

# Conservation of Southwestern Agaves

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## Abstract

The status of Southwestern agaves being considered for listing under the 1973 Endangered Species Act are summarized. Numerous Mexican agaves appear to merit consideration for listing as threatened or endangered species. An outline of action to accomplish this and achieve some much-needed communication between the United States and Mexico is presented. The agaves are clearly of Mexican origin. Species abundance contour maps are used to locate areas and species of special significance in the study of the evolution of the genus and to map out a conservation plan for the genus.

## Acknowledgments

I would especially like to thank Dr. Gentry for inviting me to participate in this symposium. Tony Burgess (University of Arizona) and Kent Newland (Boyce Thompson Arboretum) provided valuable input. The views and comments I expressed regarding the Endangered Species Act are strictly my own opinions and should not in any way be construed as official U.S. government policy.

## Introduction

Although the Endangered Species Act became law in 1973, a reliable list of plant taxa which merited consideration for listing under the act was not available until 1978. At this time the Smithsonian Institution published its list of endangered and threatened plants of the United States (Ayensu and DeFilipps, 1978). The Act required the Smithsonian Institution to prepare the list although the U.S. Department of Interior Fish and Wildlife Service was entrusted with the responsibility of implementing the Act. Subsequently, the U.S. Fish and Wildlife Service assumed responsibility for review and republication of the list. The U.S. Fish and Wildlife Service (1980) republished the list indicating which taxa had been dropped from consideration and those which had changed listing status. Recently the U.S. Fish and Wildlife Service (1983a) published a list of the 1980 plants which changed listing status.

In 1978, 1980, and 1983, lists are of candidate species only. The Act and its amendments specify a lengthy process of review for each of the candidate plants after which the U.S. Fish and Wildlife Service will determine whether to list it as federally endangered or threatened or to drop it from further consideration. The U.S. Fish and Wildlife Service (1984a) published the names of plants and animals determined to be endangered or threatened. In brief, a taxon may be determined to be endangered if it is shown to be "in danger of extinction throughout all or a significant portion of its range" and threatened if it "is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (Sec. 3(6) and Sec. 3(20) respectively of the Endangered Species Act as amended by the Endangered Species Act amendments of 1982). Functionally, the Act specifies five principal criteria for such determination:

"(A) the present or threatened destruction, modification, or curtailment of its habitat or range;

(B) overutilization for commercial, recreational, scientific, or educational purposes;

(C) disease or predation;

(D) the inadequacy of existing regulatory mechanisms; or

(E) other natural or manmade factors affecting its continued existence" (Sec. 4(a) of the Endangered Species Act as amended by the Endangered Species Act Amendments of 1982).

## Agaves and the Endangered Species Act

Nine agave taxa have appeared on candidate taxa lists at one time or another. They are summarized in Table 1 and their geographic distributions are mapped on Figure 1.

Note that several are infraspecific taxa (i.e., subspecies or varieties). The Endangered Species Act recognizes the need to preserve reasonably distinctive infraspecific taxa if other criteria are met.

***Agave glomeruliflora* (Engelm.) Berger.** This taxon is apparently of hybrid origin, involving *A. lechuguilla* Torr., *A. gracilipes* Trel., *A. havardiana* Trel., and *A. neomexicana* Woot & Standl. It has the largest distribution of any of the candidate agaves and includes most major mountain ranges in west Texas and northern Coahuila. It was recommended as threatened by the Smithsonian in 1978 and is currently demoted to a Category 2 candidate. Few if any significant threats have been identified and substantial populations in Big Bend and Guadalupe Mountains National



**Figure 1.** Distribution of candidate and listed threatened and endangered Southwestern agaves.

Parks are already protected.

***Agave utahensis* Engelm. var. *eborispina* (Hester) Breitung.** Four of the five taxa recognized by Gentry (1982) in the group *Urceolatae* have been or are now being considered for listing. This one has the distinction of being the most northwestern member of the genus. Like most other *A. utahensis*, it shows an affinity for limestone substrates. The taxon was recommended threatened by the Smithsonian in 1978, assigned to Category 2 by Fish and Wildlife in 1980, and finally dropped in the 1983 revision. It was found locally common in rugged inaccessible sections of southeastern California and southern Nevada where few if any threats have been identified.

***Agave utahensis* ssp. *kaibabensis* (McKelvey) Gentry.** This subspecies is largely confined to the Grand Canyon and some of its major side canyons whereas ssp. *utahensis* generally occurs well away from the Grand Canyon. Subspecies *kaibabensis* was recommended for listing as threatened by the Smithsonian in 1978 and dropped from consideration in 1980. Although feral burros were apparently eating flowering stalks in some areas, the taxon is adequately protected by Grand Canyon National Park.

***Agave utahensis* var. *nevadensis* Engelm.** This variety, another localized segregate of the *A. utahensis* complex, centers in southern Nevada and southeastern

**Table 1.** Summarized history of Endangered Species Act listing status of Southwestern Agaves.

**1978**

Ayensu & DeFilipps, Smithsonian Inst. Report to the Secretary of the Interior [Ayensu and DeFilipps, 1978]

Recommended Threatened

*Agave glomeruliflora* (Engelm.) Berger  
*Agave utahensis* Engelm. var. *eborispina* (Hester) Breitung  
*Agave utahensis* ssp. *kaibabensis* (McKelvey) Gentry  
*Agave utahensis* var. *nevadensis* Engelm.

Recommended Endangered

*Agave mckelveyana* Gentry  
*Agave arizonica* Gentry & Weber  
*Agave schottii* Engelm. var. *treleasei* (Toumey) Kearney & Peebles  
*Agave toumeyana* Trel., ssp. *bella* (Breitung) Gentry

**1980**

Fish & Wildlife Service, Review of Plant Taxa for Listing as Endangered or Threatened Species [U.S. Fish and Wildlife Serv., 1980]

Category 1 (Probably merits listing as endangered or threatened)

*Agave arizonica*  
*Agave parviflora* Torr.  
*Agave toumeyana* ssp. *bella*

Category 2 (Possibly merits listing, more data needed)

*Agave glomeruliflora*  
*Agave schottii* var. *treleasei*  
*Agave utahensis* var. *eborispina*  
*Agave utahensis* var. *nevadensis*

Category 3 (Dropped from consideration for listing)

*Agave mckelveyana*  
*Agave utahensis* ssp. *kaibabensis*

**1983**

Fish & Wildlife Service, Supplement to the 1980 Review [U.S. Fish and Wildlife Serv., 1983]

Category 1 → Category 2

*Agave parviflora*

Category 1 → Category 3

*Agave toumeyana* ssp. *bella*

Category 2 → Category 3

*Agave utahensis* var. *eborispina*  
*Agave utahensis* var. *nevadensis*

**1984**

Fish & Wildlife Service, Determination of Listing as a Federally Endangered Species [U.S. Fish and Wildlife Serv., 1984].

*Agave arizonica*

California. It too was originally recommended for listing as threatened by the Smithsonian in 1978, retained in Category 2 in 1983, and dropped in 1983.

***Agave mckelveyana* Gentry.** This species is endemic to northwestern Arizona. It was recommended as endangered by the Smithsonian in 1978 and dropped in 1980 after it was found to be relatively widespread with few if any threats.

***Agave arizonica* Gentry & Weber.** This species was always considered to be very rare. Several field searches sponsored by the U.S. Fish and Wildlife Service, the U.S. Forest Service, and the Desert Botanical Garden of Phoenix

have yet to reveal any new major populations. Only 15 (possibly 16) populations, varying in size from one to several plants, have been identified to date. The low species number prompted the U.S. Fish and Wildlife Service to expedite the listing process. It was officially proposed as an endangered species by the U.S. Fish and Wildlife Service in May of 1983 and officially listed as an endangered species in 1984 (U.S. Fish and Wildlife Serv., 1983b and 1984b respectively).

The nearly paniculate inflorescence of *A. arizonica* suggests a hybrid origin possibly involving *A. toumeyana* Trel. of subgenus *Littaea* and perhaps with *A. parryi* Engelm. or *A. chrysantha* Peebles of subgenus *Agave*. Evidence indicates the hybridization event is very rare and that the hybrid progeny are sterile or nearly so. This proved the greatest stumbling block to its eventual listing as an endangered species and illustrates a problem common to many rapidly evolving groups such as *Agave*. A flexible species concept is unavoidable and even desirable in applying the Endangered Species Act to some taxa in the "gray area" between a full species and a minor variant. If the classical Mayrian species concept (Mayr, 1942) is too rigidly applied to these cases, important evolutionary advances may be unwittingly eradicated. Indeed, as Burgess (*Desert Plants*, this issue) advocates, alternative species concepts revolving around the "reticulate phylogeny" concept may be necessary in developing realistic taxonomies for groups such as *Agave*. However, the public is sensitive to abuses of the Act and inappropriate listing of inconsequential morphological variants will be perceived and reacted to negatively. The U.S. Fish and Wildlife Service must make some very difficult decisions.

***Agave schottii* Engelm. var. *treleasei* (Toumey) Kearney & Peebles.** This taxon was recommended endangered by the Smithsonian in 1978 in spite of the fact that no wild populations have been observed since its discovery by J. W. Toumey in 1896 (with the doubtful exception of a population in the Ajo Mts., Pima Co., Arizona [Gentry, 1982]). It was listed as a Category 2 candidate in 1980 and was retained in that category through the 1983 revisions. I have searched the type locality (Table Mtn., Santa Catalina Mts., Pima Co., Arizona) and found nothing that resembled var. *treleasei*. Still the possibility that wild populations exist argues against prematurely dropping the taxon from further consideration. Although if wild populations are discovered it may turn out to be one of those minor variants which simply do not merit Endangered Species Act protection.

***Agave toumeyana* Trel. ssp. *bella* (Breitung) Gentry.** Recommended endangered by the Smithsonian in 1978, Category 1 candidate in 1980, and finally dropped in 1983 by the U.S. Fish and Wildlife Service. This very attractive member of subgenus *Littaea*, group *Parviflorae*, turned out to be nearly as common as *Agave toumeyana* ssp. *toumeyana*. Its habitat is rugged mountain slopes in central Arizona.

***Agave parviflora* Torr.** This species was listed as a Category 1 candidate in 1980 and dropped to Category 2 in 1983. Both subspecies, *A. parviflora* ssp. *parviflora* and *A. parviflora* subsp. *flexiflora* Gentry, are presumably included

in the candidate listing although only subsp. *parviflora* is known from the United States. Subspecies *parviflora* is found in the mountains of south-central Arizona and north-central and northeastern Sonora while ssp. *flexiflora* is restricted to northeastern Sonora. The two are apparently sympatric in parts of Sonora. Over-collection of wild populations in Arizona has been documented.

It is likely that two of the remaining candidate species, *A. glomeruliflora* and *A. parviflora* will eventually be dropped from consideration as research turns up more localities and fails to reveal any substantial threats. *Agave schottii* var. *treleasei* will probably also be dropped if no wild populations are found. Nearly all U.S. agaves are plants of rugged mountain areas where man's influences are relatively minimal. The most pervasive human activities affecting the biota of those habitats, livestock grazing and suppression of natural wildfires, may benefit some agaves by removing competition with perennial grasses.

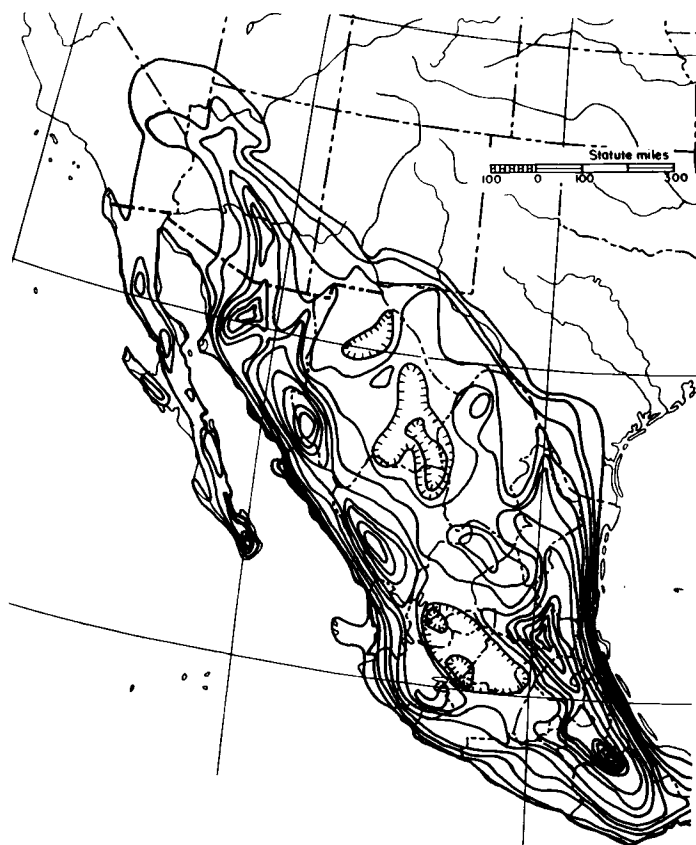
### • Conservation of Agaves in Mexico

Clearly the place to protect agaves is not in the United States at the northern edge of the genus' range. Rather, in Mexico a cursory examination of Dr. Gentry's monograph (Gentry, 1982) suggests many probably very rare species. Whole cultures have evolved through exploitation of agaves and the original wild populations of several species have succumbed to the spread of agriculture, wood cutting, and livestock grazing. I count at least 14 species never seen in the wild (approximately 10% of the genus). Table 2 shows a list of strictly Mexican agaves for which three or fewer localities appear on the distribution maps of Gentry (1982) or for which no native habitat can be identified.

The Endangered Species Act specifically directs the federal government to encourage conservation efforts of foreign governments by allowing endangered or threatened species in foreign countries to be listed if the foreign government is in agreement. It establishes a program and rules for cooperation with foreign governments which include the Convention on International Trade in Endangered Species of Wild Fauna and Flora and numerous other treaties and conventions.

Many of the species in Table 2 will turn out to be more common than previously thought, just like most of our American agaves. Still others may turn out to be extinct in the wild. Currently the only listed Mexican plant which does not also occur in the United States is *Abies guatemalensis* Rehder. Listing of some Mexican plants would substantially benefit conservation activities on both sides of the border. The strong cultural traditions and genuine rareness of some species makes the agaves an ideal starting point to apply the Endangered Species Act in Mexico.

I suggest that the only realistic approach to involving foreign governments in endangered species conservation hinges on their country's scientific communities. Governmental agencies of many so-called "Third World" countries are severely hampered by lack of funds and are largely unable, though not unwilling, to gather the necessary data. It seems incumbent on the scientists resident in those countries to assume at least part of that responsibility.



**Figure 2.** Species abundance contour map of *Agave* subgenera *Agave* (excluding group *Salmianae*) and *Littaea*. Contour interval equals one species.

### Biogeography and Conservation of Agaves

In the earlier discussion of *Agave arizonica*, I stressed the importance of flexible species concepts and alternative phylogenetic systems when dealing with endangered and threatened organisms and suggested the agaves are prime examples. In actual practice this is very difficult to apply because of the danger of abusing the Act's authority. In reviewing the distribution maps in Gentry (1982), some patterns became evident to me which may be pertinent to the problem.

Figure 2 is a species abundance contour map of the agaves prepared from the distribution maps in Gentry (1982). The confusing *Salmianae* group with its largely man-influenced artificial distributions was excluded. The greatest number of agave species occurs in southeastern Mexico in Puebla, Hidalgo, Queretaro, San Luis Potosi, and extreme southern Tamaulipas. Species abundance drops off quickly to the north and east where winter low temperatures fall below the tolerance of the genus. To the north and west agaves are abundant up the warmer west coast with several nodes of diversity. The diversity concentrations in Durango, Chihuahua, and Sonora roughly coincide with the two major trans-Sierra Madre Occidental travel routes and with Mexico Highway 15 but nonetheless probably indicate a real pattern of nature. The Cape region of the Baja peninsula supports another concentration. The concentrations of agave species range from five in the Cape region to 14 in the

**Table 2.** Mexican *Agave* species with three or fewer herbarium collections cited or for which no native habitat can be identified [see Gentry, 1982].

<b>Baja California Sur</b>	<i>A. scaposa</i> Gentry
<i>Agave margaritae</i> Brandege	<i>A. titanota</i> Gentry
<i>A. vizcainoensis</i> Gentry	
<b>Chiapas</b>	<b>Puebla</b>
<i>A. pendula</i> Schnitts.	<i>A. peacockii</i> Croucher
	<i>A. triangularis</i> Jacobi
	<i>A. stricta</i> Salm-Dyck
<b>Colima</b>	<b>Sinaloa</b>
<i>A. gypsophila</i> Gentry	<i>A. aktites</i> Gentry
<b>Guerrero</b>	<i>A. felgeri</i> Gentry
<i>A. gypsophila</i>	<i>A. fortiflora</i> Gentry
<b>Jalisco</b>	<i>A. jaiboli</i> Gentry
<i>A. attenuata</i> Salm-Dyck	<i>A. zebra</i> Gentry
<i>A. gypsophila</i>	
<i>A. stringens</i> Trel.	<b>Vera Cruz</b>
<b>Mexico</b>	<i>A. attenuata</i>
<i>A. attenuata</i>	<i>A. pendula</i>
<b>Michoacan</b>	<b>Unknown</b>
<i>A. attenuata</i>	<i>A. albomarginata</i> Gentry
<b>Morelos</b>	<i>A. bakeri</i> Hook. f.
<i>A. horrida</i> Lem. ex Jacobi	<i>A. cantala</i> Roxb.
<b>Nayarit</b>	<i>A. desmettiana</i> Jacobi
<i>A. geminiflora</i> (Tagl.) Ker-Gawl.	<i>A. ellemeetiana</i> Jacobi
<i>A. nayaritensis</i> Gentry	<i>A. ensifera</i> Jacobi
<i>A. ornithobroma</i> Gentry	<i>A. franzosini</i> Baker
<b>Oaxaca</b>	<i>A. pumila</i> De Smet ex Baker
<i>A. guiengola</i> Gentry	<i>A. ragusae</i> Terr.
<i>A. lurida</i> Aiton	<i>A. sisalana</i> Perrine
<i>A. oroensis</i> Gentry	<i>A. tecta</i> Trel.
	<i>A. warelliana</i> Baker
	<i>A. weberi</i> Cels ex Poisson
	<i>A. yuccaefolia</i> DC.

Tehuacan Valley region of southeastern Puebla. The Tehuacan Valley concentration is significant in light of Axelrod's often criticized theory of the evolution of the North American Deserts (Axelrod, 1958). He postulated that the Tehuacan Valley was ultimately the place of origin for many of our desert taxa. The large number of *Agave* species in that region suggests the possibility it was likewise the place of origin, or at least of a substantial refugia, for the agaves.

The geographical abundance of the two *Agave* subgenera, *Littaea* and *Agave*, are plotted separately in Figures 3 and 4 respectively using the data in Gentry (1982) and excluding the group *Salmianae*. Several observations can be made:

(1) The presumably more primitive subgenus *Littaea* has a much more restricted distribution than subgenus *Agave*.

(2) Only subgenus *Agave* occurs on the Baja peninsula.

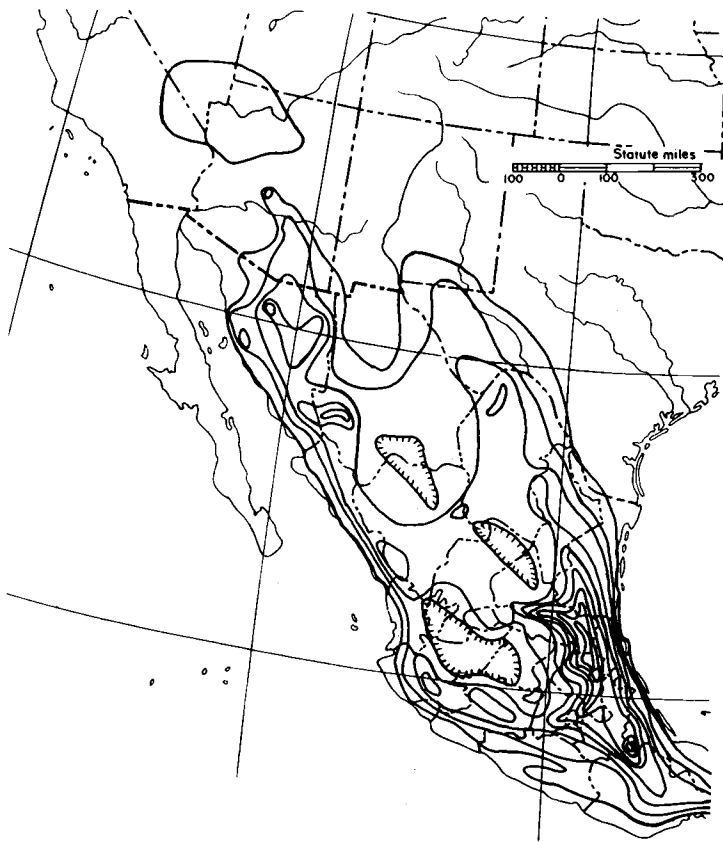
(3) Both subgenera share several concentrations along the west coast of Mexico.

(4) Both subgenera also share the same areas with few or no representatives in the dry central and northern plateau region.

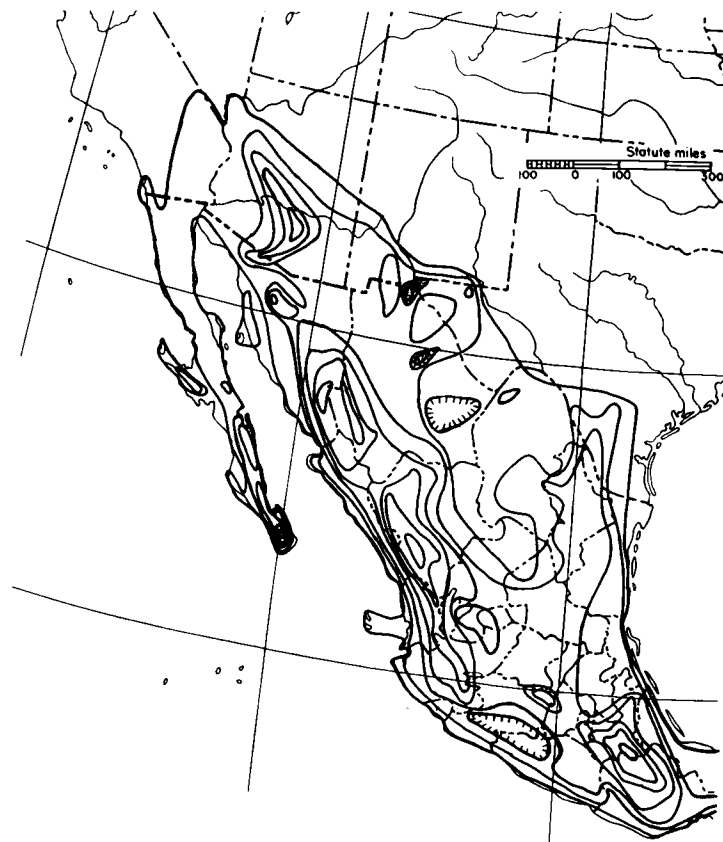
(5) The only major area of low species diversity not shared by the two subgenera is the Sierra Madre Oriental. Subgenus *Agave* is conspicuously absent from this region while *Littaea* reaches its highest diversities there.

(6) The only major area of high species density shared by the two subgenera is again the Tehuacan Valley. The region could well be the center of origin of the paniculate inflorescence which characterizes subgenus *Agave*. Gentry (1982) comments that *Agave peacockii* Croucher (subgenus

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**Figure 3.** Species abundance contour map of *Agave* subgenus *Littaea*. Contour interval equals one species.



**Figure 4.** Species abundance contour map of *Agave* subgenus *Agave* (excluding group *Salmiana*). Contour interval equals one species.

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*Littaea*) is "a remarkably distinct plant with no close relatives" and speculates that it may be a viable hybrid of *A. kerchovei* Lem. (subgenus *Littaea*) and *A. marmorata* Roez. (subgenus *Agave*). This would be one of the reticulations in the higher-order phylogenies Burgess and I envision; where two diverging but related groups of species cross reproductive barriers and exchange genetic information. It could also be an intermediate link between the two subgenera. In either case, it would make an ideal subject for further documentation and, if necessary, for recognition and preservation through the Endangered Species Act. Similarly, *Agave arizonica* represents another exchange of genetic information between the two subgenera; another "reticulation" in the evolutionary web. On the other hand, *Agave schottii* var. *treleasei* is more likely to be a single inviable hybrid or polyploid clone not involving an important evolutionary event.

The overwhelming array of species, subspecies, and varieties in complex groups makes application of the Endangered Species Act unavoidably arbitrary in some cases but some very useful perspectives can be achieved by assessing the group as a whole, sorting out the significant from the insignificant. My species abundance mapping

approach and emphasis on reticulate evolution is one way of setting priorities and targeting potentially important taxa for conservation efforts. Others may be equally valid, or even better, with other groups. In the Southwest, genera such as *Astragalus* and *Eriogonum* and even whole families such as the Cactaceae lend themselves to this sort of approach.

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