

Distribution and conservation status of *Dioon vovidesii* (Zamiaceae), a cycad from Sonora, Mexico

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Supplementary Table 1. List of online databases and herbaria consulted.

Source (Location)	
Online database	
Global Biodiversity Information Facility	https://www.gbif.org/occurrence/search
Herbaria*	
ARIZ	University of Arizona Herbarium (United States of America)
ASDM	Arizona-Sonora Desert Museum (United States of America)
HNT	Huntington Botanical Gardens Herbarium (United States of America)
K	Royal Botanic Gardens, Kew (United Kingdom)
MEXU	Herbario Nacional de México (Mexico)
MICH	University of Michigan Herbarium (United States of America)
MO	Missouri Botanical Garden (United States of America)
UCR	University of California, Riverside Plant Herbarium (United States of America)
USON	Herbario de la Universidad de Sonora (Mexico)
XAL	Herbario del Instituto de Ecología, A.C. (Mexico)

*Abbreviations follow Theirs, B. M. (2025)

Supplementary Table 2. Layers of geographic information used to identify habitat features and assess the impact of human activity on populations of *Dioon vovidesii*.

Data set	Information	Citation
Soil	Soil type	INEGI (Instituto Nacional de Estadística y Geografía). 2007. Carta edafológica H1208e. Conjunto de Datos Vectorial Edafológico. Escala 1:250 000 Serie II Continuo Nacional Hermosillo. INEGI. 2007. Carta edafológica H1212e. Conjunto de Datos Vectorial Edafológico. Escala 1:250 000 Serie II Continuo Nacional Hermosillo.
Climate	Climate formula, Rainfall regime, Temperature range, Average annual precipitation, Average annual temperature	INEGI. 2020. Carta climatológica nacional. Climas 1902-2011
Altitude	Altitude	INEGI. 2013. Continuo de Elevaciones Mexicano. Resolución 15 m del estado de Sonora.
Land use and vegetation	Vegetation type	INEGI. 2018. Conjunto de datos vectoriales de uso de suelo y vegetación. Escala 1:250 000. Serie VII. Conjunto nacional.

Topography	Location of sites	INEGI. 2015. Conjunto de datos vectoriales de
	with human activity	información topográfica H12D43 Mazatán escala
	that could have an	1:50 000 serie III
	impact due to their	INEGI. 2015. Conjunto de datos vectoriales de
	proximity	información topográfica H12D44 San José del Batuc escala 1:50 000 serie III
		INEGI.2015. Conjunto de datos vectoriales de información topográfica H12D45 Santa Teresa escala 1:50 000 serie III
		INEGI.2017. Conjunto de datos vectoriales de información topográfica H12D54 Rebeico escala 1:50 000 serie III
		INEGI.2017. Conjunto de datos vectoriales de información topográfica H12D55 Bacanora escala 1:50 000 serie III

Supplementary Table 3. Lefkovitch matrix for *Dioon vovidesii* in the 2020-2021 period.

	Seedling	I	II	III	IV	V	VI
Seedling	0.3158	0.4967	0.2488	0.4268	2.7558	2.1248	1.0650
I	0.0526	0.7500					
II		0.0227	0.8571				
III			0.0286	0.8889			
IV				0.0370	0.8148		
V					0.1111	0.9091	
VI						0.0909	0.9333

Supplementary Material 1. Fertility calculation.

Fertility was estimated as the number of seedlings produced per individual during the 2020–2021 monitoring period. To approximate seed production, we estimated the potential number of seeds per female cone. Because cones of *Dioon* species do not produce seeds at their basal or apical ends (Mora et al., 2013), they were approximated as cylinders to estimate the effective reproductive area. The length and width of 17 female cones recorded in 2020 were measured to calculate their surface area. The average area of a megasporophyll (based on 10 field measurements) was then used to estimate how many megasporophyll units fit within the cone surface area. This value was multiplied by two, as each megasporophyll produces two seeds. Fertility was calculated as the product of: (1) estimated seed production per cone, (2) a germination rate of 100% (following Álvarez-Yépiz et al., 2011; Vovides, 1990), and (3) observed seedling survival during the monitoring period (Raimondo and Donaldson, 2003). Because reproductive structures were observed in all size classes except seedlings, fertility values were estimated separately for each size class according to the number of cones recorded. A total of 17 female cones were documented: two in size class I, one in classes II and III, six in class IV, five in class V, and two in class VI. The mean number of seeds per cone was 84 ± 34 (range: 36–179). Larger individuals produced more cones and larger cones. Effective recruitment was estimated as 0.005, calculated by dividing seven newly recorded seedlings by an estimated production of approximately 1,424 seeds. It is important to note that female *Dioon* individuals produce cones intermittently, typically every 2–4 years (Lázaro-Zermeño et al., 2011; Vovides, 1990). Therefore, the fertility estimate presented here applies only to the study period and should not be interpreted as an annualized long-term reproductive rate.

Supplementary Material 2. Score for *Dioon vovidesii* according to the method for assessing the risk of extinction of wild species in Mexico (Sánchez et al., 2007; SEMARNAT, 2010).

Criterion A. Features of geographic distribution

1-Extent of distribution = 3. Distribution area covers more than 1 km² but $\leq 1\%$ of the national territory.

2-Number of known existing populations or localities = 2. Between 4 and 8 known populations.

3-Number of biogeographic provinces = 3. 1, Province of Sonora (Morrone et al., 2017).

4-Representativeness of the taxon in Mexican territory = 0. Non-peripheral or extralimital distribution.

Sum of Criterion A: $8/11 = 0.7272$

Criterion B. Habitat features

1-In how many vegetation types does it occur? (sensu Rzedowski, 1978) = 1. The species occurs in 3 vegetation types.

2-Does the taxon have a specialized habitat? = 0. No information.

3-Is the permanence of the taxon dependent on a primary habitat? = 0. No information.

4-Does the permanence of the population require particular disturbance regimes or is it associated with transitional stages of succession? = 0. No

5-Altitudinal range occupied by the taxon = 0. The species is distributed between 376 and 1397 meters above sea level, with a range of 1021 meters (INEGI, 2013).

Criterion B score: $1/9 = 0.1111$

Criterion C. Intrinsic biological vulnerability

C-1. Demography

1) Total number of individuals = 2. Total number of individuals: 501–5,000

2) Recruitment = 2. Observations of seedlings in some populations.

3) Demographic attributes

a) Is there evidence of density dependence in reproduction? = 0. No information.

b) Is there clonality? = 0. Yes, there is clonality; we have observed the formation of ramets in the studied populations.

c) Is there evidence of population decline in the country? = 1. There is evidence of decline (Gutiérrez-Ortega et al. 2014, 2018b).

d) Is there evidence of very large variance in fertility? = 0. No information.

e) Is the taxon dioecious, are individuals dichogamous or self-incompatible? = 1. The taxon is dioecious.

f) Is flowering synchronous or gregarious? = 1. Synchronous reproduction.

g) Does the taxon produce few propagules (compared to other members of its lineage)? = 1. Production of few propagules in known populations.

Sum of Criterion C-1: 8

C-2. Genetics

1) Molecular variation (heterozygosity) = 0. High molecular variation ($> 10\%$). The average level of observed (HO) and expected (HE) heterozygosity in populations is 0.232 and 0.266 (Gutiérrez-Ortega et al., 2021).

2) Molecular genetic structure = 0. Low molecular genetic structure (= 17%) (Gutiérrez-Ortega et al., 2021).

3) Amount of genetic variation (estimated indirectly) = 0. High

4) Level of differentiation between populations (estimated indirectly) = 1. High. The level of differentiation between populations is 17% (Gutiérrez-Ortega et al., 2021).

Sum of Criterion C-2: 1

C-3. Specialized biotic interactions

1) Does the taxon require a nurse plant for its establishment? = 0. No information.

2) Does the taxon require a specific host or phorophyte? = 0. No

3) Does the taxon require a specific pollinator? = 1. Specific pollinators have been identified in the family Zamiaceae and in the genus *Dioon* (Vovides, 1991)

4) Does the taxon have a specific disperser? = 1. Yes. Both seed dispersal by gravity and the location of seeds in crevices that serve as habitat/refuge for mammals have been identified (Vovides, 1990).

5) Does the taxon exhibit obligate myrmecophily? = 0. No.

6) Does the taxon show strict dependence on mycorrhiza? = 0. No information.

7) Is the taxon significantly affected by predators, pathogens

(including very intense competition with alien or invasive species? = 0. No information.

Sum of criterion C-3: 2

Sum of criterion C: $11/23 = 0.4782$

Criterion D. Impact of human activity

1-How does anthropogenic habitat alteration affect the taxon? = 1. It is highly probable that the species is affected by anthropogenic habitat alteration, particularly because populations near human settlements have fewer individuals (López-Gallego, 2008).

2-What is the level of impact of human activities on the taxon's habitat? = 2. Observations of known populations indicate a strong impact on some or a moderate impact on all populations (Gutiérrez-Ortega et al., 2014; 2018b).

3-Is there evidence (measurements, models, predictions) indicating a deterioration in habitat quality or extent as a result of global changes (e.g., sensitivity to climate change) or is a drastic change in land use anticipated? = 0. No information.

4-What is the impact of use on the taxon? = 2. Strong impact on some or moderate impact on all populations for illegal collection for sale (Ice Blue Cycad Nursery:

<https://icebluecycads.com/shop/ols/products/dioon-vovidesii-new-cycad-species-sonorensis-bacanora-heat-and-cold-tolerant>)

5-Is it cultivated or propagated ex situ? = -1. Yes

Criterion D score: $4/10 = 0.40$

Risk category assignment for *Dioon vovidesii*

Sum of MER criteria

Criterion A: 0.7272

Criterion B: 0.1111

Criterion C: 0.4782

Criterion D: 0.40

Total score obtained: 1.7165

Category: Threatened (A)

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