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Distribution of *Ferocactus emoryi* (Cactaceae) in Arizona

Root Gorelick and Shannon C. Doan

School of Life Sciences, Arizona State University, Tempe, AZ 85287-4501, USA (email: cycad@asu.edu and sdoan@asu.edu).

Summary: We describe an undocumented large population of *Ferocactus emoryi* (Engelmann) Orcutt that straddles the border of Pinal and Maricopa Counties at the southwestern base of Table Top Mesa and along Vekol Wash. This population consists of at least fifty and probably hundreds of individuals, including at least one small 10 x 15 cm individual. Further field work will be required to ascertain whether this population of *F. emoryi* is contiguous with (i) an extensive population on the western side of the Sand Tank Mountains, (ii) the main distribution of *F. emoryi* in southern Pima County, and (iii) the disjunct distribution in the Sierra Estrella. Based on our field observations, primary literature, and herbarium records, the range of *F. emoryi* in the United States is bounded to the east by the Baboquivari, Coyote, Quitojoa, Vekol, Table Top, and Estrella Mountains. The range is bounded to the north by the Gila River. The western boundary of the range is equivocal, with herbarium specimens from far western Pima County, but only written reports of *F. emoryi* from Yuma County. If the distribution of *F. emoryi* is found to be contiguous in Pima, Pinal, and Maricopa Counties, the distribution of *F. emoryi* in the United States is similar to that given in Nigel Taylor's systematic review of the genus, plus possibly peripheral populations as reported from Yuma County by Lyman Benson.

Zusammenfassung: Wir beschreiben eine bisher nicht dokumentierte, grosse Population von *Ferocactus emoryi* (Engelmann) Orcutt aus dem Grenzgebiet der Pinal und Maricopa Counties an der südwestlichen Basis der Table Top Mesa und entlang des Vekol Wash. Diese Population besteht aus wenigstens fünfzig und möglicherweise hunderten von Individuen und umfasst auch mindestens eine Jungpflanze von 10 x 15 cm. Es bedarf weiterer Feldarbeit um festzustellen, ob (i) diese Population mit der grossen Population auf der Westseite der Sand Tank Mountains zusammenhängt, (ii) welches die Hauptverbreitung von *F. emoryi* im südlichen Pima County ist, und (iii) zur Beurteilung des disjunkten Vorkommens in der Sierra Estrella. Auf Grund unserer Feldarbeit sowie Primärliteratur und Herbarbelegen ist das Vorkommen von *F. emoryi* in den USA im Osten durch die Baboquivari-, Coyote-, Quitojoa-, Vekol-, Table Top- und Estrella-Berge begrenzt. Im Norden bildet der Gila River die Grenze. Die westliche Grenze des Verbreitungsgebiet ist fraglich, und es gibt Herbarbelege aus den weit westlich gelegenen Teilen des Pima County, aber nur schriftliche Angaben zu *F. emoryi* aus dem Yuma County. Falls das Verbreitungsgebiet in den Pima, Pinal und Maricopa Counties zusammenhängend ist, entsprechen die Vorkommen von *F. emoryi* dem von Nigel Taylor in seiner systematischen Übersicht über die Gattung angegebenen Gebiet, plus möglicherweise randliche Populationen aus dem Yuma County, wie sie von Lyman Benson erwähnt werden.

Introduction

The distribution of the Coville's barrel cactus, *Ferocactus emoryi* (Engelmann) Orcutt (synonyms: *F. covillei* Britton & Rose, *Echinocactus emoryi* Engelmann), in Arizona is poorly known despite the huge recent human population increases in southern Arizona and the large conspicuous nature of this species, which can grow to 2.5 m tall (although is typically under 1.5 m tall in Arizona) and has fiery red flowers. Here we

provide data on the extent of the distribution of *F. emoryi* in Arizona, including specimens from Maricopa County to the north and Pinal County to the northeast, and literature on specimens in Yuma County to the west (Figures 1 and 2). We compare this data with several earlier published distributions, especially in light of a large and previously unreported population of *F. emoryi* along the border of western Pinal County and southern Maricopa County. This site was previously known from a single purportedly isolated specimen, which we now know belongs to one of the largest and most northerly healthy populations of *F. emoryi*. This population from Vekol Wash/Table Top Wilderness provides additional evidence for there being a single contiguous distribution of *F. emoryi* from Organ Pipe National Monument to the northeast portion of the Sierra Estrella that overlooks the Gila River.

Vekol Wash/Table Top Mesa Population

A large population of *F. emoryi* grows along Vekol Road, south from near Interstate 8 for at least 15 km, and then continues to grow along the unlabelled road that proceeds east for roughly another 5 km to the southwest base of Table Top Mesa. Along this 20 km stretch of Vekol Road and the unlabelled road to Table Top Mesa, *F. emoryi* is by far the most prevalent barrel cactus. In October of 2004, one of us saw at least fifty individuals along this drive, never walking more than a hundred metres from the road. Although *F. emoryi* is numerous along Vekol Wash, there is never a great density of individuals at any given locale. That is, although there are probably hundreds of individuals near this portion of Vekol Wash, you can usually not see more than three individuals from any single vantage point on the ground, even in areas that have fairly depauperate vegetation.

Along the drive between Interstate 8 and the Table Top Mesa trailhead, we saw the first specimens of *F. emoryi* on Vekol Road 3 km south of Interstate 8 (Figures 3–5), which is north of the first cattle guard on the dirt portion of Vekol Road (Figure 2). We saw the last specimens of *F. emoryi* about 1 km west of the campgrounds at the trailhead to Table Top Mesa (Figures 6–8). The plants just west of the Table Top Mesa trailhead occur on both sides of the border between Maricopa County and western Pinal County. *F. emoryi* was visible virtually continually in this stretch of drive in Table Top Wilderness, except in the large mesquite bosque that immediately follows the turnoff to the east from Vekol Road, and except for the first couple of kilometres south of Interstate 8 and the last kilometre before the Table Top Mesa trailhead. Individuals are as large as 1 m tall and 40 cm across (Figure 3). All specimens that we saw on 16 October 2004 were in full fruit.

There appears to be some regeneration of *F. emoryi* seedlings in the Table Top Wilderness. The smallest specimen we found was a 10 cm tall and 15 cm diameter plant, in full fruit, growing beneath a creosote bush, *Larrea tridentata* (Figure 8). Thus far, we have not found any smaller individuals despite the fact that (1) seedlings of *F. emoryi* are readily distinguishable from seedlings of other barrel cacti in Arizona by their bluish epidermis, lack of distinct ribs, and stout reddish spines and (2) every specimen we saw in October 2004 was in full fruit, making even small sexually mature specimens quite obvious. Nonetheless, even this single small specimen near Table Top Mesa is promising compared with reports from other collectors in Maricopa County. For example, Allan Zimmerman reported finding only two small adults and one large carcass of *F. emoryi* after three hours of searching in the North Maricopa Mountains (*Zimmerman* 2553 (1989); ASU 190757), while Joseph N. Rose collected a single individual near Gila Bend (*Rose* s.n. (1908); US 3045015). Marc Baker, who reported many individuals near Sand Tank Wash (*Baker* 12245 (1996); ASU 219992), found no juveniles. The smallest other specimen that we know about from Maricopa or Pinal Counties is a 28 cm specimen collected by Wendy Hodgson in the southeast Sierra Estrella (*Hodgson* 6464 (1992); DES 35862).

Almost all specimens of *F. emoryi* that we saw in the Vekol Wash/Table Top Wilderness population appeared to have had creosote bush, *Larrea tridentata*, as a nurse plant, at least when the cacti were juveniles. The one small specimen we saw was nestled under the south side of a healthy creosote bush (Figure 6). Most larger specimens of *F. emoryi* had a living or dead creosote bush right alongside or – more typically – growing out from underneath the base of the cactus stem (Figure 3), indicative of the *Ferocactus* overgrowing the originally very close creosote bush. An alternative explanation would be that the creosote bush was using the barrel cactus as a nurse plant, but this is unlikely given the extreme

longevity of *L. tridentata* (McAuliffe, 1994; Bowers *et al*., 1995; Cody, 2000). Plus, creosote size is poorly correlated with creosote age because the plants can get much smaller in times of prolonged drought (Miller & Huenneke, 1996), such as Arizona has experienced for the past seven years. Therefore, when conducting systematic surveys for *F. emoryi*, careful attention should be paid to possible seedlings under creosote bushes.

Marc Baker (*Baker* 12245 (1996); ASU 219992) reports many plants of *F. emoryi* from an area in southern Maricopa County in Sand Tank Wash, which is on the western flank of Javelina Mountain (the broadest and tallest peak in the Sand Tank Mountains), near Sand Tank Well (Figure 2). Vekol Wash is fed by several tributaries (arroyos) running down from the eastern flank of Javelina Mountain. It is unknown whether Baker's population at Sand Tank Wash is contiguous with the population that we described above at Vekol Wash/Table Top Wilderness. The most likely place to look for individuals bridging these two areas is in the area just north of Javelina Mountain and just south of Big Horn and Freeman.

The only other barrel cacti sympatric with the *F. emoryi* in Arizona are *F. wislizeni* Britton & Rose (Figures 9 and 10) and *F. cylindraceus* (Engelmann) Orcutt, which are far less common along Vekol Wash by at least a factor of ten. *F. wislizeni* can easily be distinguished from *F. emoryi* by its many slender bristle-like radial spines that complement the more robust spines; compare Figure 4 with 9 and compare Figure 5 with 10 (Benson, 1982; Taylor, 1984; Anderson, 2001; Zimmerman & Parfitt, 2004). These two species can also be distinguished by their flowers. *F. emoryi* flowers in mid-summer with exclusively fiery red flowers, especially the inner surface of the tepals. *F. wislizeni* typically flowers later in the year – in August through October in both the Sonoran and Chihuahuan Deserts (although occasional flowering does occur earlier in the year) – and, at least for specimens in the United States, *F. wislizeni* typically has much more orange flowers than does *F. emoryi* (Figure 10). *F. cylindraceus* is readily distinguished from *F. emoryi* by yellow flowers, more spines per areole, presence of bristle-like or yellow radial spines and less visible epidermis through the spines. *F. cylindraceus* is distinguished from *F. emoryi* and *F. wislizeni* by its narrower and less massive stems and often by more flattened spines. Based on herbarium records and the distribution maps in the literature discussed below, there are no records of *F. cylindraceus* in the Table Top Wilderness. However, *F. cylindraceus* is sympatric with *F. emoryi* in Maricopa County, in the Sierra Estrella and near Gila Bend (Benson, 1982), and we found one specimen of *F. cylindraceus* (Figure 11) along Vekol Road approximately 13 km south of Interstate 8.

Review of other records from Arizona

There are many herbarium records for *F. emoryi* in Pima County, but few from Maricopa and Pinal Counties and none that we can find from Yuma County (Figure 1). We have examined herbarium specimens from ASU; had the staffs of US, PH, DES, and RSA report data from their herbaria to us; and examined the electronic records from ARIZ, ASC, and NY. All of the Maricopa County records are from south of the Gila River. Even though *F. emoryi* has been found as far north as the northeast portion of the Sierra Estrella, virtually overlooking the Gila River at approximately 33° 22' N (*E & M Sundell* 461 (1974); ASU 67944), none have been found at South Mountain, which is on the opposite side of the Gila River (Daniel & Butterwick, 1992) (but see our discussion regarding Lindsay's dissertation, below). Other specimens are known from further southeast in the Sierra Estrella, including in Pinal County (Earle, 1980; *Hodgson* 6464 (1992); DES 35862). There is also a collection from 16 km west of the town of Mobile, in southwest Maricopa County (*Zimmerman* 2553 (1989); ASU 190757), in which only two living and one dead specimen were found after three hours of searching.

Benson (1982) is the only source we can find reporting *F. emoryi* (as *F. covillei*) from Yuma County, where he reports one site just south of the Gila River very near Interstate 8 in the northeastern portion of the Gila Mountains and a second site very close to the southern border of Yuma County in the Cabeza Prieta National Wildlife Refuge, in what appears to be the Tule Mountains or the southern portion of the Cabeza Prieta Mountains (Figure 1). However, we have not visited these sites nor have found any herbarium specimens from Yuma County.

We compiled the two distribution maps herein (Figures 1 and 2) from a non-exhaustive search of records from the aforementioned

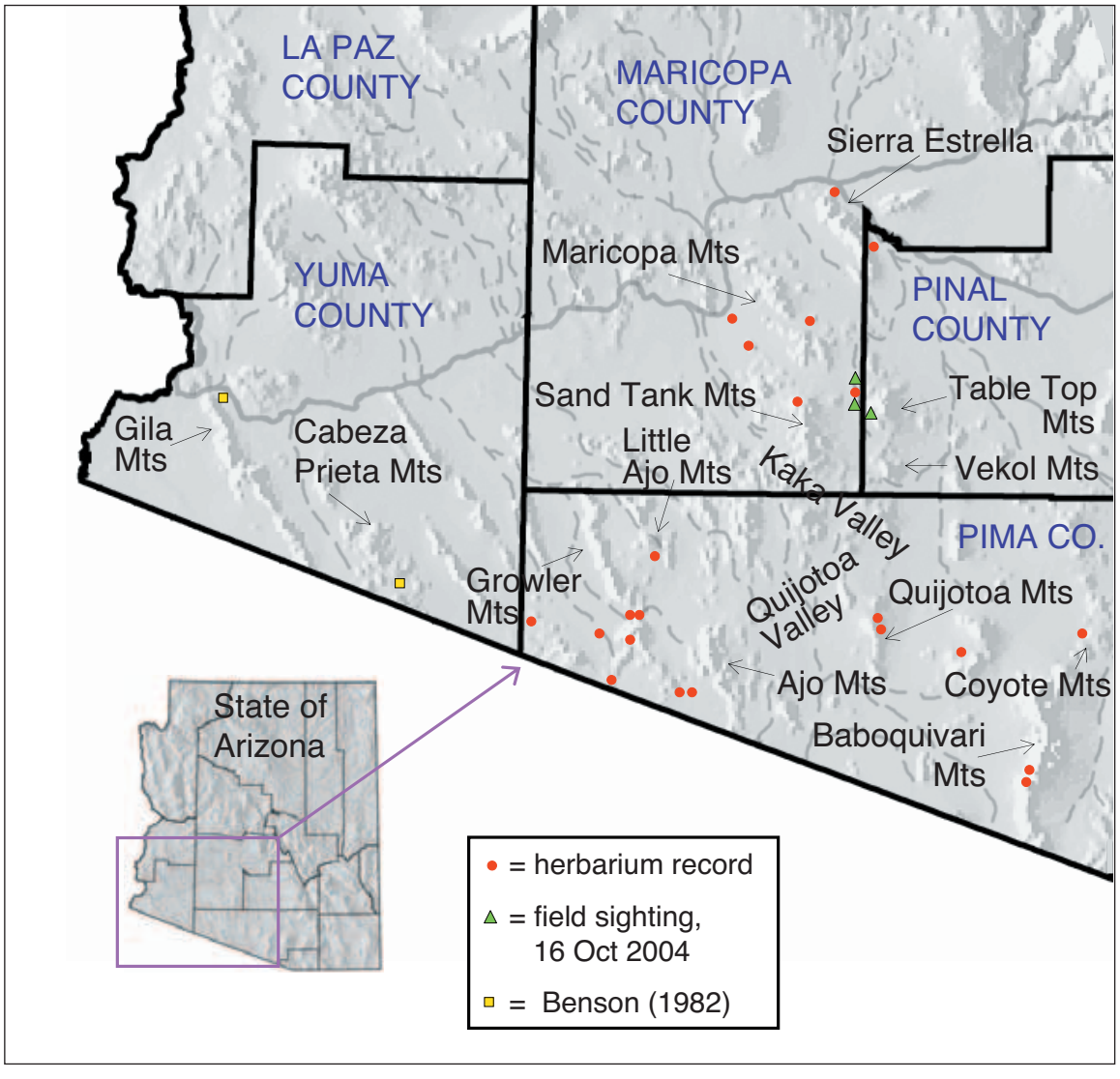

Figure 1. Distribution of *F. emoryi* in southwestern Arizona. This relief map shows county borders with bold lines. Perennial river beds are depicted with faint solid lines; ephemeral stream beds (arroyos) with faint dashed lines.

herbaria, our field observations on 16 October 2004, and Benson's (1982) two reported specimens from Yuma County.

Next we review the four definitive works on the genus *Ferocactus* in the United States, each of which presents detailed distributions of the five native *Ferocactus* species, only three of which are native to Arizona: George Lindsay's Ph.D. dissertation (1955), which was reprinted with additional chapters by other authors in 1996; Lyman Benson's magnum opus on *Cacti of the United States and Canada* (1982); Nigel Taylor's systematic review of the genus (1984); and Allan Zimmerman and Bruce Parfitt's recent treatment of the genus for the *Flora of North America* (2004).

George Lindsay (1955) records the main distribution – not including two disjunct distributions – of *F. emoryi* (as *F. covillei*) extending only into southern Pima County, with the most northerly and westerly portion of the main distribution being in the Growler Valley just west of Growler Peak in far western Pima County. He does not show *F. emoryi* in Yuma County nor the

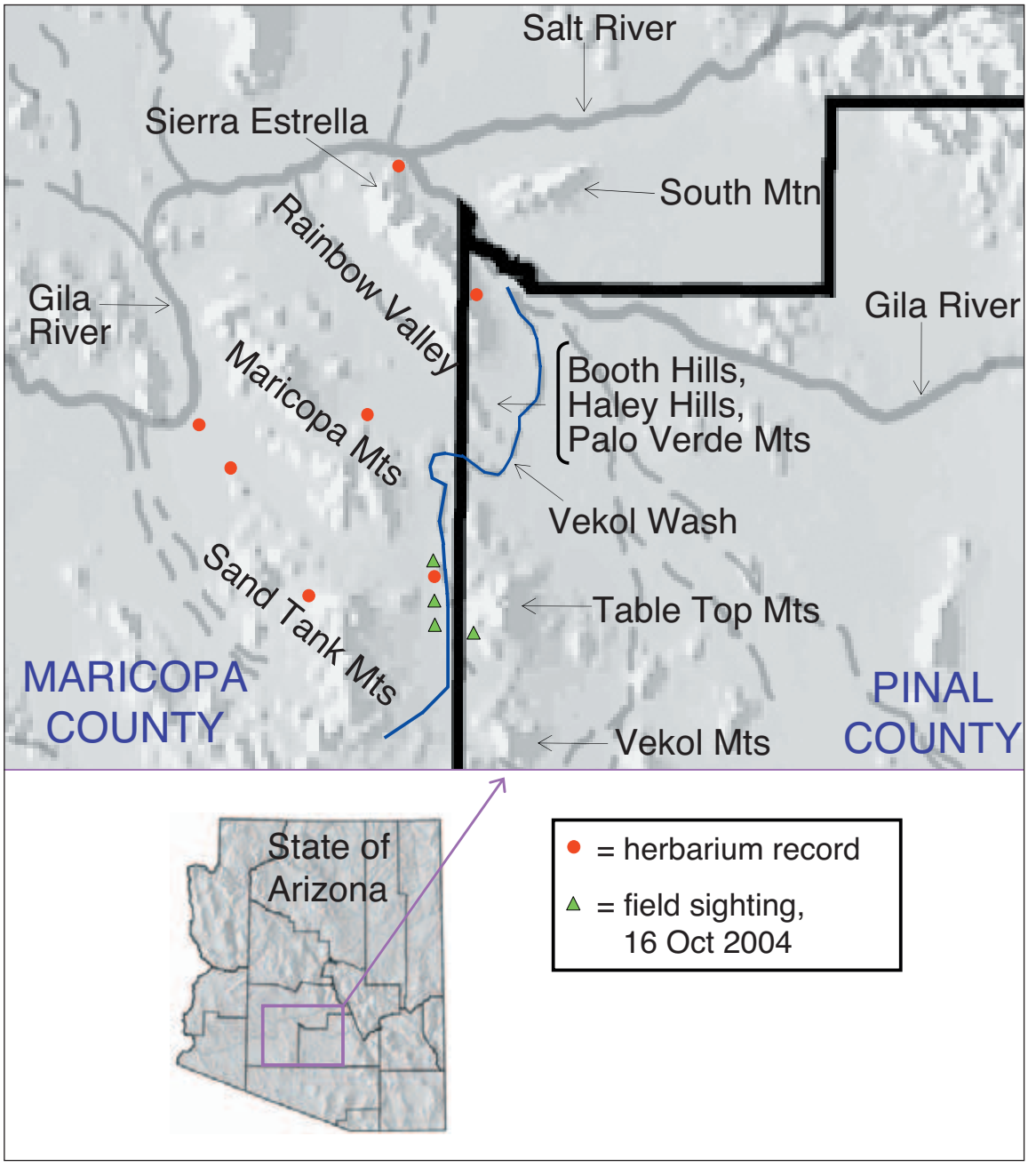

Figure 2. Distribution of *F. emoryi* in Maricopa and Pinal Counties, Arizona. The three green triangles represent many specimens that we saw interspersed along this 20 km stretch of road.

Growler Valley in Pima County. Lindsay also shows a pair of more northerly disjunct distributions for *F. emoryi* in southwest Arizona. However, Lindsay lists all but one of his representative specimens from the area circumscribed by his main distribution of *F. emoryi* (*F. covillei*) in southern Pima County, and lists no representative specimens from the more northerly of his two disjunct distributions. He does, however, list one representative sample from the southernmost portion of his more southerly disjunct distribution, in the Quitojoa Mountains (*Blakley &*

Speck 262; DES), which is also in Pima County. Thus, all of his representative specimens are from Pima County. However, in his statement on the distribution of *F. covillei*, Lindsay (1955) states, "In Arizona [*F. emoryi* is] usually found between 1,500 ft. and 3,000 ft. elevation, mostly in the Organ Pipe National Monument and the Papago [Tohono O'odham] Indian Reservation in Pima County, with isolated colonies in Maricopa and Pinal counties."

The more southern of Lindsay's (1955) two disjunct distributions extends from the Quijotoa Mountains in the south, north to the Sand Tank Mountains, and is bounded to the west by the Kaka Valley and Saucedo Wash. His distribution map shows that this southerly disjunct distribution barely extends into far southwestern Pinal County, in the area of Kohatk Wash and Cathedral Rock and the edge of the nearby Vekol Mountains. We concur with Lindsay's (1955) southern disjunct distribution except that we would – at a minimum – extend it to the north to include Table Top Valley, Vekol Wash, the western flank of Table Top Mesa, and the western flank of Javelina Mountain. It is unknown whether Lindsay's (1955) southern disjunct distribution is contiguous with his main distribution area in southern Pima County. The best places for further exploration are the small (circa 20 km) gap between these two putative distributions, especially in the Gu Oidak Valley, Quijotoa Valley, and the bajada of the nearby South Mountain and Quijitoa Mountains, all of which are on the Tohono O'odham Indian Nation.

The most northern of Lindsay's (1955) two disjunct distributions is the entire Sierra Estrella Range, plus contiguous areas to the northwest and southeast (Figure 2). The portion to the northwest of the Sierra Estrella contains an area just north of the Gila River, i.e. the southeastern portion of Buckeye Valley. Although small numbers of *F. emoryi* may extend a short distance away from the base of the Sierra Estrella, we do not know of any live or herbarium specimens from the opposite (north) side of the Gila River nor from the arroyos draining the northwestern portion of the Sierra Estrella. The portion of this disjunct distribution to the southeast of the Sierra Estrella contains the Palo Verde Mountains, Papago Butte, and the bajada and alluvial fans between these hills and the surrounding arroyos, i.e. Waterman Wash to the west and Vekol Wash to the south and east. However, we only know of one collection from the far southern portion of the Sierra Estrella or from further areas just to the south or east. This is a large population of *F. emoryi* in the southeast Sierra Estrella between Montezuma Peak and Montezuma Head (*Hodgson* 6464 (1992); DES 35862). We have no reason to question Lindsay's (1955) circumscription of the southeast portion of this disjunct distribution except that we do not know of any collections or populations from the Palo Verde Hills, Papago Butte, Haley Hills, Booth Hills, nor along the nearby portions of Vekol Wash…all of which would thus be fine places for further field work. If *F. emoryi* is found in these places, especially near or along Vekol Wash between 32°50' and 33°10' N, this would make Lindsay's (1955) two disjunct distributions contiguous with one another. It would also be worth conducting field work in Mobile Valley, Rainbow Valley and possibly the Maricopa Mountains to their west to ascertain whether Lindsay's two disjunct distributions are contiguous but to the west of the Sierra Estrella.

Lindsay's 1955 dissertation was reprinted in 1996, and was purportedly reprinted verbatim, with new editorial comments clearly indicated in italics. The photos and figures were all purportedly scanned from the original dissertation, although no explicit mention is made of how the original distribution maps were rendered in the 1996 reprint. The dust-jacket (flyleaf) states that Lindsay helped reassemble the 1996 reprint. Yet, both the text and distribution maps for *F. emoryi* in the 1996 reprint differ from his original dissertation. For example, in the 1996 reprint, the northernmost of the two disjunct populations of *F. emoryi* is roughly half the area that it was in his 1955 dissertation. The 1996 reprint excluded all the areas in Pinal County, such as Montezuma Peak and the Palo Verde Mountains, which is a mistake. In the main distribution, the 1996 reprint includes the well-documented Growler Valley population of *F. emoryi*, which was excluded in the original dissertation. Distribution map number 4 in the 1996 reprint also contains labels for various other *Ferocactus* species distributions, which are absent from the original. The original was probably colour-coded, but regrettably this is not evident on the copies of the original dissertation supplied by UMI. Because there is no explicit indication in the 1996 reprint that Lindsay intended to alter his notion of the distribution of *F. emoryi*, we suspect that the 1996

reprint contains transcription errors of the original (1955) distribution map.

Lyman Benson (1969, 1982) only records *Ferocactus emoryi* (as *F. covillei*) from the southern halves of both Pima and Yuma Counties, and never anywhere near the Vekol Wash/Table Top Wilderness, Sand Tank Wash, or Sierra Estrella populations in southern Maricopa and western Pinal Counties. His two locales for *F. emoryi* in Yuma County are both south of the Gila River – one near the northeast portion of the Gila Mountains just south of the Gila River and the other in the Tule Mountains or possibly southern tip of the Cabeza Prieta Mountains (Figure 1). We have not found any herbarium records of *F. emoryi* from Yuma County, including in RSA which subsumed the POM collection after Benson's death. Steve Boyd of RSA suggests that Benson may have simply made living collections – and no herbarium specimens – from these two Yuma County sites.

Nigel Taylor (1984) provided a distribution map for *F. emoryi* in which he simply filled in the geographic gaps in Lindsay's 1955 map between the main and two disjunct populations (Nigel Taylor, personal communication). Taylor thereby shows a single contiguous distribution for *F. emoryi*, even though he did not examine herbarium specimens or living individuals in habitat from the geographic gap between the Sierra Estrella and Table Top Mountains nor from the geographic gap between the Quijitoa Mountains and the town of Sells. Based on our discussions of Lindsay's (1955) distribution maps, above, we concur with Taylor's (1984) distribution map. Like us, Taylor (1984) has never found herbarium specimens or living individuals of *F. emoryi* from Yuma County (Nigel Taylor, personal communication).

Zimmerman & Parfitt's (2004) distribution map in the *Flora of North America* appears to be incorrect for both the northern and southern extents of the range of *F. emoryi* in the United States. Although a thumbnail map, their distribution map clearly excludes southern Pima County and includes *F. emoryi* extending north through eastern La Paz County and southern Mojave County to somewhere between Kingman and Wikieup. We have not found specimens in the field, herbarium, nor literature from either La Paz or Mojave Counties, both of which are well north of the Gila River. However, to the south, *F. emoryi* has been documented numerous times in Cabeza Prieta National Wildlife Refuge, is relatively common in Organ Pipe National Monument, and has been documented as far east as Fresnal and Feddington Canyons in the Baboquivari Mountains and the Coyote Mountains. Zimmerman & Parfitt (2004) scrutinized Benson's distribution maps in the genus *Ferocactus* – in fact, they criticised Benson's (1982) distribution map for *F. hamatacanthus* var. *sinuatus* – yet were uncritical of Benson's distribution map for *F. emoryi*. Based on their extreme care and thorough review of the literature and herbarium records and their extensive field experience, we suspect that there was simply an inadvertent error in constructing and/or printing the distribution map for *F. emoryi* in Zimmerman & Parfitt (2004).

Concluding Remarks

We believe that the current distribution map of *F. emoryi* in the United States should be roughly an amalgamation of Benson's (1982) and Taylor's (1984) maps. Lindsay's (1955) distributions were probably a little too conservative, although fifty years have given us the benefit of many new herbarium specimens and new roads to explore. These intervening fifty years have largely, but not completely, allowed us to fill in the gaps between Lindsay's two disjunct distributions and his main distribution for *F. emoryi*. More field work is needed, especially between Sells and the Sierra Estrella (e.g. Gu Oidak Valley, Kaka Valley, Quijotoa Valley, Palo Verde Hills, Haley Hills, Booth Hills, and Vekol Wash). Likewise, it is possible but unlikely that Benson (1982) made a pair of independent errors in recording such a distinctive species as *F. emoryi* from Yuma County. We hope this also provides impetus to search for new or existing herbarium specimens of *F. emoryi* from Yuma County.

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Figure 3. *F. emoryi* on Vekol Road, 3 km south of Interstate 8. Note the creosote bush which probably originally served as a nurse plant that is now being overgrown and displaced by the barrel cactus. Plant approximately 90 cm tall. **Figure 4**. Close-up of the plant in Figure 3. **Figure 5**. *F. emoryi*, top down view of the plant in Figures 3 and 4. **Figure 6**. *F. emoryi* with Table Top Mesa in the background.

Figure 7. *F. emoryi* near base of Table Top Mesa, growing in particularly lush vegetation (compared with the unusually depauperate vegetation in which large specimens of this species are often found), with chain fruit cholla (*Cylindropuntia fulgida*). **Figure 8**. *F. emoryi* near base of Table Top Mesa. This plant is 15 cm across and 10 cm tall, growing under the south side of a creosote bush (*L. tridentata*) nurse plant. **Figure 9**. *F. wislizeni* along Vekol Road growing in a creosote bush nurse plant. Note the many bristly radial spines that are typical of *F. wislizeni*, but lacking from *F. emoryi*. **Figure 10**. Top down view of *F. wislizeni* along Vekol Road. Note the combination of stout and bristly radial spines. Also note the orange flower on 16 October 2004, which is redder than is typical. **Figure 11**. A 1.5 m tall specimen of *F. cylindraceus* along Vekol Road, 12 km south of Interstate 8.

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