

OLSON, M. E., J. A. LOMELÍ S., AND N. IVALÚ CACHO. 2005. Extinction threat in the *Pedilanthus* clade (*Euphorbia*, Euphorbiaceae), with special reference to the recently rediscovered *E. konzattii* (*P. pulchellus*). *American Journal of Botany* 92(4): 634-641.

APPENDIX 3. Preliminary MER (Method for Evaluation of Risk of Extinction for Mexican Wild Species) assessments for other species of the *Pedilanthus* clade in Mexico.

Endemic Mexican species of conservation concern—Insufficient information is available to perform MER assessments for the following five species in as much detail as could be desired. However, the apparent urgency of their situations justifies these preliminary assessments: the first two species may already be extinct, at least in the wild, and the continued survival of the other three may soon be an issue. These preliminary evaluations are presented following the Global Strategy for Plant Conservation that established as an objective for the year 2010 preliminary assessments of the conservation status of all known plant species (Anonymous, 2002). Total scores are summarized in Table 2.

Euphorbia dressleri V. W. Steinm.—This species was described (as *Pedilanthus gracilis*) by Dressler in 1957 based on a single collection (Hinton 10973, isotypes: MEXU!, MO!, NY!, P!). Hinton's vague locality information reads "Guerrero, Distr. Galeana, Atoyac. Wooded hill. 240 m a.s.l. 25 Nov. 1937". We made two visits to the area of Atoyac, in December 2002 and February 2003, and thoroughly searched the slopes of all the hills that met the following criteria: (1) They occurred in sufficient proximity to Atoyac that they could be construed as being located at "Atoyac", sensu Hinton's label; (2) The elevation corresponded to 500 m a.s.l. or lower; (3) The presence of at least some non-ruderal vegetation. Similar criteria have allowed us to relocate other Hinton localities. For example, the locality of a *Cnidocolus* species in Michoacán, which Hinton described as "Villa Victoria, Distr. Coalcomán" (G. B. Hinton 13908, NY!) was collected less than two kilometers away from that village. If the type population of *E. dressleri* still exists, it seems likely that it would be within a similar radius around Atoyac.

We carefully searched numerous hills on both sides of the Atoyac River, including Cerro La Piedra, Cerro La Mina and canyons on their northern flanks, Cerro Rasca Viejo (the 360 m a.s.l. peak NNE of the dam on the Atoyac River), and the slopes of Cerro La Piedra del Diablo. Farther afield, we searched higher elevations in the vicinity of Agua Fría and between Cacalutla and the area of El Quemado and Cerro Prieto de Los Blanco. We also visited the low coastal hills (less than 100 m a.s.l.) to the southwest of San Jerónimo de Juárez, which can be seen from the vicinity of Atoyac.

Of the nearly 30 residents interviewed in the areas visited, all confirmed that a plant fitting the description given was not to be found in the local area. Many asserted that such a plant occurred higher in the mountains. We initially discounted these reports, because it is common for residents of seasonally dry areas to regard the evergreen vegetation of higher elevations as lush and more diverse than the lowlands. However, because of the persistence of these reports, we extended our search to an elevational belt between 500 and 1500 m a.s.l. Indeed, *Pedilanthus* clade species do occur in the mountains above Atoyac, but they are not *E. dressleri*, as documented by collections of *E. peritropoides* (e.g., Olson and Cacho 996, MEXU!) and *E. calcarata* (*G. Espinosa* 9, and *N. Turrubiate* *G. 110*, FCME!) in the mountains northeast of Atoyac at approximately 1000 m where it shares the common name "zapatito de la virgen" or "zapatito de niño" with the cultivated *E. tithymaloides*. That we were able to locate slipper spurses in the area and that we were able to confirm that local people are aware of the plant when it is present suggest that our methods would have located *E. dressleri* if it still occurred in the hills around Atoyac. Additionally, staff of the FCME herbarium have been exploring the state for over 10 years for their Flora of Guerrero project but have never collected this species. Carauta (1989) would consider this species already extinct because it has not been collected for more than fifty years.

(A) Distribution. This species is only known from a single collection from an area less than 5 % of the Mexican territory (score = 4).

(B) Condition of habitat. There are apparently no existing sites suitable for this species, so the condition must be considered hostile (score = 3).

(C) Intrinsic biological vulnerability. We consider the vulnerability of this species to be high (score = 3). Although this species is only known from a unique collection and therefore its biological requirements are practically unknown, we can deduce likely factors that make it vulnerable. Some of these could be the low recruitment rate or low resistance to disturbance that might be inferred by our failure to relocate it in the highly altered forest of Atoyac.

(D) Impact of human activity. No primary forest remains in the area of Atoyac. Much has been cleared for agriculture and pasture, and all of the forests we visited receive heavy pressure from wood collectors. Extensive areas are covered with weedy secondary vegetation that is probably inappropriate for slipper spurge. Residents reported that the eradication of opium poppy and marijuana cultivation in the area involved aerial herbicide spraying and semicontrolled burns. We attribute our failure to locate *E. dressleri* and the lack of local knowledge of such a plant to this extensive perturbation that has virtually destroyed the lowland forests of Atoyac. The impact of humans on this species has clearly been high (score = 4).

Euphorbia cyri V. W. Steinm.—Documents referring to the uses and abundance of this species go back more than two centuries. De Ávila (1998) cites an anonymous 18th century author who describes the plant and mentions its latex as a violent laxative. According to De Ávila, this species grew on land that is now part of Oaxaca City. Juan Caballero, author of a set of 18th century drawings of plants from Oaxaca to which De Ávila refers, provides an illustration recognizable as *E. cyri* (plate 26 in De Ávila, 1998), whose common name is “cordobán.” Given the endemic nature of this species and the evidence of its long tradition as a cultivated plant for living hedges, home remedies, and ornamental uses in the Oaxaca Valley, we urge the preservation of this important cultural and biological resource.

Euphorbia cyri presumably spreads in the wild mainly by seed, as does the similar *E. bracteata*, but it is propagated horticulturally by cuttings. A study of the population genetics of the species would indicate whether or not it consists of a few clones or has any substantial variation. A significant advantage for reintroduction efforts is that specific sites are known where the plant grew wild.

(A) Distribution. This species is known from at least seven localities reported in about 20 sets of specimens collected over more than a century in the Valley of Oaxaca. Our survey of recent collection localities of this species in January 1999, December 2002, and January 2003 revealed no extant wild populations. Interviews with local residents indicated that many were familiar with the plant and were able to describe it accurately, including its habit and distinctive yellow latex. Residents of towns from the area of Tlaxiactac de Cabrera, Mitla, and Santo Domingo Tomaltepec, to the area of Zaachila, on opposite sides of the Valley of Oaxaca, were able to show us areas where *E. cyri* formerly grew that are now replaced by housing. The collection Calzada 20316 (MEXU!) near San Sebastián Tecomaxtlahuaca bears label information that erroneously implies that *E. cyri* occurs in the wild there, whereas it is clearly only cultivated, as attested by our observations and interviews with ~30 local residents. Searches for *E. cyri* in the Valley of Oaxaca, where it is apparently endemic, are urgently needed. This is clearly a crucial time for this species, which still exists in local memory but perhaps is no longer in the wild. We assess its distribution as being very restricted (score = 4).

(B) Condition of habitat. No sites are known where *E. cyri* grows in the wild, so the habitat must be considered hostile or very limiting (score = 3).

(C) Intrinsic biological vulnerability. This species produces few seeds and consequently sexual reproduction is rare. However, it does produce large clumps of stems that appear to reach great ages, judging from stem diameters. It has a limited capacity to reproduce vegetatively, a property exploited by local people who propagate the plant using stem sections. We consider its intrinsic vulnerability to be intermediate (score = 2).

(D) Impact of human activity. This species occurred in a region that for centuries has been highly pressured by human activity, leading to changes in vegetation and land use. This alteration of the natural environment is singlehandedly responsible for the disappearance of *E. cyri*, so we assign the highest score in this category (score = 4).

Euphorbia colligata V. W. Steinm.—(A) Distribution. This recently described species is known from at least five localities within a restricted area on the Pacific slope in the Sierra Madre del Sur between Talpa de Allende and El Tuito, in Jalisco State. The species is distributed in less than 5% of Mexican territory and is thus considered very restricted (score = 4).

(B) Condition of habitat: This species grows on slopes and in ravines at the interface between tropical subdeciduous forest and pine–oak forest. This unusual ecotone is present only in thin ribbons within the greater landscape. Though populations are small and separated from one another by ridges, the habitat is favorable (score = 1).

(C) Intrinsic biological vulnerability. This species has a limited capacity to spread vegetatively via root sprouts, but it produces cyathia, fruits, and seeds in small amounts. These factors limit its reproductive

potential. We have seen the species persisting in conditions with at most very light disturbance and consider its vulnerability intermediate (score = 2).

(D) Impact of human activity. Seasonal burns and cattle grazing are common at *E. colligata* localities. *Euphorbia colligata* produces large clonal groups that spread via sprouts from tuberous roots. It seems possible therefore that the plant could resprout after fires, but this crucial information is not known. Because populations tend to be small and are restricted to a narrow ribbon of habitat, they appear easily eliminated. This idea is borne out by our observation that at least one population may be extirpated. We therefore assign an intermediate impact (score = 3).

Euphorbia finkii (Boiss.) V. W. Steinm.—This species is of crucial interest because it is the species that inhabits the wettest habitats and may be sister to the rest of the *Pedilanthus* clade. Unlike any other *Pedilanthus* clade species, this species grows in moist evergreen forest (cloud forest or tropical evergreen forest sensu Rzedowski, 1983) and has few physiological or anatomical adaptations to deal with drought.

(A) Distribution. This species is known from about 12 localities and 17 sets of specimens taken over more than 135 years in a range stretching central Veracruz to the Isthmus of Tehuantepec in eastern Oaxaca. Despite this wide range, the localities are extremely small and the species is distributed in less than 5% of the Mexican territory (score = 4).

(B) Condition of habitat. The cloud forest and tropical evergreen forest where this species grows have a highly restricted distribution in southeastern Mexico. However, where these habitats occur they are apparently favorable (score = 1).

(C) Intrinsic biological vulnerability. It is considered low (score = 1). This species flowers and presumably fruits abundantly. In addition, stems of *E. finkii* often fall and re-root, suggesting that it may be able to withstand a moderate degree of disturbance. That we have also observed an individual growing on a road cut supports this notion. Therefore, *E. finkii* may be able to persist along with the coffee plantations common in its range in a manner similar to *E. peritropoides*.

(D) Impact of human activity. This species is affected by clearing for crops, pasture, and urbanization. The small extent of many patches of moist forest makes them highly vulnerable to clearing for crops, pasture, and urbanization. At least one population, near Córdoba, Veracruz, has been extirpated by cultivation of coffee and sugar cane. It has not been collected in the area since 1948. Most of the other areas where *E. finkii* occurs are forest fragments in otherwise highly perturbed landscapes. We therefore consider impact of human activity to be high (score = 4).

Euphorbia tehuacana (Brandege) V. W. Steinm.—(A) Distribution. This species is known from about 20 collections from less than 10 localities in the Valley of Tehuacán in Puebla and Oaxaca, within a nominally protected area, the Tehuacán-Cuicatlán Biosphere Reserve. A small population of *E. tehuacana* occurs near a military reservation in which development is unlikely, but apparently does not occur within the boundaries. Only a very small expansion of the military reservation would be necessary to include this population, thereby conserving it. Its distribution is less than 5% of Mexican territory (score = 4).

(B) Condition of habitat. This species grows only on flats and on relatively gentle limestone slopes. The few such areas that are left appear suitable for the species, and we thus consider habitat condition to be favorable (score = 1).

(C) Intrinsic biological vulnerability. Both in the field and in cultivated plants, we have observed high production of seeds and recruitment of progeny. One population near Tehuacán is composed of individuals of several ages with a predominance of juvenile and adult plants and scant seedlings. High recruitment and some tolerance to perturbation allow us to consider the intrinsic vulnerability of this species as low (score = 1).

(D) Impact of human activity. Three populations of this species are located near Tehuacán and could easily disappear with the expansion of the city. Goats graze intensively in this region and can restrict the establishment of progeny. Populations have probably already been eliminated by urbanization, but no collections exist to document this. We therefore consider human impact to be high (score = 4).

Endemic Mexican Pedilanthus clade species likely of lesser conservation concern—The following five species are either sufficiently widespread, amply abundant, or both, suggesting a favorable outlook at present. Every effort should be made to keep such species in this favorable outlook category. Total scores are summarized in Table 2.

Euphorbia bracteata Jacq.—(A) Distribution. Because of the very wide range of this species, with disjunct patches from southern Sonora to northern Jalisco on the northwestern Pacific coast and in central Mexico in Querétaro, Michoacán, and northern Guerrero, special effort is needed to assess its conservation status. With a distribution apparently between 5 and 15% of Mexican territory, it is considered restricted (score = 3).

(B) Condition of habitat. This species grows in several vegetation types in a wide elevational range. Habitat may be considered favorable or only slightly limiting (score = 1).

(C) Intrinsic biological vulnerability. This species produces abundant cyathia and seeds and young plants are frequently found, so its intrinsic vulnerability appears to be low (score = 1).

(D) Impact of human activity. Like its relatives *Euphorbia cyri* and *E. tehuacana*, this species has a tendency to grow in flat or slightly rolling country ideal for urbanization. Indeed, the populations that we have visited in southern Sinaloa and northern Guerrero are suffering the impact of urban expansion, either directly as the result of land clearing, or as the result of proximity to urban areas and the alteration of habitat by grazing animals, cutting of wood, and other impacts associated with population centers. Ongoing urban expansion threatens to destroy at least several populations of this species. We therefore consider the impact level to be intermediate (score = 3).

Euphorbia cymbifera (Schltdl.) V. W. Steinm.—(A) Distribution. This species is restricted to the Valley of Tehuacán, in the states of Puebla and Oaxaca, making its distribution very restricted (score = 4).

(B) Condition of habitat. In addition to occurring in flat or rolling low country, this species can also grow on narrow, rocky ridgetops. We assess the condition of habitat to be favorable or only slightly limiting (score = 1).

(C) Intrinsic biological vulnerability. This species produces relatively abundant seeds and often persists on roadsides and other disturbed areas, suggesting a low inherent vulnerability (score = 1).

(D) Impact of human activity. Extraction of quicklime sediments, urbanization, and grazing of goats restrict the establishment of progeny, but the species is sufficiently abundant that its prospects for continued survival seem favorable and we may assign it a low impact (score = 2).

Euphorbia peritropoides (Millsp.) V. W. Steinm.—(A) Distribution. This species is distributed here and there from Nayarit to Oaxaca, between 5 and 15% of the Mexican territory and is therefore considered restricted (score = 3).

(B) Condition of habitat. This species often grows in moist canyons in several types of vegetation on the Pacific slope. Though the surrounding upland vegetation may be destroyed, the canyon slopes may escape development and persist relatively intact. We therefore assess its habitat condition as favorable or only slightly limiting (score = 1).

(C) Intrinsic biological vulnerability. This species flowers and fruits abundantly. Seedlings are common as is vegetative propagation via tubers. Intrinsic vulnerability may therefore be considered low (score = 1).

(D) Impact of human activity. *Euphorbia peritropoides* seems to tolerate moderate levels of disturbance. We have observed it growing on the margins of coffee plantations in Nayarit and Guerrero and on roadcuts in Nayarit as well as sprouting in cut forest in western Michoacán, suggesting a capacity to persist indefinitely in coexistence with light disturbance. Because of the relatively wide range of the species, we assign a low impact value (score = 2), though we have seen *E. peritropoides* habitat severely degraded for planting coffee and maize in several states.

Euphorbia lomelii V. W. Steinm.—(A) Distribution. This species is restricted to the Sonoran Desert of the Baja California Peninsula, Sonora, and Sinaloa, occupying between 5 and 15% of the Mexican territory. It is therefore considered restricted (score = 3).

(B) Condition of habitat. *Euphorbia lomelii* occurs over large stretches of mostly undisturbed desert, so habitat condition may be considered favorable or only slightly limiting (score = 1).

(C) Intrinsic biological vulnerability. This species apparently needs relatively intact vegetation to provide the nurse plants it needs to establish. It seems doubtful that *E. lomelii* could persist given much perturbation, so we assess an intermediate level of vulnerability (score = 2).

(D) Impact of human activity. This species is occasionally collected for ornamental purposes, but otherwise human impact may be considered low (score = 2).

Euphorbia diazlanana (J. A. Lomelí & Sahagún) V. W. Steinm.—(A) Distribution. This species only grows on a semiarid continental island, in six localities on the leeward slope of the NE side of the Sierra de Manantlán and adjacent ravines in the municipalities of Tolimán and Tuxcacuesco, Jalisco. Distributed in less than 5% of the Mexican territory, it may be considered very restricted (score = 4).

(B) Condition of habitat. Within the tropical deciduous habitat that is widely distributed in the area, *E. diazlanana* is restricted to drier locations and precipitous slopes that are common in the region. Healthy populations are found inside the Sierra de Manantlán Biosphere Reserve. Therefore, the condition of habitat is considered favorable (score = 1).

(C) Intrinsic biological vulnerability. This species flowers and fruits abundantly all year. We have observed high rates of recruitment of progeny both in the wild as in the botanical garden of the Universidad Autónoma de Guadalajara. We therefore consider its intrinsic vulnerability to be low (score = 1).

(D) Impact of human activity. Apparently this species does not have any utility for people in the region except for children who use the milky sap as glue at school. We have seen goats grazing in the region, but the local abundance of plants suggests they do not significantly impact the establishment of progeny. *Euphorbia diazlanana* grows in steep hilly areas that do not seem likely to be cleared for agriculture or settlements, and so human impact may be considered low (score = 2).

Species extending beyond Mexico—The rest of the species of the *Pedilanthus* clade have ranges that extend to some extent beyond Mexico. The MER assessments that follow are with respect to the distributions of the species in Mexico only. Only *E. tithymaloides* has ranges extensively beyond Mexico. *Euphorbia calcarata* barely reaches into Guatemala, and *E. personata* reaches northern Costa Rica. Total scores are summarized in Table 2.

Euphorbia calcarata (Schltdl.) V. W. Steinm.—(A) Distribution. It ranges from southern Sinaloa to Chiapas in Mexico and northern Guatemala on the Pacific slope, as well as a disjunct population in central Veracruz, Mexico on the Atlantic slope. This species is distributed between 5 and 15% of Mexican territory and is considered restricted (score = 3).

(B) Condition of habitat. This species grows in five different types of vegetation within an elevational range of 50 to 1500 m a.s.l. Populations in protected areas include the Sierra de Manantlán Biosphere Reserve and Chamela Biological Station in Jalisco, and the Sumidero Canyon National Park in Chiapas. Within this wide range, the localities are generally favorable or only slightly limiting (score = 1).

(C) Intrinsic biological vulnerability. This species flowers and fruits abundantly. We have seen a high rate of recruitment of progeny in natural forests as well as resprouting of plants that had been cut in the forest for planting coffee. Intrinsic vulnerability is therefore considered low (score = 1).

(D) Impact of human activity. Urbanization and deforestation has sectioned this species' habitat throughout its range. Nevertheless, we assign a low score (2), mainly because of the wide range of the species diluting the effect of impacts in any one area.

Euphorbia personata (Croizat) V. W. Steinm.—This species is of interest in that it apparently represents a derivation of the stem succulent habit from a *E. tithymaloides*-like ancestor, independent of the stem succulent group comprising *E. bracteata*, *E. cyri*, *E. diazlanana*, and *E. lomelii*.

(A) Distribution. This species is found here and there from the northern Yucatán to Costa Rica and is known from about 32 sets of specimens of which 24 are from Mexico, where the oldest collection was made in 1899. This species is distributed in less than 5% of the Mexican territory (score = 4).

(B) Condition of habitat. This species grows in clearings on limestone outcrops near the coast of the Yucatán Peninsula within areas of dense forest. Though found over a relatively wide range, suitable sites are few and we therefore assign an intermediate habitat condition (score = 2).

(C) Intrinsic biological vulnerability. The species is locally abundant, apparently recruits well, and flowers and fruits abundantly, so we assess its vulnerability as low (score = 1).

(D) Impact of human activity. In the northern Yucatán, we observed populations mainly in forest clearings on limestone outcrops. The surrounding forest is often cleared for pasture and agricultural fields. Exposed rock is avoided for agriculture, so the occurrence of *E. personata* on outcrops may help protect the species to some extent. Human impact to date therefore may be considered low (score = 2).

Euphorbia tithymaloides L.—(A) Distribution. This is the most widespread species of the group, ranging from northeastern Mexico to South America and throughout the Caribbean. In Mexico, it is considered moderately restricted (score = 2).

(B) Condition of habitat. This species occurs on a variety of soils and vegetation types, and we assign a favorable score (score = 1).

(C) Intrinsic biological vulnerability. It is considered low (score = 1). This species is able to persist under conditions of moderate disturbance. In addition to recruiting well from seed, when sections of the succulent stems are broken and fall on soil, they often root and form new individuals.

(D) Impact of human activity. We have observed *E. tithymaloides* growing in old cleared areas within forests and roadsides, indicating a capacity to coexist with moderate disturbance. The species is extremely widely cultivated, often using foreign cultivars, raising questions of possible gene pool dilution of wild populations. Nevertheless, we consider human impact to be low (score = 2).