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EXTINCTION THREAT IN THE *PEDILANTHUS* CLADE (*EUPHORBIA*, EUPHORBIACEAE), WITH SPECIAL REFERENCE TO THE RECENTLY REDISCOVERED *E. CONZATTII* (*P. PULCHELLUS*)[1]

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The type locality of the slipper spurge *Euphorbia conzattii* has been in doubt because the 1917 type is a mixed collection with vague label data. In recent field work, the species was found on Cerro Espino, Pochutla District, Oaxaca, Mexico. We used the Method for Evaluation of Risk of Extinction for Mexican Wild Species (MER), required to protect a species under Mexican law, to assess the conservation status of *E. conzattii* and found it to be endangered. We discuss the mixture in the type of this species with *E. calcarata* and present an updated description and an illustration of *E. conzattii*. Preliminary MER assessments of the other Mexican *Pedilanthus* clade species show two species to be extinct (*E. cyri*, *E. dressleri*) and four threatened (including *E. colligata*, *E. finkii*, *E. tehuacana*). The remaining eight have more favorable outlooks. We comment on MER robustness and aspects vulnerable to confusion and offer clarifications. Extinction risk is not distributed evenly throughout the clade, with a subclade of leafy treelets from a variety of habitats having the greatest number of endangered species. Extinction risk is distributed across all *Pedilanthus*-clade habitats; the strongest association noted is that both species from moist highlands are endangered.

Key words: Cerro Espino; Euphorbiaceae; *Euphorbia*; extinction; Oaxaca; *Pedilanthus*; threatened plants.

Less than a quarter of vascular plants have been evaluated for their conservation status, with 33 000 of these classified as rare or threatened with extinction (Walter and Gillett, 1998). Detailed knowledge of a species is needed before effective management decisions can be made, yet such documentation is extremely heterogeneous. Whereas some species are represented by thousands of specimens, most biologists can name species known from few collections or few localities. For example, in a survey of 317 neotropical plant species in 15 genera, nearly 55% were known from two or fewer specimens (Madriñán-Restrepo, 1996; fide Donoghue and Alverson, 2000). In many cases, these collections are old and the locality data on the labels may be extremely vague. Such species are for all practical purposes lost to management.

One example of a plant ''lost'' until recently is the slipper spurge *Euphorbia conzattii* V. W. Steinm. We present an account of the rediscovery of this species on a mountain in Oaxaca, Mexico, along with assessment of its conservation status, using the Method for Evaluation of Risk of Extinction for Mexican Wild Species (MER; SEMARNAT, 2002). We also provide preliminary evaluations of the conservation status of the other species of the slipper spurge clade (formerly *Pedilanthus*) in Mexico. All of the narrow endemic slipper spurges are restricted to Mexico, and thus their conservation there is of central interest. Of the 15 species of slipper spurge, a MER assessment has been conducted only for *E. coalcomanensis* (Croizat) V. W. Steinm., which was found to be threatened (Lomelí-Sención and Sahagún-Godínez, 2002). We show that other species in the group range from critically endangered to relatively risk-free.

We selected the MER for our study because it has been required by Mexican law since 2002 for listing organisms for protection. Many methods for assessing extinction risk have been proposed, from diversity-driven ''hotspot'' methods (e.g., Meijaard and Nijman, 2003) to those that build on population genetic studies (e.g., Cavers et al., 2003). These methods were rejected as the sole basis for the MER in favor of one that would provide a reasonably reliable way to identify species of conservation concern in the face of rapid extinction rates in a large, extremely diverse country. We note aspects of the MER resulting from this strategy that can make it vulnerable to subjectivity or misinterpretation and suggest that the MER nevertheless likely can meet its intended goals of facilitating timely conservation decisions and generating testable hypotheses. We also make specific suggestions that attempt to clarify points that are vague in the original formulation of the MER.

The slipper spurges were until recently grouped in the genus *Pedilanthus*. This neotropical group forms a well-supported clade nested within *Euphorbia*, a finding that necessitated subsuming within *Euphorbia* (Table 1; Steinmann and Porter, 2002; Steinmann, 2003). We refer to these species informally as the *Pedilanthus* clade. Mexico is the only country in which all 15 species may be found; 12 are endemic (Dressler, 1957; Webster, 1994). Most species occur in seasonally dry tropical habitats. In Mexico as in most of the world, such areas are densely populated, and thus are subject to intense pressure from human activities. In addition to being of conservation

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TABLE 1. Nomenclature of the *Pedilanthus* clade of *Euphorbia* (after Steinmann, 2003).

Current name (*Euphorbia*)	Former name (*Pedilanthus*)
E. bracteata Jacq.	*P. bracteatus* (Jacq.) Boiss.
E. coalcomanensis (Croizat) V. W. Steinm.	*P. coalcomanensis* Croizat
E. colligata V. W. Steinm.	*P. connatus* Dressler & Sacamano
E. conzattii V. W. Steinm.	*P. pulchellus* Dressler
E. cymbifera (Schltdl.) V. W. Steinm.	*P. cymbiferus* Schltdl.
E. cyri V. W. Steinm.	*P. tomentellus* B. L. Rob. & Greenm.
E. diazlunana (Lomelí & Sahagún) V. W. Steinm.	*P. diazlunanus* Lomelí & Sahagún
E. dressleri V. W. Steinm.	*P. gracilis* Dressler
E. finkii (Boiss.) V. W. Steinm.	*P. finkii* Boiss.
E. lomelii V. W. Steinm.	*P. macrocarpus* Benth.
E. peritropoides (Millsp.) V. W. Steinm.	*P. palmeri* Millsp.
E. personata (Croizat) V. W. Steinm.	*P. nodiflorus* Millsp.
E. tehuacana (Brandegee) V. W. Steinm.	*P. tehuacanus* Brandegee
E. tithymaloides L.	*P. tithymaloides* (L.) Poit.

concern, the *Pedilanthus* clade is an attractive study system for evolutionary studies. The remarkable array of life forms, from leafy treelets in evergreen moist forests to small-statured leafless stem succulents in true deserts, makes the *Pedilanthus* clade exceptionally diverse morphologically (Fig. 1A–C). Likewise, the spurred zygomorphic involucre that is an unequivocal synapomorphy of the group varies from bird- to insect-pollination (Fig. 1D–G; Dressler, 1957; Sahagún-Godínez and Lomelí-Sención, 1997). Economic uses include rubber and waxes from several species (Sternburg and Rodriguez, 1982; Sternburg, 1984), and *E. tithymaloides* is a widely cultivated houseplant.

Having assessments of the conservation status of all *Pedilanthus* clade members allows us to examine phylogenetic and ecological patterns of vulnerability to extinction. For example, do all of the threatened species come from a single subclade or are they evenly distributed throughout the group? Based on the hypothesis of Dressler (1957) and modifications from ongoing molecular phylogeny reconstructions, the *Pedilanthus* clade consists of four major groups. *Euphorbia finkii* is apparently the sister taxon to the rest of the group, which consists of two large clades and one small one. The small clade is made up of *E. tithymaloides* and *E. personata*. The two large clades both have six species. One is a clade of mostly leafless succulent species with minimal amounts of xylem and large, water-storing pith and cortical regions (Fig. 1C). The final clade is made up of leafy shrubs or treelets that have more conventional proportions of xylem (Fig. 1A, B). The relationships within and between these clades have yet to be resolved, but this level of resolution is sufficient for the question of whether or not extinction threat in the *Pedilanthus* clade is more likely in one subclade than another. Similarly, we examine associations between extinction risk and habitat type, testing the idea that extinction risk is greater in species that are restricted to flat country prone to urbanization, whereas species in rugged low country or highlands should be at less risk. Finally, we provide comments on the implications of the conservation status of the species of the *Pedilanthus* clade for the areas that they occur in as a whole.

Euphorbia conzattii was first collected in April 1917 from a locality specified only as ''Cerro Espino, Dto. Pochutla, Oaxaca; Elevation 1200 m.'' There is little doubt as to the general locality, which is in a well-known coffee-growing area in southern Oaxaca. However, as Dressler (1957) noted, both the type specimen (US) and the isotype (MEXU) are mixed collections, with well-dried samples of *E. conzattii* mounted with browned, overdried twigs of *E. calcarata* Schltdl. Dressler (1957, p. 112) notes that, ''There must thus remain some doubt as to whether they were collected together and as to the correctness of the data.'' We present evidence that Cerro Espino is the type locality of *E. conzattii* and discuss the mixture of the type with *E. calcarata*.

MATERIALS AND METHODS

MER methodology (SEMARNAT, 2002) consists of four risk criteria, each of which is divided into risk categories with numerical scores, with higher numbers denoting higher risk. The total score is calculated by summing the results from the following four criteria scored as follows: (A) Geographical distribution is assessed as a percentage of the total area of Mexico (~1 953 162 km², SEP, 1996). Species that have a distribution that is <5% of the national territory are considered highly restricted and are assigned a risk factor of 4; those between 5 and 15% are considered restricted, risk 3; those between 15 and 40% are considered widely distributed or only moderately restricted, risk 2; those >40% are considered widely distributed, risk 1. (B) Habitat condition is an estimate of the current biotic and abiotic factors that are known or thought to be important for the species being assessed. Note that this assessment is carried out with respect to the taxon under consideration and is not an assessment of the general state of the habitat. The following scores correspond to the risk scores in parentheses: hostile or highly limiting (3); intermediate to limiting (2); favorable or only slightly limiting (1). (C) The intrinsic biological vulnerability of a species includes factors such as reproductive strategy, life history, phenology, habitat requirements, genetic variation, recruitment rates, and the need for nurse plants, and has three score levels: 3, high; 2, medium; and 1, low. (D) Finally, the impact of human activity reflects factors such as proximity to human settlements, habitat fragmentation, pollution, commercial or other uses, land use patterns, invasive species, and the construction of highways and power lines. Like the previous criterion, there are three risk categories, but the scores begin at 2 because it is assumed that all species are affected to some extent by human activity: 4, high; 3, medium; and 2, low. Total scores between 12 and 14 are considered in danger of extinction; those with a score of 10 or 11 are threatened, and those of 9 or below are considered to be of little current risk.

We evaluated *E. conzattii* using these criteria on four field trips to the Cerro Espino area in January 1999, June 2002, December 2002, and January 2003. We measured the geographical distribution of *E. conzattii* on a 1: 50 000 scale topographic map (Instituto Nacional de Estadística, Geografía e Informática, Mexico) using the image analysis software Carnoy 2.0 (Laboratory of Plant Systematics, Katholieke Universiteit, Leuven, Belgium). Five measurements were taken and the mean used as our estimate.

We also applied the MER procedure to the 13 other species of the *Pedilanthus* clade that had not been assessed to date. We offer these assessments as preliminary but feel that the obviously dire conservation situation of many of the species justifies them. The basis for the estimates of range were herbarium specimen labels and maps of geographic distribution generated with this information. Habitat condition and intrinsic biological vulnerability were estimated based on our field work and herbarium label information. We examined material from the following herbaria: ARIZ, C, CHAPA, CHIP, CIDDIR, CIMI, CICY, CR, CREG, ENCB, F, FCME, FLAS, G, GH, GUADA, HCIB, HUAP, IBUG, IEB, IJ, JBSD, K, MAPR, MEXU, MICH, MO, NY, OAX, P, PH-PENN, RSA, S, TEFH, U, UAMIZ, UC, UPR, US, W, and XAL. Herbarium abbreviations follow Holmgren et al. (1990). Critical cited specimens are listed in Appendix 1 (see Supplemental Data accompanying online version of this article).

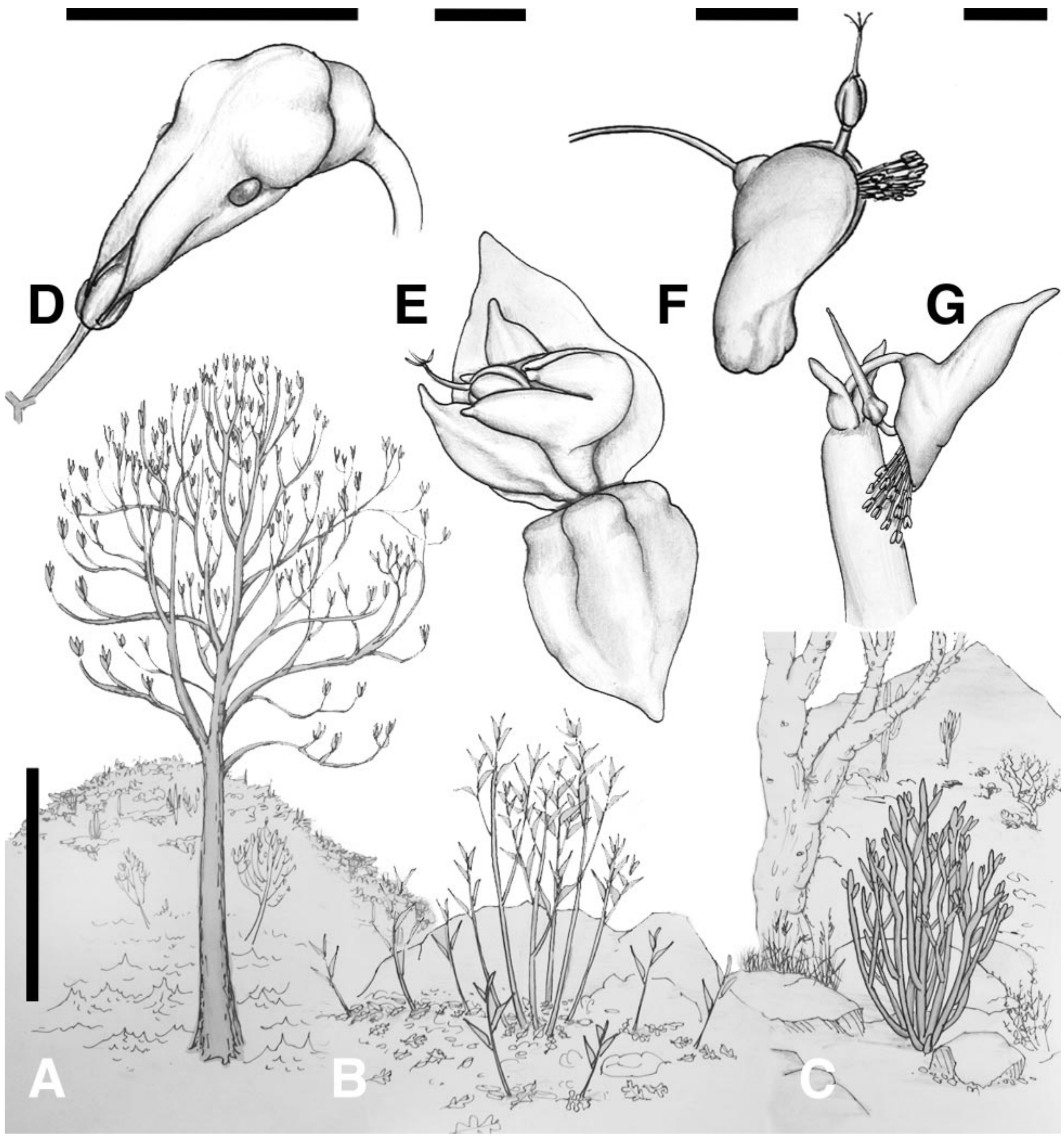

Fig. 1. Morphological diversity within the *Pedilanthus* clade. (A) *Euphorbia coalcomanensis*, a tree to 6 m that grows on dogtooth limestone in tall, seasonally dry tropical forest. (B) *E. colligata*, a shrubby species that forms large colonies of shoots that sprout from roots. (C) *E. lomelii*, a small, leafless stem succulent of the Sonoran Desert. A–C, bar at left of A = 1 m. (D) Cyathium of the hummingbird-pollinated *E. personata* with young fruit. The ''eyes'' are large glands. (E) *E. cyri*, with one bract peeled down to show cyathia, one with young fruit. The related *E. diazlunana* has similar inflorescences that have been shown to be insect-pollinated. (F) *E. peritropoides* inflorescences are with the spur pointing down or upside-down, a unique condition in the group; the pollinator is not known. (G). *E. lomelii* has large, hummingbird-pollinated inflorescences. Bars for all inflorescences = 1 cm. Drawing by Mark Olson.

RESULTS

MER assessment for E. conzattii—*Geographical distribution*—*Euphorbia conzattii* is known only from the peak of a single mountain, known as Cerro Espina to local residents (but Cerro Espino on maps), in the municipalities of Pochutla and Pluma Hidalgo, Oaxaca, Mexico. Our GPS readings put the elevation of the peak at 1420 m; we encountered the plants only within an elevational band reaching from the peak to 1380 m. Though *E. conzattii* is by no means evenly distributed throughout this area, we present a generous estimate of the range of *E. conzattii* as the area of Cerro Espino above 1380 m (Fig. 1). The forest in this area is dense but low, with few trees exceeding 8 m. Our visit was in the dry season, but the area receives abundant moisture in the rainy season, as suggested by abundant ephiphytic ferns, bromeliads, orchids, *Pep-*

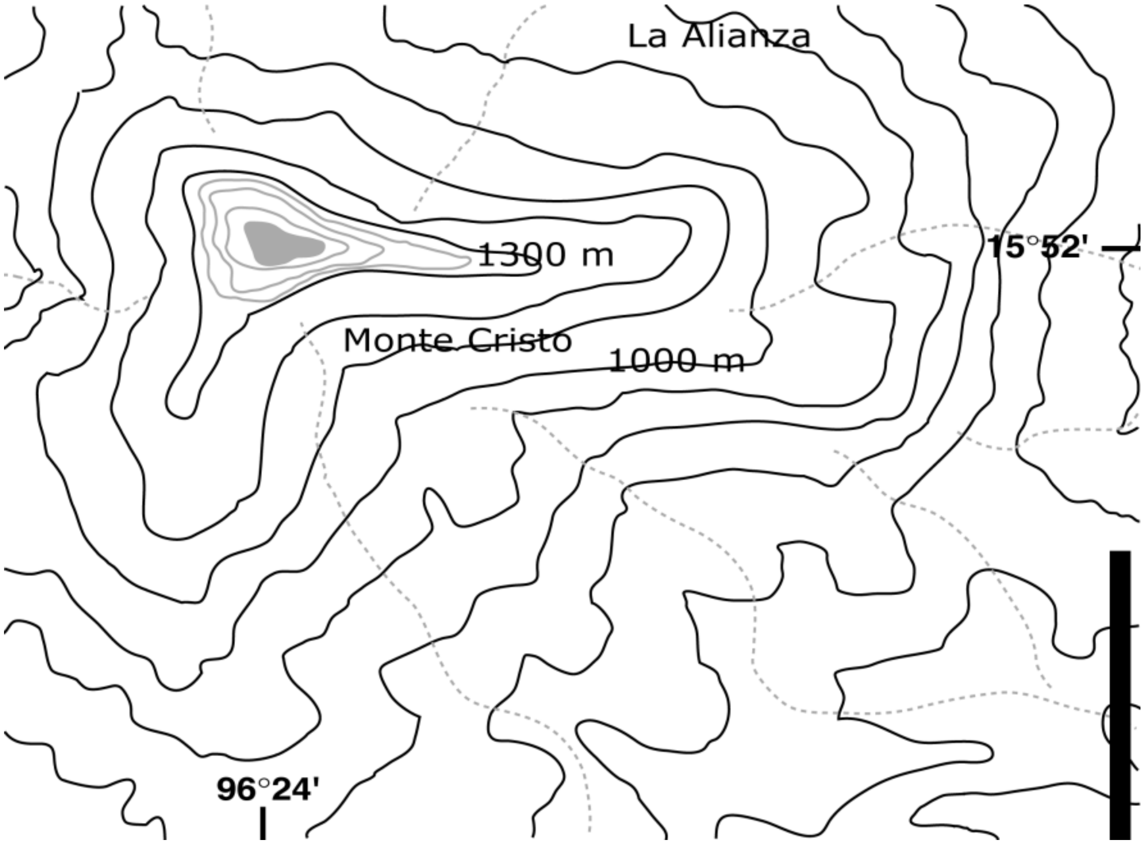

Fig. 2. Map of Cerro Espino, Oaxaca, Mexico. Names refer to important coffee plantations of the peak area. Interval of black contours = 100 m; gray contours of peak area = 20 m. The shaded area above 1380 m a.s.l. is considered the range of *Euphorbia conzattii*. Scale bar = 1 km.

eromia, *Anthurium*, mosses, and lichens. We estimate the peak area above 1380 m to be 0.02 km². The southern, northern, and eastern shoulders of Cerro Espino are below the elevation at which we encountered *E. conzattii*, but they do share to some extent the lower, drier vegetation of the high peak that distinguishes it from the tall forest on the lower slopes. Nevertheless, we did not observe *E. conzattii* in these areas. Though the Sierra Madre del Sur rises abruptly several kilometers to the north of Cerro Espino, reaching and surpassing 1400 m a.s.l., *E. conzattii* is apparently unknown in the vicinity of Pluma Hidalgo and the neighboring coffee plantations in the Sierra closest to the Cerro Espino locality. This microendemic species thus occupies a range that is approximately 0.000001% of the area of Mexico and thus it is rated as 4, the highest risk factor.

Condition of habitat—Euphorbia conzattii grows only in shaded areas in pockets of soil on the otherwise rocky limestone surface of the mountain, conditions absent over most of the peak area. Because of this apparent scarcity of suitable microsites, we assess the condition of habitat as intermediate and assign it a score of 2 (Table 2).

Intrinsic biological vulnerability—Approximately 20 plants were counted. The plants apparently grow slowly in the wild. Most of the plants were small (less than 1 m in height), but their stems have considerable secondary xylem accumulation, and the secondary phloem is nearly 100 cells thick, suggesting relatively great age. Lichens and liverworts growing on the leaves suggest that the leaves are also long-lived. The production of cyathia in this species is relatively scant, and reproduction appears to be chiefly by seed. *Euphorbia conzattii* forms a small shrub with a single trunk that branches well above the base, a life form that seems unlikely to react well to the clearing typical of coffee plantations (cf. *E. peritropoides* and *E. finkii*). Because of low recruitment, a small population size, slow growth rates, and most likely little capacity to recover from disturbance, we assess the intrinsic vulnerability of *E. conzattii* as high and assign it a score of 3 (Table 2).

Impact of human activity—Human use of the peak is currently minimal. No trails exist to the summit, and hunting and wood collecting are limited to the slopes. The forest of the peak area is in good condition, with naturally fallen trees permitted to rot in place. However, as with the lower slopes of Cerro Espino and indeed the entire region, coffee plants are frequently encountered all the way to the peak. We received conflicting reports regarding the origin of these peak plants. Some reported that coffee was planted all over the mountain, including the summit area, whereas others reported that only the lower slopes were utilized, implying that the coffee plants at the summit are feral. In either case, coffee is firmly established on the summit of Cerro Espino. Because a significant invasive plant population is present in the tiny habitat of *E. conzattii*, our assessment is that the impact of human activities is intermediate (risk 3). This assessment assumes that *E. conzattii* has always been restricted to the high peak. If it truly

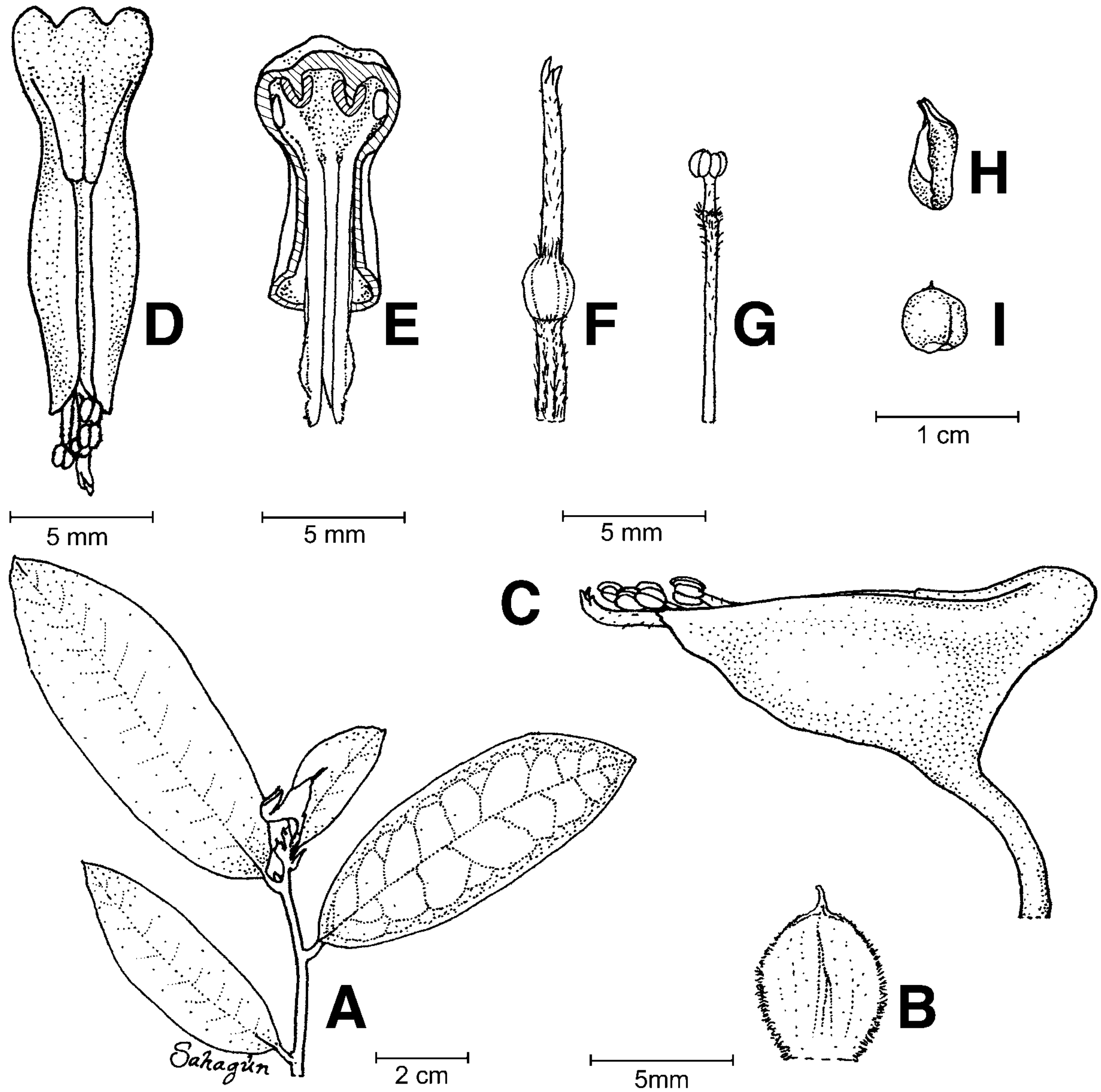

Fig. 3. *Euphorbia conzattii*. (A) Apex of stem with leaves and a cyathium. Venation is detailed on one leaf only. (B) Bract. (C) Lateral view of cyathium. (D) Dorsal view of cyathium. (E) Dissected involucre showing four glands and the accessory involucral lobes. Note that the medial glands were sectioned. (F) Pistillate flower. (G) Mature staminate flower. (H) Valve showing inner part. (I) Seed, ventral view. All from *M. Olson and I. Cacho 971.* Drawing by Eduardo Sahagún-Godínez.

was present at 1200 m, as reported by Conzatti, Reko, and Makrinius on the type specimen, then its range has been restricted from ca. 1 km^2 to 0.02 km^2 (a 50-fold reduction in area) and the impact would be assessed as high. Because the report of 1200 m was either based on an estimate or on a barometric altimeter that was subject to pressure fluctuations, for the purposes of the MER, we prefer the more cautious estimate of an intermediate impact level.

Taxonomic, cultural, and economic significance—In addition to being of interest for the genus-wide characteristics discussed earlier, *E. conzattii* is of particular interest for phylogenetic studies. In habit, it is most similar to *E. calcarata* or some populations of *E. peritropoides*, although it is much smaller, more delicate and intricately branched. Dressler (1957) notes similarities to *E. coalcomanensis* in that the ovary remains within the involucre instead of being exserted at anthesis as in most other species of this clade. Dressler (1957) also notes similarities to *E. tithymaloides* L. and comments that *E. conzattii* provides a ''link'' between these species groups. The availability of fresh material of *E. conzattii* makes it possible to test these ideas. Local residents were not aware of its presence on Cerro Espino, even when shown samples of the plant. Therefore, we assume that there are no current local uses for the plant. However, because of its delicate habit, brightly colored inflorescences, slow growth, and tendency to flower when very small, *E. conzattii* has great horticultural potential. The wild population of this species is so small that live material of *E. conzattii* should be collected in an extremely responsible manner. We have found that cuttings readily root, so it should not be necessary to remove the scarce established plants.

TABLE 2. Summary of Method for Evaluation of Risk of Extinction for Mexican Wild Species (MER) results for *Pedilanthus* clade species (*Euphorbia*) in Mexico. Numerical scores have the following meanings: DIST = Distribution: 4 = Very restricted (<5% of Mexican territory), 3 = Restricted (5–15% of Mexican territory), 2 = Widely distributed (15–40% of Mexican territory); HAB = Condition of habitat: 3 = Hostile, 2 = Intermediate, 1 = Favorable or only slightly limiting; IBV = Intrinsic Biological Vulnerability: 3 = High, 2 = Intermediate, 1 = Low; IHA = Impact of Human Activity: 4 = High, 3 = Intermediate, 2 = Low. See text for explanation of scores for *E. conzattii*, Lomelí-Sención and Sahagún-Godínez, 2002 for *E. coalcomanensis*; for the remainder of the species, see Appendix 3 in Supplemental Data with online version of this article.

Species	Risk criteria				Risk rank and conservation status
	DIST	HAB	IBV	IHA	
E. dressleri	4	3	3	4	14 = In danger (probably extinct)
E. cyri	4	3	2	4	13 = In danger (probably extinct)
E. conzattii	4	2	3	3	12 = In danger of extinction
E. coalcomanensis	4	2	1	3	10 = Threatened
E. colligata	4	1	2	3	10 = Threatened
E. finkii	4	1	1	4	10 = Threatened
E. tehuacana	4	2	1	3	10 = Threatened
E. personata	4	2	1	2	9 = Not threatened
E. bracteata	3	1	1	3	8 = Not threatened
E. cymbifera	4	1	1	2	8 = Not threatened
E. diazlunana	4	1	1	2	8 = Not threatened
E. lomelii	3	1	2	2	8 = Not threatened
E. calcarata	3	1	1	2	7 = Not threatened
E. peritropoides	3	1	1	2	7 = Not threatened
E. tithymaloides	2	1	1	2	6 = Not threatened

The mixed type of E. conzattii—We consider the uncertainty Dressler (1957) noted with regard to the type locality of *E. conzattii* to be resolved by the finding that the species is restricted to the summit of Cerro Espino. Likewise, the mixing of the type of *E. conzattii* with *E. calcarata* is understandable, given the overlapping flowering times and proximity of localities. Even though it occurs as close as 2 km to the summit locality of *E. conzattii*, *E. calcarata* is only found at lower elevations. We collected *E. calcarata* in three localities on the upper-middle elevations of Cerro Espino (see critical specimens in Appendix 1; see Supplemental Data accompanying online version of this article), where it grows under the canopy of tall tropical subdeciduous forest or tropical deciduous forest at an elevation of 1040–1320 m. How the tropical deciduous vegetation differs from that of the peak and why the species are allopatric is not clear. Dressler (1957) cited two specimens from somewhat lower on the mountain (Reko 3574 and Morton and Makrinius 3678). In addition, coincidence in the flowering period of *E. conzattii* and *E. calcarata* easily could have led to their being mixed on the type of *E. conzattii*. *Euphorbia conzattii* was collected in flower on 12 April 1917, and Reko's collection *E. calcarata* 7 d before (*3574* US!) was also in flower. Thus, though the species are allopatric, they grow on the same mountain and probably were confused and collected as the same species. The differences between the species are less conspicuous than their similarities, and the distinctness of *E. conzattii* was not recognized until 1957.

TABLE 3. Extinction risk in the *Pedilanthus* clade and habitat type in Mexico. Asterisks indicate threatened or endangered species. Risk ranks are the total MER (Method for Evaluation of Risk of Extinction for Mexican Wild Species) scores from Table 2. Scores can range from 5 (not threatened) to 14 (endangered).

Habitat type	Species	Risk rank
Moist to very moist highlands	*E. conzattii*	12*
	E. finkii	10*
Moist canyons	*E. colligata*	10*
	E. peritropoides	7
Rugged tropical drylands	*E. dressleri*	14*
	E. coalcomanensis	10*
	E. cymbifera	8
	E. diazlunana	8
	E. calcarata	7
	E. tithymaloides	6
Dry flatlands	*E. cyri*	13*
	E. tehuacana	10*
	E. personata	9
	E. bracteata	8
	E. lomelii	8

Description of E. conzattii—Because of our recent collection, we can now supplement the original description with features that are unavailable from the type (Appendix 2, see Supplemental Data with online version of this article).

MER assessments of other Mexican species of the Pedilanthus clade—The results for the other species examined are summarized in Table 2; explanations for the decisions behind the risk factors assigned are given in Appendix 3 (in Supplemental Data with online version of this article). We found that *E. dressleri* is probably entirely extirpated and *E. cyri* is extinct in the wild but persisting in cultivation. Three other species are threatened. The distribution of risk ranks with habitat preference is summarized in Table 3, and the distribution of risk ranks in the clades within the *Pedilanthus* clade is summarized in Table 4.

DISCUSSION

There is no substitute for population genetic and demographic information in the management of threatened species. But in a country as diverse as Mexico, such detailed studies cannot encompass the entire flora. The MER protocol appears to offer a realistic balance between traditional methods in which conservation risk is assessed subjectively with unspecified criteria and methods that provide more information but also require time and funding that may not be available. The assessments summarized here were based on 10 field trips and

TABLE 4. Extinction risk in the major groups of the *Pedilanthus* clade phylogeny. Asterisks indicate threatened or endangered species. Risk ranks are the total MER (Method for Evaluation of Risk of Extinction for Mexican Wild Species) scores from Table 2. Scores can range from 5 (not threatened) to 14 (endangered).

Group	Species	Risk rank
E. finkii	*E. finkii*	10*
Leafy treelets	*E. dressleri*	14*
	E. conzattii	12*
	E. coalcomanensis	10*
	E. colligata	10*
	E. calcarata	7
	E. peritropoides	7
Stem succulents	*E. cyri*	13*
	E. tehuacana	10*
	E. bracteata	8
	E. cymbifera	8
	E. diazlunana	8
	E. lomelii	8
E. tithymaloides	*E. personata*	9
	E. tithymaloides	6

a review of herbarium specimens; identifying priority species for further study was a generous return for this time investment.

Robustness of MER assessments—Our assessments raise the question of how trustworthy MER results are. We comment here on MER performance based on our work and make suggestions to resolve points that are particularly prone to confusion.

Geographical distribution, measured as a percentage of the total area of Mexico, is the criterion that is most amenable to quantification. This category is also the one most directly afflicted by lack of knowledge about extant populations. Discovery of additional populations similar to known ones would not necessarily change scores in the other criteria substantially, but could result in a lower score for the distribution criterion. This is a crucial point, because a small distribution is a major factor contributing to the status of species of conservation concern (e.g., Table 2). On the other hand, discovering more populations of the many microendemic species in Mexico is unlikely to put them in a lower risk rank, because their ranges are so small that it is unlikely that they will be found to have distributions over 5% of the national territory. For example, finding another population of *E. conzattii* similar to the known one would double its known range, which would still be exceptionally small.

Habitat condition and impact of human activity are the most difficult criteria to separate. SEMARNAT (2002) gives little guidance on the distinction between these categories, beyond what is summarized in the Materials and Methods and the rather vague note that they are independent ''in general terms.'' Clarifications, based on our experience, could include the following: In general, the habitat of a species is favorable in the middle of its distribution. In most cases, if anthropogenic degradation is ignored, it is not surprising to find that, with respect to the known or hypothesized needs of a plant, conditions are favorable. Cases in which all populations of a species have been destroyed or leave only marginal peripheral populations or scattered waif individuals is a situation in which the condition of habitat could be assessed as hostile. We assigned species to the intermediate risk category if the conditions of the microhabitat were favorable, but such microsites were rare within the range (e.g., for *Euphorbia personata*). Intrinsic biological vulnerability must examine only factors that are inherent to the biology of a species independent of the condition of habitat. *Euphorbia conzattii* is an example of a species with high intrinsic vulnerability that occurs in a habitat of intermediate condition and low human impact.

Given subtle delineations between categories and ultimately subjective assignment of risk score, what effect might these potential pitfalls of the MER have? That is, how likely is it that species assessed to be endangered are not, and how likely is it that species that are endangered are assessed as being safe? Table 2 reveals few surprises: the species with the highest overall risk scores all have very small ranges, many have intrinsic factors that conspire against them in resisting disturbance, and all are impacted by humans. For reasons detailed later, other populations of *E. conzattii* are not likely to be found; none have appeared in 80 years of botanical exploration of southern Oaxaca. Even if other populations are found, they are probably on similarly small mountaintops and *E. conzattii* will remain a microendemic in need of protection. Likewise, based on extensive documentation of the flora of the well-studied Valley of Oaxaca, *E. cyri* is clearly being decimated if not already extirpated. It is not clear what discoveries, apart from the extremely unlikely event of locating previously overlooked large, healthy populations, could change the conservation status of such species, as assessed by MER or other methods. On the other hand, our low risk assessments for species such as *E. tithymaloides* and *E. calcarata* are also likely to be robust; these species have wide ranges, moderate capacity to tolerate disturbance, and recruit well.

If, as we suggest here, high MER scores do indeed reflect situations of urgent conservation concern, then scores should be roughly comparable across all taxa. This is likely true: virtually any species with a tiny range, low population number, slow growth, low recruitment, and co-occurring with an invasive species is likely to be threatened. Likewise, species that are no longer found in the wild are obviously of great conservation concern. The MER scores reflect these expectations.

Clade- and habitat-related patterns—Extinction risk is not uniformly distributed across clades or habitats, and the patterns recovered here differed notably from our expectations. The clearest habitat-related trend is that both species in moist highlands are threatened (Table 3). Though such habitats may be found throughout tropical America, patches are often very limited in size and are under heavy pressure from agriculture, resulting in small populations that are easily eliminated. Within dry habitats, we expected flatland species, which are extremely vulnerable to development, to be much more likely to be menaced than those from rugged areas. Although we noted this trend, it was less intense than expected; two of the five flatland species were threatened relative to two of the six rugged dryland species. Likewise, we expected more species from the succulent clade to be threatened than those from the leafy clade (Table 4). This expectation was based on habitat preferences: 67% of the succulent clade are found in flatlands, whereas none of the leafy clade species occur in these habitats. Also, succulent clade species receive some pressure from collection for ornamental use. However, just 33% of the succulent clade species are threatened, compared with 67% of the leafy clade, which occur in moist canyons, rugged drylands, and moist highlands. All of the threatened species have very small ranges, and a tendency for small ranges is apparent in the leafy clade.

The future of E. conzattii—We remain hopeful that *E. conzattii* will be located elsewhere. Where it might be is not clear. Cerro Espino is an imposing peak rising from the warm coastal lowlands; based on its observed elevational range, *E. conzattii* presumably requires a minimum elevation of ca. 1400 m. However, the other isolated peaks in the vicinity of Cerro Espino are well below this elevation. Cerro Sinaloa rises a few kilometers SSE of Cerro Espino but is nearly 500 m lower; Cerro Huatulco lies approximately 8 km E of Cerro Espino, but fails to reach the elevation of *E. conzattii* by 300 m. No other isolated peaks in the area approach the elevation of Cerro Espino. In the wake of Hurricane Paulina and recent economic downturns, coffee cultivation is currently on the decline in this area. A potential benefit is the return of native vegetation. A chilling prospect is the introduction of crops that require complete destruction of the forest such as maize.

Conclusion—Alhough we feel that our MER assessments are likely robust, we regard them as hypotheses for further testing through searches for additional populations and studies of population genetics and demographics. Our hypotheses could be falsified by any number of findings, such as thriving populations of *E. dressleri* or *E. cyri*. The most important test is a long-term one; the loss of any more species of the *Pedilanthus* clade will mark a failure to recognize vulnerable species or implement effective protection.

We are aware of the problems associated with the assessment of threats at community or higher scales based on exemplar species (e.g., Lindenmayer and Fischer, 2003). However, we do suggest that the threats outlined against *Pedilanthus* clade species may be symptomatic of the overall state of conservation of the areas in which they are found. For example, the generalized perturbation apparently responsible for the extinction of *E. dressleri* is also quite likely to be adversely affecting many other species. Likewise, other species that share the plains or low-lying habitats of *E. cyri* and *E. tehuacana* are certainly suffering as well. *Pedilanthus* clade species serve well to highlight areas of conservation concern because they are relatively easy to locate and local people are often aware of their presence. If the unique inflorescence fails to catch attention, then the abundant latex that pours from the slightest wound impresses itself upon locals. Far from being weedy, most species tolerate only a moderate degree of disturbance. Therefore, our intent is not only to call attention to species such as *E. dressleri*, *E. cyri*, and *E. conzattii* as being of conservation concern, but also to highlight that the biological communities in which these species are found are also likely in danger.

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