CONVENTION ON INTERNATIONAL TRADE IN ENDANGERED SPECIES
OF WILD FAUNA AND FLORA

Twenty-fifth meeting of the Plants Committee
Online, 2-4, 21 and 23 June 2021

Species specific matters

Maintenance of the Appendices

Periodic review of species included in Appendices I and II

PERIODIC REVIEW OF *CERATOZAMIA HILDAE*

1. This document has been submitted by the Scientific Authority of Mexico.*

2. At the 23rd meeting of the Plants Committee (Geneva, Switzerland, July 2017) and in response to Notification to the Parties No. 2017/069, Mexico volunteered to assess the bamboo cycad, *Ceratozamia hildae*, as part of the Periodic Review of species included in the CITES Appendices in accordance with Resolution Conf. 14.8 (Rev. CoP17).

3. The CITES Scientific Authority of Mexico (CONABIO) coordinated a project aimed at assessing *C. hildae* in terms of its conservation status, use, management, threats and trade. The project was led by Dr. Maria del Carmen Mandujano Sanchez of the Institute of Ecology of the National Autonomous University of Mexico in cooperation with Cadereyta Regional Botanic Garden and entitled *Evaluación del estado de conservación, aprovechamiento y amenazas de* Ceratozamia hildae *en el marco del examen de revisión periódica de especies listadas en los Apéndices de la CITES* (Assessment of the conservation status, use of and threats to *Ceratozamia hildae* in the framework of the Periodic Review of species listed in the CITES Appendices).

4. The project involved analysing data obtained in the field, consulting Mexican and international CITES Authorities, conducting a comprehensive literature review, consulting the database of the World Conservation Monitoring Centre (UNEP-WCMC) and surveying the Internet to compile information about the use and international trade of the species.

5. According to the UNEP-WCMC database, the imports of live plants of the species decreased by up to 98% from 1985, when *Ceratozamia hildae* was included in CITES Appendix I. Between 2000 and 2018, trade in *C. hildae* was moderate: records show the export of a total of 429 live plants, 6 flowers, 6 leaves and 1,673 seeds, of which Mexico only exported 6 flowers and 10 seeds in 2000 for scientific purposes, with source code “W” (wild specimens); the remaining records were of specimens with source codes “A” and “D” (artificially propagated specimens) exported for commercial purposes. There are no nurseries registered in CITES for the artificial propagation of the species.

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6. Based on the information obtained (see paragraphs 3 and 4), a document was prepared assessing the species against the “Criteria for amendment of Appendices I and II” of Annex 6 of Resolution Conf. 9.24 (Rev. CoP16).

Results and conclusions

7. The main results were the following:

   a) *Ceratozamia hildae* is a cycad that is endemic to Mexico and has a sporadic distribution in the boundary between San Luis Potosi and Queretaro States, in the Sierra Madre Oriental.

   b) It grows in oak forests on steep slopes with rocky outcrops, clay and limestone soils and plenty of shade. The species has a potential area of distribution of about 7,475 km^2; however, this figure is not considered to represent its spatial distribution, which is not continuous but in small patches. In 2020, the authors of the review visited five populations of *C. hildae* in Sierra Gorda Biosphere Reserve and found fewer than 60 individuals in four of them; all these populations had a size of less than one hectare each.

   c) The species has intrinsic biological, reproductive and demographic restrictions, which, *combined* with changes in land use and the history of illegal harvests of wild specimens, threaten the persistence and viability of its wild populations.

   d) In Mexico, two nurseries include *C. hildae* in the records of species that they manage. However, there are currently no records of use, legal or illegal trade of the species.

   e) On an international level, although the UNEP-WCMC database has not recorded any exports from Mexico since 2000, there are some records of exports from other countries with source codes “A” and “D” (artificial propagation). In addition, there are websites offering the species for sale in several countries other than Mexico.

8. After analysing the information compiled, the authors concluded that the species meets the biological criteria for remaining in CITES Appendix I, in accordance with Resolution Conf. 9.24 (Rev. CoP17), Annex 1, criteria A ii), B i) and C ii).

Recommendations to the Plants Committee

9. The Plants Committee is invited to:

   a) Take note of the results of this review; and

   b) Make the comments and recommendations it deems appropriate on the information submitted to consider maintaining *C. hildae* in CITES Appendix I.

A. Proposal

Maintain *Ceratozamia hildae* in CITES Appendix I, in accordance with Resolution Conf. 9.24 (Rev. CoP17), Annex 1, criteria A (ii), B (i) and C (ii).

B. Proponent

Mexico*

C. Supporting statement

1. Taxonomy

1.1	Class:	Cycadopsida	
1.2	Order:	Cycadales	
1.3	Family:	Zamiaceae	
1.4	Genus, species or subspecies, including author and year:		*Ceratozamia hildae* (G.P. Landry & M.C. Wilson 1979)
1.5	Scientific synonyms:	none	
1.6	Common names:	English:	bamboo cycad
		Spanish:	cícada bambú, chamalillo, pata de gallo, palma cícada de la Sierra Gorda
1.7	Code numbers:	xxx	

2. Overview

At the 23rd meeting of the Plants Committee (2017, Geneva), Mexico volunteered to conduct the review of *Ceratozamia hildae* as part of the Periodic Review process in accordance with Resolution Conf. 14.8 (Rev. CoP17) during the period between CoP17 and CoP19.

3. Species characteristics

3.1 Distribution

Ceratozamia hildae is endemic to Mexico and is distributed in the boundary between San Luis Potosi and Queretaro States, in the Sierra Madre Oriental (Vovides & Nicolalde-Morejón 2010). Mandujano *et al.* (2020) developed a potential distribution map of the species using the Maxent algorithm (version 3.4.1), based on abiotic variables and georeferenced records of occurrence reported in herbaria and databases of the Mexican National Commission for Natural Protected Areas (Comisión Nacional de Áreas Naturales Protegidas CONANP) as well as records obtained in field visits. The resulting model suggests that *C. hildae* has a potential distribution of 7,475 km^2; however, this figure does not take into account the spatial distribution of the species, which is not continuous but in small patches. All the georeferenced records found and used to develop the model were within the protected area Sierra Gorda Biosphere Reserve, in Queretaro State, or in its surroundings (**Figure 1**).

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3.2 Habitat

Ceratozamia hildae grows in forests dominated by oak (e.g., *Quercus reticulata* Bonpl.) and with the presence of other dominating species such as *Brahea dulcis* Mart., *Brahea* sp., *Dioon edule* Lindl. and *Zamia fischeri* Miq., at an altitude between 850 and 1300 m.a.s.l. In those sites, the predominant climate is warm and humid, with a mean annual temperature around 23 ºC and 900 mm of annual precipitation (Vovides & Nicolalde-Morejón 2010, Vovides & Chemnick 2010, Mandujano *et al.* 2020). The species grows on steep slopes with clay and limestone soils classified as Leptosol and Vertisol and in the anticlines of the Sierra Gorda in Queretaro, in the steepest areas with rocky outcrops and plenty of shade (Landry & Wilson 1979, Vovides & Rees 1980, Mandujano *et al.* 2020).

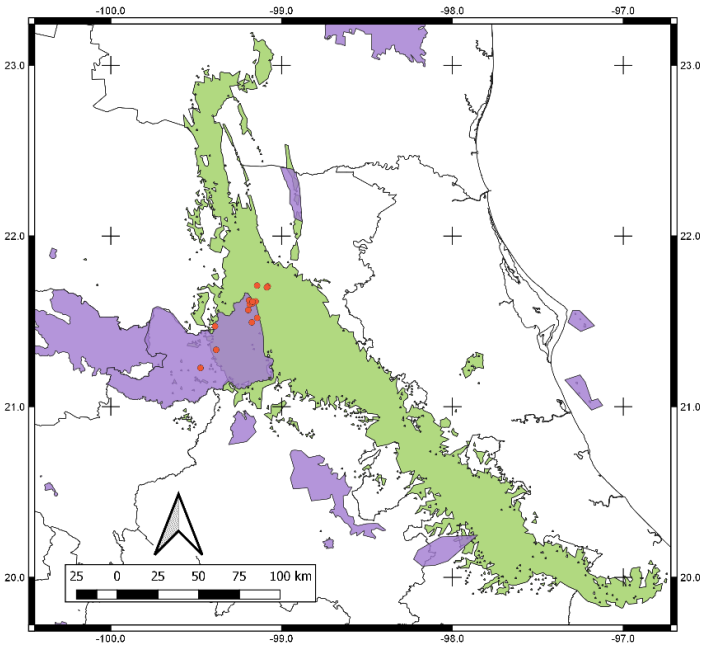

Figure 1. Records of the presence (red dots) and potential distribution (in green) of *Ceratozamia hildae* in Mexico, in Queretaro and San Luis Potosi States. In purple, protected areas near the species' area of distribution.

3.3 Biological characteristics

According to Vovides and Chemnick (2010), the mean age of reproduction of *Ceratozamia hildae* is 45 years. In most cycads, pollination is entomophilous (i.e., mediated by insect vectors) (Mandujano *et al.* 2020); particularly in the genus *Ceratozamia*, pollination by beetles of the Erotylidae family through a symbiotic process has been reported (Tang *et al.* 2008). The insects spend most of their life inside the male cones (microstrobili), where they go through several stages of their life cycle and go into diapause when plants are not reproductive; however, during periods of receptivity of female plants, they are attracted by temperature changes in the cone (megastrobilus), in a process known as thermogenesis that leads to the release of volatile odours (Terry *et al.* 2007).

According to Nicolalde-Morejón *et al.* (2014), pollination and fertilization processes occur in a well-defined manner in cycads and take place within a period of 3 to 7 months. These authors also reported that cycads have motile sperm, which is an apomorphic trait of this plant group. Gametes are produced in the pollen tube soon after germination takes place following pollination. Landry (1990) reported that pollination takes place between mid-April and early June and that the seeds produced take several months to mature, so cones pollinated in April-May disintegrate with ripened seeds in November-December. However, Pérez-Farrera and Vovides (1997) reported that the maturation period of cycad seeds can take 12-14 months. Specifically in the genus *Ceratozamia*, seed development takes 24 months from pollination to the full development of the embryo. Megasporogenesis and megagametophytogenesis occur during the first three months. Germination takes approximately 12 months; this phase is known as pre-germination dormancy (Pérez-Farrera & Vovides 1997, Sánchez-Tinoco *et al*. 2000). New seeds are covered with a light yellow pulp. Observations by field experts suggest that the sarcotesta is not easily removed. The seeds germinate within 90 days of falling to the ground (Landry 1990). When the embryo matures, it elongates and produces the cotyledon, which shows the upper epicotyl, composed of an apical meristem and a leaf primordium. The cotyledons remain in the seed and obtain nutrients from the megagametophyte until the root system has become

fully established in the soil. The anatomy of the sporophytes is defined during the growth of the unifoliar stage plantlets. With the passage of time, the number of leaves increases, the trunk grows and finally the plant develops strobili, in which male and female gametophytes develop (Nicolalde-Morejón *et al.* 2014).

In general, species of the genus *Ceratozamia* do not produce seeds with a coloured sarcotesta. This is probably because the seeds disperse mechanically as the cones open on the steep slopes and cliffs where the plants normally grow. Birds and small mammals such as peccaries have been found to be biological dispersers of *Ceratozamia* seeds (Whitelock 2002, Pérez-Farrera 2006).

3.4 Morphological characteristics

Ceratozamia hildae is a cycad species that differs from all the other species in its genus. It is a small plant with a unique leaf arrangement and texture. Each leaf has leaflets in clusters on the rachis (3-12 leaflets per node). Leaves may measure up to 1.5 m in length. The leaflets are thin and papery rather than thick and leathery, like other cycads. The trunk is partially subterranean (i.e., semi-hypogeal) and erect and may eventually reach a height and diameter of 30+ cm (Landry 1990). Cones are produced between February and April; the microstrobilus is cylindrical to conical and measures 9-15 cm in length and 0.9-1.4 cm in diameter; it is green when the plant is young and turns to light brown when it matures. The megastrobilus is cylindrical, green to dark green, and measures 4-10 cm in length and 3-4 cm in diameter. Seeds are ovate and measure 1.3-1.9 cm in length and 1.1-1.4 cm in diameter (Vovides 1999). The leaves of seedlings of *C. hildae* have 1-3 pairs of opposite leaflets that resemble those of other cycad species such as *C. latifolia*; however, as the plant matures the arrangement of the leaflets changes and it is not until the third leaf is produced that clustered leaflets appear along the rachis (Landry 1990, **Figure 2**).

a)

b)

Figure 2. a) *Ceratozamia hildae* G. P. Landry & M. C. Wilson; wild specimen. El Pocito, Jalpan de Serra, Queretaro (author: Beatriz Maruri Aguilar, 2020); b) Female cone of *C. hildae* (author: Philip John Brewster; photo taken from the CONABIO Image Bank (http://bdi.conabio.gob.mx/fotoweb/).

3.5 Role of the species in its ecosystem

Mandujano *et al.* (2020) recorded the presence of eggs, caterpillars, chrysalis and adults of *Eumaeus toxea* (Lycaenidae) in the leaflets of *C. hildae* (**Annex 1**). Moreover, a high proportion of leaves without leaflets was observed in these plants. The highly specific interaction between cycads and butterflies specialized in their consumption has been documented in Mexico and South America (Whitaker & Salzman 2020).

Apart from being pollinated by beetles of the Erotylidae family, it has been reported that some diptera such as those of the genus *Trigona* and beetles of the genus *Rhopalotria* also act as pollinators of cycad species (Norstog & Stevenson 1980).

A relevant aspect of these plants in their ecosystems is the fact that they develop succulent and tuberous roots that form masses on the soil surface, whey they have symbiotic interactions with

nitrogen-fixing bacteria species; this is a highly relevant process, particularly after a wildfire (Norstog & Nicholls 1997). Another type of associations reported in the family is with arbuscular mycorrhizae, which help capture water and nutrients in poor soils (Vovides 1991).

There is little information available on the role played by *C. hildae* in its ecosystem as it is a rare species that has not been the subject of research aimed at identifying its interactions with other species.

4. Status and trends

4.1 Habitat trends

In 1997, the Mexican Ministry of the Environment, Natural Resources and Fisheries (SEMARNAP, Secretaría de Medio Ambiente, Recursos Naturales y Pesca) considered that, on average, 550 hectares were lost every year in Sierra Gorda Biosphere Reserve, in Queretaro State (De la Llata *et al.* 2006). Between 2005-2010, it is estimated that changes in the biosphere reserve resulted mainly from the conversion of land to pasture (2,193 hectares) and cropland (549 hectares). The main types of vegetation affected were low deciduous forest, mixed forest and oak forest (Ríos Saís 2015); *C. hildae* grows in the latter.

4.2 Population size

Mandujano *et al.* (2020) compiled information on sites in which *C. hildae* was present and found 14 georeferenced records. Occurrence of the species in the field had been verified in 10 of them, while the remaining four were herbarium records. In March 2020, the authors visited seven of the 14 sites mentioned above; however, they did not find the species in one site and found only four individuals in another one. In the five remaining sites, the authors recorded a total of 307 individuals. Densities observed are shown on **Table 1**. It should be noted that, apart from this information, no population studies of *C. hildae* have been conducted earlier.

Table 1. Estimated density of *Ceratozamia hildae* in each of the populations visited (Mandujano et al. 2020)

Population	**No. of ind.**	**Area sampled (m^2)**	**Ind/area (m^2)**
Yerbabuena	61	2500	0.0244
Chijol	54	2500	0.0216
Rancho Nuevo	97	5000	0.0194
San Francisco Arenitas	50	5000	0.01
Lindero Querétaro-San Luis Potosí	45	1000	0.045
TOTAL	**307**	**16000**	**Average: 0.0241**

4.3 Population structure

In the five populations visited by Mandujano *et al.* (2020), the age class of individuals was determined on the basis of the length of their largest leaf. Plants were classified as seedlings (leaf less than 30 cm long), juveniles (leaf between 30 cm and 1 m long) or adults (leaf longer than 1 m). The authors also recorded whether the plant had any male or female strobili. In four populations, the population structure presented an inverted J distribution (Leak 1965), that is, the adult class was better represented than the classes of seedlings and juveniles (**Figure 3**). These populations were San Francisco Arenitas, Rancho Nuevo, Lindero Querétaro-San Luis Potosí and Rancho Chijol; in La Yerbabuena, however, researchers found a greater number of juvenile individuals but few seedlings.

This suggests that the regeneration of populations through seedling recruitment is not frequent; this may be due to low reproductive ability, seed predation or poor establishment of seedlings.

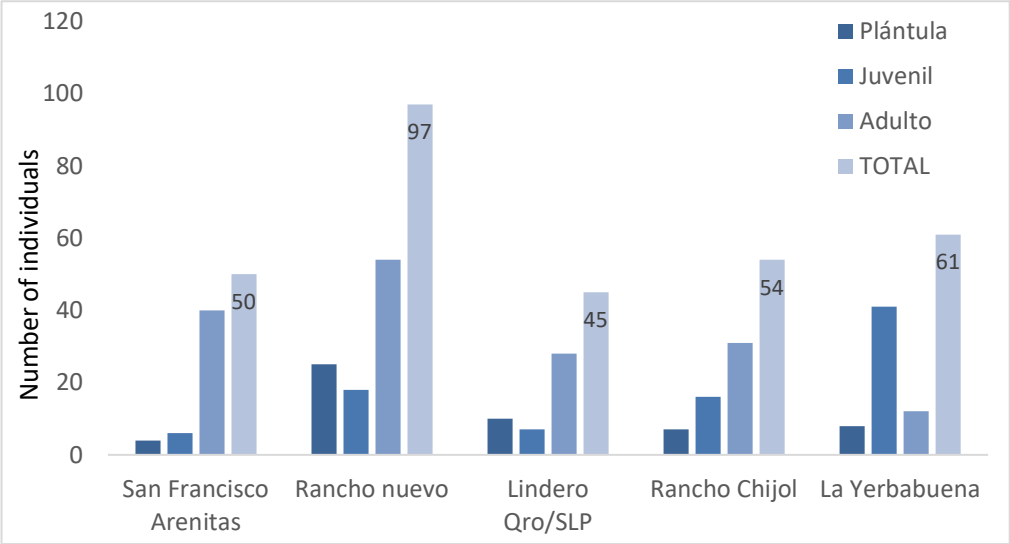

Figure 3. Frequency of occurrence of individuals of *Ceratozamia hildae* at different development stages in the five populations observed during the field visit conducted in March 2020: San Francisco Arenitas, Rancho Nuevo, Lindero Querétaro-San Luis Potosí, Rancho Chijol and La Yerbabuena (Mandujano et al. 2020). [Note: *Plántula* = Seedling].

Male cones were only found in three of these populations (i.e., Rancho Chijol: 1 cone; San Francisco Arenitas: 5 cones; la Yerbabuena: 1 cone) and one female cone was found in one of them (Rancho Chijol). The low presence of reproductive structures may be associated with a lower reproduction and the few seedlings found in the populations visited (Mandujano *et al*. 2020).

4.4 Population trends

Populations of *C. hildae* in Sierra Gorda Biosphere Reserve are scarce, demographically small (i.e., fewer than 60 individuals in most of those surveyed directly in the field) and locally rare (i.e., each of them covers a surface of less than one hectare), mostly with an inverted J population structure, showing low regeneration (Mandujano *et al*. 2020).

4.5 Geographic trends

There is no specific information available on the geographic trends of *C. hildae* over time.

5. Threats

Between the decades of 1960-1970, thousands of plants of *C. hildae* were harvested from the wild and exported to the United States and other countries; this intensive harvest resulted in the extirpation of several wild populations and the dramatic decline of the number of individuals in others; many populations have taken very long to recover and some may never manage to do so (Landry 1990).

Trade in *C. hildae* started to be regulated once the species was included in CITES Appendix I. However, its wild populations faced other problems, such as living in a precarious habitat in a highly deforested area, where the greatest threats to the species are habitat destruction to increase the surface of pastures for livestock and deforestation due to the logging of timber species (Vovides 2001).

In March 2020, Mandujano *et al.* assessed anthropogenic environmental disturbances in the Rancho Chijol population using the metrics proposed by Martorell and Peters (2003, 2005, 2008), which were designed to quantify the impact of anthropogenic agents of disturbance in a specific area. Based on the results obtained, the authors estimated the percentage that each agent contributed to the rate of disturbance. This revealed that the agent that contributes the most (61.2%) is human activities, followed by livestock farming (36.32%).

Overall, the sites where Mandujano *et al.* (2020) found populations of *C. hildae* were relatively well conserved. In Rancho Chijol, where the agents of disturbance were assessed, a very low rate of disturbance was observed (i.e., 8.08 on a scale of 0 to 100, in which 0 corresponds to a perfectly well-preserved site), as if the site were pristine; however, in the field it was obvious that livestock farming is one of the main threats faced by the populations of *C. hildae* in Sierra Gorda Biosphere Reserve, due to the clearing of plant cover

to establish pastures for livestock – mainly cattle – and the free grazing of livestock. The existence of trails for people and livestock allow the animals to reach more shaded areas, which leads to soil compaction. One of the advantages of the species is that it inhabits steep slopes and shaded areas that are inaccessible, which grants it a certain protection against deforestation and the presence of livestock.

6. Utilization and trade

6.1 National utilization

The most comprehensive knowledge about the utilization of cycads comes from the Xi'uy or Pames del sur indigenous people of San Luis Potosi and Queretaro States and from the mestizos of the Sierra Gorda and their descendants. In the region, cycads are commonly known as “types of maize”, “friends of maize” or “ancestors of maize”. There is a tight bond between cycads and maize, reflected in the belief that good years for maize are bad years for cycads and vice versa (Bonta *et al.* 2019).

The seeds of female cones of cycads contain carbohydrates with high starch content and the use of cones of *Ceratozamia* has been documented to produce various types of food. For example, the wet meal (nixtamal) and dry cycad flour is used for making tortillas, tamales and atoles; tamales play an important role in the *ofrendas* or offerings of the Xi'uy people for the Day of the Dead; on this occasion, the leaves are also used to decorate altars (Bonta *et al.* 2019).

Despite the great cultural, religious and economic importance of the genus *Ceratozamia* throughout the broad region of the Sierra Madre Oriental where it occurs, information about its ethnobotanic aspects is limited.

6.2 Legal trade

The authors consulted trade records of *C. hildae* in the World Conservation Monitoring Centre (UNEP-WCMC) database. The information obtained was grouped into three periods: 1975-1985, 1986-2013 and 2014-2018. For each period, specimens of *C. hildae* were classified as imported or exported. Figures are shown on **Table 2**.

Table 2. Number and type of specimens of *C. hildae* imported or exported in the world per period

Period	1975-1985	1986-2013	2014-2018
Imports			
Live plants	5,420	135	93
Seeds		106	365
Exports			
Live plants	208	303	144
Seeds		1,221	665
Cones		6	
Leaves		6	

Over time, there has been a continuous movement of live plants and seeds. Other specimens such as male or female cones and leaves appear as isolated events in the records.

Taking the years 1975 and 2018 as a reference, imports of live plants almost disappeared, decreasing by 98%, while those of seeds increased by 244.3% from 1986; there were no records of seed imports during 1975-1985. Overall, exports of live plants also decreased by 30.7% between 1975 and 2018, although they increased during 1986-2013; exports of seeds also decreased by 45.4%. This behaviour is represented in Annex 3, Figure 1.

The global map of trade in the species has also changed in the last 45 years. In 1975-1985, the importing countries of the species were Australia, Great Britain, the United States and the Republic of South Africa, while the exporters were Mexico and the United States – artificially propagated plants. The United States was the only country that was both an importer and an exporter.

In 1986-2013, the number of exported plants or parts decreased, but the import routes of *C. hildae* on a global level increased: 20 countries of all continents received plants from other nations (**Africa**: Niger and the Republic of South Africa; **Americas**: Brazil, Mexico and the United States; **Asia**: Indonesia, Japan, Pakistan, Singapore and Thailand; **Europe**: Austria, France, Germany, Great Britain, Italy, the Netherlands, Portugal and Spain; **Oceania**: Australia and New Zealand). Exporting countries also imported artificially propagated specimens of the species (Australia, Mexico, the Republic of South Africa, Thailand and the United States).

In the most recent period for which data are available (2014-2018), only 144 live plants and 665 seeds were exported; the main exporting countries in order of importance based on the volume of biological material involved were Australia, the Republic of South Africa and the United States. The main importers, also in decreasing order of importance, were Germany, New Zealand, Thailand, Japan, Gabon and Saudi Arabia (**Annex 3, Figures 2-4, maps**). The consultation did not show records of re-exports. These operations mainly involved seeds and global commercial trade was extremely low (Annex 3, Figure 5, graphs).

Comparing those data for 2014-2018 to data for 1975-1985, in which there were more than 5,000 plants imported, it can be stated that imports decreased after *C. hildae* was included in Appendix I (in 1985); by contrast, trade in seeds exploded from that moment.

It is also important to mention that the recorded purpose in most transactions was commercial trade (code T); only three transactions were recorded with code P (personal effects) and two transactions were recorded with code S (scientific) (**Annex 3, Tables 1 and 3**). Regarding the latter, in the year 2000, Mexico reported two exports of wild-harvested reproductive parts (6 flowers and 10 seeds) to the United States.

Most events or transactions conducted were recorded with source codes A or D used indistinctly. Yet, given that the species is included in Appendix I, the correct code to refer to commercial trade would have been D.

In Mexico there are two Wildlife Management and Conservation Units known as UMAs (Unidades de Manejo para la Conservación de la Vida Silvestre) with intensive schemes (i.e., nurseries that deal with conservation aspects of the wild species that they manage) that reported having specimens of *C. hildae*; yet, there is no additional information about the use of this species in those UMAs (e.g., requests for authorizations to harvest specimens). Thus, there are no recorded cases of use of this species to date.

6.3 Parts and derivatives in trade

See Table 2, section 6.2.

6. Illegal trade

On an international level, the UNEP-WCMC database does not include any records of illegal trade across borders.

On a national level, the Mexican environmental law enforcement agency (PROFEPA, Procuraduría Federal de Protección al Ambiente), which is also the CITES Enforcement Authority of Mexico, is in charge of monitoring and ensuring compliance with the environmental protection legislation in the country and has not reported any activity related to this species.

6.5 Actual or potential trade impacts

See sections 4.4. and 6.4.

7. <u>Legal instruments</u>

7.1 National

The species is included as Threatened in the Mexican list of species at risk (Anexo Normativo III, modificado en 2019; DOF 2019) of the Official Mexican Standard NOM-059-SEMARNAT-2010 (SEMARNAT 2010). This category includes species or populations of species that could become

endangered with extinction in the short or medium term if factors negatively influencing their viability by damaging or modifying their habitat or directly decreasing their population size continue (this category partially coincides with the category Vulnerable on the IUCN Red List). According to Article 420, Section IV of the Mexican Federal Penal Code (CPF), the inclusion of *C. hildae* in the Official Mexican Standard implies that any illegal activity for the purpose of trafficking, capture, possession, transportation, storage, import or export is punishable with a fine equivalent to 300-3,000 days and a maximum of nine years' imprisonment (CPF 2020). There is an additional penalty of three years' imprisonment and a fine equivalent to up to 1,000 days if these illegal activities take place in or affect a protected area or are conducted with commercial purposes. The legal harvest and use of the species are also regulated by the Mexican General Wildlife Act (Ley General de Vida Silvestre).

7.2 International

Ceratozamia hildae was included in CITES Appendix II In 1977 as part of the Zamiaceae family and transferred to Appendix I in 1985 as part of the genus *Ceratozamia* spp.

8. Species management

8.1 Management measures

Given that the species is listed in the Official Mexican Standard as Threatened, the responsibility for its management in Mexico lies with the Ministry of the Environment and Natural Resources (SEMARNAT) under the provisions of the General Ecological Balance and Environmental Protection Act (Ley General de Equilibrio Ecológico y Protección al Ambiente, LGEEPA) and the General Wildlife Act (Ley General de Vida Silvestre, LGVS) and their respetive regulations. According to the Mexican Wildlife Agency (Dirección General de Vida Silvestre, DGVS-SEMARNAT), 124 applications to use the species were recorded in 2005-2018; they were all made by nurseries legally registered in Mexico.

8.2 Population monitoring

There are no particular measures in place to monitor the species.

8.3 Control measures

8.3.1 International

See section 7.2.

8.3.2 Domestic

See section 7.1.

8.4 Captive breeding and artificial propagation

The CITES Management Authorities of Australia, South Africa and the United States were consulted (because these were the main countries reporting exports in 2014-2018) to obtain information about the nurseries that produce and export *C. hildae*. Additionally, the authors of this reviewed conducted an Internet search of the nurseries that advertise, propagate or trade in the species. Including the information provided by the CITES Authorities of Australia and the United States and the results of the Internet search, the authors compiled data about 26 nurseries and 3 additional sites (i.e., blogs and discussion forums of cycad enthusiasts) (listed in **Annex 4**). To date (March 2021), there are no nurseries registered with the CITES Secretariat for the artificial propagation of *C. hildae* for export purposes in accordance with Resolution Conf. 9.19 (Rev. CoP15) (https://cites.org/eng/common/reg/nu/summary.html).

Mandujano *et al.* (2020) conducted a search in the database of Botanic Gardens Conservation International (BGCI) of botanic gardens that report having specimens of *C. hildae* in their collections. They identified 50 botanic gardens; the presence of specimens of *C. hildae* was confirmed by direct communication with the botanic gardens in 13 cases (four in Mexico, four in the United States, four in the United Kingdom and one in Canada; see **Annex 5**).

8.5 Habitat conservation

All the populations reported by Mandujano *et al*. (2020) are distributed in Sierra Gorda Biosphere Reserve, a protected area in Queretaro State; yet, there are no programs for the conservation of *C. hildae*. The non-governmental organization Grupo Ecológico Sierra Gorda I. A. P. (GESG) is leading a partnership of civil society organizations that have managed to conserve forests and prevent deforestation in those areas by acquiring land and developing programs for the conservation and sustainable use of natural resources and environmental education. There are reports of the presence of *C. hildae* in some well-conserved land plots owned by GESG.

8.6 Safeguards

One of the protection measures implemented by the Mexican government to safeguard priority or endangered species including *C. hildae* is the designation of protected areas (see previous section).

Another way of safeguarding the species is through botanic gardens (see section 8.4), which allow the conservation and in some cases the propagation of species outside their natural habitat in Mexico.

9. Information on similar species

There have been several phylogenetic studies of the genus *Ceratozamia* (González and Vovides (2002), Martínez-Domínguez (2018) and Medina-Villarreal (2019)). These studies have revealed that the species that are most closely related to *C. hildae* are *C. latifolia* Miq., *C. kuesteriana* Regel., *C. sabatoi* Vovides & al., and *C. zaragozae* Medellín-Leal, *C. fuscoviridis* W. and *C. huastecorum* Avendaño, Vovides & Cast.-Campos. A summary of the morphological characters of *C. hildae* and its related species is provided in **Annex 2**.

The morphology of adult specimens of *Ceratozamia hildae* is unique within the genus, given the arrangement of its leaflets into fascicles, with a broad distance between them (**Figure 2**). The plant can only be confused with *Ceratozamia latifolia* at the seedling stage.

10. Consultations

See section 6.1.

11. Additional remarks

None

12. References

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(a)

(b)

(c)

Eumaeus toxea presente en el mismo sitio que *C. hildae.*
(a) Huevos y orugas sobre foliolos de *Ceratozamia hildae* (b) Crisálidas, (c) Adultos.
(Fotografías: Emiliano Navarrete Sauza, 2020).

Concentrado de características morfológicas de *Ceratozamia hildae* y sus especies relacionadas filogenéticamente.

ESPECIE	***Ceratozamia hildae***	***Ceratozamia fuscoviridis***	***Ceratozamia huastecorum***	***Ceratozamia kuesteriana***	***Ceratozamia latifolia***	***Ceratozamia sabatoi***	***Ceratozamia zaragozae***
Tipo de tallo	Semiepigeo	Epigeo	Semihipogeo	Semihipogeo	Semihipogeo	Epigeo	Epigeo
Hábito del tallo	Erecto	Erecto y decumbente	Erecto	Erecto	Erecto	Erecto y decumbente	Erecto y decumbente
Aguijones sobre el raquis	Ocasionalmente	Presentes	Presentes	Presentes	Ausentes	Presentes	Ausentes
Arreglo de foliolos en el raquis	**Fascículos**	Opuestos a subopuestos	Opuestos a subopuestos	Opuestos a subopuestos	Opuestos a subopuestos	Opuestos a subopuestos	Opuestos a subopuestos
Forma del foliolo	Lanceolado	Lanceolado	Oblanceolado	Basalmente falcado	Oblongo	Lanceolado a angostamente obovado	Linear-lanceolado
Textura del foliolo	Membranoso	Papiráceo	Coriáceo	Papiráceo	Papiráceo	Papiráceo	Membranoso
Color del estróbilo polinífero	Café a café rojizo	Café amarillento en emergencia, café verdoso con pubescencia café rojizo en la madurez	Verde claro	Verde amarillento con pubescencias café en emergencia, Café amarillento con pubescencia café rojizo en la madurez	Verde amarillento con pubescencias rojizas en la emergencia, Café rojizo en la madurez	Verde amarillento en emergencia, amarillo verdoso con pubescencia negra en la madurez	Verdoso con pubescencia café rojizo en emergencia, café rojizo en la madurez
Ángulo de los cuernos de la megasporófila	Recto	Obtuso		Obtuso	Obtuso	Recto	Obtuso
Distancia entre foliolos medios	6-15 cm	0.6-2 cm		0.3-2.5 cm	1-7-12.5 cm	0.5-1.5 cm	0.8-2.3 cm
Largo del estróbilo polinífero	9 a 15 cm	26.5-28 cm		11-15 cm	10.5-20 cm	11-18 cm	15-19 cm
Diámetro del estróbilo polinífero	0.9 a 1.4 cm	5-8 cm	3 cm	2.2-3 cm	2.1-2.5 cm	3.5-4.8 cm	2-3.5 cm
Fuentes	Martínez-Domínguez, 2018, y Vovides, 1999.	Martínez-Domínguez, 2018 y Osborne *et al*., 2006.	Avendaño *et al*., 2003	Martínez-Domínguez, 2018	Martínez-Domínguez, 2018	Martínez-Domínguez, 2018, y Vovides, 1999.	Martínez-Domínguez, 2018 y Vovides y Nicolalde Morejón 2010

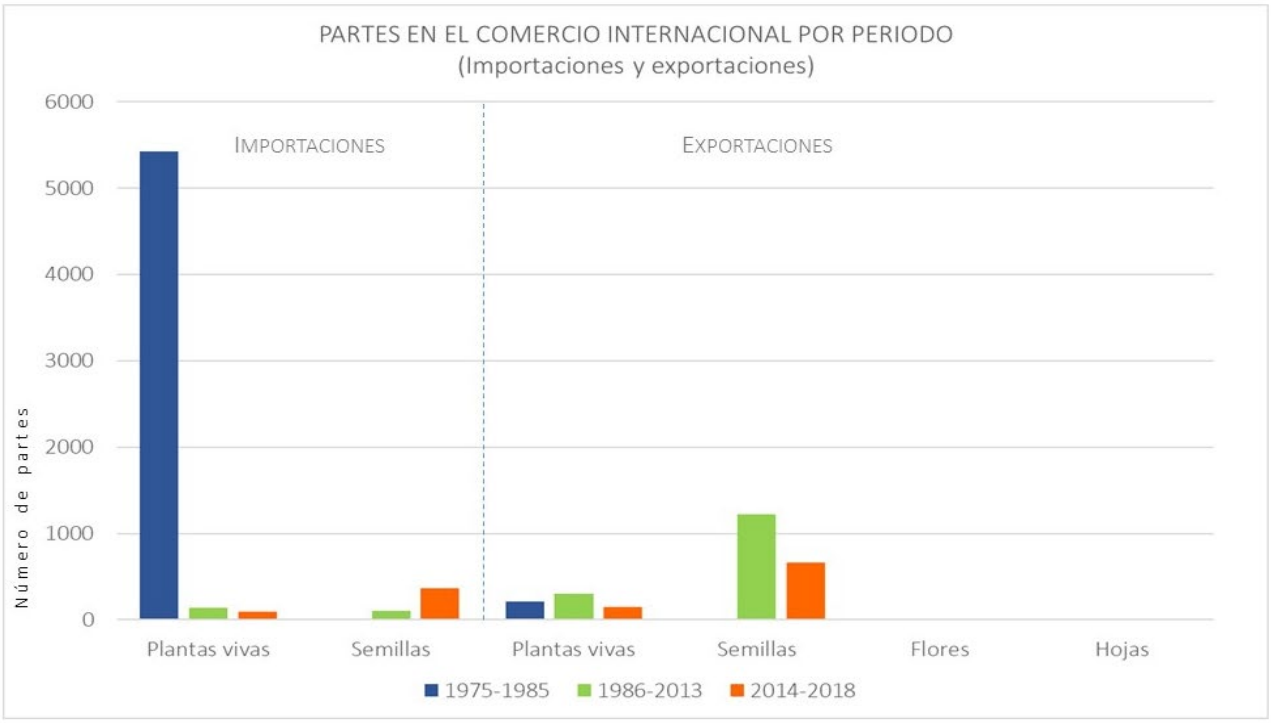

Figura 1. Comportamiento de importaciones y exportaciones de plantas vivas y partes de *C. hildae* entre 1975 y 2018 (Elaborado con datos de UNEP- WCMC CITES Trade Database)

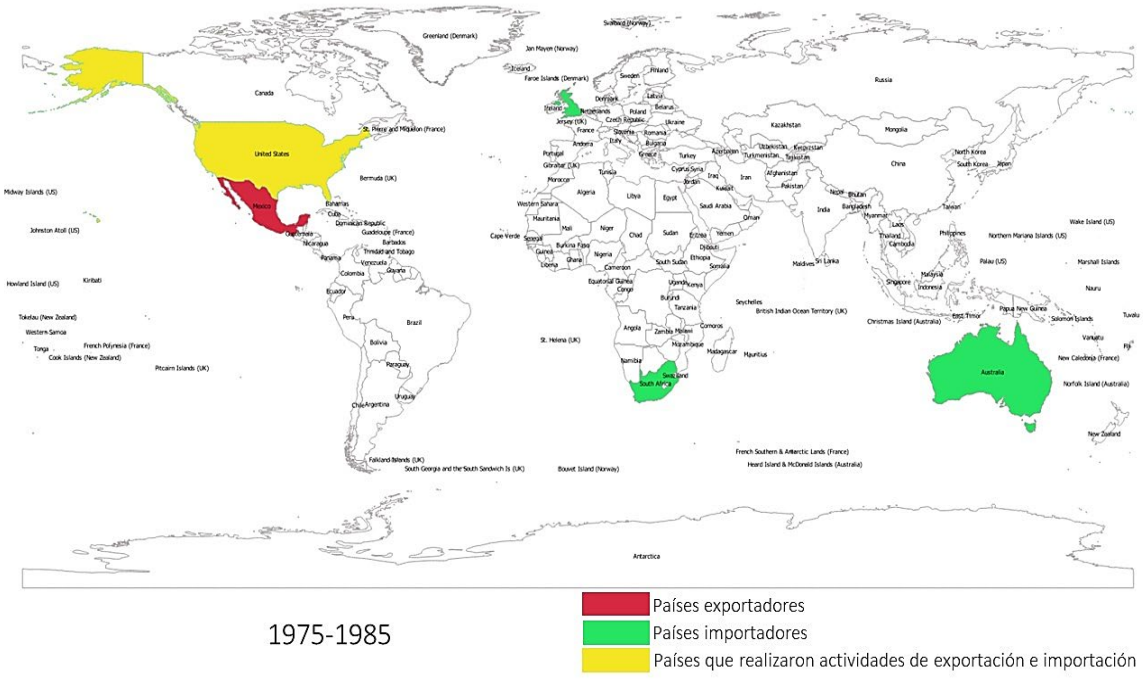

Figura 2. Comercio internacional de *C. hildae* entre 1975 y 1985. Elaborado con datos de UNEP- WCMC CITES Trade Database.

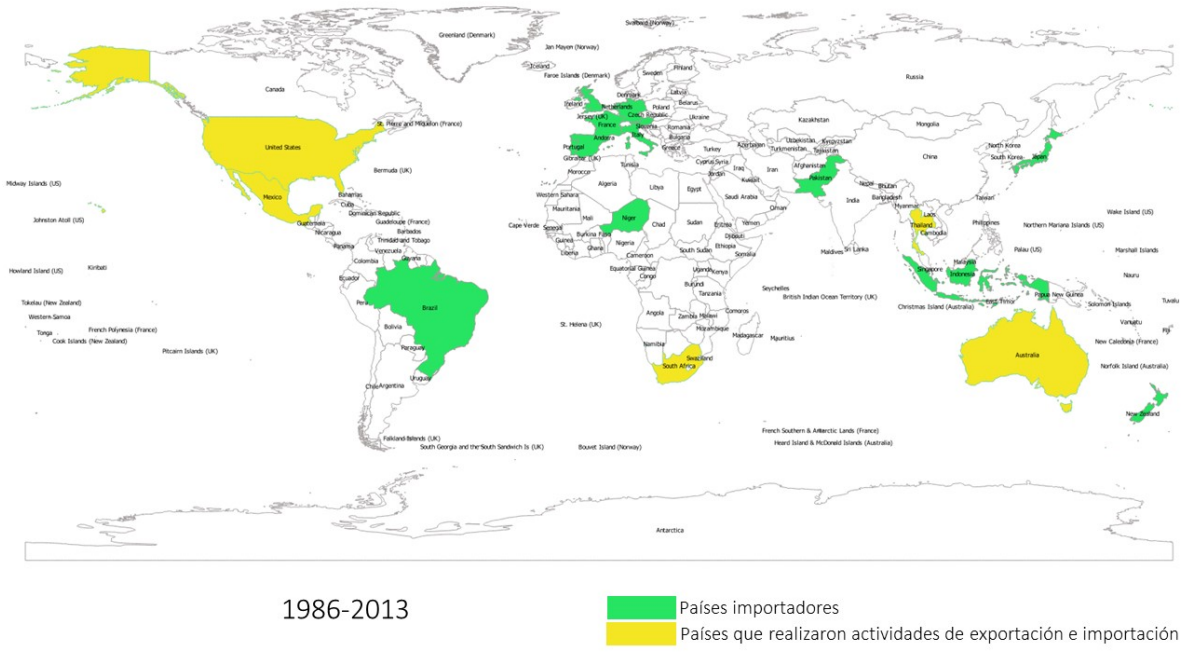

Figura 3. Comercio internacional de *C. hildae* entre 1986 y 2013. Elaborado con datos de UNEP- WCMC CITES Trade Database.

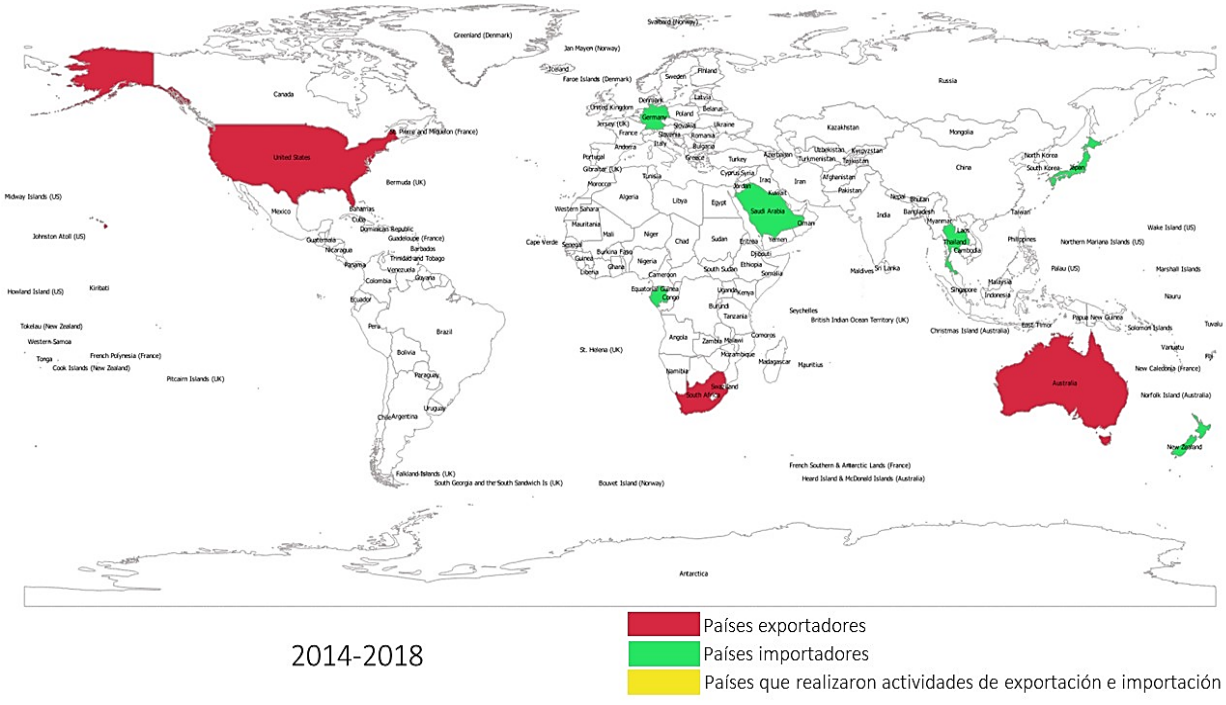

Figura 4. Comercio internacional de *C. hildae* entre 2014 y 2018. Elaborado con datos de UNEP- WCMC CITES Trade Database.

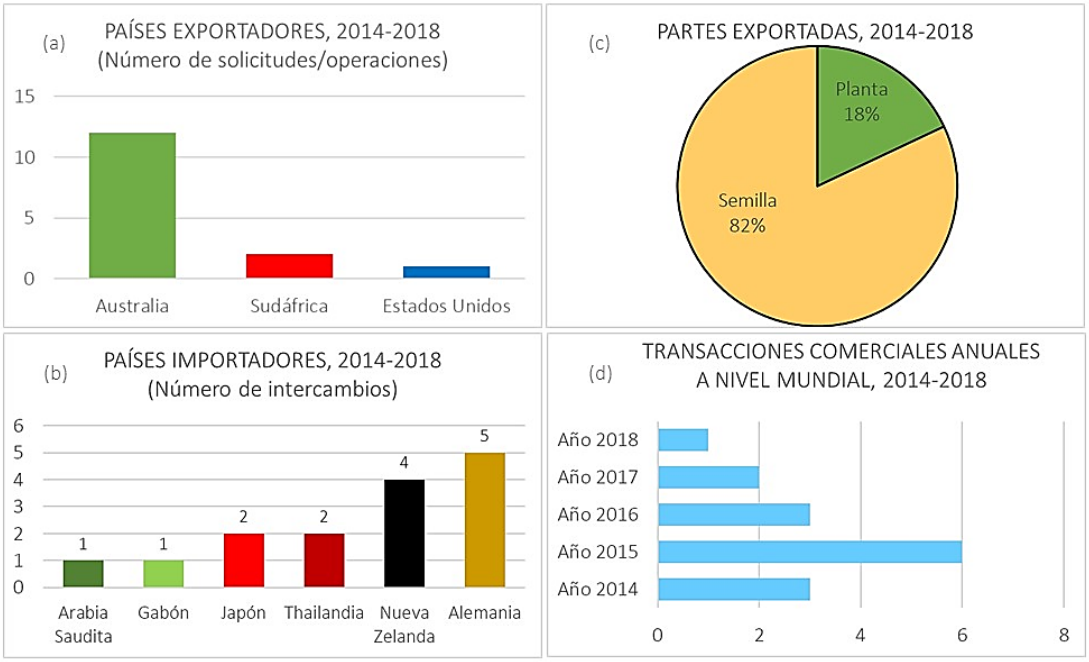

Figura 5. Cifras del comercio internacional de *C. hildae* entre 2014 y 2018. (a) Países exportadores, (b) Países importadores, (c) Partes exportadas y (d) Número de transacciones comerciales internacionales. Elaborado con datos de UNEP- WCMC CITES Trade Database.

Table 1. Número de plantas y derivados de *C. hildae* exportados de acuerdo con sus propósitos en la transacción. (T= Comercial, S= Científico, P= Personal) y código de origen (W= silvestre, A= plantas reproducidas artificialmente, D= plantas del Apéndice I reproducidas artificialmente).

Propósito	**Código de origen**		
	A	D	W
P			
S			16
T	549	1509	3
Total general	554	1509	19

Table 2. Número de plantas y derivados importados de *C. hildae* de acuerdo con sus propósitos en la transacción. (T= Comercial, S= Científico, P= Personal) y código de origen (W= silvestre, A= plantas reproducidas artificialmente, D= plantas del Apéndice I reproducidas artificialmente).

	Código de origen			
Propósito	A	D	W	No especifica
P	8	20		
S				
T	346	325		5420
Total general	356	345		5420

Lista de viveros con actividad comprobada o relacionada de comercialización de *C. hildae*.

CONTINENTE	PAÍS	NOMBRE DEL VIVERO
i. Viveros que ofrecen actualmente venta de *C. hildae*		
	América	
1	Estados Unidos	Indian Rock Cycads and Palms (California, EU).
2		Jungle Music, Palms & Cycads
3		Palm Cycad Exchange
4		The Cycad Jungle
	Europa	
5	Alemania	Exclusive Cycads
	Oceanía	
6	Australia	Palms for Brisbane
ii. Viveros que en el pasado han ofrecido venta de *C. hildae*, y/o que actualmente ofrecen especies de Zamiaceae		
	América	
7	Estados Unidos	Albert and Merkel Bros
8		Botanic Wonders
9		Jones Landscaping Nursery
10		Jurassic Garden A&A Cycads
11		Plant Creations
12		Plant Delights
13		Redland Nursery
14		San Marcos Growers
	Europa	
15	Alemania	EuroCycas
16		Rare Palm Seeds
17		Thrinax

18	Francia	A l'ombre des figuiers
19	Reino Unido	Minor Garden Plants
20		The Palm Centre
21		Treebrown Nurseries
	Oceanía	
22	Australia	Cycad Gardens of Eudlo
23		Cycad International
24		Plantation 2000
25		Tropical Coast Palms
iii. Sitios de interés dada la información que contienen sobre comercialización de *C. hildae* o Zamiaceae		
	América	
26	Estados Unidos	Agaveville, Xeric Plant Enthusiast Forum
27		Gardening in the Coastal Southeast.
28		The Evolution of Plants
	África	
30	República de Sudáfrica	CYCADfriends (Conservation through propagation)

Jardines Botánicos de México y el mundo en los que se pudo comprobar la presencia de *C. hildae*.

	i. México
1	Jardín Botánico Culiacán
2	Jardín Botánico Francisco Javier Clavijero. Instituto de Ecología, A. C.
3	Jardín Botánico de la Benemérita Universidad Autónoma de Puebla (BUAP)
4	Jardín Botánico Roger Orellana (CICY)
	ii. Estados Unidos
5	Edison and Ford Winter Estates Homes, Gardens, Museum and Laboratory.
6	Montgomery Botanical Center
7	San Diego Botanic Garden
8	University of Connecticut

	iii. Canadá
9	Jardin Botanique de Montréal, Espace pur la vie
	iv. Reino Unido
10	Royal Botanic Gardens, Kew
11	Paignton Zoo Environmental Park
12	Royal Botanic Garden Edinburgh
13	Glasgow City Council Botanic Gardens