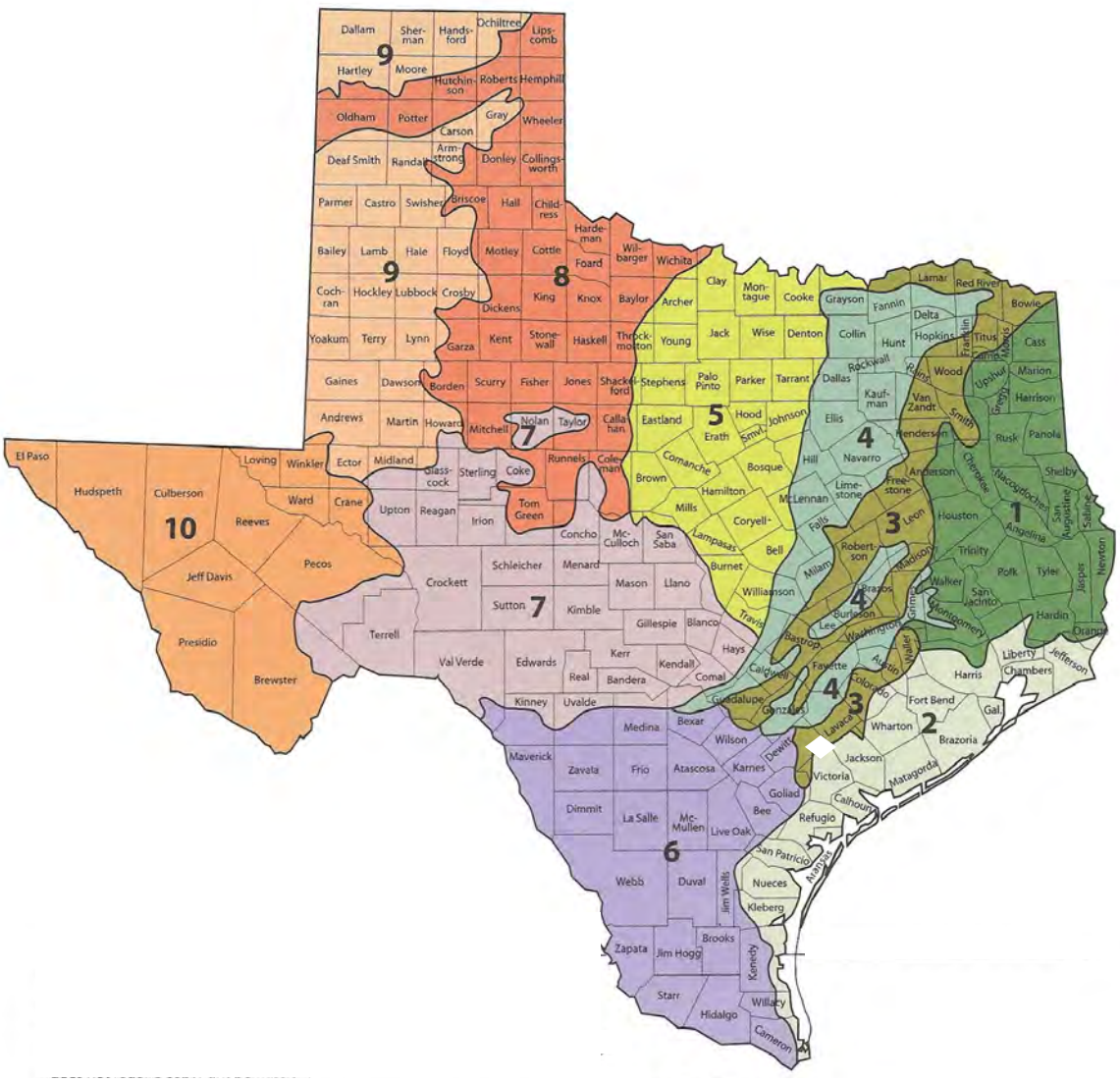


Fig. 1. Vegetational areas of Texas: (1) Pineywoods, (2) Gulf Prairies and Marshes, (3) Post Oak Savannah, (4) Blackland Prairies, (5) Cross Timbers and Prairies, (6) South Texas Plains, (7) Edwards Plateau, (8) Rolling Plains, (9) High Plains, (10) Tran-Pecos, Mountains and Basins. Map produced by the Botanical Research Institute of Texas/Austin College; modified from Correll & Johnston (1970) and Hatch et al. (1990).

Because there are so many intergrading regions, there is high potential for finding species out of their expected ranges. The area is topographically complex, providing microclimates that may have allowed new species a chance to evolve. The Chihuahuan Desert has many endemics, but, instead of being widespread, they have mostly local distributions (Brown 1994), increasing the likelihood of new discoveries in large, remote areas like the Dead Horse. Indeed, in Trans-Pecos Texas, Brewster County tallies the highest numbers of endemic (TAM-BWG 2007) and rare plant species (Alex et al. 2006; Poole et al. 2007, in press). Often, however, species of concern are little known beyond data taken at their original collection site. For example, the bluet *Hedyotis pooleana* (Jackie's bluet) was discovered in the Dead Horse in 1985. Because it is not known from any other location or collection since, much remains unknown about this controversial species and its taxonomy in relationship to its more variable and very similar Mexican cousin *Hedyotis mullerae* (Terrell 1996, 2001; Turner 1997). Providing more information about little-known species is one objective of this study.

The flora of the Dead Horse in its entirety will also be considered. Many collections on the periphery of the mountain range have been made over the past 60 years. This is probably due to the proximity of Sul Ross State University (SRSU) with a significant regional herbarium (SRSC), and the large proportion of state and federal protected lands in the area; areas under public management are typically more accessible to the scientific community than those under private ownership. Despite the history of collection activity, there has been limited effort to catalog DH species or to place the range and its floristics in a larger context. The current study includes all known specimens from the DH, with both the current collections and those found in an extensive

search of herbaria. Putting this area into a regional context and comparing the floras of similar mountain ranges north and south of the international border will help identify patterns of distribution and abundance which can help future studies elucidate details of the establishment and the evolution of the present-day flora.

Beyond limiting area-specific understanding, the lack of data hampers the ability to make responsible management decisions. Species data from field-collected herbarium specimens can be a fundamental tool used in conservation and management (Funk & Richardson 2002). It is crucial that managers know about what they are trying to protect, whether from direct or indirect sources. The species-distribution information gained in this survey can help place the DH and other regional species assemblages in a larger, biogeographical context, help explain previous patterns of establishment and migration, and allow speculation on future developments. One such development might be response to climate change, and this study provides a reference benchmark for species occurrence. If species are found that are obviously occurring at the limits of their ranges, they may be useful as proverbial canaries in the coal mine to signal biologically significant shifts in temperature or precipitation.

The main study objective was to create a collective body of work on the floral composition of the DH, documenting all known vascular plants through field collections and herbarium records. Subsequent analysis demonstrates regional patterns of species richness, both in terms of regions within Texas and as compared to other Southwestern areas.

Geography and Study Area Description

The DH are located in that part of West Texas known as the Big Bend region—generally the land south of the Union Pacific railway bounded to the east, west, and south by the Rio Grande. BBNP is in south Brewster County, bordering Mexico for 118 mi (190 km; Fig. 2). The park comprises over 800,000 acres (323,752 ha) and includes elevations between 1700 and 7854 ft (518 and 2394 m). The closest towns fall along TX Hwy 90, paralleling the railway. Alpine (110 mi/177 km, pop. 6500) is home to Sul Ross State University, and Marathon (70 mi/113 km, pop. 600) is the eastern-most gateway to the park. Directly west of the park are the communities of Study Butte (23 mi/37 km) and Terlingua (30 mi/48 km). Bordering the park to the east is Texas Parks and Wildlife's Black Gap Wildlife Management Area (BGWMA) and a few parcels of private ranchland, including the Adams Ranch, which was recently purchased by Cemex, the Mexican government-owned cement company involved in conservation efforts on both sides of the Rio Grande. The DH are primarily within BBNP, with the eastern extents falling within BGWMA and private property.

Looking at historical accounts and topographic maps of the area, the DH are also considered part of the Sierra del Carmen range that originates in Mexico. South of the border the del Carmens reach elevations over 9000 ft (2750 m) and serve as BBNP's distinctive southeastern skyline of massive, banded cliffs that glow in the sunset. The DH are a smaller, northern extension of the impressive Mexican range.

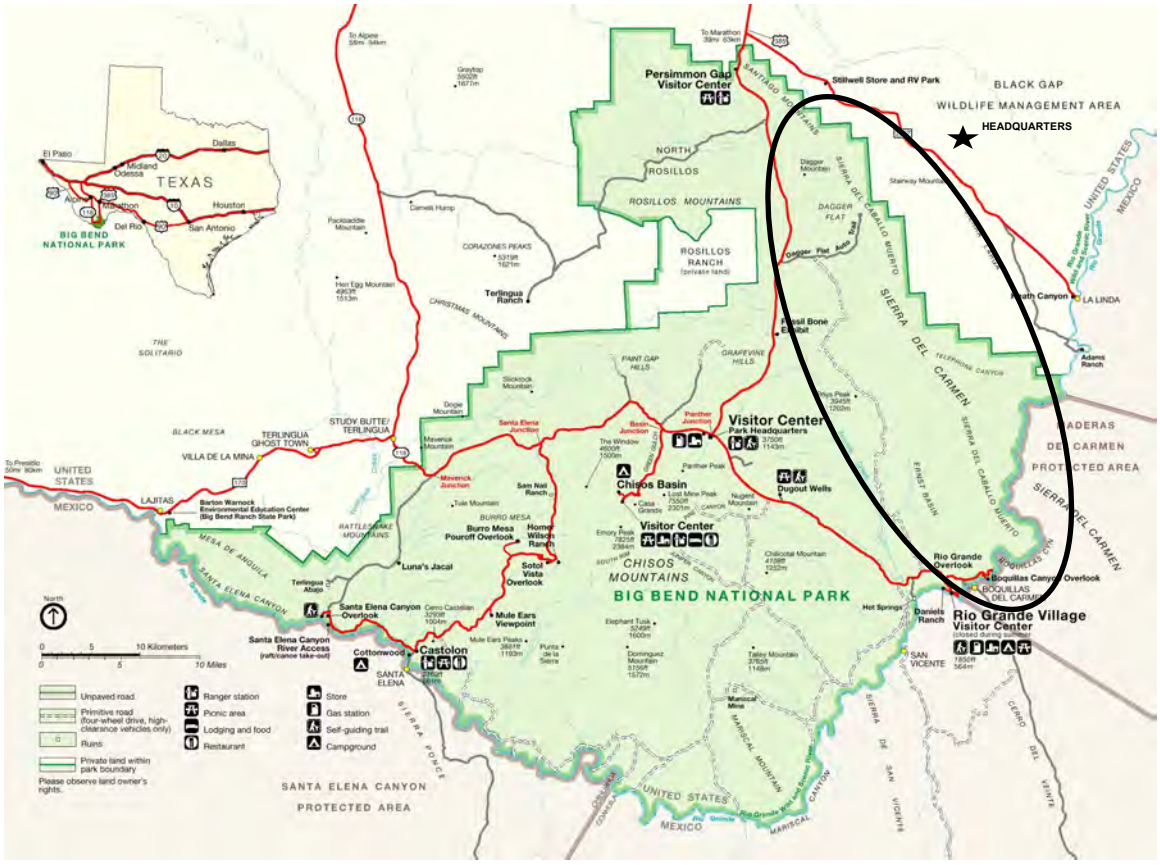
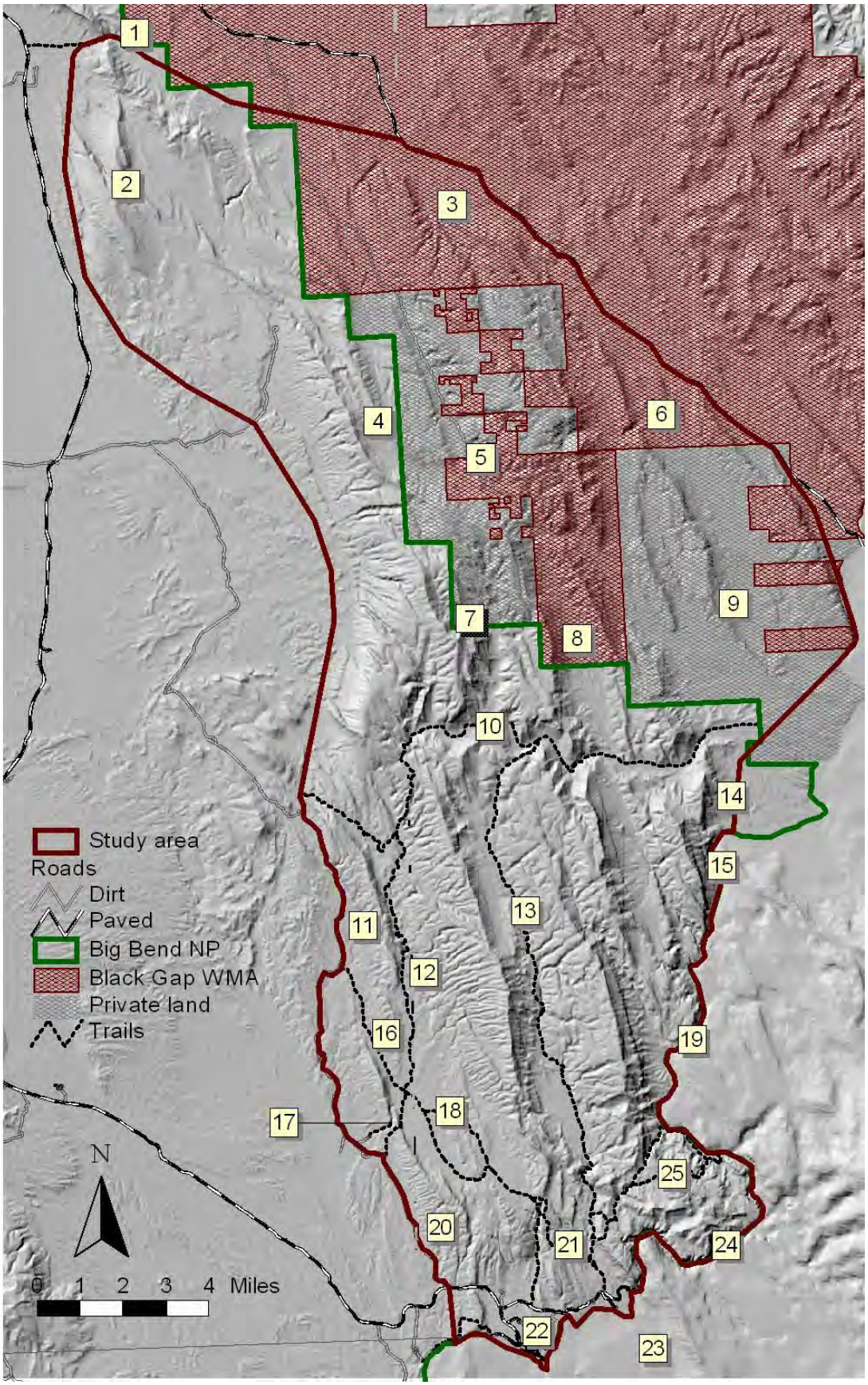


Fig. 2. Map of Big Bend National Park (NPS 2004) with the study area circled. The Dead Horse Mountains are labeled “Sierra del Carmen” and “Sierra del Caballo Muerto”.

There are various stories recorded about how the DH got their name, and all embody the colorful history of the region. The most common theme involves Texas Rangers who were escorting a party of state boundary surveyors down the Rio Grande in the late 1800s. When the party encountered a rugged canyon, they either had to abandon their horses because it was only feasible to continue in rafts or surprised and scattered a band of Indians, who left behind their horses in their escape. The universal conundrum was how to prevent the horses from falling into Indian hands so that they would not be used for future raids against the Anglo community. Thus, the horses were killed with one account describing how all ammunition had been previously lost, so that the horses were blindfolded and knocked in the head with an axe (Maxwell & Dietrich 1965), and the other relating that the 30–40 head were simply shot (Smith 1924). Those historical tales, along with a more modern story that a rancher's horse fell off a cliff while the man was out looking for lost stock (Maxwell 1985) all serve to validate the area's name as a description of the harshness of the region.

Main physical characteristics of the DH include its northwest-trending mountains, with basins in between and sharp peaks overlooking the surrounding desert. Extending 31.5 mi (51 km) N/S and an average of 8.5 mi (14 km) E/W, the study area falls between 29° 37' 22", 29° 10' 17" latitude and 103° 7'14", 102° 52' 26" longitude (Fig. 3). The resulting plot of land covers approximately 176,800 acres (71,548 ha; 276 mi^2, 716 km^2). The elevation range of the study area is approximately 4100 ft (1250 m). All land-feature names used were taken from the eight United States Geological Survey 1:24,000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Study area
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Black Gap WMA
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Trails
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Fig. 3. Dead Horse Mountains study area locations: (1) Dog Canyon, (2) Dagger Mountain, (3) Stairway Mountain, (4) Stuarts Peak, (5) Brushy Canyon, (6) Frog Canyon/Frog Tank, (7) Sue Peaks, (8) Margaret Basin, (9) Sierra Larga, (10) Telephone Canyon, (11) Alto Relex, (12) Passionflower Canyon, (13) Strawhouse Trail, (14) Hubert Ridge, (15) Cow Canyon, (16) Arroyo Venado, (17) Cuesta Carlotta, (18) Ernst Tinaja, (19) Ernst Basin, (20) Ernst Ridge, (21) Ore Terminal trail, (22) RGV developed area, (23) Boquillas, Mexico, (24) Boquillas Canyon, (25) Marufo Vega.

topographic quadrangle maps covering the area: Dog Canyon, Black Gap, McKinney Springs, Sue Peaks, Roy's Peak, Ernst Valley, San Vicente, and Rio Grande Village (RGV).

Obvious topographic features of the study area include Dagger Mountain (4160 ft/ 1268 m) to the north, Stuarts Peak (5080 ft/1548 m), and the highest points at Sue Peaks (5840 ft/1780 m). The DH meet their southern end along the river, at 1700 ft (518 m). There the Rio Grande has carved out the spectacular Boquillas Canyon, a 33-mile-long (53 km) slice through massive limestone rock, with canyon walls rising to almost 1500 ft (457 m) tall. The area targeted for this research was chosen using topographic limits as opposed to administrative boundaries, although the majority of current field work was done within BBNP (Fig. 3).

The study area boundary starts to the north at Dog Canyon, and continues south along the western foothills to include Dagger Mountain, Alto Relex, Cuesta Carlotta, and Ernst Ridge. McKinney Springs and Roy's Peak were excluded because of their disjunct volcanic nature. The river makes the southern limit, including the RGV developed area and all of Boquillas Canyon. Heading north, the boundary skirts the lowest foothills of Hubert Ridge, the Sierra Larga, and Stairway Mountain in BGWMA. The current field work extended from BBNP as far east as Brushy Canyon and the mouth of Cow Canyon along the Rio Grande, and as far north as Dagger Mountain. The herbaria search was extended to cover the topographic extent of the entire DH-related uplift.

Over this entire area, the only physical feature that trends east-west besides Boquillas Canyon is 14-mile-long (22.5 km) Telephone Canyon, which bisects the DH. Even though Telephone Canyon is a major drainage, its Heath Creek does not contain

any permanent surface moisture, nor do any of the other major drainages such as Brushy Canyon, Strawhouse, Margaret Basin, Arroyo Venado, or Cow Canyon. These are all host to water at one time or another, but only in the form of ephemeral torrents after summer thundershowers. Surface water away from the Rio Grande is found only in tinajas, stone basins eroded usually out of arroyo or canyon beds with bedrock outcrops. The only reliable source like this is Ernst Tinaja, in the southern part of the DH. Other tinajas can be found, usually just by luck, but they are not large enough to hold more water than will evaporate after a few days. In light of the low frequency of rain events, such tinajas are inherently ephemeral.

Access to the study area was primarily through BBNP, though one trip was made into BGWMA territory. There are few human-created ways to access the DH, mostly on the periphery of the range. The Old Ore Road runs along the western flats and hits the paved road, which continues as a good point of access to the study area as it passes through the tunnel in Ernst Ridge to RGV. Providing good peripheral access to the southern foothills, the Boquillas Canyon road leads to the entrance of Boquillas Canyon. During the study period, the best interior road access was into Brushy Canyon through BGWMA and the Shackelford Ranch, a private inholding. The best trail for interior access was through Telephone Canyon, a 20-mile-long (32 km) path bisecting the DH, following the largest, and the only east-west-draining, canyon in the range. Access to the mouth of Telephone Canyon, by way of ranch roads from the east, was not available during the study period. The only other substantial, established trails within the DH are the 12 mi (19 km) Marufo Vega loop, the Ore Terminal Trail (4 mi/6.5 km), and the Strawhouse Trail (14 mi/22.5 km), all in the extreme southern end of the study area.

Climate

Some fairly comprehensive work has been done to document the climate of the Chihuahuan desert (Morafka 1977; Schmidt 1979, 1986). The general information about the Chihuahuan desert to follow is based on Schmidt's (1986) conclusions. Typical year-round climate for the Chihuahuan desert consists of hot summers and cool-to-cold winters. Temperatures reach lower levels than in the other hot North American deserts due to the higher altitude of the uplifted plains that form the majority of the desert area. Rainfall patterns also differ: being in the rainshadow of both Mexican Sierra Madre ranges limits rainfall to one peak summer season instead of a spring and summer season, as in the Sonoran and Mojave deserts. This regional aridity is more the effect of the orographic barriers than of actual distance from moisture sources.

The higher summer temperatures begin to drop in association with the developing rainy season: higher humidity and increased cloud cover elevate the thunderstorm potential. Summer moisture, in large part, is influenced by storms coming from the Gulf of Mexico. Winter precipitation is dependent on tropical Pacific storms, which push moist air toward the interior of the continent. Though winter is typically a drier time of year, it is these very storms that can cause higher-than-normal precipitation and influence the intensity or existence of the spring and early summer bloom. Summer thundershowers can be quite intense, with hail often falling over limited areas. Snow is always a possibility but is highly sporadic and always ephemeral.

Many mountains in the southwest are high enough to support flora and even fauna that do not fall within typical desert descriptions, though their foothills are solidly rooted in the desert. The altitudinal maximum of the Chihuahuan desert, as delimited by

Schmidt (1986) using climatic conditions, is 5900 ft (1800 m). The DH fall just under that, indicating that climatically the vegetation encountered should be representative of that occurring in the Chihuahuan desert. Being situated in the northern part of the Chihuahuan Desert (Fig. 4), the DH have temperatures registering slightly lower than the average of the Chihuahuan Desert as a whole. The northern cold fronts typical of Trans-Pecos region winters do not extend into the lower latitudes. High temperatures are on par with the desert's averages. It seems that the more northern latitude does not overwhelm the propensity for high temperatures at low elevations: the RGV area falls at the lowest recorded elevations in the Chihuahuan desert.

All temperature and precipitation data were gathered from BBNP files, originating from the National Weather Service or directly from park weather station records. The period of record varies in length and completeness for each weather station. The weather stations most useful for the DH (Fig. 2) are located at both ends of the range. The Persimmon Gap (PGAP) station is just outside the northern edge of the study area and has temperature and precipitation data from 1989–2005. RGV, at the southern limit, has reliable temperature data from 1979–2005, and precipitation records spanning 51 years since 1954. Average annual lows for the two stations are similar, averaging 53°F/12°C (Fig. 5). Highs at RGV, on the other hand, consistently remain about six degrees hotter than the those at PGAP throughout the year: the average annual high at PGAP is 82°F (28°C) and at RGV is 88°F (31°C), making an average annual high of 85°F (29°C) for the DH area.

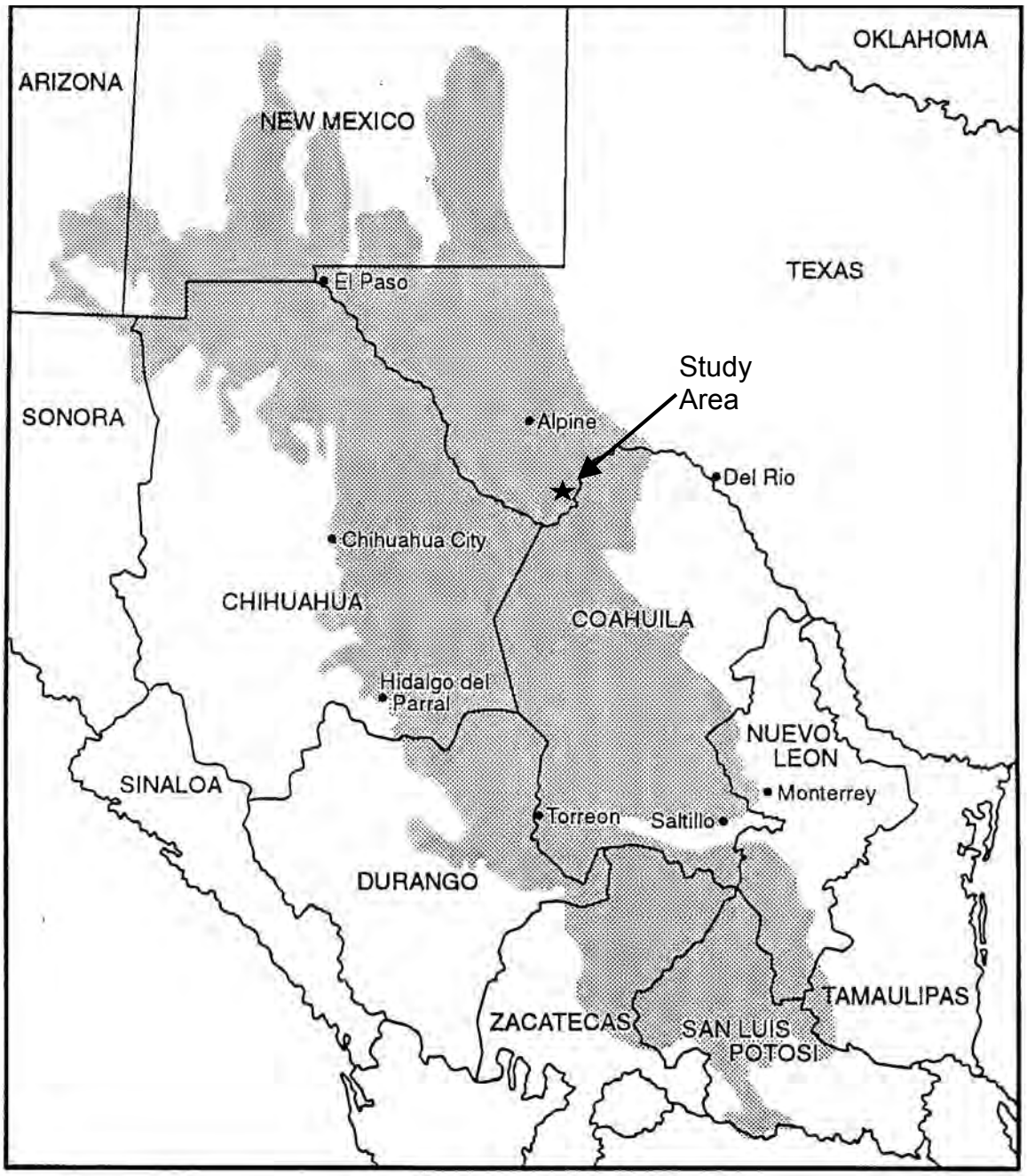


Fig. 4. The extent of the Chihuahuan Desert Region from Hardy 1997, used with permission.

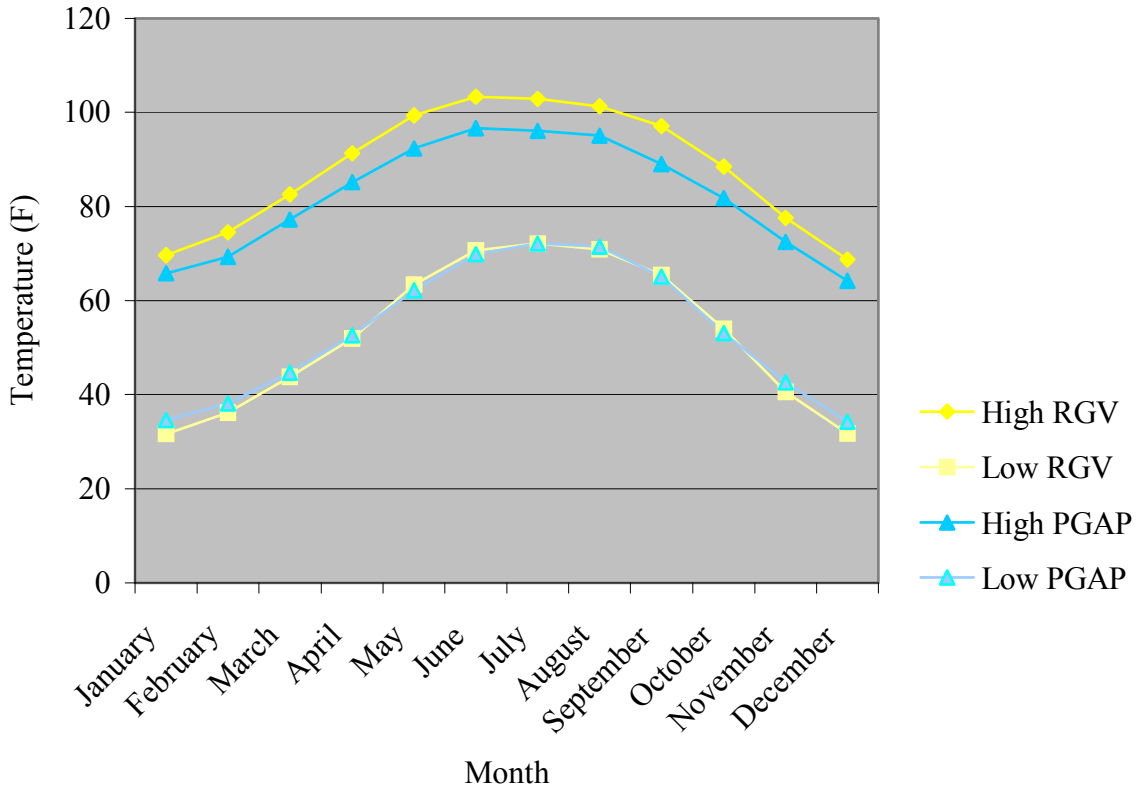


Fig. 5. Average annual high and low temperatures of the Dead Horse Mountains. Period of record varies between stations: Persimmon Gap (PGAP): 16 year record, 1989–2005; Rio Grande Village (RGV): 26 year record, 1979–2005.

The hottest month at both stations is June, with a combined daily average high of 100°F/38°C (max. 117°F/47°C at RGV), while December is coldest, with daily station lows averaging daily 33°F/1°C (min. 4°F/16°C at RGV). High diurnal temperature ranges are common for the Chihuahuan Desert as a whole. In the DH, the daily range can average between 29°F (16°C) at PGAP and 35°F (20°C) at RGV. Maximum daily fluctuations of over 50°F (28°C) can occur, usually in May and December. More stable temperatures coincide with the rainy summer months. Compared to higher-elevation locales in the park (Fig. 6), the DH stations experience lower average temperatures in winter months and temperatures among the highest during summer months. This extreme range of annual mean temperatures is probably due to the area's habitually low humidity and the lack of buffering topography. The lowest annual average temperatures do occur at the highest elevations in the Chisos Mountains, with a minimum low of -3°F (-19°C) recorded at the Basin station in January 1949.

Rainfall data for the DH come from the two park stations and from data recorded at BGWMA headquarters, just east of the DH. The highest rainfall comes predictably in the summer months, peaking between May and October (Fig. 7). Annual totals average close to 10 in. (25 cm) for both stations, which is less than the higher-elevation stations in the park (Fig. 8). The DH are high enough to catch and even create their own weather, but they cover enough area and contain such varied topography that storm cells form patchily. The amount of rainfall within the DH is highly variable, and any calculated average may not be adequately representative of actual precipitation seen in any given location. However, the average DH precipitation would never match that for the Chisos

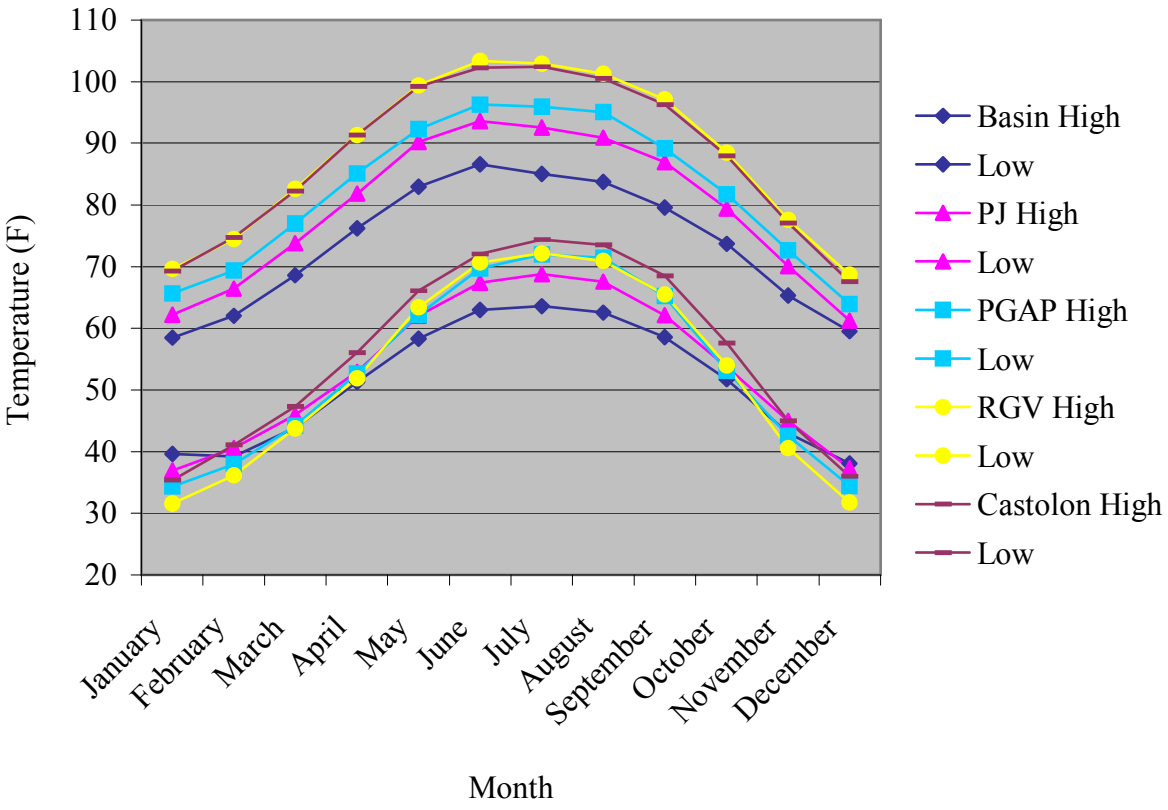


Fig. 6. High and low temperatures of weather stations of Big Bend National Park, Texas. Period of record varies between stations: Basin: 57 year record, 1948–2005; Panther Junction (PJ): 19 year record, 1986–2005; Persimmon Gap (PGAP): 16 year record, 1989–2005; Rio Grande Village (RGV): 26 year record, 1979–2005; Castolon: 19 year record, 1986–2005.

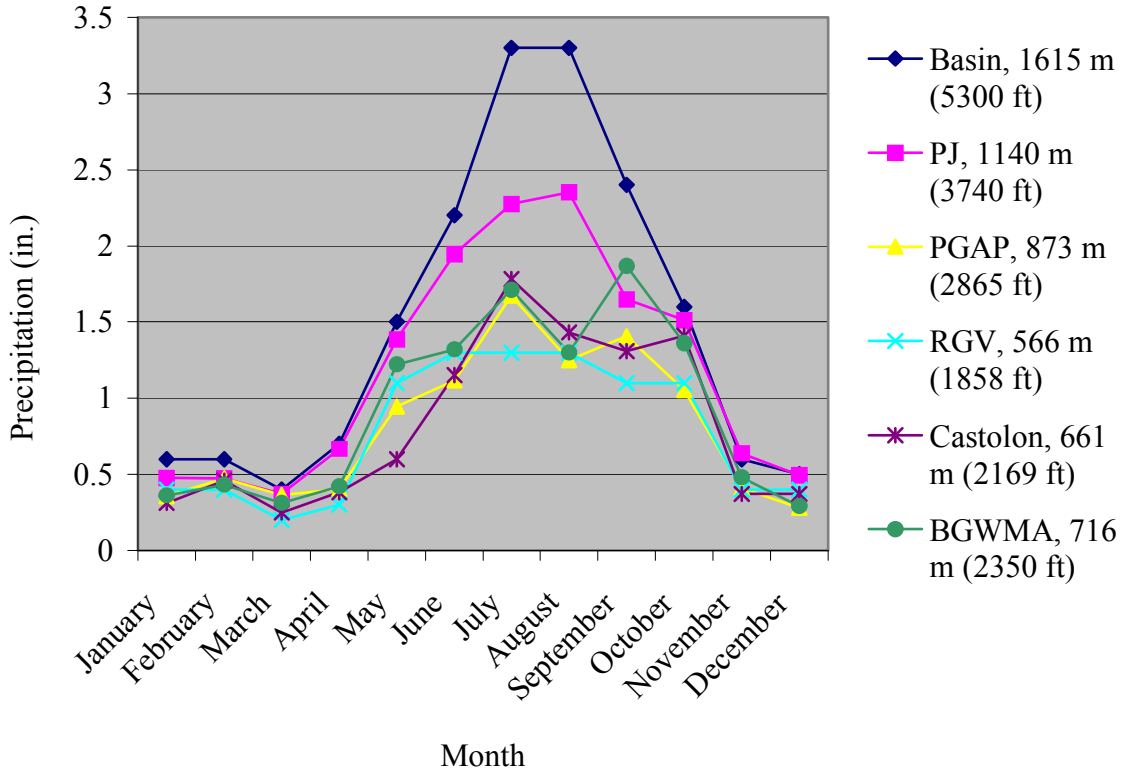


Fig. 7. Average annual precipitation by month for Big Bend National Park weather stations and for the Black Gap Wildlife Management Area (BGWMA); elevation of station listed beside name; the period of record varies between stations: Basin: 28 year record, 1948–2006; Panther Junction (PJ): 30 year record, 1976–2006; Persimmon Gap (PGAP): 18 year record, 1988–2006; Rio Grande Village (RGV): 52 year record, 1954–2006, missing Jun–Sep 2002 and Aug–Sep 2003; Castolon: 20 year record, 1986–2006; BGWMA: 36 year record, 1952–2005, missing data from 1978–1989 and 1991–1996.

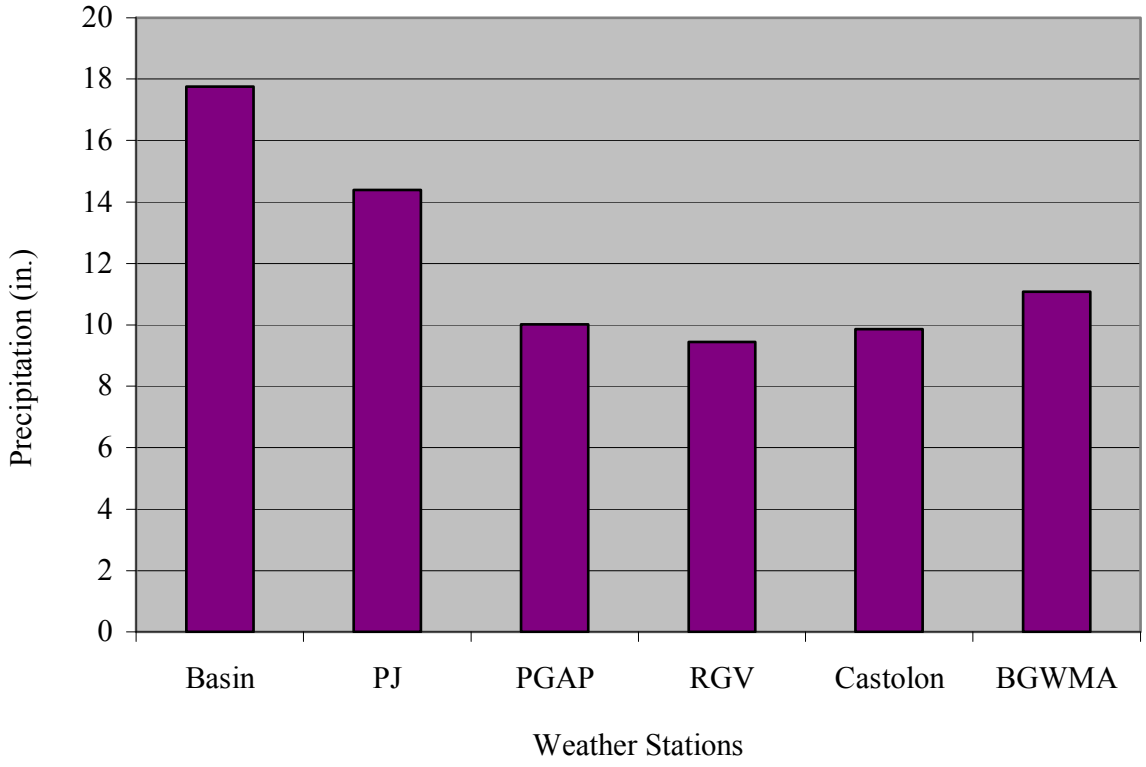


Fig. 8. Average annual precipitation totals for Big Bend National Park weather stations and for the Black Gap Wildlife Management Area (BGWMA); the period of record varies between stations: Basin: 28 year record, 1948–2006; Panther Junction (PJ): 30 year record, 1976–2006; Persimmon Gap (PGAP): 18 year record, 1988–2006; Rio Grande Village (RGV): 52 year record, 1954–2006, missing Jun–Sep 2002 and Aug–Sep 2003; Castolon: 20 year record, 1986–2006; BGWMA: 36 year record, 1952–2005, missing data from 1978–1989 and 1991–1996.

Basin, nor even levels at Panther Junction, due to physiographic differences between the sites. The Chisos Mountains are higher than the DH and, thus, have more powerful orographic lift and vegetative feedback to produce, catch, and/or drive storm cells. Panther Junction sees higher rainfall due to its location on the lower slopes of the Chisos.

During the cooler months, well-developed cold fronts sweep in from the north and sometimes bring snow to the higher elevations of the park. Over the past 57 years, there was snow during 83% of the winters at the Basin station, averaging 2.9 in. (7.3 cm) per snow year. Interestingly, over the last 30 years, there was snow in only 47% of the years, and the average snow-year total dropped to 1.8 in. (4.6 cm). During the last 15 years it snowed in only 27% of the years, averaging 0.43 in. (1.1 cm) per snow year. The peaks of the DH do get snow (J. Fenstermacher pers. observ.), but only as a rare novelty. Recorded snowfall in the DH is minimal: at RGV, 14 events over the last 52 years (av. 0.1 in./0.25 cm), two events during the last 30 years (av. 0.3 in./0.76 cm), and zero snowfall in the last 15 years have been recorded. Recorded precipitation is underrepresented, however; it did snow at least once at RGV in 1999, enough to supply the bulk for three snowmen at the campground (J. Fenstermacher pers. observ.), and until recently the rain gauge at RGV was partially under the eaves of the ranger station and the canopy of a mesquite tree (J. Forsythe pers. comm.).

A sporadic weather phenomenon may supplement moisture levels at higher DH elevations. Occasionally, during the more humid summer months, fog or low-lying clouds lay over the top of the peaks. This seems to occur when west-moving moist air is blocked by the DH and held by an inversion to create a bank of low-lying clouds over the

large alluvial Stillwell/Maravillas plain to the east (Fig. 9). The clouds eventually waft up the slopes of the DH and may sit on the higher elevations for part of a day. This phenomenon may provide significant humidity for some non-vascular and vascular plants at the higher elevations. For example, several lichen species were observed on the rocks around Stuarts Peak that were not seen elsewhere, including Sue Peaks.

Desert plants are highly tuned to the amount and timing of moisture they receive, both in order to bloom and for germination and establishment. Thus, the amount of rain received prior to and during any given study period greatly influences the composition of species found. Yearly rainfall totals for sites in BBNP are not consistent throughout history, though higher-elevation stations receive more precipitation than lower ones (Fig. 10). In the first two years of the study period the area experienced a rebound from the lowest rainfall in years, occurring in 2001. However, 2005 was another lower-rainfall year, especially over the winter of 2005–06 which caused an absence of plants in flower during the spring field season of 2006. Good rains in 2006 began only in August (Fig. 11), finally stimulating the desert to green up.

Geology

The DH are entirely limestone in nature, while the rest of BBNP is characterized by significant igneous features, in addition to isolated sandstone deposits and metamorphic rock. Ross Maxwell was the first superintendent of BBNP and a geologist by training. He was involved in mapping the park's geology in the late 1960s and went on to publish that mapping and other informative treatments in following years (Maxwell

Fig. 9. Low-lying clouds over higher Dead Horse peaks can remain for up to a day, perhaps creating a significant source of available moisture.

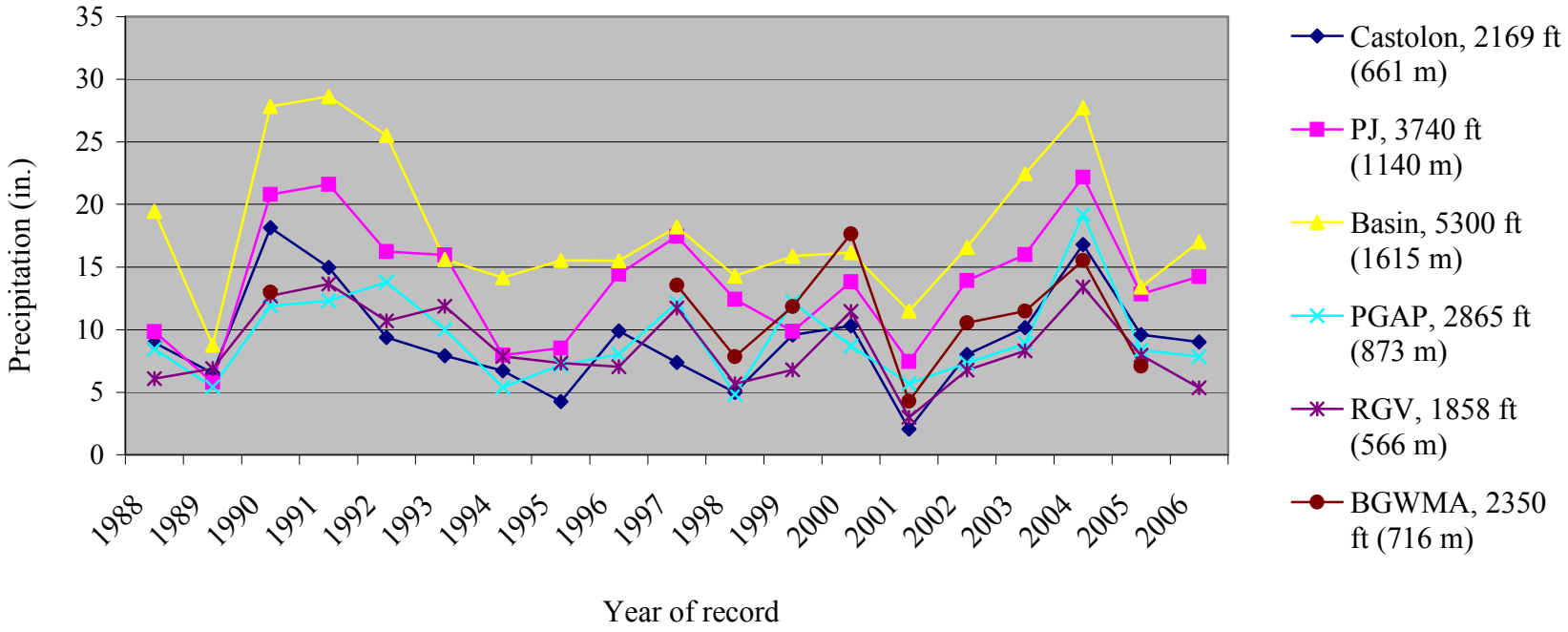


Fig. 10. Historical annual precipitation levels for Big Bend National Park weather stations and for the Black Gap Wildlife Management Area (BGWMA) between 1998 and 2006. BGWMA averages do not include data from the following years: 1988, 1999, 1991–1996, and 2006.

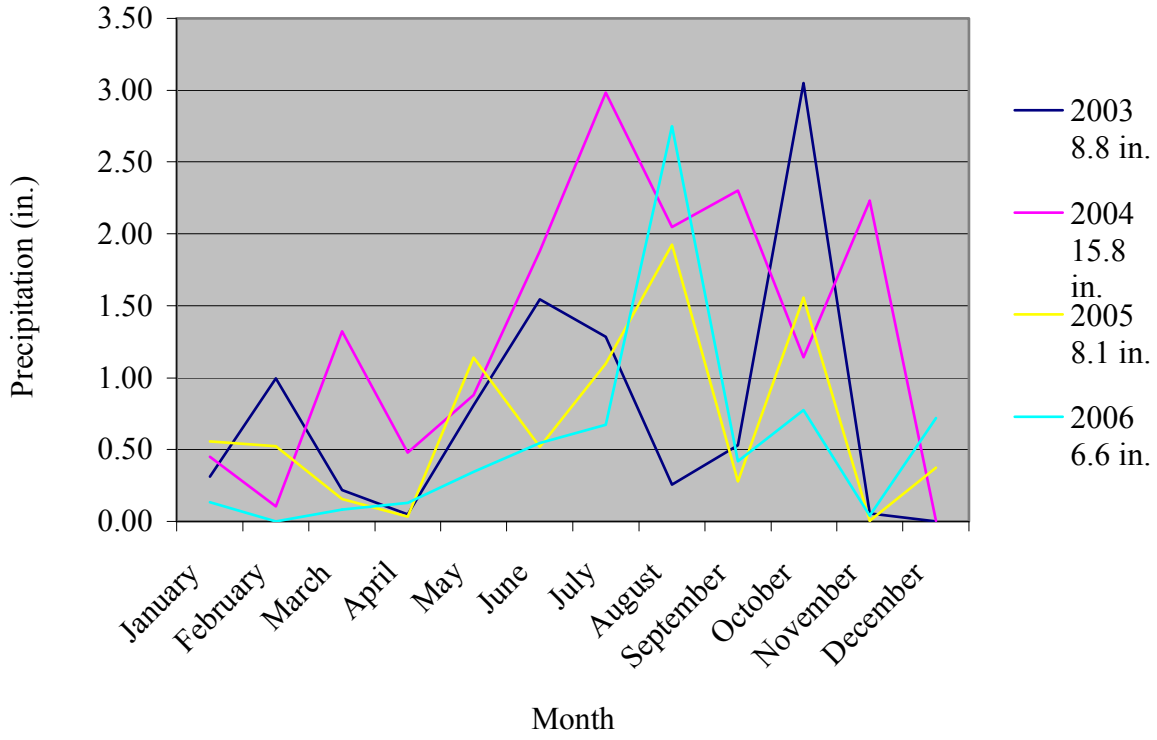
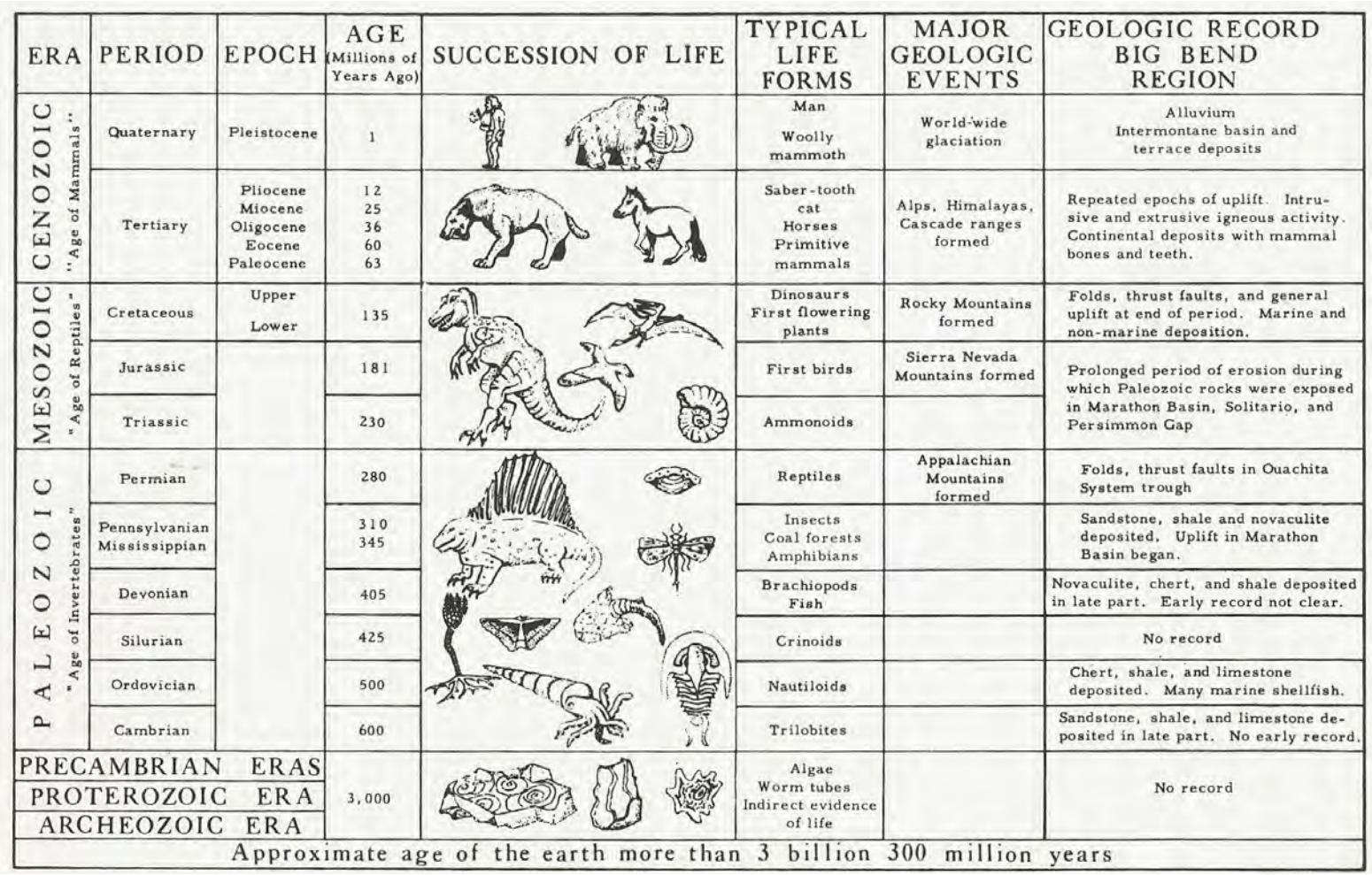


Fig. 11. Yearly precipitation patterns during the study period, 2003–2006, for the Dead Horse Mountains area. Data represents an average between values from PGAP and RGV. The average annual total for the two DH stations is listed by the appropriate year in the legend.

1979, 1985, Maxwell & Dietrich 1965, Maxwell et al. 1967). Unfortunately, the original geological map is not georeferenced, making updated maps desirable. Updating is occurring, but slowly and in pieces.

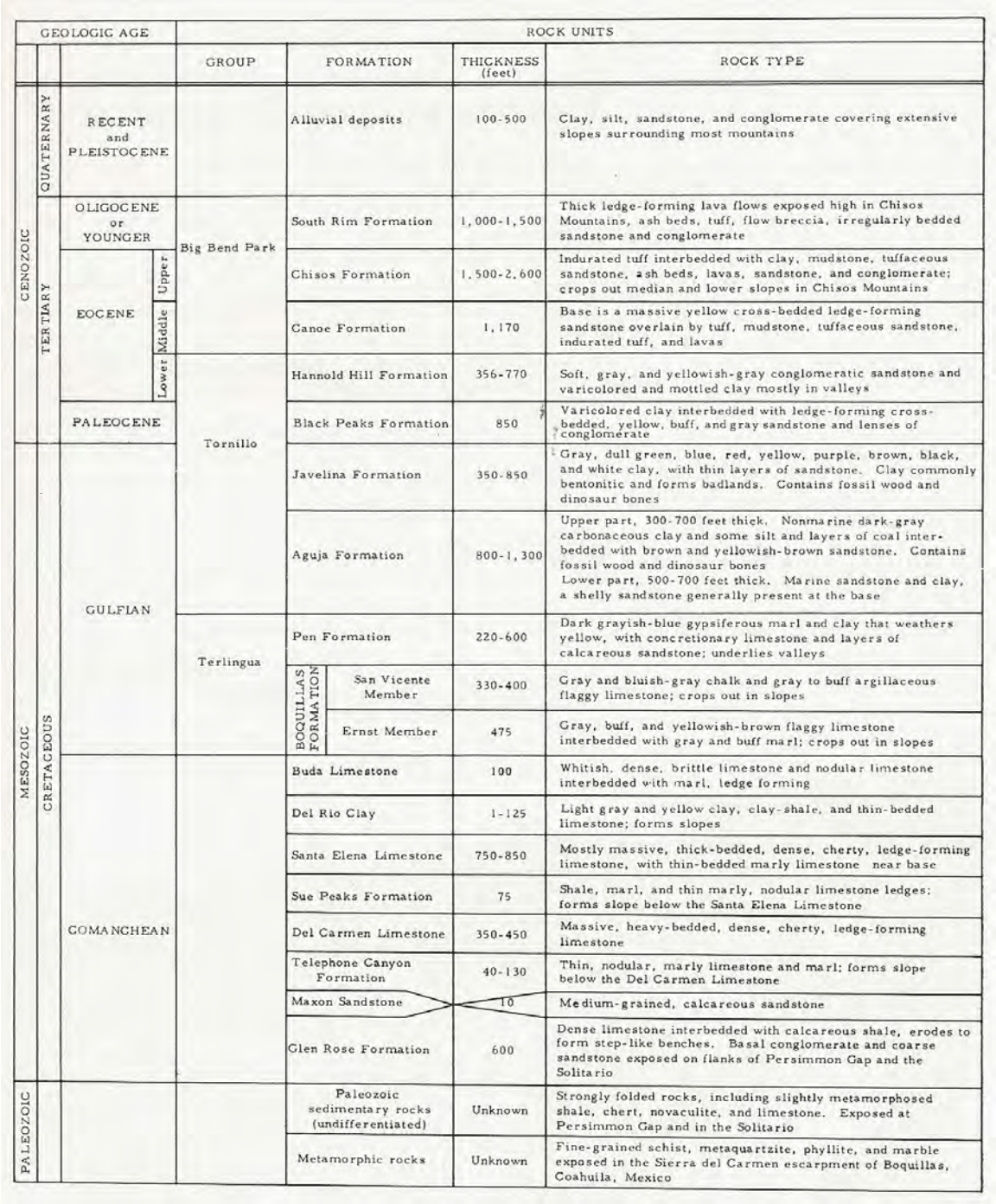
One current study relevant to the DH involves mapping outcrops of the Boquillas formation (R. Cooper unpub. data). The mapping by Moustafa (1988) is the only project to focus specifically on the DH, but it is not reliable: created using remote sensing, the resulting map was not ground-truthed to accurately map differing geological layers with similar reflectance values (D. Corrick pers. comm.). To this day, Maxwell's work is the best reference and was used to create the following basic treatment of landscape formation and the nature of important stratigraphic layers.

Most of the rocks visible in the DH today were formed during the lower Cretaceous period, ca. 180 million years ago (mya). By that time, the continents were moving into familiar positions, and flowering plants and pollinating insects were becoming an increasing part of the biota (Fig. 12). A large ocean covered the majority of North America, and as the remains of marine invertebrates fell to the bottom, they eventually solidified into different rock layers, depending on the amount of clay (continental deposits), as opposed to silica or calcium carbonate/limestone (marine deposits), that was present. Continental crust movements that shaped the North American continent are recorded in the different rock layers we see today; the type and thickness of deposits correlate with how deep or shallow the sea was and how close or far an area was from the shoreline.



ERA	PERIOD	EPOCH	AGE (Millions of Years Ago)	SUCCESSION OF LIFE	TYPICAL LIFE FORMS	MAJOR GEOLOGIC EVENTS	GEOLOGIC RECORD BIG BEND REGION
CENOZOIC "Age of Mammals"	Quaternary	Pleistocene	1		Man Woolly mammoth	World-wide glaciation	Alluvium Intermontane basin and terrace deposits
	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene	12 25 36 60 63		Saber-tooth cat Horses Primitive mammals	Alps, Himalayas, Cascade ranges formed	Repeated epochs of uplift. Intrusive and extrusive igneous activity. Continental deposits with mammal bones and teeth.
MESOZOIC "Age of Reptiles"	Cretaceous	Upper Lower	135		Dinosaurs First flowering plants	Rocky Mountains formed	Folds, thrust faults, and general uplift at end of period. Marine and non-marine deposition.
	Jurassic		181		First birds	Sierra Nevada Mountains formed	Prolonged period of erosion during which Paleozoic rocks were exposed in Marathon Basin, Solitario, and Persimmon Gap
	Triassic		230		Ammonoids		
PALEOZOIC "Age of Invertebrates"	Permian		280		Reptiles	Appalachian Mountains formed	Folds, thrust faults in Ouachita System trough
	Pennsylvanian Mississippian		310 345		Insects Coal forests Amphibians		Sandstone, shale and novaculite deposited. Uplift in Marathon Basin began.
	Devonian		405		Brachiopods Fish		Novaculite, chert, and shale deposited in late part. Early record not clear.
	Silurian		425		Crinoids		No record
	Ordovician		500		Nautiloids		Chert, shale, and limestone deposited. Many marine shellfish.
	Cambrian		600		Trilobites		Sandstone, shale, and limestone deposited in late part. No early record.
PRECAMBRIAN ERAS PROTEROZOIC ERA ARCHEOZOIC ERA			3,000		Algae Worm tubes Indirect evidence of life		No record
Approximate age of the earth more than 3 billion 300 million years							

Fig. 12. Geologic periods, typical life forms, and general Big Bend geologic record (Maxwell 1979). Used with permission of the Bureau of Economic Geology, University of Texas, Austin.



GEOLOGIC AGE			GROUP	FORMATION	THICKNESS (feet)	ROCK TYPE
CENOZOIC	QUATERNARY	RECENT and PLEISTOCENE		Alluvial deposits	100-500	Clay, silt, sandstone, and conglomerate covering extensive slopes surrounding most mountains
CENOZOIC	TERTIARY	OLIGOCENE or YOUNGER	Big Bend Park	South Rim Formation	1,000-1,500	Thick ledge-forming lava flows exposed high in Chisos Mountains, ash beds, tuff, flow breccia, irregularly bedded sandstone and conglomerate
CENOZOIC	TERTIARY	EOCENE, Upper	Big Bend Park	Chisos Formation	1,500-2,600	Indurated tuff interbedded with clay, mudstone, tuffaceous sandstone, ash beds, lavas, sandstone, and conglomerate; crops out median and lower slopes in Chisos Mountains
CENOZOIC	TERTIARY	EOCENE, Middle	Big Bend Park	Canoe Formation	1,170	Base is a massive yellow cross-bedded ledge-forming sandstone overlain by tuff, mudstone, tuffaceous sandstone, indurated tuff, and lavas
CENOZOIC	TERTIARY	EOCENE, Lower	Tornillo	Hannold Hill Formation	356-770	Soft, gray, and yellowish-gray conglomeratic sandstone and varicolored and mottled clay mostly in valleys
CENOZOIC	TERTIARY	PALEOCENE	Tornillo	Black Peaks Formation	850	Varicolored clay interbedded with ledge-forming cross-bedded, yellow, buff, and gray sandstone and lenses of conglomerate
MESOZOIC	CRETACEOUS	GULFIAN	Tornillo	Javelina Formation	350-850	Gray, dull green, blue, red, yellow, purple, brown, black, and white clay, with thin layers of sandstone. Clay commonly bentonitic and forms badlands. Contains fossil wood and dinosaur bones
MESOZOIC	CRETACEOUS	GULFIAN	Tornillo	Aguja Formation	800-1,300	Upper part, 300-700 feet thick. Nonmarine dark-gray carbonaceous clay and some silt and layers of coal interbedded with brown and yellowish-brown sandstone. Contains fossil wood and dinosaur bones Lower part, 500-700 feet thick. Marine sandstone and clay, a shelly sandstone generally present at the base
MESOZOIC	CRETACEOUS	GULFIAN	Terlingua	Pen Formation	220-600	Dark grayish-blue gypsiferous marl and clay that weathers yellow, with concretionary limestone and layers of calcareous sandstone; underlies valleys
MESOZOIC	CRETACEOUS	GULFIAN	Terlingua	BOQUILLAS FORMATION, San Vicente Member	330-400	Gray and bluish-gray chalk and gray to buff argillaceous flaggy limestone; crops out in slopes
MESOZOIC	CRETACEOUS	GULFIAN	Terlingua	BOQUILLAS FORMATION, Ernst Member	475	Gray, buff, and yellowish-brown flaggy limestone interbedded with gray and buff marl; crops out in slopes
MESOZOIC	CRETACEOUS	COMANCHEAN		Buda Limestone	100	Whitish, dense, brittle limestone and nodular limestone interbedded with marl, ledge forming
MESOZOIC	CRETACEOUS	COMANCHEAN		Del Rio Clay	1-125	Light gray and yellow clay, clay-shale, and thin-bedded limestone; forms slopes
MESOZOIC	CRETACEOUS	COMANCHEAN		Santa Elena Limestone	750-850	Mostly massive, thick-bedded, dense, cherty, ledge-forming limestone, with thin-bedded marly limestone near base
MESOZOIC	CRETACEOUS	COMANCHEAN		Sue Peaks Formation	75	Shale, marl, and thin marly, nodular limestone ledges; forms slope below the Santa Elena Limestone
MESOZOIC	CRETACEOUS	COMANCHEAN		Del Carmen Limestone	350-450	Massive, heavy-bedded, dense, cherty, ledge-forming limestone
MESOZOIC	CRETACEOUS	COMANCHEAN		Telephone Canyon Formation	40-130	Thin, nodular, marly limestone and marl; forms slope below the Del Carmen Limestone
MESOZOIC	CRETACEOUS	COMANCHEAN		Maxon Sandstone	10	Medium-grained, calcareous sandstone
MESOZOIC	CRETACEOUS	COMANCHEAN		Glen Rose Formation	600	Dense limestone interbedded with calcareous shale, erodes to form step-like benches. Basal conglomerate and coarse sandstone exposed on flanks of Persimmon Gap and the Solitario
PALEOZOIC				Paleozoic sedimentary rocks (undifferentiated)	Unknown	Strongly folded rocks, including slightly metamorphosed shale, chert, novaculite, and limestone. Exposed at Persimmon Gap and in the Solitario
PALEOZOIC				Metamorphic rocks	Unknown	Fine-grained schist, metaquartzite, phyllite, and marble exposed in the Sierra del Carmen escarpment of Boquillas, Coahuila, Mexico

Fig. 13. Stratigraphic layers in Big Bend National Park (Maxwell 1979). Used with permission of the Bureau of Economic Geology, University of Texas, Austin.

The earliest Cretaceous rock in the DH is the Glen Rose Limestone (Fig. 13). Deposited in a near-shore environment, it is primarily calcium carbonate, with some additional clay and sandstone interbedding. A small outcrop of the Glen Rose is found near Dog Canyon and there is a more substantial exposure in the Marufo Vega area. The majority of this layer is seen in the Mexican Sierra del Carmen.

Telephone Canyon is the succeeding formation. Found in the canyon of the same name, the type locality is described from the arroyo bed in the eastern end. There is also a small exposure in the Marufo Vega area. The Telephone Canyon limestone is a soft lithological unit in contrast to the Glen Rose and its overlying neighbor the Del Carmen Limestone. The Del Carmen was also newly described from local outcrops and corresponds to the Edwards Limestone from central Texas. It is more prominent on the western side of the park; in the DH it is exposed on the eastern flanks of the mountains, out of view to most park visitors unless they hike the Marufo Vega trail. The Del Carmen and the Santa Elena Limestone, the latter an overlying layer of similar massive character, are the main blocks of rock that were uplifted to form the DH. They were both deposited in deep-sea environments, which accounts for the abundance of fossils and the compact, pure nature of the rock, mostly devoid of interbedding or clay content.

Widely found in the rock of both deep-sea layers are nodular or linear inclusions of chert. In the right conditions, silica can precipitate out of seawater and, over time, develop into chert masses—rusty-colored knobs or lens-shaped deposits that, when found in large concentrations, have been used as source rock for arrowheads and other sharp tools. The DH inclusions are only a few inches thick and only periodically seen; thus, they were probably not widely used as source rock by Native Americans.

Sandwiched in between these two massive strata is the Sue Peaks Formation, a softer, thinner unit of marly, buff-colored shale that erodes out, forming a sloping, debris-filled bench between the sheer faces of its neighbors, sometimes leaving the Santa Elena exposed as an overhanging ledge. Stuarts Peak is part of a thin band of this friable formation, otherwise seen on the steep eastern escarpments of the ranges and, to some extent, along the Marufo Vega trail.

The Santa Elena Limestone is the most abundant surface layer in the DH. It has a lighter gray color and a smoother surface than the Del Carmen, but locally they are difficult to distinguish. Fossils are frequently exposed in the Santa Elena, often weathering more quickly than the encasing rock to form small pits. These cavities create unique niches that are utilized by many area plants (J. Fenstermacher pers. observ.). Overlying layers on the steeper slopes and high elevations have long disappeared, the deposits having eroded away down to the resistant surface of the Santa Elena. Weathered material from those younger layers now comprises many of the basin-fill and foothills soils.

The Del Rio Clay is one, younger member that can be found in conjunction with outcrops of Buda Limestone. The Del Rio is seen as thick, greenish clay interbedding with flaggy, silica-rich limestone. The Buda is a more compact limestone that creates scalloped “hogbacks” at the base of the western DH slopes where erosion has not completely erased those components of geologic history.

Mid-to-late Cretaceous deposits are represented as the Boquillas Formation, most easily seen around Ernst Tinaja as the Ernst Member. The silty limestone flags occur with siltstone and calcareous clays, indicating that they were deposited in a near-shore,

shallow environment. Many outcrops are artistically striped with various shades of brown and red, the pigments coming from varying amounts of silica in the rock. The extreme folding and compression evident at the Tinaja are now considered a result of high-pressure activity: as the Cretaceous sea retreated, there were periods when the shoreline waxed and waned, with silty or muddy conditions alternating with clearer, deeper water. Many silty, therefore flexible and slippery, layers were deposited, and it is hypothesized that, due to the accumulated weight, the overlying deposits finally slumped and folded in on themselves, the underlying Buda Limestone having served as a slick surface that enabled friction-free movement (D. Corrick pers. comm.).

The Upper Cretaceous period, ca. 100 mya, was a time of uplift and continental development contemporaneous with the presence of dinosaurs. A critical event of the time was the Laramide Orogeny, which created, among other North American geologic features, the Rocky Mountains. That same compressive activity caused the faults and uplift associated with several mountains in BBNP and the Sierra Madre ranges of Mexico. The intense pressures caused clinal folding, many instances of which are visible in the DH. In the Cenozoic era, crustal stretching, beginning around 30 mya and continuing today, resulted in the basin and range topography common in the desert west and obvious locally in the DH. Resisting the stretching, massive blocks of sedimentary limestone split apart. Faults were created along a NW-SE line, and eventually the blocks were uplifted and tilted (Fig. 14), creating gradual slopes to the west and steeper escarpments to the east. The DH area is a prominent example of this geological process. Also, as a result of faulting and expansion, the central area of the park was down-dropped, which served to further accentuate the DH.

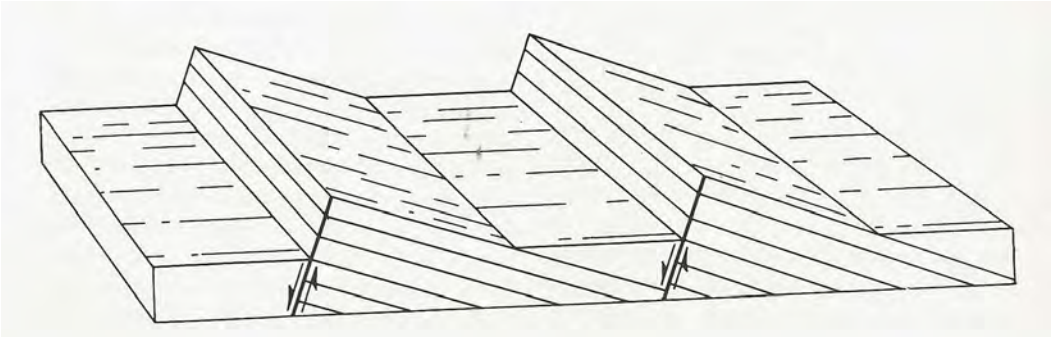


Fig. 14. Diagram of upthrust fault blocks, creating basins in between (Maxwell 1979).

Repeated mountain-building events in the Cenozoic resulted in a variety of formations. The Chisos Mountains in the center of the park are Tertiary-period, igneous formations (ca. 60 mya); most relevant to the DH, the McKinney Hills and Roy's Peak are eroded laccoliths from the same period. Dagger Mountain is recognized as a fault-banded anticlinal fold, but the power to deform the rock may have come from some kind of igneous intrusion below that is not yet exposed for verification.

The most recent geologic history is that of simple weathering: once the basin and range faulting subsided, the mountains began to weather down instead of building, and the sunken valleys, or grabens, began to fill up with eroded material. Representative stratigraphic layers from this period are the Quaternary gravel and silt deposits (ca. 1 mya). These consist of gravel and silt deposits that in-filled the fault-formed, internally draining basins. Once external drainage developed, arroyos formed and eroded the fill, leaving high-level terrace and pediment gravels in addition to remaining valley-fill deposits. The most recent Quaternary stratum is the general alluvium that forms alluvial fans and terraces. These features are mostly found downstream of Ernst Tinaja, in Ernst Basin and other basins between the uplifted interior ranges, and at the south end of the DH around RGV and the Strawhouse trailhead.

As the internally-drained bolsons were finally finding outlets, major hydrologic patterns began to take shape. The Rio Grande had wound its way through the Big Bend, cutting a course through the softer, overlying layers, when it finally reached more resistant rock such as the Santa Elena and Del Carmen limestone. Already trapped in the

channel it had created, the river was forced to continue, and the tons of silt and particulate matter its waters carried slowly eroded the hard river bed until the canyons of the Rio Grande were formed.

Soils

In general, the DH soils are shallow to very shallow, very gravelly or cobbly, with a high percentage of rock fragments. Rock outcrops are frequent, slopes are steep to very steep, and virtually all soils are limestone-derived, with a high percentage of calcium carbonate. There are small, localized areas on alluvial uplands where the soils are shallow-to-deeper and gravelly, and there are even some deeper, loamy soils found in valleys or near the Rio Grande. It is often stated (Shreve 1942; Powell & Turner 1977) that localized occurrences of gypsiferous soils are important in the Chihuahuan Desert Region (CDR), but this is not the case in the DH. There are areas along the Old Ore Road that may have higher gypsum levels, where the dog cholla *Opuntia aggeria* seems to occur in large part as a monoculture (pers. observ.), in addition to occasional *Larrea tridentata* (creosote) and the purportedly obligate gypsophile *Psathyrotes scaposa* (naked turtleback; Powell & Turner 1977).

Classifying soils can only be done in relation to the surrounding environment. The elevation of a site determines its climate. The climate shapes the community of plants occurring there, and the plants demonstrate what the soil is capable of, or what conditions are present: the amount of organic matter, water capacity/availability, minerals, root zone depth, and soil temperature. Using this pattern of associations, the Natural Resource Conservation Service (NRCS) creates regional soil maps. It is an active process: the soil survey of BBNP first completed in 1985 (Cochran & Rives 1985)

is currently being revised and refined as new information becomes available. Some of the current changes affect the DH and are discussed below as understood from Lynn Loomis (pers. comm.), the Big Bend regional soil conservationist. As the park's map is updated, new information will be available first on the United States Department of Agriculture website (USDA 2006). Information on soils that are not being reclassified is based on Cochran and Rives (1985).

The basic soil units of the DH follow general elevational divisions used in the USDA's concept of regional vegetation communities (Turner 1977). The highest elevations in the DH fall into its Mountain Grassland ecological zone, 4500–6700 ft (1370–2040 m). DH areas with this elevation are on the summits and shoulders of the main DH plateau and continue up to Sue Peaks (Fig. 15). Previously known as Ector soils, these now carry the updated name of Altuda. These soils are classified as loamy-skeletal, carbonatic, thermic, and lithic, calciustolls. These technical terms translate into many important characteristics. The soils at this elevation and on the whole for the DH are evenly balanced and dominated neither by clays nor sands. In most areas of the DH, the soil is shallow (bedrock found within 20 in of the soil surface) and contains a high percentage of rock fragments. The mean annual soil temperature (MAT) is 14–22° C (58–72° F) at the Ector/Altuda elevations and gets progressively warmer in decreasing elevation. Also, at the highest elevations the soil is darker in color because of its high organic content and may be moist more often than dry, although this has not been ground-truthed and may not apply in this area. Throughout the DH, the high amount of

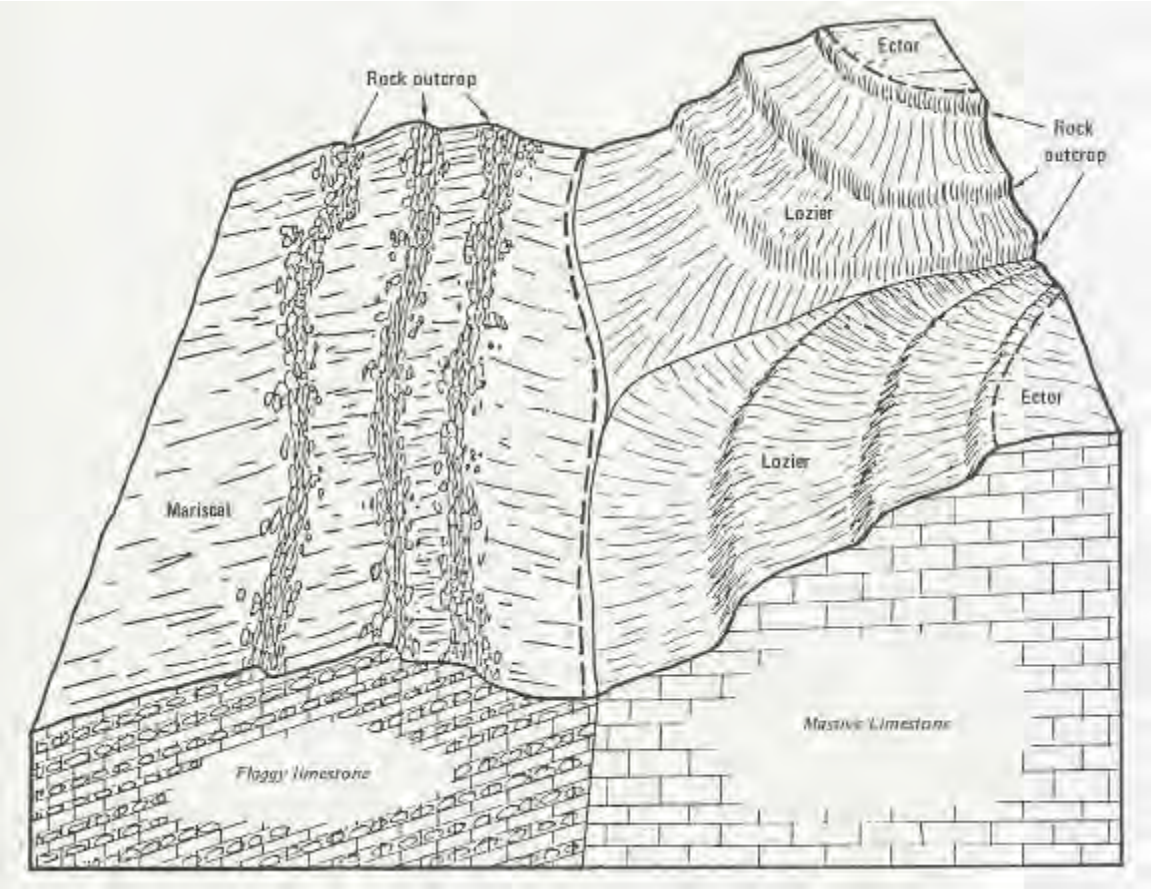


Fig. 15. Schematic drawing of high elevation soil units (Altuda/Ector and Lozier/Bissett) in the DH Mountains (Cochran and Rives 1985).

calcium carbonate in the soil is not leached out by high rainfall and persists in solution in the soil column long enough to precipitate out on the underside of suspended rock fragments.

The Ector/Altuda map unit is found in areas with an approximate 3:1 ratio of soil to rock outcrop, which manifests as limestone ledges, escarpments, and bedrock exposures. Slopes are from 5 to 65%, with rocky outcrops common on slopes over 20%. The water-holding capacity of the soil is generally low because of the high percentage of rock fragments, but after a small rain the availability of water is higher because of the resultant higher water potential. Runoff is rapid and permeability is moderate.

Associated plants in this map unit, as listed by the NRCS for Jeff Davis County (USDA 2006) are short and mid-grasses, with main shrubs being *Quercus mohriana* (Mohr shinoak), *Juniperus pinchotii* (redberry juniper), *Pinus* sp. (pinyon pines), *Nolina texana* (sacahuista), *Dasylirion leiophyllum* (sotol), and *Agave lechuguilla* (lechuguilla). The communities listed at this elevation in the BBNP soil survey are the mountain savannah (>5500 ft) and mixed prairie (4500–5500 ft). Characteristic vegetation listed for mountain savannah are pinyon pine, oak species, *Cercocarpus* spp. (mountain mahogany) *Muhlenbergia emersleyi* (bull muhly), *Bouteloua gracilis* (blue grama), and *Schizachyrium* spp. (little bluestem). Mixed prairie vegetation is expected to contain *Bouteloua curtipendula* and other grama grasses, perennial *Aristida* spp., (threeawns), *Leptochloa dubia*, *Bothriochloa barbinodis* (cane bluestem), *Dalea formosa* (feather dalea), and *Menodora* sp. A combination of these lists gives more suggestions as to what may occur in the DH rather than a true picture of the dominant species at these elevations in the DH: the junipers are not uncommon, pines are very rare, no sacahuista was seen

during the current study, and the shinoak occurs in patchy thickets. More abundant are the monocot rosette species such as *Yucca* spp. (yuccas), *Dasylirion leiophyllum* (sotol), and *Nolina erumpens* (beargrass). Grasses are very important at this elevation and are mainly a mixture of *Muhlenbergia* and *Aristida* species, with *Bouteloua curtipendula* (sideoats grama) being the dominant grama grass.

Moving downslope, what were previously known as two Lozier Rock-outcrop units are currently being redefined; the Lozier name is now associated only with soils in the Pecos River drainage, approximately 95 mi (150 km) east of the DH. The new units are centered around the 3500 ft elevational split that divides the two, lower-elevation USDA vegetation groups. The higher unit is called the Bissett, generally between 3500 and 4500 ft, as is the Desert Grassland vegetative zone. The USDA associates the following plants with the Bissett unit: *Bouteloua curtipendula* (sideoats grama), *Leptochloa dubia* (green sprangletop), *Viguiera stenoloba* (skeleton-leaf golden-eye), and *Leucaena retusa* (goldenball leadtree; L. Loomis pers. comm.). Major differences from the Altuda include steeper slopes, higher percentage of rock outcrop, warmer MAT, and drier soil for a longer portion of the year.

The lower Lozier Rock outcrop unit associated with the DH has been redefined and is now called Black Gap. This new determination was precipitated by newly available soil temperature data. It has become apparent that soils at the lower elevations are hyperthermic: the MAT is over 72° F (22°C), making soil conditions equivalent to those in South Texas. The distinctive plant species of the Black Gap unit are located generally from the river corridor up to 3500 ft (1065 m) and fall into the USDA Desert

Shrub vegetation zone. They are the most drought tolerant encountered so far: *Jatropha dioica* (leatherstem), *Hechtia texensis* (hechtia); and *Euphorbia antisyphilitica* (candelilla).

The previous BBNP soil survey (Cochran & Rives 1985) delineates an area between 2600 and 4500 ft (792–1370 m) as a Desert Grassland vegetative zone, supposedly receiving 10–12 in. (25–30 cm) of rain per year, as opposed to a projected 12–15 in. (30–38 cm) for the Mixed Prairie and over 15 in. (38 cm) within the survey's Mountain Savannah zone. Dominant grasses and shrubs in the BBNP soil survey for Desert Grassland vegetative zone in large part match those suggested for the new Bissett unit but are not as markedly arid-adapted in nature as are those of the Black Gap. The current revelations about soil MAT seem to be appropriately revising the previous vegetation interpretation, moving the transition between grassland and the more arid-adapted desert scrub zone from 2600 ft up to 3500 ft (792–1065 m).

Several other soil units occur at lower and flatter elevations within the DH. Found sporadically along the western foothills, Mariscal soils are in areas of interbedded limestone and shales, resulting in a higher percentage of clay. The Upton-Nickel association is found above and along drainages cutting through pediment valley fill (Fig. 16). This is another unit undergoing reclassification and is now known as Strawhouse-Stillwell. These deep-to-shallow, gravelly soils are well drained, calcic, and coarse-to-sandy loams. Occurring on remnants of erosional fans, alluvial flats, and pediments, they develop along the base of the western foothills and in depositional areas like Dagger Flat and Ernst Basin. Slopes are up to 30 percent. Calcium carbonate leaches through the soil slowly and, in some areas, solidifies below the surface into a hard impermeable layer

called caliche, making soil depths variable. Common plants include lechuguilla, *Fouquieria splendens* (ocotillo), *Bouteloua ramosa* (chino grama), *Tridens mutica* (slim tridens), and *Dasyochloa pulchella* (fluffgrass).

Deeper, finer soils generally associate with the larger drainages of the area like Tornillo Creek and the Rio Grande. Tornillo soils are formed in alluvium across broad valley floors (Fig. 16). When disturbed, this soil erodes easily, resulting in exposed rootstocks and, eventually, badlands-type landscapes (Fig. 17). Historically this soil was believed to support extensive meadows of *Hilaria mutica* (tobosa grass). A small area of tobosa covers the western edge of Ernst Basin, in stark contrast to the sparsely vegetated, more elevated flats over the rest of the basin (Fig. 18). The area contains many deep erosion channels, presumably due to hydrologic action across and along numerous established mammal trails. As water drained across the valley, fine particles may have been transported farther than the rest, then settled out to create good substrate for tobosa. This area may represent a small inclusion of Tornillo soils (L. Loomis pers. comm.).

Along the Rio Grande floodplain at the south end of the DH, cyclic deposition of silt from floodwaters has created the Glendale-Harkey unit. These are deep, well drained, silty-clay loams on nearly level floodplains. Fresh alluvium remaining after each flood would enrich the soil, promoting farming as an important area industry. Today, with a history of heavy use and with natural flood cycles broken by upstream dams, in many places these soils have eroded, and the surface is bare if not occupied by creosote or thickets of mesquite-dominated brush.

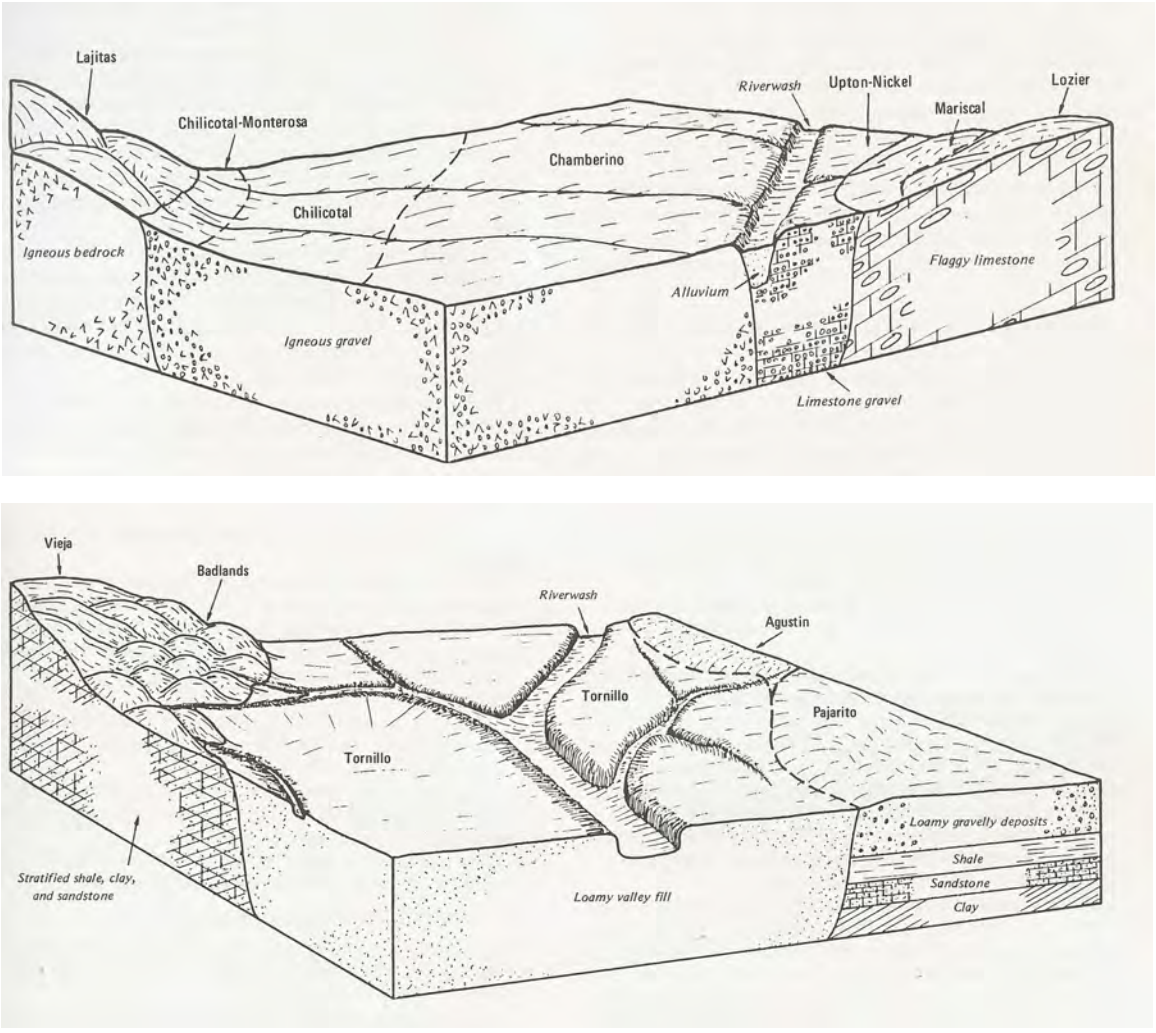


Fig. 16. Schematic drawings of lower elevation soil units (Upton-Nickel and Tornillo) in the DH Mountains and BBNP (Cochran and Rives 1985).

Fig. 17. Erosion of Tornillo soils into badlands formations, north of Tornillo Creek bridge, March 2007.

Fig. 18. Tobosa grassland on the western side of Ernst Basin. Note disturbance of fine soils at bottom center of picture, due to entrenched mammal trails and fluvial erosion.

In all of the major streambeds and drainage channels, the soils are termed Riverwash, consisting of sandy-to-silty, gravelly alluvium. The arroyo beds are expected to be mostly barren. Any plants that might establish themselves in the streambeds would be deep-rooted perennials; annuals are more expected, according to the soil survey descriptions (Cochran & Rives 1985). These areas are subject to frequent flash floods and then are dry for long periods. Erosion rates are high, creating cut banks on both sides of the drainages.

Human History

People have been living in the Big Bend for thousands of years. The research done and literature available about all phases of regional occupation are extensive and highly entertaining. The two sources used to compile the following summary (Tyler 1975; Alex 1990) are a good starting point. The first people thought to occupy the area now encompassed by BBNP were there during the Late Paleo-Indian period (12,000–6,500 BC). At the end of the last glacial period, the climate was cooler and wetter, with more vegetation, and the local people lived a nomadic hunting-and-gathering life. Though few sites in BBNP have evidence of occupation from this time, one happens to be at the foot of the DH. Dated superficially by the type of point (arrowhead) found there, the site is nestled at the southwest foot of Alto Relex. There, nomads may have enjoyed a small, spring oasis that may have existed in the more mesic environment of the time (A. Cloud pers. comm.).

Gradually the climate warmed, and both the flora and fauna adapted to the increasingly arid climate. Humans altered their hunting and gathering techniques by focusing on smaller game, using an atl-atl to propel their spears, and becoming more

dependent on plant foods. Archaeological evidence from this Archaic Period (6500 BC–ca. 100 AD) is abundant in the Big Bend. In a survey of a 5000-acre (2023 ha) area of the DH, 99 sites were found, ranging from general lithic scatter to pictographs and obvious cave utilization. On a few, higher-elevation precipices, low, crescent-shaped rock walls were found, thought to be vision quest sites (A. Cloud pers. comm.). In a side drainage downstream of Passionflower Canyon, a mid-Archaic (4000 BC) point was found below a previously occupied cave. The shelter had a fire-blackened roof and was full of significant artifacts, including a storage pit lined with a woven, sotol-leaf mat, a metate (rock used for grinding and processing food), fiber sandals, yucca- and lechuguilla-fiber cordage, and various implements, including a wooden scoop (Niebuhr 1936).

The nomadic life was slowly transformed as the Jornada-Mogollon culture began to influence the region. During the Prehistoric Period (1000 AD–1535 AD), the bow and arrow replaced the atl-atl, and lifestyles focused more on agrarian settlements; ceramic shards are some of the common artifacts observed today. Remains of this culture are most abundant west of BBNP at La Junta, where the Rio Grande meets the Mexican Río Conchos. This area figures prominently in the Historic era (1535 AD– present), as the site of the first documented interactions between Europeans and Native Americans in the region.

In 1581, Spaniards exploring from their New World kingdom to the south recorded their encounters with local natives, groups commonly known as the Chisos and Jumanos Indians. Initially welcoming, the native peoples became more hostile due to poor treatment from their southern neighbors. The Spanish, amidst conscripting slaves

and souls, were focused on using the Big Bend as a safe foothold from which to find the riches imagined by many to be awaiting discovery and extrication in the North American interior. However, as the Mescalero Apache were forced southward by the plains-dominating Comanche, the peaceful frontier envisioned by the Spanish deteriorated. Missions and presidio forts were established but, ultimately, to no avail as Indian raids increased south of the Rio Grande.

Regional instability was a major factor in the European loss of control; between the 1821 Mexican independence from Spain and the ensuing Texan independence from Mexico in 1836, no government existed that could provide the stability needed to neutralize Indian hostilities. An established cycle developed: Apache, and eventually Comanche, bands would summer to the north in New Mexico and Oklahoma, sweep down through the Big Bend into northern Mexico, raiding anyone and any place they chose, and then return with livestock, horses, and other spoils. Their travels resulted in a wide, beaten path along this route. The Comanche Trail was clearly visible for many years after the cycle was broken and consisted of several routes heading north from the river. These routes converged at Persimmon Gap, which formed an important conduit during the annual migration.

The next, non-Indian presence in the Big Bend was slow to develop. A few early ranchers and traders in the mid 1800s strove to take advantage of the abundant grasses and economic opportunities offered by trading with the Mexican interior. The U.S. military established a fort in the Davis Mountains in 1854 to help protect the fledgling trade routes. Searching for a way to match Native Americans' survival abilities in the harsh desert, the army brought camels to the region as an experiment in arid military

operations. The camel corps passed through Dog Canyon and traveled on the flanks of Dagger Mountain in 1859 as they moved in and out of the rough country to the west and south. The Civil War brought that experiment to an end, as well as any protection and stability that the U.S. military had brought, as all troops were recalled east. Despite the threat of constant raids and loss of cargo or livestock, trading increased. By 1881, after several violent attacks had eliminated the remaining, resistant Native American bands, Indians were no longer a threat to the new settlers. The railroad came to the region in 1882, enabling towns like Alpine and Marathon to be established along the route. Ranching became more logistically feasible, and amid reports of unending amounts of forage and opportunity (Langford 1995), a wave of settlement moved out in all directions from the railway.

Ranching was successful in many areas of the Big Bend, but the DH, as a whole, never provided a consistent range for grazing animals. The Adams family headquartered on the eastern side of the DH near Hubert Ridge and the mouth of Telephone Canyon. They originally ran mohair goats, a popular choice during the early 1900s in Big Bend, but, eventually, it was not a successful venture due to low prices and environmental challenges (Adams 1978). One of the stories about how the DH were named tells of a rancher who took his horses to the higher plateaus to graze on the belly-high grasses, only for them to die of thirst (Fulcher 1959). Few remnants of human use persist in the mountains—old pieces of wood, some wire—but the lack of water was probably the primary limitation. The Adamses did finally find success but only through utilizing another biological resource.

Euphorbia antisyphilitica (candelilla) was harvested and rendered to produce blocks of wax for commercial sale. One of the main factories was in the McKinney hills, just west of the DH proper. The Adams family had an extensive system of wax camps on the eastern side, clearing $125,000 in one year, above and beyond $15,000 of product lost to fire (Adams 1978). Many residents lining both sides of the Rio Grande were involved in wax production, since the river provided the large quantities of water needed in the rendering process. This small-scale industry continues along the river today, providing wax used, most notably, in lip balm and other cosmetics.

Rubber was another product to come out of the Big Bend: a high-grade natural product can be extracted from the shrub *Parthenium argentatum* (guayule). In 1909 a factory was built in Marathon and produced rubber intermittently for twenty years, but it was determined that the natural population would not produce enough rubber to be economically sustainable. Interest in the industry eventually faded. A consistently utilized plant, though not for human consumption, was *Bouteloua ramosa* (chino grama), extensively harvested to feed the area's increasing numbers of working mules, burros, and horses.

Mining was an important industry in turn-of-the-century Big Bend. While cinnabar or mercury mining was flourishing in other parts of the Big Bend, important minerals in Sierra del Carmen history were silver, lead, and zinc. The Puerto Rico mine, on the western front of the Mexican Sierra del Carmen, was the source for tons of ore to be smelted at Boquillas, Mexico. A store supplying the mining community opened after a supply road finally connected Marathon with Boquillas, Texas, in 1894 (Maxwell 1979). When the smelter shut down in 1914, the ore was transported into the U.S. by a

six-mile, aerial tramway over the Rio Grande. At the terminal in Ernst Basin, 7.5 tons (6804 kg) of ore per hour were loaded into mule-drawn carts, which then completed the journey north to the railroad (Pearson 1990). Today the Old Ore Road travels the route almost as it was at the turn of the century.

The southern end of the DH, as a whole, was an especially popular commercial area of the time. A succession of post offices, trading posts, and even a hot springs "resort" on the river were among the amenities available in the early 1900s. The services targeted residents on both sides of the river, who lived as friends and neighbors, depending heavily on each other in light of their isolation. For a short time, however, unrest and banditry associated with the Mexican revolution caused the US military to station troops in the Big Bend. Apart from two significant raids, which occurred before most troops were deployed to the area, the soldiers spent much of their time grumbling about their plight, stranded in the desert with no maneuvers in sight. Some of their time was put to good use, however, stringing a telephone line across the DH to add yet another modern convenience to the area. Remnants of that project can still be found along the Telephone Canyon trail. True to the resourceful nature of area pioneers, the Adams family used abandoned caches of poles to outfit a large cave in which they lived for a time (M. Paredes pers. comm.).

Partly due to the military-era publicity, word spread about a spectacular place in western Texas, with rugged scenery and impressive, river-carved canyons, a place certainly worthy of national park status. Momentum built until the Texas legislature created Texas Canyons State Park in 1933, destined to become part of the National Park Service eleven years later. The Civilian Conservation Corps worked in the new park,

improving access and accommodations at the original park headquarters in the Chisos Basin. Over time, however, other areas in the park that had seen so much life and death through the steady flow of human occupiers were left to crumble back into the desert. Most settlements and signs of life are but lumps of melted adobe or twisted, rusty wire barely emerging from the ground. Today, the only humans seen in the DH are hardy souls from our current times: those willing to forgo a soft bed and air conditioning to adventure into what was many peoples' backyard and now is our wilderness. Each year up to 400,000 people visit Big Bend park, participating in a wide variety of recreational pursuits. Hiking, camping, river running, bird watching, geology and nature tours, and ranger activities are among the many opportunities available to today's visitors.

Disturbance Regimes

Human-induced disturbance regimes that have affected DH vegetation include grazing, natural-resource harvesting, fire, non-native species establishment, and recreation. The absence of surface water in the DH has most likely saved it from most of the historical grazing-induced impacts. Early park biologists noted that good grass was found only where no water was available. According to these early reports, whereas *Euphorbia antisyphilitica* (candelilla) and *Bouteloua ramosa* (chino grama) had been collected almost to the point of extirpation in more accessible areas of the park, the populations in the interior of the DH appeared untouched (McDougall 1936). This contrasts with sites with available surface water, such as man-made tanks and dams. At one time, perhaps 8,000 goats watered at Ernst Tank, leaving hardly any remaining plants in the surrounding area (NPS 2003). Today there is a small strip of tobosa grassland

there, with the rest of the basin being gravelly creosote flats. Since the advent of the National Park, the land has been allowed to rest and recover, although in the DH it would be difficult to show whether this area has returned to its original stature.

Tornillo Flats, extending west of the DH, once supported good grazing (Langford 1995), but the soils are fine and silty. When the grass cover was disturbed, the soil eroded, creating the barren flats and badlands-type areas that are visible today when driving through the National Park south of Persimmon Gap. Some grassland areas have seen improvement since the removal of stock animals, most notably in the Dog Flats area west of Dog Canyon.

Noticeable remains from human use of the DH include header dams, built across narrow drainages to catch runoff from thunderstorms, and tanks, built with berms to catch water in more open areas. They may hold water for extended periods if rain falls in the right place, but generally are not permanent sources. There is a dam along the Telephone Canyon trail, where a few non-native grasses, e.g. *Eragrostis lehmanniana* (Lehmann's lovegrass) have occurred but likely will not spread into the arid surroundings. Tanks often develop into mesquite thickets or provide wallows for javelina and non-native feral hogs. The two mapped tanks, in Dagger Flat and Ernst Basin, were not visited during this study.

The harvesting of *Euphorbia antisyphilitica* (candelilla), *Bouteloua ramosa* (chino grama), and *Parthenium argentatum* (guayule) probably impacted the area to some extent, but again, without water, the possibility for people or animals of burden to spend long amounts of time in the area was low. There is no historical quantitative basis from which to compare pre- and post-harvest plant densities with the current populations, but

the populations of grasses and "weed," as *Euphorbia antisyphilitica* (candelilla) was called, today appear healthy and widespread. *Parthenium argentatum* (guayule) is not common at lower elevations in the DH, which may have restricted its collection to areas closer to the factory at Marathon. This resource harvesting does not seem to have been a significant impact in the DH.

Fire may be a significant factor in creating patchiness of higher elevation vegetation. NPS fire records date from 1948. Over the last 57 years, a total of 84 recorded fires have burned in the DH (Fig. 19), five occurring outside of BBNP, in total covering 12,153 acres, or 4918 ha (J. Morelock pers. comm.). In many places, one yucca struck by lightning would constitute a "fire." Often vegetation is so patchy that flames will not spread beyond the spot where they started. In higher elevations or in some major drainages, it would be possible for larger fires to maintain themselves, because the vegetation is denser and larger than on more arid slopes and flats. Fifty of the recorded fires covered less than one acre; six of those were human caused. In the twelve fires larger than 20 acres (8 ha), lightning strikes burned 12,082 acres (4,889 ha). Human-caused fires do not seem to be a significant impact, especially outside of developed areas.

Long-term impacts to vegetation from fire have not been thoroughly researched in the Chihuahuan Desert. In current, land-management philosophy, it is commonly believed that fire is a positive and necessary force in the environment but one that has been suppressed by humans for too long, thus unnaturally changing the vegetative character of (especially western) landscapes. There has been little suppression effort in the DH, so current states should be considered normal. Henrickson and Johnston (1986)

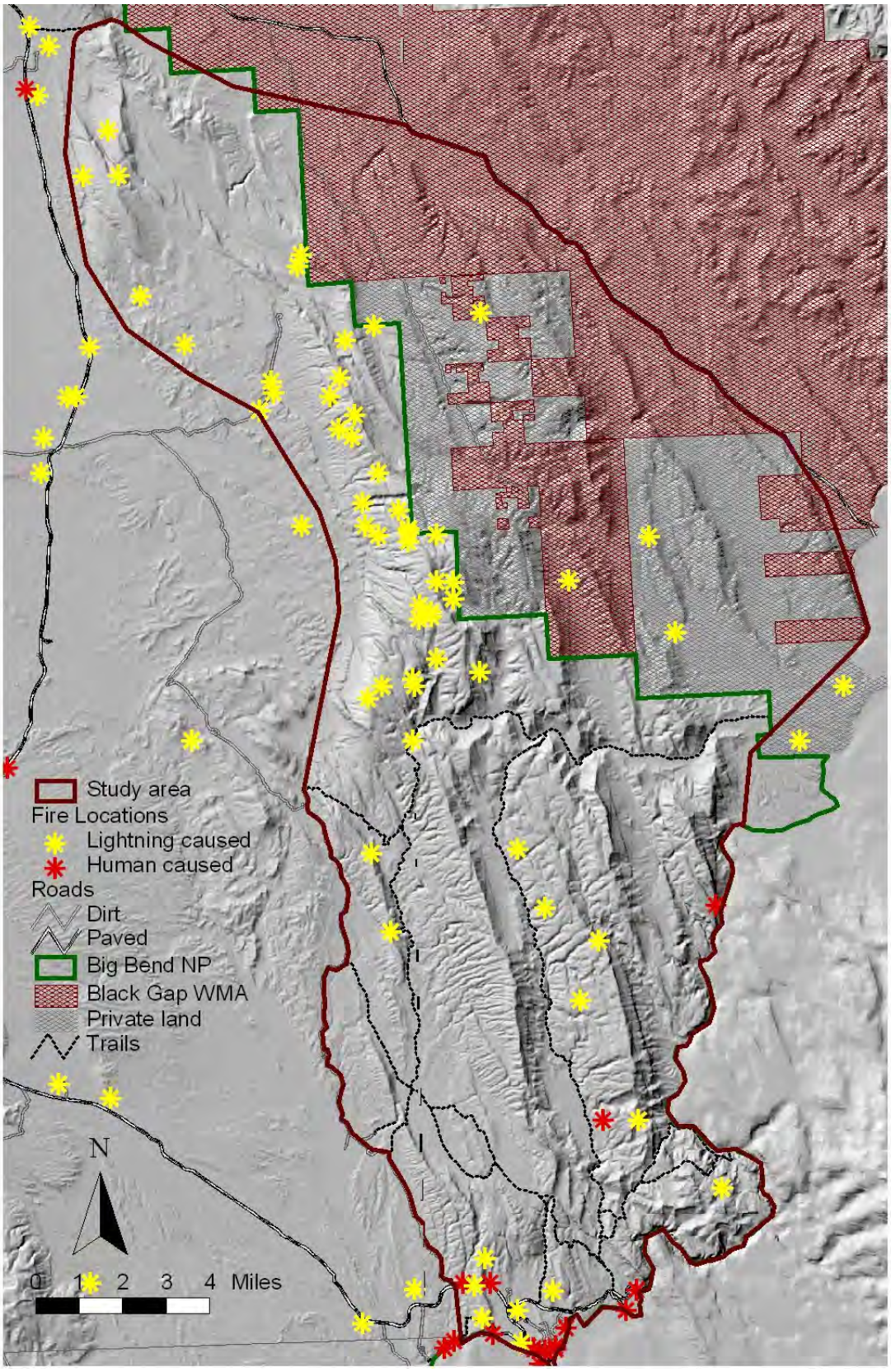


Fig. 19. Recorded fires in the Dead Horse Mountains, 1946–1998 (B. Alex pers. comm.).

suggest that the unique Yucca Woodland community at higher Chihuahuan Desert elevations may be maintained by fire, favoring the semi-succulent monocots over more woody species. This hypothesis could be looked at in the DH, where woody chaparral thickets occur in patches within the Yucca Woodland and where fires have impacted both life forms.

The establishment and spread of non-native vegetation is a significant issue, most striking along the river corridor. The invasion of the southwest by *Tamarix* spp. (tamarisk, salt cedar) is well known and is a major issue along the Rio Grande. This species can also be a problem at inland springs because its tiny seeds are easily transported by birds. The non-native *Arundo donax* (giant river cane) is also densely present along the river, interspersed with smaller populations of its similar native (Saltonstall 2003) cousin *Phragmites australis* (common reed). These three species create a homogeneous thicket along miles and miles of riverbank (Fig. 20). The dense canopy cover, in addition to increased soil salinity levels created by the tamarisk, prohibits the establishment and/or success of previously existing native species. The dense growth of roots and cane rhizomes stabilize the sandy banks. With upstream dams breaking the historic flood cycles, the river channel does not see the regular scouring and replenishment of beaches and gravel bars, places where native *Salix* spp. (willows), *Populus* spp. (cottonwoods), and other riparian species would normally take root. The stabilized banks entrench the river, limiting the possibilities for native species and leaving non-natives as the dominant riparian species on the Rio Grande. Currently there

Fig. 20. Non-native *Arundo donax* (a.) growing densely along the Rio Grande, with a *Tamarix* sp. (b) thicket established slightly higher up the riverbank.

is a bi-national effort underway to clear selected areas of tamarisk and cane within Boquillas Canyon and then track the success of exotic removal and the hoped-for reestablishment of native species (J. Sirotnak pers. comm.).

Pennisetum ciliare (buffelgrass) is another invasive, non-native species that is well known in the southwest. The robust African grass was introduced as a drought-tolerant range species and has spread, excluding much of the native flora and fauna where it takes hold. In BBNP it is increasing at the lower elevations, and on the flanks of Boquillas Canyon *Pennisetum ciliare* (buffelgrass) can be seen almost to the top of the canyon walls. Though ubiquitous, it is not as dense as it has become in other low-elevation areas, perhaps being held in check by other non-native species, burros and horses.

Though legal grazing was eliminated from BBNP by the mid 1950s, some livestock still forage within the park along the river corridor. Termed "trespass livestock," many horses, burros, and even cattle cross the river from Mexico, taking advantage of all forage available during their free-range existence (there are no fences at the river along the NPS boundary, and the few on the Mexican side are discontinuous). It is unclear whether *Pennisetum ciliare* (buffelgrass) seeds are spread through dung or if the stock are, in truth, limiting seed establishment by grazing. What is certain is that the animals trample and eat native vegetation (Fig. 21). Collecting trips through Boquillas canyon revealed that the sides of the canyon did not support much diversity; the few plants able to exist on rocky outcrops and ledges that were not frequented by burros were the only ones to remain. Biological crusts that form on the sandy surfaces were relegated to sunken areas between rocks and thin margins of soil that escaped being trodden. At

Fig. 21. Impacts from trespass livestock: a. burro eating prickly pear, b. trampled vegetation and disturbed fine soils.

the mouths of side canyons feeding into the Rio Grande, some slopes were almost denuded and the soil churned up to a fine powder due to the stock traffic. Park rangers are only just beginning to assess the impacts to park resources due to trespass livestock (D. VanInwagen pers. comm.).

Humans are also potential sources of disturbance, but recreational use in the DH is minimal. There are many ways for visitors to enjoy the DH: driving the high-clearance/4-wheel-drive Old Ore Road, hiking, camping, and floating the river through Boquillas Canyon. Front-country use is intensive at the RGV developed area, where there are a campground, RV hook-up site, ranger station, store, and boat ramp. There, human activity does not stray far from these impacted areas. For those who want to hike, several trails are available throughout the DH, with those at Ernst Tinaja and Boquillas Canyon being the most heavily used. Impacts are minimal along the trails, as hiking cross country means difficult navigation between the spines of lechuguilla, cacti, ocotillo, and catclaw, not to mention the possibility of encountering various venomous creatures; this scenario does not appeal to the majority. The lack of water sources limits recreational use of longer trails in the DH, such as the Telephone Canyon and Strawhouse trails. The Marufo Vega loop is the most-used longer trail of the DH, but the numerous search-and-rescue operations that have involved this area attest to its challenging environment.

For those wishing for an overnight backcountry experience, permits are available for the primitive car-camping sites along the Old Ore Road (offering only a cleared area for parking and a tent), backpacking, or river trips. In 2005, only 13% of BBNP backcountry users chose to recreate in the DH area (NPS 2006; S. McAllister pers.

comm.). That is only 0.5% of the 400,000 visitors to the park in 2005. Only 14% of those backcountry visitors went backpacking, meaning a very small impact to more pristine areas. Twice as many people used the river than went backpacking, but any human-caused disturbances along the river corridor are are focused around the few usable campsite areas in the canyon, and the floodplain is naturally a highly impacted area to begin with. Human use in the riverine portion of the DH appears less significant long term than are the increasing non-native vegetation or damage done by trespass livestock.

On the whole, the impacts of current human use do not seem significant over most of the DH backcountry. People can serve as vectors in transporting and dispersing non-native seeds, on their cars, shoes, clothing, and through stock use, but no buffelgrass was observed away from the river or the lower Old Ore Road. The few tanks may support non-native species, but these species are likely restricted to those areas due to moisture requirements. It is the human impacts on a larger scale, i.e. the changes in river dynamics and regional dominance of non-native riparian species, that are most obvious today. Increasingly, impacts from trespass livestock are becoming apparent as well. In the end, the most realistic outlook may be to rely on the old axiom: good vegetation will be found only where there is no water.

Paleoenvironment

There has probably never been a unified CDR flora, and the modern vegetation is as sparse as at any time during the current Holocene period (Van Devender 1990). Since the glacial period during the late Wisconsin, species ranges have expanded and contracted due to climate changes and the environmental tolerance of individual species. The changes in climate have been mediated largely by alterations of large-scale,

atmospheric flow cycles, similar to the forces that have caused the El Niño/La Niña weather patterns and the successes and failures of fisheries in more recent years (Neilson 1986). The resulting characteristics of vegetation communities present at different points through paleohistory can be interpreted from analyzing the contents of packrat middens. These nests consist of material gathered within a 98–164 ft (30–50 m) radius of the site. The nests are reused through time and, if sheltered well, can accumulate as much as 40,000 years of local biotic history (Van Devender et al. 1987).

Vegetative remains in middens across the Southwest, dating from the last glacial period through to the present, suggest a progressively warming and drying climate (Van Devender 1990). During the late Wisconsin period (20,000–11,000 years ago) North America was in a full glacial period. At this time, an extensive pinyon-juniper-oak woodland covered the entire elevational range of the CDR. It is hypothesized that the region experienced cooler, overall temperatures, along with dominant winter rains, in order to support this type of vegetation. At this time, a more equable climate with few winter freezes is envisioned, likely created by the blockage of arctic air masses by the continental glaciers (Bryson & Wendland 1967 in Van Devender 1990). This situation may have allowed warmer-adapted species to migrate north and more cold-adapted species to extend south, creating a level of vegetative complexity that no longer exists (Van Devender 1990) yet could still be reflected by relicts occurring in local floras.

During the early Holocene (11,000–9000 years ago), glaciers retreated, and pinyon pines disappeared from the midden record; increased summer temperatures combined with winter rain and increasing summer monsoons most likely precipitated the shift to an oak-and-juniper dominated flora. By the middle Holocene (9000–4000 years

ago), winter rainfall is thought to have ceased, while summer temperatures and rainfall increased substantially, favoring the increase of graminoids. A vast, unbroken grassland spanned the entire central section of North America from Canada down through the Mexican highlands, with warm-season perennial grasses (utilizing the C4 photosynthetic pathway) replacing cold-adapted C3 grasses in the central Great Plains (Van Devender et al. 1987). Winter freezes, with higher intensity and frequency than the region sees today, most likely continued through the middle Holocene, preventing subtropical elements from becoming an established part of the regional flora.

Moving into the late Holocene (4000–present), temperatures continued to increase. The advent of milder winters and continued abundant summer rain, with variable drought periods, favored the establishment of subtropical desert shrubs and a decrease in the primacy of grasslands by the lower Holocene. This period also saw the reestablishment of a corridor connecting the Chihuahuan and Sonoran Deserts. The modern, plant-community composition of the Big Bend and larger Southwest is thought to have been established more recently than 4,300 years ago.

In the DH area, middens from Dagger Mountain, RGV, and Maravillas Canyon (in BGWMA, ca. 15 mi/24 km east of Sue Peaks) have been examined (Wells 1966; Van Devender et al. 1987, Van Devender 1990). There are clear differences between the species able to persist throughout the known paleohistory and those that disappeared or appeared, presumably because of changing environmental conditions. *Agave lechuguilla* (lechuguilla), *Ephedra aspera* (Mormon tea), and *Opuntia phaeacantha* (variable prickly pear) were the only species consistently represented throughout the entire 40,000-year record at RGV. Cold-adapted species, or at least those currently requiring more mesic

conditions, dominated the late Wisconsin period. *Juniperus pinchottii* (red-berry juniper) was the most abundant species represented in the midden data, accompanied by *Pinus remota* (papershell pinyon), *Dasylirion leiophyllum* (sotol), *Koeberlinia spinosa* (allthorn), and *Quercus hinckleyi* (Hinckley oak). In the Dagger Mountain middens, *Quercus pungens* (shrub oak) replaced *Quercus hinckleyi* to become the dominant scrub oak of the DH today. Beginning about 9000–10,000 years ago, the previously dominant species at RGV were replaced by a more xeric shrub assemblage, initially dominated by *Prosopis glandulosa* (mesquite) and *Lycium puberulum* (silver wolfberry), with an increased representation of *Agave lechuguilla* (lechuguilla) and *Opuntia phaeacantha* (variable prickly pear). Over the middle Holocene, more xeric-adapted species began to occur, including *Larrea tridentate* (creosote), *Opuntia rufida* (blind prickly pear), *Fouquieria splendens* (ocotillo), *Acacia greggii* (Gregg catclaw), and even *Castela stewarti* (crucifixion thorn) for a short time.

The midden data create a slightly different picture at the Maravillas Canyon site. During the late Wisconsin, while RGV showed a more xeric-oriented species assemblage, with *Juniperus* spp. (junipers) and some *Pinus* spp. (pinyon pines), *Dasylirion leiophyllum* (sotol), *Koeberlinia spinosa* (althorn), *Ephedra aspera* (Mormon tea), and *Agave lechuguilla* (lechuguilla), the Maravillas Canyon site recorded more of a woodland association, being dominated by pine, juniper, and oak, with none of the above-listed shrubs that were occurring contemporaneously at RGV. Around 9000–10,000 years ago, as more xeric-tolerant species began to occur at both sites, the increased diversity at Maravillas, unlike RGV, included species that today are typical of the larger, protected drainages of the DH: *Purshia ericifolia* (heath cliffrose), *Guaiacum angustifolium*

(guayacan), *Shaefferia cuneifolia* (desert yaupon), and *Acacia roemeriana* (Roemer acacia). This discrepancy between the vegetations of the two sites, in terms of the degree to which each has adapted to xeric conditions, highlights an important difference between the sites. They are both found at the same elevation (ca. 1970 ft/600 m), which suggests that the Maravillas site has a less arid microclimate. Van Devender (1990) attributes this simply to the Maravillas Cave's northern aspect and its being geographically closer to the eastern edge of the CDR. However, the topography of the region should also be considered highly significant.

The Maravillas Cave is on the eastern side of the DH, the DH being the northern extension of the Sierra del Carmen of Mexico, which is itself an extension of the Mexican Sierra Madre Oriental range. Van Devender (1990) suggests that because desert scrub elements, such as *Agave lechuguilla* (lechuguilla), *Koeberlinia spinosa* (allthorn), and *Dasylirion leiophyllum* (sotol), were present in the RGV area during the late Wisconsin and because those species were mainly absent in the Maravillas samples dating to that time, the environment west of the DH has apparently been more xeric for the last 28,000 years. He continues to extrapolate that the DH, as an extension of the Sierra Madre Oriental, may serve as an important air mass barrier that influences the local climate. Throughout this report, this idea is supported based on findings during the current study.

General Vegetation Description

The plant life characteristic of the study area is that of the CDR. This in and of itself does not provide detailed insight, however, beyond assumptions that the plants will be adapted to extreme heat and aridity and that *Agave lechuguilla* (lechuguilla) and *Larrea tridentata* (creosote) may figure prominently in the species composition. Many

workers have proposed vegetation classification systems relevant to the region. For the Chihuahuan Desert as a whole, there exist excellent overviews of basic and detailed vegetation structure (Morafka 1977; Henrickson & Johnston 1986, 2004; Brown 1994; Powell & Hilsenbeck 1995). Descriptions in several local floras (Rogers 1964; Butterwick & Strong 1976; Amos & Giles 1992; Hardy 1997) demonstrate the degree of local diversity possible within hierarchies created by the above publications. Two vegetation maps, produced through remote sensing and some vegetation sampling, generally include the study area (Plumb 1991, 1992; Wood et al. 1999). However, neither study adequately sampled representative DH vegetation nor ground-truthed the resulting maps and should not be considered definitive representations of what actually occurs in the DH.

Giving a sense of foreshadowing, Plumb (1992: 386) makes a discerning statement that no one classification system is universally the best and that researchers should "…select the one that most appropriately suits their purposes." Beyond an overall tendency towards homogeneity (Brown 1994), the DH and larger CDR have basic plant-community types that intergrade and change in abundance and dominance in response to the complex physiography. Perhaps Whittaker, as quoted in Takhtajan (1986), has offered the best explanation for general Chihuahuan Desert vegetation patterns: in warm, semi-arid deserts there is no clear convergence of dominant forms as can be found in cool semi-deserts. Warm deserts may be too dry to support arborescent life-forms or consistent canopy cover. However a diversity of non-arborescent growth is supported in pockets of higher moisture availability, maintained by the right combination of aspect, slope, elevation, and substrate. Larger plants, such as shrubs and *Yucca* spp. (yuccas),

can also create special microclimates. Many species take advantage of the shade and wind protection that these larger nurse plants provide. This could be considered the canopy of the Chihuahuan Desert—low and discontinuous, but functional.

The vegetation types used herein to describe the DH are based on observations made during the study period in addition to the classifications by Henrickson and Johnston (1986) for the CDR and Plumb (1992) for BBNP. Henrickson and Johnston (1986) comment on the high degree of intergradation between types in the CDR, which makes it difficult to place many areas into an exact classification, especially when many sub-types are recognized, as in their and Plumb's (1992) work. Henrickson and Johnston's 16 general vegetation groups incorporate the communities of the entire CDR. Not all of their communities occur in the DH, and because of the high degree of intergradation, the basic categories used to describe DH vegetation have been combined and simplified, though their names are taken from, and basically correlate to, the Henrickson and Johnston terminology (Table 1).

Plumb's categories (1991, 1992) are extremely specific, utilizing 24 categories for vegetation types within just BBNP. Park managers found that level of specificity unwieldy and, therefore, combined some categories (Table 2). Plumb's combined categories can also be generally correlated with those chosen to describe the DH, and because the vegetation class types were based on remote sensing data, they are computerized and able to be analyzed for coverage percentages within the study area (Table 3). The vegetation type with the largest coverage is the Lechuguilla Scrub, at 50.4% of the study area. This type includes Plumb's lechuguilla-prickly pear-grass and

Table 1. Outline of plant communities of the Chihuahuan Desert Region (Henrickson & Johnston 1986). Types in bold are used to describe DH vegetation.

I. Desert Scrub and Woodlands	II. Grasslands	III. Chaparral	IV. Montane Woodlands
A. Chihuahuan Desert Scrub	A. Grama Grassland	A. **Montane Chaparral**	A. Juniper-Pinyon
1. Larrea Scrub	(*Bouteloua* spp.)		Woodland
2. **Mixed Desert Scrub**	B. Sacaton Grassland		B. Oak Woodland
3. **Sandy Arroyo Scrub**	(*Sporobolous* spp.)		C. Pine Woodland
4. **Canyon Scrub**	C. Tobosa Grassland		D. Mixed Fir Forest
5. Sand Dune Scrub	(*Pleuraphis* spp.)		
B. Lechuguilla Scrub			
C. Yucca Woodland,			
Sotol Scrub (Rosetófilo)			
D. *Prosopis-Atriplex* Scrub			
E. Alkali Scrub (halophiles)			
F. Gypsophilous Scrub			

Table 1, continued. Outline of plant communities of the Chihuahuan Desert Region (Henrickson & Johnston 1986). Types in bold are used to describe DH vegetation.

I. Desert Scrub and Woodlands	II. Grasslands	III. Chaparral	IV. Montane Woodlands
G. Cactus Scrub			
H. Riparian Woodland			

Table 2. Vegetation types of Big Bend National Park, as circumscribed by BBNP staff from Plumb (1991, 1992).

BBNP category	Plumb's categories
Upland Riparian	Mesquite Thicket
	Desert Willow
Riverine Riparian	Reed Grass
	Cottonwood Grove
	Mixed Riparian
Lechuguilla Scrub	Lechuguilla-Prickly Pear-Grass
	Lechuguilla-Candelilla-Grass
Creosote Scrub	Creosote Flats
	Creosote-Tarbush
	Creosote-Lechuguilla
	Creosote-Grass
High Desert Grasslands	Sotol-Lechuguilla-Grass
	Lechuguilla-Grass
	Lechuguilla-Grass-Viguiera
	Sotos-Nolina-Grass
	Yucca-Sotol
	Creosote-Yucca-Grass
Scrub Woodland	Mixed Scrub
	Oak Scrub

Table 3. Percent composition of vegetation types in the BBNP portion of the study area, as translated from remote sensing (Plumb 1991, 1992).

Vegetation Type	Percentage of Study Area
Lechuguilla Scrub	50.4
High Desert Grassland	45.1
Creosote Scrub	1.6
Scrub Woodland	1.5
Upland Riparian	0.9
Bare	0.3
Riverine Riparian	0.2
Water	0.01
Total study area in BBNP	117, 659 acres (47,615 ha)

lechuguilla-candelilla-grass categories. This type is closely followed by the High-Desert-Grassland type at 45.1%, which includes the subcategories with the Rosetófilo species like *Nolina erumpens* (nolina), *Dasylirion leiophyllum* (sotol), and *Yucca* spp. (yuccas), with grass species as co-dominants.

Previous Work, Notable Species

Many people have collected in and around the DH but are remembered only by their names on herbarium labels. Vernon Bailey made the earliest known collections in 1901 around the Boquillas area (*Bailey 34, 355* TEX-LL), and with the exception of the author of the current study, Barton H. Warnock remains the most prolific collector from the area. Specific scholarly work in the DH has been attempted twice previously as unfinished master's theses, most notably by Miller Talbot, whose collections reside at SRSC and TEX. Tom Rogers (1964) produced an MS thesis dealing with the vegetation of BGWMA, and many of his collections added depth to the current effort.

Only one formal publication focuses on the vegetation of the Dead Horse Mountains: Philip V. Wells, in the course of his packrat midden research, spent time in the DH and subsequently published a paper of his observations during two hikes to Sue Peaks (Wells 1965). The paper includes an excellently characterized description of vegetation patterns and a species list; although incompletely vouchered (C. Morse pers. comm.), the list is still a useful tally of species present at the time.

The most extensive data documenting DH taxa were compiled for an unpublished report (Amos & Giles 1992) completed for the Nature Conservancy when it owned the parcel of property including Brushy Canyon. This property has since been deeded to Texas Parks and Wildlife (TPWD) as part of BGWMA. The report on the Brushy

Canyon flora is the only other intensive, documented work to be done in the DH prior to the current research. Qualitative descriptions of vegetative communities are given in the report, in addition to notes on species of concern tracked by the TPWD. The species list of 276 vascular taxa was compiled using collections and observations made during six, one-day fieldtrips over two years. It includes flowering time, general habitat, and abundance and notes voucher collections made. Only one of the five species of concern noted in the report, *Physaria mcvaughiana* (McVaugh bladderpod), was located growing abundantly in the creekbed of Big Brushy Canyon. The other four species of concern, *Senna orcuttii* (Orcutt senna), *Hedyotis pooleana* (Jackie's bluet), *Perityle bisetosa* var. *scalaris* (stairstep rockdaisy), and *Cirsium turneri* (cliff thistle), were expected to be present and had been located there previously by TPWD biologists.

Species that were of particular import as the current project began included relatively unknown taxa and historically collected species that had not been seen for many years. *Hedyotis pooleana* (Jackie's bluet), a species described as endemic to the Dead Horse, is known from only two collections. Not mentioned in the current literature (Powell 1998, Turner et al. 2003), *Quercus intricata* (Coahuila scrub oak) was collected by Wells (1965) near the summit of Sue Peaks (*Wells s.n.* KANU); this species was previously known to occur in the U.S. only in the Chisos Mountains of BBNP and in the Eagle Mountains of Hudspeth County (Fig. 22). Another historical record, the northern Chihuahuan Desert endemic *Andrachne arida* (Trans-Pecos maidenbush) had not been verified as extant since 1958. Unconfirmed historical reports of *Quercus hinckleyi* (Hinckley oak) should not be entirely dismissed (J. Sirotnak pers. comm.); it currently occurs with *Andrachne arida* in the Solitario, a limestone area 40 mi (64 km) west of the

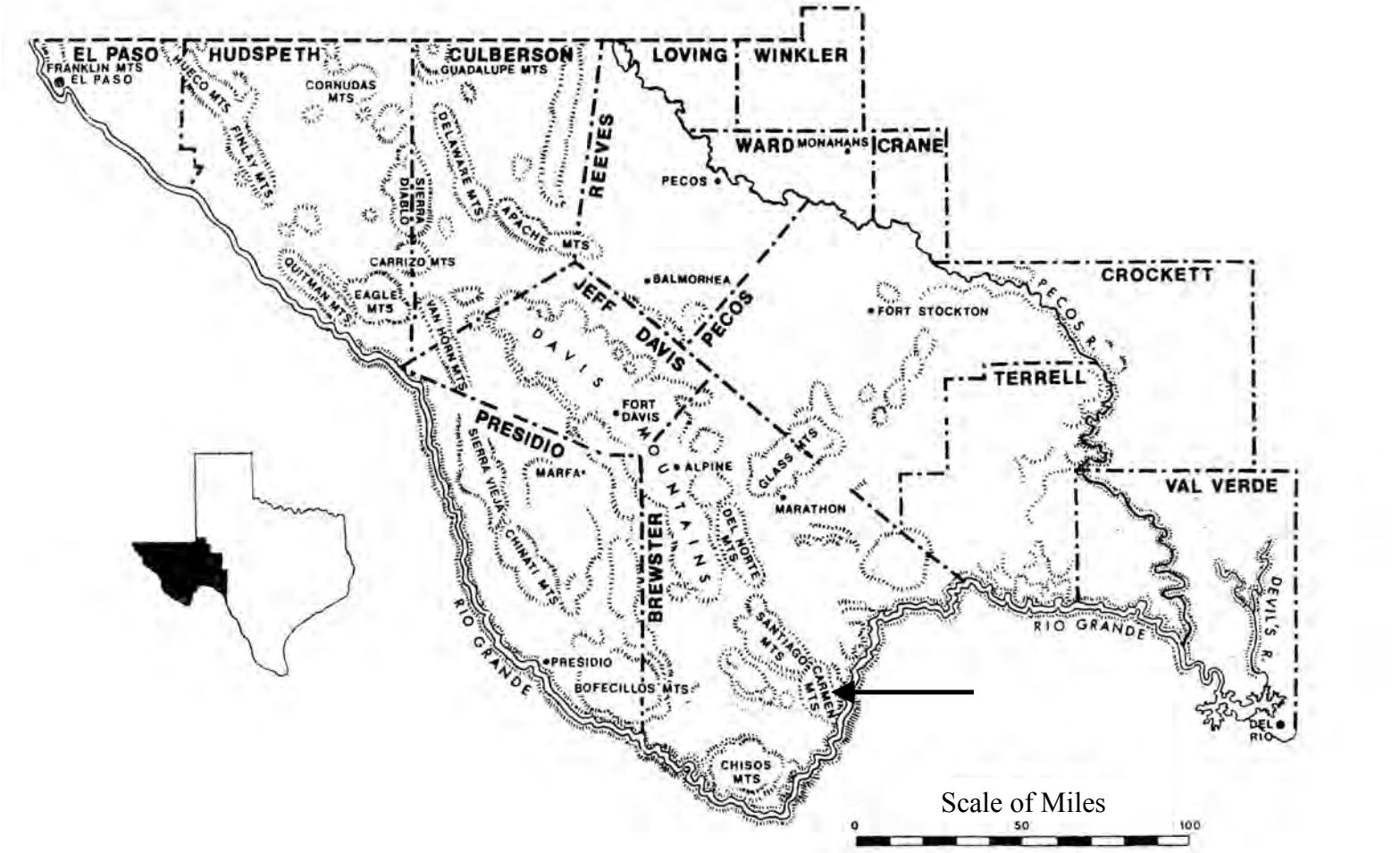


Fig. 22. Schematic map of Trans-Pecos mountain ranges, created for use in the Sul Ross State University herbarium and used by permission. The Dead Horse Mountains are labeled “Carmen Mts”.

DH. This oak species figures abundantly in packrat midden records (Van Devender et al. 1987), indicating that it is a cooler-weather, more mesic species. This could suggest it is relegated to protected niches at the higher elevations, but individuals have been found in the Solitario (Bofecillos Mountains, Fig. 22) at only 3500 ft/1066 m (*BHW 21571* BBRSP).

Other work that relates to DH flora includes a recent, rare-plant project by park personnel (Alex et al. 2006), which has added to the previously known extent of special plant populations (Louie 1996). An overall plant list of BBNP exists (Clelland 2001), in addition to accounts of and a key for BGWMA vegetation (Rogers 1964, Mahler 1971), but these may not adequately represent the full complement of species found in the DH. While useful for determining presence or absence on a larger scale, these reports do not list all collection locations and are not clear as to whether any herbaria were searched to add known species that may occur only within the DH.

The main study objective was to create a collective body of work on the floral composition of the DH, documenting all known vascular plants through field collections and herbarium records. Goals to accomplish this objective included gaining more field-based information on rare and little-known species, obtaining historical records and collections through research, and increasing voucher collections through focused effort in under-botanized areas. Subsequent analysis was used to interpret the DH flora in a regional context, both within the Trans-Pecos and the larger Southwest.

CHAPTER II

METHODS

Herbarium search

Herbaria thought to hold specimens from the DH were contacted and, when possible, electronically searched. These included institutions that sponsored botanists known to collect in the Big Bend, those geographically close to the study area, and those that were otherwise promising and electronically available: Angelo State University (SAT), the Botanical Research Institute of Texas (BRIT), the New York Botanical Garden (NYBG), Sam Houston State University (SHST), Sul Ross State University (SRSC), the Texas A&M University Biology Department herbarium (TAMU), Texas A&M's Tracy herbarium (TAES), Texas State University (SWT), University of Kansas (KANU), University of Texas at Austin (TEX-LL), the University of Texas at El Paso (UTEP), and the on-site holdings of BBNP and BGWMA. Sheet-by-sheet searches were conducted at SRSC and BGWMA.

The relevant herbaria that were part of the Flora of Texas Consortium (SAT, SHST, SWT, TAES, TAMU, TEX-LL,) were searched through the project's website (FTC 2003). The University of Texas, Austin herbarium was also searched on its gateway website (PRC 2006), which had a larger and more current body of digital records available. Specimen information for the majority of Brushy Canyon collections (Amos & Giles 1992) was retrieved by an onsite search of the SAT database. Inquiries

were made to KANU about Philip Wells's possible collections mentioned in his publication (1965). Collections, and their whereabouts, made by William Mahler, previous faculty member at Southern Methodist University and long-time collector at BGWMA, were investigated. The collections of NYBG have the potential to house historical collections from early expeditions to the Big Bend area and were easily searchable online (NYBG 2006).

Search parameters used to limit digital searches were county (Brewster) and, when practical, the following key words, entered individually: alto, Arroyo Venado, Boquillas, brushy, Cow Canyon, dagger, devil's, Dead Horse, dog, Ernst, frog, Hubert, McKinney, ore, persimmon, Sierra Caballo, Sierra Larga, stairway, strawhouse, Stuart, Sue, telephone, tunnel. Names of collectors besides Mahler who are known to have worked in the region were also used as database search parameters: M.S. Young, E. Butterwick, B.H. Warnock, P.V. Wells, O.C. Wallmo, and O.E. Sperry. A spreadsheet was created in Microsoft Excel to house the accumulating specimen records. To populate the spreadsheet, TEX-LL search results were received directly from the curator as text files and converted, the SAT and sheet-by-sheet search results were manually entered, and the rest were downloaded as text files and converted or were copied and pasted directly into the spreadsheet from the internet.

Each entry in the resulting list was then reviewed for accuracy of occurrence within the study area. Any localities that were vague (e.g. "between Hot Springs and Marathon") or did not seem to fall within the study area (e.g. "15 miles down

Boquillas road from Panther Junction") were deleted. Locations not included in the study area, but that were often returned using the above key words, included McKinney Springs, Hot Springs, Roy's Peak, Muskhog Spring, and Dog Flats.

The majority of specimens at institutions outside of SRSC were not examined to verify their identification. All determinations of species found through the digital searches were assumed to be correct unless Turner et al. (2003) did not support that species' occurrence in the DH. Specimens with such suspect records were requested for examination from the relevant institutions, annotated, and included or excluded from the final flora (Appx. A) as appropriate. Unvouchered species that were listed in Wells (1965) or Amos and Giles (1992) and species collected close to but not within the study area were excluded from the DH flora and placed on a "possible" or "unlikely" list of taxa (Appx. B, C). Species that were observed in the field during the current study but were unable to be vouchered were included in the DH flora only if they were within an expected range according to Turner et al. (2003); these are noted accordingly in the annotated list (Appx. A). The resulting "historical" species list was cross-checked against the collections made for the current study, with nomenclature updated and matched as accurately as possible with current taxonomic standards.

Field Collections

Field work occurred between August 2003 and September 2006. An attempt was made to collect in all seasons and throughout the entire range. All species found in flower were collected during every trip. Often sterile specimens were collected, mostly to improve the author's field identification abilities but also to document the presence of an unfamiliar or previously unobserved taxon. Collection of rare species or plants of

uncertain identity and/or distribution was guided by BBNP protocol: no more than 10% of the viable reproductive population of rare plants should be harvested. This could mean no more than 10% of a flowering population in any given area or only one flower out of ten on a lone individual. Most collecting was done within the National Park, due to easier and quicker access to more areas. Access was mainly on foot, but two river trips allowed limited southern access. A few extended, overnight trips were enabled by water caches previously transported into the backcountry by NPS trail crew personnel and packstock.

Sampling areas were chosen based on intricacy of topography such as deep and/or sinuous canyons, unvisited but probably unique areas such as the higher peaks, and otherwise intriguing spots identified on USGS 1:24000 topographic maps. Search methodology was a directed meander (Goff et al. 1982) at each locality visited, focusing on promising microhabitats and moving from patch to patch as the observable species diversity was documented.

Field notes and resulting label data included collection location, habitat, habit and description of notable plant features, and associated species. Spatial location data were often taken onsite, recorded in Universal Transverse Mercator (UTM) projection for zone 13 using a Compaq iPac 3850 with a World Navigator Global Positioning System (GPS). The iPac operating system was ArcPad 6.0.2 for Windows, and data entry was facilitated by an application developed by NPS Geographic Information System specialist Betty Alex in ArcPad Application Builder 6.0.1. When time or GPS satellite availability were

compromised, digital coordinates were approximated and/or generalized post-field in the office, using ESRI's ArcPad 6.0 software and hypsography layers derived from one-meter Digital Elevation Model files for the Big Bend National Park.

Specimens were harvested, placed in a large plastic bag carried by hand during the field trips, and eventually pressed between newspapers and cardboards for several days until dry, either in the back of a closed pickup truck or over light bulbs to provide a heated drying environment. When dry, specimens in their newspaper were labeled with collection number, and name, if known, and then transferred to a freezer for two weeks to kill any insects, larvae, or eggs. When sterilized, the majority of specimens were mounted by SRSC herbarium technicians per SRSC specifications, using watered-down Elmer's glue, acid-free specimen sheets and labels, and packets of regular, white copy paper.

Identifications and Nomenclature

Specimens were identified using multiple sources, including Correll and Johnston (1970), Warnock (1970, 1974, 1977), *Flora of North America* Poaceae and Asteraceae volumes (FNA 2003b, 2006, 2007), Powell (1998, 2000), Yarborough and Powell (2002), Turner et al. (2003), and Powell and Weedin (2004). The majority of specimens were determined by B.L. Turner at the time of writing. The remaining specimens were of common species and thought to be correctly identified by the author. Turner et al. (2003) was the primary source for nomenclature and distributional data, and various online sources (ITIS 2007, MBG 2007) provided author information. Though the *Manual of Vascular Plants of Texas* (Correll & Johnston 1970) could be considered the taxonomic underpinning of this work, numerous updated sources provided the bulk of reference

material, most notably Powell (in prep.) and Powell et al. (in ms.) for non-woody vascular species and genera, the *Flora of North America* volumes for the Poaceae and Asteraceae (FNA 2003b, 2006, 2007), and Powell and Weedin (2004) for the Cactaceae.

CHAPTER III

RESULTS

Herbarium Search

No DH specimens were found at UTEP or BRIT: UTEP had no records in its electronic database, and BRIT's specimens were not available electronically and, unfortunately, were not able to be manually searched for inclusion in this project. Using the Flora of Texas Consortium website (FTC 2003), 64 collections were returned from SAT, two from SHST, 10 from TAES, and only one specimen was held by SWT, while TAMU returned no records. The on-site search of the SAT digital database revealed 245 DH specimens, only three of which were also found during the consortium search. According to its online database, TEX-LL houses 390 DH specimens (PRC 2006). The databased DH holdings of BBNP and SRSC tallied 163 and 579 specimens respectively (Automated National Catalog System 2006). KANU reported 23 known specimens (C. Morse pers. comm.), and NYBG holds five vascular DH collections (NYBG 2006).

The sheet-by-sheet search at SRSC uncovered 490 DH specimens, the vast majority from the BGWMA side, though there were a few BBNP specimens that had escaped documentation in the NPS databasing effort. The Black Gap herbarium houses 203 specimens from the study area. Recent collections made by BBNP staff as part of ongoing projects increased the historical specimen count by 44. The previous reports by Amos and Wells list 22 unvouchered taxa (entities at or below the species level) that fall either in the "possible" or "unlikely" categories.

Taking the above records into account, the historic baseline flora of the DH is based upon 2212 specimens, representing 570 taxa (564 species) from 85 families and 294 genera. Beginning with the first known collections in 1901 by Vernon Bailey, 126 collectors have contributed to the documentation of the Dead Horse flora (Appx. A). Barton H. Warnock has been the most prolific collector; he and Bonnie Amos, with the help of many collecting partners, have contributed more than half of the historically collected specimens.

Vegetation Patterns

For the purposes of this research, six vegetation types are distinguished in the DH, separated generally by elevation and water availability. The three dominant types follow elevational zones, with Mixed Desert Scrub at lower to mid elevations, Sotol-Yucca Grassland at mid to high elevations, and Chaparral appearing in patches at the highest elevations within the Sotol-Yucca Grassland. These types are similar to the previously mentioned vegetation zones created by the USDA for use in classifying soils (Turner 1977). The remaining three vegetation types involve anything riparian-related, including arroyos, canyons, and the Rio Grande corridor. The Sandy-Desert-Arroyo and Desert-Canyon types interlace with and intersect mainly lower elevations of the Mixed Desert Scrub but can allow intermixing of high- and lower-elevation species in steep, protected drainages on mountain slopes. The Rio Grande Riparian Corridor is the only vegetation type that occurs in association with permanently flowing water and mainly occurs within Boquillas Canyon, although the developed areas around RGV have significant riparian

habitats that are important to the diversity of the study area. The six types correlate well to the existing classifications (Table 1) but do have some significant differences and omissions.

Mixed Desert Scrub

The Mixed Desert Scrub vegetation type extends from the lowest elevations to about 4000 ft (1220 m), nearing the higher plateaus within the Dead Horse (Fig. 23). Though certainly there are distinct community associations that occur sporadically within this elevational range, they are so interconnected with the entire matrix that it is easier to refer to the overall community as a whole, discussing notable associations in due course. The lowest elevations and flattest terrain of the park are dominated by *Larrea tridentata* (creosote), which is seen most often on low, foothill approaches and interior basins of the DH. A few other species intermingle, including *Opuntia aggeria* (clumped dog cholla) and *Opuntia grahamii* (Graham dog cholla), *Parthenium incanum* (mariola), *Nama hispidum* (bristly nama), and *Acacia neovernicosa* (viscid acacia).

Flourensia cernua (tarbush) is often cited as being important, even co-dominant, in this ecological zone of the Chihuahuan Desert, but it was rarely seen during this research, perhaps indicating that what is considered *Larrea* Scrub by Henrickson and Johnston (1986) and others is not a true component of the DH vegetation matrix. Also not officially included in the DH is Henrickson and Johnston's Sand Dune Scrub. There are limited sand dunes at the mouth of Boquillas Canyon, but they are not significant enough to support a distinct vegetative zone. It is, however, a unique habitat for a few species including the rare *Chamaesyce golondrina* (Boquillas sandmat) and the sand-

Fig. 23. Examples of the Mixed Desert Scrub vegetation type: a. North Dagger Mountain flats, b. Marufo Vega trail, c. south of Dagger Mountain, d. looking north towards Dagger Canyon, e. ridge above and southwest of Telephone Canyon, f. dam along the Telephone Canyon trail.

loving *Heliotropium convolvulaceum* (phlox heliotrope), *Corispermum americanum* (American bugseed), and *Dalea terminalis* (woolly dalea). Other CDR Desertscrub types (Table 1) that are absent from the DH are the *Prosopis-Atriplex*, Gypsophilous, and Cactus scrubs.

Moving upslope, various shrubs, succulents, and grasses become more important. Species commonly encountered and expected include the following: *Parthenium incanum, Tiquilia greggii* (plume tiquilia), *Prosopis glandulosa* (mesquite), *Condalia* sp., *Ziziphus obtusifolia* (lotebush), *Buddleja marrubiifolia* (butterfly bush), *Leucophyllum minus* (Big Bend silverleaf) and *Leucophyllum candidum* (Boquillas silverleaf), *Viguiera stenoloba* (skeletonleaf goldeneye), *Chrysactinia mexicana* (damianita), *Menodora scabra* (rough menodora), *Polygala* spp. (milkworts), *Croton* spp. (crotons), *Koeberlinia spinosa* (allthorn), *Ephedra aspera* (mormon tea), *Fouquieria splendens* (ocotillo), *Dasylirion leiophyllum* (sotol), *Agave lechuguilla* (lechuguilla), *Euphorbia antisyphilitica* (candelilla), *Chamaesyce* spp. (ground spurge), *Jatropha dioica* (leatherstem), *Yucca torreyi* (Torrey yucca), *Opuntia leptocaulis* (pencil cholla, tasajillo), *Opuntia* spp. (prickly pears), *Echinocactus horizonthalonius* (eagle-claw or turks-head cactus), *Ariocarpus fissuratus* (living rock cactus), *Echinocereus mariposensis* (mariposa cactus), *Bouteloua ramosa*, (chino grama), *B. trifida* (red grama), *Aristida* spp. (three-awns), *Tridens muticus* (hairy tridens), *Dasyochloa pulchella* (fluffgrass), and others. Usually associated with higher elevations, *Hedyotis intricata* (bluet) and *Purshia ericifolia* (heath cliffrose) are sometimes seen at lesser elevations where bedrock outcrops are sufficiently protected. Also intergrading with lower-elevation species is *Dasylirion leiophyllum* (sotol), which begins to occur as low as 3500 ft (1066 m). *Dasylirion leiophyllum* and

Bouteloua ramosa (chino grama) are commonly thought of as occurring in a vegetation type called Sotol Grassland, but these two species occur so widely between lower and high elevations, and with such different associate species, that this name was considered too ambiguous in scope for use in defining DH vegetation dynamics.

Some areas within the Mixed Desert Scrub are dominated by lechuguilla, which can form dense concentrations as it spreads by rhizomes; these areas were even accorded a separate phase within the CDR Desertscrub and Woodlands community by Henrickson and Johnston (Table 1). These patches of lechuguilla are perhaps best developed on rockier, exposed, and well-drained slopes. In many places the plants grow so densely that the only way to walk through the thickets is on top of the plants themselves. *Hechtia texensis* (hechtia) also occasionally forms dense stands, typically on south-facing, steeper slopes with shallow soils and sharply-eroded bedrock outcrops. In addition to the species included in Mixed Desert Scrub, areas with higher concentrations of lechuguilla and/or hechtia often include more obvious occurrences of the following species: *Selaginella lepidophylla* (resurrection fern), *Selaginella wrightii* (Wright spikemoss), *Astrolepis* spp. (starcloak ferns), *Argyrochosma microphylla* (small-leaf false cloak fern), *Calliandra iselyi* (Isely stickpea), *Opuntia rufida* (blind prickly pear), *Opuntia* spp., and others. Other interesting components of the Mixed Desert Scrub, and, actually, all throughout the DH, are the ubiquitous *Selaginella* spp. (spikemoss), biological soil crusts, and various species of ferns. *Selaginella wrightii* (Wright spikemoss) may not, at first glance, be noticed or its extent appreciated. After a good rain, however, this plant unfurls, turns bright green instead of looking yellowed and dead, and makes a majority of inter-rock spaces appear covered by a lush carpet (Fig. 24a). *Selaginella lepidophylla* (resurrection

fern) is well known in the region to turn a previously barren-looking limestone hillside into a riot of verdant growth (Fig. 24b). Biological soil crusts are also important members of the inter-rock spaces, harboring various species of cyanobacteria, mosses, lichens, and other cryptogamic components (Figs. 24c–d). Ferns may be more expected in wetter areas, but they are surprisingly abundant throughout the arid landscape of the DH. Certainly there are habitat preferences, with certain species such as *Asplenium resiliens* (blackstem spleenwort) and *Cheilanthes alabamensis* (Alabama lipfern) occurring only in more protected habitats, but the majority of species are commonly encountered in harsher environments.

Desert Arroyo

Many of the general, Mixed-Desert-Scrub species overlap into the arroyos and canyons that intersect the region, where two xeric-riparian phases are generally distinguishable, according to the amount of moisture available. The Desert Arroyo, or Sandy Arroyo Scrub as named by Henrickson and Johnston (Table 1), occurs in more open, low-elevation drainages. The margins are rich with perennial plants, which often grow into impenetrable thorny thickets across the wash. *Fallugia paradoxa* (apache plume) and *Brickellia laciniata* (splitleaf brickellia) are common species present in the wash cobbles of larger drainages, while *Prosopis glandulosa* (mesquite), *Guaiacum angustifolium* (guayacan), *Forestiera angustifolia* (narrowleaf forestiera), *Celtis pallida* (spiny hackberry), *Lycium berlandieri* (wolfberry), and *Porophyllum scoparium* (shrubby poreleaf) are common throughout.

Fig. 24. Potentially less-appreciated members of the DH flora: a. *Selaginella wrightii* forms a lush carpet covering soil surfaces after good rains; b. *Selaginella lepidophylla* turns hillsides green after a rain; c. lichens grow on top of soil held together with cyanobacteria and fungal hyphae; d. cyanobacteria (dark areas, especially at edges of drainage) are primary colonizers of bare soils and can help to decrease erosion.

Desert Canyon

In rockier habitats and larger drainages and within canyons that provide partial shade, the Desert Canyon vegetation type includes additional species, including *Berberis trifoliolata* (agarita), *Fraxinus greggii* (gregg ash), *Diospyros texana* (Texas persimmon), *Clematis drummondii* (virgin's bower), *Eysenhardtia texana* (Texas kidneywood), *Lippia graveolens* (scented lippia), *Mimosa* spp. (catclaw), *Acacia roemeriana* (Roemer acacia), *Shaefferia cuneifolia* (desert yaupon), *Rhus virens* (evergreen sumac), *Passiflora tenuiloba* (passionflower vine), *Maurandya antirrhyniflora* (snapdragon vine), and *Tecoma stans* (yellow bells). Common wash-associate grasses are *Bothriochloa laguroides* (silver bluestem), *Heteropogon contortus* (tanglehead), *Setaria leucopila* (bristlegrass), and *Aristida* spp. (Fig. 25).

More water-dependent species such as *Ungnadia speciosa* (Mexican buckeye) and *Chilopsis linearis* (desert willow) occur infrequently, restricted to the largest drainages. *Juglans microcarpa* (little walnut) is not a typical DH species within BBNP; it was seen only once at the north end of the range but is reported to be dominant in BGWMA's Brushy Canyon (Amos & Giles 1992). In the same Amos and Giles (1992) report, *Cercis canadensis* var. *mexicana* (Mexican redbud) was listed as a dominant in Brushy Canyon; it was not observed in the National Park portion of the DH. Canyon walls throughout the range provide a unique habitat for cliff-dwelling species, including *Cirsium turneri* (Turner thistle), *Perityle aglossa* (rayless rockdaisy), and *Perityle bisetosa* var. *scalaris* (stairstep rockdaisy).

Fig. 25. Desert Canyon environment: a. Dagger Canyon, b. north of the Barker House.

Rio Grande Riparian Corridor

A more traditional riparian woodland vegetation type exists only along the Rio Grande (Fig. 26), where the consistent water table can support species such as *Populus fremontii* (cottonwood) *Salix* spp. (willows), *Baccharis salicifolia* (seepwillow), and *Phragmites australis* (common reed) and the introduced *Arundo donax* (giant cane) and *Tamarix* spp. (salt cedars). A few solitary individuals of more water-dependent genera (e.g. *Salix*, *Baccharis*, and *Tamarix*) occur in at least one other place in the DH interior: above Ernst Tinaja, where their water-hungry roots may have found a perched water table. Also important along the Rio Grande are *Acacia farnesiana* (huisache)*, Nicotiana glauca* (tree tobacco)*, Prosopis glandulosa* (mesquite), and *Chilopsis linearis* (desert willow).

The major, non-native species have altered and continue to alter the riparian landscape. Thickets of cane with abundantly dense rhizomes have solidified the river banks, channelizing the watercourse. This creates, in many cases, an irreversible cycle: the channel concentrates the river flow, which increases its velocity and thus erosive power, which, in turn, creates a deeper channel that does not allow flooding over its banks as easily as before. With over-bank flooding decreased due to channelization and a generally reduced flow/flood cycle due to upstream dams, dense canopies of *Arundo donax* (giant cane) and *Tamarix* spp. (salt cedar) are allowed to establish, precluding the formation of native *Salix* spp. (willow) and *Populus* spp. (cottonwood) bosques (Howe & Knopf 1991, Bell 1997).

Fig. 26. Riparian Corridor vegetation along a slightly less-channellized, more flood-prone lee shore on the Rio Grande near Marufo Vega.

Sotol-Yucca Grassland

Found on the higher elevation slopes and plateaus to the highest peaks, Sotol-Yucca Grassland is the dominant vegetation above the Mixed Desert Scrub. The vegetational split seems to occur, at least on the western side of the range, at around 5000 ft (1524 m), where the steep slopes break out onto the main plateau of the DH range. Stuarts Peak, though slightly lower at 4800 ft (1463 m), should also be included, due to its many, unique floristic characteristics, including a diverse lichen flora and, in the DH, the only known populations of two species that are more expected in montane forested vegetation—*Philadelphus microphyllus* (littleleaf mockorange) and *Achnatherum curvifolium* (Guadalupe ricegrass).

The Sotol-Yucca Grassland is a visually distinct zone where large yuccas and sotol stand out from the shrub- and grass-dominated understory. Also known as Izotal, Sotolal, and Rosetófilo (Table 1; Henrickson and Johnston 1986), this vegetation type is considered by some to be shrub-dominant (e.g. Henrickson & Johnston 1986), and, thus, many omit the term "grassland" in official terminology. The DH do seem to have a persistent shrub component dominated by *Dasylirion leiophollym* (sotol), *Nolina erumpens* (beargrass), and *Yucca* spp. (yuccas), even when the grass diversity and abundance increase with elevation (Fig. 27). However, the two life-forms seem to be co-dominant, and the term "grassland" is used here to convey the importance of bunch grasses in the inter-shrub spaces. On the main DH plateau, *Nolina erumpens* becomes a significant, visual member of this group, creating, along with the sotol, large masses of thick vegetation standing almost head high in some places.

The DH are virtually the only area in the park where the giant dagger, *Yucca faxoniana*, occurs. Usually growing at higher elevations, they can easily be seen along the Dagger Flat road. Alhough quantitative data on density or abundance are not within the scope of this study, these giant daggers generally do not seem to occur as densely as in some pictures of this vegetation zone further south in the CDR. The only comparable area observed during the study was in BGWMA, on a higher plateau above the head of Brushy Canyon. The giant daggers on the higher plateaus associated with Sue Peaks did not seem as abundant or as tall as those at the lower-elevation plateau in the Black Gap. This comparison and the aforementioned differences in the plant community of Brushy Canyon lend support to the idea that the highest elevations of the DH limit the moisture-laden air flowing westward from the Gulf of Mexico.

Common plants associated with the Sotol-Yucca Grassland of the DH include *Yucca torreyi* (Torrey yucca), *Yucca rostrata* (beaked yucca), *Yucca thompsoniana* (Thompson yucca), *Nolina erumpens* (beargrass), *Agave lechuguilla* (lechuguilla), *Fouquieria splendens* (ocotillo), *Chrysactinia mexicana* (damianita), *Gymnosperma glutinosum* (gumhead), *Parthenium argentatum* (guayule), *Parthenium incanum* (mariola), *Bouchea spathulata* (spoonleaf bouchea), *Leucophyllum* spp. (silverleafs), *Viguiera stenoloba* (skeletonleaf goldeneye), *Bernardia obovata* (desert myrtlecroton), *Vauquelinia angustifolia* (slimleaf vauquelinia), *Mortonia scabrella* (sandpaper bush), *Zinnia acerosa* (spinyleaf zinnia), *Coryphantha tuberculosa* var. *tuberculosa* (cob cactus), *Coryphantha echinus* (sea urchin cactus), *Neolloydia conoidea* (Texas cone cactus), *Epithelantha macromeris* (common button cactus), *Bouteloua curtipendula*

Fig. 27. Sotol-Yucca Grassland: a.–b. Western ridgetop and saddle near Telephone Canyon, c. western ridge on approach to the DH plateau, d. west aspect near Sue Peaks, e.–f. mesa top NW of Shackelford cabin in BGWMA.

(sideoats grama), *Aristida* spp. (three-awns), *Enneapogon desvauxii* (feather pappusgrass), *Leptochloa dubia* (green sprangletop), *Muhlenbergia tenuifolia* (mesa muhly), and *Selaginella wrightii* (Wright spikemoss).

True grasslands, though included in reviews of Chihuahuan Desert vegetation types, are not functionally a part of the DH flora. These areas that are clearly dominated by the Poaceae without a significant shrub component are more commonly associated with the higher plains around Marathon, Alpine, and Marfa, to the north. In the DH, small areas dominated by grasses do occur but on the scale of remnant patches rather than functional ecosystems. In a small area of Ernst Basin is the previously mentioned stand of *Pleuraphis mutica* (tobosa grass). The area west of Dog Canyon is in a recovery state; bands of grasses and shrubs stretching across the flats with bare soil in between can hardly be called a grassland. Interestingly, Amos and Giles (1992) considered the highest portion of Margaret Basin in BGWMA a "high elevation grassland"; unlike in the scrub-filled Brushy Canyon to the north, only scattered *Yucca faxoniana* (giant dagger) reportedly were present. Presumably, the grass understory of the giant daggers was a *Bouteloua* (grama grass) mix; however, this area was not investigated during the current study. Perhaps some of the other interior basins also support a grassland-like community, but it remains to be documented.

Grasses are important components of the shrubby slopes and higher plateaus, and a few species occurring at the higher elevations are important components of the vast grama grasslands to the north. However, they are not dense or contiguous enough, nor dominated enough by the typical grassland species *Bouteloua eriopoda* (black grama) and *Bouteloua gracilis* (blue grama), to be considered a true grassland. This seems to

follow a general trend of grama grasslands' being established on igneous soils, whereas limestone substrates in similar conditions will support only desert-scrub assemblages (Henrickson & Johnston 1986).

Chaparral

Small pockets of shrub thickets, or chaparral vegetation, occur within the Sotol-Yucca Grassland on plateaus and eastern slopes associated with the high elevations of the Sue Peaks area (Fig. 28). Small and sometimes dense clumps of *Quercus pungens* (sandpaper oak), some *Quercus mohriana* (Mohr shinoak) and *Quercus grisea* (grey oak), *Cercocarpus glaberoides* (mountain mahogany), *Berberis trifoliolata* (agarita) and *Rhus virens* (evergreen sumac) associate with large *Dasylirion leiophyllum* (sotol) and *Nolina erumpens* (beargrass), all overshadowed by occasional but conspicuous *Yucca faxoniana* (giant dagger). Associated species include *Fraxinus greggii* (Gregg ash), *Garrya ovata* (eggleaf silktassel), *Ptelea trifoliolata* (common hoptree), *Bouteloua curtipendula* (sideoats grama), and *Muhlenbergia parviglumis* (longawn muhly). Oaks and other more mesic species also occur at the highest summits and in more protected parts of drainages, even in steep drainages and lower elevations of the western slopes. These micro-niche species include *Malacomeles denticulata* (toothed serviceberry), *Quercus pungens, Fendlera falcata* (cliff fendlerbush), *Fraxinus greggii, Prunus havardii* (Havard plum), and *Cheilanthes* spp. (lip ferns).

Junipers, including *Juniperus coahuilensis* (rose-fruited juniper) and *Juniperus pinchotii* (red-berry juniper), occur sporadically on the high plateaus amongst the chaparral clumps and, very rarely, in large, lower-elevation canyons. Pinyon pines are

Fig. 28. Chaparral, interspersed in Sotol-Yucca Grassland, as thickets of larger shrubs: a. DH plateau looking at Sue Peaks, b. mesa top NW of Shackelford cabin in BGWMA, c. east side of the south sister of Sue Peaks looking into Heath Creek drainage.

rare, documented only at a few eastern-slope locations. These species are probably relicts from the previously extensive juniper-pinyon-oak woodland covering the region between 22,000 and 11,000 years ago. The main pine of the DH is *Pinus remota* (papershell pinyon), a limestone specialist (Powell 1998). Once more widespread, *Pinus remota* (papershell pinyon) in the Trans-Pecos is limited to isolated pockets, being more abundant on the Edwards Plateau and in Mexico. Records of *Pinus cembroides* (Mexican pinyon) in the DH are unusual; it is a higher-elevation taxon, although the two species are known to occur together elsewhere in the Big Bend region (Powell 1998).

Field Collections

Between August 2003 and September 2006, a total of 49 days and approximately 400 hours were spent in the field. The 1549 voucher collections made during those three years, with four observations without vouchers, represent 84 families, 283 genera, and 490 species, totaling 493 taxa when including all subspecies and varieties. The herbaria search revealed 7 families, 58 genera, and 173 species (178 taxa) that were not encountered during the current study. However, many new taxa were added to the historic baseline in this current study, with seven additional families, 45 additional genera, and 120 additional species (121 taxa) vouchered. Fifty-five of those additional species were new records for the DH, representing a 10% increase in known species. The remaining 65 species (67 taxa) were considered simple voucher collections of more common species that were expected to occur or that had been previously observed in the DH but not collected.

These new collections increased vouchered DH taxa by 22%. Four additional species were observed over the past three years that were not vouchered but were included in the final flora. After the combination of the current and historical records, including specimens and observations, and after editing for nomenclatural consistency and currency was done, the total known flora of the DH to date consists of 91 families, 344 genera, and 663 species (671 total taxa when including all subspecies and varieties; Table 4). The flora includes 75 taxa recognized at the varietal or subspecific level. An annotated list, including common name, synonymy, life form, abundance, habitat notes, and a list of all known specimens of every taxon, is given in Appendix A.

The Asteraceae is the most prominent family in the DH, with 80 species (12.0% of the flora) found in the DH (Table 5). Other important families in the DH include the Poaceae (75 species, 11.3%), Fabaceae (52 species, 7.8%), Euphorbiaceae (34 species, 5.1%), Cactaceae (31 species, 4.7%), Pteridaceae (20 species, 3.0%), Boraginaceae (20 species, 3.0%), Brassicaceae (16 species, 2.4%), Nyctaginaceae (16 species, 2.4%), and the Solanaceae (15 species, 2.3%). The eight most species-rich families comprise 50% of the flora while 24 families are represented by an individual taxon. The most abundant genera represented in the DH are *Chamaesyce* (ground spurges, 13 species) and *Dalea* (dalea, 13 species), while *Opuntia* (opuntia, 12 species), *Acacia* (acacia, 8 species), *Bouteloua* (grama grass, 8 species), *Polygala* (milkworts, 7 species), *Cheilanthes* (lip ferns, 7 species), and *Muhlenbergia* (muhly, 7 species) are also well represented (Table 5). Collections were made throughout most of the Dead Horse range, but interior locations, such as along the Strawhouse trail, the eastern end of Telephone Canyon, Margaret Basin, and areas interior to Boquillas Canyon, remain undercollected (Fig. 29).

Table 4. Top 20 plant families and top 10 genera of the Dead Horse Mountains, ranked by number of species.

Family	Number of Genera	Number of Species	Percent of Flora
Asteraceae	52	80	12.1
Poaceae	38	74	11.3
Fabaceae	22	52	7.8
Euphorbiaceae	10	34	5.1
Cactaceae	12	34	4.7
Pteridaceae	5	20	3.1
Boraginaceae	7	20	3.0
Brassicaceae	12	16	2.4
Nyctaginaceae	8	16	2.4
Solanaceae	8	15	2.3
Malvaceae	8	15	2.3
Scrophulariaceae	6	14	2.1
Asclepiadaceae	4	14	2.1
Onagraceae	4	13	2.0
Cyperaceae	6	11	1.7
Verbenaceae	8	11	1.7
Liliaceae	5	10	1.5
Convolvulaceae	5	10	1.5
Lamiaceae	4	9	1.4

Table 4, continued. Top 20 plant families and top 10 genera of the Dead Horse Mountains, ranked by number of species.

Family	Number of Genera	Number of Species	Percent of Flora
Polygonaceae	4	9	1.4
Genus			
Chamaesyce	–	13	2.0
Dalea	–	13	2.0
Opuntia	–	12	1.8
Acacia	–	8	1.2
Bouteloua	–	8	1.2
Polygala	–	7	1.1
Cheilanthes	–	7	1.1
Muhlenbergia	–	7	1.1
Oenothera	–	6	0.9
Heliotropium	–	6	0.9

Table 5. Taxonomic composition of the flora of the Dead Horse Mountains.

Taxonomic group	Families	Genera	Species		Total Species
			Native	Non-native	
Ferns and fern allies	3	7	24	0	24
Gymnosperms	3	3	7	0	7
Monocotyledons	10	57	100	7	107
Eudicotyledons	75	277	508	17	525
Totals	91	345	639	24	663

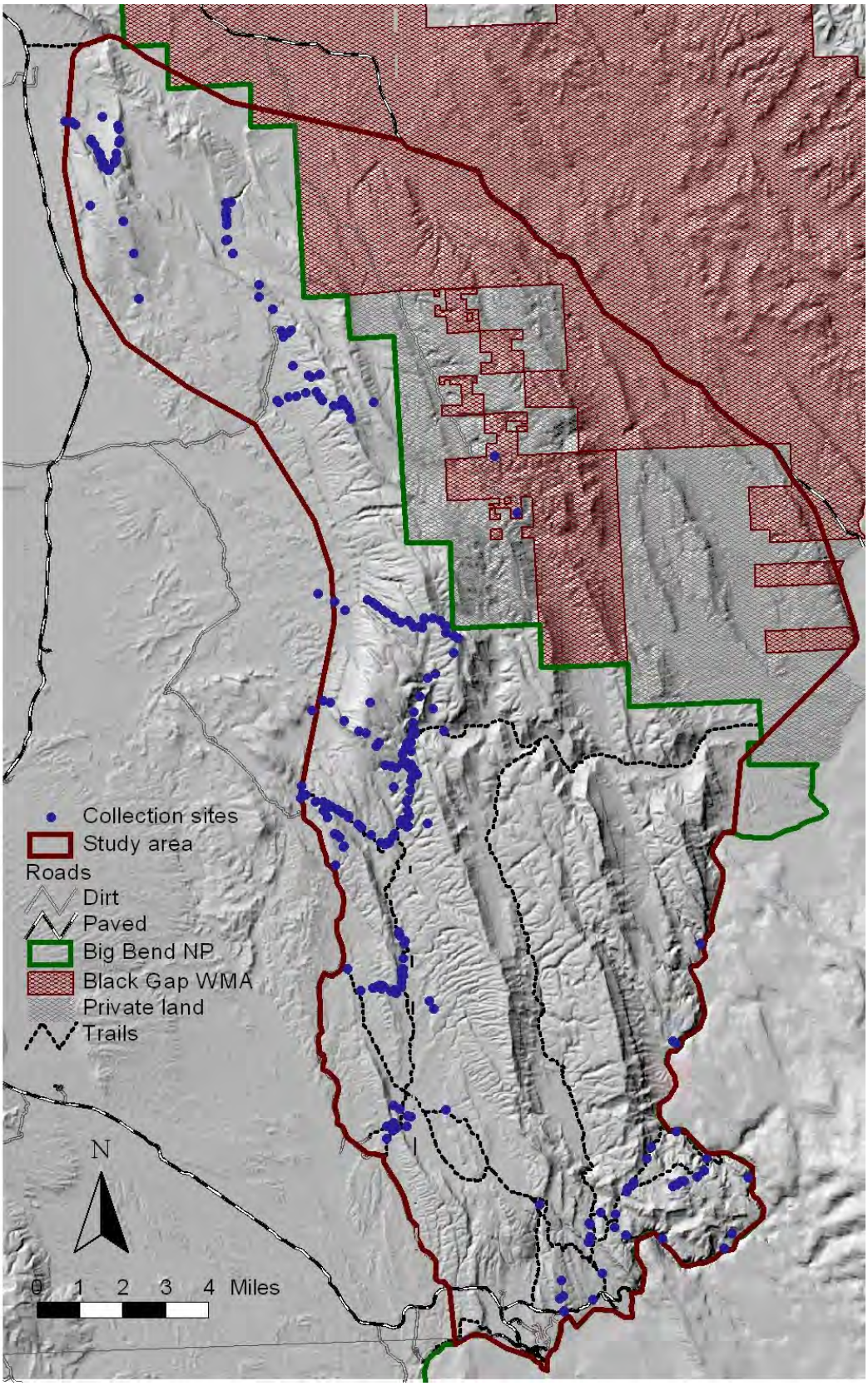


Fig. 29. Study area collection locations between 2003 and 2006.

A taxonomic breakdown of species found in the DH shows that eudicots make up the largest proportion of the flora at 78.9% (Tables 4 & 5). Gymnosperms comprise the smallest portion of the flora after monocots and the ferns and fern allies (Table 5). Perennial herbs were the most abundant life form encountered, followed by annual herbs, shrubs, subshrubs, succulents, vines, and trees (Table 6). Non-native species constitute a small part of the DH flora. The USDA considers 24 species collected in the DH as exotic (USDA 2007; Table 7). Six of those species are considered invasive, and three are state-listed noxious weeds: *Arundo donax* (giant cane), *Tamarix aphylla* (salt cedar), and *Tamarix chinensis* (salt cedar; PTI 2006). Significantly, *Pennisetum ciliare* (bufflegrass), an introduced grass from Africa, is not among the Texas-listed invasives; however, it is a demonstrated threat to native ecosystems throughout the southwest (e.g. TNC 2005) and is listed by the state of Arizona as a noxious weed (AZDA 2005). The fact that it is widely planted in Texas and northern Mexico as a range grass makes its listing perhaps unlikely. Overall, non-native species constitute 3.6% of the DH flora.

Eleven species found in the DH are endemic to Texas, according to the Texas A&M Bioinformatics Working Group and updated taxonomic and distribution information (TAM-BWG 2006; Table 8). The occurrence of *Matelea sagittifolia* (arrowleaf milkvine) is not currently reflected on the referenced website, but it was collected during the present study and also during a recent survey of the Lone Mountain area of BBNP (Fenstermacher et al. 2006). *Lycium puberulum* var. *berberioides* (silvery wolfberry) is also not listed by the Bioinformatics Working Group as occurring in Brewster County but should be; it has been a known member of the BBNP flora for

Table 6. Summary of the Dead Horse Mountain flora by life form (USDA 2007). The semi-succulent members of the Agavaceae, Liliaceae, and Bromeliaceae were included in the shrub category. Eight taxa can be either trees or shrubs depending on the habitat. These were divided equally between the tree and shrub categories. Twenty-eight taxa were listed by USDA as both annual and perennial herbs. These were split evenly between the two herb categories. Graminoid species were included under herbs.

Life Form	Number of Species	Percent of Flora
Trees	27	4.1
Shrubs and semi-succulents	97	14.6
Sub-shrubs	55	8.3
Vines		4.4
Annual herbaceous	1	0.2
Perennial herbaceous	24	3.6
Woody	4	0.6
Herbs		63.6
Perennial	278	41.9
Annual	143	21.7
Cacti and succulents	34	5.1

Table 7. Non-native species (USDA 2007) collected in the Dead Horse Mountains. NAT = naturalized; ! = invasive; !! = state-listed noxious weed (PTI 2006).

Species	Status
Amaranthus blitoides	
Arundo donax	!!
Atriplex rosea	
Cynodon dactylon	!
Echinochloa colona	
Eragrostis lehmanniana	!
Leptochloa dubia	
Malva parviflora	
Medicago sativa	
Melilotus indicus	
Nicotiana glauca	! NAT
Opuntia ficus-indica	
Pennisetum ciliare	
Polygonum persicaria	
Polypogon monspeliensis	
Rumex crispus	
Salsola tragus	!
Sisymbrium irio	
Sonchus asper	
Sonchus oleraceus	

Table 7, continued. Non-native species (USDA 2007) collected in the Dead Horse Mountains. NAT = naturalized; ! = invasive; !! = state-listed noxious weed (PTI 2006).

Species	Status
Sorghum halepense	!
Tamarix aphylla	!!
Tamarix chinensis	!!
Tribulus terrestris	!

Table 8. Species endemic to Texas occurring in the Dead Horse Mountains.

Bouteloua kayi
Chamaesyce golondrina
Hedyotis pooleana
Lesquerella mcvaughiana
Lycium puberulum var. *berberioides*
Matelea sagittifolia
Opuntia aureispina
Oxalis drummondii
Perityle bisetosa var. *scalaris*
Prunus havardii
Tradescantia wrightii var. *glandulopubescens*

some time (Powell 1998). *Hedyotis pooleana* (Jackie's bluet), though included in this DH-endemics list, is another species not listed by the Bioinformatics Working Group, perhaps due to the lack of consensus over its taxonomy. However, whether it is a variety of *Stenaria mullerae* or a species unto itself, the only known populations thus far are within the Dead Horse Mountains. Endemic species account for 1.7% of the DH flora.

Many noteworthy collections were made during the study period. The Wildlife Diversity Program of TPWD, in conjunction with the Texas Conservation Data Center of the Nature Conservancy of Texas, tracks seventeen rare species that were collected in the DH (Table 9; TPWD 2006). Several of these species were collected at new locations. *Bouteloua kayi* (Kay grama; Fig. 30a) was previously known only from one location east of the DH; it is now known that it is one of the dominant grasses at higher elevations near Sue Peaks. *Hedyotis pooleana* (Jackie's bluet; Fig. 30 b–d) was discovered as a new species and first collected in the DH in the mid 1980s. Subsequently it remained uncollected until the present study, in which it was found throughout the majority of the range in higher-elevation bedrock exposures.

Andrachne arida (Trans-Pecos maidenbush; Figs. 31 a–b) was last collected in the DH in the 1960s, and during the study period it was relocated in the general vicinity of the historical collections. One localized population of the diminutive legume *Senna ripleyana* (Ripley senna; Figs. 31 c–d) was discovered, clarifying its status as having remained extant north of the international border since its last documented collection in northern Brewster County in the 1940s. Another historically collected taxon, *Sedum nanifolium* (dwarf stonecrop; Figs.31 e–f), was encountered in shallow soil pockets on the DH plateau. Locally, it was previously known from one collection; it was labeled

Table 9. Rare species collected in the Dead Horse Mountains that are tracked by the Texas Parks and Wildlife Department and the Nature Conservancy of Texas (TNC 2004).

Species	Global rank	State rank	Federal status	State status
Bouteloua kayi	G1	S1		
Perityle bisetosa var. *scalaris*	G2T1	S1		
Streptanthus cutleri	G2			
Coryphantha duncanii [syn: *Escobaria dasyacantha* var. *duncanii*]	G3T1T2	S1S2		
Coryphantha sneedii	G2G3	S2S3		
Echinomastus mariposensis	G2	S2	LT	T
Opuntia azurea var. *aureispina* [syn: *Opuntia aureispina*]	G1	S1		
Andrachne arida	G2	S1		
Chamaesyce golondrina	G2	S2		
Chamaesyce triligulata [syn: *Chamaesyce chaetocalyx* var. *triligulata*]	G5T1	S1		
Croton thermophilus [*C. pottsii* var. *thermophilus*]	G5T2	S1		

Table 9, continued. Rare species collected in the Dead Horse Mountains that are tracked by the Texas Parks and Wildlife Department and the Nature Conservancy of Texas (TNC 2004).

Species	Global rank	State rank	Federal status	State status
Senna orcuttii	G2	S2		
Senna ripleyana	G1	SH		
Phacelia pallida	G2	S1		
Gaura boquillensis	G2	S2		
Polygala maravillasensis	G2	S1		
Hedyotis pooleana [syn: *Stenaria mullerae* var. *pooleana*]	G1T1	S1		

G1 = less than 6 occurrences known globally; critically imperiled, especially vulnerable to extinction; G2 = 6–20 occurrences known globally; imperiled and very vulnerable to extinction throughout its range; S1 = less than 6 occurrences known in Texas; critically imperiled in Texas; especially vulnerable to extirpation; S2 = 6–20 known occurrences in Texas; imperiled in the state because of rarity; very vulnerable to extirpation; SH = historical in Texas, not verified within the past 50 years but suspected to be extant; T = following a global rank denotes the rank for subspecific taxa. Two G or S ranks together (e.g. G2G3; S1S2) indicate that the plant is borderline between the ranks.

Fig. 30. Rare species in the Dead Horse Mountains: a. *Bouteloua kayi* (Kay grama); b. *Hedyotis pooleana* (Jackie's bluet) and example of unique habitat (utilized by both species) created by differential weathering of fossilized marine organisms and the surrounding parent material; c. *Hedyotis pooleana* with woody taproot exposed; d. *Hedyotis pooleana*, plants range in size from this small individual to several times this size, either forming dense mats or sometimes exhibiting more elongated stems and leaves.

Fig. 31. Reconfirmed and newly collected rare species of the Dead Horse Mountains: a.–b. *Andrachne arida* (Trans-Pecos maidenbush) in fruit and flower; c.–d. *Senna ripleyana* (Ripley senna) in flower and fruit, legume is at top center of Fig. 31d; e.–f. *Sedum nanifolium* (dwarf stonecrop), habitat and habit. Fig. 31e. shows a few plants at the lower left of photo in gravel.

Sedum robertsianum and was commonly seen by Warnock in the Del Norte and Glass mountains of northern Brewster County (Warnock 1977). More common in the Mexican highlands, its overall extent in the U.S. is in question, although this species has been observed also on hilltops of the Cox and Guadalupe ranches, about 15 mi (24 km) west of Sanderson (M. Terry pers. comm.).

One taxon, a member of the genus *Galactia* (milkpeas; Figs. 32 a–d), as yet is not identified to the specific level. It does not fit descriptions of known Texan taxa (B. Turner pers. comm.) and is waiting for further review when appropriate herbarium specimens become available. Several populations have been found in several southern DH locations; the plant is seemingly most common near the Rio Grande within Boquillas Canyon. It is a sprawling, procumbent perennial from a central taproot, often growing vine-like within larger, surrounding vegetation. It has dense, silvery pubescence on all vegetative parts but more pronounced on the leaves, those having prominent under-surface veins. The flowers are pink, which is unusual for this genus (B. Turner pers. comm.), with the banner having a green-yellow base. Upon dessication, the petals turn a deep blue-purple, giving no sign they were ever lighter in color. Alhough this taxon may be undescribed, or simply a new record for the U.S., many definitive new records were made during this study. *Seymeria falcata* var. *falcata* (falcate blacksenna; Figs. 32 e–f) was collected for the first time in the United States, actually, in 1994, but it was not recognized until collections for the current study spurred a review of previous collections of its more widespread relative *Seymeria scabra* (limpia blacksenna; Fenstermacher 2006). Eight other species were newly recorded for Brewster County, according to Turner et al. (2003) and known herbarium specimens: *Achnatherum curvifolium*

Fig. 32. Unusual species of the Dead Horse Mountains: a–d: *Galactia* sp. (milkpea), a–b. pink inflorescence, c. dried corolla showing the original pink has faded to blue-purple, d. sprawling habit at base of a *Yucca torreyi* (Torrey yucca), e.–f.: *Seymeria falcata* var. *falcate* (falcate blacksenna), e. habit and habitat, f. flower just emerging from bud.

(Guadalupe needlegrass), *Atriplex rosea* (red orache), *Argemone mexicana* (Mexican pricklepoppy), *Hedeoma serpyllifolia* (Reverchon false pennyroyal), *Matelea sagittifolia* (arrowleaf milkvine), *Maurandya wislizeni* (balloonbush), *Nama dichotomum* (wishbone fiddleleaf), and *Rumex maritimus* (golden dock). Three of these species, *Atriplex rosea*, *Argemone mexicana*, and *Maurandya wislizeni*, were collected by NPS staff in conjunction with the restoration site at the mouth of Boquillas Canyon. Many of the newly collected species for the DH are taxa that normally occur in much less arid conditions at the highest elevations in the Trans-Pecos.

Achnatherum curvifolium is a C3 grass previously known from a restricted range in the Guadalupe Mountains of Texas and New Mexico (Powell 2000). *Nama dichotomum* is another elevation-restricted species, previously known from the Franklin, Davis, and Guadalupe Mountains. Its distribution ranges from Colorado down through the Mexican highlands and into temperate South America (Correll and Johnston 1970; Turner et al. 2003). In addition to the sparsely occurring relict taxa of *Juniperus* (junipers) and *Pinus* (pinyon pines), several other species were found whose presence was not expected in such relatively arid conditions: *Philadelphus microphyllus* (littleleaf mockorange) and additional C3 grasses *Achnatherum eminens* (southwestern needlegrass), *Achnatherum lobatum* (littleawn needlegrass), *Hesperostipa neomexicana* (New Mexico feathergrass), and *Melica montezumae* (Montezuma melicgrass).

Several unique habitats were encountered during the course of the study; they all would profit from further exploration. The remnant tobosa grassland in Ernst Basin was previously mentioned and was unique not only for the *Pleuraphis mutica* (tobosa grass), but also for other species that were collected only there, including *Malvella leprosa*

(alkali mallow), *Leptochloa panicea* (mucronate sprangletop), and *Chamaesyce serpens* (matted sandmat). The possibility of the occurrence of similar sites in other large basins in the DH should be explored, in particular at the northern end of the Ore Terminal trail, in Margaret Basin, and along the Strawhouse trail.

An interesting area was encountered in a high saddle just north and west of Sue Peaks. The saddle, at 5300 ft (1615 m), is a dividing point between two drainages, one flowing north and the other draining the western side of Sue Peaks and flowing south. The vegetation in this area was unique, being completely different than the immediate surroundings of *Dasylirion leiophyllum* (sotol), *Nolina erumpens* (beargrass), *Agave lechuguilla* (lechuguilla), and *Bouteloua* spp. (grama grasses). The soil was finer, deeper, and less rocky than the surroundings; old wire, pieces of wood, and many prehistoric rock flakes and partial tools were found on the ground surface (Fig. 33). Many plant species found there are reminiscent of the tobosa grassland area north of the Rosillos Mountains in the Harte Ranch area of BBNP, *Pleuraphis mutica* (tobosa grass), *Panicum obtusum* (vine mesquite), and *Hoffmanseggia drepanocarpa* (sicklepod rushpea) in particular. Other species making up the unique community included *Sporobolus airoides* (alkali sacaton), *Sporobolus cryptandrus* (sand dropseed), *Aristida adscensionis* (six-weeks three-awn), and *Muhlenbergia arenicola* (sand muhly).

The other habitats deserving of more attention are the unique niches of the high elevation peaks, especially Sue Peaks and Stuarts Peak. They each have different characteristics that make them interesting. Stuarts Peak is rather narrow, with not much area forming the actual summit ridge (Fig. 34). However, many plants collected there

Fig. 33. Environment of the high saddle northwest of Sue Peaks. a–b. prehistoric point bases found on soil surface in saddle area, c. a view of the saddle looking north. Note the fine soil without the typical surface gravel layer, and the lack of the surrounding area's Sotol-Yucca Grassland plants, instead replaced by *Parthenium incanum* (mariola), *Pleuraphis mutica* (tobosa), and several other grass species.

Fig. 34. Views from Stuarts Peak: a. looking south from peak, b. a view of the peak looking north.

were surprising to find in such a seemingly arid location, including *Achnatherum curvifolium* (Guadalupe ricegrass) and *Philadelphus microphyllus* (littleleaf mockorange). The lichen and moss flora on the summit ridge was impressive in its diversity, which was not observed to the same extent anywhere else during the study period. Also notable was that the summit ridge was one of the few places encountered where the cactus *Neolloydia conoidea* (Texas cone cactus) was growing so densely that it was difficult to walk and not be forced to step on some of the plants.

Sue Peaks, though not having a monopoly on harboring all of the unique and unusual discoveries of this study, is the highest spot in the study site. Chaparral is the best developed in this area, with shrub oaks being very common in the whole DH plateau area. The peaks themselves are rather bare of large shrubs, those being relegated to niches between boulders and ledges (Fig. 35). Several species, found only in this area, were observed and collected on a trip following significant rains in the area: *Phemeranthus brevicaulis* (dwarf fameflower), *Ipomoea costellata* (crest-rib morning glory), *Nama dichotomum* (wishbone fiddleleaf), and *Mirabilis linearis* (linearleaf spiderling). These species in addition to others known only from the peaks or the surrounding area, including *Asplenium resiliens* (blackstem spleenwort), *Asclepias sperryi* (Sperry milkweed), *Quercus mohriana* (Mohr shinoak), *Fraxinus cuspidata* (fragrant ash), *Quercus lacyei* (Lacey oak), and *Pinus remota* (papershell pinyon), indicate that conditions, on the whole, are relatively mesic and that the Sue Peaks area may harbor additional, interesting species.

Fig. 35. Views of Sue Peaks: a. south sister from the north, b. north sister from the south.

CHAPTER IV

DISCUSSION

Herbarium Search

It is highly probable that more DH collections exist at various regional herbaria. Digitalizing herbarium holdings is a supremely helpful advent in floristic research; however the digital records are only as good as the data entered. This is relevant for many reasons. Undoubtedly, BRIT has specimens collected in the DH; W. Mahler collected extensively in BGWMA, and after the Southern Methodist University (SMU) herbarium was closed, his specimens, along with the rest of SMU holdings, were donated to BRIT. Unfortunately, these collections are not electronically inventoried. When the staff and funding exist at BRIT to digitalize their records, many more DH specimens will most likely be discovered there. This is a problem at many herbaria, not only at small ones.

The SRSC collection is perhaps the third largest in Texas but is not available in digital format. Computerized specimen information for part of the SRSC collection was available for this study due only to an effort by the NPS in 2001 that compiled a list of known BBNP herbarium specimens. The digital records included all specimens housed in the park museum facility, in addition to those specimens found through a sheet-by-sheet search of SRSC. DH specimens collected on the BGWMA side of the study area were found only through physically searching SRSC. Even the significant herbaria are not digitally accessible in their entireties, a problem caused by the sheer size of their

holdings and the staff time required for data entry. TEX-LL is searchable online, but their entire collection has not been entered into the system. Also, not all databases are created equal: searching the TEX-LL website returned a smaller and perhaps different set of results than a search through the Flora of Texas Consortium website. This is also true for SAT. The onsite search at Angelo State (245 records) and a search of the Consortium website (64 records) resulted in only three records in common. The rest of the returns were all different specimens. Perhaps those from the FTC website have been loaned or gifted to other herbaria, or perhaps the data are lost within the SAT system due to data input errors, a highly possible occurrence when using low-paid, under-skilled, workers or databases that are not sufficiently structured (B. Alex pers. comm.). The availability of herbarium collections through the internet is a boon to the botanical research community, but the limitations should be clearly understood, so that the usefulness and limitations of the resulting data are taken into consideration.

Collector bias is also worth mentioning as a potential, hidden source of under-representing diversity. Not all collectors are interested in common weeds or traveling much beyond easily negotiable access points, whether they be roads, trails, or easy topography. This is reflected in the majority of historical specimens being collected along the periphery of the DH at places such as RGV and Boquillas, in the Ernst Tinaja area, and along the Old Ore Road. That the interior area of Brushy Canyon has many historical collections is likely the result of the jeep road's presence along the drainage. It seems that the only significant departure from easily accessible areas was the visit Wells made to Sue Peaks. The Brushy Canyon survey, although increasing the species list by a great deal, took place within a mile or two of the entry road.

Field Collections

A significant increase in known plant species was attained as a result of the current study. In the entire history of collection efforts in the study area, including those during the past 15 years, there was a significant rise in species found, without any evident leveling of return for effort (Fig. 36). This is to be expected, with much new territory having been covered by the Amos survey of Brushy Canyon in addition to the current work. However, when looking at a curve of new species collected over the past three years, a different picture emerges: there is a slight leveling of new species collected per field-year (Fig. 37).

The tapering return of new species over the course of the current study could be used to indicate that the DH flora is close to being completely sampled. However, it is important to keep in mind the vagaries of desert floras. The precipitation regime over the preceding year, or even longer, has a profound effect on not only the annual flora but also the timing – and even the possibility– of reproductive activity in perennial plants. The search image and the ability of the collector to notice novel taxa are also important. When we consider the results of making repeated visits to one location over several years (Fig. 38), we find that three visits over the same path to the same area during the same season failed to produce any leveling of a species/effort curve. Bearing in mind that after winter rains a completely different cohort of species may exist, there is much potential, not only here but in other areas, to find more species. The potential may vary from site to site, however, based on climate and the inherent diversity-encouraging/limiting properties of the area. In another example, two visits made to the highest peaks in the range differed by exactly one year and only somewhat in route. Additionally, the second visit

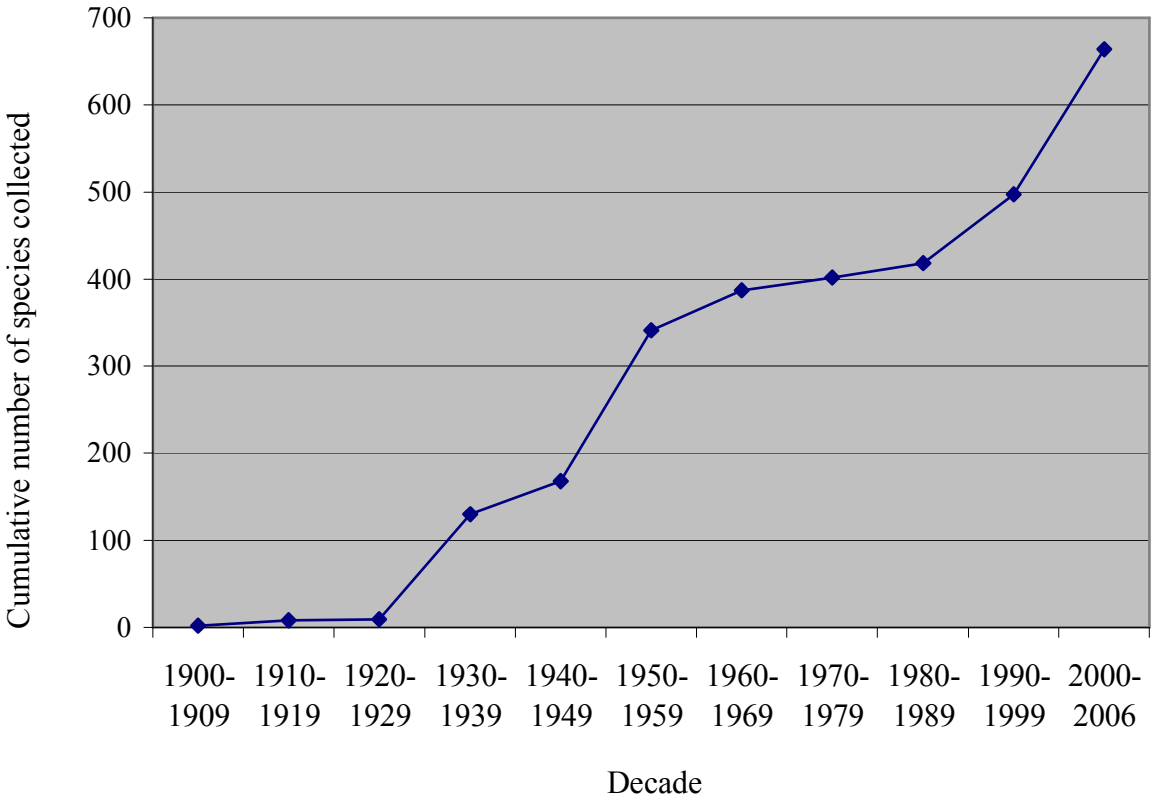


Fig. 36. Species/time trend after 100 years of collecting effort in the Dead Horse Mountains, showing cumulative number of novel species collected by decade.

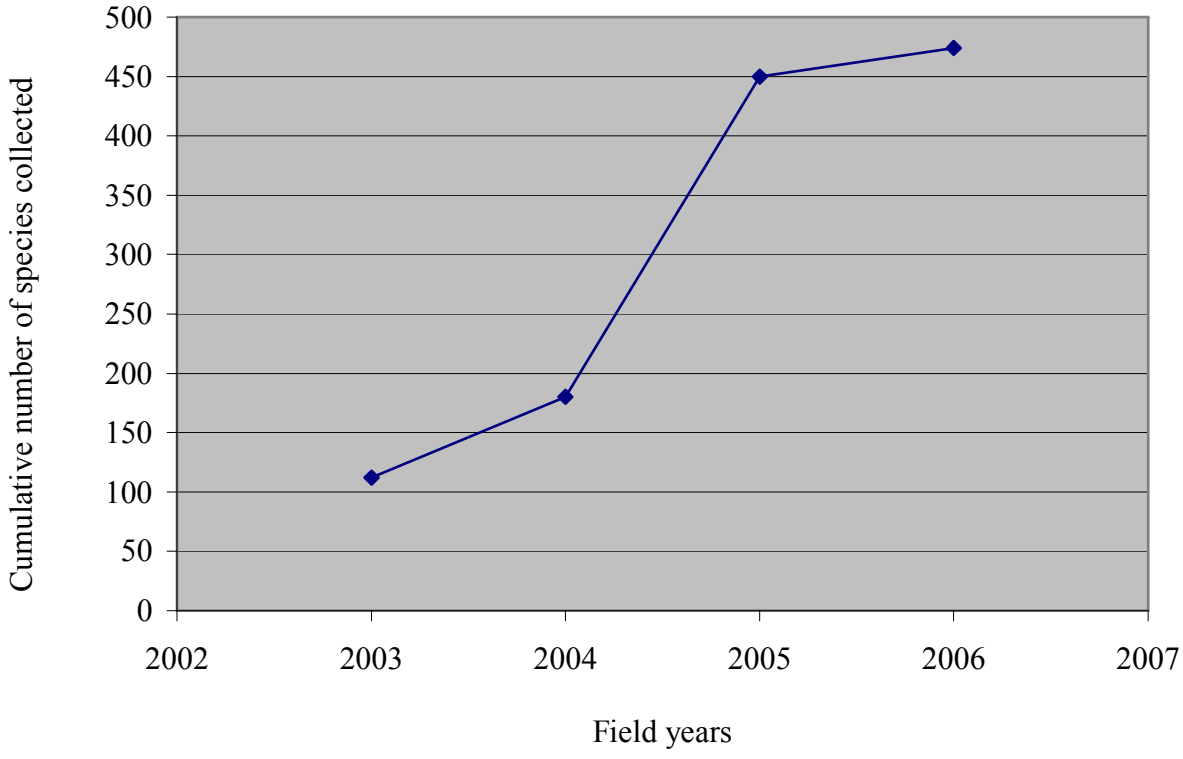


Fig. 37. Cumulative number of species collected between 2003 and 2006 in the Dead Horse Mountains.

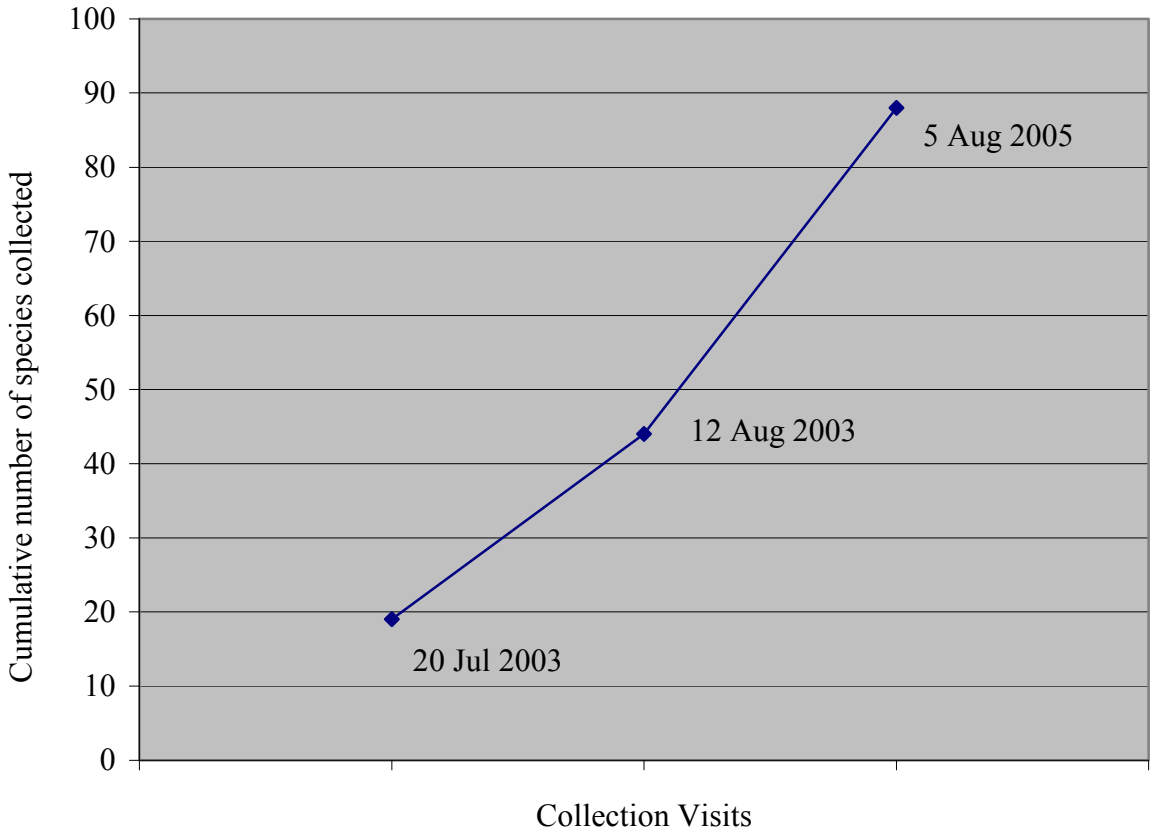


Fig. 38. Species/effort trend after three visits to the Passionflower Canyon area, summer 2003–2005.

followed a significant rainy period such that many new finds were anticipated. Several new collections were made on the second trip, but they numbered about half as many as those made in the initial foray (Fig. 39). Because this area is one of the unique habitats in the range, there may be other important finds yet to reveal themselves, but results thus far suggest that future collection efforts there will continue to diminish over time.

Bearing in mind the potential for discovery of previously unrecorded species for the DH, this study still failed to encounter 127 species previously collected within the study area (Appx. A). This, in some part, is due to sampling away from major riparian habitats like tanks and the Rio Grande and other historical collection localities. including Dog Canyon. There are also thirty-eight species that were not included in the final known flora list, but they are likely to occur, whether in unvouchered observations or as specimens that need verification before being accepted into the official list (Appx. B). These taxa that were not seen by the author in the course of this study amount to 26% of the entire flora, a significant number when attempting to determine floristic completeness.

Previously unrecognized, unique habitats also contribute to the ever-changing nature of a flora. Niches utilized by rare species and newly created habitats can be significant sources of diversity. *Seymeria falcata* var. *falcata* (falcate blacksenna), *Bouteloua kayi* (Kay grama), and *Hedyotis pooleana* (Jackie's bluet) were all seen utilizing a similar habitat niche observed only in the higher DH elevations: small holes that have developed in slick bedrock outcrops of Santa Elena limestone, where it is hypothesized that fossilized marine organisms have weathered out faster than the surrounding parent rock (Fig. 30b). Newly available habitat like that at the Boquillas

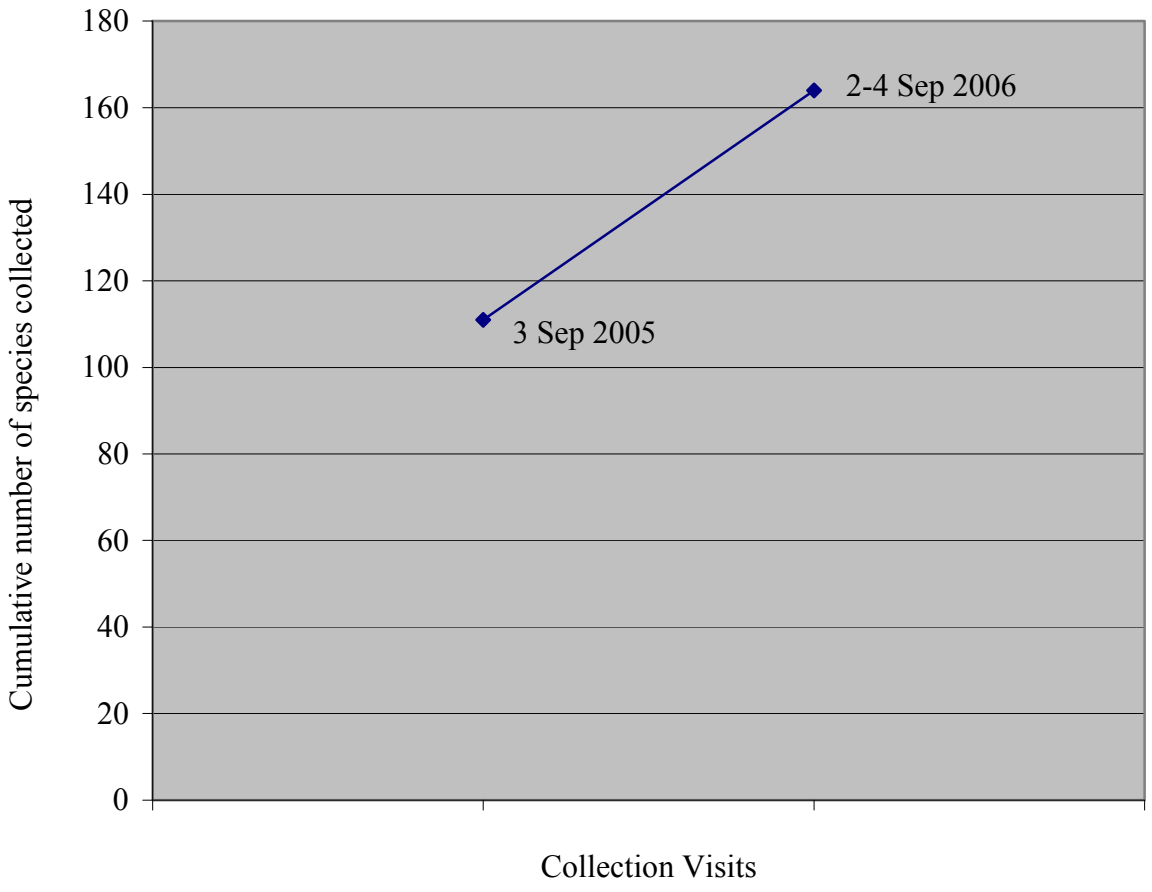


Fig. 39. Species/effort trend after two visits to the Sue Peaks area, September 2005 and 2006.

restoration site, where a dominant canopy of tamarisk and giant cane was removed, allowed species such as *Maurandya wislizeni* (balloonbush) and *Argemone mexicana* (Mexican pricklepoppy) to germinate from seeds that had apparently been dormant in the native seed bank for an unknown number of years until the right conditions for growth occurred. The potential for increasing the size of known floras is great, and as more data become available for the region, predictive equations based on floristic statistics may prove to be a useful method to estimate the completeness of area floras more accurately (Bowers & McLaughlin 1982).

Floristic Analysis and Comparison: Local level

The Dead Horse Mountains are just one range in a larger, regional picture. As a portion of Big Bend National Park, the flora of the DH is 54% of the park's listed total (NPS 1996) yet is found only on 24% of the land area. Clearly, this eastern side of the national park, with its riverine and high-elevation habitats, is an important source of area diversity. But how do the DH compare with similar regional areas? Many initial studies have been done on areas in the Trans-Pecos, but they are not comprehensive enough to accurately represent the true flora of the area (e.g. Carignan 1988), lacking large enough sample areas, an adequate collection history, or both. However, floras of BBNP, BGWMA, and the Solitario have sufficient depth to be useful for exploring floristic relationships of the southern Big Bend region.

The Solitario flora provides an excellent comparison for the DH flora, because it is based on several years of field collections, in addition to a compilation of numerous historical collections. Being located only 40 mi (64 km) west and having a similar limestone substrate, the Solitario could be expected to present a similar floristic picture to

that of the DH. While this is generally true, there are some interesting differences. To begin, both areas share eight of the top 10 families, in terms of percent composition of the flora (i.e. importance; Table 10). In this discussion, the term "importance" denotes a larger proportion of the total number of known species that comprise an area's flora rather than a subjective judgment or statement of overall abundance. The two families not in common in the top 10 make it into the top 13 of the other flora, so the difference is not so great. Asteraceae and Poaceae dominate the two floras and are split slightly more equally in the DH. The Poaceae account for one-third more species in the DH than in the Solitario, which could be a result of the 79% larger area sampled in the DH (40,700:176,800 acres; 16,471:71,548 ha). However, it is more likely a result of the higher elevations encountered in the DH, where many of the different grass species were collected.

This increased habitat sampling may be responsible for the higher proportion of leguminous species in the DH, yet may not be a contributing factor for increasing cacti diversity. While a similar number of cactus species are found in the two areas, almost twice the number of leguminous genera and 39% more leguminous species were found to occur in the DH. This may reflect the importance of the Fabaceae in the Tamaulipan Thornscrub vegetation zone (WWF 2001), found to the east and downriver of the Big Bend area. The DH harbor other Tamaulipan species, and this trend may be a continuation of that influence. Within the Fabaceae, species in the genus *Dalea* are responsible for a large proportion of its diversity in the DH and may be explained by its importance statewide, after the more mesic monocots like *Carex* that are not significant

Table 10. Top 10 families of the Dead Horse Mountains and the Solitario (Hardy 1997), including the number of genera and species recorded in each family, listed in order of species percentage of the total flora for each site.

Dead Horse Mountains	Total genera	Total species	% of flora
Asteraceae	52	80	12.0
Poaceae	37	75	11.3
Fabaceae	22	52	7.8
Euphorbiaceae	10	34	5.1
Cactaceae	11	31	4.7
Pteridaceae	5	20	3.0
Boraginaceae	7	20	3.0
Brassicaceae	12	16	2.4
Nyctaginaceae	8	16	2.4
Solanaceae	8	15	2.3

Table 10, continued. Top 10 families of the Dead Horse Mountains and the Solitario.

Solitario	Total genera	Total species	% of flora
Asteraceae	49	71	13.4
Poaceae	30	55	10.3
Cactaceae	12	33	6.2
Fabaceae	14	32	6.0
Euphorbiaceae	10	28	5.3
Pteridaceae	7	16	3.0
Malvaceae	8	15	2.8
Brassicaceae	10	14	2.6
Solanaceae	8	14	2.6
Scrophulariaceae	7	14	2.6

parts of the arid Trans-Pecos flora (Table 11). The genus *Dalea* may be undercollected in the Solitario. Also undercollected may be *Opuntia* species (prickly pear) in the DH. The recognition of many of the different taxa is highly dependent on detailed understanding of field habits, which the author does not possess. Many hybrids of prickly pear species are probably also present (Powell & Weedin 2004), confounding attempts at accurate identification.

The similar importance of Euphorbiaceae and Pteridaceae in the Solitario and the DH may reflect a tenacious character of the families, persisting through temperature and precipitation inconsistencies. These species may be more evenly dispersed through the landscape: parallel to the increase in the size of the DH flora, there was an equal increase in species of both Pteridaceae and Euphorbiaceae, maintaining a proportion equal to that in the Solitario. The similarity of the sites is also supported by species restricted in their distributions to the local area. As mentioned previously, the rare *Andrachne arida* (Trans-Pecos maidenbush) occurs at both sites, in addition to the Bullis Gap range, east of the DH about 50 miles (Butterwick & Lott [1977]). *Quercus laceyi* (Lacey oak), found in the DH during the current study, is more normally a central-Texas species (Turner et al. 2003). In 1974 it was found in a side canyon of the Solitario, making that the westernmost locality for the species (Hardy 1997).

Broadening the scope to include BBNP and BGWMA (Table 12), the floras generally hold together well as a cohesive body, which is an encouraging sign that the conclusions drawn are based on a well-founded characterization of the regional flora: the Asteraceae and Poaceae are co-dominant, with many families being similarly important throughout the entire southern Big Bend. Of course, differences exist, and, as discussed

Table 11. Genera with the highest number of species occurring in Texas (Turner et al. 2004).

Genus	Number of Species
Carex	96
Cyperus	56
Quercus	48
Eleocharis	42
Chamaesyce	40
Dalea	39
Muhlenbergia	39
Ipomoea	35
Oenothera	32
Astragalus	32
Juncus	30

Table 12. Comparison of top ten families in terms of proportion of flora, between four floras of the southern Big Bend region of Texas (Solitario: Hardy 1994; BBNP: NPS 1996; Black Gap WMA: Mahler 1971).

Dead Horse Mountains	T/sp	% of flora	Big Bend National Park	T/sp	% of flora	Black Gap WMA	T/sp	% of flora	Solitario	T/sp	% of flora
Asteraceae	80	12.0	Asteraceae	168	13.9	Asteraceae	69	12.2	Asteraceae	71	13.4
Poaceae	75	11.3	Poaceae	148	12.2	Poaceae	57	10.1	Poaceae	55	10.3
Fabaceae	52	7.8	Fabaceae	76	6.3	Cactaceae	47	8.3	Cactaceae	33	6.2
Euphorbiaceae	34	5.1	Cactaceae	63	5.2	Fabaceae	34	6.0	Fabaceae	32	6.0
Cactaceae	31	4.7	Euphorbiaceae	51	4.2	Euphorbiaceae	26	4.6	Euphorbiaceae	28	5.3
Pteridaceae	20	3.0	Solanaceae	34	2.8	Boraginaceae	21	3.7	Pteridaceae	16	3.0
Boraginaceae	20	3.0	Brassicaceae	33	2.7	Brassicaceae	19	3.4	Malvaceae	15	2.8
Brassicaceae	16	2.4	Pteridaceae	29	2.4	Verbenaceae	16	2.8	Brassicaceae	14	2.6
Nyctaginaceae	16	2.4	Nyctaginaceae	27	2.2	Solanaceae	14	2.5	Solanaceae	14	2.6
Solanaceae	15	2.3	Boraginaceae	25	2.1	Nyctaginaceae	12	2.1	Scrophulariaceae	14	2.6

T/sp = total species

above, an increased elevational range may be one factor creating those discrepancies in the importance of a given family between floras. Big Bend National Park includes 2000 more feet (610 m) of elevation than the DH and is 2723 ft (829 m) higher than the Solitario, which creates potential for change in family-level statistics. The Chisos Mountains of BBNP support well-developed pinyon-oak-juniper vegetation as well as more montane forests. In comparison with the DH and the Solitario, the increase of elevation range and inclusion of different vegetation types does not influence the status of the Asteraceae and Poaceae in BBNP as the co-dominant families. The fact that the Solitario has a slightly different composition in its top 10 families may signify that the sample area was too small to adequately represent the flora of the larger region, or it may reflect a difference in local conditions, such as complex geology and, thus, substrate, that could produce changes in the dominant flora.

Black Gap is easily comparable to the other floras, being contiguous to BBNP, containing part of the DH, and having all limestone substrate. It does lack about 3000 ft (914 m) of the higher-elevation habitats and contains 50% less land area than the whole of the DH. Those facts notwithstanding, a provisional account of the Black Gap flora (Mahler 1971) supports the main trends already observed but introduces other differences. The top 10 families are similar, and the regional co-dominance of the Asteraceae and Poaceae is supported. However, the current flora of BGWMA does not support the hypothesis that, due to an increased presence of the Fabaceae, Tamaulipan vegetation has a strong influence on the eastern side of the Big Bend: the proportion of the Fabaceae in BGWMA is more similar to that recorded for BBNP and the more westerly-located Solitario. Perhaps more striking are the high percentage of the

Cactaceae, the omission of the Pteridaceae, and the inclusion of the Verbenaceae within the most important families. All of these differences may be artifacts of a plant list that is out of date.

The BGWMA flora used here for comparison is from 1971 and has not been updated to include the significant contributions made during the Brushy Canyon survey nor any other collecting over the past 35 years. The Cactaceae may be more highly represented in Mahler's (1971) list because they are perennial plants and more obvious, and thus more recorded, members of a flora as opposed to, for example, rain-dependent annuals. Cactaceae numbers may also be high because of the long-standing nomenclatural and systematic complexities surrounding the family, that have only recently been comprehensively treated for the area (Powell and Weedin 2004). Upon review, a few species may be deleted due to nomenclatural tidying, but, ultimately, individual specimens would need review to determine whether the species number is artificially inflated.

Ferns are certainly underrepresented in the Black Gap list. Perhaps Pteridaceae was not of interest to the workers involved in compiling the list. The Fabaceae could be undercollected and could very easily rise in importance with a more complete flora, thus better supporting the argument for the spreading influence of eastern vegetation types. This possibility should certainly be pursued, along with validating and updating the species list for BBNP (NPS 1996). As with the Black Gap flora, the conclusions drawn in the current report with respect to the national park flora should be considered

preliminary; the list dates from 1996, and many inconsistencies and omissions no doubt still exist, despite heavy editing in order to get a more accurate accounting of the park's flora for this analysis.

Finalizing any flora is a difficult process, and, even if brought up to date as much as possible, differences in floras may not necessarily be due to inherent dissimilarities. Collector bias, environmental conditions unconducive to collection, or a host of other variables that may remain inscrutable to science can play a part in preventing a flora from being truly complete. For example, the Boraginaceae have more than twice as many species in the DH, and the family is nearly twice as important in the DH as in the Solitario. The reason for this discrepancy is not clear; the borage family is known to be well represented in desert floras (Takhtajan 1986) and perhaps may simply be undercollected in the Solitario, especially considering that this family is well represented in BBNP and BGWMA. In the greater southwestern United States, the Boraginaceae the represent on average 2.9% of the flora (McLaughlin 1986), which is more consistent with other southern Big Bend numbers. However, comparisons between the Big Bend and the greater Southwest are hardly exact parallels.

Floristic Analysis and Comparsion: Regional level

Based on data from 50 floras throughout the southwestern United States, including western Texas, western New Mexico and Colorado, all of Utah, Nevada, Arizona, and southeastern California, the Southwest (SW) was characterized floristically (McLaughlin 1986). In addition to statistics on taxonomic composition, McLaughlin (1986) calculated similarity indices based on the degree of similarity between all 50 floras. The top three SW families are shared with the DH and BBNP, but the Asteraceae

are clearly the dominant family of SW floras (Table 13). Interestingly, the average number of Asteraceae species per SW flora is equal to the number found in the DH. Without knowing the average area of the SW flora sites used to compile the SW data, it is not possible to correlate these numbers exactly. However, it seems that the reduced importance of the Asteraceae in the southern Big Bend is due to the proportional increase in Poaceae species. This demonstrates the connection to the Great Plains grasslands, moving into Texas through the High and Rolling Plains vegetation zones of the Panhandle region. This relationship is visually apparent when traveling through the Trans-Pecos but is also supported by quantitative methods: similarity indices between a central Arizona flora and surrounding floras were computed and demonstrated a strong graminoid connection among parts of Arizona, western Texas, and the central U.S. (Christie 2006).

The Fabaceae are more important locally in the DH but are also important in the SW. This family comprises a larger percentage of the species of the SW flora than in the DH, yet the DH have more fabaceous species (52) than the average for SW floras (28). This increased diversity at the species level may, again, relate to possible peripheral influences of the Tamaulipan Thornscrub flora. Another family discrepancy involves the Cactaceae. This family is more than twice as important in the southern Big Bend as it is for the entire SW, though, because it is a desert-oriented family, the numbers are not representative of what might occur within, for example, the Sonoran Desert alone. Another great discrepancy involves the Polemoniaceae. This family accounts for only

Table 13. Comparison of family percentages between the southern Big Bend of Texas (BGWMA: Mahler 1971; BBNP: NPS 1996; Solitario: Hardy 1994) and the average of 50 southwestern U.S. floras (McLaughlin 1986).

Family	% of total flora for southern Big Bend region				Family	% of total flora, Southwestern U.S.
	BGWMA	BBNP	Dead Horse Mountains	Solitario		
Asteraceae	12.2	13.9	12.0	13.3	Asteraceae	17.1
Poaceae	10.1	12.2	11.3	10.3	Fabaceae	9.0
Fabaceae	6.0	6.3	7.8	6.0	Poaceae	6.6
Euphorbiaceae	4.6	4.2	5.1	5.3	Scrophulariaceae	5.1
Cactaceae	8.3	5.2	4.7	6.2	Brassicaceae	3.8
Pteridaceae	1.4	2.4	3.0	3.0	Polygonaceae	3.2
Boraginaceae	3.7	2.1	3.0	1.5	Boraginaceae	3.0
Brassicaceae	3.4	2.7	2.4	2.6	Polemoniaceae	2.6
Nyctaginaceae	2.1	2.2	2.4	2.3	Cactaceae	2.0
Solanaceae	2.5	2.8	2.3	2.6	Rosaceae	2.0

0.8% of the DH flora, while it is in the top 10 SW families at 2.6%. This may be a more cosmopolitan family that requires more habitats than the southern Big Bend can offer for increased species diversity.

Diversity is even less aligned at the generic level than at the family level. There are only two genera in common within the top 10 genera of the SW and the DH. Only five DH genera make the SW's top-twenty list, and they do not include *Dalea* (dalea), one of the two dominant genera of the DH. The genera that are shared in common with the SW list have more species present in the DH than, on average, throughout the SW. Although the importance of this would be clearer if the average size of the SW flora sites were known, it does seem clear that the DH flora differs significantly from the average diversity of Southwestern floras. The centers of diversity, perhaps, are shifted, or perhaps it is not appropriate to include the southern Big Bend region with the general SW in terms of their floristics. To further illustrate this, a floristic study done in central Arizona, within a pinyon-juniper vegetation type and including only 1312 ft (400 m) of elevation range (Christie 2006), recorded 85% of the most common SW species (McLaughlin 1986). This compares to only 41% similarity with the DH. The differences continue on a broader scale when comparing relative importance of taxonomic groups (Table 14).

At first glance, the importance of ferns and fern allies seems greater in the SW, but if the entire range of habitats within the Big Bend is considered, the percentages become more equal. The entire BBNP, encompassing 2000 ft (610 m) more elevation than the DH, is home to at least seven pteridophyte families (NPS 1996). This increase in diversity makes floristic comparisons with the Southwest more equal, although the

Table 14. Taxonomic summary of Southwestern floristic areas: number of families and species per taxonomic group and the resulting proportion of the entire area flora. SW= data summary from 50 southwestern U.S. floras (McLaughlin 1986); DH= Dead Horse Mountains, Brewster County, Texas; SOL= the Solitario, Brewster and Presidio Counties, Texas; CDR= Chihuahuan Desert Region (Henrickson and Johnston 2004).

Taxonomic group	Families								Species							
	SW	%	DH	%	SOL	%	CDR	%	SW	%	DH	%	SOL	%	CDR	%
Ferns and Allies	9	7	3	3.3	2	2.3	11	7.3	120	2.2	24	3.6	20	3.8	94	2.9
Gymnosperms	3	2.4	3	3.3	2	2.3	4	0.3	36	0.6	7	1.1	4	0.8	36	1.1
Monocots	10	7.9	10	11	10	11.6	20	13.3	723	13.2	107	16.1	74	13.9	515	15.9
Eudicots	105	82.7	75	82.4	72	83.7	125	83.3	4579	83.9	525	79.2	434	81.6	2588	80

increase in species tallied is due to montane populations that are anomalous relicts in the context of the desert landscape surrounding them. The slightly enhanced proportion of gymnosperms in the DH may be explained by the overlapping ranges of similar species that regionally do not often occur together. It is possible that the two juniper species and the two pinyon pine species reported for this flora may be reduced to only one taxon per genus when the specimens can be further examined by experts. Though *Juniperus coahuilensis* (rose-fruited juniper) is the common grassland species and *Juniperus pinchotii* (red-berry juniper) is more expected on rocky slopes and mountains, they are documented to occur together elsewhere in the southern Big Bend (Powell 1998). The sympatric distributions are thought to have been influenced by population expansions and contractions across present-day Texas and Mexico during the Pleistocene glacial periods (Adams 1975).

The pinyon pine species occur together in few localities in the Big Bend, and, despite previous synonomy, they are currently recognized as distinct taxa. Growth habit and cone morphology are important distinguishing characters but, unfortunately, are not present on enough specimens from the DH to make an easy determination. *Pinus cembroides* (Mexican pinyon) is a mainly Mexican taxon, while *Pinus remota* (papershell pinyon) is, perhaps, the most widespread pinyon in the Trans-Pecos (Powell 1998). That these junipers and pines seem to occur in the same location provides more evidence for the DH as a place where multiple floristic influences can be seen.

In a comparison of the relative proportions of monocots and eudicots between regions, the major anomaly relates to the monocots. At the family level the number of monocot families is, on average, equal in the SW and southern Big Bend, but monocots

comprise a larger percentage of the southern Big Bend floras. At the species level, however, the Solitario is more similar to the SW than are the other southern Big Bend floras. It may be that the Solitario constitutes too small an area to accurately reflect regional characteristics, and when one examines the corresponding taxonomic numbers for the CDR, the regional importance of monocots is clarified. The Chihuahuan Desert has a higher percentage of monocots at the family level than the other areas under consideration and is more equal to the DH, BBNP, and BGWMA at the species level (Table 14). This suggests that monocots as a group are more important in the CDR and, by association, northern Mexico, than in the southwestern US. That the southern Big Bend in general reflects this pattern suggests, perhaps, a purer connection to the CDR rather than to other southwestern areas. Apart from this observation's being convenient because the southern Big Bend is located solidly within the CDR, it also provides an avenue to explore the larger connections at work throughout the southwestern U.S.

Phytogeographic Context

Where do these comparisons with the local and regional flora leave the Dead Horse in a floristic context? Of peripheral vegetational areas, the study area has connections to the Great Plains through its significant graminoid flora, which relates back to the Holocene-era dominance of grasslands. The importance of the Tamaulipan Thornscrub area may be seen in the local importance of the Fabaceae and certainly in the many other resident thornscrub species, including *Aloysia gratissima* (beebrush), *Ziziphus obtusifolia* (lotebush), and *Leucophyllum* spp. (silverleaf). For the few Trans-Pecos individuals of the more Tamaulipan species, *Acacia berlandieri* (guajillo)*, Croton*

torreyi (Torrey croton), and *Karwinskia humboltiana* (coyotillo), the Rio Grande corridor has most likely provided a conduit of limited habitat that enabled these species to extend their distributions upriver into generally more arid surroundings.

To the northeast, the Edwards Plateau region is perceived by some to overlap floristically with the Trans-Pecos (Gould 1962; Hatch et al. 1990), which seems a natural connection, according to Johnston (1977). He considered the Edwards Plateau a disjunct piece of the Sierra Madre Oriental, the main eastern mountain range of Mexico and the primary floristic influence for the CDR; the Chihuahuan Desert is not simply an extension of the Sonoran region, as Cronquist (1982) suggests. Rzedowski (1973) notes that both desert areas have several endemic genera (21 Sonoran, 16 CDR), suggesting a long period of isolation and autochthonous development. He goes further and provides evidence through similarity indices that the CDR flora shows more affinity to the southern end of the Sierra Madre Oriental than it does to Baja/Sonoran flora. Still, it is hard to delineate the Chihuahuan Desert exactly.

Due to inconsistencies in climate and vegetation, the boundaries of the CDR are not drawn exactly the same by all workers (Henrickson & Johnston 2004). Because there do not seem to be distinctive topographic limits to northern vegetative expansion (McLaughlin 1989), the limits may be more climatically controlled: CDR flora shows more similarity to coastal Peru than to the Great Basin (Rzedowski 1973). This becomes more significant when realizing that the Great Basin, Sonoran, and Chihuahuan Deserts are linked topographically and geologically as members of the Basin and Range province. Anthropomorphic change is another cause behind the hazy borders of the CDR, with

grazing and deforestation hastening the advance of desert scrub (Henrickson & Johnston 2004). However, debatable floristic extent does not imply lack of a central floristic connection.

The individualistic species concept (Gleason 1926) is well known and certainly is logical on a local scale. Each species undoubtedly responds to the range of environmental conditions available and will exploit those niches that are best suited to its own particular needs, independent of the surrounding vegetation. Individual species' tolerances are probably what drove the paleovegetational changes in response to the changing climate. However, as McLaughlin (1986) points out, that is no reason why, on a larger scale, there cannot be found coherent assemblages of species occurring in non-random patterns. Many floristic regions, delineated as places where the climate acts upon the vegetation (as opposed to more local vegetational areas, using delimiters like soils or geography), have been applied to the Southwest (Dice 1943, Cronquist 1982, Takhtajan 1986, McLaughlin 1986, Bailey 1998). The boundaries of these large-scale, ecological regions can be drawn strictly using climate and gross vegetational features (Bailey 1998), by using centers of endemism to create distinct groupings (Cronquist 1982, Takhtajan 1986), which could be called a "scarceness" model, or the focus could be on the degree of overlap between individual floras throughout a region (McLaughlin 1986, 1989). This particular model does not focus on the dominant or rare taxa; rather, it takes into account all extant species and is a method based on "commonness." To this end, McLaughlin's (1986, 1989) work has provided floristically-based evidence supporting many historical floristic distinctions, intuitive or otherwise.

Considering the commonness of floristic data, the Sonoran and Chihuahuan Deserts are seen to be distinct. Interestingly, the area of southeast Arizona and southwest New Mexico, where Henrickson and Johnston (2004) draw an arbitrary border of the CDR because of its perceived transitional nature, is shown to be part of a distinct floristic area that was intuitively recognized by Dice (1943). There is even an outlying connection of this so-called "Apachian" area to the Davis Mountains of the Big Bend, which Turner (1959) reflected in his floristic interpretation of the area. In support of this connection, the Davis Mountains, based on a subset of its flora (Larke 1989), has a family profile more similar to the Southwest—and is located more closely to the core of the Apachian element—than to floras in the southern Big Bend. As discussed, the Asteraceae dominate the flora of the SW, as opposed to being co-dominant with the Poaceae as in the southern Big Bend. Comparison with floras covering larger areas, such as the entire Davis Mountains region, the entire Big Bend National Park, and the CDR as a whole, would be more informative; further work will be possible once these floras are completed and available for further research. However, at this point these relationships pose interesting questions.

The Apachian floristic element is thought to be autochthonous but allied to the Sierra Madre Occidental (McLaughlin 1989). Perhaps during the expansions and contractions of vegetation communities in response to Pleistocene climate change, this Apachian center extended its influence into the Big Bend. As many as 25 glacial-interglacial periods have affected the southwest (Henrickson & Johnston 2004), allowing more temperate plant species to expand into the Big Bend region from both the north and south. In the Chisos Mountains of BBNP, *Pseudotsuga menzezii* (Douglas-fir) and

Populus tremuloides (quaking aspen) occur with the Mexican montane species *Cupressus arizonica* (Arizona cypress) and what is believed to be *Ponderosa arizonica* (Arizona ponderosa pine; Powell 1998). In the DH, cooler-climate species that may be remnants of glacial expansion include *Achnatherum curvifolium* (Guadalupe ricegrass) from the north and the Mexican pinyons from the south. In warmer times, the desert scrub and more tropical species expanded from the south. These climate fluctuations allowed for speciation through isolation, but there would have been more opportunities for diversification in the southern CDR, away from more extreme climate changes coming from the continental interior (Van Devender 1986).

The California floristic area is suggested by Raven and Axelrod (1978) to have a similar history, with a high center of diversity where speciation was allowed by long-term stable evolution, where "old" species were able to persist, even as bursts of speciation occurred to exploit new niches created by climate change (the uplift of the Sierra Nevada and a shift to Mediterranean climate on the coast). Both long-term species and "neoendemics" were able to persist in California and the southern CDR, creating areas of high endemism and species/genus ratios. Any discussion of speciation must acknowledge that the process is not simply a function of time or climate. Life forms, breeding systems, and genetics are also critical in producing differential speciation abilities (Grant 1958).

The resulting diversity can be measured, in one sense, by the species-per-genus ratio: high for the California floristic area (5.7) and then declining slightly for the Sonoran Desert (3.3), the CDR (3.8), and Texas (3.9), as noted in Raven and Axelrod (1978) and Henrickson and Johnston (2004). The Big Bend ratios are much lower: Davis

Mountains 1.5 (Larke 1989); Solitario 1.8 (Hardy 1997); DH 1.9; and BBNP 2.3 (Worthington 2001). The smaller size of the floras may limit the full expression of this view of diversity, but that, in itself, may be the limiting factor. The areas with high habitat diversity in the Big Bend, which are thus often the focus of floristic research, are centered around mountain ranges, which are highly isolated from each other by large expanses of desert terrain. Where places such as the more equable southern CDR may have benefited from the oscillating climate (in terms of increased speciation), the persistence of diversity in the Big Bend region may have been hindered by the extinction of isolated populations left over from previous expansions and contractions.

Relicts persisting at the highest elevations in the DH hint at the complex history of environmental response to climate change through recent geologic history. The Big Bend region, including the DH, can be seen as a transition area between several floristic regions, with its higher elevations providing habitat for many isolated populations that are much more extensive elsewhere. Instead of providing equable conditions over the long term, which could have allowed for steady progress of evolution in addition to speciation into available niches, extinction may have been a more effective mechanism than speciation in affecting today's floristic diversity in the Big Bend. More floristic study is warranted for the region. Beyond simply improving baseline knowledge of the Trans-Pecos flora, previous floristic work (McLaughlin 1986, 1989) should be revisited and improved by updating the original data, since several Trans-Pecos floras have increased by 40–50% since the 1980s (Worthington 2001, F. Armstrong pers. com.). A forthcoming review of North American floristic relationships may address these changes (McLaughlin 2007). Regionally, similarity index studies similar to those by McLaughlin

(1986, 1989) and, especially, Christie (2006) could be used to elucidate in more detail the floristic influences on the Big Bend region and might help to more concretely identify the distinctions between CDR provinces. The completion of the current Dead Horse Mountains flora is an important step towards a more complete understanding of West Texas regional floristic relationships.

CHAPTER V

LITERATURE CITED

Adams, M.B. 1978. From darkness into light. Pioneer Book Publishers, Seagraves, TX.

Adams, R.P. 1975. Numerical-chemosystematic studies of infraspecific variation in *Juniperus pinchotii*. Biochem. Syst. & Ecol. 3:71–74.

Alex, B.L., A. Leavitt, J. Timmer, and J. Sirotnak. 2006. Final report on the sensitive plant project, Big Bend National Park, Texas, Field Seasons: June 2003–April 2006. Science & Resource Management, Big Bend National Park, Texas. Unpublished report to the National Biological Infrastructure Inventory, U.S. Geological Survey, Washington, D.C.

Alex, T. 1990. Big Bend Archaeology pamphlet. Big Bend Natural History Association, Big Bend National Park, TX.

Amos, B. and D. Giles. 1992. Survey of the vascular plants of Brushy Canyon. Unpublished report to the Nature Conservancy of Texas, Fort Davis.

Anthony, M. 1956. The *Opuntiae* of the Big Bend region of Texas. Amer. Midl. Naturalist 55:225–256.

Arizona Department of Agriculture [AZDA]. 2005. Prohibited, regulated, and restricted noxious weeds website. URL: www.azda.gov/PSD/quarantine5.htm.

Automated National Catalog System [ANCS+]. 2006. The museum collection management system of the National Park Service. Big Bend National Park specimen records. Re:discovery Software, Inc., Charlottesville, VA.

Bailey, R.G. 1998. Ecoregion map of North America. United States Fish and Wildlife Service misc. pub. 1548.

Barneby, R.C. 1977. Daleae imagines. Mem. New York Bot. Gard. 27:1–891.

Bell, G. 1997. Ecology and management of *Arundo donax*, and approaches to riparian habitat restoration in Southern California. In: J.H. Brock, M. Wade, P. Pysek, and D. Green eds. Plant invasions: studies from North America and Europe. Blackhuys Publishers, Leiden, Netherlands.

Bowers, J.E. and S.P. McLaughlin. 1982. Plant species diversity in Arizona. Madroño 29:227–233.

Brown, D.E. (ed). 1994. Biotic communities: southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City.

Bryson, R.A. and W. Wendland. 1967. Tentative climatic patterns for some late glacial and post-glacial episodes in central North America. In: S.J. Mayer-Oakes, Jr., ed. Life, land, and water, University of Manitoba Press, Winnipeg.

Butterwick, M. and E. Lott. [1977]. A botanical survey of the Bullis Gap range – San Francisco Canyon area, Brewster County, Texas. Unpublished report, Natural Area Survey series, University of Texas, Austin.

Butterwick, M. and S. Strong. 1976. A vegetational survey of the Solitario. In: Lyndon B. Johnson School of Public Affairs. The Solitario: a natural area survey, No. 9. Lyndon B. Johnson School of Public Affairs, University of Texas, Austin.

Carignan, J.M. 1988. Ecological survey and elevational gradient implications of the flora and vertebrate fauna in the northern Del Norte Mountains, Brewster County, Texas. MS Thesis, Sul Ross State University, Alpine, TX.

Christie, K. 2006. Vascular flora and floristic analysis of the lower San Francisco Volcanic Field, Coconino County, Arizona. MS Thesis, Northern Arizona University, Flagstaff.

Clausen, R.T. 1981. Variation of species of *Sedum* of the Mexican cordilleran plateau. Robert T. Clausen, Ithaca, NY.

Clelland, R. 2001. Inventory of vascular flora of the Big Bend National Park. Big Bend Natural History Association, Big Bend National Park, Texas.

Cochran, R.A. and F.L. Rives. 1985. Soil survey of Big Bend National Park, part of Brewster County, Texas. United States Department of Agriculture, Soil Conservation Service, in cooperation with United States Department of Interior, National Park Service, and Texas Agricultural Experiment Station, College Station.

Correll, S. and M. C. Johnston. 1970. Manual of the vascular plants of Texas. University of Texas, Dallas.

Cronquist, A. 1982. Map of the floristic provinces of North America. Brittonia 34:144–145.

Dice, L.R. 1943. The biotic provinces of North America. University of Michigan Press, Ann Arbor.

Fenstermacher, J. 2006. *Seymeria falcata* (Scrophulariaceae), a new record for Texas and the United States. Sida 22:811–812.

Fenstermacher, J., A. Leavitt, J. Sirotnak, and W. Weckesser. 2006. Floristic inventory of proposed mountain bike trail in Big Bend National Park, Texas: Survey 1 – late summer/rainy season. Unpublished report to the Science and Resource Management division, Big Bend National Park, TX.

Flora of North America Editorial Committee (eds.) [FNA]. 2002. Flora of North America north of Mexico, Vol. 26: Magnoliophyta: Liliidae: Liliales and Orchidales. Oxford University Press, New York, NY.

Flora of North America Editorial Committee (eds.) [FNA]. 2003a. Flora of North America north of Mexico, Vol. 4: Magnoliophyta: Caryophyllidae, part 1. Oxford University Press, New York, NY.

Flora of North America Editorial Committee (eds.) [FNA]. 2003b. Flora of North America north of Mexico, Vol. 25: Magnoliophyta: Commelinidae (in part): Poaceae, part 2. Oxford University Press, New York, NY.

Flora of North America Editorial Committee (eds.) [FNA]. 2006. Flora of North America north of Mexico, Vols. 19–21: Magnoliophyta: Asteridae: Asteraceae, parts 1–3. Oxford University Press, New York, NY.

Flora of North America Editorial Committee (eds.) [FNA]. 2007. Flora of North America north of Mexico, Vol. 24: Magnoliophyta: Commelinidae (in part): Poaceae, part 1. Oxford University Press, New York, NY.

Flora of Texas Consortium [FTC]. 2003. Digital flora of Texas herbarium specimen browser, version II. URL: www.texasflora.org/dfthsbbase.htm.

Fulcher, W. 1959. The way I heard it: tales of the Big Bend. University of Texas Press, Austin.

Funk, V.A. and K.S. Richardson. 2002. Systematic data in biodiversity studies: use it or lose it. Sys. Biol. 51:303–316.

Gleason, H.A. 1926. The individualistic concept of the plant association. Bull. Torr. Bot. Club 53:7–26.

Goff, F.G., G.A. Dawson, and J.J. Rochow. 1982. Site examination for threatened and endangered plant species. Environm. Managem. 6:307–316.

Gould, F.W. 1962. Texas plants—a checklist and ecological summary. Texas Agricultural Experiment Station, Texas A&M University, College Station.

Gould, F.W. 1975. The grasses of Texas. Texas A&M University Press, College Station.

Grant, V. 1958. The regulation of recombination in plants. Cold Spring Harbor Symp. Quantit. Biol. 23:337–363.

Hardy, J.E. 1997. Flora and vegetation of the Solitario dome, Brewster and Presidio Counties, Texas. MS Thesis, Sul Ross State University, Alpine, TX.

Hatch, S.L., K.N. Gandhi, and L.E. Brown. 1990. Checklist of the vascular plants of Texas. Miscellaneous Publication 1655, Texas Agricultural Experiment Station, Texas A&M University, College Station.

Haynie, S.D. 2000. A floristic analysis of Fort Davis National Historic Site, Fort Davis, Texas. MS Thesis, Sul Ross State University, Alpine, TX.

Henrickson, J. 2003. Studies in *Glandularia* (Verbenaceae): the *Glandularia quadrangulata* complex. Sida 20:953–967.

Henrickson, J. 2005. A new species of *Leucospora* (Scrophulariaceae) from the Chihuahuan Desert of Mexico. Aliso 24:435–439.

Henrickson, J. and M.C. Johnston. 1986. Vegetation and community types of the Chihuahuan Desert. In: J.C. Barlow, A.M. Powell, and B.N. Timmermann, eds. Second symposium on resources of the Chihuahuan Desert Region, United States and Mexico. Chihuahuan Desert Research Institute, Alpine, TX.

Henrickson, J. and M.C. Johnston. 2004. A Flora of the Chihuahuan Desert Region. Unpublished manuscript, edition 1.5, CD version. University of Texas, Austin.

Howe, W.H. and F.L. Knopf. 1991. On the imminent decline of Rio Grande cottonwoods in central New Mexico. SouthW. Naturalist 36:218–224.

Integrated Taxonomic Information System [ITIS]. 2007. Online database. URL: http://itis.gov.

Johnston, M.C. 1977. Brief resume of botanical, including vegetational, features of the Chihuahuan Desert Region with special emphasis on their uniqueness. In: R.H. Wauer and D.H. Riskind, eds. Transactions of the symposium on the biological resources of the Chihuahuan Desert Region, United States and Mexico. U.S. Department of the Interior, National Park Service transactions and proceedings series, number three.

Langford, J.O. with F. Gipson. 1995. Big Bend, a homesteader's story. University of Texas Press, Austin.

Larke, J.O. 1989. Flora and vegetation of the Forbidden Mountains area, Jeff Davis County, Texas. MS Thesis, Sul Ross State University, Alpine, TX.

Louie, D. 1996. The rare and threatened plant species of Big Bend National Park, Texas. MS Thesis, Sul Ross State University, Alpine, TX.

Mahler, B. 1971. Keys to the vascular plants of the Black Gap Wildlife Management Area, Brewster County, Texas. Privately published by Wm. F. Mahler, Dallas, TX.

Maxwell, R.A. 1979. The Big Bend of the Rio Grande: a guide to the rocks, geologic history, and settlers of the area of Big Bend National Park. The University of Texas at Austin, Bureau of Economic Geology, Guidebook 7.

Maxwell, R.A. 1985. The Big Bend Country: a history of Big Bend National Park. Big Bend Natural History Association, Big Bend National Park, TX.

Maxwell, R.A and J.W. Dietrich. 1965. Geology of the Big Bend area, Texas with road log and papers on the natural history of the area. Fieldtrip guidebook publication 65–51. West Texas Geological Society, Midland.

Maxwell, R.A., F.T. Lonsdale, R.T. Hazzard, and J.A. Wilson. 1967. Geology of Big Bend National Park, Brewster County, Texas. The University of Texas at Austin, Bureau of Economic Geology, pub. no. 6711.

McDougall, W.B. 1936. Special report: preliminary report on the vegetation of the Dead Horse Mountains, Big Bend area of Texas. Unpublished report held by the National Archives and Records Administration, Rocky Mountain Region, Denver, CO.

McLaughlin, S.P. 1986. Floristic analysis of the southwestern United States. Great Basin Naturalist 46:46–65.

McLaughlin, S.P. 1989. Natural floristic areas of the western United States. J. Biogeogr. 16:239–248.

McLaughlin, S.P. 2007. Tundra to tropics: the floristic plant geography of North America. Sida, Bot. Misc. 30. Botanical Research Institute of Texas, Fort Worth.

Missouri Botanical Garden [MBG]. 2007. VAScular Tropicos nomenclatural database, Release 1.5. URL: http://mobot.mobot.org/W3T/Search/vast.html.

Morafka, D.J. 1977. A biogeographical analysis of the Chihuahuan Desert through its herpetofauna. Biogeographica (The Hague) 9. Dr. W. Junk B.V. Publishers, The Hague, Netherlands.

Moustafa, A.R. 1988. Structural geology of the Sierra del Carmen, Trans-Pecos, Texas. Geologic quadrangle map no. 54. Bureau of Economic Geology, University of Texas, Austin.

National Park Service [NPS]. 1996. The vascular flora of Big Bend National Park, Texas. In-house publication prepared by the Science and Resource Management Division.

National Park Service [NPS]. 2003. Archives, administrative history, Big Bend National Park. Chapter 11: discovering nature's way: scientific research and resource protection, 1936. URL: www.nps.gov/archive/bibe/adhi/adhi11b.htm.

National Park Service [NPS]. 2004. Basic park map. URL: www.nps.gov/bibe/planyourvisit/upload/BIBEmap3.pdf.

National Park Service [NPS]. 2006. Web query of the National Park Service Visitor Report, internal website. URL: http://165.83.32.36/mpur/reports.

The Nature Conservancy [TNC]. 2005. The Global Invasive Species Initiative red alert archive: weed alert website: http://tncweeds.ucdavis.edu/alert/alrtcenc.html.

Neibuhr, E. 1936. The Excavation of Chisos 8:2, August 24 to 28, 1936. In: E.K. Reed, ed. Special report of archaeological work in the Big Bend. Unpublished report submitted to the National Park Service, Region Three, Santa Fe.

Neilsen, R.P. 1986. High-resolution climatic analysis and southwest biogeography. Science 232:27–34.

Nesom, G. and B.L. Turner. 1995. Systematics of the *Sedum parvum* group (Crassulaceae) in northeastern Mexico and Texas. Phytologia 79:257–268.

New York Botanical Garden [NYBG]. 2006. New York Botanical Garden international plant science center virtual herbarium website. URL: http://sciweb.nybg.org/science2/hcol/allvasc/index.asp.

Palmer, M.W., G.L. Wade, and P. Neal. 1995. Standards for the writing of floras. Bioscience 45:339–345.

Pearson, J. (ed). 1990. Hikers guide to the trails of Big Bend National Park. Big Bend Natural History Association, Big Bend National Park, TX.

Pinkava, D.J. 1984. Vegetation and flora of the bolson of Cuatro Cienegas region, Coahuila, Mexico: IV. Summary, endemism and corrected catalogue. J. Arizona-Nevada Acad. Sci. 19:23–47.

Plant Resources Center, University of Texas at Austin [PRC]. 2006. Flora of Texas TEX-LL database. URL: http://129.116.69.198:427/Tex.html.

Plumb, G.A. 1991. Assessing vegetation types of Big Bend National Park, Texas for image-based mapping. Vegetatio 94:115–124.

Plumb, G.A. 1992. Vegetation classification of Big Bend National Park, Texas. Texas J. Sci. 44:375–387.

Poole, J.M., J.R. Singhurst, D.M. Price, and W.R. Carr. 2007. A list of the rare plants of Texas, January 2007 edition. Wildlife Diversity Program, Texas Parks and Wildlife Department and the Nature Conservancy of Texas, Austin and San Antonio.

Poole, J.M., W.R. Carr, D.M. Price, and J.R. Singhurst. [in press.] Rare plants of Texas: a field guide. Texas A&M University Press, College Station.

Powell, A.M. 1998. Trees and shrubs of Trans-Pecos Texas. University of Texas Press, Austin.

Powell, A.M. 2000. Grasses of the Trans-Pecos and adjacent areas. Iron Mountain Press, Marathon, TX.

Powell, A.M. [in prep.] Flowering plants of the Trans-Pecos and adjacent areas: Eudicots. Sul Ross State University, Alpine, TX.

Powell, A.M. and R.A. Hilsenbeck. 1995. A floristic overview of the Chihuahuan Desert Region. Chihuahuan Desert Disc. Winter/Spring. Chihuahuan Desert Research Institute, Alpine, TX.

Powell, A.M. and B.L. Turner. 1977. Aspects of the plant biology of the gypsum outcrops of the Chihuahuan Desert. In: R.H. Wauer and D.H. Riskind, eds. Transactions of the symposium on the biological resources of the Chihuahuan Desert Region, United States and Mexico. U.S. Department of the Interior, National Park Service transactions and proceedings series, No. three.

Powell, A.M. and J.F. Weedin. 2004. Cacti of the Trans-Pecos and adjacent areas. Texas Tech University Press, Lubbock.

Powell, A. M., S. C. Yarborough, and S. D. Jones. [in ms.]. Flowering plants of the Trans-Pecos and adjacent areas: Monocots, excluding the grasses: cat-tails, sedges, and rushes to lilies, agaves, and orchids. Sul Ross State University, Alpine, Texas.

Pulling Together Initiative [PTI]. 2006. Texas invasive plant database. URL: www.texasinvasives.org/Invasives_Database/Invasives.html.

Ralston, B.E. 1987. A biosystematic study of the *Opuntia schottii* complex (Cactaceae) in Texas. M.S. Thesis, Sul Ross State University, Alpine, TX.

Ralston, B.E. and R.A. Hilsenbeck. 1989. Taxonomy of the *Opuntia schottii* complex (Cactaceae) in Texas. Madroño 36:221–231.

Ralston, B.E. and R.A. Hilsenbeck. 1992. *Opuntia densispina* (Cactaceae): a new club cholla from the Big Bend region of Texas. Madroño 39:281–284.

Raven, P.H. and D.I. Axelrod. 1978. Origin and relationships of California flora. Univ. Calif. Publ. Bot. 72. University of California Press, Berkeley.

Raven, P.H., R.F. Evert, and S.E. Eichhorn. 2003. Biology of plants. W.H. Freeman, New York, NY.

Rogers, T.D. 1964. Biological observations with emphasis on the vegetation of the Black Gap Wildlife Management Area, Brewster County, Texas. MS Thesis, Sul Ross State University, Alpine, TX.

Rzedowski, J. 1973. Geographical relationships of the flora of Mexican dry regions. In: A. Graham, ed. Vegetation and vegetational history of northern Latin America. Elsevier, New York, NY.

Saltonstall, K. 2003. Microsatellite variation within and among North American lineages of *Phragmites australis*. Mol. Ecol. 12:1689–1702.

Schmidt, R.H., Jr. 1979. A climatic delineation of the 'real' Chihuahuan Desert. J. Arid Environm. 2:243–250.

Schmidt, R.H., Jr. 1986. Chihuahuan climate. In: J.C. Barlow, A.M. Powell, and B.N. Timmermann, eds. Second symposium on resources of the Chihuahuan Desert Region, United States and Mexico. Chihuahuan Desert Research Institute, Alpine, Texas.

Shreve, F. 1942. The desert vegetation of North America. Bot. Rev. 8:195–246.

Sikes, S. and J. Smith. 1973. Victorio Canyon, a vegetational survey. In: Lyndon B. Johnson School of Public Affairs. Victorio Canyon: a natural area survey, Part IV of IV. University of Texas, Austin.

Smith, V.J. 1924. How Dead Horse Canyon got its name. In: J.F. Dobie, ed. Legends of Texas. Publications of the Texas Folklore Society, Number III. Held by the Archives of the Big Bend, Alpine, TX.

Takhtajan, A. 1986. Floristic regions of the world. University of California Press, Berkeley.

Terrell, E.E. 1996. Taxonomic notes on Texan and Mexican species of *Hedyotis* and *Houstonia* (Rubiaceae). Phytologia 81:108–114.

Terrell, E.E. 2001. Taxonomy of *Stenaria* (Rubiaceae: Hedyotidae), a new genus including *Hedyotis nigricans*. Sida 19:591–614.

Texas A&M Bioinformatics Working Group [TAM-BWG]. 2006. Texas Endemics: checklist of all endemics. URL: www.csdl.tamu.edu/FLORA/endemics/ endemics2.htm.

Texas Parks and Wildlife Department [TPWD]. 2006. Rare and threatened species of Texas by county. URL: www.tpwd.state.tx.us/landwater/land/maps/gis/ ris/endangered_ species.phtml.

Turner, A.J. 1977. Soil Survey of Jeff Davis County, Texas. United States Department of Agriculture, Soil Conservation Service in Cooperation with the Texas Agricultural Experiment Station, College Station.

Turner, B.L. 1959. The legumes of Texas. University of Texas Press, Austin.

Turner, B.L. 1997. Turner's rebuttal to Terrell's taxonomic notes on Turner's treatment of Texan and Mexican *Hedyotis*. Phytologia 82:82–85.

Turner, B.L., H. Nichols, G. Denny, and O. Doron. 2003. Atlas of the vascular plants of Texas. Sida, Bot. Misc. 24. BRIT Press, Fort Worth, Texas.

Turner, B.L. and A.M. Powell. 2005. Chromosome numbers of *Glandularia* (Verbenaceae) from central and Trans-Pecos, Texas. Sida 21:1657–1661.

Tyler, R.C. 1975. The Big Bend: a history of the last Texas frontier. National Park Service, Washington, D.C.

United States Department of Agriculture [USDA]. 2006. Natural Resources Conservation Service soils website. URL: www.soils.usda.gov.

United States Department of Agriculture [USDA]. 2007. Natural Resources Conservation Service PLANTS Database website. URL: http://plants.usda.gov/.

Van Devender, T.R. 1986. Pleistocene climates and endemism in the Chihuahuan Desert. Quatern. Res. 15:278–290.

Van Devender, T.R. 1990. Late quaternary vegetation and climate of the Chihuahuan Desert, United States and Mexico. In: J.L. Betancourt, T.R. Van Devender, and P.S. Martin, eds. Packrat middens: the last 40,000 years of biotic change. University of Arizona Press, Tucson.

Van Devender, T.R., R.S Thompson, and J.L. Betancourt. 1987. Vegetation history of the deserts of southwestern North America; the nature and timing of the Late Wisconsin-Holocene transition. In: W.F. Ruddiman and H.E. Wright, Jr., eds. North America and adjacent oceans during the last deglaciation, The Geology of North America Vol. K–3. The Geological Society of America, Boulder, CO.

Warnock, B.H. 1946. The vegetation of the Glass Mountains, Texas. PhD Dissertation, University of Texas, Austin.

Warnock, B.H. 1970. Wildflowers of the Big Bend country, Texas. Sul Ross State University, Alpine, TX.

Warnock, B.H. 1974. Wildflowers of the Guadalupe Mountains and the sand dune country, Texas. Sul Ross State University, Alpine, TX.

Warnock, B. H. 1977. Wildflowers of the Davis Mountains and the Marathon Basin, Texas. Sul Ross State University, Alpine, TX.

Weckesser, W. [in prep.] Vascular flora of Reed's Plateau, Brewster County, Texas. MS Thesis, Sul Ross State University, Alpine, TX.

Wells, P.V. 1965. Vegetation of the Dead Horse Mountains, Brewster County, Texas. SouthW. Naturalist 10:256–260.

Wells, P.V. 1966. Late Pleistocene vegetation and degree of pluvial climatic change in the Chihuahuan Desert. Science 153:970–975.

Wood, S., G. Harper, E. Muldavin, and P. Neville. 1999. Final report: vegetation map of the Sierra del Carmen, U.S.A. and Mexico. Unpublished report to the National Park Service, Big Bend National Park, TX.

World Wildlife Fund [WWF]. 2001. Tamaulipan mezquital ecoregion (NA1312) full scientific report. URL: www.worldwildlife.org/science/ecoregions/nearctic.cfm.

Worthington, R.D. 1995. A floral inventory of the Big Bend Ranch State Natural Area, Presidio and Brewster Counties, Texas. Unpublished report, University of Texas, El Paso.

Worthington, R.D. 2001. Inventory of the flora of Big Bend National Park, Brewster County, Texas: first working draft. Floristic inventories of the southwest program, University of Texas, El Paso.

Yarborough, S. C. and A. M. Powell. 2002. Fern and fern allies of the Trans-Pecos and adjacent areas. Texas Tech University Press, Lubbock.

APPENDIX A:

ANNOTATED SPECIES LIST OF THE DEAD HORSE MOUNTAINS

APPENDIX A

ANNOTATED SPECIES LIST OF THE DEAD HORSE MOUNTAINS FLORA

Species are arranged by divisions following Raven et al. (2003): Lycophyta, Pteridophyta, Coniferophyta, Gnetophyta, and Anthophyta. The flowering plants are subdivided into the classes Monocotyledones and Eudicotyledones. Within these hierarchical groupings, taxa are listed alphabetically by family, genus, species, and infraspecific rank, as appropriate. Beyond a basic reliance on the *Manual of Vascular Plants of Texas* (Correll and Johnston 1970), taxonomy and nomenclature were taken preferentially from several updated sources, including Powell (in prep.) and Powell et al. (in ms.) for non-woody vascular species and genera, the *Flora of North America* volumes for the Poaceae and Asteraceae (FNA 2003b, 2006, 2007), and Powell and Weedin (2004) for the Cactaceae. Online databases were also checked for currency, authorities, and synonomy (ITIS 2007, MBG 2007, USDA 2007).

Turner et al. (2003) was the fundamental source for nomenclature and distributional data. Specimens found through the herbaria search were assumed to be correctly identified unless the distribution information (dot maps reflecting collection localities) in Turner et al. (2003) raised significant doubts. In some cases, specimens were examined, and species were added to the flora or were placed on a "likely to occur" list (Appx. B). Also placed on that list were species without vouchers from the study area but that had conducive distributions according to various sources cited accordingly. Some species—either listed without a voucher or that were unable to be examined, with distributions far

away from the study area—were placed on an "unlikely to occur" list (Appx. C). If a taxon was listed (without a voucher collection) by either of the two previous area surveys (Wells 1965, Amos and Giles 1992), it is noted as such. Nativity, common names, and life forms (Table 6) were taken from the United States Department of Agriculture's PLANTS Database (USDA 2007). Locally used common names from regional literature were included if not utilized by the USDA. Graminoid life-forms were included under the herb category. A generic entry for the annotated list is given below, followed by explanations of the different components:

* *Scientific name* Author var. *variety* Author – Common name

[*Synonym* Author] Abundance and life form, substrate and habitat comments; VEGETATION COMMUNITY, elevation; collections. If the species is uncommon or rarer within the study area, more specific collection localities are given. Any other pertinent comments on distribution, taxonomy, etc., are included at the end of the entry.

Symbols:

Various symbols precede the species entries (Table 15), indicating native status and the type of collection as it relates to the historical baseline. In addition to the USDA nativity designations, state-level rankings for non-native/invasive/noxious species were also incorportated (PTI 2006).

Table 15. Symbols used in association with the species entries in Appendix A.

Symbol	Description
*	non-native
!	invasive non-native
!!	noxious non-native weed listed by TPWD/USDA
Δ	observed but not collected
§	previously collected, but not during the current study period
+	first voucher of a common or expected taxon
#	newly documented taxon for the DH
bold	Species names in bold are considered rare and are currently tracked by the Texas Parks and Wildlife Department and the Nature Conservancy of Texas as species of conservation concern (Poole et al. 2007). An explanation of ranking terminology is provided previously (Table 9).

Abundance categories:

The categories employed here are subjective and based on observations made and impressions gleaned during the current study. The scale used (Table 16) is based on Palmer et al. (1995). Any historical abundance observations taken from label data are placed within quotations. The terms used were not changed (e.g. from "infrequent" to "uncommon"), because the historical collector's frame of reference or personal distinctions of scale categories is unknown. Many species may have a "rare" abundance within the study area but are not tracked by TPWD or TNC as being imperiled state or worldwide and, thus, are not listed in bold (Table 15) and do not have a G or S ranking (Table 9).

Habitat and vegetation communities:

These data represent field notes and observations made during the current study and any other notes included in the historical digital database. Elevations given represent the range where actual collections were made, often augmented by field notes on other observations of the species' distributions. Vegetation community designations (Table 17) were created based on field observations as a way to generally represent where each species was expected/known to occur. Categories used were based on the elevational/moisture-availability gradients found in the study area, as discussed in the Vegetation Patterns section of this report. Supplemental data for previously collected specimens (**§**), such as elevation and vegetation community, were included only if such

Table 16. Abundance categories used to describe species occurences in the study area.

Density	Description
Abundant	Dominant or co-dominant in one or more common habitats
Common	Easily seen or found in one or more common habitats but not dominant in any common habitat
Occasional	Widely scattered but not difficult to find
Uncommon	Difficult to find with few individuals or colonies but found in several locations
Rare	Very difficult to find and limited to one or very few locations or uncommon habitats

Table 17. Acronyms for vegetation types in the study area.

Acronym	Vegetation Community
DSC	Desert Scrub
DAR	Desert Arroyo
DCA	Desert Canyon
RIO	Rio Grande Riparian Corridor
SYG	Sotol-Yucca Grassland
CHP	Chaparral

information was present on the specimen label or in an electronic database. Two vegetation communities listed together (e.g. SYG/CHP) indicate that the species is found in an intermediate matrix of vegetation types, with one designation not being sufficient.

Voucher specimens:

All collections made during the current study are housed at SRSC. Selected duplicates were sent to BIBE, TEX-LL, and BRIT. All collections in the annotated list are grouped by the responsible herbarium (Table 18). Collectors were abbreviated using the initials of names taken from the databases and are listed alphabetically by the first initial (Table 19).

Locality information and comments:

Species classified as uncommon or rare have their general collection location listed after the list of collections and respective herbaria. Additional comments about localities, including local place names (Fig. 22), taxonomy, or any other notes of import, are included at the end of the listing.

Barker House. Historic adobe structure currently used for researcher housing. On the banks of the Rio Grande, about 1.4 miles east on the Boquillas Canyon road from the main road (NPS Route 12) to Rio Grande Village (RGV).

Boquillas. The site of Boquillas, Texas, equivalent to the current area of RGV.

Boquillas restoration site. Along the Rio Grande and on the old river floodplain terrace, on the southern side of the Boquillas Canyon trail. Burned in 2005, repeatedly treated with herbicide to eliminate the cane and tamarisk. Replanted with native species throughout 2006 and 2007.

Table 18. Acronyms for herbaria housing DH specimens.

Acronym	Herbarium and location
BBRSP	Big Bend Ranch State Park, Warnock Environmental Center, Lajitas, Texas
BGWMA	Black Gap Wildlife Management Area site headquarters on TX FM 2627
BIBE	Big Bend National Park, Texas
BRIT	Botanical Research Instituite of Texas, Fort Worth
KANU	R.L. McGregor Herbarium, University of Kansas, Lawrence
NYBG	New York Botanical Garden, Bronx
SAT	Angelo State University Herbarium, San Angelo, Texas
SHST	S.R. Warner Herbarium, Sam Houston State University, Huntsville, Texas
SRSC	A. Michael Powell Herbarium, Sul Ross State University, Alpine, Texas
SWT	Southwest Texas State Univeristy Herbarium, San Marcos
TAES	S.M. Tracy Herbarium, Texas A&M University, College Station
TEX-LL	University of Texas at Austin Herbarium

Table 19. Index to workers who have made collections in the study area.

Initials	Collector	Initials	Collector
ACK	A.C. Koelling	CA	C. Adkins
AD	A. Denyas	CAB	C.A. Bane
AG	A. Grimes	CMR	C.M. Rowell
AL	A. Freeman/ A. Leavitt	CN	C. Newman
AL2	A. Lewis	DAL	D.A. Louie
AMP	A.M. Powell	DAZ	D.A. Zimmerman
AT	A. Traverse	DB	D. Baker
B	Blevins	DB2	D. Benham
BA	B. Alex	DF	D. Flyr
BA2	B. Amos	DG	D. Giles
BAR	B.A. Ralston	DHR	D.H. Riskind
BCT	B.C. Tharp	DM	D. Miller
BD	B. Dodson	DS	D. Seigler
BDGL	B.D.G. Leopold	DS2	D. Smith
BGH	B.G. Hughes	DSC	D.S. Correll
BHW	B.H. Warnock	ECM	E. Castro-Mendoza
BLT	B.L. Turner	EGM	E.G. Marsh
BM	B. Moon	EJL	E.J. Lott
BPM	Billy Pat McKinney	EW	Eula Whitehouse
BR	B. Rector	GJG	G.J. Goodman
BRM	B.R. McKinney	GL	G. Jones

Table 19, continued. Index to workers who have made collections in the study area.

Initials	Collector	Initials	Collector
GLB	G.L. Bradley	JLB	J.L. Blassingame
GLW	G.L. Webster	JM	J. Masters
HBC	H.B. Correll	JMM	J.M. Miller
HBP	H.B. Parks	JMP	J.M. Poole
HC	H. Croad	JS	J. Sirotnak
HCC	H.C. Cutler	JT	J. Todd
HCH	H.C. Hanson	KJC	K.J. Castro
HKB	H.K. Beuchner	LCH	L.C. Hinckley
HL	Hillary Loring	LEB	L.E. Brown
HTF	H.T. Fletcher	LF	L. Fowle
IMJ	I.M. Johnston	LJT	L.J. Toolin
JAM	J.A. Moore	LS	L. Slauson
JAS	J.A. Steyermark	MA	M. Anthony
JC	J. Clark	MC	M. Cole
JDA	J.D. Allen	MCJ	M.C. Johnston
JDB	J.D. Bacon	MD	M. Darrach
JEA	J.E. Averett	MLP	M.L. Powell
JF	J. Fenstermacher	MPG	M.P. Griffith
JFW	J.F. Weedin	MSY	M.S. Young
JH	J. Hardy	MT	M. Talbot
JJ	J. Jernigan	MT2	M. Turner

Table 19, continued. Index to workers who have made collections in the study area.

Initials	Collector	Initials	Collector
MWB	M.W. Bierner	SAP	S.A. Powell
MY	M. Yuhas	SS	S. Sikes
OCW	O.C. Wallmo	TA	T. Anderson
OES	O.E. Sperry	TE	T. Emerson
PAS	P.A. Smith	TJW	T.J. Watson
PC	P. Cruze	TK	Tony Klein
PDW	P.D. Whitson	TM	T. Mollhagen
PM	P. Manning	TR	T. Rogers
PM2	P. McNeal	TRV	T.R. Van Devender
PVW	P.V. Wells	TXDOT	Tx Highway Dept.
RAH	R.A. Hilsenbeck	UTW	U.T. Waterfall
RB	R. Baker	VB	V. Bailey
RE	R. Eckhardt	VLC	V.L. Cory
RH	R. Halfmann	WBM	W.B. McDougall
RLH	R.L. Hartman	WEH	W.E. Hall
RLU	R.L. Ufkes	WFB	W.F. Barr
RN	R. Nichols	WFM	W.F. Mahler
RRI	R. Rose-Innes	WGD	W.G. Degenhardt
RS	R. Studhalter	WH	W. Hodgson
SJ	S. Jones	WOD	Justice W.O. Douglas
SMU	SMU-DMNH	WRC	W.R. Carr

Dagger Canyon. Unnamed on USGS maps, refers to the tight, steep-walled canyon beginning 2.4 air-miles directly east of the top of Dagger Mountain, with three obvious 90° turns in the canyon.

Dagger Tank. Named on the USGS 7.5 minute topographic map and drawn on many others; large tank just north and west of the mouth of Dagger Canyon.

Devil's Den. Tight, steep-walled canyon 1.2 air-miles south of Dog Canyon, cutting through the hill north of Dagger Mountain.

DH plateau. Flattish plateau, generally above 5000 ft but down to 4500 ft on the eastern side of Brushy Canyon, generally located around Sue Peaks.

Dog Flats. West of Dog Canyon and east of the Persimmon Gap-Panther Junction paved road.

Frog Tank, Frog Canyon. Three miles south and slightly east of BGWMA headquarters, on the east side of Sierra Larga.

Heath Creek. Named on most topographic maps, the main drainage feeding Telephone Canyon, the origin of which is on the east side of Sue Peaks.

High saddle. Between drainages heading north and south, one-half air-mile NW of the northern Sue Peak at 289°. Elevation 5300 ft.

North Dagger Mountain. Northern part of Dagger Mountain, which is split into two parts by a SE-NW drainage on its northwestern side, with a peak at about 2.6 air-miles south of Dog Canyon. Collections from this area include the SE-NW draining valley.

Passionflower Canyon. Southeast end of Alto Relex, 1.4 air-miles east of the Old Ore Road at Ernst Basin roadside campsite turnoff.

Shackelford cabin. Ranch house at the end of the Brushy Canyon road, approximately 16 road-miles from FM 2627. On some specimen labels, referred to as the Nature Conservancy/Brushy Canyon lodge.

Stairstep/Stairway Mountain. Northeastern-most mountain of the study area, just west of TX FM 2627 and the BGWMA headquarters.

Strawhouse Canyon. Southern-most constriction of the drainage that the Strawhouse trail follows, about 1.3 air-miles north of the Boquillas Canyon road.

Sue Peak Canyon. Sinuous canyon that drains the western slopes of Sue Peaks.

TC. Telephone Canyon.

TC dam. Man-made stone-and-concrete dam, trailside, about one mile in from the TC trailhead off the Old Ore Road.

Tunnel. On the road between Panther Junction and Rio Grande Village, about 2.2 miles from RGV.

LYCOPHYTA

SELAGINELLACEAE

Selaginella lepidophylla (Hook. & Grev.) Spring – Resurrection fern
Common perennial, open rocky slopes; DSC, DCA, SYG, 2200-4200 ft; *BA2 5391, JLB 3973, MC 158* (SAT); *BHW 18407, 10760, BHW & MCJ 15988, JF 253, MT 99, 420* (SRSC); *BHW 10760, BHW & RRI 562, DSC & BHW 14980, RRI & BM 1316a* (TEX-LL).

§ *Selaginella pilifera* A. Braun – Resurrection plant
Perennial; Stairway Mountain; *JLB 3980* (SAT). Also occurs in the Chisos and Glass Mountains.

Selaginella wrightii Hieron. – Wright spikemoss
Occasional to common perennial, rock interspaces, shallow soil; DSC, DCA, SYG, 3500–4000 ft; *WFM 43* (BGWMA); *JF 458, 912, BHW 10827 & 18409, BHW & MCJ 15985* (SRSC); *BHW 10827, DSC & BHW 14981* (TEX-LL).

PTEROPHYTA

ASPLENIACEAE

+ *Asplenium resiliens* Kunze – Blackstem spleenwort
Rare perennial, east aspect cliff faces in moister protected soil in cracks or under rock ledges; SYG, CHP, 5680–5840 ft; *JF 1279, 1993* (SRSC). Sue Peaks summit. Turner et al. (2003) indicates a collection was made in the study area but no specimens were discovered.

PTERIDACEAE

Argyrochosma limitanea (Maxon) Windham ssp. *mexicana* (Maxon) Windham – Southwestern false cloakfern
Uncommon perennial herb, cracks in cliff faces or in shallow rocky soil, exposed or protected sites; DCA, SYG, CHP, 2120–5840 ft; *JF 270, 432, 529, 675, 1504, 2023, 2198; AMP & SAP 6142* (SRSC). Sue Peaks and TC trail environs, Alto Relex, north of the Barker House, Boquillas Canyon.

Argyrochosma microphylla (Mett. ex Kuhn) Windham – Small leaf false cloakfern
Occasional perennial, cracks and crevices, shallow soil on open slopes; DSC, SYG, CHP, 2780–5000 ft; *JLB 2957, BA2 5392* (SAT); *JF 183, 484, 527, 768, 1175, 1198, BHW 10822* (SRSC), *BHW 10822, BHW & LCH BG-143* (TEX-LL).

Astrolepis cochisensis (Goodding) Benham & Windham – Cochise scaly cloakfern
Common perennial, shallow to deeper soil, exposed to more sheltered areas; DSC, DCA, SYG, CHP, 1800–5500 ft; *WFM 58, BHW & LCH s.n.* (BGWMA); *PVW s.n.* (KANU); *JF 305, 953, 1232, 1257, 1546, 2098a, JF & MD 462, AMP & SAP 6143a, 6160, MT 54, BHW 10829, BHW & LCH BG-131, BHW & MCJ 16861* (SRSC); *BHW 10829* (TEX-LL).

Astrolepis integerrima (Hook.) Benham & Windham – Hybrid cloakfern
Common perennial, shallow to deeper soil, exposed to more sheltered areas, slightly less common than *A. cochisensis* and in less extreme habitat; DSC, SYG, 1900–4320 ft; *BA2 5393, 5578, 5579, JLB 938, 2599, HC 1, 32, 34* (SAT); *JF 206a, 433, 487, 680, 952, 1054, 1138, 1489, 1496, 1547, 2043, AMP & SAP 6143b, 6161, TR 88, 464, MT 55, BHW & MCJ 16068;* (SRSC); *DSC & BHW 14982a* (TEX-LL).

Astrolepis sinuata (Lag. ex Sw.) Benham & Windham – Wavy scaly cloakfern
Uncommon perennial, sheltered moister habitats; DAR, DCA, 3050–3560 ft; *WFM s.n.* (BGWMA); *JLB 939, SJ 6510* (SAT); *JF 535, 1125, 1156* (SRSC); *DSC & BHW 14982* (TEX-LL). Dagger Flat, TC trail, Ernst Tinaja, Brushy Canyon, Frog Canyon.

+ *Astrolepis windhamii* Benham – Windham cloakfern
Uncommon perennial, bottom of scree slope, crevices, steep slopes with shallow soil, varied exposures; DSC, SYG, 2200–4700 ft; *JF 1697, 1705, 1892, 2202* (SRSC). Dagger Mountain, western slopes of DH below Sue Peaks, Strawhouse Canyon.

Cheilanthes alabamensis (Buckl.) Kunze – Alabama lipfern
Rare perennial, rocky slopes below ridges, shaded limestone crevices in canyons; DCA, SYG, 4650 ft; *JF 2199, MT 229* (SRSC); *MT 229* (TEX-LL). Sue Peaks Canyon, north rim of DH plateau/Brushy Canyon.

§ *Cheilanthes bonariensis* (Willd.) Proctor – Golden lipfern
Perennial; 4650 ft; *BA2 5394* (SAT). Near Shackelford cabin in Brushy Canyon.

Cheilanthes eatonii Baker – Eaton lipfern
Occasional perennial, unprotected sites to areas with more soil and shade; DSC, SYG, 3700–4960 ft; *JF 767, 1201, 1501, MT 116, BHW 20629* (SRSC).

Cheilanthes feei T. Moore – Slender lipfern
Occasional perennial, crevices in protected or north-facing cliffs; DCA, SYG, 3050–4900 ft; *JF 533, 758, 1127, 1200, 1500, 1708, 1919, BHW 10765, 20605* (SRSC); *BHW 10765* (TEX-LL).

Cheilanthes horridula Maxon – Rough lipfern
Occasional perennial, crevices in rocks and ledges, more protected sites; DAR, DCA, RIO, 1850–3050 ft; *CMR 2602* (BGWMA); *BA2 5498, 5580, HC 36, 40* (SAT); *JF 670, 1059, 1141, 1611, 2046, TR 465, BHW 18412, 20607* (SRSC); *DSC & BHW 14977* (TEX-LL).

Cheilanthes villosa Davenp. ex Maxon – Villous lipfern
Uncommon perennial, crevices and base of cliffs; DCA, 3560–3800 ft; *JLB 2596, 3801* (SAT); *JF 533a, BHW 10757* (SRSC); *BHW 10757, DSC & BHW 14983* (TEX-LL). TC trail mile 3.5 area, head of Heath Canyon and Boquillas Canyons, Frog Canyon.

§ *Notholaena aschenborniana* Klotzsch – Scaled cloakfern
Rare perennial; *JLB 2597, 2956* (SAT). Frog Canyon, Stairway Mountain.

§ *Notholaena greggii* (Mett. ex Kuhn) Maxon – Gregg cloak fern
Uncommon perennial, boulders, bluffs, and ledges; DCA, 1800–4300 ft; *CMR 2600* (BGWMA); *JLB 2600* (SAT); *BHW 10841, BHW 20897, BHW & LCH 16061, BHW & MCJ 16859* (SRSC); *DSC & BHW 14978, DS 1096* (TEX-LL). Head of Brushy and Boquillas canyons, Frog Canyon.

Notholaena nealleyi Seaton ex J.M. Coult. – Nealley cloak fern
Rare perennial, base of cliffs; DSC, DCA, 3650 ft; *JLB 3806* (SAT); *JF 479* (SRSC). TC trail area, Frog Canyon.

Notholaena neglecta Maxon – Maxon cloak fern
Rare perennial, base of ledges, underneath rocks in canyon bed; DCA, 1850–3560 ft; *JF 603, 1088* (SRSC); *DSC 14984, DSC & BHW 14979* (TEX-LL). TC trail area, Boquillas Canyon.

Notholaena standleyi Maxon – Star cloak fern
Occasional perennial, base of boulders, cracks in canyon walls; DSC, DAR, DCA, SYG, 2880–4360 ft; *JLB 2595, KJC 176, HC 35, ECM 251* (SAT); *JF 604, 867, 1126, 1007a, BHW 9157, BHW & LCH 15987* (SRSC); *DSC & BHW 14985, BHW 9157* (TEX-LL).

Pellaea atropurpurea (L.) Link – Purple cliffbrake
Rare perennial, protected areas, in thick duff underneath plants or in crack of cliff wall; SYG, CHP, 3500–5680 ft; *JF 1285, 1299a, 2200, BHW & LCH BG-144* (SRSC). Sue Peaks area, DH plateau, upper Brushy Canyon.

Pellaea intermedia Mett. ex Kuhn – Intermediate cliffbrake
Rare perennial, protected areas, in thick duff underneath plants or in crack of cliff wall; SYG, CHP; 2560–4900 ft; *JF 1199, 2201, MT 119* (SRSC). *BHW 559* (TEX-LL). Dog Canyon, DH plateau, near Shackelford cabin.

CONIFEROPHYTA

CUPRESSACEAE

Juniperus coahuilensis (Martínez) Gaussen – Rose-fruited juniper
[*Juniperus erythrocarpa* Cory] Rare shrub-tree, mesa tops and high elevation hillsides; CHP; 4600–5470 ft; *JF 1240* (BIBE); *JF 1037, 1219, 1240, MT 237* (SRSC); *BA2 5370* (SAT). Brushy Canyon, DH plateau.

Juniperus pinchotii Sudw. – Red-berry Juniper
Uncommon shrub-tree, mesa tops, sporadic at higher elevations, one individual at lower elevation in large canyon east of Dagger Mountain; DCA, SYG, CHP; 3050–5680

ft; *PVW s.n.* (KANU); *JF 499, 1048, 1136, 1298, 1913, AMP & SAP 5135, BHW & LCH BG-157* (SRSC). Dagger Mountain, Dagger Canyon, upper TC trail, Sue Peaks environs, Brushy Canyon.

PINACEAE

§ *Pinus cembroides* Zucc. – Mexican pinyon

Rare tree, rocky limestone soil; SYG, ca. 4200–5300 ft; *WFM 54* (BGWMA); *BA2 5229* (SAT); *BHW 313* (SRSC). Brushy Canyon, northern DH plateau. Listed by Amos and Giles (1992).

Pinus remota (Little) D.K. Bailey & Hawksw. – Papershell pinyon

Rare tree, eastern slopes of central DH plateau; SYG, 5200 ft; *JF 1249, 1310, MT 88, 258, AMP 5492* (SRSC).

GNETOPHYTA

EPHEDRACEAE

§ *Ephedra antisyphilitica* Berland. ex C.A. Mey. – Clapweed

Uncommon to "frequent" shrub, northwest slopes; DSC, 3520 ft; *CMR 17227* (BIBE); *BHW 490* (SRSC & TEX-LL). Dagger Flat and northwest slopes of the DH.

Ephedra aspera Engelm. ex S. Watson – Rough jointfir

[*Ephedra nevadensis* var. *aspera* (Engelm. ex S. Watson) L.D. Benson] Common shrub, ridges, washes, open slopes, cracks in bedrock; DSC, DAR, DCA, SYG, CHP, 1900–5250 ft; *OES 1366* (BIBE); *BA2 5710, ECM 72, CMR 17227* (SAT); *JF 349, 455, 474, 563, 578, 723, 745a, 806, 1003, 1237, 1438, 1485, 1665, 2052, JF & MD 583, OES 1365, 1743, BHW 1742* (SRSC).

Ephedra trifurca Torr. ex S. Watson – Longleaf jointfir

Common shrub, sand, limestone soil, alluvium; DSC, DCA, 1800–3500 ft; *EGM 143, ACK 830* (BIBE); *HCC 1856* (NYBG); *CMR 14224, 17226* (SAT); *JF 1388, BHW 47059* (SRSC); *BHW & RRI 557a, 57b, 47059* (TEX-LL).

ANTHOPHYTA – Monocotyledones

AGAVACEAE

Agave lechuguilla Torr. – Lechuguilla

Abundant shrub/semi-succulent, ubiquitous; DSC, DCA, SYG, 1800–5840 ft; *BA2 5264, DB s.n.* (SAT); *JF 257, TR 78* (SRSC); *MSY s.n.* (TEX-LL).

#Δ *Agave havardiana* Trel. – Havard century plant

Rare shrub/semi-succulent, shallow soil, west aspect; SYG, 5840 ft; Observed at south end of southern Sue Peak. Several (ca. five) small individuals were observed, clustered in one spot, rosettes had few leaves.

AMARYLLIDACEAE

Cooperia drummondii Herbert – Evening rainlily

Uncommon perennial herb, gravelly soil, open areas; DSC, SYG, CHP 3150–5840 ft; *BA2 5686* (SAT); *JF 1102, 1984* (SRSC). Dagger Flat, Sue Peaks, Brushy Canyon.

Zephyranthes longifolia Hemsl. – Copper zephyrlily

Rare perennial herb, open areas, gravelly soil; DSC, SYG, 3500–4840 ft; *JF 584, BHW 1080-178* (SRSC). Upper TC trail, near McKinney Springs, Stairway Mountain.

BROMELIACEAE

Hechtia texensis S. Watson – Texas false agave

[*Hechtia scariosa* L.B. Sm.] Occasional shrub/semi-succulent, rocky areas, usually on slight slopes with very sharp, eroded bedrock outcrops and boulders; DSC, 1800–4300 ft; *DG 219* (BIBE); *BA2 5253, 5273, DG 219, MC s.n.* (SAT); *JF 328, 1002, 1004, OES 1323, BHW 13036, 14047, 20625, 21206* (SRSC); *AT 2242* (TEX-LL).

COMMELINACEAE

Commelina erecta L. – Whitemouth dayflower

Rare perennial herb, deeper soil with shade; DAR, DSC; 2300-2400 ft; *BRM 3032* (BGWMA); *JF 1445, OCW 507* (SRSC). Found within a thicket of vegetation in a low spot of a slight drainage flowing across Ernst Basin; also in Brushy Canyon.

§ *Tradescantia wrightii* Rose & Bush var. *glandulopubescens* B.L. Turner – Wright spiderwort

Rare perennial herb; 3800 ft; *BHW 10775* (SRSC & TEX-LL). Specimens collected at head of Heath Canyon in the DH. The SRSC specimen is labelled as *T. wrightii*, the only locality recorded in Turner et al. (2003) for this variety. Label data notes that the species is, "abundant and widespread on top of mountains".

CYPERACEAE

Carex muriculata F.J. Herm. – Schiede sedge

[*Carex schiedeana* Kunze] Uncommon perennial, dry western slopes, rocky shallow soil; SYG, 3000–5250 ft; *BHW & LCH BG-136* (BGWMA); *JF 2193* (BIBE); *BA2 5219, 5305* (SAT); *JF 772, 1193, 1236, 2193, MT 69, BHW 10821, 10847, BHW & LCH BG-136* (SRSC); *JF 1236, BHW 10821* (TEX-LL).

§ *Cladium mariscus* (L.) Pohl ssp. *jamaicense* (Crantz) Kükenth. – Jamaica swamp sawgrass

Uncommon perennial, silty soil; ca. 1800 ft; *BHW 13068* (SRSC). Collected in 1955 at Graham farm in the RGV area.

+ *Cyperus elegans* L. – Royal flatsedge

Rare perennial, sandy outwash deposit; DAR, 2400 ft; *JF 1449* (SRSC). Just below Ernst Tinaja. Turner et al. (2003) shows dots in the study area but no specimens were discovered.

§ *Cyperus laevigatus* L. – Smooth flatsedge
"Rare" perennial; DCA, 1800 ft; *BHW 772* (SRSC). Collected in 1937 at the entrance to Boquillas Canyon.

§ *Cyperus odoratus* L. – Fragrant flatsedge
"Infrequent" annual or perennial; RIO, 1800 ft; *CAB 31* (BIBE); *JS s.n., EGM 162m, BHW 13046, 21441* (SRSC); *BHW 327* (TEX-LL). At the beaver marsh and along the Rio Grande at Boquillas in 1955.

§ *Cyperus squarrosus* L. – Bearded flatsedge
"Rare to infrequent" annual; RIO, 1800 ft; *BHW 774* (SRSC & TEX-LL). Collected in 1937 at the entrance of Boquillas Canyon.

§ *Eleocharis geniculata* (L.) Roemer & J.A. Schultes – Canada spikesedge
[*Eleocharis caribaea* (Rottb.) S.F. Blake] "Infrequent" annual; RIO, 1800 ft; *BHW 13047* (BIBE & SRSC); *BHW 772b* (TEX-LL). Last collected in 1955.

§ *Eleocharis montevidensis* Kunth – Sand spikerush
"Frequent" annual; RIO, 1800 ft; *HTF 288* (SRSC). Collected in 1932 along the Rio Grande at Boquillas.

§ *Eleocharis palustris* (L.) Roemer & J.A. Schultes – Common spikerush
[*Eleocharis macrostachya* Britton] "Frequent" perennial, mud tank; ca. 3000 ft; *BHW & MCJ 16673* (SRSC). Collected in 1958 near Alto Relex.

§ *Fuirena simplex* Vahl var. *aristulata* (Torr.) Kral – Western umbrella-sedge
Uncommon perennial; RIO, 1800 ft; *BA2 4605* (SAT); *BHW 21444* (SRSC & TEX-LL). Along the Rio Grande at Boquillas, last collected in 1988.

§ *Schoenoplectus pungens* (Vahl) Palla – Common threesquare
[*Scirpus americanus* Pers. var. *longispicatus* Britton] Perennial; *OES 1350* (SRSC). Banks of the Rio Grande at Ogle Spring, RGV area, in 1938.

JUNCACEAE

§ *Juncus acuminatus* Michx. – Tapertip rush
Perennial; 1800 ft; *CMR 17236* (SAT). Collected in 1988 at Rio Grande Village.

§ *Juncus bufonius* L. – Toad rush
Rare annual; RIO, 1800 ft; *BHW C298* (SRSC & TEX-LL). Collected in 1938 along the Rio Grande at Boquillas.

LILIACEAE

Allium kunthii G. Don – Kunth onion

Rare perennial herb, open rocky slopes with sparse other vegetation; SYG, 4700–5500 ft; *JF 1514, 1983* (SRSC). Perhaps found other than on slopes surrounding Sue Peaks but were discovered only after significant rains and so may not be an apparent member of the plant community elsewhere.

Dasylirion leiophyllum Engelm. ex Trel. – Sotol

Common shrub/semi-succulent, ubiquitous above 3000 ft; DSC, DAR, DCA, SYG, CHP, ca. 3000–5840 ft *WFM s.n., TR s.n.* (BGWMA); *OES 1321* (BIBE); *JF 860, OES s.n.* (SRSC).

Nolina erumpens (Torr.) S. Watson – Foothill beargrass

Shrub/semi-succulent, common element of SYG and CHP of higher elevations; 4320 ft; *BA2 5704* (SAT); *JF 128, 821, AMP & SAP 5127, TR 130, MT 188, 190* (SRSC); *BHW & LCH BG-167* (SRSC & TEX-LL).

§ *Nolina texana* S. Watson – Texas sacahuista

Rare shrub/semi-succulent; 3500 ft; *BHW & LCH s.n.* (BGWMA). One collection from 1950 at Big Brushy Canyon. Listed by Amos and Giles (1992).

Nothoscordum bivalve (L.) Britt. – Crowpoison

Rare perennial herb; SYG; *BHW 10773* (SRSC). Collected in 1952 at the head of Heath Canyon. May have been seen during present study also, on ridge above mile 5.5 of Telephone Canyon trail, but not enough material was present to make a confident identification.

§ *Yucca elata* Engelm. – Soaptree yucca

Shrub/semi-succulent, more common at lower to mid-elevations; DSC, DCA, 3520 ft; *BA2 & DG 4861, BHW 877* (BIBE); *BA2 4861* (SAT); *BHW 877* (SRSC); *BHW 877, s.n., MSY s.n.* (TEX-LL).

§ *Yucca faxoniana* Sarg. – Giant dagger yucca

Occasional shrub/semi-succulent, open rocky soil; DSC, SYG, CHP, 3500–5840 ft *OES 1322* (BIBE); *BRM s.n.* (BGWMA); *SMU 162* (SAT); *WH, TA, LS, & JP 9024, OWS 1322, MT 124* (SRSC); *RN E-4-6-92, 5-8-92, BHW Lot 45* (SRSC & TEX-LL).

Yucca rostrata Engelm. ex Trel. – Beaked yucca

Occasional shrub/semi-succulent, open scrub; DSC, 2150-3400 ft; *PVW s.n.* (KANU); *WH, TA, LS & JP 9025, JF 849, TR 129, MT 50, BHW & LCH BG-62* (SRSC); *RN E-5-08-92, 4-6-1992* (TEX-LL). In the past, this species has been placed in synonomy with *Yucca thompsoniana* (Powell 1998) however currently they are considered separate species (Powell in prep, FNA 2002); *Yucca rostrata* is more of a south Brewster County, or lower elevation, species that is generally taller with longer leaves than *Yucca thompsoniana*.

§ *Yucca thompsoniana* Trel. – Thompson yucca
Occasional shrub/semi-succulent; *MSY s.n.* (TEX-LL). Collected in 1915 near McKinney Springs. Also known from the Persimmon Gap area.

Yucca torreyi Shafer – Torrey yucca
Occasional shrub/semi-succulent, gravelly soil; DSC, DAR, DCA, SYG, 2100–3500 ft; *SMU 164* (SAT); *WH, TA, LS & JP 9026*, *JF 683, 1723* (SRSC); *BHW 9940* (TEX-LL).

ORCHIDACEAE

Dichromanthus cinnabarinus (Llave & Lex.) Garay – Scarlet ladies' tresses
Rare perennial herb, open west slope, in small pocket of shallow soil mostly surrounded by slick bedrock outcrops; SYG, 5500 ft; *JF 1958* (SRSC). Southern Sue Peaks. Few individuals were seen; found after good rains had passed through the area, causing many novel species to emerge including *Allium kunthii*. Also known locally from the Chisos and Glass mountains.

POACEAE

Achnatherum curvifolium (Swallen) Barkworth – Guadalupe ricegrass
[*Stipa curvifolia* Swallen] Rare perennial herb, just off open summit of Stuarts Peak in more vegetated area with sheltered grasses and rock outcrops, northeast aspect, deeper soil; SYG, 5000 ft; *JF 735a* (SRSC). New Brewster County record. This species was previously known only from a restricted area in the Guadalupe Mountains in Culberson County.

Achnatherum eminens (Cav.) Barkworth – Southwestern needlegrass
[*Stipa eminens* Cav.] Rare perennial herb, wash gravel, shallow rocky soil; DSC, SYG, 3400–5300 ft; *JF 366, 1990; BHW 10768* (SRSC); *BHW 10768* (TEX-LL). *JF 366* was collected from a very robust plant growing trailside just downstream of the dam along the Telephone Canyon trail in 2004. However, on successive visits the plant had disappeared, perhaps having been removed during trail maintenance activities.

Achnatherum lobatum (Swallen) Barkworth – Littleawn needlegrass
[*Stipa lobata* Swallen] Uncommon perennial herb, loose rocky soil; DSC, SYG, 3800–5000 ft; *JF 760, MT 146, BHW 10771* (SRSC); *BHW 10771* (TEX-LL). At Heath Canyon and Stuarts Peak.

§ *Andropogon glomeratus* (Walt.) B.S.P. – Bushy bluestem
Perennial herb, marsh; RIO, 1800 ft; *CAB 30* (BIBE). Collected in 1973 at the beaver marsh at RGV.

+ *Aristida adscensionis* L. – Six-weeks Threeawn
Rare annual herb, deeper soil in saddle and high peaks to compacted soil in trail; SYG, 5300–5840 ft; *JF 1304, 1918, 1987* (SRSC). Sue Peaks and TC trail. Turner et al. (2003) shows dots in the study area but no specimens were discovered.

Aristida purpurea Nutt. var. *purpurea* – Purple threeawn
[*Aristida roemeriana* Scheele] Occasional perennial herb, open desert, slopes, washes; DSC, DAR, DCA, 1800–3400 ft; *JF 173, 325, 344, 1327, 1382, 2079; MT 71* (SRSC).

Aristida purpurea Nutt. var. *nealleyi* (Vasey) Allred – Blue threeawn
[*Aristida glauca* (Nees) Walp.] Common perennial herb, slopes, washes, ridges, all aspects; DSC, DAR, DCA, SYG, 2250–4800 ft; *JF 486, 811, 935, 1178, 1192, 1536, 1537, CMR 5069, MT 70, 160, BHW 10758, 10811, 10816, 10835, BHW & LCH BG-159, 191, 193* (SRSC); *GJG & UTW 4628, BHW 10758, 10811, 10816, 10835, 13028* (TEX-LL).

§ *Aristida purpurea* Nutt. var. *wrightii* (Nash) Allred – Wright threeawn
Perennial herb; 3500 ft; *BHW & LCH BG-159*. Upper Brushy Canyon.

§ *Aristida ternipes* Cav. – Spidergrass
"Frequent" perennial herb; 1800 ft; *BHW 20944, 20946; BHW & LCH BG-186* (SRSC). Collected in 1950 at Stairway Mountain and in 1966 at Boquillas.

!!+ *Arundo donax* L. – Giant reed
Abundant perennial herb, banks of Rio Grande and extending into appropriate habitat within the mouths of side drainages; RIO, DCA, 1800 ft; *JF 2039* (SRSC).

+ *Blepharidachne bigelovii* (S. Wats.) Hack. – Bigelow desertgrass
Rare perennial herb, open desert; DSC, 3440 ft; *JF 355* (SRSC). TC trail. Turner et al. (2003) shows a dot in the study area but no specimen was discovered.

Bothriochloa barbinodis (Lag.) Herter – Cane bluestem
Uncommon perennial herb, in areas that retain more moisture; DAR, SYG, RIO, 1800–4400 ft; *BHW 779* (BIBE); *JF 1534* (SRSC). Upper TC trail and Boquillas Canyon.

Bothriochloa laguroides (DC.) Herter ssp. *torreyana* (Steud.) Allred & Gould – Silver beardgrass
Occasional perennial herb, washes, rocky crevices; DAR, DCA, 2350–4360 ft; *CMR 5096* (BGWMA); *JF 358, 531, 937, 1113, 1371, 1377, 1531, MT 198, 224, BHW s.n., BHW & BLT 8320* (SRSC); *BHW 21514, BHW & BLT 8320* (TEX-LL).

§ *Bouteloua aristidoides* (Kunth) Griseb. – Needle grama
"Frequent" annual herb, sandy soil; DSC, RIO, 1800 ft; *BA2, DG, TE, & PC 4597a, BHW 13034* (BIBE); *BHW 12894, 13034* (SRSC). All collections from the head of Boquillas Canyon, last collected in 1988.

Bouteloua barbata Lag. – Sixweeks grama
Rare annual herb, sandy soil; RIO, DCA, 1800 ft; *BA2, DG, TE, & PC 4597b* (BIBE); *JF 2096* (SRSC). At the head of Boquillas Canyon and inside the mouth of Arroyo Venado within Boquillas Canyon.

Bouteloua curtipendula (Michx.) Torr. – Sideoats grama
Common perennial herb, washes, slopes, less common at lowest elevations; DSC, DAR, DCA, SYG, CHP, 1800–5250 ft; *JF 254, 1107, 1176, 1238, 1393, 1512, 1524, 2139, 2166, MT 38, 162, BHW 10780, BHW & LCH BG-190, BHW & BLT 8329* (SRSC); *BHW 10780* (TEX-LL).

+ *Bouteloua eriopoda* (Torr.) Torr. – Black grama
Rare perennial herb, sides of lightly sloped high-elevation drainage; SYG, 4400 ft; *JF 1533* (SRSC). Upper TC trail area. Black grama does not seem to be an important component of DH grassland areas. Other parts of the DH plateau, or perhaps Margaret Basin may yield more populations.

+ *Bouteloua hirsuta* Lag. – Hairy grama
Occasional perennial herb, rocky soil; SYG, CHP, 3300–5500 ft; *JF 1221* (BIBE); *JF 1027, 1032, 1221, 1248, 1256, 1319, 1523, MT 46, 80, 131, 175* (SRSC). Replaces *Bouteloua ramosa* to be the common higher elevation grama grass, in addition to *Bouteloua curtipendula*.

Bouteloua kayi Warnock – Kay grama
Uncommon (G1S1) perennial herb, holes or crevices in bedrock or boulders; DSC, SYG, CHP, 3500–5800 ft; *JF 2186* (BIBE, SRSC, & TEX-LL); *JF 296, 1169, MT 134, 182, 191, OCW 318, BHW 20621* (SRSC). This species is rare at lower elevations, but becomes one of the common species at higher elevations near Sue Peaks, in areas of slick bedrock exposures, commonly growing out of holes eroded out of the bedrock. Also collected on Stairstep Mountain and in Brushy Canyon.

Bouteloua ramosa Scribn. ex Vasey – Chino grama
Abundant perennial herb, ubiquitous below 5000 ft; DSC, DAR, DCA, SYG, CHP, 1800–4400 ft; *CMR 5075* (BGWMA); *JF 191, 338, 443, 930, 1160a, 1331, 1452, 1544, 1545, 2009, 2152, BHW 10853* (SRSC).

Bouteloua trifida Thurb. – Red grama
Occasional to "frequent" perennial herb, open desert, slopes, drainages; DSC, DAR, DCA, 1800–3360 ft; *JF 341, 1398, 1406, 1474, 1476, 1543, 2144, BHW 12341, 21190, BHW & LCH BG-183* (SRSC); *TRV, GLB & WEH 85-38* (TEX-LL).

Cathestecum erectum Vasey & Hack. – False grama
Occasional perennial herb, open desert, alluvial hills; DSC, 1800–2450 ft; *JF 1340, MT 121, 141, BHW 10813, 12900, BHW & MCJ 16842* (SRSC); *BHW 110813, 12900* (TEX-LL).

§ *Cenchrus spinifex* Cav. – Coastal sandbur
[*Cenchrus incertus* M.A. Curtis] Locally frequent annual or perennial herb, sandy soil; RIO, DCA, 1800–2400 ft; *BA2, DG, TE, & PC 4601* (BIBE); *AMP & SAP 5862, BHW 23037, BHW & MCJ 16844, BHW & BLT 8322* (SRSC); *BHW 16844* (TEX-LL). Boquillas Canyon.

Chloris virgata Sw. – Feather fingergrass
Rare annual herb, close to water sources; DSC, RIO, 1800–3440 ft; *JF 364* (SRSC); *EGM 51-1129* (TEX-LL). TC trail dam and Boquillas area.

! *Cynodon dactylon* (L.) Pers. – Bermudagrass
Locally abundant perennial herb, sandy soil; DCA, RIO, 1800–2350 ft; *BA2, DG, TE, & PC 4610* (BIBE); *JF 1336* (SRSC); *EGM 141, 51-1115* (TEX-LL). Abundant along the river corridor, the only other place this was encountered was in a sand bank in the canyon above Ernst Tinaja.

Dasyochloa pulchella (Kunth) Willd. ex Rydb. – Fluffgrass
[*Erioneuron pulchellum* (Kunth) Tateoka, *Tridens pulchellus* (Kunth) Hitchc.]
Occasional perennial herb, open desert, slopes, rocky to sandy soil; DSC, DCA, 1900–2760 ft; *BA2, DG, TE, & PC 4595* (BIBE); *JF 194, 678, 1338, 2025, 2049, BHW & LCH BG-198* (SRSC).

Digitaria californica (Benth.) Henr. – Arizona cottontop
Uncommon perennial herb, slightly more mesic sites, water catchments; DSC, DAR, DCA, SYG, CHP, 3000–4000 ft; *CMR 5095* (BGWMA); *JF 335, 839, BHW 10801* (SRSC); *BHW 10801* (TEX-LL). TC trail, near Sue Peaks, Frog Canyon. Observed in Ernst Basin.

§ *Digitaria ciliaris* (Retz.) Koel. – Southern crabgrass
Rare annual herb; 1800 ft; *BHW 775* (BIBE, SRSC, TEX-LL). Along the Rio Grande at Boquillas in 1937.

+ *Digitaria pubiflora* (Vasey) J. Wipff – Carolina crabgrass
[*Digitaria cognata* (J.A. Schultes) Pilger var. *pubiflora* Vasey ex L.H. Dewey] Rare perennial herb, rock crevice of cliff wall; DCA, 1800 ft; *JF 2121* (SRSC). Inside the mouth of Cow Canyon from Boquillas Canyon. Turner et al. (2003) shows dots in the study area but no specimens were discovered. Also known locally from Maravillas Creek and the Chisos Mountains.

***** *Echinochloa colona* (L.) Link – Junglerice
Uncommon annual herb, sandy soil associated with more permanent water; DAR, RIO, 1800–3440 ft; *DG & TE 4611* (BIBE); *JF 1330, EGM 139, BHW 793* (SRSC); *EGM 51-1113, BHW 793* (TEX-LL). Locally common along the river.

§ *Echinochloa muricata* (Beauv.) Fern. – Rough barnyardgrass
"Rare" annual herb; RIO, 1800 ft; *BHW s.n.* (SRSC)*, BHW C299* (TEX-LL). Collected in 1938 along the Rio Grande at Boquillas. Also known from Dog Flats.

Enneapogon desvauxii Desv. ex Beauv. – Nineawn pappusgrass
Occasional perennial herb, slopes, plateaus, washes; DAR, DCA, SYG, 1800–5000 ft; *JF 193, 231a, 347, 1510, 1551, 2097, BHW 10770, 12897, BHW & MCJ 16865* (SRSC); *BHW 10770* (TEX-LL).

Eragrostis intermedia A.S. Hitchc. – Plains lovegrass
Rare perennial herb, western slopes; DSC, DCA, 2500–3800 ft; *JF 1894, BHW & MCJ 15984* (SRSC). Canyons in the Dagger Mountain area.

! *Eragrostis lehmanniana* Nees – Lehmann lovegrass
Uncommon perennial herb, sandy soil in washes; DAR, 2900–3440 ft; *CMR 16950* (BGWMA); *JF 211, 313, 1106, MT 202, BLT 22-143* (SRSC). Collected in the Dagger Mountain/Dagger Flat area, at the TC dam, and at Frog Canyon.

§ *Eragrostis pectinacea* (Michx.) Nees ex Steud. – Tufted lovegrass
"Infrequent" annual herb, in rocks by mortar holes; RIO, 1800 ft; *BHW 785* (BIBE); *BHW C595* (TEX-LL). At the entrance to Boquillas Canyon in 1937.

Erioneuron avenaceum (Kunth) Tateoka – Shortleaf woolygrass
Uncommon perennial herb, wash bottoms, open desert; DSC, SYG, 3560–4400 ft; *JF 515, 1532* (SRSC); *BHW 10781* (TEX-LL). This species was only seen twice during the current study (along the TC trail), though Warnock reported it as a frequent perennial near the top of the DH close to Sue Peaks on his 1952 specimen label.

Erioneuron pilosum (Buckl.) Nash – Hairy woolygrass
Common perennial herb, washes, slopes, plateaus, ridges; DSC, DAR, DCA, SYG, CHP, 2150–5800 ft; *CMR 5089* (BGWMA); *JF 756, 850, 1031, 1057, 1179, 1225, 1251, 1271, 1992, 2160, JF & HL 1905, MT 44, 73, 174, 197, BHW 10781, BHW & LCH BG-75* (SRSC); *BHW 10789* (TEX-LL).

*Hesperostipa neomexicana* (Thurb. ex Coult.) Barkworth – New mexico feathergrass
[*Stipa neomexicana* (Thurb. ex Coult.) Scribn.] Rare perennial herb, deeper soil, with other rare grasses and rock outcrops; SYG, 5000 ft; *JF 735* (SRSC). Just north of Stuarts Peak. Also known locally from the Glass and Chisos Mountains.

Heteropogon contortus (L.) Beauv. ex Roemer & J.A. Schultes – Tanglehead
Occasional perennial herb, usually in gravelly or sandy washes; DAR, DCA, DSC, 1800–4400 ft; *JF 345, 574, 1396, 1473, 1596, 2138, MT 176, BHW 13074, 20947, BHW & LCH BG-189* (SRSC).

***** *Leptochloa dubia* (Kunth) Nees – Green sprangletop
Uncommon throughout, perennial herb, open areas at higher elevations; DAR, SYG, 3750–5800 ft; *OCW 319* (BGWMA); *JF 233, 299, 1046, 1055, 1268, 1516, 1528, MT 231, OCW 319* (SRSC). No other sources consulted (Correll and Johnston 1970, Gould 1975, Powell 2000, Turner et al. 2003) note this species as being non-native other than the PLANTS database (USDA 2007).

§ *Leptochloa fusca* (L.) Kunth ssp. *uninervia* (J. Presl) N. Snow – Mexican sprangletop
[*Leptochloa uninervia* (J. Presl) A.S. Hitchc. & Chase] "Infrequent to frequent" annual or perennial herb; RIO, 1800 ft; *HTF 289, BHW 13041* (SRSC); *EGM 140, 51-1114* (TEX-LL). All collections were made previous to 1956 along the Rio Grande at Boquillas.

Leptochloa panicea (Retz.) Ohwi ssp. *mucronata* (Michx.) Nowack – Mucronate sprangletop
[*Leptochloa mucronata* (Michx.) Kunth] Rare annual or perennial herb, silty clay soil; DSC, 2400 ft; *JF 1428* (SRSC). Western Ernst Basin, in patch of tobosa grassland. Well-represented regionally Turner et al. (2003).

Lycurus phleoides Kunth – Wolfstail
Uncommon perennial herb, plateaus and slopes at higher elevations; SYG, CHP, 3800–5000 ft; *JF 1034, MT 39, BHW 10769* (SRSC); *BHW 10769* (TEX-LL).

+ *Lycurus setosus* (Nutt.) C.G. Reeder – Bristly wolfstail
Rare perennial herb, in open pockets within shrub forest; SYG, CHP, 5150 ft; *JF 1230* (SRSC). DH plateau. Turner et al. (2003) shows a dot but no specimen was discovered.

+ *Melica montezumae* Piper – Montezuma melicgrass
Rare perennial herb, north aspect, crack in cliff face, with *Phildadelphus microphyllus*; DSC/DCA, 4040 ft; *JF 721* (SRSC). Steep drainage on the western slopes of Stuarts Peak. Listed by Amos and Giles (1992).

Muhlenbergia arenicola Buckl. – Sand muhly
Rare perennial herb, finer, deeper soil that supported *Pleuraphis mutica*, *Sporobolus* spp., and other grasses; SYG, 5300 ft; *JF 1253* (BIBE); *JF 1253, 1991* (SRSC). High saddle below Sue Peaks. Species that were abundant in surrounding area, including lechuguilla, sotol, nolina, and grama grasses, were absent from this saddle area in favor of various grass species. Some old wood and wire were present, as well as prehistoric rock flakes and a few partial tools and/or arrowheads. Locally known from the NW two-thirds of Brewster County.

Muhlenbergia dubia Fourn. ex Hemsl. – Pine muhly
Occasional perennial herb, wash gravel, talus slopes, shallow to deeper soil; DAR, SYG, 3500–5500 ft; *JF 734, 762, 1217, 1261, 2180* (SRSC). Possibly the dominant grass above 5000 ft. This species concept includes *Muhlenbergia metcalfei*. *Muhlenbergia* replaces *Bouteloua* to be the most abundant high-elevation grass genus at the highest elevations of the DH.

Muhlenbergia spiciformis Trin. – Longawn muhly
[*Muhlenbergia parviglumis* Vasey] Occasional perennial herb, ridges, plateaus, in open pockets of chaparral; SYG, CHP, 4280–5840 ft; the common high-elevation grass on the west side of Sue Peaks; *JF 1053, 1216, 1243, 1262, 1303, 1513, 1525* (SRSC).

Muhlenbergia porteri Scribn. ex Beal – Bush muhly
Uncommon perennial herb, sandy to loamy soils, wash bottoms; DSC, DAR, 2900 ft; *CMR 16956* (BGWMA); *JF 207* (SRSC). North Dagger Mountain and Brushy Canyon.

+ *Muhlenbergia rigens* (Benth.) A.S. Hitchc. – Deergrass
Rare perennial herb, in wash gravel; DAR/SYG, 4320 ft; *JF 1527* (SRSC). Around mile five of the Telephone Canyon trail, in the shade of *Vauquelinia corymbosa* and *Fraxinus greggii*.

§ *Muhlenbergia setifolia* Vasey – Curlyleaf muhly
Perennial herb; DCA; *OCW 316* (BGWMA & SRSC). Collected in Big Brushy Canyon in 1958; label data states that the species was common above 3000 ft. Also listed by Amos and Giles (1992).

Muhlenbergia tenuifolia (Kunth) Trin. – Slender muhly
[*Muhlenbergia monticola* Buckl.] Locally common annual or perennial herb, drainages, slopes, ridges, and plateaus of higher elevations; DCA, SYG, CHP, 5000 ft; *OCW 315b* (BGWMA & SRSC); *JF 845, 1191, 1489a, 1515, 1526, 1930, BHW 10750* (SRSC). Upper TC trail, Sue Peaks environs, Brushy Canyon.

Panicum hallii Vasey – Hall panicgrass
Common perennial herb, washes, slopes, areas with slightly higher water availability; DSC, DAR, DCA, SYG, CHP, 2400–5150 ft; *CMR 5091* (BGWMA); *BHW 12893* (BIBE); *JF 195, 575, 1221a, 1229, 1395, 1456, 1519, 1921, MT 81, 211, BHW & LCH BG-192* (SRSC).

§ *Panicum hirticaule* J. Presl – Mexican panicgrass
Uncommon annual herb; DSC, 1800–3800 ft; *BHW 12896* (BIBE); *BHW 10795* (SRSC & TEX-LL). At head of Boquillas Canyon and near McKinney Springs.

Panicum obtusum Kunth – Vine mesquite
Rare perennial herb, finer, deeper soil supporting *Pleuraphis mutica*, *Sporobolus* spp., and other grasses; SYG, 5300 ft; *JF 1997, TR s.n.* (SRSC). High saddle below Sue Peaks. Species that were abundant in surrounding area, such as lechuguilla, sotol, nolina, and grama grasses, were absent from this saddle area in favor of various grass species. Some old wood and wire were present as well as prehistoric rock flakes and a few partial tools and/or arrowheads.

Pappophorum bicolor Fourn. – Pink pappusgrass
Rare to "infrequent" perennial herb, sandy wash, upper limestone valley; DAR, DCA, 3050–3700 ft; *JF 1105* (BIBE & SRSC); *BHW 20629, BHW & LCH BG-166* (SRSC). Dagger Canyon, Stairway Mountain, Brushy Canyon.

Pappophorum vaginatum Buckl. – Whiplash pappusgrass
Uncommon perennial herb, washes, finer soil that gets runoff; DSC, DAR, 2350–3480 ft; *JF 1394a* (BIBE & SRSC); *JF 1095, 1368, 1412, BHW & LCH BG-151* (SRSC). Dagger Flat, Ernst Basin, Ernst Tinaja. This species concept includes *Pappophorum mucronatum* (Turner et al. 2003).

***** *Pennisetum ciliare* (L.) Link – Buffelgrass
[*Cenchrus ciliaris* L.] Overall rare, but locally abundant, perennial herb in washes, slopes, and open desert; DSC, DAR, DCA, RIO, 1850–2500 ft; *BA2 4323* (BIBE); *JF 1065, 2222; AMP 5861* (SRSC). Not seen anywhere in the DH during the current study except along the Old Ore Road south of the Ernst Tinaja turnoff and above Ernst Tinaja. It is prominent in the southern study area around RGV and the Boquillas Canyon trail. Plants can be seen extending up the slopes of the entrance to Boquillas Canyon almost to the top of the canyon. This species does occur elsewhere in the park, especially along the unpaved river road, and increasingly at higher elevations, including various populations along the paved road between RGV and the BBNP western entrance.

§ *Phragmites australis* (Cav.) Trin. ex Steud. – Common reed
Locally abundant perennial herb, sandy banks of the Rio Grande; RIO, 1800 ft; *WFM s.n.* (BIBE). Though still an important part of the riparian corridor in the study area, no collections were made of this species during the current study period.

Pleuraphis mutica Buckl. – Tobosa grass
[*Hilaria mutica* (Buckl.) Benth.] Uncommon perennial herb, finer, deeper soils usually associated with erosional deposition; DSC, DAR, SYG, 2350–5300 ft; *DG & TE 4614* (BIBE); *JF 1255, 1399, 1435, 1478* (SRSC). High saddle by Sue Peaks, base of western DH slopes, Ernst Tinaja, Ernst Basin.

Poa bigelovii Vasey & Scribn. – Bigelow bluegrass
Uncommon annual herb, gravelly alluvial soil and tasajillo-mesquite thickets; DSC, DCA, 3560 ft; *JF 516, 537, BHW 21134, 47056, BHW & MCJ 15982, 15984* (SRSC); *BHW 21134* (TEX-LL). Dog Canyon, TC trail.

***§** *Polypogon monspeliensis* (L.) Desf. – Rabbitfoot grass
[*Alopecurus monspeliensis* L.] Locally occasional annual herb in sandy soil; RIO, 1800 ft; *HTF 290* (SRSC). Collected along the Rio Grande in 1932; also observed during current study in the restoration site at the mouth of Boquillas Canyon.

Schizachyrium scoparium (Michx.) Nash – Little bluestem
Rare perennial herb, slickrock washbed; DCA, 3500–4650 ft; *JF 1950* (BIBE); *JF 1939, 1950, OCW 317* (SRSC). Brushy and Sue Peaks canyons.

+ *Setaria grisebachii* Fourn. – Grisebach bristlegrass
Rare annual herb; DSC, 2960 ft; *JF 217* (SRSC). North Dagger Mountain.

Setaria leucopila (Scribn. & Merr.) K. Schum. – Streambed bristlegrass
Occasional perennial herb, in shade and good duff layer, in deeper soils, associated with higher moisture content; DSC, DAR, DCA, SYG, 2400–5300 ft; *JF 356, 1134, 1416, 1988, MT 102* (SRSC); *EGM 164* (TEX-LL).

§ *Setaria parviflora* (Poir.) Kerguélen – Marsh bristlegrass
[*Setaria geniculata* P. Beauv.] Locally common perennial herb, sandy soil, moist areas; RIO, 1800 ft; *CAB 32, BHW 13053* (BIBE); *BHW 13053* (SRSC); *EGM 51-1112, BHW 13053* (TEX-LL). Last collected in 1973; all collections from along the Rio Grande or at the beaver marsh at Boquillas.

§ *Setaria reverchonii* (Vasey) Pilger – Reverchon bristlegrass
[*Setaria ramiseta* (Scribn.) Pilg.] Perennial herb; 1800 ft; *BHW & MCJ 16856* (SRSC). Collected in 1958 at the head of Boquillas Canyon.

!+ *Sorghum halepense* (L.) Pers. – Johnsongrass
Rare perennial herb, deep soil; DAR, 3440 ft; *JF 362* (SRSC). Upstream base of the TC dam. Listed by Amos and Giles (1992). Occasional to abundant in other areas of BBNP and the Trans-Pecos in general.

Sporobolus airoides (Torr.) Torr. – Alkali sacaton
Uncommon perennial herb, talus slope, deeper soil; DSC, SYG, 1800–5300 ft; *JF 1254, 1542, BGH 642* (SRSC). High saddle by Sue Peaks, mile 4.5 of the TC trail, and at Rabbit Ears (river mile 791) in Boquillas Canyon.

Sporobolus cryptandrus (Torr.) Gray – Sand dropseed
Uncommon perennial herb, rocky to sandy soil; DSC, DAR, DCA, SYG, 1800–5300 ft; *JF 352, 1999, 2050, 2146, MT 103* (SRSC). High saddle by Sue Peaks, lower elevations of the TC trail, Brushy and Boquillas canyons. Listed by Amos and Giles (1992).

§ *Sporobolus flexuosus* (Thurb. ex Vasey) Rydb. – Mesa dropseed
"Frequent" perennial herb; RIO, 1800 ft; *BHW & MCJ 16845, 16853* (SRSC). Collected in 1958 at the head of Boquillas Canyon.

§ *Sporobolus pyramidatus* (Lam.) A.S. Hitchc. – Madagascar dropseed
"Infrequent" annual or perennial herb, sandy soil; RIO, 1800 ft; *BHW 786* (SRSC). Collected in 1937 at Boquillas Canyon.

§ *Sporobolus wrightii* Munro ex Scribn. – Big sacaton
Perennial herb; *EGM 123* (SRSC); *EGM 123, 51-1110* (TEX-LL). Collected in the Boquillas area in 1937.

§ *Tridens eragrostoides* (Vasey & Scribn.) Nash – Lovegrass tridens
Perennial herb; 3700 ft; *BHW 20626* (SRSC). Stairstep Mountain.

Tridens muticus (Torr.) Nash – Slim tridens
Common perennial herb, rock crevices, talus slopes, wash gravel, generalist; DSC, DAR, DCA, SYG, 1800–5500 ft; *JF 327* (BIBE); *JF 196, 208, 212, 327, 762a, 1017, 1039, 1174, 1177, 1260, 1369, 1437, 1475, 1937, 2017, 2078, TR 25, MT 138, 161, BHW 10789, 20628, BHW & LCH BG-65, BG-179* (SRSC).

Urochloa arizonica (Scribn. & Merr.) O. Morrone & F. Zuloaga – Arizona signalgrass
[*Brachiaria arizonica* (Scribn. & Merr.) S.T. Blake, *Panicum arizonicum* Scribn. & Merr.] Uncommon annual herb; RIO, DCA, 1800 ft; *JF 2105, BHW 12896, 20945, BHW & MCJ 16855* (SRSC). Boquillas Canyon.

§ *Vulpia octoflora* (Walt.) Rydb. – Sixweeks fescue
Annual herb, fine soils; DCA; *RRI 21160* (TEX-LL). Collected in 1941 on the flats near Dog Canyon in tasajillo thickets. Also known locally from western Brewster County.

TYPHACEAE
§ *Typha domingensis* Pers. – Southern cattail
Perennial herb; RIO, 1800 ft; *EGM 155* (SRSC); *BHW 835* (BIBE & TEX-LL). Collected along the Rio Grande at Boquillas in 1937. Currently, this species is mainly restricted to the beaver pond area at RGV.

ANTHOPHYTA – Eudicotyledones

ACANTHACEAE
Carlowrightia arizonica A. Gray – Arizona carlowrightia
Uncommon subshrub, slickrock crevices, rocky soil; DSC, DAR, DCA, 1800–2350 ft; *BHW 12898* (BIBE); *JF 648, 1342, 2061, BHW 8334, 12898, 18408* (SRSC). Collected in the southern half of the study area, in the environs of Boquillas Canyon and Ernst Tinaja.

+ *Carlowrightia serpyllifolia* A. Gray – Trans-Pecos wrightwort
Occasional subshrub, cracks in cliff walls, steep slopes in shallow rocky soil; DSC, DCA, 3680 ft; *JF 447, 607, 667, 972, 1013, 1343, 2016, 2080* (SRSC). Known locally from Heath Canyon and Hot Springs in addition to elsewhere in the southern Big Bend.

Dyschoriste linearis var. *cinerascens* (Henrickson & Hilsenb.) B.L. Turner – Polkadots
Uncommon and "locally frequent" perennial herb, rocky limestone soils; DSC, DAR, DCA, 2150–4360 ft; *BRM 3138*, *CMR 5093* (BGWMA); *BA2 5198, 5350, JF 1517, 1915, MT 65, BLT 22-145, BLT & BD 23-177, BHW & LCH 160 (*SRSC*); BLT 22-145*, *BHW& LCH BG-87*, *BG-160 (*TEX-LL*).* TC trail, Brushy Canyon, Stairway Mountain. Turner et al. (2003) does not reflect these collections.

Justicia pilosella (Nees) Hilsenb. – Gregg tubetounge
Uncommon perennial herb, wash banks, shaded areas with higher moisture content; DSC, DAR, DCA, 2100–3050 ft; *JF 1133, 1351, TRV s.n., BHW 21195* (SRSC). Dagger Flat, Ernst Tinaja canyon, mouth of Heath Creek, near tunnel. Turner et al. (2003) reflects no dots for these collections.

Justicia warnockii B.L. Turner – Warnock water-willow
Occasional subshrub, sides of drainages, slopes, low hills; DSC, DAR, DCA, 1800–3720 ft; *BHW & LCH BG-137* (BGWMA); *AL 161, 162, CMR 17231, BHW 13063(266)* (BIBE); *JF 229, 687, 1667, 2053, 2087, MT 152, 181, 227, BLT 22-149, BLT & BD 23-178, BHW 10786, 13063, 20410, BHW & LCH BG-137, BHW & MCJ 16827* (SRSC); *BLT 22-149, BLT & BD 23-178, BHW 10786, BHW & LCH s.n.* (TEX-LL).

Ruellia parryi A. Gray – Parry wild petunia
Common subshrub, rocky limestone soils; DSC, DAR, DCA, 1800–4600 ft; *SMU 48* (BGWMA); *JF 202, 434, 520, 829, 945, 2042, 2113, AMP & SAP 5136, MT 27, BLT 22-144* (SRSC); *BLT 22-144* (TEX-LL).

AMARANTHACEAE

*+ *Amaranthus blitoides* S. Wats. – Mat amaranth
Rare annual herb, deeper soil, washes; DAR, 3000 ft; *JF 218* (SRSC). Dagger Mountain area. Listed by Amos and Giles (1992).

§ *Amaranthus palmeri* S. Wats. – Carelessweed
Annual herb, sedimentary soil; RIO, 1800 ft; *EGM 125, 128, 136* (BIBE). Collected in 1937 at the mouth of Boquillas Canyon.

Amaranthus scleropoides Uline & Bray – Bonebract amaranth
Rare annual herb, rocky wash bed; DCA, 1800 ft; *JF 2107* (SRSC). Arroyo Venado, near the Rio Grande. Also known locally from the Chisos Mountains.

§ *Amaranthus torreyi* (Gray) Benth. ex S. Wats. – Torrey amaranthus
"Frequent" annual herb; DSC, 3800 ft; *BHW 10796* (SRSC & TEX-LL). Collected in 1952 near McKinney Springs.

§ *Froelichia arizonica* Thornb. ex Standl. – Arizona snakecotton
"Occasional" perennial herb, dry soils in arroyos and ridges; DSC, DAR, DCA; *BHW & BLT 8318, BHW & MCJ 16847, GLW 4477* (SRSC); *DSC & HBC 30635, BLT & MT2 97-333* (TEX-LL).

Tidestromia lanuginosa (Nutt.) Standl. – Wooly tidestromia
Uncommon annual herb, dry, chalky soil; DSC, DCA, 2850 ft; *JF 942, BHW & MCJ 16852* (SRSC). Passionflower Canyon.

Tidestromia suffruticosa (Torr.) Standl. – Shrubby honeysweet
Occasional subshrub, dry, open desert; DSC, DCA, 1800–2760 ft; *JF 149, 197, BHW 694* (SRSC); *BHW 694* (TEX-LL).

ANACARDIACEAE
Rhus microphylla Engelm. ex A. Gray – Littleleaf sumac
Rare shrub, drainage, deeper soil; DAR, 2100-2400 ft; *CMR 5076* (BGWMA); *JF 1444, BHW & LCH BG-89* (SRSC). Ernst Basin, Frog Creek, east slopes Stairway Mountain.

Rhus trilobata var. *pilosissima* Engl. – Skunkbush sumac
Rare shrub, east aspect, base of cliff; CHP, 5680 ft; *JF 1292* (SRSC). Near top of southern Sue Peak. Also known locally from the Chisos Mountains.

Rhus virens Lindh. ex A. Gray var. *virens* – Evergreen sumac
Uncommon to occasional at higher elevations, shrub, higher moisture areas; DCA, CHP, 3050–5680 ft; *CMR 15830* (BGWMA); *JF 767a, 1040, 1135, 1182, 1295, 1508* (SRSC). Dagger Canyon, Sue Peaks environs, Brushy Canyon.

APOCYNACEAE
Haplophyton crooksii (L.D. Benson) L.D. Benson – Cockroach plant
[*Haplophyton cimicidum* A. DC. var. *crooksii* L. Benson] Rare perennial herb; DCA, 1850 ft; *JF 1067* (SRSC). Just inside the mouth of Arroyo Venado in Boquillas Canyon. East side of wash, in crevice of canyon wall/boulders. New park record, nearest known locality is in the Chinati Mountains west of BBNP.

Telosiphonia macrosiphon (Torr.) Henrickson – Rocktrumpet
[*Macrosiphonia macrosiphon* (Torr.) A. Heller] Uncommon subshrub, rocky steep drainage, platey limestone hill; DSC, DAR, 2700–3350 ft; *CMR 11625* (BGWMA); *JF 815, 933, 1481* (SRSC). TC trail, Passionflower Canyon. The species listed as *Macrosiphonia languinosa* by Amos and Giles (1992) is most likely this, as *M. languinosa* occurs in south Texas, according to Turner et al. (2003).

ARISTOLOCHIACEAE
Aristolochia coryi I.M. Johnst. – Dutchman pipe
Occasional perennial herb, sheltered areas, shaded spots on slopes and in drainages; DSC, DAR, DCA, RIO, SYG, 1800–4280 ft; *BA2, DG, TE, & B 4933* (BIBE); *BA2 5716* (SAT); *JF 955, 1483, 1491, 2093, 2119, BLT & MT2 97-338, BHW 8332* (SRSC); *BLT & MT2 97-338* (TEX-LL).

ASCLEPIACEAE
+ *Asclepias asperula* (Dcne.) Woods. – Spider milkweed
Uncommon perennial herb, open desert to bedrock crack; DSC, 2560–3800 ft; *JF 368, 1405, 1911* (SRSC). Dagger Mountain, TC trail, Ernst Tinaja. Locally known also from Dog Flats.

Asclepias oenotheroides Cham. & Schlecht. – Zizotes milkweed
Rare perennial herb, dry soils along arroyos and on ridges; DSC, DCA, 2300–2750 ft; *JF 914* (SRSC); *BLT & MT2 97-341* (TEX-LL). Ernst Tinaja and Passionflower Canyon.

Asclepias sperryi Woods. – Sperry milkweed
Rare subshrub, cracks of cliffs and bedrock; CHP, 5100–5680 ft; *JF 1286, 2194* (SRSC). Nose of DH plateau summit and on the eastern side, below and slightly north of the southern Sue Peak. A new park record, this was previously known only from the Glass and Del Norte mountains of northern Brewster County.

§ *Cynanchum barbigerum* (Scheele) Shinners – Bearded swallow-wort
Perennial herbaceous vine; *JLB 870* (SAT).

Cynanchum pringlei (Gray) Henrickson – Pringle swallow-wort
[*Cynanchum barbigerum* var. *breviflorum* Shinners] Uncommon to occasional perennial herbaceous vine, wash gravel, rock crevices and outcrops, exposed rocky slopes; DSC, DAR, DCA, 3000–4240 ft; *BA2 5315* (SAT); *JF 256, 301, 1164, 1488, 2203, MT 30, BLT & BD 23-174, BHW 10785, BHW & LCH BG-133* (SRSC); *BLT & BD 23-173, BHW 10785, BHW & LCH BG-133* (TEX-LL).

Cynanchum racemosum (Jacq.) Jacq. var. *unifarium* (Scheele) E. Sundell – Talayote
[*Cynanchum unifarium* (Scheele) Woodson] Uncommon to locally common perennial herbaceous vine, wash gravel and banks; DAR, DCA, 2780–4040 ft; *JF 1928, AL 144* (BIBE); *BA2 5317* (SAT); *JF 169, 858, 1928* (SRSC). Passionflower and Brushy Canyons. After good rains in summer of 2006, it was found growing thickly and abundantly on large shrubs/trees in the bed of Telephone Canyon.

Matelea parvifolia (Torr.) Woods. – Spearleaf milkvine
Rare perennial herbaceous vine, rock crevice at side of arroyo; DSC/DAR, 1900 ft; *JF 2057* (SRSC). Boquillas Canyon, upstream of Marufo Vega. New park record; known also from the Chinati Mountains; recently collected on Reed Plateau west of Terlingua (Weckesser in prep.).

§ *Matelea producta* (Torr.) Woods. – Texas milkvine
Perennial herbaceous vine, sandy soil; RIO, 1800 ft; *BHW 13050* (BIBE). One collection from along the Rio Grande at Boquillas in 1955.

Matelea reticulata (Engelm. ex Gray) Woods. – Netted milkvine
Uncommon perennial herbaceous vine, wash gravel, deep shade in steep ravine; DAR, DCA, 3160–4600 ft; *BRM 3225, BHW & LCH BG-170* (BGWMA); *JF 1938* (BIBE); *BA2 5339* (SAT); *JF 221, 1938, JF & MY 1317, AMP & SAP 5132, BHW & LCH BG-170* (SRSC). North Dagger Mountain, TC trail, Brushy Canyon near Shackelford cabin.

Matelea sagittifolia (Gray) Woods. – Arrowleaf milkvine
Rare perennial herbaceous vine, exposed west slope in shade of large boulder; DSC, 3350 ft; *JF 1484* (SRSC). Found also in Brewster County on Reed Plateau near Terlingua (Weckesser in prep.), and near Lone Mountain in BBNP (Fenstermacher et al. 2006). These concurrent discoveries constitute a new county record for this species. The closest locality known previously was in Val Verde County (Turner et al. 2003).

§ *Sarcostemma crispum* Benth. – Wavyleaf twinvine
Perennial herbaceous vine; DSC; *TR 147* (BGWMA); *BA2 5365* (SAT). Brushy Canyon.

§ *Sarcostemma cynanchoides* Dcne. var. *cynanchoides* – Fringed twinevine
"Frequent on shrubs", perennial herbaceous vine, sandy soil; RIO, DSC, 1825 ft; *BA2 & DG 5158* (BIBE); *BHW 13050* (TEX-LL). Collected along the Rio Grande, at Graham farm, and at Boquillas.

Sarcostemma cynanchoides Dcne. var. *hartwegii* (Vail) Shinners – Hartweg twinevine
Rare perennial herbaceous vine, on shrubs on hills; DSC, DCA, 1800–2350 ft; *JF 1347* (SRSC); *BHW 12904* (BIBE, SRSC, TEX-LL). *JF 1347* collected in the canyon upstream of Ernst Tinaja. Warnock reported this plant was infrequent at the old Graham farm near Boquillas in 1955.

Sarcostemma torreyi (Gray) Woods. – Soft twinevine
Uncommon perennial herbaceous vine, sandy soil, wash bed; DAR, DCA, RIO, 1800–4650 ft; *BA2 5223, 5280, 5375* (SAT); *JF 1956, 2000, TR 147, BHW 13050, BHW & LCH BG-165* (SRSC). Brushy Canyon near Shackelford cabin, along Rio Grande in Boquillas Canyon, and in Sue Peaks Canyon.

ASTERACEAE

Acourtia runcinata (Lag. ex D. Don) B.L. Turner – Featherleaf desertpeony
Occasional perennial herb, in somewhat protected niches such as between rocks, at base of cliffs, etc; DSC, DCA, 1800–3700 ft; *BRM 3147* (BGWMA); *BA2 5217, 5440* (SAT); *JF 147, 302, 459, 1339, 1353, 2115, OCW 342, BHW 10815, 20610, BHW & LCH BG-181, BHW & MCJ 15899* (SRSC); *BLT & MT 97-339, BHW 10815* (TEX-LL).

Ageratina wrightii (A. Gray) R.M. King & H. Rob. – Wright snakeroot
[*Eupatorium wrightii* A. Gray] Uncommon shrub, ravines, open slopes; DSC, DCA, SYG, 4040–4900 ft; *OCW s.n.* (BGWMA); *JF 722, 1549, 2189; OCW 336* (SRSC); *BA2 5481, 5457* (TEX-LL). Stuarts Peak, DH plateau, Brushy Canyon, Stairway Mountain.

§ *Ambrosia confertiflora* DC. – Weakleaf burr ragweed
Perennial herb; *BA2 5360* (SAT). Shackelford cabin area.

§ *Aphanostephus ramosissimus* DC. var. *humilis* (Benth.) B.L. Turner & Birdsong – Plains dozedaisy
Annual herb, sandy soil; DCA, RIO, 1800–2560 ft; *AL 310* (BIBE); *VLC 18730* (TEX-LL). From Dog Canyon in 1936 and the restoration site at Boquillas Canyon in 2006.

Artemisia ludoviciana Nutt. – White sagebrush
Occasional perennial herb at higher elevations,, in crevices associated with cliff walls, wash banks, shaded by boulders in deeper soil; DSC, DAR, DCA, SYG, CHP, 3050–5680 ft; *BA2 5491* (SAT); *JF 222a, 1152* (SRSC); *BA2, DG & TE 5491* (TEX-LL).

Baccharis havardii Gray – Havard false willow
Rare subshrub, wash gravel; DAR, DCA, 4050–4350 ft; *JF 1933, 1941* (SRSC). From lower elevations of Sue Peak Canyon. Known also from the Chisos, Glass, and Davis mountains.

Baccharis salicifolia (Ruiz & Pavón) Pers. – Seepwillow, jara
[*Baccharis glutinosa* Pers.] Locally common shrub, rare away from the river, in wash gravel and sandy soil; DAR, DCA, RIO, 1800–4280 ft; *EGM 12* (BIBE); *BA2 5511* (SAT); *JF 1345* (SRSC); *BA2, DG & ET 5511* (TEX-LL). Upstream of Ernst Tinaja, Boquillas, Brushy Canyon.

§ *Baccharis salicina* Torr. & Gray – Great plains false willow
Subshrub; DSC; *BGH 643* (SRSC). On bluff overlooking Rio Grande, near Rabbit Ears in Boquillas Canyon. Turner et al. (2003) reflects no dot for this collection.

Bahia absinthifolia Benth. var. *dealbata* (Gray) Gray – Dealbata bahia
Common at lower elevations, perennial herb, various soil types; DSC, DAR, 1800–3560 ft; *BHW 12888* (BIBE); *JF 347a, 543, 810, 2109, MT 120, 235, 253, BHW 12888, GLW 4486* (SRSC); *BA2 & TE 5301, BHW 12888* (TEX-LL).

Bahia pedata Gray – Bluntscale bahia
Uncommon annual herb, sandy soil and low ridges with shallow rocky soil; DSC, DCA, 3050–3150 ft; *JF 1102a, 1104* (SRSC); *WFB 67* (TEX-LL). Dagger Flat and north of Boquillas.

Baileya multiradiata Harvey & Gray ex Gray – Desert marigold
Common to occasional annual herb at lower elevations, roadside/trailside, in sandy soil and wash gravel; DSC, DAR, DCA, 2400–3050 ft; *BA2, DG, TE, & PC 4598, CN 1194;* (BIBE); *JF 1132, 1455, 1466, MT 16* (SRSC).

Brickellia coulteri Gray – Coulter brickellia
Occasional subshrub, wash gravel, crevices in bedrock, rocky soil; DSC, DAR, DCA, RIO, 1800–3800 ft; *JF 686, 1061, 1593, 1669, 2064; BHW 10834* (SRSC); *DSC & HBC 30626, BHW 10834* (TEX-LL).

Brickellia eupatorioides (L.) Shinners var. *chlorolepis* (Woot. & Standl.) B.L. Turner – False boneset
Rare subshrub, open hills and washes; DSC, DAR, 4280 ft; *BA2 5510* (SAT & TEX-LL); *JF 1041* (SRSC). Shackelford cabin area.

Brickellia laciniata Gray – Splitleaf brickellia
Occasional shrub, gravel and cobble wash beds; DAR, DCA, 1850–3050 ft; *BA2 5483* (SAT & TEX-LL); *JF 1084, 1146* (SRSC).

Brickellia lemmonii var. *conduplicata* (B.L. Rob.) B.L. Turner – Lemmon brickellbush
Uncommon perennial herb, washbed gravel, bedrock along ravine; DCA, 4650 ft; *BA2 5441, DG 328, 329* (SAT); *JF 1944, 1949* (SRSC); *BA2 5455, BA2 & TE 5441* (TEX-LL). Collected in Sue Peak and Brushy Canyons. Turner et al. (2003) does not reflect the historical collections.

+ *Chaetopappa bellioides* (Gray) Shinners – Manyflower leastdaisy
Rare perennial herb, open desert, rocky soil; DSC, 2680 ft; *JF 190* (SRSC). Western edge of study area by Dagger Mountain; generally infrequent in the Trans-Pecos. Turner et al. (2003) shows dots in the study area but no specimens were discovered.

+ *Chaetopappa ericoides* (Torr.) Nesom – Rose heath, leucelene
[*Leucelene ericoides* (Torr.) Greene] Rare annual or perennial herb, open meadow, base of cliff outcrop; SYG, 5000–5300 ft; *JF 773, 2157* (SRSC). Stuarts Peak and the high saddle near Sue Peaks.

Chloracantha spinosa (Benth.) Nesom – Mexican devilweed
[*Aster spinosus* Benth., *Erigeron ortegae* S.F. Blake] Occasional perennial herb, along the Rio Grande in sandy soil; RIO, 1800 ft; *BA2, DG, TE, & B 4922* (BIBE); *JF 2019a* (SRSC).

Chrysactinia mexicana A. Gray – Damianita
Common at higher elevations, subshrub, scattered throughout rocky limestone soils; DCA, SYG, CHP, 4080–5200 ft; *SMU 52* (BGWMA); *PVW s.n.* (KANU); *BA2 5297* (SAT); *JF 572, MT 223* (SRSC); *BA2 & TE 5297* (TEX-LL).

Cirsium turneri Warnock – Cliff thistle
Uncommon, yet not surprising to find it in larger canyons with sheer walls; perennial herb, cliff faces, boulders; DCA, 2920–4200 ft; *AL 163* (BIBE); *JF 187, 1121, 1704, AMP & SAP 5126, MT 215* (SRSC); *JF 1121* (TEX-LL). Also seen but not collected from the top of the northern ridge of Dagger Mountain. Occurs throughout the entire north to south range of the DH, at least within BBNP.

§ *Conyza canadensis* (L.) Cronq. – Canadian horseweed
Annual herb; *EGM 142* (BIBE). Collected in 1937 at Boquillas.

Diaperia verna (Raf.) Morefield – Manystem evax
[*Evax verna* Raf., *Evax multicaulis* DC.] Rare annual herb, alluvial sand and sandy clay bottoms; DSC, DAR, 2400–2520 ft; *JF 1429* (SRSC); *RRI 555* (TEX-LL). May be undercollected due to its life strategy; very few plants were seen during the study period and all were dry and barely recognizable.

Dyssodia acerosa DC. – Prickleleaf dogweed
[*Thymophylla acerosa* (DC.) Strother] Common perennial herb, bedrock, oepn rocky soils, various habitats; DSC, DAR, DCA, 2150–4400 ft; *BHW & LCH BG-72* (BGWMA); *JF 512, 1588, MT 72, BHW & LCH BG-72, GLW 4447* (SRSC); *BA2, DG & TE 5505* (TEX-LL).

Dyssodia micropoides (DC.) Loes. – Wooly dogweed
[*Thymophylla micropoides* (DC.) Strother] Uncommon perennial herb, bare rocky soil with bedrock outcrops; DSC, 2350–2560 ft; *AL 316, 317* (BIBE); *JF 1401, 1684* (SRSC); *BA2, DG & TE 5461* (TEX-LL). Devil's Den, Brushy Draw, Ernst Tinaja environs, Strawhouse trail.

Dyssodia pentachaeta (DC.) B.L. Robins. – Prickly dogweed
[*Thymophylla pentachaeta* (DC.) Small var. *pentachaeta*] Occasional perennial herb, wash gravel, rocky soil, terraces; DSC, DAR, DCA, SYG, 1800–5150 ft; *CMR 5056* (BGWMA); *BA2, DG, TE, & PC 4599* (BIBE); *PVW s.n.* (KANU); *JF 192, 320, 460, 540c, 542, 576, 1033, 1085, 1226, 1228, 1927, 2108, HTF 1230, MT 62, 242, BHW 10817* (SRSC); *BA2 & TE 5295, 5296* (TEX-LL). The degree of pubescence varies among specimens.

§ *Eclipta prostrata* (L.) L. – False daisy
[*Eclipta alba* (L.) Hassk.] "Infrequent to frequent" annual or perennial herb, sandy soil; RIO, 1800–1825 ft; *BHW 13039* (BIBE, SRSC, TEX-LL); *BHW 13035* (TEX-LL). Boquillas.

Erigeron flagellaris A. Gray – Trailing fleabane
Uncommon biennial herb; 3300-4600 ft; *JF 754*, *799, AMP & SAP 5129*, *MT 78* (SRSC). TC trail mile 3.5, Ernst Tinaja, and near the Shackelford cabin.

Erigeron modestus Gray – Plains fleabane
Uncommon perennial herb, wash gravel, limestone ledges, rocky slopes; DSC, DAR, 3460 ft; *VLC 43989; JF 264, 373, MT 249* (SRSC); *BA2 & TE 5324, BA2, TE & DG 5494* (TEX-LL). Dog Canyon, Stuarts and Sue peaks, TC trail, Brushy Canyon.

Erigeron tracyi Greene– Running fleabane
[*Erigeron colomexicanus* A. Nels.] Occasional annual herb, wash gravel to open ridgetops; DSC, DAR, DCA, SYG, 2880–5150 ft; *JF 1025* (BIBE); *JF 763, 1008, 1025, 1153, 1231, 1272, BLT & BD 23-170, BHW 10833* (SRSC); *BLT & BD 23-170* (TEX-LL).

§ *Flaveria trinervia* (Spreng.) C. Mohr – Running yellowtops
"Frequent" annual herb, sandy soil; RIO, 1800 ft; *EGM 132, BHW 750, 13042* (BIBE); *BHW 13042* (SRSC); *EGM 132, BHW 750* (TEX-LL).

§ *Flourensia cernua* DC. – Tarbush
Rare shrub; *BA2 5520* (TEX-LL). Collected ca. 1.5 miles N-NW of the Shackelford cabin near a man-made dam. This species was observed only twice during the current study in BBNP, seemingly limited to the Dagger Flat area.

§ *Flyriella parryi* (Gray) King & H.E. Robins. – Chisos mountains brickellbush
"Infrequent" perennial herb; *BHW 18403* (SRSC). Collected in 1961 on a trip through Boquillas Canyon.

Grindelia arizonica Gray – Arizona gumweed
Annual or perennial herb, open rocky rise; SYG, 4280 ft; *JF 1043* (SRSC). Collected on a small rise along old road SW of the Shackelford cabin. Locally known also from the Chisos, Glass, and Davis mountains.

§ *Grindelia nuda* Wood var. *nuda* – Curlytop gumweed
Annual or perennial herb, drainage; DAR, *BA2 & TE 5355* (TEX-LL). Brushy Canyon. Turner et al. (2003) does not reflect this collection.

Gutierrezia microcephala (DC.) Gray – Threadleaf snakeweed
Occasional to locally common subshrub, rocky soil; DAR, DCA, DSC, SYG, 2500–5840 ft; *JF 1324a, MT 45, 219, 252* (SRSC); *BA2, DG, & TE 5521, TR 251* (TEX-LL).

Gutierrezia sarothrae (Pursh) Britt. & Rusby – Broom snakeweed
Common subshrub, wash gravel, sandy clay bottoms, river floodplain, open gravelly slopes and plateaus; DSC, DAR, DCA, RIO, SYG, 1800–5100 ft; *BA2, DG, B & TE 4921, JF 1411* (BIBE); *PVW s.n.* (KANU); *JF 318, 1411, 1417, TR 251, BLT & BD 23-179* (SRSC).

Gutierrezia sphaerocephala Gray – Roundleaf snakeweed
Uncommon subshrub, sandy clay bottom, flats, open rocky soil; DSC, DAR, SYG, 2400–4280 ft; *JF 1411a, OES 763* (SRSC); *BLT & BD 23-179* (TEX-LL). Dog Canyon, Ernst Basin, near Shackelford cabin.

Gymnosperma glutinosum (Spreng.) Less. – Tatalencho, gumhead
[*Xanthocephalum glutinosum* (Spreng.) Shinners] Common subshrub, washes, slopes, summits; DSC, DAR, DCA, SYG, 2350–5300 ft; *OCW 339* (BGWMA); *JF 238, 321, 498a, 579, 712, 752, 1181, 1376, 1989, OCW 339* (SRSC); *BA2 & TE 5323, BA2, DG & TE 5515* (TEX-LL).

§ *Helenium elegans* DC. var. *amphilobum* (Gray) Bierner – Pretty sneezeweed
Annual herb, sandy soil; RIO, 1800 ft; *MWB & JEA 232a, 232c, 232d* (TEX-LL). Label data states that two of these collections are considered by the collector as being possible hybrids between *Helenium elegans* DC. var. *amphibolum* (Gray) Bierner and *Helenium microcephalum* DC. var. *ooclinium* (Gray) Bierner.

§*Helenium microcephalum* DC. var. *microcephalum* – Smallhead sneezeweed
"Frequent" annual herb, sandy soil, river floodplain; RIO, 1800 ft; *AL 322, CN 504* (BIBE); *BHW 13031* (SRSC); *OES & CN 504, BHW 13031* (TEX-LL).

§ *Helenium microcephalum* DC. var. *ooclinium* (Gray) Bierner
[*Helenium ooclinium* A. Gray] Annual herb, sandy alluvial soil; RIO, 1800 ft; *MWB & JEA 232b, 232e* (TEX-LL).

Helianthus annuus L. – Common sunflower
"Frequent" annual herb; RIO, 1800 ft; *EGM 129, BHW 13045* (BIBE); *JF 2263*, *BHW 13045* (SRSC). A few patches of plants have reestablished at the Boquillas Canyon restoration site since the last collections in 1955.

§ *Helianthus ciliaris* DC. – Texas blueweed
"Locally frequent" perennial herb, sandy soil; RIO, 1800 ft; *BHW 13051* (BIBE & SRSC).

Heliopsis parvifolia Gray – Mountain oxeye
Rare perennial herb, east aspect slope, rocky dark soil; SYG/CHP, 5680 ft; *JF 1276* (BIBE & SRSC). Collected just off the saddle between the two Sue Peaks. Also known locally from the Chisos Mountains.

§ *Isocoma pluriflora* (Torr. & Gray) Greene – Jimmyweed
[*Haplopappus heterophyllus* (A. Gray) S.F. Blake, *Haplopappus pluriflorus* (Torr. & A. Gray) H.M. Hall] Subshrub, dry hills; DSC; *BHW 1076* (TEX-LL). Collected in 1937 at Boquillas near Rio Grande.

Iva ambrosiifolia (Gray) Gray – Rag sumpweed, ragged marsh-elder
Rare annual herb, open desert; DSC, DAR, 3640 ft; *JF 289* (SRSC); *BA2, DG, & TE 5492* (TEX-LL). From Dagger Flat and upper watershed of Brushy Canyon.

Jefea brevifolia (A. Gray) Strother – Shorthorn zexmenia
[*Zexmenia brevifolia* A. Gray] Occasional shrub, slopes, cracks in and at base of cliff walls and bedrock ledges; DSC, DCA, SYG, 1800–4700 ft; *PVW s.n.* (KANU); *JF 472, 708, 2132, CMR 5068, MT 106, BHW 10736* (SRSC); *BA2, DG, & TE 5503, BA2 & TE 5298, DF 223, BHW 10763* (TEX-LL).

+ *Laennecia coulteri* (Gray) Nesom – Coulter horseweed, annual horsetail
[*Conyza coulteri* A. Gray] Rare annual herb, sandy clay bottom; DCA, 2400 ft; *JF 1420* (SRSC). From Ernst Basin near remnant tobosa grassland.

+ *Machaeranthera tanacetifolia* (Kunth) Nees – Tahoka daisy
Rare annual herb; DAR, 3480 ft; *JF 544* (SRSC). TC trail, east of Alto Relex. Turner et al. (2003) shows a dot in the study area but no specimen was discovered.

Melampodium leucanthum Torr. & A. Gray – Blackfoot daisy
Occasional subshrub, gravelly to sandy soil, open and protected areas; DSC, DAR, DCA, RIO, SYG, 1800–4450 ft; *JF 228, 269, 490, 967, 2006, 2123, MT 4, 47, 58, 74, 238, BLT & BD 23-176, BHW & BLT 8328, GLW 4483* (SRSC); *BLT & BD 23-176* (TEX-LL).

+ *Packera millelobata* (Rydb.) W.A. Weber & A. Löve – Uinta ragwort
[*Senecio millelobatus* Rydb.] Rare perennial herb, shallow soil, at base of rock outcrop, and amongst rocks and boulders; SYG/CHP, 5680–5840 ft; *JF 1287, 1971* (SRSC). Collected on the southern Sue Peak. Also listed by Amos and Giles (1992) as a "rare herb in shaded ravines" in Brushy Canyon. According to Turner et al. (2003), this species occurs in many locations throughout western Brewster County and into Jeff Davis and Presidio counties.

Parthenium argentatum A. Gray – Guayule
Uncommon to occasional in northern part of the range, shrub, open areas with rocks and bedrock outcrops at mid- to higher elevations; DSC, SYG, 2920–4880 ft; *BHW & LCH BG-177* (BGWMA); *JF 1024, BDGL s.n.* (BIBE); *PVW s.n.* (KANU); *JF 744, 1024, 1139, 1155, 1183, 1901, JMM 888, 900, 903, AMP & SAP 4297, MT 49, BHW 10753* (SRSC); *BHW 10753* (TEX-LL).

Parthenium confertum A. Gray – Lyreleaf parthenium
Uncommon to occasional throughout, annual or biennial herb, wash gravel, shallow rocky soil, sandy clay bottom; DSC, DAR, DCA, 1850–5840 ft; *JF 206, 359a, 524, 852, 1068, 1083, 1433, 1907, DM & JC 380, 900, 904, MT 41, 254, BHW 20608, BHW & MCJ 16836* (SRSC); *BA2 & TE 5304* (TEX-LL).

Parthenium incanum Kunth – Mariola
Common shrub, ubiquitous; DSC, DAR, DCA, SYG, 2300–5000 ft; *JF 350, 1023, OCW 511* (SRSC); *BA2 & TE 5303* (TEX-LL).

§ *Pectis angustifolia* Torr. var. *angustifolia* – Limoncillo
"Frequent" annual herb; *BHW & BLT 8323* (SRSC); *VLC 30209, DF 224* (TEX-LL). Collected at Dog Canyon, near the tunnel, and in Boquillas Canyon, between 1938 and 1964.

§ *Pectis papposa* Harvey & Gray var. *grandis* Keil – Manybristle cinchweed
"Frequent in sandy soil", annual herb; 1800 ft; *BHW 286* (SRSC); *BHW & BLT 8323* (TEX-LL). Collected at entrance to Boquillas Canyon 1937 and 1948.

Perityle aglossa A. Gray – Bluff rockdaisy

Occasional subshrub, cracks in cliff walls, boulders; DSC, DCA, 1850–3560 ft; *AL 141* (BIBE); *JF 184, 530, 650, 685, 1005, 1007, 1073, 1350, 2014, SS 38, 931, BHW 20409* (SRSC); *SS 931* (TEX-LL). The DH is the center of this species' distribution, with outliers in Terlingua and Terrell County. A possible *Perityle aglossa* × *P. bisetosa* var. *scalaris* has been collected in Passionflower Canyon, *AL 202* (BIBE), with white flowers and only one pappus bristle.

Perityle bisetosa var. ***scalaris*** A.M. Powell – Stairstep rockdaisy

Uncommon to occasional (G2T1S1), subshrub, sheer rock walls with north to east aspects; DCA, SYG, CHP, 3050–5680 ft; *AL 146* (BIBE); *JF 475, 608a, 1123, 1289, 1917, BHW 20604* (SRSC); *JMP 2742* (TEX-LL). Expected in canyons with sheer walls such as Dagger Canyon, side canyons in the TC trail area, and Passionflower Canyon. Also collected at Sue Peaks and Stairway Mountain.

Perityle vaseyi J.M. Coult. – Vasey rockdaisy

Rare subshrub, rocky soil; DSC, DAR, 2080–2350 ft; *JF 1367, SS 39, TRV & LJT 1816* (SRSC); *SS 39* (TEX-LL). Roadside near tunnel and at upstream mouth of Ernst Tinaja canyon.

+ *Plectocephalus americanus* (Nutt.) D. Don – American basketflower or star-thistle

[*Centaurea americana* Nutt.] Rare annual herb, alluvial terraces; DSC, DAR, 3550–4420 ft; *JF 507a, 843* (SRSC). Listed by Amos and Giles (1992).

Porophyllum scoparium A. Gray – Shrubby poreleaf

Occasional subshrub, sandy slopes, rock crevices, wash gravel; DSC, DAR, DCA, RIO, 1800–4000 ft; *BRM 3132, 3227, CMR 11592, SMU 38* (BGWMA); *JEA & TJW 170, JF 332, 471, 645, 1379, 2081, BGH 633, OES 1351, MT 184, BHW 18396, 20618, 21191* (SRSC); *BA2 & TE 5336, BA2 & DG 5207, DSC & HBC 30633, DF 51* (TEX-LL).

Psilostrophe gnaphalioides DC. – Cudweed paperflower

Rare to "infrequent" perennial herb, sandy hillside, east aspect; DSC, 1900 ft; *JF 2044, BHW 20627* (SRSC). At Stairstep Mountain and in Boquillas Canyon, upstream from Marufo Vega, along a social trail away from river.

Psilostrophe tagetina (Nutt.) Greene var. *cerifera* (A. Nels.) B.L. Turner – Wooly paperflower

Uncommon throughout, perennial herb, wash gravel, terraces above wash, rocky soil; DSC, DAR, 2300–3560 ft; *JF 523, 605, 855, MT 17, 18, BHW 10788, 18390, GLW 4470* (SRSC); *BA2 & TE 5362, TRV 85-37* (TEX-LL).

+ *Senecio flaccidus* Less. – Threadleaf groundsel

[*Senecio douglasii* DC.] Rare perennial herb, terrace above wash and in a sandy clay bottom; DSC, DAR, 2400–3560 ft; *JF 513, 1431* (SRSC).

*§ *Sonchus asper* (L.) Hill – Prickly sow thistle
Annual herb, reed stands along sandy river soil; RIO, 1800 ft; *BA2 4320* (BIBE). Boquillas Canyon.

*§ *Sonchus oleraceus* L. – Sow-thistle
"Frequent" annual herb, waste places; RIO; *BHW 733* (BIBE & TEX-LL); *HTF 209* (SRSC). Along Rio Grande at Boquillas, collected in the 1930s.

+ *Stephanomeria pauciflora* (Torr.) A. Nelson – Brownplume wirelettuce
Rare perennial herb; DCA, 2350 ft; *JF 1358* (SRSC). In canyon upstream of Ernst Tinaja.

§ *Symphyotrichum divaricatum* (Nutt.) G.L. Nesom – Southern saltmarsh aster
[*Symphyotrichum subulatum* var. *ligulatum* (Shinners) S.D. Sundb.] Annual herb; *EGM 134*, *BHW 730* (BIBE). Along river at Boquillas.

Symphyotrichum expansum (Poepp. ex Spreng.) Nesom – Southwestern saltmarsh aster
[*Symphyotrichum subulatum* var. *ligulatum* (Shinners) S.D. Sundb.] Occasional annual herb, sandy soil; RIO, 1800 ft; *JF 2037, BHW 13044* (SRSC). In riverbank sand, in interior of tamarisk/mesquite thicket. Locally known also from Hot Springs.

Tetraneuris scaposa (DC.) Greene var. *scaposa* – Stemmy four nerve daisy
[*Hymenoxys scaposa* (DC.) Parker, *Tetraneuris scaposa* var. *villosa* (Shinners) Shinners] Occasional perennial herb, shallow rocky soil, washes; DSC, DAR, DCA, 2150–5840 ft; *CMR 5088* (BGWMA); *BHW 12895* (BIBE); *JF 258, 524a, 614, 739, 755, 1052, 1234, 1247, 1374, 1403, 1970, MT 79, 233, BHW 10850, 12895, BHW & LCH BG-67* (SRSC); *BA2 & TE 5300, 5434, BHW 12895* (TEX-LL).

§ *Thelesperma filifolium* (Hook.) Gray – Stiff greenthread
Annual herb; 3520 ft; *ACK 826* (BIBE). At Dagger Flat in 1963.

Thelesperma longipes A. Gray – Longstalk greenthread
Occasional perennial herb, rock crevices, washes, limestone ledges, open areas; DSC, DAR, DCA, SYG, CHP, 1800–5150 ft; *BRM 3140*; *CMR 5083, 16949* (BGWMA); *BHW 12892* (BIBE, SRSC, & TEX-LL); *JF 761, 1233, 1394, 2125, BHW & LCH BG-73* (SRSC); *BA2 & TE 5325, OES 734, BHW & LCH BG-73* (TEX-LL).

Thelesperma megapotamicum (Spreng.) Kuntze var. *megapotamicum* – Rayless greenthread
Uncommon perennial herb, rocky slopes, wash/river gravel, open rocky slopes; DSC, DAR, DCA, RIO, SYG, 1800–4800 ft; *CMR 5084* (BGWMA); *JF 164, 262, 263, 1389, 2167* (SRSC); *DSC & HBC 30634, JAM & JAS 3429, AMP & SAP 3610* (TEX-LL). Southern end of study area.

§ *Thelesperma megapotamicum* (Spreng.) Kuntze var. *ambiguum* Gray – Colorado greenthread
Occasional perennial herb, wash gravel, rocky slopes; DAR, DCA, RIO, 1800 ft; *AMP & SAP 3610, BHW 21189, GLW 4476* (SRSC). Collected along the Rio Grande in Boquillas Canyon and at the mouth of Heath Creek between 1952 and 1981. In Texas this may be more of an eastern species but there is some overlap in distribution in west Texas. Some workers elevate these varieties to species (FNA 2006), other sources lump them together under *Thelesperma megapotamicum* (ITIS 2007).

Thelesperma simplicifolium Gray – Slender greenthread
Uncommon perennial herb, side of wash in rock crevice; DCA, 1900-4180 ft; *CMR 324*, *OCW 3243*, *BHW & LCH BG-68* (BGWMA); *JF 865, MT 63, 151, 163, AMP & SAP 5135, OCW 324, BHW 21185, BHW & LCH BG-68* (SRSC). Brushy Canyon, Stairway Mountain, Frog Tank, Telephone Canyon. Turner et al. (2003) does not reflect the historical collections.

Trixis californica Kellogg – American trixis
Occasional shrub, wash gravel, talus slope; DSC, DAR, DCA, 1800–4160 ft; *JF 473, 649, 1062, 1079, 1314, 2003, 2114, BHW 10751, GLW 4455* (SRSC); *BA2, DG, & TE 5493* (TEX-LL).

Verbesina encelioides (Cav.) Benth. & Hook. f. ex A. Gray – Golden crownbeard
Uncommon annual herb, sandy to silty soil; DCA, RIO, 1000–2560 ft; *EGM 138, OES 746* (BIBE); *JF 1066, 2036* (SRSC). In Boquillas Canyon and Dog Canyon.

Viguiera dentata (Cav.) Spreng. – Sunflower goldeneye
Uncommon to "frequent and widespread" perennial herb, well vegetated drainages, mesa tops, east aspect high elevation slopes; DAR, SYG, CHP, 3500–5150 ft; *BHW & LCH BG-15* (BGWMA); *JF 291, 759, 1028, 1224, MT 234, BHW & LCH BG-155* (SRSC). Dagger Basin, Stuarts Peak, DH plateau, and Brushy Canyon. Also known from the Chisos Mountains and north, in addition to along the Rio Grande in Val Verde County.

Viguiera stenoloba S.F. Blake – Skeletonleaf goldeneye
Common shrub, wash gravel, shallow rocky soil; DSC, DAR, DCA, SYG, CHP, 1800–5000 ft; *TR 56*, *CMR 16939*, *BHW & LCH BG-86* (BGWMA); *JF 260, 1029, 1370, 2140, TR 56, MT 145, 173, BHW & LCH BG-86* (SRSC); *BA2 & TE 5302* (TEX-LL).

§ *Xanthisma spinulosum* (Pursh) D.R. Morgan & R.L. Hartman *var. spinulosum* – Lacy tansyaster, cutleaf goldenweed
[*Haplopappus spinulosus* (Pursh) DC., *Machaeranthera pinnatifida* (Hook.) Shinners] "Fairly common" perennial herb, washes, rocky soil; DSC, DAR; *GLW 4469* (SRSC); *BA2 & TE 5389, BA2 & DG 5272* (TEX-LL).

Xanthisma spinulosum (Pursh) D.R. Morgan & R.L. Hartman *var. chihuahuanum* (B. L. Turner & R. L. Hartman) D. R. Morgan & R. L. Hartman – Lacy tansyaster [*Machaeranthera pinnatifida* var. *chihuahuana* B.L. Turner & Hartman] Occasional perennial herb, wash gravel, rocky and/or sandy soil; DSC, DCA, RIO, 2300–3050 ft; *JF 800, 958, 1130, 1373, MT 207, 210, BHW 18391* (SRSC); *RLH & JDB 3504b, 3503* (TEX-LL).

Xylothamia triantha (Blake) Nesom – Trans-Pecos desert goldenrod
[*Ericameria triantha* (S.F. Blake) Shinners] Rare subshrub, sandy clay bottom; DSC, DAR, 2400 ft; *JF 1450* (SRSC). In remnant tobosa grassland patch. Ernst Basin. Also known from the Chisos Mountains and westward in southern Brewster County.

Zinnia acerosa (DC.) A. Gray – Spinyleaf zinnia
Common perennial herb, shallow rocky soil, ledges; DSC, SYG, 2760–4400 ft; *BRM 3228*, *BHW & LCH BG-142* (BGWMA); *JF 153, 851, 1094, 1180, MT 5, 59, BHW 10837, BHW & LCH BG-142* (SRSC); *BH2 & TE 5294, BHW 10837* (TEX-LL).

BERBERIDACEAE
+ *Berberis trifoliolata* Moric. – Agarita, algerita
[*Mahonia trifoliolata* (Moric.) Fedde] Uncommon to occasional shrub, wash gravel, shaded areas; DSC, DAR, DCA, SYG, 2880–4600 ft; *JF 508, 528, 1001, 1036* (SRSC). Listed by Amos and Giles (1992).

BIGNONIACEAE
Chilopsis linearis (Cav.) Sweet – Desertwillow
Uncommon shrub or tree wash gravel; DCA, 1800–4280 ft; *TR 140* (BGWMA); *BA2 5234* (SAT); *JF 1355, 1356, 2137, TR 140, MT 189* (SRSC). Occurs only in the largest canyons (Passionflower Canyon drainage, TC, above Ernst Tinaja, Marufo Vega area, Frog Tank, Brushy Canyon) with higher potential storm flow and moisture retention.

Tecoma stans (L.) Juss. ex Kunth – Yellow bells
Occasional shrub, rocky soils, wash gravel; DSC, DAR, DCA 1800–3050 ft; *TR 141* (BGWMA); *BA2 5331* (SAT); *JF 179, 1010, TR 141, MT 11 193, BHW & LCH BG-85, BHW & MCJ 16866* (SRSC); *BLT & MT2 97-347, BHW & LCH BG-85* (TEX-LL).

BORAGINACEAE
Antiphytum heliotropioides A. DC. – Mexican saucerflower
Rare, "locally common" shrub, wash gravel; DAR, DCA, 4200–4350 ft; *BA2 5220, 5313, 5453, 5465, 5600* (SAT); *JF 1936* (SRSC). Sue Peaks Canyon and Brushy Canyon near Shackelford cabin. Turner et al. (2003) does not reflect any dots for the SAT specimens. Otherwise known from one location each in northern Brewster and Val Verde counties; it is more common in Mexico.

+ *Cryptantha albida* (Kunth) I.M. Johnst. – New mexico cryptantha
Rare annual herb, areas that hold water after runoff; DCA, 1920–3000 ft; *JF 646, 805* (SRSC). At Ernst Tinaja and a canyon north of the Barker House. Turner et al. (2003) shows a dot in the study area but no specimens were discovered.

Cryptantha angustifolia (Torr.) Greene – Panamint cryptantha
Rare annual herb, gravel terrace, alluvial sand on flats; DSC, 2560–3560 ft; *JF 522* (SRSC); *RRI 552* (TEX-LL). At Dog Canyon and a canyon off the TC trail.

Cryptantha coryi I.M. Johnst. – Cory cryptantha
[*Cryptantha palmeri* (A. Gray) Payson] Rare subshrub, rocky open soil, sandstone-derived soils; DSC, 3560 ft; *JF 280* (SRSC); *BLT & BD 23-164* (TEX-LL). Dagger Basin and along Brushy Canyon road.

#Δ *Cryptantha crassisepala* (Torr. & A. Gray) Greene – Thicksepal catseye
Annual herb, 1800 ft. Seen at the Boquillas Canyon restoration site. Turner et al. (2003) shows dots in the area but no specimens were discovered.

§ *Cryptantha mexicana* (Brandegee) I.M. Johnst. – Mexican cryptantha
"Infrequent" annual herb; 2300 ft; *OCW 506* (SRSC). Big Brushy Canyon. Also known from Dog Flats and the Chisos Mountains.

Heliotropium confertifolium (Torr.) Torr. ex A. Gray – Leafy heliotrope
Occasional subshrub, open rocky shallow soil; DSC, 1800–3800 ft; *EGM 147, BHW 907, 940* (BIBE); *JF 155, 367, BHW s.n., 940, 10848, BHW & LCH BG-76* (SRSC); *BHW s.n., 10848; BHW & LCH BG-76* (TEX-LL).

Heliotropium convolvulaceum (Nutt.) A. Gray – Phlox heliotrope
Locally common annual herb, sandy soil; RIO, DSC, 1800 ft; *BA2, DG, TE, & PC 4608, BHW 13029* (BIBE); *WRC & PM212200, JF 2232, AMP & SAP 5860, BHW 686, 13029, 16851, GLW 4474* (SRSC); *DSC & HBC 30631, BHW 686* (TEX-LL). Several species, in addition to *Heliotropium convolvulaceum*, that normally occur in the northern Trans-Pecos sand hills have disjunct populations at the head of Boquillas Canyon.

Heliotropium curassavicum L. – Salt heliotrope
Locally common subshrub, sandy soil; RIO, 1800 ft; *EGM 124, 943, CN 495* (BIBE); *JF 2256*, *BCT 8802* (SRSC); *BCT 8802, BHW 943* (TEX-LL). Boquillas Canyon restoration site.

#Δ *Heliotropium glabriusculum* (Torr.) A. Gray – Greeneye heliotrope
Perennial herb, observed at the Boquillas Canyon restoration site. Also known from just outside the study area, on the flats near Dog Canyon.

§ *Heliotropium greggii* Torr. – Fragrant heliotrope
Perennial herb; 1800 ft; *DSC & IMJ 21926* (SRSC). Boquillas Canyon, 1959. Also known locally from Dog Flats.

§ *Heliotropium procumbens* Mill. – Fourspike heliotrope
Subshrub; *BHW 1089* (TEX-LL). Boquillas Canyon, 1937.

Lappula redowskii (Hornem.) Greene – Flatspine stickseed
Occasional annual herb, gravelly soil, slopes, shaded areas; DAR, DCA, 1800–3560 ft; *DB 22*, *TK 10*, *BRM 3124* (BGWMA); *JF 427, 540a, 797, 2101, BHW 47057, 47059* (SRSC).

+ *Lithospermum incisum* Lehm. – Fringed puccoon, narrowleaf stoneseed
Rare perennial herb, gravelly soil/rubble in wash median; SYG, 4360–4800 ft; *BA2 5539, 5597* (SAT); *JF 554, 1948* (SRSC). Turner et al. (2003) does not reflect the BA2 collections, but there are many dots at the Chisos Mountains and to the north and east of the study area.

§ *Omphalodes aliena* A. Gray ex Hemsl. – Mexican navelwort
"Frequent" annual herb, among rocks; DSC, DCA, RIO, 1800–2560 ft; *BRM 3131* (BGWMA); *JLB 1578, ECM 49* (SAT); *AMP 5367, BHW 15991, 18395* (SRSC); *DSC & WOD 30715* (TEX-LL). Dog and Frog canyons, tunnel, Boquillas. Recently collected at Reed Plateau (Weckesser in prep.); known mostly near the Rio Grande, from Presidio through Val Verde counties.

§ *Tiquilia canescens* (A. DC.) A.T. Richardson – Woody crinklemat
[*Coldenia canescens* A. DC.] Occasional subshrub, lowlands, rocky soil; DSC, 2200–2400 ft; *BA2 5340* (SAT); *TR 4* (SRSC); *TR 4, BHW 1230* (TEX-LL).

Tiquilia gossypina (Wooton & Standl.) A.T. Richardson – Texas crinklemat
Occasional subshrub, open rocky soil; DSC, DCA, 1800–3440 ft; *JF 360, 2059, BHW 12899* (SRSC); *BHW 909* (TEX-LL).

Tiquilia greggii (Torr.) A.T. Richardson – Plume tiquilia
Occasional shrub, brushy canyons; DSC; *CMR 11634* (BGWMA); *BA2 5270* (SAT); *JF 359, 369*; *MT 213, BHW 10800* (SRSC).

§ *Tiquilia hispidissima* (Torr.) A.T. Richardson – Rough coldenia
Occasional subshrub, sandy to rocky soil, open areas; DSC, 1850–3520 ft; *BA2, DG, TE, & B 4923, ACK 822, BHW 908, 909* (BIBE); *BLT & BD 23-162, BHW 21682, 21692* (TEX-LL).

Tiquilia mexicana (S. Watson) A.T. Richardson – Mexican crinklemat
Occasional subshrub, platey limestone, bedrock outcrops, sandy soil; 1800–3400 ft; *JF 152a, 812, 1443, BHW 13072, 23038, GLW 4487* (SRSC).

BRASSICACEAE

Descurainia pinnata (Walter) Britton – Tansymustard
Uncommon annual herb, washes, places where water pools over soil; DSC, DAR, DCA, 3440–3500 ft; *BA2 5587* (SAT); *JF 422, 617* (SRSC). TC trail and Shackelford cabin area. Also at Hot Springs and Dog Flats.

§ *Dimorphocarpa wislizeni* (Engelm.) Rollins – Spectacle pod, touristplant
Locally common annual herb, sandy soil; DCA, 3500 ft; *BHW 47060* (SRSC & TEX-LL); *VLC 43958, RRI 558* (TEX-LL). Dog Canyon area.

Draba cuneifolia Nutt. ex Torr. & A. Gray – Wedgeleaf draba
Occasional annual herb, wash gravel, alluvial terrace, open peak; DSC, DAR, DCA, SYG, 1800–5080 ft; *JF 429, 536, 566, 738, 802, BHW 18392, BHW & MCJ 15990* (SRSC); *BHW & MCJ 15990* (TEX-LL).

§ *Lepidium alyssoides* var. *angustifolium* (C.L. Hitchc.) Rollins – Mesa pepperwort
Perennial herb; *HBP 1923* (TEX-LL). Dog Canyon. According to Turner et al. (2003), this species is common, or at least commonly collected, in western Texas. The lack of collections in the eastern part of Brewster County could be due to a relatively lower collecting effort in the local area.

Lepidium lasiocarpum subsp. *wrightii* (A. Gray) Thell. – Wright pepperweed
Uncommon annual herb, wash gravel, rocky terrace; DAR, DCA, 3440–3560 ft; *JF 619* (BIBE); *BA2 734, 5540, 5586; RE 734* (SAT); *JF 421, 565, 619* (SRSC). TC trail area, above dam. The specimens at SAT identified as *Lepidium lasiocarpum* would most probably be this variety, based on distributions shown in Turner et al. (2003). Also known at Persimmon Gap and Hot Springs.

§ *Lesquerella purpurea* (A. Gray) S. Watson – Rose bladderpod
"Frequent" perennial herb; *BHW & MCJ 15995* (SRSC). Dog Canyon. Also collected at Dog Flats, McKinney Springs, and Hot Springs.

Nerisyrenia camporum (A. Gray) Greene – Bicolored mustard
Common at lower elevations, perennial herb, gravelly flats, open desert; DSC, DCA, SYG, 2120–4280 ft; *CMR 16047* (BGWMA); *JF 492* (BIBE); *JF 372, 492, 615, 681, MT 105BHW 208, 47054, BHW & HKB 47063* (SRSC); *BHW T208, 47063* (TEX-LL).

Physaria fendleri (A. Gray) O'Kane & Al-Shehbaz – Fendler bladderpod
[*Lesquerella fendleri* (A. Gray) S. Watson] Occasional perennial herb, gravelly flats, open drainages and peaks with some shelter; DSC, DAR, DCA, SYG, 2200–5000 ft; *JF 557* (BIBE); *TR 105* (BGWMA); *JF 200, 497a, 555, 557, 736, 1189, TR 139, MT 75, 104, BHW 47062* (SRSC). The revision of *Physaria* accord to Al-Shehbaz and O'Kane (2002) and cited by Powell (in prep.) is followed here.

+ *Physaria gordonii* (A. Gray) O'Kane & Al-Shehbaz – Gordon bladderpod
Rare annual herb; SYG, 4360 ft; *JF 570* (SRSC). TC trail, five miles in from the trailhead.

Physaria mcvaughiana (Rollins) O'Kane & Al-Shehbaz – Mcvaugh bladderpod
Rare perennial herb, shallow soil with rock and boulders, deeper soil under shrubs in duff and shade, also open ridges; SYG, 4120–5840 ft; *JF 497, 714, 1535, 1964, AMP & SAP 5133* (SRSC). Listed by Amos and Giles (1992). At Sue Peaks, Telephone Canyon trail mile six, and Brushy Canyon. Also known from the Chisos and Glass Mountains.

Schoenocrambe linearifolia (A. Gray) Rollins – Slimleaf plainsmustard
Rare perennial herb, rocky areas on open peak; SYG, 3500–5680 ft; *BRM 3110* (BGWMA); *JF 734, 1291, 2185, MT 42, 43, 246, BHW & LCH BG-154* (SRSC). Stuarts and Sue peaks environs, Brushy Canyon.

§ *Selenia dissecta* Torr. & A. Gray – Texas selenia
"Frequent" annual herb, sandy soil; DCA, 3500 ft; *CMR 16410* (BGWMA); *BHW 47058, BHW & MCJ 15989* (SRSC); *BHW 47058* (TEX-LL). From Dog Canyon and near the mouth of Big Brushy Canyon.

*§ *Sisymbrium irio* L. – London rocket
Annual herb, alluvial sand on flats; DCA, 2560 ft; *RRI 551* (TEX-LL). Dog Canyon. This collection in not reflected in Turner et al. (2003).

Streptanthus cutleri Cory – Cutler twistflower
Uncommon (G2S2) biennial herb, rocky soil, alluvium and slopes; DSC, DAR, DCA, 1800–3500 ft; *JF 420, AMP 3570, 5366, AMP & SAP 4299, 5387, BHW 18399, BHW & MCJ 15992* (SRSC). Dog Canyon, Dagger Flats, TC trail, Ernst Tinaja, Boquillas Canyon. This became evident/locally common only after good local spring rain.

§ *Thelypodium texanum* (Cory) Rollins – Texas thelypody
Annual herb, dry areas; *OES 1288* (SRSC). Hills near Boquillas, 1938. This species concept includes *Thelepodium tenue* (Turner et al. 2003).

§ *Thelypodium wrightii* A. Gray – Wright thelypody
Perennial herb; DCA; *BRM 3106* (BGWMA). Twelve miles south of FM 2627 on Brushy Canyon road.

CACTACEAE

Ariocarpus fissuratus (Engelm.) K. Schum. – Living rock cactus
Common succulent, rocky soil, gravel terraces; DSC, SYG, 3350–ca. 4500 ft; *BA2 5278, DB 468* (SAT); *JF 274, 1479, DS2 12b* (SRSC).

§ *Coryphantha dasyacantha* (Engelm.) Orcutt. – Desert pincushion cactus
Succulent; 4125 ft; *MT 90* (SRSC). Brushy Canyon near Shackelford cabin.

Coryphantha duncanii (Hester) L.D. Benson – Duncan cory cactus
[*Escobaria dasyacantha* var. *duncanii* (Hester) N.P. Taylor] Rare (G3T1T2S1S2) succulent, open ridge, coarse gravel on rocky slope with large boulders and outcrops; DSC, ca. 2000–4146 ft; *JF 549, JF & MD 612, AMP 5373, DS2 2228* (SRSC). Mid-elevation of TC trail, upper Ore Terminal trail, near Boquillas road.

Coryphantha echinus (Engelm.) Britton & Rose var. *echinus* – Sea-urchin cactus
[*Mammillaria scolymoides* Scheidw.] Occasional succulent, rocky soils, open desert and slopes; DSC, SYG, 3500–4360 ft; *JF 593, 868, 1493, BHW 11061* (SRSC). *JF 1493* was found growing with *JF 1494*, identified as var. *robusta*, on a western slope of the DH.

Coryphantha echinus (Engelm.) Britton & Rose var. *robusta* A.M. Powell – Multi-stemmed sea-urchin cactus
Rare succulent, uplands, bare slopes, rocky soil; DSC, 2400–3650 ft; *JF 1440, 1494* (SRSC). In Ernst Basin and on western slopes of the southern DH. These collections were made approximately four and 13 miles north, respectively, of the previously known locality for this relatively new taxon.

Coryphantha sneedii (Britton & Rose) A. Berger var. *albicolumnaria* (Hester) A.D Zimmerman – Silverlace cactus
[*Coryphantha albicolumnaria* (Hester) Zimmerman, *Corphantha sneedii* var. *albicolumnaria* (Hester) A.D. Zimmerman, (forthcoming, cited in Powell and Weedin 2004), *Escobaria albicolumnaria* Hester] Rare (G2G3S2S3) succulent, gravelly flats, open ridgetop, bedrock outcrops; DSC, SYG, 1800–4840 ft; *DAZ 1541* (BIBE); *JF 556, 587, 588* (SRSC). Boquillas Canyon and high elevations of the TC trail.

Coryphantha tuberculosa (Engelm.) A. Berger var. *tuberculosa* – Cob cactus
[*Mammillaria tuberculosa* Engelm.] Common succulent, open ridge, shallow rocky soils, rock crevices; DSC, DCA, SYG, 1900–5840 ft; *CMR s.n.* (BGWMA); *JF 273, 386, 550, 625, 781, 1300, MT 89* (SRSC).

§ *Coryphantha tuberculosa* (Engelm.) A. Berger var. *varicolor* (Tiegel) A.D. Zimmerman – Varicolor cob cactus
[*Coryphantha dasyacantha* var. *varicolor* (Tiegel) L.D. Benson] Succulent; *BA2 471* (SAT).

Echinocactus horizonthalonius Lem. – Eagle claw cactus
Occasional succulent, rocky limestone soils; DSC, DCA, SYG, 4360 ft; *CMR 5173* (BGWMA); *DB 470* (SAT); *JF 591* (SRSC).

Echinocereus dasyacanthus Engelm. – Rainbow cactus
Common succulent, gravelly flats or slopes, some bedrock; DSC, SYG, 1900–5700 ft; *DB 469* (SAT); *JF 558, 623* (SRSC).

+ *Echinocereus enneacanthus* Engelm. var. *enneacanthus* – Strawberry cactus
Occasional succulent, fine soil; DSC, 1800 ft; *JF 2148* (SRSC). Observed by Amos and Giles (1992). The variety *brevispinus* (W.O. Moore) L.D. Benson occurs east of the study area with a "taxonomically ambiguous" area of overlap inside the study area near the Rio Grande (Powell and Weedin 2004).

+ *Echinocereus stramineus* (Engelm.) Rumpler var. *stramineus* – Strawberry pitaya
Common succulent, rocky soil, open exposed areas, slopes; DSC, DCA, SYG, 1800–4440 ft; *JF 780, 2149* (SRSC). Observed by Wells. Turner et al. (2003) shows dots in the study area but no specimens were discovered.

Echinomastus mariposensis Hester – Mariposa cactus
[*Neolloydia mariposensis* (Hester) L.D. Benson, *Sclerocactus mariposensis* (Hester) N.P. Taylor] Occasional (G2S2; LT/T) succulent, rocky limestone soils, slight hills, fine-gravel-surfaced flats; DSC, DCA, 3300–3520 ft; *CMR 5172* (BGWMA); *JF 391, 624, AMP & SAP 5925, DS2 2221* (SRSC).

Echinomastus warnockii (L.D. Benson) Glass & R. Foster – Warnock cactus
[*Sclerocactus warnockii* (L.D. Benson) N.P. Taylor] Occasional succulent; DSC, DCA, 1900–2560 ft; *JF 2150, BHW 47459, BHW & HKB 47012* (SRSC).

+ *Epithelantha micromeris* (Engelm.) F.A.C. Weber ex Britton & Rose – Common button cactus
Uncommon succulent, open ridges with bedrock outcrops, rock crevices; DSC, SYG, 3560–4140 ft; *JF 268a, 271, 586, 613, 613a, 1486* (SRSC). TC trail area, western slopes of DH, Alto Relex. Observed by Amos and Giles (1992).

Ferocactus hamatacanthus (Muehlenpf.) Britton & Rose var. *hamatacanthus* – Giant fishhook cactus
Occasional succulent, open rocky slopes; DCA, SYG, 4300–4900 ft; *CMR 5174* (BGWMA); *JF 590, 1507, MT 96* (SRSC).

Glandulicactus uncinatus var. *wrightii* (Engelm.) Backeb. – Eagle claw cactus
[*Ancistrocactus uncinatus* var. *wrightii* (Engelm.) L.D. Benson, *Echinocactus uncinatus* Galeotti ex Pfeiff., *Ferocactus uncinatus* (Galeotti ex Pfeiff.) Britton & Rose] Uncommon throughout, succulent, open flats, rocky areas; DSC, SYG, 3520–4040 ft; *DS2 03b, JF 548* (SRSC).

§ *Mammillaria heyderi* Muehlenpf. – Heyder pincushion cactus
"Rare" succulent; DSC, 2500 ft; *AMP, SAP, MLP, & AL2 6103* (SRSC). Near mouth of Dog Canyon in 1996.

§ *Mammillaria lasiacantha* Engelm. – Golf ball cactus
Succulent; DSC, ca. 3520 ft; *DS2 18b, 2222, JFW s.n.* (SRSC). Dagger Flats and the upper end of the Ore Trail in the 1970s.

§ *Mammillaria meiacantha* Engelm. – Nipple cactus
Succulent; *BHW 11065* (SRSC). "Dead Horse Mountains" in 1952.

Neolloydia conoidea (DC.) Britton & Rose – Texas cone cactus
Occasional to locally abundant succulent in rocky open areas; SYG, 3080–5200 ft; *JF 380, 782, DS2 2220, MT 52, 53, 122, BHW 11055, 11058* (SRSC). Dagger Flat, Brushy Canyon, Stuarts Peak. This cactus seems to be either hyper-abundant or not very noticable. In some places, like the summit of Stuarts Peak and near mile five of the TC trail (the highest point of the trail before dropping into the TC watershed), it is almost not possible to walk cross-country without stepping on individuals of this species. In these areas they seem to co-occur with *Coryphantha echinus* var. *echinus*.

Opuntia aggeria Ralston & Hilsenb. – Clumped dog cholla
Common at lower elevations, succulent, open flats and some slopes, rocky soil, perhaps more abundant in silty, clayey, or possibly gypsiferous soil; DSC, 1850–300 ft; *JF 691, 704, 1562, 1563, 1574, 1574a, 1576, 1620, BAR & RAH 136* (SRSC). The specimen *MA 5638* (BIBE) identified as *Opuntia grahamii* × *Opuntia schottii* was determined to be *Opuntia aggeria*, instead of a hybrid as was long surmised (Anthony 1956, Ralston 1987), based on morphology and its being a diploid, while the purported parents are tetraploids (Ralston and Hilsenbeck 1989). Ongoing chromosome work on the dog chollas of the southern Big Bend has uncovered the existence of a triploid hybrid (parents undetermined), an even broader species concept of *Opuntia aggeria* than was previously described (Fenstermacher unpub. data), and other anomalies, suggesting the taxonomy of this group is not completely understood.

Opuntia azurea Rose var. ***aureispina*** (S. Brack & K.D. Heil) A.M. Powell & J.F. Weedin – Golden-spined prickly pear
[*Opuntia aureispina* (S. Brack & K.D. Heil) Pinkava & B.D. Parfitt] G1S1 succulent; RIO, 1800 ft; *BGH 802* (SRSC). Boquillas Canyon, river mile 795. From a mesa NW of the Shackelford cabin. The purple prickly pear *Opuntia azurea* var. *parva*, with its small orbicular pads with very long spines, is more widespread in southern Brewster county, with var. *aureispina* being locally restricted along the Rio Grande east of Mariscal Canyon up to the eastern side of the DH Mountains. The other local variety of diploid purple prickly pears, var. *diplopurpurea*, is widespread to the west and north of BBNP (Powell and W
eedin 2004).

+ *Opuntia camanchica* Engelm. & J.M. Bigelow – Comanche prickly pear
Succulent, on terrace above river floodplain; DSC, DAR, 3560 ft; *MA 848, JF 626* (SRSC). Known locally from Hot Springs; this is the dominant and expected prickly pear of the area (Powell and Weedin 2004).

§ *Opuntia densispina* – Densely-spined dog cholla
Succulent; *DOK & JFW 53, AMP & SAP 6275* (SRSC). On Old Ore Road at Ernst Tinaja turnoff, overlook on Boquillas Canyon road. Many individuals, especially at Ernst Tinaja, fit the morphology for *Opuntia densispina* though it has been

considered restricted in distribution to the Solis area of BBNP, near the Rio Grande (Ralston and Hilsenbeck 1992, Powell and Weedin 2004). Recent chromosome work, however, supports the occurence of *Opuntia densispina* at Ernst Tinaja (J. Fenstermacher unpublished data).

Opuntia dulcis Engelm. – Sweet prickly pear
Succulent; DSC, 1800–3560 ft; *JF* 628; *AMP & SAP 6278; MPG 87, 88, 89* (SRSC).

+ *Opuntia engelmannii* Salm-Dyck ex Engelm. var. *engelmannii* – Engelmann prickly pear
Uncommon succulent, east aspect hillside, in a clump of thick vegetation; SYG, 4440 ft; *JF 589* (SRSC). Upper elevations of the TC trail. Turner et al. (2003) shows dots in the study area, in addition to the wider region, but no DH specimens were found.

§ *Opuntia engelmannii* var. *lindheimeri* (Engelm.) B.D. Parfitt & Pinkava – Texas prickly pear
Succulent; DSC, 1800 ft; *AMP & SAP 6277, JFW 1171* (SRSC). RGV area and just west of the Boquillas Canyon trailhead.

*§ *Opuntia ficus-indica* (L.) Mill. – Indian fig
Rare succulent; *BGH 646* (SRSC). Boquillas Canyon by Rabbit Ears, mile 791.

Opuntia grahamii Engelm. – Graham dog cholla
Occasional succulent, gravelly flats and low hills; DSC, 3000–3520 ft; *CMR 5178* (BGWMA); *MA 892* (BIBE); *JF 333, 377, 378, 389, 783, 892, 1142a* (SRSC). Recent chromosome work has shown that all of the *Opuntia grahamii* tested were sterile, effectively producing no pollen (J. Fenstermacher unpub. data).

Opuntia kleiniae DC. – Candle cholla
Occasional along the river, succulent, sandy banks; RIO, 1800 ft; *BGH 841, JF 2040* (SRSC).

Opuntia leptocaulis DC. – Tasajillo, christmas cactus
Occasional succulent, small drainages, terrace above wash, flats; DSC, DAR, 3360–4120 ft; *JF 388, 448, 816, WH, TA, LS & JMP 9028* (SRSC).

Opuntia rufida Engelm. – Blind prickly pear
Common succulent, rocky slopes; DSC, DAR, DCA, 1800–3560 ft; *JF 627, BGH 803, WH, TA, LS & JMP 8985* (SRSC).

Opuntia spinosibacca M.S. Anthony – Spiny-fruited prickly pear
Succulent; DSC, 1800–4600 ft; *MA A-3, A-7, JF 385, BGH 801, 842, AMP & SAP 5824, 6089* (SRSC).

Opuntia sp. – Prickly pear

Undetermined prickly pear species, chromosome count n=11, an erect shrub to one m high. *BGH 800, 840; AMP & SAP 6276* (SRSC). In Boquillas Canyon, river mile 800.5 and at overlook west of Boquillas Canyon near trailhead.

CAPPARACEAE

Koeberlinia spinosa Zucc. – Allthorn

Occasional shrub, rocky soil, exposed areas, flats and slopes; DSC, DAR, DCA, 2500–3800 ft; *WFM s.n., CMR 32* (BGWMA); *JF 1441, JF & HL 1891, MT 8* (SRSC).

CAPRIFOLIACEAE

Lonicera albiflora Torr. & A. Gray – Western white honeysuckle

Rare perennial woody vine, east aspect below cliff, sheltered high elevation drainage under trees; SYG/CHP, DCA, 4280–5680 ft; *BRM 3230* (BGWMA); *PVW s.n.* (KANU); *BA2 5436* (SAT); *JF 1296, AMP & SAP 5125* (SRSC). Brushy Canyon above BGWMA boundary, vicinity of Sue Peaks, near Shackelford cabin.

CARYOPHYLLACEAE

§ *Arenaria benthamii* Fenzl ex Torr. & A. Gray – Hilly sandwort

Annual herb; *BRM s.n.* (BGWMA). Big Brushy Canyon, 12 mi south of TX FM 2627.

Paronychia jamesii Torr. & A. Gray – James nailwort

Uncommon throughout, perennial herb, rocky soils, slightly sheltered spots; DSC, SYG, 3800–5800 ft; *BA2 5475* (SAT); *JF 235, 765, 1269a, MT 33, 248* (SRSC).

CELASTRACEAE

Mortonia scabrella A. Gray – Tickbush, Rio Grande saddlebush, sandpaper bush

Uncommon shrub, open exposed areas, shallow rocky soil amongst bedrock; DSC, SYG, 3840–5000 ft; *PVW s.n.* (KANU); *JF 268, 1167, 2190, MT 2* (SRSC). Western slopes of the DH, Alto Relex.

Schaefferia cuneifolia A. Gray – Desertyaupon

Occasional shrub, sides of washes and canyons; DSC, DAR, DCA, 1900–3300 ft; *TR 126* (BGWMA); *JF 676, 973, 1366, 2041, AMP & SAP 4302, BHW 15912* (SRSC); *AMP & SAP 4302* (TEX-LL).

CHENOPODIACEAE

Atriplex canescens (Pursh) Nutt. – Fourwing saltbush

Uncommon throughout, shrub, open exposed summits, sandy-clay and gravelly drainages; DSC, DAR, DCA, SYG, 1800–4160 ft; *BA2 5262* (SAT); *JF 336, 861, 1091, 1410, 1895, 2143, MT 203, BHW & LCH BG-132* (SRSC); *BHW & LCH BG-132* (TEX-LL).

***** *Atriplex rosea* L. – Tumbling saltweed, red orache
Rare annual herb, sandy soil, old river floodplain; RIO, 1800 ft; *AL 306* (BIBE); *AL 307, JF 2236* (SRSC). New county record; independently reestablished at the Boquillas Canyon restoration site.

*Chenopodium berlandieri* Moq. – Pitseed goosefoot
Rare annual herb, finer soils that are innundated periodically; DAR, RIO, 1800–3440 ft; *JF 361, 616, 2122, 2238* (SRSC). Above dam on the TC trail and in cracked mud of Rio Grande floodplain at the mouth of Cow Canyon. Known from the Chisos Mountains and around Alpine and Marathon.

Corispermum americanum (Nutt.) Nutt. – American bugseed
Locally common annual herb, sandy soil; DSC, RIO, 1800–2100 ft; *BHW 8330, JF 2221, 2224* (SRSC); *DSC & HBC 30630, BHW 8330* (TEX-LL). At head of Boquillas Canyon in sand slide area.

!# *Salsola tragus* L. – Tumbleweed
[*Salsola kali* L.] Locally common annual herb; sandy soil; RIO, 1800 ft; *JF 2252* (SRSC). Seen only at Boquillas restoration site where it was a common reestablishing weed.

*Suaeda suffrutescens* S. Watson var. *suffrutescens* – Desert seepweed
[*Suaeda nigra* (Raf.) J.F. Macbr.] Rare perennial subshrub in sandy soil, old river floodplain; RIO, 1800 ft; *JF 2234* (SRSC). Naturally reestablished at the Boquillas restoration site.

CONVOLVULACEAE

§ *Bonamia ovalifolia* (Torr.) Hallier f. – Bigpod lady's nightcap
"Locally common" subshrub, sandy soil, can be among rocks; DSC, RIO, 1800 ft; *BA2, DG, TE, & PC 4551; JS 303* (BIBE); *HBC 30628* (NYBG); *BA2 5502* (SAT); *BGH 622, DAL 40, AMP 3347, AMP & JH 5696, AMP & SAP 3609, 5859, GLW 4482* (SRSC); *DSC & HBC 30628, AMP 3347, AMP & SAP 3609* (TEX-LL).

Bonamia repens (I.M. Johnst.) D.F. Austin & Staples – Creeping lady's nightcap
[*Petrogenia repens* I.M. Johnst.] Common subshrub, trailing over rocks, ledges, bedrock, in shallow soils; DSC, DAR, 1800–4280 ft; *CA & BA2 69*, *BA2 6191, SMU 41* (BGWMA); *CA s.n.* (SAT); *JF 154, 307, 435, 1075, 2062, 2131, MT 167, BHW & MCJ 16834* (SRSC).

Convolvulus equitans Benth. – Texas bindweed
Uncommon throughout, perennial herbaceous vine, wash gravel, sandy clay bottom; DAR, DCA, RIO, 1800–4350 ft; *BRM 3149* (BGWMA); *JF 1945, EGM 150* (BIBE); *BA2 5309, 5470, 5720* (SAT); *JF 181, 853, 1349, 1432, 1945, 2077, 2116* (SRSC).

Dichondra brachypoda Wooton & Standl. – New Mexico ponysfoot
Rare perennial herb, well shaded spots, deep duff layers at side of washes under shrubs,; DAR, DCA, 3056–4600 ft; *JF 859, 1122, AMP & SAP 5134* (SRSC). Dagger and Telephone canyons, and near Shackelford cabin above BGWMA boundary. Listed by Amos and Giles (1992). Known also from the Chisos Mountains and northward.

Evolvulus alsinoides (L.) L. – Slender dwarf morning-glory
Occasional perennial herb, wash bottoms/sides, base of cliffs in shade, protected rocky areas; DSC, DAR, DCA, 1900–3880 ft; *TR 249* (BGWMA); *BA2 5312, 5464* (SAT); *JF 209, 309, 957, 1472, 2060, TR 250; MT 127* (SRSC).

§ *Ipomoea cardiophylla* A. Gray – Heartleaf morning-glory
Rare annual vine; *BHW 10799* (SRSC). Collected in 1952 on top of the DH near Sue Peaks.

Ipomoea costellata Torr. – Crest-rib morning glory
Rare but locally common perennial herbaceous vine, shallow soil amongst rocks and boulders; SYG, 5300–5840 ft; *JF 1994* (BIBE); *JF 1969, 1994, MT 241* (SRSC). Sue Peaks environs. Observed during current study only after significant rains. Also known locally from the Chisos Mountains and near Boquillas Canyon.

§ *Ipomoea lindheimeri* A. Gray – Lindheimer morning-glory
"Infrequent" perennial herbaceous vine, on juniper; 3520 ft; *MA & AD 874* (SRSC). At Dagger Flat in 1948.

Ipomoea rupicola House – Cliff morning-glory
Occasional to uncommon perennial herbaceous vine, open rocky slopes in shallow soil, over boulders, sides of washes; DSC, DAR, DCA, SYG, 3050–4800 ft; *JF 248* (BIBE); *JF 248, 308, 1103, 1186, 1196, MT 31, 144, 172, BHW 962, BLT & BD 23-167, OCW 352, BHW & LCH BG-148, BHW & MCJ 16828* (SRSC); *BLT & BD 23-167* (TEX-LL).

§ *Ipomoea tenuiloba* Torr. – Spiderleaf
Rare perennial herbaceous vine; *MT 236* (SRSC). North rim of the DH proper [north of Stuarts Peak] in 1994.

CRASSULACEAE

Echeveria strictiflora A. Gray – Siempreviva, desert savior
Rare succulent; shallow, dark soil; SYG/CHP, 5700–5840 ft; *BRM 3224* (BGWMA); *JF 1263, 1301, BHW 10774* (SRSC).

Sedum nanifolium Fröd. – Dwarf stonecrop
[*Sedum robertsianum* Alexander, *Sedum parvum* Hemsl. subsp. *robertsianum* (Alexander) R.T. Clausen] Rare, but locally occasional, succulent, shallow lenses of soil within large areas of bedrock exposures; SYG, 5150 ft; *JF 1215* (BIBE & SRSC).

DH plateau. Warnock (1977) reported that this species was "frequent" in the Del Norte and Glass Mountains, the Del Nortes being the type locality for the synonymized population (Clausen 1981). This taxon is part of a Mexican cohort of species/infraspecific taxa that occur in the Sierra Madre highlands; the higher-elevation yellow-flowered sedums are now split into two species, ours being widespread in eastern Chihuahua, Coahuila, Nuevo León, but apparently rarer in the Trans-Pecos. In the U.S., *Sedum nanifolium* was only known to occur in Brewster County (Nesom and Turner 1995), but was recently reported in the southern sliver of Pecos County on the Guadalupe Ranch (M. Terry pers. comm.).

Sedum wrightii A. Gray – Wright stonecrop

Rare succulent, crevices in highly fractured bedrock outcrops; SYG, 4200–5000 ft; *JF 581, 1163, 1506* (SRSC). On western slopes, below the DH plateau. Known locally from the Chisos Mountains and other area peaks.

CROSSOSOMATACEAE

Glossopetalon spinescens A. Gray – Spiny greasebush

[*Forsellesia spinescens* (A. Gray) Greene] Uncommon shrub, sheltered areas, by cliff outcrops, ridges; SYG, 4200–5000 ft; *PVW s.n.* (KANU); *JF 1205, 1505, BHW 10843* (SRSC). In the vicinity of Sue Peaks, on and just below the DH plateau.

CUCURBITACEAE

Ibervillea lindheimeri (A. Gray) Greene – Lindheimer globeberry

Rare perennial herbaceous vine, in dappled shade, growing on *Aloysia gratissima*; DSC, 3080 ft; *JF 1143* (SRSC). Known locally from the Chisos Mountains and further north through Brewster County.

§ *Ibervillea tenuisecta* (A. Gray) Small – Slimlobe globeberry

Uncommon perennial herbaceous vine; DSC, 3500–3800 ft; *BA2 5368* (SAT); *MA & AD 3500*, *BHW 10802, MT 206* (SRSC); *BHW 10802* (TEX-LL). Near Sue Peaks, in Dagger Flat, and near the Shackelford cabin.

EBENACEAE

Diospyros texana Scheele – Texas persimmon

Common to occasional shrub, washes; DAR, DCA, 1800–3840 ft; *BRM 3146*, *CMR 5080* (BGWMA); *BA2 5239, MC 157, CMR 15102* (SAT); *JF 689, 2088, WH, TA, LS, & JMP 8986* (SRSC).

EUPHORBIACEAE

Acalypha monostachya Cav. – Round copperleaf

[*Acalypha hederacea* Torr.] Common perennial herb, flats, rock crevices, wash bottoms; DSC, DAR, DCA, 1850–3050 ft; *BA2 5237, 5334* (SAT); *JF 1069, 1118, 1680, BHW 646, 21200* (SRSC); *BHW 646* (TEX-LL).

Acalypha phleoides Cav. – Shrubby copperleaf
[*Acalypha lindheimeri* Müll. Arg.] Occasional perennial herb, wash gravel, rock crevices; DAR, DCA, 2200–4800 ft; *JF 1946* (BIBE); *TR 68, CMR 11583* (BGWMA); *BA2 5240, 5265* (SAT); *JF 1108, 1128, 1149, 1946, JF & MY 1315, TR 68, MT 187* (SRSC); *OCW s.n.* (TEX-LL).

Andrachne arida (Warnock & M.C. Johnst.) G.L. Webster – Trans-Pecos maidenbush
Rare but locally common (G2S1) shrub, open rocky western slopes with bedrock outcrops and rocky soil; SYG, 4200–4900 ft; *JF 1170, 1194, 1207, 1499, 2164, 2177, BHW 10767, 1077,; BHW & MCJ 16681, 16840, 16841* (SRSC). Limited to a thin elevation range on a few western slopes of the DH. This species may occur more widely throughout the range in similar elevations.

Bernardia obovata I.M. Johnst. – Desert myrtlecroton
Occasional shrub, rocky hillsides, talus slopes, drainages; DSC, DAR, DCA, 1920–4900 ft; *CMR 5134, BHW & LCH s.n.* (BGWMA); *BA2, DG, TE, & B 4925* (BIBE); *BA2 5250, BR 293* (SAT); *JF 203, 496, 642, 715, 1093, 1212, MT 86, BHW 10832, BHW & LCH BG-178, BHW & MCJ 16833* (SRSC); *BHW 10832, BHW & LCH BG-178* (TEX-LL).

Chamaesyce acuta (Engelm.) Millsp. – Pointed sandmat
Rare perennial herb, very shallow rocky soil on bedrock; SYG, 5700 ft; *JF 1264* (SRSC). On north ridgeline of northern Sue Peak. Known also from western Brewster County and east towards the Edwards Plateau.

Chamaesyce albomarginata (Torr. & A. Gray) Small – Whitemargin sandmat
Uncommon perennial herb, cracked, silty clay hills, flats, low elevations; DSC, DAR, 1800–2560 ft; *JF 1447* (SRSC); *HBP & VLC 30177, OES 1540* (TAES). Dog Canyon, Ernst Basin, along the Rio Grande below Hot Springs.

Chamaesyce chaetocalyx (Boiss.) Wooton & Standl. – Bristlecup sandmat
Locally common subshrub, rock crevices, talus slope; DSC, DCA, 1960–4600 ft; *BHW & LCH s.n.* (BGWMA); *JF 261, 652, 943, AMR & SAP 5142, MT 32, 68, BHW & LCH BG-176* (SRSC). Flanks of Stuarts Peak, Passionflower Canyon, Brushy Canyon, north of the Barker House.

Chamaesyce cinerascens (Engelm.) Small – Ashy sandmat
[*Euphorbia cinerascens* Engelm.] Occasional perennial herb, rocky slopes, sandy soil, cracks in bedrock, flats, drainages; DSC, DAR, DCA, SYG, 1800–4450 ft; *OCW s.n.* (BGWMA); *BA2, DG, TE, & B 4934* (BIBE); *BA2 5291, 5526, 5705* (SAT); *JF 174, 340, 342, 489, 547, 653, 684, 863, 1078, 1087, 1171, 1337, 2133, 1645, AMP & SAP 3612, 5305, AMP, SAP, MLP, & AL2 6101, MT 3, 66, 67, 165, 166, BLT 22-146, BHW 10756, 10762, 10840, 18393, BHW & LCH BG-66, BHW & MCJ 15908, GLW 4442* (SRSC); *DSC & HBC 30632, BLT 22-146, BHW 10756, 10762, BHW & LCH BG-66* (TEX-LL).

Chamaesyce fendleri (Torr. & A. Gray) Small – Fendler sandmat
[*Euphorbia fendleri* Torr. & A. Gray] Uncommon perennial herb, rock cracks, shallow soil pockets; DSC, SYG, CHP, 3000–5250 ft; *JAM & JAS 3444* (NYBG); *BA2 5210, 5276, 5619, 5692* (SAT); *JF 784, 1235, 1243, 1470, 2197* (SRSC). Stuarts Peak, DH plateau, TC trail, Brushy Canyon, Boquillas Canyon. Turner et al. (2003) does not reflect the historical collections.

Chamaesyce glyptosperma (Engelm.) Small – Rib-seed sandmat
"Frequent" annual herb, in sandy soil; RIO, DSC, 1800–3120 ft; *JF 223, BHW & BLT 8317* (SRSC); *BHW & BLT 8325* (TEX-LL). At the head of Boquillas Canyon and in the north Dagger Mountain area.

§ ***Chamaesyce golondrina*** (L.C. Wheeler) Shinners – Boquillas sandmat
Rare but locally frequent (G2S2) annual herb, sandy soil; DSC, ca. 1800 ft; *AL 175, BHW 998* (BIBE); *WRC & PM212199, AMP & SAP 3613, BHW 20900, 20951, 20954, 23035, BHW & MCJ 16854, BHW & BLT 8325a, 8325b, GLW 4484* (SRSC); *AMP & SAP 3613* (TEX-LL). At head of Boquillas Canyon at sandslide. Known also from Mariscal Canyon area in BBNP.

+ *Chamaesyce serpens* (Kunth) Small – Matted sandmat
Rare annual or perennial herb, sandy clay bottom; DSC/DAR, 2400 ft; *JF 1422* (SRSC). In Ernst Basin, near the remnant tobosa grassland patch. Known also from Dog Flats.

§ *Chamaesyce serpyllifolia* (Pers.) Small – Thyme-leaf sandmat, thymeleaved spurge
Uncommon annual herb, sandy to limestone soil; DSC, 3800 ft; *BHW 10794* (TEX-LL). DH near McKinney springs.

Chamaesyce serrula (Engelm.) Wooton & Standl. – Sawtooth sandmat
Uncommon but locally frequent annual herb, flats to high ridges; DSC, SYG, 1800–5100 ft; *EGM 165* (BIBE); *JF 2196, BHW 10794, 10838* (SRSC); *BHW 10838* (TEX-LL). DH plateau, near McKinney Springs, Boquillas.

Chamaesyce theriaca (Wheeler) Shinners – Terlingua sandmat, Terlingua broomspurge
Rare to frequent annual herb, sandy soil, rock cracks, slopes; DSC, DCA, 1800–3800 ft; *CMR 15117* (SAT); *JF 2018, 2095, AMP & SAP 6138, 6139, BHW 13033, 23402, BHW & LCH BG-180, BHW & MCJ 16678, 16680, BHW & BLT 8325, 8326* (SRSC); *BHW & BLT 8325, 8326* (TEX-LL). Boquillas Canyon, Ernst Tinaja, Stairstep Mountain, Frog Tank, Frog Canyon.

Chamaesyce triligulata (L.C. Wheeler) B.L. Turner – Bristlecup sandmat, three-tounge spurge
[*Chamaesyce chaetocalyx* var. *triligulata* (L.C. Wheeler) Mayfield, *Chamaesyce fendleri* (Torr. & Gray) Small var. *triligulata* (L.C. Wheeler) Shinners] Rare (G5T1S1) perennial herb, rocky cliffs, rock cracks; DSC, DCA, 1800–2200 ft; *AL 164, 165* (BIBE); *JF 1695, AMP & SAP 3611, BHW 20899, BHW & MCJ 16960* (SRSC). Locally frequent at the Boquillas sand slide site.

Chamaesyce villifera (Scheele) Small – Hairy sandmat
Rare perennial herb, shallow soil on open rocky slopes; SYG, 4360–5840 ft; *JF 1173, 1305, 1960* (SRSC). Known from the Chisos and Glass Mountains, and from south-central Texas.

Croton bigbendensis B.L. Turner – Big Bend croton
Occasional perennial herb, sandy to limestone soils, open exposed areas; DSC, 3000–3880 ft; *JF 292, 707, 1463, 1904, MT 158* (SRSC); *BLT & BD 23-163* (TEX-LL).

§ *Croton dioicus* Cav. – Grassland croton, hierba del gato
Perennial herb; DSC, 2150 ft; *EGM 144* (BIBE); *WGD s.n.* (TAES); *BHW & LCH BG-64* (SRSC & TEX-LL). "Frequent and widespread" at Stairway Mountain in 1950, but not observed during the current study. This species is more common in northern Brewster County.

Croton fruticulosus Engelm. ex Torr. – Bush croton, encinilla
Occasional perennial herb, wash gravel, looser soil, protected areas; DAR, DCA, 2200–4100 ft; *BRM 3137, TR 72, 73, OCW 314* (BGWMA); *JF 298* (BIBE); *JF 298, 300, 509, 1114, TR 72, 73, MT 40, 98, 256, OCW 340, BHW 10748* (SRSC); *BHW 10748* (TEX-LL).

Croton incanus Kunth – Torrey croton
Rare shrub, wash gravel; DCA, 1800 ft; *JF 2128, BHW 18406* (SRSC). Boquillas Canyon.

+ *Croton lindheimerianus* var. *tharpii* M.C. Johnst. – Tharp croton
Rare annual herb, sandy clay bottom; DSC/DAR, 2400 ft; *JF 1427* (BIBE & SRSC). In Ernst Basin in the patch of remnant tobosa grassland. Also known from the flats near Dog Canyon. Listed by Amos and Giles (1992).

§ *Croton pottsii* (Klotzsch) Müll. Arg. – Leatherweed
Perennial herb; 2200–2400 ft; *TR 71* (BGWMA & SRSC). Brushy Canyon.

Croton thermophilus (M.C. Johnst.) B.L. Turner – Leatherweed
[*Croton pottsii* var. *thermophilus* (M.C. Johnst.) M.C. Johnst.] Occasional (G5T2S1) perennial herb, sandy soil to open gravelly limestone soils; DSC, DCA, SYG, 1850–4400 ft; *BRM 3113* (BGWMA); *AL 158* (BIBE); *JF 175, 353, 431, 457, 682, 1077, 1397, 1541, 1932, 2011, 2058, MT 159, BHW 18401, 20895, BHW & MCJ 16837, 16862, BHW & BLT 8321, GLW 4439* (SRSC).

Ditaxis humilis (Engelm. & A. Gray) Pax – Low silverbush
[*Argythamnia humilis* (Engelm. & A. Gray) Müll. Arg., *A. laevis* Torr.] Rare perennial herb, platey limestone; DSC, 2560–2760 ft; *JF 152, 1404, BHW & LCH BG-201* (SRSC). Ernst Tinaja and Passionflower Canyon environs, east slopes Stairway Mountain.

Ditaxis neomexicana (Müll. Arg.) A. Heller – New Mexico ditaxis
[*Argythamnia neomexicana* Müll. Arg.] Occasional to common perennial herb, washes, rocky soil; DSC, DAR, 1800–3500 ft; *CMR 5032* (BGWMA); *EGM 133, BHW 12889* (BIBE); *BA2 5319, 5584* (SAT); *JF 168, 439, 674, 2051, BLT 22-151, BHW 12889, BHW & LCH BG-199, BHW & MCJ 16858* (SRSC); *BLT 22-151, BHW 12889* (TEX-LL).

Euphorbia antisyphilitica Zucc. – Candelilla
Common perennial herb, sandy alluvial flats, rocky limestone flats and slopes; DSC, DAR, DCA, SYG, 1900–4400 ft; *BA2 5241, 5695* (SAT); *JF 259, 573, 778, MT 84, 170, BHW & MCJ 16839* (SRSC); *AT 2243* (TEX-LL).

Euphorbia brachycera Engelm. – Horned spurge
Uncommon perennial herb, wash gravel, base of cliffs; DCA, SYG/CHP, 3500–5680 ft; *JF 160* (BIBE); *BHW & LCH s.n.* (BGWMA); *BA2 2513, 5445* (SAT); *JF 1273, 1290, 1934, 1940, AMP & SAP 5141, BHW & LCH BG-174* (SRSC). Sue Peaks environs, TC, Brushy Canyon.

Euphorbia eriantha Benth. – Desert poinsettia, beetle spurge
Uncommon annual herb, talus slopes below cliffs; DSC, 1800–1850 ft; *JF 2010, 2103; BGH 634* (SRSC). Limited to Boquillas Canyon, patchy distribution in desert scrub along sides of the canyon.

Euphorbia exstipulata Engelm. – Square-seed spurge
Uncommon annual herb, mid slopes, open peak, flats; DSC, SYG, 2800–5840 ft; *JF 198, 1980, BHW & MCJ 16832* (SRSC). North Dagger Mountain, Sue Peaks.

Jatropha dioica var. *graminea* McVaugh – Sangre de drago, leatherstem
Common perennial herb, rocky often unconsolidated soils; DSC, DAR, DCA, 1800–4360 ft; *CMR 17230* (BIBE); *BA2 5479* (SAT); *JF 709, 586, 2029, BHW 12902, 13073* (SRSC).

Phyllanthus polygonoides Nutt. ex Spreng. – Knotweed leafflower
Occasional subshrub, wash gravel, sometimes soil; DSC, DAR, DCA, 1850–4360 ft; *BHW & LCH s.n.* (BGWMA); *JF 160* (BIBE); *BA2 5206, 5292, 5593, 5693* (SAT); *JF 160, 205, 297, 526, 825, 1074, 1400, TRV s.n., BHW & LCH BG-146, BHW & MCJ 16830, GLW 4450* (SRSC).

Tragia amblyodonta (Müll. Arg.) Pax & K. Hoffm. – Dogtooth noseburn
Uncommon in central DH areas, perennial herb, rocky soils, rock crevices; DSC, DAR, DCA, 2680–5680 ft; *JF 146, 718, 832, 1297, BLT 22-150, BHW & LCH BG-188* (SRSC); *BLT 22-150* (TEX-LL).

Tragia ramosa Torr. – Branched noseburn

Uncommon perennial herb, shallow soil with rocks and boulders; DSC, 2120–5840 ft; *TR 74, CMR 5085* (BGWMA); *BA2 5208, 5283, 5694* (SAT); *JF 688, 1966* (SRSC). Sue Peaks, Brushy Canyon, Frog Tank.

FABACEAE

Acacia berlandieri Benth. – Guajillo

Rare tree, exposed southern exposures, amongst bedrock outcrops; DSC, SYG, 2520–4700 ft; *JF 669* (BIBE); *JF 669, 2187, BHW 21189b* (SRSC); North of the Barker House and western slopes of the DH. Primarily a south Texas species, it is known as far west as the Candelaria area of western Presidio County.

Acacia constricta Benth. ex A. Gray – Whitethorn acacia

Occasional shrub or tree sandy soil, general rocky limestone soil; DSC, DCA, 2350 ft; *CMR 11592* (BGWMA); *LF 86, PAS 58* (SHST); *JF 1385* (SRSC); *VB 355* (TEX-LL).

Acacia farnesiana (L.) Willd. – Huisache

[*Acacia smallii* Isely] Uncommon tree, sandy to silty soil; DSC, RIO, 1800 ft; *BHW 13040* (BIBE); *JF 2030, EJL 126-H, TCM 2003-66b, PM 2037, AMP 3348, BHW 13040, 18386* (SRSC); *AMP 3348, BHW 13040* (TEX-LL). Along river and in old floodplain areas, Boquillas Canyon area.

Acacia greggii A. Gray var. *greggii* – Catclaw acacia

Uncommon shrub; DSC, DAR, DCA, 2350 ft; *SJ 6505* (SAT); *JF 1372, BHW 21201, 21204* (SRSC). Ernst Tinaja area, mouth of Heath Creek, near Frog Tank.

Acacia neovernicosa Isely – Viscid acacia

Uncommon to occasional at lower elevations, shrub or tree platey limestone, sandy clay drainage, sandy rocky slopes; DSC, DAR, DCA, 1800–3408 ft; *EGM 149* (BIBE); *JF 934, 1089, 1462, 2020a-c, BHW 20777* (SRSC).

+ *Acacia rigidula* Benth. – Blackbrush acacia

Uncommon tree, rocky or sandy terraces above the Rio Grande; DSC/ RIO, 1000–1850 ft; *JF 2002, 2027* (SRSC). In Boquillas Canyon. Primarily a south Texas species, it has been collected as far west as Mariscal Canyon in BBNP.

Acacia roemeriana Scheele – Roemer acacia

Common shrub or tree rock crevices in drainages and ridgetops, wash beds and sides; DSC, DAR, DCA, 1800–4180 ft; *BRM 3116, BHW & LCH s.n.* (BGWMA); *JF 249, 644, 1012, BHW & LCH BG-147* (SRSC).

§ *Acacia schottii* Torr. – Schott acacia

Rare shrub or tree; DSC; *BHW 20896* (SRSC). Hills at Boquillas.

+ *Astragalus austrinus* (Small) Schulz – Smallflowered milkvetch
[*Astragalus nuttallianus* var. *austrinus* (Small) Barneby] Rare annual or perennial herb, alluvial terrace and slope; DSC, DAR, DCA, 3000–3560 ft; *JF 426, 540b, 804* (SRSC). Below Ernst Tinaja and around the TC trail about 3.5 miles in.

§ *Astragalus mollissimus* (Greene ex Rydb.) Tidestr. – Woolly locoweed
Perennial herb; *BA2 4755, SJ 4755* (SAT). Ernst Tinaja area.

§ *Astragalus wrightii* A. Gray – Wright milkvetch
Annual herb; *VLC 43964* (TEX-LL). Dog Canyon. This collection is not reflected in Turner et al. (2003).

+ *Calliandra iselyi* B.L. Turner – Falsemesquite
Occasional subshrub, platey limestone hills, open gravelly desert, perhaps some in clayey or gypsous soil, also deeper soils at higher elevations; DSC, SYG, 2800–5150 ft; *JF 813, 938, 1142, 1324, 1469* (SRSC). The low woody *Calliandra* common in this area has been commonly referred to as *Calliandra conferta*; that species is now thought to occur east of BBNP.

§ *Cercis canadensis* subsp. *mexicana* (Rose) E. Murray – Mexican redbud
"Infrequent" to “common” tree, wash gravel, limestone valley; 3500-4600 ft; *BA2 5232* (SAT); *AMP & SAP 5140* (SRSC), *BHW & LCH BG-172* (SRSC & TEX-LL). Apparently occurs only on the eastern side of the DH, beginning in the northward-draining Brushy Canyon.

§ *Dalea aurea* Nutt. ex Fraser var. *aurea* – Golden prairie clover
Perennial herb; *BRM 3223* (BGWMA); *BA2 5318* (SAT). Near Shackelford cabin, Brushy Canyon.

Dalea formosa Torr. – Feather dalea, plume dalea
Occasional shrub, gravelly flats and ridges, wash gravel, rocky loamy soil; DSC, DAR, DCA, SYG/CHP, 2560–5840 ft; *CMR 17225* (BIBE); *BA2 315, 5191, 5538* (SAT); *JF 483, 559, 1014, 1047,1096, 1402, 1914, 1996, MT 136* (SRSC); *VB 342* (TEX-LL).

Dalea frutescens A. Gray var. *frutescens* – Black dalea
Uncommon throughout, shrub, lowlands and ridges; DSC, DAR, DCA, SYG, 3350–5800 ft; *BA2 5484, 5332* (SAT); *JF 374a, 1195, MT 230, 245, BHW 10754* (SRSC); *BHW 10754* (TEX-LL).

Dalea greggii A. Gray – Gregg prairie clover
[*Dalea alopecuroides* Willd.] Uncommon subshrub, rocky limestone hills and mesa tops; DSC, SYG, 3800-4600 ft; *OCW 9022* (BGWMA); *BA2 5277, 5469, 5548* (SAT); *JF 1038, OCW 337* (SRSC). Brushy Canyon and "top of the DH mountains SW of Frog Tank".

§ *Dalea jamesii* (Torr.) Torr. & A. Gray – James prairie clover
Perennial herb; *BA2 5228* (SAT). Near Shackelford cabin.

§ *Dalea laniceps* Barnebey – Woolyhead prairie clover
Perennial herb; *MT 150* (SRSC). Brushy Canyon north of Shackelford cabin.

§ *Dalea leporina* (Aiton) Bullock – Foxtail prairie clover
Annual herb, gravelly flats; DSC; *OCW 584-21* (TAES). West of Frog Tank road.

§ *Dalea longipila* (Rydb.) Cory – Downy prairie clover
Uncommon perennial herb, dry calcareous soils along arroyos and mountain ridges; DSC, DAR, ca. 2500 ft; *AMP & SAP 6140, BLT & MT2 97-344* (SRSC); *BLT & MT2 97-344* (TEX-LL). Ernst Tinaja area.

+ *Dalea nana* Torr. & A. Gray – Dwarf prairie clover
Uncommon perennial herb, wash bed and mountain ridge; DAR, SYG/CHP, 2750–5700 ft; *JF 959, 1265* (SRSC). North Sue Peak and Passionflower Canyon.

Dalea neomexicana (A. Gray) Cory – New mexico dalea
"Frequent" perennial herb, dry calcareous soils along arroyos and on mountain ridges, rock crevices, sandy soil; DSC, DCA, 1800–3440 ft; *BHW 13032* (BIBE); *JF 357, BHW 13032, BHW & MCJ 16679, BHW & BLT 8319, GLW 4473* (SRSC); *BHW 13030* (TAES); *BLT & MT2 97-334, BHW 13032, BHW & BLT 8319* (TEX-LL).

Dalea pogonathera A. Gray var. *pogonathera* – Bearded dalea
Uncommon throughout, perennial herb, talus/unconsolidated slope, streambed; DSC, DAR, 3560 ft; *BRM 3119, OCW 5094* (BGWMA); *JF 461* (BIBE & SRSC); *BHW & LCH BG-196* (SRSC); *BA2 5377, 5488* (SAT); *VLC 43968* (TEX-LL).

§ *Dalea terminalis* M.E. Jones – Wooly prairie clover
[*Dalea lanata* var. *terminalis* (M.E. Jones) Barneby] Uncommon perennial herb, limestone crevices, rocky ledges, gravelly streambed, sandy soil; DSC, DCA, 1800 ft; *BA2, DG, TE, & PC 4602, BHW 13030* (BIBE); *BLT, JDA & BHW 8337, BHW 13030, GLW 4480* (SRSC); *BHW 13030* (TAES); *DSC & HBC 30629, BHW 13030* (TEX-LL). At the head of Boquillas Canyon. The individuals collected seem to more closely resemble *Dalea lanata* of the northern Trans-Pecos sand hills; The "intermediate" specimen *DSC & HBC 30629* (from Boquillas Canyon) was reviewed by Barneby (1977) and referred to *Dalea terminalis*, seemingly based on geography more than morphological characters. Other Rio Grande corridor specimens examined fit the description for *Dalea terminalis*, where the Boquillas Canyon ones may be a disjunct sand hills population. Other sand-loving species have disjunct populations at Boquillas including *Heliotropium convolvulaceum* and *Corispermum americanum*.

Dalea wrightii A. Gray – Wright dalea
Uncommon throughout, perennial herb, wash gravel and dry mountain ridges; DSC, DAR, 2750–3560 ft; *BA2 5430* (SAT); *JF 282, 468a, 962, MT 13, 15, 220, BLT &*

MT2 97-345, 97-349, BHW C300 (SRSC); *VLC 43969, BHW C300* (TEX-LL). *MT 220* has been identified as *Dalea wrightii* var. *warnockii*, but varietal distinctions are not clear for the remaining specimens.

Desmanthus velutinus Scheele – Velvet bundleflower
Uncommon in northern part of range, perennial herb, rock crevices, open slopes, drainages; DSC, DAR, SYG, 3360–5840 ft; *JF 227, 322, 713a, 1097, 1910, 1978, MT 35* (SRSC).

Eysenhardtia texana Scheele – Texas kidneywood
Occasional shrub, washes; DCA, DAR, 1800–4150 ft; *WFM 27, CMR 5125, 11611, OCW s.n., 320a* (BGWMA); *BA2 5254* (SAT); *SCB 223, JF 201, 1112, 1929, 2136, JF & MY 1318, MT 195, OCW 320, BHW & LCH BG-63* (SRSC).

Galactia sp. – Milkpea
Rare perennial herb, wash gravel usually in shade, rock crevices; DAR, DCA, 1800–2780 ft; *JF 961* (BIBE); *JF 188, 940, 961, 1060, 2090, 2141* (SRSC); *JF 2090* (TEX-LL). Passionflower Canyon, and within one mile of the Rio Grande inside Cow Canyon and Arroyo Venado from Boquillas Canyon. The individuals seen were larger, more robust, and more abundant at the Boquillas Canyon sites, perhaps indicating it is a Mexican species. Mexican specimens of this genus at TEX-LL are on loan to another institution, precluding further work on identification at the time of writing. More of a description and pictures of this species (Fig. 32) are included within the body of the thesis.

+ *Hoffmannseggia drepanocarpa* A. Gray – Sicklepod rushpea
Rare annual herb, fine, siltier soil; SYG, 5300 ft; *JF 1998* (SRSC). At the high saddle west of the northern Sue Peak. This was yet another species occuring in the distinctly different patch where the vegetation was representative of lower-elevation tobosa grassland environments.

Leucaena retusa Benth. – Goldenball leadtree, woohoo tree
Occasional tree, washes, open slopes, in the northern part of the range; DSC, DAR, DCA, 2200–5200 ft; *WFM s.n.* (BGWMA); *PVW s.n.* (KANU); *BA2 5190* (SAT); *JF 748, 1020, 1309, AMP & SAP 5144, TR 19, OCW 1, BHW 10849, BHW & LCH BG-135, GLW 4472* (SRSC); *RB 1502, BHW & LCH BG-135* (TEX-LL).

§ *Lupinus havardii* S. Watson – Big bend bluebonnet
Annual herb, wash; DAR, 2560 ft; *OES 1344* (TEX-LL). Dog Canyon wash. Turner et al. (2003) shows many dots close to the study area, especially along the Rio Grande.

*§ *Medicago sativa* L. – Alfalfa
Annual herb; 1800 ft; *EGM 136a* (BIBE & SRSC). At Boquillas in 1937. Turner et al. (2003) does not reflect this collection.

*§ *Melilotus indicus* (L.) All. – Annual yellow sweetclover
"Infrequent" annual herb; 1800 ft; *HTF 1225* (SRSC). Along the Rio Grande at Boquillas in 1933.

Mimosa aculeaticarpa var. *biuncifera* (Benth.) Barneby – Catclaw mimosa
[*Mimosa biuncifera* Benth.] Common shrub, washes; DSC, DAR, DCA, 3050 ft; *WFM 26, 29, 30* (BGWMA); *BA2 5238, 5702* (SAT); *JF 1150* (SRSC).

Mimosa borealis A. Gray – Fragrant mimosa
"Infrequent" to common shrub, drainages; DAR, DCA, 1900–3760 ft; *JF 711, 1693, BHW 21186* (SRSC).

Mimosa emoryana Benth. – Emory mimosa
Occasional shrub, arid desert plains and hills, drainages/canyons; DSC, DAR, DCA, 2850–3560 ft; *JF 848, 970, GLW 4445* (SRSC).

+ *Mimosa texana* (A. Gray) Small – Catclaw
Occasional shrub, wash gravel and banks, open rocky soil; DAR, DCA, SYG, 1800–4600 ft; *JF 1015, 1019, 1357, 2145* (SRSC).

Mimosa turneri Barneby – Desert mimosa, Turner mimosa
Uncommon shrub, limestone terraces, sandy gravel, open high ridges; DSC, DAR, SYG, 3000–4900 ft; *JF 1161, 1467, 1552, 2188* (SRSC). Western slopes of the DH and in the TC trail area. Known locally from the west side of the Chisos Mountains, and more recently from near Lone Mountain (Fenstermacher et al. 2006).

Parkinsonia aculeata L. – Retama, Jerusalem thorn
Rare tree, sandy soil near river; RIO, 1800 ft; *DG 217* (BIBE); *JF 2257* (SRSC). At head of Boquillas Canyon.

Peteria scoparia A. Gray – Rush peteria
Rare shrub, open limestone slope/slight valley, north aspect; DSC, 3840 ft; *JF 247* (SRSC). North end of Alto Relex, up from TC trail. Considered more of a Davis Mountain species, it has also been collected in the Chinati Mountains of Presidio County and in various mountain ranges of the western Trans-Pecos.

Pomaria melanosticta S. Schauer – Parry holdback
[*Caesalpinia parryi* (E. Fisher) Eifert, Correll & Johnston, *Caesalpinia melanosticta* (S. Schauer) Fisher, *Caesalpinia wootonii* (Britt.) Eifert ex Isely, *Hoffmannseggia parryi* (Fisher) B.L. Turner] Occasional subshrub, washes, rocky hillsides; DSC, DAR, DCA, 1800–3500 ft; *BRM 3148, CMR 5143a-c, BHW & LCH s.n.* (BGWMA); *AL 183; BHW 884, 12891* (BIBE); *BA2 5383, 5431* (SAT); *JF 148, 343, 655, 1328, 2130, 2182, BLT & MT2 97-332, BHW 10830, 12891, 20952, BHW & LCH BG-141, BHW & MCJ 16063, 16835, MT 221* (SRSC); *BHW & MCJ 16835* (SWT); *BLT & BD 23-168, BLT & MT2 97-332, BHW 12891, BHW & LCH BG-141* (TEX-LL).

+ *Prosopis glandulosa* Torr. – Mesquite
Occasional shrub or tree open rocky soil; DSC, DAR, SYG, 1800–4400 ft; *JF 807* (SRSC). Usually at elevations below 3400 ft, one lone individual was observed in an open high saddle near mile five of the TC trail at 4400 ft. Listed by Amos and Giles (1992).

+ *Rhynchosia senna* var. *texana* (Torr. & A. Gray) M.C. Johnst. – Texas snoutbean
Rare perennial herbaceous vine, in duff layer and shaded by shrubs, next to slickrock washbed; DCA, 3050 ft; *JF 1119* (BIBE & SRSC). Dagger Canyon.

+ *Senna bauhinioides* (A. Gray) H.S. Irwin & Barneby – Twinleaf senna
[*Cassia bauhinioides* A. Gray] Occasional perennial herb, open hot desert; DSC, 2400–3000 ft; *JF 1457, 1465* (SRSC).

Senna lindheimeriana (Scheele ex Schltdl.) H.S. Irwin & Barneby – Lindheimer sennna
Rare perennial herb, wash gravel, arid plains and hills; DSC, DAR, 1800 ft; *JF 2072, MT 101* (SRSC). Shackelford lodge environs and at Arroyo Venado, one half mile up from the Rio Grande.

Senna orcuttii (Britton & Rose) H.S. Irwin & Barneby – Orcutt senna
Uncommon (G2S2) perennial herb, gravel wash, shallow soil amongst boulders and slickrock outcrops; SYG, CHP, 4200–5250 ft; *JF 1030* (BIBE); *JF 827, 1030, 1218, 1244, 2191, MT 110, BLT 22-153* (SRSC); *JF 1030, BLT 22-153* (TEX-LL). DH plateau, high TC trail, Brushy Canyon. Known also from northern Brewster County mountains and sparsely in Terrell County.

Senna pilosior (Robinson ex J. F. Macbr.) H.S. Irwin & Barneby – Trans-Pecos senna
[*Senna durangensis* (Rose) H.S. Irwin & Barneby] Occasional perennial herb, flats, rock crevices, talus slopes; DSC, DCA, 1800–3500 ft; *JF 437, 673, 1326, 1603, 2020, 2048, CN T263, BHW 20953, GLW 4475* (SRSC); *LEB 9640* (TAES); *BHW 20727* (TEX-LL).

§ *Senna pumilio* (A. Gray) H.S. Irwin & Barneby – Dwarf senna
Northwest of Dagger Flat loop in gravelly outwash; 3200 ft; *PDW & BHW 319* (SRSC).

Senna ripleyana (H.S. Irwin & Barneby) H.S. Irwin & Barneby – Ripley senna
Rare (G1SH) perennial herb, open, gradually sloping hillside, in somewhat unconsolidated rocky soil; SYG, 4320–5000 ft; *JF 820, 1518, MT 214* (SRSC). TC trail mile six and above road in pass at head of Margaret Basin. A sterile specimen (*MT 214*) was collected in 1994 and thought to be *Senna durangensis*, but the specimen collected during this study (with flower and fruit) enabled a mixed collection at SRSC (*BHW 23518*) to be corrected and subsequently all individuals were accurately identified as *Senna ripleyana* by B.L. Turner.

§ *Sophora secundiflora* (Gomez-Ortega) Lag. ex DC. – Mescal bean
Shrub, creek bed; DCA; *BRM 3248* (BGWMA). Frog Canyon, three miles south of BGWMA headquarters.

Vicia ludoviciana Nutt. var. *occidentalis* (Shinners) B.L. Turner – Deer pea vetch
[*Vicia leavenworthii* Torr. & Gray, *Vicia ludoviciana* ssp. *leavenworthii* (Torr. & Gray) Lassetter & Gunn.] Uncommon annual herb, rubbly soil on north-facing alluvial slope in curve of canyon; DCA, 3560 ft; *BRM 3114* (BGWMA); *JF 540, BHW & MCJ 15994* (SRSC). Dog Canyon, TC trail area, Brushy Canyon.

FAGACEAE
Quercus grisea Liebm. – Gray oak
Uncommon shrub, terraced outcrops, rocky soil; CHP, 4880–5680 ft; *JF 757* (BIBE); *JF 744c, 757, 1246, 1258, 1280, 1282, 1320, MT 149, 225, 240, 250* (SRSC); *JF 1282* (TEX-LL). Environs of Stuarts and Sue Peaks.

§ *Quercus intricata* Trel. – Dwarf oak
Shrub; 5800 ft; *PVW s.n.* (KANU). Both summits of Sue Peaks. As noted in Wells (1965) and Powell (1998), *Quercus intricata* is rarely found north of the international border with Mexico. In the U.S. it also occurs in the Chisos Mountains of BBNP and in the Eagle Mountains of Hudspeth County.

Quercus laceyi Small – Lacey oak
Rare shrub, wash gravel/rocks; DCA, 4350 ft; *JF 1935* (SRSC). In Sue Peaks canyon. This is a new park record, also having been found recently in Panther Canyon of the Chisos Mountains (*AL s.n.* BIBE). The farthest west known locality for this species is the Solitario, as reported in Hardy (1997). That collection (*Warnock 23860* BBRSP) is not reflected in Turner et al. (2003). Terrell County was previously the western edge of its known range.

Quercus mohriana Buckl. ex Rydb.– Mohr shin-oak
Uncommon shrub, peaks, high slopes and terraces; CHP, 5240–5840 ft; *JF 1245, 1972, 2161* (SRSC). Summit plateau of the DH and environs of Sue Peaks. This species is expected on limestone, and does occur in the Glass and Del Norte Mountains of northern Brewster County.

Quercus pungens Liebm. – Sandpaper oak
[*Quercus pungens* subsp. *vaseyana* (Buckley) E. Murray] Occasional shrub, summits, ridgetops, drainages/washes; DSC, DCA, SYG/CHP, 3150–5680 ft; *CMR 15828, BHW & LCH s.n.* (BGWMA); *JF 303, 1223* (BIBE); *PVW s.n.* (KANU); *BA2 5193, 5203, 5214, 5224, 5225, 5243, 5251, 5275, 5279, 5328, 5450, 5459, 5485, 5709* (SAT); *JF 234, 303, 725, 736a, 749a-b, 818, 819, 1209a, 1220, 1022, 1045, 1223, 1308, 1550, 1709, 1897, JF & MY 1318a, AMP & SAP 5139, MT 76, 82, 83, 111, 112, 113, 117, 118, 130, 135, 139, 140, 142, 143, 186, 192, 194, 247, BHW 10755, 21184, 23397, BHW & LCH BG-163* (SRSC); *BHW 10755, BHW & LCH BG-163* (TEX-LL). This is the common scrub oak of the DH area. This species has

commonly been split into two separate taxa, but is lumped here following Turner et al. (2003). In general, there is a lot of variability in the species; on the whole, however, the *Quercus vaseyana* morphological form, with wavy-margined and mostly entire leaves, is more common in the DH.

FOUQUIERIACEAE

Fouquieria splendens Engelm. – Ocotillo, devil's coachwhip

Common shrub, rocky soils, open flats, slopes, and ridges; DSC, SYG, 1800–4880 ft; *JM 89* (SAT); *JF 750, 779* (SRSC).

GARRYACEAE

Garrya ovata subsp. *goldmanii* (Wooton & Standl.) Dahling – Goldman or eggleaf silktassel

Uncommon shrub, wash gravel, talus slope, sheltered terrace by cliffs, high plateau/summit; DCA, SYG, CHP, 4040–5840 ft; *PVW s.n.* (KANU); *JF 504, 770, 1202, 1239, 1307, PM 975, MT 114* (SRSC). Highest peaks, DH plateau, Brushy and Telephone canyons. Other treatments put this species into the Cornaceae family, and it is listed as such by Amos and Giles (1992) and Wells (1965).

GENTIANACEAE

Centaurium arizonicum (A. Gray) A. Heller – Arizona centaury, rosita

Uncommon annual herb, slight depressions/drainages, wet places; DSC, DAR, RIO, 1800–3640 ft; *JF 710a, HTF 1232, MT 10* (SRSC). Flanks of Stuarts Peak, TC trail, Boquillas Canyon.

Centaurium calycosum (Buckley) Fernald – Centaury

Uncommon to "rare" or "sparse" annual herb, high plateau, rocky soil; CHP, 5150 ft; *BA2 5194, 5689* (SAT); *JF 1323, AMP & SAP 5130, TR 153, MT 178, 196, BHW & LCH BG-156* (SRSC). Summit plateau of DH, Brushy Canyon near Shackelford cabin.

Eustoma exaltatum (L.) Salisb. ex G. Don – Catchfly prairie gentian

Uncommon annual herb, sandy soil; RIO, 1800 ft; *BA2, DG, TE, & PC 4604, EGM 135, BHW 648, 13048* (BIBE); *JF 2254*, *BHW 13048* (SRSC); *BHW 13048* (TEX-LL). Along the Rio Grande at Boquillas, Boquillas restoration site.

HYDRANGACEAE

Fendlera falcata Thornber – Cliff fendlerbush

Rare shrub, high drainages, cracks in cliff faces, shallow soil amongst rocks and boulders; SYG, CHP, 4040–5840 ft; *JF 721a, 1266, 1277, 1963* (SRSC). Summit plateau of DH and Stuarts and Sue Peaks environs. Also known from the Glass and Del Norte Mountains.

Philadelphus microphyllus A. Gray var. *microphyllus* – Littleleaf mockorange
Rare shrub, crevices in bedrock outcrops/cliffs, base of chert-rich limestone outcrop; SYG, CHP, 4040–4900 ft; *JF 719, 726, 753* (SRSC). Stuarts Peak area: high western drainage and summit ridge. Known from the other high mountain ranges in the region: the Chisos, Glass, and Davis Mountains.

HYDROPHYLLACEAE

Nama dichotomum (Ruiz & Pav.) Choisy – Wishbone fiddleleaf
Rare annual herb, shallow dark soil amongst rocks and boulders; CHP, 5840 ft; *JF 1965* (SRSC). Summit of southern Sue Peaks. New county record. Known also from the Franklin, Guadalupe, and Davis Mountains—the highest elevations in Texas.

Nama havardii A. Gray – Havard fiddleleaf
Uncommon annual herb, hillsides, loose gravel; DSC, DAR, 1800–3480 ft; *JF 317, 2035* (SRSC); *AT 2241* (TEX-LL). TC trail and in the Boquillas area.

Nama hispidum A. Gray – Bristly nama
Uncommon annual herb, flats, wash gravel; DSC, DAR, 1850–3560 ft; *AL 176* (BIBE); *JF 477, 1006, GLW 4467* (SRSC); *BHW C307* (TEX-LL). Dagger Flats, Boquillas, TC trail.

Phacelia congesta Hook. – Spike phacelia, bluecurls
Uncommon annual herb, wash, in shade and good duff, open bare peak, sandy soil; DAR, DCA, SYG, 2560–5080 ft; *JF 423, 505a, 744a* (SRSC); *RRI 556* (TEX-LL). Dog Canyon, Stuarts Peak, TC trail.

Phacelia pallida I.M. Johnst. – Pale phacelia
[*Phacelia petiolata* I.M. Johnst.] Rare (G2S1) perennial herb, base of rock outcrop/cliff and in small cave to side of wash, in chalky to gravelly soil; DCA, 2780–2850 ft; *JF 185, 954* (SRSC). Passionflower Canyon. Taxonomy of these specimens should be explored with other collections from the area, both north and south of the Rio Grande, to resolve the relationship between/nomenclature of *Phacelia pallida* and *Phacelia petiolata*. *Phacelia pallida* was previously thought to occur only in Terlingua (just west of BBNP). As mentioned in Powell et al. (in prep.), the U.S. specimens of *Phacelia pallida* don't exactly match the original species description. It may be that all U.S. specimens are actually *Phacelia petiolata* which was described from Ojinaga, Chihuaha (Mexico) but has since been placed into synonomy with *Phacelia pallida* by many authors: Henrickson and Johnston (2004) and Turner et al. (2003) use *Phacelia pallida*, Poole et al. (2007) uses *Phacelia petiolata.*

§ *Phacelia popei* Torr. & A. Gray – Pope phacelia
Annual herb, alluvial sand on flats; DCA, 2560 ft; *RRI 553* (TEX-LL). At the mouth of Dog Canyon in 1941.

Phacelia robusta (J.F. Macbr.) I.M. Johnst. – Stout phacelia
Rare to "infrequent" annual herb, cracks in cliff walls, wash gravel; DAR, DCA, 2000–3150 ft; *JF 1587, 1703, BHW 18402* (SRSC). Marufo Vega trail and environs, Boquillas Canyon.

JUGLANDACEAE
§ *Juglans major* (Torr.) A. Heller – Arizona walnut
Tree; DCA; *CMR 2602, 2607* (SAT). Frog Canyon.

Juglans microcarpa Berland. – Little walnut
Occasional tree, wash gravel; DCA, 3050 ft; *JF 1151* (BIBE & SRSC); *WFM s.n., CMR 5130* (BGWMA); *BA2 5235* (SAT). Rare in the BBNP side of the range, only in Dagger Canyon. More common east of the NPS boundary, in Brushy and Frog Canyons. In BBNP, known also from the Chisos Mountains.

KRAMERIACEAE
Krameria erecta Willd. ex Schult. – Range ratany
[*Krameria parvifolia* Benth.] Uncommon shrub, open limestone soil; DSC, SYG, 3800–4360 ft; *BA2 5344* (SAT); *JF 569, BHW 10792* (SRSC); *BHW 10792* (TEX-LL). TC trail mile six, near McKinney Springs and Shackelford cabin.

Krameria grayi Rose & Painter – White ratany
Occasional shrub, rocky ridges and slopes with bedrock outcrops, sandy soil in floodplain; DSC, DCA, RIO, SYG; 1800–4800 ft; *SMU 49, TR 52* (BGWMA); *BA2, DG, TE, & B 4920* (BIBE); *BA2 5189, 5480* (SAT); *JF 236, 371, 828, 1056, 1188, 1898, 2102, TR 17, 152, MT 85, BHW & LCH BG-195, BHW & MCJ 16863* (SRSC); *BHW 636* (TEX-LL).

LAMIACEAE
Hedeoma costata Hemsl. – Ribbed false pennyroyal
Rare perennial herb, east aspect cliff wall and washbed gravel; DCA, SYG/CHP, 4650–5680 ft; *JF 1283a, 1951* (SRSC). Near top of southern Sue Peak in in Sue Peak canyon. Also known locally from the Chisos Mountains and north through Brewster County.

§ *Hedeoma drummondii* Benth. – Drummond pennyroyal
Annual or perennial herb, rocky limestone soils; *BLT 22-147* (TEX-LL). Head of Brushy Canyon near Shackelford cabin.

Hedeoma nana (Torr.) Briq. – Dwarf false pennyroyal
Occasional annual or perennial herb, gravel wash, rock outcrops, north aspects or more sheltered spots; 2120–5800 ft; *JF 679* (BIBE); *JF 494, 534, 546, 679, 869, 949, 1042, 1270, 1329, 1702, 1719, BLT 22-152* (SRSC). Listed by Amos and Giles (1992) as *Hedeoma nanum* var. *nanum*.

§ *Hedeoma plicata* Torr. – Veiny false pennyroyal
Perennial herb, rocky limestone soils; *BRM 3129, CMR 5071* (BGWMA); *BLT 22-152* (TEX-LL). Brushy and Frog canyons. These collections are not reflected in Turner et al. (2003). Known also from the Chisos and Del Norte Mountains and further west.

Hedeoma serpyllifolia Small – Reverchon false pennyroyal
[*Hedeoma reverchonii* var. *serpyllifolia* (Small) R.S. Irving] Occasional perennial herb, rocky limestone soils, bare peaks, rock outcrops, trailside; DSC, SYG, 3560–5080 ft; *JF 740* (BIBE); *JF 230, 281, 740, 834* (SRSC). New county record. More of a central/south Texas species, the closest previous collections shown in Turner et al. (2003) were from eastern Val Verde County.

§ *Mentha arvensis* L. – Wild mint
Rare perennial herb, hills and ravines; 1800 ft; *EGM 158, 167, BHW 832* (BIBE); *BHW 832* (SRSC & TEX-LL). At Boquillas and locally along the Rio Grande in 1937. Turner et al. (2003) shows Boquillas as the only collection location within Brewster County.

Salvia greggii A. Gray – Autumn sage
Uncommon shrub, wash gravel in shade, east aspect talus slope and cliff wall; DAR, DCA, SYG/CHP, 3500–5680 ft; *BRM & BPM 3103* (BGWMA); *JF 505, 766, 1283, 2171, TR 154, MT 107, BHW & LCH BG-171* (SRSC). Western flanks of DH, Stuarts and Sue Peaks, TC trail near mile seven, Brushy Canyon area.

Salvia roemeriana Scheele – Cedar sage, Roemer sage
Uncommon perennial herb, crevices in cliff/canyon walls; DCA, SYG/CHP, 2000–5840 ft; *JF 1284, 1671, 1675, 1975, BHW 18404* (SRSC); *BHW 18404* (TEX-LL). Boquillas Canyon, Sue Peaks environs, Strawhouse Canyon.

§ *Teucrium depressum* Small – Small coastal germander
[*Teucrium cubense* var. *densum* Jeps., *Teucrium cubense* subsp. *depressum* (Small) E.M. McClint. & Epling] Uncommon annual herb, wet places, open ground near pond; 1800–3520 ft; *HTF 1234, BHW 8331, GLW 4465* (SRSC). Along the Rio Grande at Boquillas and at Dagger Flats 1933-1952.

LINACEAE

Linum berlandieri Hook. – Berlandier flax
Occasional annual or perennial herb, wash gravel, open ridge in shallow soil with north-east aspect; DSC, DAR, DCA, SYG, 3560–4600 ft; *CMR 5090*; *BHW & LCH s.n.* (BGWMA); *ACK 827* (BIBE); *BA2 5338, 5568* (SAT); *JF 265, 295, 525, 552, 826, 1049, AMP & SAP 5137, BHW & LCH BG-149* (SRSC).

Linum hudsonioides Planch. – Texas flax
[*Cerastium clawsonii* Correll] Rare perennial herb, southwest rocky slope; DSC, 3800 ft; *JF & HL 1893* (SRSC). On Dagger Mountain. Known locally from the Chisos Mountains, to the north, and is also in central Texas.

Linum rupestre (A. Gray) Engelm. ex A. Gray – Rock flax
Occasional perennial herb, wash gravel, rock crevices, rocky slopes; DSC, DAR, DCA, 1800–3840 ft; *BRM 3136*, *BHW & LCH s.n.* (BGWMA); *BA2 5218, 5310, 5703* (SAT); *JF 241, 276, 847, 1016, 2071, MT 48, 177, TR 282, OCW 509, BHW 10828, BHW & LCH BG-84, BG-164* (SRSC); *BHW 10828* (TEX-LL).

LOASACEAE
Cevallia sinuata Lag. – Stinging cevallia
Occasional perennial herb, rocky limestone soils; DSC, DAR, DCA, 2000–3400 ft; *CMR 5077* (BGWMA); *JF 172, 808, 1383, 1724, MT 218* (SRSC).

Eucnide bartonioides Zucc. – Yellow rocknettle
Uncommon to occasional annual or perennial herb, rock crevices, wash gravel, sheltered mini-cave in finer soil; DSC, DCA, 1800–3700 ft; *BA2 & PC 4754* (BIBE); *BRM 3104* (BGWMA); *BA2 4754, 5509* (SAT); *JF 177, 286, 532, 2089, BHW 18400, 20619* (SRSC). Many dead plants were observed on the walls of DH canyons, indicating that this species was once more abundant than it is currently. This perception is supported by recollections of the Hot Springs trail by at least one long-time area resident (Yuhas pers. comm.).

+ *Mentzelia mexicana* H.J. Thompson & Zavortink – Mexican blazingstar
Rare perennial herb, wash gravel, sandy bank; DAR, DCA, 1800 ft; *JF 2031, 2066* (SRSC). Boquillas Canyon and Arroyo Venado. Turner et al. (2003) shows dots in the study area but no specimens were discovered.

+Δ *Mentzelia multiflora* (Nutt.) A. Gray – Desert mentzelia
Annual or perennial herb. Observed at the Boquillas restoration site; Turner et al. (2003) shows many dots along the Rio Grande in the study area but no specimens were found.

+ *Mentzelia oligosperma* Nutt. – Chickenthief, stickleaf
Rare perennial herb, rock crevices; DSC, DCA, 2350–3720 ft; *JF 231, 1333* (SRSC). North Dagger Mountain area and upstream of Ernst Tinaja. Turner et al. (2003) shows dots in the study area but no specimens were discovered.

Mentzelia pachyrhiza I.M. Johnst. – Coahuila blazingstar
Uncommon perennial herb, igneous rock outcrop, chalky talus slopes, roadside; DSC, DCA, 2850–3640 ft; *JF 312, 840, 950, BHW 13071* (SRSC). TC trail, Passionflower Canyon, and near tunnel.

LOGANIACEAE
Buddleja marrubiifolia Benth. – Wooly butterflybush
Occasional shrub, talus slopes, rocky limestone soils– hills and drainages; DSC, DAR, DCA, 1850–3900 ft; *CMR 11586* (BGWMA); *SJ 6502* (SAT); *JF 150, 436, 835, 1375, 1721, 2012, MT 9, 168, BHW 10759, BHW & LCH BG-77* (SRSC); *BHW 10759, BHW & LCH BG-77* (TEX-LL).

LYTHRACEAE

§ *Lythrum californicum* Torr. & A. Gray – California loosestrife
"Infrequent" perennial herb; 1800 ft; *BHW 896* (TEX-LL). At head of Boquillas Canyon in 1937. That this species still occurs within the study area is probable; many collections have been made in BBNP and Brewster County into the 1990s, including at Hot Springs.

MALPHIGIACEAE

Janusia gracilis A. Gray – Helicopter bush, slender janusia
Occasional perennial herbaceous vine, rock crevices, drainages with thicker brush, dry soils along arroyos and ridges; DSC, DAR, DCA, 1800–3720 ft; *EGM 122* (BIBE); *CMR 15112* (SAT); *JF 242, 647, 1332, AMP & SAP 5308, BLT & MT2 97-377, BHW 10793* (SRSC); *BLT & MT2 97-337* (TEX-LL).

MALVACEAE

Abutilon malacum S. Watson – Yellow indian mallow
Uncommon subshrub, base of pouroffs, gravelly soil; DSC, DAR, DCA, 1850–2050 ft; *EGM 154* (BIBE); *JF 643, 1082, 1604, 1643, 2004, 2019, BHW 12886* (SRSC). North of the Barker House, Boquillas Canyon, Marufo Vega trail near river.

Abutilon parvulum A. Gray – Dwarf indian mallow
Uncommon perennial herb, wash gravel, cut banks, thickets of vegetation; DSC, DAR, DCA, 2750–3700 ft; *AF 187* (BIBE); *JF 841, 969, 1140, 2169* (SRSC). TC trail, Passionflower Canyon, Dagger Flat.

Abutilon wrightii A. Gray – Wright indian mallow
Occasional perennial herb, rock crevices, dry limestone soil; DSC, DAR, DCA, 1800–3560 ft; *TR s.n.* (BGWMA); *JF 469a, 668, 1011, 1648, 2084, BLT & BD 23-171* (SRSC); *BLT & BD 23-171, BHW 9158, 10839* (TEX-LL).

§ *Herissantia crispa* (L.) Brizicky – Netvein mallow
"Frequent" subshrub, rocky gullies and canyons; DSC, DAR, 1800–1900 ft; *HCH s.n., BHW 13064* (SRSC); *HCH s.n.* (TEX-LL). At Boquillas and near tunnel.

Hibiscus coulteri Harv. ex A. Gray – Desert rosemallow
Occasional subshrub, wash gravel, talus slope, rocky hills; 2400–4300 ft; *JF 444, 846, 1480, 1582, 2184, MT 51, BHW 10820, BHW & LCH BG-152* (SRSC); *BHW 10820, BHW & LCH BG-152* (TEX-LL).

Hibiscus denudatus Benth. – Paleface rosemallow
Rare subshrub, rocky limestone soils; DSC, DCA, 3200 ft; *BRM 3120* (BGWMA); *JF 1471* (SRSC). TC trail area, Brushy Canyon.

§ *Hibiscus martianus* Zucc.– Heartleaf rosemallow
"Sparse" subshrub, limestone soil; 2100 ft; *OCW 358* (SRSC). Cave Canyon in Black Gap Refuge, 1961.

*# *Malva parviflora* L. – Cheeseweed mallow
Rare annual or perennial herb, sandy soil, old river floodplain; RIO, 1800 ft; *AL 304, 308* (BIBE & SRSC). Boquillas Canyon restoration site. New park record; collected during the study period by park staff at the Boquillas restoration site. Also known locally from the Glass Mountains and the Solitario.

§ *Malvella lepidota* (A. Gray) Fryxell – Scurfymallow
Perennial herb; DAR, 2560 ft; *OES 1335* (TAES). Dog Canyon. Turner et al. (2003) does not reflect this collection.

Malvella leprosa (Ortega) Krapov. – Alkali mallow, dollarweed
Rare perennial herb, sandy clay bottom; DSC/DAR, 2400 ft; *JF 1423* (SRSC). Ernst Basin, in remnant patch of tobosa grassland. New park record. Several collections (SRSC) have been made of this species in Brewster County which are not reflected in Turner et al. (2003).

§ *Rhynchosida physocalyx* (A. Gray) Fryxell – Spearleaf sida, buffpetal
"Infrequent" perennial herb, limestone soil; 2250 ft; *BRM 3171* (BGWMA); *BHW & LCH BG-194* (SRSC). Frog Canyon, east slopes of Stairway Mountain.

Sida abutifolia Mill. – Spreading sida
Occasional perennial herb, chalky soil at base of cliffs, bedrock outcrops, rocky slopes; DSC, DCA, 1800–2850 ft; *JF 166, 956, 1325, 1439, 2008, HCH s.n.* (SRSC).

+ *Sida longipes* A. Gray – Stockflower fanpetals
Uncommon perennial herb, open rocky ridgeline, rocky slopes; DSC, DAR, SYG, 3440–4800 ft; *JF 1539, 1920, 2175* (SRSC). TC trail mile five and at dam, western slopes below DH plateau. Turner et al. (2003) shows dots in the study area but no specimens were discovered. Listed by Amos and Giles (1992).

Sphaeralcea angustifolia (Cav.) G. Don – Narrowleaf globemallow
Occasional perennial herb, sandy clay bottom, wash gravel, sandy soil, summit ridge; DSC, DAR, DCA, RIO, SYG, 1800–5300 ft; *BRM 3121, CMR 11593* (BGWMA); *CN 499* (BIBE); *JF 585, 803, 1415, 1461, 1986, 2104, 2268, BH 641* (SRSC); *BHW 247* (TEX-LL). Abundant at the Boquillas Canyon restoration site.

§ *Sphaeralcea hastulata* A. Gray – Spear globemallow
"Infrequent" perennial herb; DCA, 2560 ft; *RRI 21431* (TEX-LL). Dog Canyon. Turner et al. (2003) does not reflect this specimen.

NYCTAGINACEAE

Acleisanthes angustifolia (Torr.) R.A. Levin – Narrowleaf moonpod
[*Selinocarpus angustifolius* Torr.] Occasional to uncommon subshrub, sandy to calcareous soils along arroyos and ridges; DSC, DAR, DCA, 1800–3720 ft; *JF 243*

(BIBE); *JF 243, 844, 1352, 2015, 2022, BLT & BD 23-160, BHW 9159, 10790, BHW & MCJ 16846, BHW & BLT 8324* (SRSC); *BLT & BD 23-160, BLT & MT2 97-346b, BHW 10790* (TEX-LL).

Acleisanthes longiflora A. Gray – Angel trumpets, hierba de la rabia
Uncommon perennial herb, cut banks, ledges; DSC, DCA, 1850–4000 ft; *BA2 5188* (SAT); *JF 1070, MT 157, GLW 4479* (SRSC). Boquillas canyon, near Shackelford cabin.

Allionia incarnata L. – Trailing four o'clock, pink windmills
Occasional perennial herb, rocky slopes and flats, clayey soil, platey limestone; DSC, DCA, 1800–2750 ft; *EGM 168* (BIBE); *BA2 5356* (SAT); *JF 171, 651, 936, 2065, AMP & SAP 5304, BHW 20879, BHW & MCJ 16848* (SRSC); *BHW 702* (TEX-LL).

§ *Ammocodon chenopodioides* (A. Gray) Standl. – Goosefoot moonpod
[*Acleisanthes chenopodioides* (A. Gray) R.A. Levin] Perennial herb, sandstone derived soil along base of rocky hill; *BLT & BD 23-160* (SRSC). Brushy Canyon road.

§ *Anulocaulis eriosolenus* (A. Gray) Standl. – Big bend ringstem
[*Boerhavia eriosolena* A. Gray] "Infrequent to locally common" annual or perennial herb, gravel banks, dry calcareous soils along arroyos and ridges; DSC, DAR, DCA, 1800–2320 ft; *EGM 146* (BIBE); *AMP & SAP 6141, BLT & MT2 97-351, BHW 16676, 20878, 20949* (SRSC); *DSC & HBC 30639, OES 1632, BLT & MT2 97-340* (TEX-LL).

Boerhavia anisophylla Torr. – Wineflower
Uncommon perennial herb, rock crevices, boulders; DAR, DCA, 1800–3000 ft; *JF 1468, 2073, 2134, AMP & SAP 3614, BHW 16690, BHW, BLT, & JDA 8335* (SRSC); *BHW 21031, BHW, BLT, & JDA 8335* (TEX-LL). TC trail and Boquillas Canyon.

+ *Boerhavia diffusa* L. – Red spiderling
Rare annual or perennial herb, rock crevices in canyon wall; DCA, 3065 ft; *JF 1120* (SRSC). Dagger Canyon.

§ *Boerhavia intermedia* M.E. Jones – Spreading spiderling
Uncommon to “frequent” annual herb, rocky slopes, arroyos; DSC, DAR, DCA, 1800–2320 ft; *AMP, SAP, MLP & AL2 6102, TRV s.n., BHW 20877, BHW & LCH BG-185BHW & BLT 8315* (SRSC); *HCH s.n., AMP & SAP 3614, BLT & MT2 97-342* (TEX-LL). Boquillas area and Ernst Tinaja.

§ *Boerhavia linearifolia* A. Gray – Narrowleaf spiderling
Annual herb, SW-facing limestone slope; 4600 ft; *BA2 6190, CMR 5060, OCW 5810-1* (BGWMA); *BA2 5326* (SAT); *AMP & SAP 5120* (SRSC). Frog Tank and Brushy Canyon.

§ *Boerhavia spicata* Choisy – Creeping spiderling
"Infrequent to frequent" annual herb; 1800 ft; *BHW 695, 20948, BHW & MCJ 16849* (SRSC). Boquillas Canyon environs.

§ *Boerhavia torreyana* (S. Watson) Standl. – Creeping spiderling
[*Boerhavia spicata* Choisy var. *torreyana* S. Watson] Annual herb, frequent in sandy soil; 2100 ft; *BHW 8315* (TEX-LL). Head of Boquillas Canyon in 1948. A newer taxon recognized in the Flora of North America (FNA 2003a), it is more widespread than its relative *Boerhavia spicata*.

Cyphomeris gypsophiloides (M. Martens & Galeotti) Standl. – Birdfruit, red cyphomeris
Uncommon perennial herb, rock crevices, rocky slopes and flats; DSC, DAR, DCA, SYG, 1800–4360 ft; *JF 348* (BIBE); *BA2 5449* (SAT); *JF 348, 545, 951, 1172, 2086* (SRSC). Dog Canyon, TC trail, and Boquillas Canyon.

§ *Mirabilis albida* (Walter) Heimerl – White four o'clock
[*Mirabilis grayana* (Standl.) Standl.] Perennial herb; *BA2 5527* (SAT). Near Shackelford cabin.

Mirabilis linearis (Pursh) Heimerl – Linearleaf spiderling
Rare perennial herb, shallow soil amongst rocks on open summit; SYG/CHP, 5300–5840 ft; *JF 1982, 2159* (SRSC). Northern Sue Peak. Widely represented in Turner et al. (2003), from the Chisos Mountains northward. This species concept includes *Mirabilis decumbens* and *Mirabilis gausapoides* (Turner et al. 2003).

Mirabilis texensis (J.M. Coult.) B.L. Turner – Texas mirabilis
Uncommon perennial herb, wash gravel, dry calcareous soils along arroyos and mountain ridges; DSC, DAR, DCA, 2750–4200 ft; *JF 165, 809, 960, 1502, 2173, BLT & MT2 97-343, BHW 10776, 10844, BHW & MCJ 16829* (SRSC); *BLT & MT2 97-343* (TEX-LL). Passionflower Canyon, TC trail area, Ernst Tinaja environs, Heath Canyon.

§ *Nyctaginia capitata* Choisy – Devil's boquet
Perennial herb; *TM 137* (SAT). Frog Canyon in 1968.

OLEACEAE

Forestiera angustifolia Torr. – Narrowleaf forestiera
Common shrub, rocky slopes, wash gravel; DSC, DAR, DCA, 1920–4400 ft; *BHW & LCH BG-153* (BGWMA); *BA2 5256, 5266* (SAT); *JF 374, 493, 572a, 2181, JF & HL 1899, AMP & SAP 5826, BHW 18411, 21203, BHW & LCH BG-153, BHW & MCJ 15996, GLW 4459* (SRSC); *WBM 2022* (TAES).

Fraxinus cuspidata Torr. – Fragrant ash
Rare to "sparse" tree; DAR/DCA, 3500-4800 ft; *BHW & LCH BG-173* (BGWMA & SRSC); *JF 1947* (SRSC). In a high side drainage of Sue Peaks Canyon and an upper valley of Brushy Canyon. Also known locally from the north Rosillos and Chisos Mountains.

Fraxinus greggii A. Gray – Gregg ash
Common shrub, wash gravel/boulders, open rocky ridges; DSC, DAR, DCA, SYG, 2500–4900 ft; *TR 243* (BGWMA); *BA2 5358, 5570* (SAT); *JF 246, 568, 728, 1131, TR 296, MT 07b, BHW 20623, BHW & MCJ 15983* (SRSC).

Menodora longiflora A. Gray – Showy menodora, twinpod
Occasional perennial herb, calcareous and sandy arroyos, rock crevices on slopes; DSC, DAR, DCA, 2350–4600 ft; *CMR 5062, OCW 9027* (BGWMA); *JF 334* (BIBE); *BA2 5447, 5528* (SAT); *JF 226, 334, 517, 946, 1115, 1359, 1360, AMP & SAP 5122, 5145, MT 7* (SRSC).

Menodora scabra A. Gray – Rough menodora
[*Menodora scoparia* Engelm. ex Gray] Common subshrub, rocky slopes; DSC, DAR, DCA, 1800-5080 ft; *BHW 1123, 12887* (BIBE); *BA2 5699* (SAT); *JF 582, 754, 1482, 1520, BGH 639, MT 56, 180, 222, BHW 10783, 10803, 12887, 13037* (SRSC); *BHW 10783, 12887* (TEX-LL). Listed by Amos and Giles (1992).

ONAGRACEAE

§ *Calylophus greggii* A. Gray – Gregg sundrops
[*Calylophus hartwegii* (Benth.) P.H. Raven subsp. *pubescens* (A. Gray) Towner & P.H. Raven] "Infrequent" subshrub in sandy soil along the Rio Grande at Boquillas in 1933; 2150 ft; *HTF 1225* (SRSC).

Calylophus hartwegii (Benth.) P.H. Raven subsp. *hartwegii* – Hartweg sundrops
Uncommon perennial herb, wash gravel; DCA, 1800–3050 ft; *BA2, DG, TE, & PC 4609* (BIBE); *BA2 5247* (SAT); *JF 1110, 117a, OCW 508* (SRSC). Dagger Canyon, Boquillas Canyon, Brushy Canyon.

Gaura boquillensis P.H. Raven & D.P. Gregory – Boquillas gaura
Occasional (G2S2) subshrub, sandy soil/old floodplain, gravel and boulders, rocky hillside in duff and shade; DSC, DCA, RIO, 1800–4400 ft; *JS & AL 301, 304* (BIBE); *JF 1363, 1380, 1538, 2091, 2117, 2147, AMP & SAP 3608, BHW 1008, 18397, GLW 4481* (SRSC); *BHW 1008* (TAES); *AMP & SAP 3608* (TEX-LL).

§ *Gaura calcicola* P.H. Raven & D.P. Gregory – Texas beeblossom
"Infrequent" perennial herb; 2200–2400 ft; *TR 75* (SRSC). Brushy Canyon.

Gaura coccinea Pursh – Scarlet gaura
Occasional perennial herb, sandy clay bottom, lower areas; DSC, DAR, 2200–3520 ft; *TR 75* (BGWMA); *BA2 5186, 5248, 5290, 5306, 5522, 5563, 5576* (SAT); *JF 1418, 1460, BLT & BD 23-173, GLW 4449* (SRSC); *BLT & BD 23-173* (TEX-LL).

§ *Gaura parviflora* Lehm. – Velvetweed
[*Gaura mollis* Kunth] Perennial herb, sandy soil, old river floodplain; RIO, 1800 ft; *AL 305* (BIBE). Boquillas Canyon trail at river restoration site.

§ *Ludwigia peploides* (Kunth) P.H. Raven – Floating primrose-willow
"Infrequent to rare" perennial herb; RIO, 1800 ft; *HTF 1231, EGM 159* (SRSC); *EGM 159, BHW C297* (TEX-LL). Along the Rio Grande at Boquillas in the 1930s.

+ *Oenothera brachycarpa* A. Gray – Shortpod evening-primrose
Rare perennial herb, thin, platey, shallow gravel, in pockets between flat bedrock outcrops; DCA, SYG/CHP, 3560–5200 ft; *JF 521, 1311, 1953* (SRSC). TC trail mile three, summit plateau of DH. According to Turner et al. (2003), this is the eastern-most locality known in Brewster County.

Oenothera kunthiana (Spach) Munz – Kunth sundrops
Occasional annual or perennial herb, terraces above washes, flats; DSC, DAR, DCA, RIO, 1800–3560 ft; *BRM 3170, CMR 5139* (BGWMA); *JF 510, HTF 1229, AMP & SAP 4300, 5388, BHW 18384, 47055* (SRSC); *RRI & BHW 21362* (TEX-LL). Turner et al. (2003) does not reflect these historical collections.

§ *Oenothera laciniata* Hill – Cutleaf evening-primrose
Annual or perennial herb; *BA2 5513, 5574* (SAT). Near Shackelford cabin. These collections are not reflected in Turner et al. (2003).

§ *Oenothera primiveris* A. Gray – Large yellow desert primrose
"Frequent" annual herb, limestone soil; 2000 ft; *BHW & MCJ 16088* (SRSC & TEX-LL). Strawhouse Canyon in 1958. Also known from Hot Springs and Dog Flats.

+ *Oenothera rosea* L'Hér. ex Aiton – Rose sundrops
Rare perennial herb, sandy bank of wash, fine gravel at lip of pouroff plungepool; DCA, 1800–3000 ft; *JF 798, 2076* (SRSC). Ernst Tinaja and Arroyo Venado/Boquillas Canyon. New park record. Listed by Amos and Giles (1992).

§ *Oenothera triloba* Nutt. – Stemless evening-primrose
"Infrequent" annual or biennial herb; 1800–4000 ft; *BA2 5564* (SAT); *HTF 1228* (SRSC). Along Rio Grande at Boquillas and near Shackelford cabin. Also known from Dog Flats.

ORBANCHACEAE

Orobanche ludoviciana Nutt. – Louisiana broomrape

Uncommon annual herb, gravel wash bottom; growing on mesquite; DAR, DCA, 1800–2120 ft; *BRM 3172* (BGWMA); *JF 677* (SRSC); *DSC & WOD 30714, BHW 838* (TEX-LL). Boquillas Canyon and north of the Barker House. This species concept includes *Orobanche cooperi* (Turner et al. 2003).

Orobanche multicaulis Brandegee – Spiked broomrape

Occasional annual herb, wash gravel, on mesquite roots; DAR, DCA, RIO, 1800–4080 ft; *JF 564, 931, BHW 738* (SRSC). Bed of Telephone Canyon, Passionflower Canyon wash, head of Boquillas Canyon.

OXALIDACEAE

§ *Oxalis drummondii* A. Gray – Drummond woodsorrel

Perennial herb; *MT 228* (SRSC). Below N rim of DH plateau, N of Stuarts Peak.

PAPAVERACEAE

+ *Argemone chisosensis* G.B. Ownbey – Chisos mountain pricklepoppy

Rare annual or perennial herb, sandy clay bottom, gravelly limestone flats; DSC, DAR, 2350–2400 ft; *JF 1414, 1579* (SRSC). Ernst Basin and Marufo Vega trail environs. Well-represented regionally.

§ *Argemone mexicana* L. – Mexican pricklepoppy

Rare annual herb, sandy soil, old river floodplain; RIO, 1800 ft; *AL 299* (BIBE); *AL 300* (SRSC). Collected by NPS staff at the Boquillas Canyon restoration site, it is a new county record. The nearest collections shown in Turner et al. (2003) are in eastern Val Verde County.

Argemone sanguinea Greene – Red pricklypoppy

Rare annual or perennial herb, rocky banks/terrace beside wash; DSC/DAR, DCA, 2800 ft; *CMR 2605* (SAT); *JF 966* (SRSC). Passionflower Canyon wash and Frog Canyon. The SAT collection is not reflected in Turner et al. (2003), though there are collections shown from northern Brewster County.

PASSIFLORACEAE

Passiflora tenuiloba Engelm. – Passionflower vine

Occasional perennial herbaceous vine, washes and canyons in gravel and boulders, rarely on open slopes in deep shade and debris; DSC, DAR, DCA, 1800–4280 ft; *BRM 3150, 3150b; CMR 5082* (BGWMA); *AL 142, 143, 318* (BIBE); *BA2 5215* (SAT); *JF 189, 306, 963, 1076, 1361, 1591, 2129, TR 281, BHW 20606* (SRSC); *TR 249* (TEX-LL).

PEDALIACEAE

§ *Proboscidea louisianica* subsp. *fragrans* (Lindl.) Bretting – Devil's claw

[*Proboscidea fragrans* (Lindl.) Decne.] "Infrequent" annual herb; 1800 ft; *BHW 12890* (SRSC). At head of Boquillas Canyon in 1955.

PHYTOLACCACEAE

Rivinia humilis L. – Pigeonberry

Uncommon perennial herb, sandy wash gravel, sides of arroyos; DAR, DCA, 2920–3050 ft; *CMR 5031* (BGWMA); *JF 216a, 1137* (SRSC). North Dagger Mountain, Dagger Canyon, near Brushy Creek.

PLANTAGINACEAE

Plantago helleri Small – Heller plantain

Locally common annual herb, low and high elevation flats, silty soil, talus slope; DSC, SYG/CHP, 3300–5300 ft; *OCW 584-20* (BGWMA); *JF 620, 785, 1250* (SRSC). TC trail, Stuarts Peak, DH plateau, west of Frog Tank.

§ *Plantago hookeriana* Fisch. & C.A. Mey. – California plantain

"Infrequent" annual herb; DCA, 2560 ft; *BHW 21422* (TEX-LL). Dog Canyon in 1941.

\+ *Plantago patagonica* Jacq. – Bristlebract plantain

Uncommon annual herb, sandy to silty soil, arroyos; DSC, DAR, DCA, SYG, 1800–5300 ft; *JF 1252, 1609, 2082* (SRSC). High saddle, Arroyo Venado/Boquillas Canyon, Marufo Vega trail along river. Turner et al. (2003) shows dots in the study area but no specimens were discovered. Listed by Amos and Giles (1992).

Plantago rhodosperma Decne. – Redseed plantain

Uncommon annual herb, wash gravel, sandy clay bottom; DSC, DAR, DCA, 2350–2560 ft; *BRM 3112* (BGWMA); *RH 20, 43* (SAT); *JF 1335, 1430* (SRSC); *RRI 21423* (TEX-LL). Ernst Tinaja, Ernst Basin, Dog Canyon, Frog and Brushy canyons.

POLEMONIACEAE

Gilia incisa Benth. – Splitleaf gilia

Rare annual or perennial herb, steep chalky western talus slope; DSC, 2850–4000 ft; *BA2 5308, 5573, 5577* (SAT); *JF 944* (SRSC). Passionflower Canyon and near Shackelford cabin.

§ *Gilia insignis* (Brand) Cory & H.B. Parks – Marked gilia

"Infrequent" perennial herb, eastern slopes of Stairway Mountain; 2250 ft; *BHW & LCH BG-200* (SRSC). Also known from Persimmon Gap and Dog Flats.

Gilia rigidula subsp. *acerosa* (A. Gray) Wherry – Button gilia, blue gilia

Uncommon annual herb, rocky limestone soil, flats and slopes; DSC, 3560–4300 ft; *BA2 5372* (SAT); *JF 245, 284, 870, MT 97* (SRSC). Alto Relex, Dagger Flats, TC trail near canyon bottom, Shackelford cabin. Also known to the west of the Chisos Mountains and northward.

Gilia stewartii I.M. Johnst. – Stewart gilia
Uncommon annual herb, rocky soil, flats, slopes and summits; DSC, DAR, 3400–4800 ft; *BRM 3221* (BGWMA); *BA2 5557* (SAT); *JF 498, 814, 1026, 2163, BHW 10761* (SRSC); BHW 10761 (TEX-LL). TC trail, near McKinney Springs, near Shackelford cabin, western slopes of DH.

§ *Ipomopsis havardii* (A. Gray) V.E. Grant – Havard ipomopsis
"Infrequent" perennial herb; *BHW & MCJ 15907* (SRSC). DH near Roy Peak; also known from Dog and Tornillo Flats and elsewhere in BBNP.

§ *Phlox nana* Nutt. – Santa Fe phlox
[*Phlox mesoleuca* Greene] Perennial herb; *BA2 5371, 5519, 5562* (SAT). Near Shackelford cabin. Turner et al. (2003) does not reflect these collections. Locally known from the Chisos Mountains and west.

POLYGALACEAE

Polygala alba Nutt. – White milkwort
Uncommon perennial herb, rocky slopes and flats, deeper soil on high plateaus; DSC, CHP, 3500–5150 ft; *ACK 828* (BIBE); *BA2 5212, 5378* (SAT); *JF 251, 1227, MT 72, BHW & LCH BG-158* (SRSC). Dagger Flat, western slopes of DH, DH plateau, and near the Shackelford cabin.

Polygala barbeyana Chodat – Narrowleaf polygala
[*Polygala longa* S.F. Blake] Occasional to uncommon throughout, perennial herb, wash gravel, rocky hillsides and ridges; DSC, DAR, DCA, SYG, 2200–5500 ft; *TR 122*, *BHW & LCH s.n.* (BGWMA); *BHW 1006* (BIBE); *BA2 5286, SJ 6506* (SAT); *JF 158, 252, 267, 288, 864, 1099, 1160, 1259, 1503, 2174, 2183, TR 122, CMR 5070, MT 28, 244, BHW 10798, 21197, 23401, BHW & LCH BG-169, BHW & MCJ 16826* (SRSC); *BLT & BD 23-172b, BHW 10798* (TEX-LL).

Polygala lindheimeri A. Gray var. *lindheimeri* – Shrubby milkwort
Occasional perennial herb, rock crevices, canyon walls; DCA, 1800–3050 ft; *BA2 5196, 5244, 5696* (SAT); *JF 964, 1009, 1058, 1071, 1148, 2070, MT 12, 29, 200, BHW 10809, BHW & LCH BG-70, BG-134, BG-182* (SRSC); *JF 1071, BHW & LCH BG-134* (TEX-LL). This may be the species' western limit according to Turner et al. (2003). These two varieties intergrade in Brewster and Presidio County, and some individuals demonstrate mixed characters [e.g. *JF 964* (SRSC); Powell in prep.].

\+ *Polygala lindheimeri* A. Gray var. *parvifolia* Wheelock – Shrubby milkwort
[*Polygala tweedyi* Britton ex Wheelock] Uncommon perennial herb, gravel flats, slightly clayey soil, arroyos; DSC, DCA, 1850–2600 ft; *JF 929, 1081* (SRSC). Passionflower Canyon area, Arroyo Venado/Boquillas Canyon.

Polygala macradenia A. Gray – Glandleaf milkwort
Common perennial herb, rocky slopes, rock crevices, sandy and calcareous soils; DSC, DAR, DCA, 1850–4360 ft; *BRM 3226* (BGWMA); *ACK 824* (BIBE); *BA2 5228, 5547,*

5553 (SAT); *JF 239, 275, 354, 854, 1529, 2007, BHW 10797, 20955, BHw & BLT 8316, GLW 4446* (SRSC); *BLT & BD 23-166, TRV, GLB & WEH 85-46, BHW & BLT 8316* (TEX-LL).

Polygala nudata Brandegee – Littleleaf milkwort
Rare perennial herb, sandy slope, rock crevices; DSC, DCA, 1800–>4000 ft; *BA2, DG, TE, & B 4932, AL 312* (BIBE); *JF 1670, 1698, 2126* (SRSC). Big Brushy, Strawhouse, and Boquillas canyons, including lower elevations of canyons draining into the Rio Grande; Marufo Vega trail.

Polygala scoparioides Chodat – Broom milkwort
Occasional perennial herb, rocky soils, flats, slopes, and ridges; DSC, DAR, DCA, 2200–4800 ft; *CMR 5064, 11590* (BGWMA); *BA2 5289, SJ 6499* (SAT); *JF 425, 506, 580, 1165, 1190, 1365, TR 124, OCW 502, BHW 20624, 21199, GLW 4440, 4452* (SRSC); *BLT & BD 23-165, 23-172a* (TEX-LL).

POLYGONACEAE

Eriogonum havardii S. Watson – Havard buckwheat
Rare perennial herb, crevices or pockets in flat bedrock exposures; DSC, 3350 ft; *JF 1718* (BIBE & SRSC); *JF 1714* (SRSC). On high rocky cliffs overlooking the Rio Grande, above the Marufo Vega trail. Known locally from the Solitario area and in the center of Brewster County, continuing east and north.

Eriogonum platyphyllum Torr. ex Benth. – Broad-leaf wild buckwheat
[*Eriogonum tenellum* subsp. *platyphyllum* (Torr. ex Benth.) S. Stokes] Occasional perennial herb, wash gravel; DAR, DCA, 1950–4600 ft; *JF 939, 1381, 1635, AMP & SAP 5123* (SRSC). Brushy Canyon and the upper mouth of Ernst Tinaja Canyon.

+ *Eriogonum rotundifolium* Benth. – Roundleaf buckwheat
Rare annual herb, wash gravel; DAR, 2350 ft; *JF 1384* (SRSC). Just above upstream entrance to Ernst Tinaja canyon. Turner et al. (2003) shows dots in the study area but no specimens were discovered.

§ *Eriogonum tenellum* Torr. – Tall wild buckwheat
Perennial herb; *BRM 3206* (BGWMA). Three miles west of BGWMA headquarters.

§ *Polygonum hydropiperoides* Michx. – Swamp smartweed
[*Persicaria hydropiperoides* (Michx.) Small] "Infrequent" perennial herb; 1800 ft; *BHW, BLT & JDA 8336* (SRSC). At head of Boquillas Canyon in 1948.

§ *Polygonum pensylvanicum* L. – Pennsylvania smartweed
[*Persicaria pensylvanica* (L.) M. Gómez] Annual herb, sandy soil; 1800 ft; *BHW 641* (BIBE). At entrance to Boquillas Canyon in 1937.

*§ *Persicaria maculosa* Gray – Spotted ladysthumb
[*Polygonum persicaria* L.] "Infrequent" annual herb; 1800-1850 ft; *EGM 161, BHW 642* (BIBE); *BHW 21517* (TEX-LL). Along the Rio Grande at Boquillas, and below Barker House along spring area, in the 1930s.

*§ *Rumex crispus* L. – Curly dock
"Infrequent" perennial herb; 1800 ft; *BHW 18387* (SRSC). Boquillas Canyon in 1961.

Rumex maritimus L. – Golden dock
Rare annual or biennial herb, wash gravel/sand; DCA, 1800 ft; *JF 2118* (SRSC). Cow Canyon mouth in Boquillas Canyon. New county record. Few collections from Presidio and Val Verde counties. Rarely collected in Texas according to Turner et al. (2003), perhaps due to collector bias against weeds?

PORTULACACEAE

Talinum angustissimum (Engelm.) Wooton & Standl. – Narrow-leaf fameflower
[*Phemeranthus aurantiacus* (Englem.) Kiger] Rare perennial herb, sandy bank in shade; DAR, 1900 ft; *JF 2040a* (SRSC). Boquillas Canyon, upstream from Marufo Vega trail. Many treatments include this species under *Phemeranthus aurantiacus*: the Flora of North America (FNA 2003a) states that the purported distinctions creating separate species break down under a continuum of intergradation, but collections examined from Brewster County (*JF 2270-2274* SRSC) demonstrate that individuals clearly representing both concepts occur at the same site with no intergradation of characters (Powell in prep.). Based on distribution information from the Flora of North America treatment (FNA 2003a), the Big Bend region could be a zone of overlap between the two species, providing more support for the idea of the DH and larger region being a floristic mixing ground as discussed in the above thesis.

+ *Phemeranthus aurantiacus* (Engelm.) Kiger – Orange fameflower
[*Talinum aurantiacum* Engelm.] Rare perennial herb, rocky limestone soil; DSC, 3880 ft; *JF 293, 2040a* (SRSC). Lower western flanks of Stuarts Peak.

Phemeranthus brevicaulis (S. Watson) Kiger – Dwarf fameflower
[*Talinum brevicaule* S. Watson] Rare, locally more common perennial herb, shallow soil amongst rocks and boulders; SYG/CHP, 5320–5840 ft; *JF 1967, 1967a* (SRSC). Sue Peaks area. Known locally from the Chisos and Glass Mountains.

Portulaca oleracea L. – Purslane, verdolaga
Rare annual herb, sandy wash; DAR, DCA, 2500–2880 ft; *TR s.n.* (BGWMA); *JF 204* (SRSC). North Dagger Mountain and Frog Tank.

Portulaca pilosa L. – Kiss me quick
[*Portulaca mundula* I.M. Johnst.] Occasional annual or perennial herb, rock crevices, wash gravel, rocky limestone soil, shallow soil on bedrock terrace; DSC, DAR, DCA,

SYG/CHP, 1800–5840 ft; *BHW 12901* (BIBE); *BA2 5281, 5379* (SAT); *JF 176, 240, 272, 1154, 1979, 2099, MT 6, 209, 243, BHW 12901, JF & MY 1316, BHW & MCJ 16843* (SRSC); *BHW 12901* (TEX-LL).

PRIMULACEAE

§ *Anagallis arvensis* L. – Scarlet pimpernel
Annual or biennial herb, sandy soil, old river floodplain; RIO, 1800 ft; *AL 303* (BIBE). Boquillas Canyon trail, river restoration site just upstream from mouth of canyon.

§ *Samolus ebracteatus* subsp. *cuneatus* (Small) R. Knuth – Limewater brookweed
"Infrequent" perennial herb, sandy soil; RIO, 1800 ft; *EGM 130* (BIBE); *HTF 1223, BHW 13049* (SRSC). Along the Rio Grande at Boquillas.

RANUNCULACEAE

Anemone tuberosa var. *texana* Enquist & Crozier – Desert windflower, tuber anemone
Rare perennial herb, rocky hillside, north aspect, with thin bedrock outcrops and boulders; DSC, DCA, 2560–4440 ft; *JF 562, BHW & MCJ 15986* (SRSC). TC trail mile five and Dog Canyon.

Clematis drummondii Torr. & A. Gray – Virgin's bower, old man's beard
Common perennial herbaceous vine, wash gravel, sides of canyons and arroyos; DAR, DCA, RIO, 1800–4080 ft; *JF 178, 1334, 1424, TR 295* (SRSC). Listed by Amos and Giles (1992).

RESEDACEAE

+ *Oligomeris linifolia* (Vahl) J.F. Macbr. – Desert spikes
Occasional annual herb, rocky desert soil, flats, sandy floodplain; DSC, RIO, 1800-2600 ft; *JF 932, 2226* (SRSC). Passionflower Canyon area and at the Boquillas Canyon restoration site. Turner et al. (2003) shows a dot in the study area but no specimens were discovered.

§ *Ranunculus sceleratus* L. – Cursed buttercup
Rare native herb, in mud at river's edge; *BHW & RLU s.n.* (SRSC). RGV area, at Ojo Caliente crossing in 1950.

RHAMNACEAE

Ceanothus greggii A. Gray – Desert ceanothus
Uncommon shrub, cliff outcrops, crevices in canyon walls, north and east aspects; DCA, SYG, 4040–5840 ft; *PVW s.n.* (KANU); *BA2 5537* (SAT); *JF 727, 746a, 771, 1211, 1275, 1976, PM 974, MT 226, 239* (SRSC). Stuarts and Sue peaks area, Brushy Canyon.

§ *Condalia ericoides* (A. Gray) M.C. Johnst. – Javelinabush
Shrub; *CMR 11624* (SAT). Observed occasionally in the study area. Collection from near Shackelford cabin.

Condalia viridis I.M. Johnst. – Green condalia
Occasional shrub, wash gravel, sandy clay bottom, rocky limestone soil; DSC, DAR, DCA, SYG, 2350–4880 ft; *JF 161, 744b, 1348, 1386, 1421, TVR s.n.* (SRSC).

Condalia warnockii M.C. Johnst. – Warnock condalia
Uncommon shrub, rocky ridge and canyons, with bedrock and rock outcrops; DSC, DAR, DCA, SYG, 1800–4650 ft; *JF 1185, 2085, BHW 10814* (SRSC); *BHW 10814* (TEX-LL). Western slopes of DH, head of Heath Canyon, Arroyo Venado/Boquillas Canyon.

Karwinskia humboldtiana (Willd. ex Roem. & Schult.) Zucc. – Coyotillo
Locally uncommon shrub, rock crevices, terraces, bouldery sides of washes; DCA, RIO /DSC, 1800–3150 ft; *BHW 834* (BIBE, SRSC, & TEX-LL); *JF 1595, 2001, 2135* (SRSC). Various sites in Boquillas Canyon, and in the upper Marufo Vega trail area away from the river.

Ziziphus obtusifolia (Hook. ex Torr. & A. Gray) A. Gray – Lotebush Occasional shrub, rocky limestone soil, cut banks, sandy clay bottom; DSC, DAR, DCA, 2200– ca. 4000 ft; *BA2 5226, 5261, 5706* (SAT); *JF 1312, 1419, 1426, TR 117* (SRSC); *AG 380* (TEX-LL).

ROSACEAE

Cercocarpus breviflorus A. Gray – Small-leaf mountain mahogany
[*Cercocarpus montanus* Raf. var. *paucidentatus* (S. Wats) F.L. Martin] Rare shrub, holes/cracks in bedrock and boulders; CHP, 5800–5840 ft; *PVW s.n.* (KANU); *JF 1267, 1977* (SRSC). Northern Sue Peak. Known from other high elevations in Brewster and Jeff Davis counties as well.

Cercocarpus glaberoides R.A. Denham var. *glaber* – Smooth mountain mahogany
[*Cercocarpus betuloides* Nutt., *Cercocarpus montanus* Raf. var. *glaber* (S. Wats) F.L. Martin] Uncommon shrub, canyon bottoms, base of cliffs, rocky summits; DCA, SYG/CHP, 3500–5680 ft; *OCW 9036*, *BHW & LCH s.n.* (BGWMA); *PVW s.n.* (KANU); *BA2 5439, 5452* (SAT); *JF 716, 1021, 1197, 1274, 1278, 1281, MT 64, 109, 115, OCW 338, BHW & LCH BG-150* (SRSC). Stuarts and Sue Peaks environs, DH plateau, TC area. Trans-Pecos mountain mahoganies were previously treated as varieties of *Cercocarpus montanus* (Powell 1998) and are now recognized by some as different species (Turner et al. 2003, Powell in prep.). Two other *Cercocarpus* species occur in western Texas: *Cercocarpus montanus* Raf. var. *montanus* (Guadalupe and Sierra Diablo mountains) and *Cercocarpus montanus* Raf. var. *argenteus* (Rydb.) F.L. Martin (Texas Panhandle).

Fallugia paradoxa (D. Don) Endl. ex Torr. – Apacheplume
Occasional to locally common shrub, wash gravel; DAR, DCA, 2350–4040 ft; *BRM 3108, TR s.n.* (BGWMA); *BA2 5249, 5329* (SAT); *JF 157, 1111, 1378, PM 978, TR 114, MT 201, BHW & LCH BG-168* (SRSC); *BHW & LCH BG-88* (TEX-LL).

Malacomeles denticulata (Kunth) G.N. Jones – Serviceberry
[*Amelanchier denticulata* (Kunth) K. Koch] Uncommon shrub, drainages, open ridgelines; DCA/SYG, CHP, 3800–5080 ft; *PVW s.n.* (KANU); *BA2 5536* (SAT); *JF 511, 717, 728a, 822, 1184, 1954, BHW 10826* (SRSC); *DHR 2298, BHW 10826* (TEX-LL). Stuarts and Sue Peaks environs, interior TC trail area, Brushy Canyon.

Petrophyton caespitosum (Nutt.) Rydb. – Mat rockspirea, tufted rockmat
Rare subshrub, cracks and crevices in slick bedrock outcrops; SYG, 4750–5840 ft; *JF 786, 1269, MT 232* (SRSC). Stuarts and Sue Peaks areas, and on N rim of the DH plateau/Brushy Canyon.

Prunus havardii (W. Wight) S. C. Mason – Havard plum
Uncommon to occasional shrub in northern half of the range, washes, ridgelines; DAR, DCA, SYG, 3050–5840 ft; *JF 1109* (BIBE); *JF 742, 1109, 1266a, 1973, PM 973* (SRSC); *BHW & LCH BG-140* (SRSC & TEX-LL).

Purshia ericifolia (Torr. ex Gray) Henrick. – Heath cliffrose
[*Cowania ericifolia* Torr. ex Gray] Common shrub, crevices in bedrock; DCA, SYG, CHP, 2050–5150 ft; *BA2 6192, CMR 5067, 5133, 15832, TR s.n.* (BGWMA); *PVW s.n.* (KANU); *BA2 5366* (SAT); *JF 751, 948, 1098, 1601, 1672, 1902, MT 25, 94, 171, TR 115, BHW 10836, 16682, 20622, BHW & LCH BG-138, BHW & MCJ 16831* (SRSC); *BHW 10836, BHW & LCH BG-138* (TEX-LL).

Vauquelinia corymbosa Humb. & Bonpl. subsp. *angustifolia* (Rydb.) W.J. Hess & Henrickson – Narrow-leaf vauquelinia
[*Vauquelinia angustifolia* Rydb.] Occasional shrub or tree open rocky limestone slopes, drainages; DCA, SYG, 4200–4800 ft; *BA2 5555* (SAT); *JF 496a, 577, 862, PM 972, BHW 10778, 10784, BHW & MCJ 16683* (SRSC); *BHW 10778* (TEX-LL).

RUBIACEAE

+ *Galium proliferum* A. Gray – Limestone bedstraw
Rare annual herb, wash gravel and amongst boulders on open peak; DAR, DCA, SYG, 3500–5080 ft; *JF 428, 745* (SRSC). TC trail mile three and on top of Stuarts Peak. Turner et al. (2003) shows a dot in the study area but no specimen was discovered.

Hedyotis acerosa A. Gray var. *acerosa* – Needleleaf bluet
[*Houstonia acerosa* (Gray) Gray ex Benth. & Hook. f. var. *acerosa*] Common perennial herb, rocky limestone soils, bedrock outcrops; DSC, DAR, DCA, SYG/CHP, 3500–5840 ft; *BRM 3229* (BGWMA); *BHW 889* (BIBE); *JF 250, 287, 330, 480, 491, 824, 1051, 1101, 1717, MT 27a, 57, OCW 323, BHW 10825* (SRSC); *BHW 10825* (TEX-LL).

Hedyotis intricata Fosberg – Tangled starviolet, fascicled bluet
[*Houstonia fasciculata* Gray, non Bertol.] Occasional shrub, cracks in bedrock and cliff walls; DSC, DCA, SYG/CHP, 3800–5800 ft; *PVW s.n.* (KANU); *JF 294, 481, 749, 866, 1487, MT 91, 169, BHW & MCJ 16684* (SRSC).

Hedyotis nigricans (Lam.) Fosberg var. *nigricans* – Diamondflowers
[*Stenaria nigricans* (Lam.) Terrell var. *nigricans*] Common perennial herb, wash gravel; DAR, DCA, 1800–4360 ft; *BRM 3139* (BGWMA); *JF 500, AL 196* (BIBE); *BA2 5342* (SAT); *JF 156, 186, 424, 500, 541, 801, 823, 1129, 1530, 1924, 1925, 1926, 1931, JF & MY 1354* (SRSC); *BLT & MT2 97-335* (TEX-LL).

Hedyotis pooleana B.L. Turner – Jackie's bluet
[*Stenaria mullerae* var. *pooleana* (B.L. Turner) Terrell] Occasional (G1T1S1) perennial herb, slick bedrock outcrops, slope less than 50%, seemingly all aspects; DSC, SYG, 2700–5680 ft; *JF 237, 713, 775, 1168, 1288, 1553, 1605, 1715, 1716, 1916, 1961, 1962, 2192, 2195, JF & MD 553, JMP 2527* (SRSC); *JMP 2527* (TEX-LL). This taxon is deserving of more systematic work; its relationship to the variable Mexican species *Houstonia mullerae*, and the regional *Hedyotis angulata* is of interest; in addition to the previously mentioned dispute over varietal versus specific designation of *Hedyotis pooleana*, two specimens of *Hedyotis angulata* seem to approach vegetative characters of *Hedyotis pooleana* (*Tharp 270*, *Warnock 23716* SRSC) which is supposedly restricted to the DH mountains. *Hedyotis pooleana* is also apparently slightly morphologically plastic, with a few specimens showing a more branched habit, even approaching *Hedyotis angulata*, as opposed to the characteristic densely-matted growth (Fig. 30).

RUTACEAE

Ptelea trifoliata subsp. *angustifolia* (Benth.) V.L. Bailey – Common hoptree, skunkbush
Rare shrub, base of and in shade of cliff outcrops; SYG, CHP, 480–5680 ft; *BA2 327* (SAT); *JF 1213, 1294, 2162, MT 185* (SRSC). DH plateau, near Shackelford cabin.

Thamnosma texanum (A. Gray) Torr. – Dutchman's breeches, Texas desertrue
Occasional to uncommon throughout, perennial herb, wash gravel, rocky desert slopes with some protection; DSC, DAR, DCA, SYG, 1800–5840 ft; *BRM 3122, CMR 5081* (BGWMA); *JF 488, 747, 1583, 1995, BHW 18394, BHW & LCH BG-69, BHW & MCJ 15906, GLW 4441* (SRSC).

SALICACEAE

§ *Populus fremontii* S. Wats. – Fremont cottonwood
Locally occasional tree; sandy soil, river floodplain; RIO, 1800 ft; *EW 19709* (SRSC). East of Hot Springs on the river. Cottonwoods currently grow in the RGV campground and picnic areas; many were planted and are probably the upstream-native Rio Grande cottonwood *Populus deltoides* subsp. *wislezeni*.

§ *Salix exigua* Nutt. – Narrowleaf willow, coyote willow
"Infrequent to frequent" tree, on hills; at old Graham farm/ Boquillas area 1930s-1950s; *BHW 12911* (SRSC); *BHW s.n.* (TEX-LL).

§ *Salix exilifolia* Dorn – Yewleaf willow
[*Salix taxifolia* Kunth] Tree, at Boquillas in 1937; *EGM 166* (BIBE).

Salix nigra Marshall – Black willow

Uncommon tree; DCA, RIO, 1800–2350 ft; *BHW 647* (BIBE); *JF 1344, BHW 18389* (SRSC); *EGM 71, BHW 21505* (TEX-LL). At Boquillas and in canyon upstream of Ernst Tinaja. Also known from Hot Springs, McKinney Springs areas. This species concept includes *Salix gooddingii* (Turner et al. 2003).

SAPINDACEAE

+ *Sapindus saponaria* L. – Western soapberry, jaboncillo

Rare tree, dark sandy median of wash; DAR, 3050 ft; *JF 1116* (SRSC). At mouth of Dagger Canyon.

Ungnadia speciosa Endl. – Mexican buckeye

Uncommon tree, canyon walls and wash gravel; DCA, 1800–4420 ft; *BRM 3109, TR 84* (BGWMA); *DB s.n.* (SAT); *JF 817, 1144, 2075, 2127, TR 84* (SRSC). In the larger canyons. Usually only isolated individuals were seen, but this species was unusually common in Dagger Canyon and noted as "frequent" in Brushy Canyon on *TR 84*.

SAPOTACEAE

§ *Sideroxylon lanuginosum* Michx. ssp. *rigidum* (Gray) T.D. Pennington – Gum bully, ironwood

Rare tree, banks of drainage below canyon walls DCA, 2560 ft; *AL 240* (BIBE); *BHW & MCJ s.n.* (SRSC). Dog Canyon.

SCROPHULARIACEAE

§ *Castilleja integra* A. Gray – Wholeleaf indian paintbrush

Perennial herb, calcareous soils; Brushy Canyon; *BA2 5227, 5345, 5390, 5448, 5460, 5542, 5588* (SAT); *BLT & BD 23-169* (TEX-LL).

Castilleja rigida Eastw. – Rigid indian paintbrush, broadbract paintbrush

[*Castilleja latebracteata* Pennell] Occasional perennial herb, talus slopes, cliff outcrops, open rocky soils; DSC, SYG/CHP, 2150–5200 ft; *TR 111, OCW 9035* (BGWMA); *OES 1332* (BIBE); *SJ 6497* (SAT); *JF 151, 214, 331, 485, 774, 830, 833, 1210, 1580, 1720, 1908, AMP & SAP 5121, TR 111, MT 14, 126, 133, 148, 153, 154, BHW 10851, BHW & LCH BG-71* (SRSC); *BHW 10851, BHW & LCH BG-71* (TEX-LL).

Leucophyllum candidum I.M. Johnst. – Boquillas silverleaf

[*Leucophyllum violaceum* Pennell] Occasional to common shrub, rocky limestone slopes, washes, cliffs; DSC, DAR, DCA, 1800–4080 ft; *EGM 153, BHW 13070* (BIBE); *JF 329, 567, 836, 837, 1464, 1711, 2092, 2124, PM 238, BHW 13070, BHW & LCH BG-61BHW & MCJ 16857* (SRSC); *BHW s.n.* (TEX-LL).

+ *Leucophyllum frutescens* (Berland.) I.M. Johnst. – Barometer bush, ceniza, purple sage

Rare shrub, wash gravel; DCA, 1800 ft; *JF 2083* (SRSC). Arroyo Venado/Boquillas Canyon. Listed by Amos and Giles (1992).

Leucophyllum minus A. Gray – Big Bend silverleaf
Common shrub, open rocky limestone soil, alluvium, ridges, slopes; DSC, DAR, DCA, 2600–4300 ft; *CMR 5066* (BGWMA); *BA 107* (BIBE); *DB s.n.* (SAT); *JF 244, 266, 470, 831, 842, 1162, MT 23, 24, 125, BLT 22-148, BHW 10804, BHW & LCH BG-161, GLW 4471* (SRSC); *BLT 22-148* (TEX-LL).

Maurandya antirrhiniflora Humb. & Bonpl. ex Willd. – Snapdragon vine, roving sailor
Common perennial herbaceous vine, chalky soil on talus slope in shade, wash gravel/banks on shrubs; DSC, DAR, DCA, 1800–4080 ft; *BRM 3105*, *TR 110* (BGWMA); *JF 438, 971, TR 110, 113, MT 100, BHW 10807* (SRSC).

§ *Maurandya wislizeni* Engelm. ex A. Gray – Balloonbush
Rare perennial herbaceous vine, sandy soil, old river floodplain; RIO, 1800 ft; *AL 301* (BIBE); *AL 302* (SRSC). Collected by NPS staff at the Boquillas Canyon trail river restoration site; new county record.

Penstemon baccharifolius Hook. – Baccharisleaf beardtounge
Occasional perennial herb, slickrock of canyon walls, protected areas; DCA, 1800–4600 ft; *CMR 5061, SMU 39* (BGWMA); *AL 145* (BIBE); *JAS 3450* (NYBG); *JLB 866* (SAT); *JF 180, 838, 974, 1313, 1681, 2106, AMP & SAP 5124, TR 112, MT 95, 183, BHW & LCH BG-162* (SRSC).

Penstemon barbatus (Cav.) Roth – Beardlip penstemon
Rare perennial herb, gravelly arroyo bottoms, crevice in canyon wall; DAR, DCA, 3160–4000 ft; *JF 222, MT 216, BHW 10732* (SRSC); *LCH & BHW BG-175* (TEX-LL). North Dagger Mountain, Brushy Canyon, head of Heath Canyon.

\+ *Penstemon dasyphyllus* A. Gray – Cochise beardtounge
Rare perennial herb, north aspect cliff face; DAR/DCA, 4120 ft; *JF 724* (SRSC). Drainage on flanks of Stuarts Peak. Turner et al. (2003) shows a dot in the study area but no specimen was discovered.

Penstemon lanceolatus Benth. – Lanceleaf beardtounge
Uncommon to "rare" perennial herb, limestone rockland, north-facing slope, rocky summit; 3500–5840 ft; *JF 1306, BHW & LCH BG-175* (SRSC); *JMP 2725, BHW 10752* (TEX-LL). Summit of southern Sue Peak, head of Heath Canyon, near Shackelford cabin. The DH is the only population for this species in Texas, according to Turner et al. (2003).

\# *Seymeria falcata* B.L. Turner var. *falcata* – Falcate blacksenna
Locally common annual herb, holes and crevices in slick bedrock outcrops, wash gravel; DAR/SYG, 4000–5500 ft; *JF 1943* (BIBE, BRIT, SRSC, & TEX-LL); *JF 571, 1187, 1548, 1952, 1959; MT 137* (SRSC). Sue Peaks and Shackelford cabin environs. New to the U.S. (Fenstermacher 2006).

Seymeria scabra A. Gray – Limpia blacksenna
Uncommon annual herb, rocky limestone soil; SYG, 4880–5840 ft; *BA2 5330* (SAT); *JF 744d, 1302; MT 255* (SRSC). Stuarts Peak, Sue Peaks, near Shackelford cabin.

Stemodia coahuilensis B.L. Turner – Coahuila twintip
[*Leucospora coahuilense* Henrickson] Rare annual herb, wash gravel, extremely ephemeral; DAR; 2200 ft. Photo documented by Roy Morey in February 2007: at the first mini-side drainage encountered when walking up the wash towards Ernst Tinaja from the parking area; "one clump" of plant(s) was found. Also known from Reed Plateau (Weckesser in prep). Rare in the U.S.; mostly a Mexican species from Cuatro Cienegas area (Henrickson 2005).

SIMAROUBACEAE
Holacantha stewartii C.H. Mull. – Crucifixion thorn
[*Castela stewartii* (C.H. Mull.) Moran & Felger] Rare shrub, rocky limestone soils; DSC, 3480–3700 ft; *JF 1145, JF & HL 1900, BHW 11760* (SRSC). Dagger Mountain and Dagger Flats. Warnock's collection in 1953 was the first record of its occurance in the United States. Known from south of Glen Springs, Paint Gap, and other spots in south Brewster County including BBRSP.

SOLANACEAE
§ *Calibrachoa parviflora* (Juss.) D'Arcy – Wild petunia
Annual herb, sandy soil, old river floodplain; RIO, 1800 ft; *AL 309* (BIBE); Boquillas Canyon trail, river restoration site just upstream from mouth of canyon.

Chamaesaracha pallida Averett – Pale five eyes, false nightshade
Uncommon perennial herb, rock crevices, shallow soil; DSC, DCA, SYG/CHP, 1800–4800 ft; *JF 2204, BHW 16846, 21198, BHW & MCJ 16685* (SRSC). Western slopes of the DH, Heath Canyon, Boquillas Canyon.

Chamaesaracha sordida (Dunal) A. Gray – Hairy false nightshade
Occasional perennial herb, rocky flats and hills, base of cliffs; DSC, DCA, 1900–3640 ft; *BHW & LCH BG-74* (BGWMA); *JEA & MWB 519, 520, CMR 17157, TXDOT 1324* (BIBE); *JF 290, 449, 629, 654, 965, 2047, BLT & BD 23-175, BHW 20898* (SRSC); *BLT & BD 23-175* (TEX-LL).

Chamaesaracha villosa Rydb. – Trans-Pecos five eyes, wooly false nightshade
Uncommon perennial herb, rocky soil, bedrock oucrops; DSC, DAR, DCA, 1900–2560 ft; *JF 1442, TXDOT s.n., BHW 21205, BHW & LCH BG-74, BHW & MCJ 15909, BHW & BLT 8327* (SRSC); *JEA & TJW 172, BHW 21205* (TEX-LL). Dog Canyon, Ernst Basin, near Roys Peak, Frog Tank, Boquillas Canyon. Includes *Chamaesaracha crenata* Rydb.

Datura wrightii Regel – Sacred datura, thorn apple
Annual or perennial herb, sandy soil; RIO; 1800 ft; *JF 2262* (SRSC). Few plants at the Boquillas Canyon restoration site.

Lycium berlandieri Dunal – Berlandier wolfberry
Occasional shrub, limestone soil, poorly drained ground, sandy clay soil; DSC, DAR, DCA, 1800–3480 ft; *EGM 10, BHW 13025* (BIBE); *JF 1090, 1387, 1390, 1391, 1451, 2045, 2110, MT 205, BHW 13025, 13067, GLW 4463* (SRSC).

+ *Lycium puberulum* var. *berberidoides* (Correll) F. Chiang – Downy wolfberry
[*Lycium puberulum* A. Gray] Rare shrub, flats; DSC, 2350 ft; *JF 1392* (SRSC). Ernst Basin. Turner et al. (2003) shows dots in the study area but no specimens were discovered.

! *Nicotiana glauca* Graham – Tree tobacco
Uncommon shrub, sandy/silty soil; DCA, RIO, 1850 ft; *CN 11739* (BIBE); *CMR s.n.* (SAT); *JF 1063, 2260* (SRSC). Boquillas area, Frog Canyon, Arroyo Venado.

Nicotiana trigonophylla Dunal – Desert tobacco
Uncommon annual herb, wash bottom, unconsolidated rocky slope, desert flats; DSC, DAR, DCA, 2400–3500 ft; *CMR 16411* (SAT); *JF 370, 440, 1446* (SRSC). TC trail, near Shackelford cabin, Ernst Basin.

Physalis cinerascens (Dunal) Hitchc. var. *cinerascens* – Smallflower groundcherry
Uncommon perennial herb, rocky summit; SYG/CHP, 2300–5840 ft; *BA2 5231, 5311* (SAT); *JF 1981, MT 128, OCW 504* (SRSC). Summit of northern Sue Peak and in Brushy Canyon.

Physalis hederifolia A. Gray – Ivyleaf groundcherry
Uncommon to occasional throughout, perennial herb, throughout entire range in wash gravel and rock crevices; DSC, DAR, DCA, 1800–4650 ft; *OES 1334* (BIBE); *JF 159, 216, 441, 1086, 1906, 2069, 2074, MT 36, 37, BHW 10779, BHW & MCJ 16825* (SRSC); *TRV & GLB 85-36, BHW 10779* (TEX-LL).

Quincula lobata (Torr.) Raf. – Chinese lantern, purple groundcherry
[*Physalis lobata* Torr.] "Infrequent/sparse" perennial herb, limestone and sandy soil; DSC, RIO, 1800–3800 ft; *BHW 1227, 10747, JF 2269* (SRSC); *BHW 10747* (TEX-LL). Near Norton's mine, along the Rio Grande at Boquillas, Boquillas Canyon restoration site.

Solanum elaeagnifolium Cav. – Silverleaf nightshade
Uncommon perennial herb, sandy-silty soil; DCA, RIO, 1800–1850 ft; *EGM 160, BHW 645* (BIBE); *JF 1064* (SRSC). Along the Rio Grande at Boquillas and at Arroyo Venado/Boquillas Canyon junction.

§ *Solanum ptychanthum* Dunal – West Indian nightshade
[*Solanum americanum* Mill.] Annual herb; *EGM 137* (BIBE). At Boquillas in 1937.

Solanum triquetrum Cav. – Texas nightshade
Uncommon perennial woody vine, wash gravel, sides of wash within shrubs, rocky ridges; DSC, DAR, DCA, SYG, 2780–4800 ft; *JF 162, 249a, 1035, 2176, 2178, 2185, PM 976, BHW & MCJ 16838* (SRSC). In southern half of the study area, also Brushy Canyon.

STERCULIACEAE
Ayenia filiformis S. Watson – Trans-Pecos or narrowleaf ayenia
Uncommon subshrub, washes, clay-loam limestone; DSC, DCA, RIO, 1800–2250 ft; *CMR 17160* (BIBE); *JF 2034, BHW 18398, 20950, BHW & LCH BG-187* (SRSC). Boquillas environs and through Boquillas Canyon.

Ayenia microphylla A. Gray – Dense ayenia
Uncommon to occasional subshrub throughout the entire range, wash gravel, rocky slopes and boulder piles; DSC, DAR, DCA, 1800–4800 ft; *JF 1124, 1957, 2038, 2172, BGH 632, AMP & SAP 5307, BHW 20620* (SRSC); *DSC & HBC 30627, BHW 10791* (TEX-LL).

§ *Ayenia pilosa* Cristóbal – Hairy or dwarf ayenia
Subshrub; 3000 ft; *BHW & LCH s.n.* (BGWMA); *BHW & LCH BG-139* (SRSC). Upper Brushy Canyon in 1950.

TAMARICACEAE
!!§ *Tamarix aphylla* (L.) H. Karst. – Athel tamarisk, saltcedar
Locally occasional tree, sandy banks, wash gravel; DSC, RIO, 1800–1900 ft; *BHW 13052* (BIBE); *AMP 3349, BHW 13052* (SRSC); *AMP 3349* (TEX-LL). These large trees were historically planted around developed areas; those in the RGV area are being targeted and removed by NPS exotic plant eradication teams, as are the *Tamarix chinensis*, but they are firmly established in upstream areas and so will likely continue to reestablish along the river corridor into the future.

!! *Tamarix chinensis* Lour. – Five-stamen tamarisk, saltcedar
Locally abundant tree, sandy banks, wash gravel; DCA, RIO, 1800–ca. 4000 ft; *JF 1346, 2233, 2253, MT 179* (SRSC). At the Boquillas Canyon restoration site, above Ernst Tinaja, and near the Shackelford cabin. Along the Rio Grande this is the *Tamarix* species dominating the riparian bosques. *Tamarix gallica* was listed by Amos and Giles (1992) and is reported to occur at RGV (Powell 1998) but no specimen was discovered.

ULMACEAE
Celtis pallida Torr. – Spiny hackberry
Common shrub or tree wash gravel and banks; DAR, DCA, RIO, 1800–2800 ft; *CMR 5078* (BGWMA); *JF 2112, TR 80, MT 204 BHW 14048* (SRSC).

§Δ *Celtis reticulata* Torr. – Netleaf hackberry, palo blanco
Tree. Listed by Amos and Giles (1992) as occurring in Brushy Canyon. Known from BBNP and commonly through the rest of Brewster County.

URTICACEAE

\+ *Parietaria pensylvanica* Muhl. ex Willd. – Pennsylvania pellitory
Rare annual herb, rubbly soil on north-facing alluvial slope, crack in a boulder on talus slope; DSC, DCA, 3150–3560 ft; *JF 538, 1701* (SRSC). Environs of TC trail mile 3.5 and upper Marufo Vega trail. Listed by Amos and Giles (1992). Observed at the Boquillas Canyon restoration site. Turner et al. (2003) shows a dot in the study area but no specimen was discovered.

VERBENACEAE

Aloysia gratissima (Gillies & Hook.) Tronc. – Beebrush, whitebrush
Occasional shrub, wash gravel, rocky hills; DSC, DAR, DCA, 1880–3480 ft; *JF 671, 1362, TR 102* (SRSC). Turner et al. (2003) shows dots in the study area but no specimens were discovered.

\+ *Aloysia wrightii* A. Heller ex Abrams – Wright beebrush, oreganillo
Uncommon shrub, base of cliffs, open rocky peak; DSC, DCA, SYG/CHP, 3560–5080 ft; *JF 476, 746* (SRSC). TC trail and on top of Stuarts Peak. Turner et al. (2003) shows dots in the study area but no specimens were discovered.

Bouchea spathulata Torr. – Spoonleaf
Occasional in southern half of study area, shrub, rocky limestone slopes, cobbly stoney loam in bottom of wash, sandy slope; DSC, DAR, DCA, SYG, 1800–5000 ft; *BA2, DG, TE, & B 4927* (BIBE); *PVW s.n.* (KANU); *BA2 4927, SJ & GJ 6503* (SAT); *JF 170, 857, 1511, MT 1* (SRSC); *BHW 10749, 10766* (TEX-LL).

§ *Glandularia bipinnatifida* (Nutt.) Nutt. var. *ciliata* (Benth.) B.L. Turner – Dakota mock vervain, old blue
[*Glandularia bipinnatifida* (Nutt.) Nutt.] Uncommon perennial herb, sandy soil, in or around depressions where water collects; DSC, DAR, RIO, 1800–3520 ft; *OES 1492* (BIBE); *HTF 1226, GLW 4466* (SRSC). Dog Creek, Dagger Flat, along Rio Grande at Boquillas. The varietal status is based on recent chromosome work on this genus (Turner and Powell 2005).

Glandularia quadrangulata (A. Heller) Umber – Beaked verbena
[*Glandularia verecunda* Umber] Uncommon annual herb, flats, sandy to rocky soil, streambed; DSC, DCA, RIO, 1800–3300 ft; *CMR 5140* (BGWMA); *JF 618* (BIBE); *CMR 16409* (SAT); *JF 618, HTF 1224* (SRSC); *BHW & RRI 21430* (TEX-LL). Locally abundant after good rains, just like many generally uncommon annuals. Dog Canyon, TC trail, and along Rio Grande at Boquillas. Also known from Dog Flats. The individuals found in BBNP may be more appropriately placed under *Glandularia verecunda* based on different seed structure, with *Glandularia quadrangulata* being a

more northerly distributed taxon (Powell in prep., Henrickson 2003). The species *Glandularia wrightii* f. *albiflora* listed in Amos and Giles (1992) is most likely *Glandularia quadrangulata*.

§ *Glandularia wrightii* (A. Gray) Umber – Wright verbena, pinky
[*Verbena wrightii* A. Gray] Perennial herb; *CMR 16408* (SAT). Near Shackelford cabin in 1981. This species was included under *Glandularia bipinnatifida* var. *ciliata* in Turner et al. (2003), but they were separated based on differing chromosome counts and morphology (Turner and Powell 2005).

Lantana achyranthifolia Desf. – Brushland shrubverbena, desert lantana
[*Lantana macropoda* Torr.] Uncommon to occasional shrub in the southern half of the study area, wash gravel; DSC, DAR, DCA, 1800–2780 ft; *TR 103* (BGWMA); *BA2 4636, 4936* (SAT); *JF 163, 947, 1364, TR 103* (SRSC); *BHW 831a* (TEX-LL).

Lippia graveolens Kunth – Mexican oregano, scented lippia
Uncommon shrub, expected in canyons in the southern half of the study area, wash gravel, limestone hills, moister areas; DSC, DAR, DCA, 1800–2350 ft; *DG & TE 4613, EGM 148, BHW 13065* (BIBE); *DG 4613* (SAT); *JF 1080, 1341, 1691, 2032, 2142, AMP s.n., 5306, 5823, BHW 13065, 21202* (SRSC); *BHW 831* (TEX-LL).

Phyla nodiflora (L.) Greene – Turkey tangle frogfruit
"Frequent" perennial herb, sandy soil, old river floodplain; RIO, DCA, 1800-2300 ft; *AL 321, BHW 833* (BIBE); *JF 2243*, *OCW 510*, *BHW 20435* (SRSC). Brushy Canyon, along the banks of the Rio Grande at Boquillas, and at the Boquillas Canyon trail restoration site.

§ *Tetraclea coulteri* A. Gray – Coulter wrinklefruit, stinkweed
"Infrequent" perennial herb; 2250 ft; *BRM 3209*, *CMR 5073* (BGWMA); *BA2 5717* (SAT); *BHW & LCH BG-184* (SRSC). Near the Shackelford cabin and on Stairstep Mountain.

Verbena neomexicana (A. Gray) Small – Hillside vervain, New Mexico verbena
Occasional to "abundant" perennial herb, sandy to rocky soil; RIO, DCA, 1800–? ft; *BRM 3047, CMR 11635* (BGWMA); *JF 2265* (SRSC).

VIOLACEAE

Hybanthus verticillatus (Ortega) Baill. – Babyslippers
Uncommon to rare perennial herb, in duff under shrubs, often associated with cliff/rock outcrops; DSC, SYG, 3000–4900 ft; *JF 220, 1322, 2170, BHW 10895* (SRSC). North Dagger Mountain, DH plateau, near McKinney Springs. Turner et al. (2003) does not reflect the BHW specimen. Listed by Amos and Giles (1992).

VISCACEAE

Phoradendron hawksworthii (Wiens) Wiens – Hawksworth mistletoe
Rare subshrub, growing on *Juniperus pinchotii* (*JF 1913* SRSC), on open rocky summit; DSC/SYG, 4160 ft; *JF 1896* (SRSC). On top of Dagger Mountain. Also known from the Chisos Mountains and sparsely throughout the Trans-Pecos.

Phoradendron tomentosum (DC.) Engelm. ex A. Gray – Christmas mistletoe
Uncommon subshrub; DSC, DCA, 2780 ft; *CMR 5097* (BGWMA); *JF 182* (SRSC); *AMP & SAP 4301* (SRSC & TEX-LL). *JF 182* was found on *Acacia*, other substrates were not identified. Passionflower Canyon, Ernst Tinaja, and Frog Canyon.

Phoradendron villosum Nutt. – Oak or Cory mistletoe
[*Phoradendron villosum* (Nutt.) Nutt. subsp. *coryae* (Trel.) Weins.] Uncommon subshrub, on *Quercus vaseyana* and *Prosopis glandulosa*; SYG/CHP, 2300-5000 ft; *PVW s.n.* (KANU); *JF 769, 1209, BHW 10845, 10846, OCW 505, BHW & LCH BG-145* (SRSC). Stuarts Peak, DH plateau, head of Heath Canyon, Brushy Canyon.

VITACEAE

+ *Cissus incisa* (Nutt. ex Torr. & A. Gray) Des Moul. – Sorrelvine, ivy treebine
[*Cissus trifoliata* (L.) L.] Rare perennial woody vine, side of wash, one specimen on *Chilopsis linearis*; DSC, DAR, 2050–3740 ft; *JF 232, 1682* (SRSC). North Dagger Mountain area and Strawhouse Canyon. Observed at Dagger Canyon. Listed by Amos and Giles (1992).

§ *Vitis arizonica* Engelm. – Canyon grape
"Abundant" perennial woody vine, sandy banks, climbing in shrubbery; RIO, 1800 ft; *EGM 156, BHW 13038* (BIBE); *BHW 13038, GLW 4489* (SRSC). Along the banks of the Rio Grande, Boquillas area.

ZYGOPHYLLACEAE

Guaiacum angustifolium Engelm. – Guayacan, Texas lignum-vitae
Common shrub, wash gravel and banks, rocky limestone soils; DSC, DAR, DCA, RIO, 1800–3280 ft; *CMR 5033* (BGWMA); *JF 224, 690, 2111, TR 96, BHW 18413* (SRSC).

§ *Kallstroemia grandiflora* Torr. ex A. Gray – Arizona poppy
"Infrequent" annual herb, dry calcareous soils along arroyos and on mountain ridges; DSC, DCA, 1800–2320 ft; *BLT & MT2 97-336, BHW & MCJ 16867* (SRSC); *EGM 53, BLT & MT2 97-336* (TEX-LL). Ernst Tinaja and the Boquillas area.

Kallstroemia hirsutissima Vail – Hairy caltrop
Uncommon annual herb, rocky limestone soils; DSC, 1900–3000 ft; *JF 199, 219, BHW 13066* (SRSC). North Dagger Mountain and near tunnel. Also known from Hot Springs. *BHW 13066* is not reflected in Turner et al. (2003).

§ *Kallstroemia parviflora* Norton– Warty caltrop
Annual herb; *BHW & LCH BG-197* (SRSC). East slopes Stairway Mountain in 1950.

Larrea tridentata (Sessé & Moc. ex DC.) Coville – Creosote, gobernadora
Abundant shrub, rocky soils on flats and hills, rock outcrops, sandy clay bottoms; DSC, DAR, 1800–3560 ft; *ACK 829* (BIBE); *JJ 40, JT 30* (SAT); *JF 606* (SRSC); *DS 1091* (TEX-LL).

! *Tribulus terrestris* L. – Goathead, puncturevine
"Infrequent to frequent" annual herb, sandy soil; RIO, 1800 ft; *BA2, DG, TE, & PC 4607, EGM 157* (BIBE); *BA2 4607* (SAT); *JF 2227*, *BHW 23036*, *BHW & MCJ 16850* (SRSC). Boquillas Canyon area.

APPENDIX B:

POTENTIAL SPECIES OF THE DEAD HORSE MOUNTAINS

APPENDIX B

POTENTIAL SPECIES OF THE DEAD HORSE MOUNTAINS

These are species that have been collected close to the study area and/or species whose known distributions make their occurrence within the study area likely, or unvouchered species listed on previous surveys. Unless otherwise noted, all distribution information is based on Turner et al. (2003) and/or collection information from the University of Texas at Austin herbarium's online database (TEX 2003). If a taxon was listed without a voucher collection in either of the two previous area surveys (Wells 1965, Amos and Giles 1992), it is noted as such.

AGAVACEAE

Dasylirion heteracanthium I. Johnst. Listed by Amos and Giles (1992), citing a specimen at BIBE, however no specimen was found. During the SRSC search, a specimen collected in Brushy Canyon and originally identified as *D. heteracanthium* was discovered (*AMP & SAP 5127*). Despite having few, if any, retrorse marginal teeth, the current annotation places it with *D. leiophyllum*. This species is reported to occur in south Brewster and Presidio counties (Powell 1998) but no localities or specimens are cited.

AMARANTHACEAE

Amaranthus retroflexus L. Listed by Amos and Giles (1992); known locally from the Chisos and Glass Mountains.

ASTERACEAE

Cirsium undulatum (Nutt.) Spreng. Listed by Wells (1965); known locally from several areas in Brewster County.

Erigeron flagellaris A. Gray. Listed by Amos and Giles (1992); known locally from the Chisos Mountains and southern Pecos County.

Heterotheca sp. Listed by Amos and Giles (1992); two species occur in the region: *Heterotheca fulcrata* and *Heterotheca subaxillaris*.

Machaeranthera blephariphylla (A. Gray) Shinners. Listed by Amos and Giles (1992); north Brewster County and westward distribution.

Ratibida columnifera (Nutt.) Wooton & Standl. Listed by Amos and Giles (1992); common throughout the state.

Simsia calva (A. Gray & Engelm.) A. Gray. Listed by Amos and Giles (1992); well-represented regionally.

Tetragonotheca sp. Listed by Amos and Giles (1992); *Tetragonotheca texana* is the only species with a feasible distribution in Turner et al (2003).

BORAGINACEAE

Heliotropium molle (Torr.) I.M. Johnst. Possible; collected by NPS staff at Dog Flats; many other collections are known to the north.

BRASSICACEAE

Synthlipsis greggii A. Gray. Known from Dog Flats and to the east in BGWMA.

CACTACEAE

Echinocereus × *roetteri* (Engelm.) Engelm. ex Rümpler var. *neomexicanus* (J.M. Coult.) A.D. Zimmerman. Expected according to Powell and Weedin (2004).

Echinocereus viridiflorus Engelm. var. *russanthus* (Weniger) A.D. Zimmerman. Expected according to Powell and Weedin (2004). This name is also the best approximated synonym of the taxon *Echinocereus chloranthus* listed by Amos and Giles (1992) and collected at the McKinney Spring ranch house and northward on the Old Ore Road.

Epithelantha bokei L.D. Benson. Possible; occurs just outside of the study area near the Rio Grande.

Lophophora williamsii (Lem. ex Salm-Dyck) J.M. Coult. Possible; the study area contains the appropriate habitat.

Opuntia azurea Rose var. *parva* A.M. Powell & J.F. Weedin. Expected according to Powell and Weedin (2004).

Opuntia imbricata (Haw.) DC. Expected according to Powell and Weedin (2004).

Opuntia phaeacantha Engelm. Listed by Amos and Giles (1992). This species has a more northerly distribution in the Trans-Pecos, but the similar *Opuntia camanchica* is one of the most common species in the Trans-Pecos and is expected throughout the study area (Powell and Weedin 2004).

Opuntia strigil Engelm. var. *strigil.* Listed by Amos and Giles (1992); occurs just outside of Brewster County to the east.

FABACEAE

Desmanthus glandulosus (B.L. Turner) Luckow. Expected; has been collected elsewhere in BBNP, is not an especially restricted species, and is well-represented regionally.

HYDROPHYLLACEAE

Nama torynophyllum Greenm. Several collections have been made near Hot Springs, and in Dog Flats.

LAMIACEAE

Scutellaria drummondii Benth. Listed by Amos and Giles (1992); of several varieties, var. *edwardsiana* occurs to the north of the study area.

LILIACEAE

Allium drummondii Regel. Collected from several locations in BGWMA and west of Stillwell Crossing.

Allium perdulce S.V. Fraser var. *sperryi* Ownbey. Known from Dog Flat.

LOGANIACEAE

Emorya suaveolens Torr. Possible; the only Texas locality is on Maravillas Creek in BGWMA, just east of the study area.

PAPAVERACEAE

Argemone squarrosa Greene subsp. *glabrata* G.B. Ownbey. Listed by Amos and Giles (1992); known from northern Brewster County.

POACEAE

Scleropogon brevifolius Phil. Listed by Wells (1965). Turner et al. (2003) records this species in the study area but no specimens were discovered. Voucher collection localities near the study area include Dog Flats and the Chisos Mountains, in addition to many areas near Alpine and Marathon (TEX 2003).

POLEMONIACEAE

Gilia rigidula Benth. var. *rigidula*. Expected according to Turner et al. (2003).

POLYGALACEAE

Polygala maravillasensis Correll. Collected in Black Gap along the river and in the lower canyons of the Rio Grande.

PTERIDACEAE

Notholaena aliena Maxon. Possible according to Yarborough and Powell (2002). Locally known from BGWMA and the Chisos Mountains.

Notholaena copelandii C.C. Hall. Possible according to Turner et al. (2003) and Yarborough and Powell (2002).

RUBIACEAE

Hedyotis angulata Fosberg. Occurs sporadically in the Trans-Pecos, mostly to the east. One collection was made just east of the DH in BGWMA

SALICACEAE

Populus angustifolia E. James. Reported to occur in the RGV area (Powell 1988) and expected according to Turner et al. 2003.

SOLANACEAE

Chamaesaracha coronopus (Dunal) A. Gray. Listed by Amos and Giles (1992); regionally common.

VERBENACEAE

Glandularia racemosa (Eggert) Umber. Known from Dog Flats.

APPENDIX C:

SPECIES UNLIKELY TO OCCUR IN THE DEAD HORSE MOUNTAINS

APPENDIX C

SPECIES UNLIKELY TO OCCUR IN THE DEAD HORSE MOUNTAINS

The distribution information used to judge likelihood of occurrence and furnish any relevant comments in the species entries are taken from Turner et al. (2003), unless noted otherwise. These taxa were listed by Amos and Giles (1992), without corresponding voucher collections.

AGAVACEAE

Yucca carnerosana (Trel.) McKelvey. The name has been misapplied to the giant dagger yuccas of the Trans-Pecos, *Yucca faxoniana*, for a long time. It is a Mexican taxon, occurring well below the Rio Grande according to Powell (1998).

Yucca treculeana Carrière. Appearing similar to *Yucca torreyi*, this species occurs in south Texas.

ASTERACEAE

Brickellia brachyphylla (A. Gray) A. Gray. Known from the Guadalupe Mountains and in the Texas panhandle.

Brickellia eupatorioides (L.) Shinners var. *gracillima* (A. Gray) B.L. Turner. Listed as *Brickellia leptophylla*, it has a central Texas distribution.

Grindelia squarrosa (Pursh) Dunal. From North-central Texas.

FAGACEAE

Quercus turbinella Greene. Hand-written onto the report (Amos and Giles 1992), this species is known mostly from El Paso and Hudspeth counties, with one recent collection from the Chinati Mountains of Presidio County (TEX 2003).

GENTIANACEAE

Centaurium breviflorum (Shinners) B.L. Turner. Listed as *Centaurium calycosum* var. *breviflorum*, it is known from south Texas.

VITA

Census

Born in Washington, D.C. and raised by parents Ann and Jeff Fenstermacher, with brother Benjamin, in Burke, Virginia. Attended Lake Braddock Secondary School in Burke, Virginia.

Training

Earned a B.A. in Biology and Environmental Science and Policy, concentrating in Behavioral Ecology and Conservation Biology, from Duke University in Durham, North Carolina in 1996.

Experience

Recent work includes several positions with the National Park Service in Big Bend National Park, monitoring rare plants and serving as an interpretive Park Ranger. Previous field work in the biological sciences includes endangered forest bird recovery in Hawaii, brown bear behavior in Alaska, urban river management in Georgia, and resource management in Nevada. Other significant work experience includes serving as an outdoor experiential educator in Texas and North Carolina.