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INTRODUCTION

Since the first edition of this handbook (available on the internet at the IUCN Cycad Specialist Group website) knowledge about cycads has grown substantially, but is widely dispersed in many publications and websites. This guide is created so that workers at botanical gardens and nurseries, as well as serious hobbyists can rapidly access vital facts needed to keep these plants in good health and to use them effectively in the landscape. In this guide's Decision Table you will find, at a glance, information to select proper soil, irrigation, shading and landscaping sites for cycads, whether in the ground or in a pot. Included are pest, flood and salt susceptibility or tolerance, as well as coning times for those species for which you wish to pollinate and produce seeds.

DIVERSITY OF CYCADS

There are ten living genera of cycads. Two of these genera, *Microcycas* and *Stangeria* (from Cuba and South Africa respectively), are represented each by a single species. Another two genera, *Bowenia* and *Lepidozamia* (both from Australia), possess only two species each. The majority of cycads belong in the genera *Ceratozamia*, *Dioon* and *Zamia* (the Americas), *Encephalartos* (Africa), *Macrozamia* (Australia) and *Cycas* (Southeast Asia to Australia, with one species reaching Africa). The horticultural and ornamental characteristics of these species can be found in the Decision Table described in the next section.

CLOCKWISE FROM FAR LEFT

All extant genera: *Cycas, Encephalartos, Zamia, Microcycas, Stangeria, Bowenia, Dioon, Lepidozamia, Ceratozamia*, and *Macrozamia.*

DECISION TABLE

This table, gathered from many published and unpublished sources, is arranged in 19 columns that are elaborated on beginning on page 24.

Species	Climate trop/temp	Light sun/shade	Moisture dry/wet	Stem height >.5>2m<	Stem character	Leaf length >1>2m<	Leaflet width >1>4cm<
Bowenia serrulata	● ●	○ ○	●	○	tuber	○	●
B. spectabilis	● ●	○ ○	●	○	tuber	○	●
Ceratozamia alvarezii	● ●	○ ○	●	○		○ ○	●
Cz. becerrae	● ●	○ ○	●	○	cliff	○	●
Cz. brevifrons	● ●	○ ○	●	○		○	●
Cz. chamberlainii	● ●	○ ○	●	○ ○		○	●
Cz. chimalapensis	● ●	○ ○	●	○ ○		○ ○	●
Cz. decumbens	● ●	○ ○	●	○	cliff	○ ○	●
Cz. delucana	● ●	○ ○	●	○		○	●
Cz. euryphyllidia	● ●	○	●	○		○ ○	●
Cz. fuscoviridis	● ●	○ ○ ○	●	○		○ ○	●
Cz. hildae	● ●	○ ○	●	○		○	●
Cz. hondurensis	● ●	○	●	○		○ ○	●
Cz. haustecorum	● ●	○ ○	●	○		○	● ●
Cz. kuesteriana	● ●	○ ○ ○	●	○		○	● ●
Cz. latifolia	● ● ●	○ ○	●	○		○ ○	● ●
Cz. matudae	● ●	○ ○	●	○		○ ○	● ●
Cz. mexicana	● ● ●	○ ○	●	○		○ ○	●
Cz. microstrobila	● ●	○ ○	●	○		○	●
Cz. miqueliana	● ●	○	●	○		○	●
Cz. mirandae	● ●	○ ○	●	○		○	●
Cz. mixeorum	● ●	○ ○	●	○		○	●
Cz. morettii	● ●	○ ○	●	○		○	● ●
Cz. norstogi	● ●	○ ○	●	○		○	●
Cz. robusta	● ●	○ ○	●	○ ○		○ ○	●
Cz. sabatoi	● ●	○ ○	●	○		○	● ●
Cz. santillanii	● ●	○ ○	●	○	cliff	○ ○ ○	● ●
Cz. subroseophylla	● ●	○ ○ ○	●	○ ○		○ ○	● ●
Cz. tenuis	● ● ●	○ ○	●	○		○	●
Cz. totonacorum	● ●	○ ○	●	○		○ ○	● ●
Cz. vovidesii	● ●	○ ○	●	○ ○		○	● ●
Cz. whitelockiana	● ●	○	●	○		○	●
Cz. zaragosae	● ●	○ ○	●	○		○	●

Species	Leaflet character	Spines no./pet./lft	Cone character	Pollen	Propaga-tion C=cutting	Freeze tolerance no/yes	Flood tolerance no/yes	Salt tolerance no/yes	Trans-planting hard/easy	CAS resistance no/yes	Pests, remarks
Bowenia serrulata	bipinnate	●		May-Jun	C, S	●	○		○ ○ ○	●	
B. spectabilis	bipinnate	●		Apr-Jun	C,S	●	○		○ ○ ○	●	
Ceratozamia alvarezii		●		Mar	Seed	●		●	○	●	
Cz. becerrae		●		Jun	Seed	●		●	○	●	Lvs Pendent
Cz. brevifrons	keel	●		Apr-Jun	Seed	●	○	●	○	●	
Cz. chamberlainii		●			Seed	●					
Cz. chimalapensis		●		Jun-Jul	Seed	●	○	●	○	●	
Cz. decumbens		●		Feb-May	Seed	●		●	○	●	
Cz. delucana		●			Seed	●		●	○	●	
Cz. euryphyllidia		●		May	Seed	●		●	○	●	
Cz. fuscoviridis		●		Apr-Jun	Seed	●		●	○	●	
Cz. hildae	bunched	●		Mar-Jun	Seed	●	○	●	○	●	[1]
Cz. hondurensis		●			Seed	●		●	○	●	
Cz. haustecorum		●			Seed	●		●	○	●	
Cz. kuesteriana		●		Mar-Jun	Seed	●		●	○	●	
Cz. latifolia		●		Jun	Seed	●	○	●	○	●	
Cz. matudae		●		Mar	Seed	●		●	○	●	
Cz. mexicana		●		Feb-Apr	Seed	●		●	○	●	
Cz. microstrobila		●		Mar-Jun	Seed	●	○	●	○	●	
Cz. miqueliana		●		May-Jun	Seed	●	○		○	●	
Cz. mirandae		●		May-Jun	Seed	●	○	●	○	●	
Cz. mixeorum		●		Apr-May	Seed	●		●	○	●	
Cz. morettii		●		Feb-Apr	Seed	●		●	○	●	Lvs Pendent
Cz. norstogi	spiral	●		Jan-Jun	Seed	●		●	○	●	
Cz. robusta		●		Mar-Jun	Seed	●	○	●	○	●	[2]
Cz. sabatoi		●			Seed	●	○	●	○	●	
Cz. santillanii		● ●			Seed	●		●	○	●	
Cz. subroseophylla		●		Jun	Seed	●		●	○	●	
Cz. tenuis		●		Feb-Mar	Seed	●		●	○	●	
Cz. totonacorum		●			Seed	●				●	
Cz. vovidesii		●		Apr-May	Seed	●		●	○	●	
Cz. whitelockiana		●			Seed	●		●	○	●	
Cz. zaragosae	spiral	●			Seed	●		●	○	●	

[1] Cones moderately susceptible to CAS
[2] Cones of Belize form susceptible to CAS

Species	Climate	Light	Moisture	Stem height	Stem character	Leaf length	Leaflet width
	trop/temp	sun/shade	dry/wet	>.5>2m<		>1>2m<	>1>4cm<
Cz. zoquorum	● ●	○ ○	●	○	cliff	○ ○ ○	● ●
Cycas aculeata	● ●	○ ○	●	○	subterra	○ ○	●
C. aenigma	●	○	●	○		○	●
C. angulata	● ●	○	●	○ ○ ○	spiny	○	●
C. annaikalensis	● ●	○	●	○ ○ ○		○ ○	● ●
C. apoa	● ●	○	●	○ ○ ○		○ ○	●
C. arenicola	● ●	○	●	○ ○ ○		○	●
C. armstrongii	● ●	○	●	○ ○ ○	spiny	○	●
C. arnhemica	● ●	○	●	○ ○ ○	hairy	○	●
C. badensis	● ●	○	●	○ ○ ○		○	●
C. balansae	● ●	○ ○ ○	●	○	tuber	○ ○	●
C. basaltica	● ●	○	●	○ ○ ○		○ ○	●
C. beddomei	● ●	○	●	○ ○		○	●
C. bifida	● ●	○ ○	● ●	○	subterra	○	●
C. bougainvilleana	● ●	○ ○	●	○ ○ ○		○ ○	●
C. brachycantha	● ●	○ ○	●	○		○ ○	●
C. brunnea	● ●	○	●	○ ○ ○	spiny	○	●
C. cairnsiana	● ●	○	●	○ ○ ○		○	●
C. calcicola	● ●	○	●	○ ○ ○		○ ○	●
C. campestris	● ●	○	●	○ ○ ○		○	●
C. canalis	● ●	○	●	○ ○ ○	spiny	○	●
C. candida	● ●	○	●	○ ○ ○		○ ○	●
C. cantafolia	● ●	○	●	○ ○ ○	fissured	○	●
C. chamaoensis	● ●	○	●	○ ○ ○		○ ○	● ●
C. changjianensis	● ●	○	●	○		○ ○	●
C. cheni	● ● ●	○ ○	●	○		○ ○	● ●
C. chevalieri	● ●	○ ○	●	○		○ ○	●
C. circinalis	● ●	○	●	○ ○ ○		○ ○	● ●
C. clivicola	● ●	○	●	○ ○ ○	smooth	○	●
C. collina	● ●	○ ○	●	○		○ ○	●
C. condaoensis	● ●	○	●	○ ○	swollen	○	●
C. conferta	● ●	○ ○	●	○ ○ ○	spiny	○	●
C. couttsiana	● ●	○	●	○ ○ ○	spiny	○	●
C. cupida	● ●	○	●	○ ○ ○		○	●
C. curranii	● ●	○ ○	●	○ ○ ○		○ ○	●
C. debaoensis	● ● ●	○ ○	● ●	○	subterra	○ ○	●

Leaflet character	Spines	Cone character	Pollen	Propagation	Freeze tolerance	Flood tolerance	Salt tolerance	Transplanting	CAS resistance	Pests, remarks
	no./pet./lft			C=cutting	no/yes	no/yes	no/yes	hard/easy	no/yes	
	●		Apr	Seed	●		●	○	●	
wavy	●			Seed			●	○	●	
	●			Seed	●	○		○	●	
keel	●			C, S	●			○	●	[3]
	●			Seed				○	●	
	●			Seed	●	○		○	●	
hairy	●			Seed				○	●	[3]
	●			C, S	●			○	●	[3]
	●			Cutting				○	●	[3]
	●			Cutting				○	●	[3]
	●			Seed				○		
flat	●			Seed				○	●	[3]
	●			Seed	●			○	●	
forked	●			Seed	●			○	●	
	●			Seed	●		●	○	●	
wavy	●			Seed				○	●	
keel	●			C, S				○	●	[3]
keel, hair	●			Seed	●			○	●	[3]
hairy	●			Seed				○	●	[3]
	●			Cutting	●			○	●	
	●			Cutting				○	●	[3]
keel	●			Cutting					●	[3]
	●			Cutting				○		
	●			Seed			●	○	●	
	●			Seed			●	○	●	
	●			Seed	●			○		
	●			Seed		○		○		
	●			Seed				○	●	
	●		Feb	Seed		○	●	○	●	
wavy	●		Apr-May	Seed				○		
	●			Seed			●	○		
close, tidy	●			C, S	●	○	●	○	●	[3]
keel, hair	●			Seed	●			○	●	[3]
keel	●			Seed				○	●	[3]
	●			Seed	●		●	○		
	●		May	Seed	●			○	●	

[3] Seedlings need deep pots

Species	Climate trop/temp	Light sun/shade	Moisture dry/wet	Stem height >.5>2m<	Stem character	Leaf length >1>2m<	Leaflet width >1>4cm<
C. desolata	● ●	○	●	○ ○ ○	spiny	○ ○	●
C. diannanensis	● ● ●	○ ○	●	○ ○		○ ○	●
C. dolichophylla	● ●	○ ○	●	○ ○		○	●
C. edentata	● ●	○	●	○ ○ ○		○ ○	●
C. elephantipes	● ●	○	●	○ ○ ○		○	●
C. elongata	● ●	○	●	○ ○ ○	smooth	○	●
C. fairylakea	● ● ●	○ ○	●	○ ○		○ ○	● ●
C. falcata	● ●	○ ○	●	○ ○ ○		○ ○	● ● ●
C. ferruginea	● ●	○	●	○ ○ ○	swollen	○	● ●
C. fugax	● ●	○ ○	●	○		○	●
C. furfuracea	● ●	○	●	○ ○ ○		○ ○	●
C. glauca	● ●	○ ○	●	○ ○ ○		○ ○	●
C. guizhouensis	● ● ●	○	●	○		○ ○	● ●
C. hainanensis	● ●	○ ○	●	○ ○ ○		○ ○	● ●
C. hoabinhensis	● ●	○ ○	●	○	cliff	○ ○	●
C. hongheensis	● ● ●	○	●	○ ○ ○	swollen	○	●
C. indica	● ●	○	●	○ ○ ○	branched	○ ○	●
C. inermis	● ●	○ ○	●	○ ○ ○		○	●
C. javana	● ●	○ ○	●	○ ○ ○		○	●
C. lacrimans	● ●	○ ○	●	○ ○		○	● ●
C. lane-poolei	● ●	○	●	○ ○ ○	spiny	○	●
C. laotica	● ●	○	●	○ ○ ○	swollen	○ ○	●
C. lindstromii	● ●	○	●	○	swollen	○	●
C. maconochiei	● ●	○	●	○ ○ ○		○ ○	●
C. macrocarpa	● ●	○	● ●	○ ○ ○		○	●
C. media	● ●	○ ○	●	○ ○ ○	spiny	○	●
C. megacarpa	● ●	○	●	○ ○ ○	spiny	○	●
C. micholitzii	● ●	○ ○	● ●	○	tuber	○ ○	●
C. micronesica	● ●	○	●	○ ○ ○		○	●
C. montana	● ●	○ ○	●	○ ○		○	●
C. multifrondis	● ●	○ ○	●	○	tuber	○	●
C. multipinnata	● ●	○ ○	● ●	○	tuber	○	●
C. nathorstii	● ●	○ ○	●	○ ○ ○		○	●
C. nayagarhensis	● ●	○ ○	●	○ ○ ○	ribbed	○	●
C. nitida	● ●	○	●	○ ○ ○		○	●
C. nongnoochiae	● ●	○	●	○ ○ ○	swollen	○	●

Leaflet character	Spines no./pet./lft	Cone character	Pollen	Propagation C=cutting	Freeze tolerance no/yes	Flood tolerance no/yes	Salt tolerance no/yes	Transplanting hard/easy	CAS resistance no/yes	Pests, remarks
keel	●			Seed				○	●	[3]
	●		May	Seed	●	○		○	●	[4]
wavy	●		May	Seed		○		○		
	●		Feb-Jun	Seed	●	○	●	○	●	
	●		Feb	Seed				○	●	
keel	●		Aug	Seed			●	○	●	
	●			Seed			●	○	●	
	●			Seed	●	○	●	○		
hairy	●			Seed	●			○		
wavy	●			Seed			●	○		
keel	●			C, S	●			○	●	
	●			Seed	●			○	●	
	●		Apr-May	Seed	●	○	○	○	●	
	●		Apr-May	Seed	●	○	●	○	●	
wavy	●		Apr	Seed			●	○		
keel	●			Seed	●		●	○	●	
	●			Seed				○	●	
wavy	●			Seed			●	○		
	●			Seed	●	○	●	○	●	
	●			Seed	●	○	●	○		
	●			Seed				○	●	[3]
	● ●			Seed			●	○		
keel	●			Seed			●	○		
hairy	●			Seed				○	●	[3]
	●		Feb	Seed		○ ○	●	○	●	
	●		Jun-Jul	Seed	●			○	●	[3]
keel	●			Seed	●			○	●	[3]
forked	●			Seed	●	○		○	● ● ●	[5]
	●		May-Jun	Seed	●		●	○	●	
	●			Seed				○		
forked	●			Seed	●			○	●	
forked	●		Apr	Seed	●			○	●	
	●			Seed				○	●	
	●			Seed				○	●	
	●		Mar-Apr	Seed	●	○	○	○	●	
	●		Feb	Seed				○	●	

[3] Seedlings need deep pots
[4] Likes limestone
[5] K'Bang variety—CAS resistant

Species	Climate trop/temp	Light sun/shade	Moisture dry/wet	Stem height >.5>2m<	Stem character	Leaf length >1>2m<	Leaflet width >1>4cm<
C. ophiolitica	● ●	○	●	○ ○ ○		○	●
C. orientis	● ●	○	●	○ ○ ○	spiny	○ ○	●
C. orixensis	● ●	○ ○	●	○ ○ ○	smooth	○ ○	● ●
C. pachypoda	● ●	○	●	○ ○	swollen	○ ○	●
C. panzhihuaensis	● ● ●	○	●	○ ○ ○		○ ○	●
C. papuana	● ●	○	●	○ ○ ○		○	●
C. pectinata	● ●	○	●	○ ○ ○	branched	○ ○	● ●
C. petraea	● ●	○	●	○ ○ ○	smooth	○ ○	●
C. platyphylla	● ●	○ ○	●	○ ○		○ ○	●
C. pranburiensis	● ●	○	●	○ ○	swollen	○ ○	● ●
C. pruinosa	● ●	○	●	○ ○		○	●
C. revoluta	● ● ●	○ ○	●	○ ○ ○		○ ○	●
C. riuminiana	● ●	○ ○	●	○ ○ ○		○	● ●
C. rumphii	● ●	○ ○	●	○ ○ ○		○ ○	●
C. sainathii	● ●	○	●	○ ○ ○		○	●
C. sancti-lasallei	● ●	○ ○	●	○ ○ ○		○	●
C. saxatilis	● ●	○	●	○ ○ ○		○	●
C. schumanniana	● ●	○	●	○ ○ ○		○	●
C. scratchleyana	● ●	○	●	○ ○ ○		○ ○	●
C. seemanii	● ●	○	●	○ ○ ○		○ ○	● ●
C. segmentifida	● ● ●	○ ○	●	○		○ ○	●
C. semota	● ●	○	●	○ ○ ○		○	●
C. sexseminifera	● ●	○ ○	●	○	swollen	○ ○	●
C. siamensis	● ●	○ ○	●	○ ○	swollen	○ ○	●
C. silvestris	● ●	○ ○	●	○ ○ ○	spiny	○	●
C. simplicipinna	● ●	○ ○	● ●	○	tuber	○ ○	●
C. sphaerica	● ●	○ ○	●	○ ○ ○	branched	○	● ●
C. sundaica	● ●	○ ○	●	○ ○ ○		○ ○	●
C. szechuanensis	● ● ●	○	●	○ ○ ○		○ ○	●
C. taitungensis	● ● ●	○	●	○ ○ ○		○ ○	●
C. taiwaniana	● ● ●	○	●	○ ○		○ ○	● ●
C. tanqingii	● ●	○ ○	●	○ ○		○	●
C. tansachana	● ●	○	●	○ ○ ○	fissured	○ ○	● ●
C. terryana	● ●	○	●	○ ○ ○		○ ○	●
C. thouarsii	● ●	○	●	○ ○ ○		○ ○	● ●
C. tropophylla	● ●	○	●	○	swollen	○	● ●

Leaflet character	Spines no./pet./lft	Cone character	Pollen	Propaga-tion C=cutting	Freeze tolerance no/yes	Flood tolerance no/yes	Salt tolerance no/yes	Trans-planting hard/easy	CAS resistance no/yes	Pests, remarks
keel	●			C, S	●			○	●	[3]
	●			Seed				○	●	[3]
	●	branched	Apr	Seed				○	●	
	●		Feb, Aug	Seed			●	○	●	
	●	anise	May	Seed	●	○		○	●	
	●			C, S	●	○		○	●	
	●		Feb-Mar	Seed	●	○		○	● ● ●	[6]
	●		Feb	Seed	●			○	●	
keel	●			Seed	●			○	●	[3]
	●		Apr	Seed			●	○	●	
keel	●			Seed		○		○	●	[3]
	●		May	C, S	●	○	●	○	●	
	●			Seed	●	○		○	●	
	●		May-Jun	C, S	●	○	●	○	●	
	●			Seed			●	○		
wavy	●		Aug	Seed			●	○		
	●			Seed	●		●	○		
	●		Jun	Seed	●			○	●	
	●			Seed	●	○	●	○	●	
	●			Seed			●	○	●	
wavy	●			Seed	●			○	●	
	●			Seed				○	●	[3]
	●			Seed	●	○		○	●	
hairy	●		Feb	Seed	●			○	●	
	●			Seed	●	○	●	○	●	[3]
wavy	●		Apr-May	Seed	●			○	●	
	●		Apr	Seed				○		
	●			Seed	●	○	●	○		
	●			C, S	●			○	●	
	●			C, S	●		●	○	●	
	●			C, S	●			○	●	
wavy	●		Mar	Seed		○		○	●	
	●		Feb-Apr	Seed				○	●	
keel	●			Seed				○	●	[3]
	●			Seed	●	○	●	○	●	
keel	●			Seed			●	○	●	

[3] Seedlings need deep pots
[6] China form suspetible

Species	Climate trop/temp	Light sun/shade	Moisture dry/wet	Stem height >.5>2m<	Stem character	Leaf length >1>2m<	Leaflet width >1>4cm<	Leaflet character	Spines no./pet./lft	Cone character	Pollen	Propagation C=cutting	Freeze tolerance no/yes	Flood tolerance no/yes	Salt tolerance no/yes	Transplanting hard/easy	CAS resistance no/yes	Pests, remarks
C. tuckeri	● ●	○	●	○ ○ ○		○	●	keel	●			Seed				○	●	[3]
C. vespertillo	● ●	○ ○	●	○ ○ ○		○	● ●		●		Jan-Feb	Seed	●	○	●	○		
C. wadei	● ●	○	●	○ ○ ○		○	●		●		Apr-May	Seed	●		●	○	●	
C. xipholepis	● ●	○	●	○ ○	spiny	○ ○	●		●			Seed				○	●	[3]
C. yorkiana	● ●	○	●	○ ○ ○		○	●		●			Seed				○	●	[3]
C. zambalensis	● ●	○	●	○ ○ ○		○	●		●			Seed	●	○	●	○		
C. zeylanica	● ●	○	●	○ ○ ○		○ ○	●		●			Seed			●	○	●	
Dioon angustifolium	● ● ●	○	●	○		○	●		●	felt	Aug-Oct	Seed	●	○ ○		○	●	
D. argenteum	● ● ●	○	●	○		○	●		●	felt	Sep-Oct	Seed	●	○		○	●	
D. califanoi	● ● ●	○	●	○		○	●		●	felt	Sep-Oct	Seed	●			○	●	
D. caputoi	● ● ●	○	●	○		○	●		●	felt	Sep-Oct	Seed	●			○	●	
D. edule	● ● ●	○	●	○		○	●		●	felt	Aug-Nov	C, S	● ●	○	●	○	●	
D. holmgrenii	● ● ●	○	●	○ ○		○	●		●	felt	Nov-Dec	Seed	●	○		○	●	
D. mejiae	● ●	○	● ●	○ ○ ○		○	●		●	felt	Aug-Oct	C, S	●	○		○	●	
D. merolae	● ● ●	○	●	○		○	●	imbricate	●	felt	Nov-Feb	Seed	●	○		○	●	
D. planifolium	● ● ●	○	●	○		○	●		●	felt	Sep-Oct	C, S	●			○	●	
D. purpusii	● ● ●	○	●	○		○	●		●	felt	Oct-Nov	Seed	●			○	●	
D. rzedowskii	● ●	○ ○	● ●	○ ○ ○		○	●		●	felt,	Oct	Seed	●	○		○	●	♀ pendent
D. sonorense	● ● ●	○	●	○		○	●		●	felt		Seed	●			○	●	
D. spinulosum	● ●	○ ○	● ●	○ ○ ○		○	●		●	felt	Jul-Aug	Seed	●	○		○	●	♀ pendent
D. stevensonii	● ● ●	○	●	○		○	●		●	felt	May	Seed	●			○	●	
D. tomasellii	● ● ●	○	●	○		○	●		●	felt	Jul	Seed	●			○	●	
Encephalartos aemulans	● ● ●	○ ○	●	○ ○ ○		○	●		● ●	felt	Sep-Nov	C, S	●			○	●	
E. altensteinii	● ● ●	○ ○	●	○ ○ ○		○	●		●		Sep-Nov	C, S	●		●	○	●	Tranes borer
E. aplanatus	● ● ●	○ ○	●	○		○	●		● ●		Sep-Nov	Seed	●			○	●	Tranes borer
E. arenarius	● ● ●	○ ○	●	○ ○		○	●	lobed	●		Sep-Nov	C, S	● ●	○	●	○	●	Tranes borer[7]
E. barteri subsp. barteri	● ●	○	●	○		○	●		● ●		Feb-Apr	Seed	●			○	●	Tranes borer
E. barteri subsp. allochrous	● ●	○	●	○ ○ ○		○	●		● ●			Seed				○	●	Tranes borer
E. brevifoliolatus	● ●	○	●	○ ○ ○		○ ○	●		●	felt	Spr-E.Sum		●			○	●	Tranes borer
E. bubalinus	● ●	○	●	○ ○		○	●		● ●		Jun	C, S	●	○		○	●	Tranes borer
E. caffer	● ● ●	○	●	○	tuber	○	●		● ●		Jul-Aug	S	● ●		●	○	●	Tranes borer[8]
E. cerinus	● ● ●	○ ○	●	○		○ ○	●		● ●		Jul-Aug	C, S	●	○	●	○	●	Tranes borer
E. chimanimaniensis	● ●	○	●	○ ○		○	●		● ●			Seed	●			○	●	Tranes borer
E. concinnus	● ●	○ ○	●	○ ○		○	●		● ●			C, S	●			○	●	Tranes borer
E. cupidus	● ● ●	○	●	○		○	●		● ●		Jul-Sep	C, S	●			○	●	Tranes borer
E. cycadifolius	●	○	●	○ ○		○	●		●	felt	Feb-Jun	C, S	●			○	●	Tranes borer

[3] Seedlings need deep pots
[7] Avoid limestone
[8] Collectotrichum

Species	Climate trop/temp	Light sun/shade	Moisture dry/wet	Stem height >.5>2m<	Stem character	Leaf length >1>2m<	Leaflet width >1>4cm<
E. delucanus	● ●	●	●	●		●	●
E. dolomiticus	● ● ●	●	●	● ●		●	●
E. dyerianus	● ● ●	●	●	● ● ●		●	●
E. equatorialis	● ●	●	●	● ● ●		●	●
E. eugene-maraisii	● ● ●	●	●	● ●		● ●	●
E. ferox	● ●	● ●	●	●		●	● ●
E. friderici-guilielmi	●	●	●	● ●		●	●
E. ghellinckii	● ●	●	●	● ●		●	●
E. gratus	● ●	●	●	● ● ●		● ●	●
E. heenanii	● ●	●	●	● ●		●	●
E. hildebrandtii	● ●	●	●	● ● ●		● ●	●
E. hirsutus	● ●	●	●	● ● ●		●	●
E. horridus	● ● ●	●	●	●		●	●
E. humilis	●	●	●	●		●	●
E. inopinus	● ● ●	● ●	●	● ●		● ●	● ●
E. ituriensis	● ●	● ●	●	● ● ●		●	●
E. kisambo	● ●	● ●	●	● ● ●		●	●
E. laevifolius	●	● ●	●	● ●		●	●
E. lanatus	●	●	●	● ●		●	●
E. latifrons	● ● ●	● ●	●	● ●		● ●	● ●
E. laurentianus	● ●	● ●	●	● ● ●		●	●
E. lebomboensis	● ● ●	● ●	●	● ● ●		●	●
E. lehmannii	● ● ●	●	●	● ●		●	●
E. longifolius	● ● ●	● ●	●	● ● ●		●	●
E. mackenziei	● ●	● ●	●	● ●		●	●
E. macrostrobilus	● ●	●	●	● ●		●	●
E. manikensis	● ●	●	●	● ●		●	●
E. marunguensis	● ●	●	●	●		● ●	●
E. middelburgensis	● ●	●	●	● ● ●		●	●
E. msinganus	● ● ●	● ●	●	● ● ●		●	●
E. munchii	● ●	●	●	● ●		●	●
E. natalensis	● ● ●	● ●	●	● ● ●		● ●	● ●
E. ngoyanus	●	● ●	●	●		●	● ●
E. nubimontanus	● ● ●	●	●	● ●		●	●
E. paucidentatus	● ●	● ●	●	● ● ●		● ●	●
E. poggei	● ●	●	●	● ●		●	●

Leaflet character	Spines no./pet./lft	Cone character	Pollen	Propagation C=cutting	Freeze tolerance no/yes	Flood tolerance no/yes	Salt tolerance no/yes	Trans-planting hard/easy	CAS resistance no/yes	Pests, remarks
	●			Seed	●			●	●	Tranes borer
	●		Jul-Aug	C, S	● ●		●	●	●	Tranes borer
	● ●		Aug-Oct	C, S	●		●	●	●	Tranes borer[8]
	● ●			C, S	●			●	●	Tranes borer
imbricate	●	felt	Aug-Sep	C, S	●		●	●	●	Tranes borer
lobed	● ●		Sep-Dec	C, S	●	●	●	●	●	Tranes borer
	●	felt	Feb-May	C, S	●			●	●	Tranes borer
	●	felt	May	C, S	●			●	●	Tranes borer
	● ●		Jul-Oct	C, S	●	●	●	●	●	Tranes borer
	●	felt	Dec-Feb	C, S	● ●			●	●	Tranes borer
	● ●		May-Oct	C, S	●	●	●	●	●	Tranes borer
imbricate	●		May-Jul	C, S	●		●	●	●	Tranes borer
lobed	●		Aug-Nov	C, S	●	●	●	●	●	Tranes borer[8]
	●	felt	Feb-May	C, S	● ●			●	●	Tranes borer
	●	felt	Jul-Sep	C, S	●			●	●	Tranes borer[9]
	● ●	stalk		C, S	●			●	●	Tranes borer
	● ●			C, S	●			●	●	Tranes borer
	●	felt	Mar-May	C, S	●			●	●	Tranes borer
	●	wool	Apr-Jun	S	●			●	●	Tranes borer
lobed	●		Nov-Feb	C, S	●			●	●	Tranes borer
	● ●	stalk		C, S	●	●		●	●	Tranes borer
	● ●		Sep-Nov	C, S	●	●		● ●	●	Tranes borer
	●	felt	Sep-Nov	C, S	●			●	●	Tranes borer
	●		Nov-Jan	C, S	● ●		●	●	●	Tranes borer[8]
	● ●			C, S	●			●	●	Tranes borer
	●			Seed	●			●	●	Tranes borer
	● ●		Jun-Sep	C, S	●			●	●	Tranes borer
	● ●			C, S	●			●	●	Tranes borer
	●		Sep-Nov	C, S	●			●	●	Tranes borer
	● ●		Sep-Oct	C, S	●			●	●	Tranes borer[10]
	● ●			C, S	●		●	●	●	Tranes borer
	●		Oct-Dec	C, S	● ●		● ●	●	●	Tranes borer[11]
	●		Jun-Jul	S	●			●	●	Tranes borer
	●		Jul-Oct	C, S	● ● ●			●	●	Tranes borer
	●		Jan-Feb	C, S	●			●	●	Tranes borer
	● ●			C, S	●			●	●	Tranes borer

[8] Collectotrichum
[9] Likes limestone
[10] Fern cone w/brown felt
[11] Fern cone w/felt

Species	Climate trop/temp	Light sun/shade	Moisture dry/wet	Stem height >.5>2m<	Stem character	Leaf length >1>2m<	Leaflet width >1>4cm<
E. princeps	● ●	○	●	○ ○ ○		○	●
E. pterogonus	● ●	○	●	○ ○		○	●
E. relictus	● ●	○ ○	●	○ ○ ○		○	●
E. schaijesii	● ●	○	●	○		○	●
E. schmitzii	● ●	○	●	○		○	● ●
E. sclavoi	● ●	○	●	○ ○		○	●
E. senticosus	● ● ●	○ ○	●	○ ○ ○		○	●
E. septentrionalis	● ●	○ ○	●	○ ○ ○		○	●
E. tegulaneus subsp. powysii	● ●	○	●	○ ○ ○		○	●
E. tegulaneus subsp. tegulaneus	● ●	○ ○	●	○ ○ ○		○	●
E. transvenosus	● ●	○ ○	●	○ ○ ○		○ ○	●
E. trispinosus	● ● ●	○	●	○ ○		○ ○	●
E. turneri	● ●	○	●	○ ○ ○		○	●
E. umbeluziensis	● ●	○ ○	●	○		○ ○	● ● ●
E. villosus	● ● ●	○ ○	●	○		○ ○	●
E. whitelockii	● ●	○ ○	●	○ ○ ○		○	●
E. woodii	● ● ●	○ ○	●	○ ○		○ ○	●
Lepidozamia hopei	● ●	○ ○	● ●	○ ○ ○		○	●
L. peroffskyana	● ●	○ ○	● ●	○ ○ ○		○ ○	● ● ●
Macrozamia cardiacensis	● ●	○ ○	●	○		○ ○	● ●
M. communis	● ●	○ ○	●	○		○ ○	● ●
M. concinna	● ●	○ ○	●	○	subterra	○	●
M. conferta	● ●	○ ○	●	○	subterra	○	●
M. cranei	● ●	○ ○	●	○	subterra	○	●
M. crassifolia	● ●	○ ○	●	○	subterra	○	●
M. diplomera	● ●	○ ○	●	○	subterra	○ ○	●
M. douglasii	● ●	○ ○	●	○		○ ○	● ●
M. dyeri	● ●	○ ○	●	○ ○ ○		○ ○	●
M. elegans	● ●	○ ○	●	○	subterra	○	● ●
M. fawcettii	● ●	○ ○	●	○		○	● ●
M. fearnsidei	● ●	○ ○	●	○	subterra	○	●
M. flexuosa	● ●	○ ○	●	○	subterra	○	●
M. fraseri	● ●	○ ○	●	○ ○ ○		○ ○	● ● ●
M. glaucophylla	● ●	○ ○	●	○	subterra	○	●
M. heteromera	● ●	○ ○	●	○	subterra	○	●
M. humilis	● ●	○ ○	●	○	subterra	○	●

Leaflet character	Spines no./pet./lft	Cone character	Pollen	Propaga-tion C=cutting	Freeze tolerance no/yes	Flood tolerance no/yes	Salt tolerance no/yes	Trans-planting hard/easy	CAS resistance no/yes	Pests, remarks
	●		Oct-Dec	C, S	● ●			○	●	Tranes borer
	● ●			C, S	●			○	●	Tranes borer
	●			Cutting	●				●	Tranes borer
	● ●			Seed	●			○	●	Tranes borer
	● ●			C, S	●			○	●	Tranes borer
	● ●			C, S	●		●	○	●	Tranes borer
	● ●		Oct-Nov	C, S	● ●			○	●	Tranes borer
	● ●			C, S	●		●	○	●	Tranes borer
	● ●			C, S	●		●	○	●	Tranes borer
	● ●	stalk		C, S	●		●	○	●	Tranes borer
imbricate	●		Dec-Mar	C, S	● ●	○		○	●	Tranes borer
lobed	●		Sep-Nov	C, S	● ●			○	●	Tranes borer
	● ●			C, S	●			○	●	Tranes borer[12]
	●		Nov-Mar	Seed	●			○	●	Tranes borer
	● ●		Sep-Nov	C, S	●	○ ○		○	●	Tranes borer
	● ●	stalk	Sep-Jan	C, S	●			○	●	Tranes borer
	●		Nov-Feb	Cutting	●			○	●	Tranes borer
	●			Seed	●	○ ○	●	○	●	
	●		Mar-May	Seed	●	○ ○	●	○	●	
yello.base	●			Seed	●			○		
yello.base	●		May-Jun	Seed	●	○ ○	●	○		
spiral	●			Seed	●		●	○		
spiral	●			Seed	●			○		
spiral	●			Seed	●			○		
spiral	●			Seed	●			○		
fork	●			Seed	●			○		
yello.base	●			Seed	● ●			○		
keel	●			Seed	●		●	○		
red base	●			Seed	●		●	○		
spiral	●		Feb	Seed	● ●			○		
spiral	●			Seed	●	○ ○		○		
spiral	●			Seed	●			○		
keel	●			Seed	●			○		
keel	●			Seed	●	○		○		
keel	●			Seed	●			○		
keel	●			Seed	●			○		

[12] Fern cone orange

Species	Climate trop/temp	Light sun/shade	Moisture dry/wet	Stem height >.5>2m<	Stem character	Leaf length >1>2m<	Leaflet width >1>4cm<
M. johnsonii	● ●	○	●	○ ○ ○		○ ○	●
M. lomandroides	● ●	○ ○	●	○	subterra	○	● ●
M. longispina	● ●	○ ○	●	○	subterra	○	●
M. lucida	● ●	○ ○	●	○	subterra	○ ○	●
M. macdonnellii	● ●	○	●	○ ○ ○		○ ○	●
M. machinii	● ●	○ ○	●	○	subterra	○	●
M. macleayi	● ●	○ ○	●	○	subterra	○	●
M. miquelii	● ●	○ ○	●	○		○	●
M. montana	● ●	○ ○	●	○		○	●
M. moorei	● ●	○	●	○ ○ ○		○ ○	●
M. mountperriensis	● ●	○ ○	●	○		○	●
M. occidua	● ●	○ ○	●	○	subterra	○	●
M. parcifolia	● ●	○ ○	●	○	subterra	○	●
M. pauli-guilielmi	● ●	○ ○	●	○		○	●
M. platyrachis	● ●	○ ○	●	○	subterra	○	●
M. plurinervia	● ●	○ ○	●	○	subterra	○	●
M. polymorpha	● ●	○ ○	●	○	subterra	○	●
M. reducta	● ●	○ ○	●	○		○ ○	●
M. riedlei	● ●	○ ○	●	○		○ ○	●
M. secunda	● ●	○ ○	●	○	subterra	○	●
M. serpentina	● ●	○ ○	●	○	subterra	○	●
M. spiralis	● ●	○ ○	●	○		○	●
M. stenomera	● ●	○ ○	●	○		○	●
M. viridis	● ●	○ ○	●	○		○	●
Microcycas calocoma	● ●	○ ○	● ●	○ ○ ○		○	●
Stangeria eriopus	● ● ●	○ ○	● ●	○	tuber	○ ○	● ●
Zamia acuminata	● ●	○ ○	●	○ ○		○	●
Z. amazonum	●	○ ○	●	○	tuber	○	●
Z. amplifolia	●	○ ○	●	○ ○ ○	smooth	○ ○	●
Z. angustifolia	● ●	○ ○	●	○	tuber	○ ○	●
Z. boliviana	●	○ ○	●	○	tuber	○	●
Z. chigua	●	○	●	○ ○ ○	smooth	○ ○	● ●
Z. cremnophila	● ●	○ ○	● ●	○	cliff	○ ○	●
Z. cunaria	● ●	○ ○	●	○	tuber	○ ○	●
Z. decumbens	●	○ ○	●	○ ○		○ ○	● ●
Z. disodon	●	○	●	○		○	●

Leaflet character	Spines no./pet./lft	Cone character	Pollen	Propagation C=cutting	Freeze tolerance no/yes	Flood tolerance no/yes	Salt tolerance no/yes	Transplanting hard/easy	CAS resistance no/yes	Pests, remarks
keel	●			Seed	●			○		
spiral	●			Seed	●			○		
yello.base	●			Seed	●			○		
yello.base	●		Apr-Jun	Seed	●	○		○	●	
yello.base	●		Apr	Seed	●	○	●	○		
yello.base	●		May	Seed	●			○		
yello.base	● ●		Apr-Jun	Seed	●			○		
yello.base	●		Mar-Apr	Seed	●	○		○		
yello.base	●			Seed	●			○		
keel	●		Feb-Apr	Seed	●			○	●	
yello.base	●			Seed	●			○		
spiral	●			Seed	●			○		
spiral	●			Seed	●			○		
spiral	●		Jan-Apr	Seed	●			○		
keel	●		May	Seed	●			○		
spiral	●			Seed	● ●			○		
keel	●			Seed	●			○		
yello.base	●			Seed	● ●			○		
yello.base	●			Seed	●			○		
keel	●			Seed	●			○		
yello.base	●			Seed	●			○		
keel	●			Seed	●			○		
spiral	●			Seed	●		●	○		
spiral	●			Seed	●			○		
	●		Aug-Sep	Seed	●		●	○	●	[13]
	●	felt	Jan-Mar	C, S	●	○ ○	●	○	●	[14]
	●		Jan	Seed	●			○	●	
	●			Seed	●			○	●	[15]
corrugate	●		Oct	Seed	●	○		○	●	
	●		Dec-Feb	Seed	●	○	●	○	●	[16]
	●		Jun	Seed	●			○	●	[15]
	●			Seed	●	○	●	○	●	
	●			Seed	●		●	○	●	Lvs Pendent
	●		Nov	Seed	●			○	●	[15]
	●		Aug-Sep	Seed	●			○	●	
	●			Seed	●	○		○	●	

[13] Breaking taproot kills seedlings
[14] Cones year round in Miami
[15] Fern cone red brown
[16] Eubulus stem borer

Species	Climate		Light			Moisture		Stem height			Stem character	Leaf length			Leaflet width			
	trop/temp		sun/shade			dry/wet		>.5>2m<				>1>2m<			>1>4cm<			
Z. dressleri	●				●		●	●			tuber	●	●					●
Z. elegantissima	●	●			●		●	●	●	●	smooth		●				●	
Z. encephalartoides	●	●	●	●		●		●	●		smooth	●					●	
Z. erosa	●	●	●	●		●		●			tuber	●	●				●	
Z. fairchildiana	●	●		●	●		●	●	●		smooth	●	●	●			●	
Z. fischeri	●	●		●	●		●	●			tuber	●				●		
Z. furfuracea	●	●	●	●			●	●			tuber	●					●	●
Z. gentryi	●				●		●	●	●					●			●	●
Z. gomeziana	●	●		●	●		●	●	●				●				●	
Z. grijalvensis	●	●		●	●		●	●			tuber		●				●	
Z. hamannii	●	●		●	●		●	●	●	●			●	●				●
Z. herrerae	●	●	●	●			●	●			tuber	●			●	●	●	
Z. huilensis	●			●	●		●	●	●				●				●	●
Z. hymenophyllidia	●			●	●		●	●			tuber	●				●		
Z. imperialis	●	●			●		●	●	●		smooth	●	●	●				●
Z. incognita	●				●		●	●			tuber		●					●
Z. inermis	●	●	●	●		●		●			tuber	●	●		●	●		
Z. integrifolia	●	●	●	●		●		●			tuber	●	●		●			
Z. ipetiensis	●				●		●	●			tuber	●	●					●
Z. katzeriana	●	●		●	●		●	●			tuber	●					●	
Z. lacandona	●	●			●		●	●			tuber		●	●				●
Z. lecointei	●	●		●	●		●	●			tuber		●				●	
Z. lindenii	●	●			●		●	●	●	●	smooth		●	●			●	
Z. lindleyi	●				●		●	●	●		smooth	●			●			
Z. loddigesii	●	●	●	●		●		●			tuber	●					●	
Z. lucayana	●	●	●	●		●		●			tuber	●					●	
Z. macrochiera	●				●		●	●			tuber		●	●			●	●
Z. manicata	●				●		●	●			tuber		●					●
Z. meermanii	●	●	●	●		●		●			cliff	●	●				●	●
Z. melanorrhachis	●				●		●	●			tuber	●				●		
Z. montana	●				●		●	●	●		subterra			●				●
Z. monticola	●	●		●	●		●	●			subterra		●				●	
Z. muricata	●	●		●	●		●	●			subterra		●					●
Z. nana	●	●			●		●	●			subterra	●					●	
Z. nesophila	●	●		●	●		●	●	●	●	smooth		●	●				●
Z. neurophyllidia	●	●			●		●	●	●		smooth	●	●					●

Species	Leaflet character	Spines		Cone character	Pollen	Propagation	Freeze tolerance		Flood tolerance		Salt tolerance	Transplanting			CAS resistance	Pests, remarks
		no./pet./lft				C=cutting	no/yes		no/yes		no/yes	hard/easy			no/yes	
Z. dressleri	corrugate		●		Nov-Dec	Seed	●			●				●	●	[15]
Z. elegantissima			●		Oct-Dec	Seed	●			●				●	●	
Z. encephalartoides		●				Seed							●		●	
Z. erosa		●			Nov-Mar	Seed		●		●				●	●	[16]
Z. fairchildiana			●		Nov-Jan	Seed	●			●	●		●		●	
Z. fischeri		●			Nov	Seed		●						●	●	
Z. furfuracea			●		Jun-Sep	Seed		●		●	●			●	●	[17]
Z. gentryi			●			Seed	●					●			●	
Z. gomeziana			●			Seed	●								●	
Z. grijalvensis			●			Seed	●		●					●	●	
Z. hamannii	corrugate	●			Sep-Oct	Seed	●			●	●			●	●	
Z. herrerae			●			Seed		●						●	●	
Z. huilensis			●			Seed	●							●	●	
Z. hymenophyllidia			●			Seed	●					●			●	
Z. imperialis	corrugate	●			Oct-Nov	Seed	●			●				●	●	
Z. incognita		●	●		Nov-Dec	Seed	●							●	●	
Z. inermis		●			Oct-Dec	Seed				●				●	●	
Z. integrifolia		●			Nov-Mar	Seed		●	●		●			●	●	[18]
Z. ipetiensis			●		Sep	Seed	●							●	●	[15]
Z. katzeriana			●			Seed	●							●	●	
Z. lacandona		●			Dec-Feb	Seed	●		●					●	●	♂ decum.
Z. lecointei			●			Seed	●					●			●	
Z. lindenii			●			Seed	●			●				●	●	♀ pendent
Z. lindleyi			●		Oct-Nov	Seed	●					●			●	[19]
Z. loddigesii			●		May-Aug	Seed	●		●		●			●	●	
Z. lucayana		●			Jan	Seed		●		●	●			●	●	Eubulus borer
Z. macrochiera	collar		●			Seed	●			●		●			●	[15]
Z. manicata	collar		●	stalk	Jul-Oct	Seed	●			●		●			●	[15]
Z. meermanii			●		Oct-Nov	Seed		●						●	●	
Z. melanorrhachis			●			Seed	●					●			●	[15]
Z. montana	corrogate		●			Seed						●			●	[19]
Z. monticola			●			Seed								●	●	
Z. muricata			●		May-Aug	Seed	●							●	●	
Z. nana			●		Jan	Seed	●							●	●	
Z. nesophila	corrogate		●		Sep-Oct	Seed	●			●	●			●	●	
Z. neurophyllidia	corrogate		●		Oct	Seed	●		●					●	●	

[15] Fern cone red brown
[16] Eubulus stem borer
[17] Tranes stem borer
[18] Umbrosa form susceptible to Eubulus
[19] Requires cool, cloud forest conditions

Species	Climate trop/temp	Light sun/shade	Moisture dry/wet	Stem height >.5>2m<	Stem character	Leaf length >1>2m<	Leaflet width >1>4cm<
Z. obliqua	● ●	○	●	○ ○ ○	smooth	○	● ●
Z. oligodonta	●	○	●	○	subterra	○	●
Z. onan-reyesii	●	○	●	○ ○	bumps	○ ○	● ●
Z. oreillyi	●	○	●	○	tuber	○	● ●
Z. paucijuga	● ●	○ ○	●	○	tuber	○	●
Z. poeppigiana	●	○	●	○ ○ ○		○ ○	●
Z. portoricensis	● ●	○ ○	●	○	tuber	○	●
Z. prasina	● ●	○ ○	●	○	tuber	○	●
Z. pseudomonticola	● ● ●	○	●	○ ○	smooth	○	●
Z. pseudoparasitica	● ●	○ ○	●	○	epiphyte	○ ○	●
Z. pumila	● ●	○ ○	●	○	tuber	○	●
Z. purpurea	●	○	●	○	tuber	○	● ●
Z. pygmaea	● ●	○ ○	●	○	tuber	○	●
Z. pyrophylla	●	○	●	○	tuber	○ ○	●
Z. restrepoi	●	○	●	○	tuber	○	●
Z. roezlii	● ●	○ ○	●	○ ○ ○	smooth	○ ○	●
Z. sandovalii	●	○	●	○	cliff	○ ○	●
Z. skinneri	● ●	○	●	○ ○ ○	smooth	○	●
Z. soconucensis	● ●	○	●	○ ○	smooth	○ ○	● ●
Z. spartea	● ●	○ ○	●	○	tuber	○	●
Z. splendens	● ●	○	●	○	tuber	○	● ●
Z. standleyi	● ●	○ ○	●	○	tuber	○	●
Z. stevensonii	● ●	○	●	○	smooth	○	●
Z. stricta	● ●	○ ○	●	○	tuber	○	●
Z. tolimensis	●	○	●	○ ○ ○	smooth	○	●
Z. tuerckheimii	● ●	○ ○	●	○ ○	smooth	○	●
Z. ulei	●	○	●	○	tuber	○	●
Z. urep	●	○	●	○	tuber	○	●
Z. variegata	● ●	○ ○	●	○	tuber	○ ○	● ●
Z. vazquezii	● ●	○ ○	●	○	tuber	○ ○	● ●
Z. wallisii	●	○	●	○	tuber	○ ○	●

Leaflet character	Spines no./pet./lft	Cone character	Pollen	Propaga-tion C=cutting	Freeze tolerance no/yes	Flood tolerance no/yes	Salt tolerance no/yes	Trans-planting hard/easy	CAS resistance no/yes	Pests, remarks
	●		Sep	Seed	●	○	●	○	●	
corrugate	●		Aug	Seed				○	●	[19]
	●		Jul	Seed	●			○	●	
	●	stalk		Seed	●			○	●	
	●		May-Aug	Seed	●		●	○	●	
	●			Seed	●			○	●	
	●		Jan-Mar	Seed	●	○	●	○	●	
	●			Seed	●			○	●	Eubulus borer
	●		Oct-Feb	Seed	●	○		○	●	
	●		Sep-Oct	Seed	●			○	●	Lvs pendent
	●		Feb-Mar	Seed	●	○	●	○	●	Eubulus borer
	●		Mar-Apr	Seed	●			○	●	
	●		Mar	Seed	●	○		○	●	Eubulus borer
	●	stalk	Mar, all yr?	Seed	●			○	●	[15]
	●			Seed	●			○	●	
corrugate	●			Seed	●	○	●	○	●	
	●			Seed	●			○	●	Lvs pendent
corrugate	●		Sep-Oct	Seed	●	○		○	●	
	●		Nov	Seed	●			○	●	
	●		Jul	Seed	●	○		○	●	
	●	decumbent	May	Seed	●	○	●	○	●	[20]
	●		Mar-May	Seed	●	○	●	○	●	♂ decum.
white em	● ●		Dec	Seed	●			○	●	
	●			Seed	●			○	●	
	●		Jun-Jul	Seed	●			○	●	
	●		Feb	Seed	●			○	●	
	●			Seed	●			○	●	
	●			Seed	●			○	●	
spots	●		Jun	Seed	●	○		○	●	
	●		Nov-Dec	Seed	●	○		○	●	Eubulus borer
corrugate	●	stalk		Seed	●			○	●	

[15] Fern cone red brown
[19] Requires cool, cloud forest conditions
[20] Emerging lvs green or orange

EXPLANATION OF DECISION TABLE

Species: 350 species of cycad are listed here from the World List of Cycads. There has been a surge of field work on cycads in the last 20 years and about 100 more species are currently recognized than in 1995 when the first edition of this manual was published. Although there are undoubtedly new species to be discovered, the great majority have now been accurately described using modern scientific standards.

Climate: In this column suitable climates for cycads are indicated with the position of a dot (•) as tropical (left), subtropical (center) and warm temperate (right). A species may be suitable for two climate zones, indicated with two dots (••), or even three climate zones (•••). Many cycad species coming from seasonally cool regions, such as most *Macrozamia* and many *Encephalartos* from South Africa, or even perennially cool regions, such as cloud forest *Ceratozamia*, are not suitable for the lowland tropics. In the constantly high heat and humidity in such places as Bangkok, Thailand, these species will struggle to survive. Mild or highland tropical climates, such as found in Hawaii, as well as subtropical climates are actually the most favorable for growing the greatest range of cycad species. Warm Temperate climate is defined in this handbook as regions with mild summers and cool winters with only occasional freezing temperatures, such as the San Francisco Bay area, the Mediterranean coast or the Western Cape region of South Africa. Areas with long periods of snow and freezing temperatures are not suitable for outdoor cultivation of any cycad and in these areas only greenhouse cultivation is possible. For those species listed as suitable for warm temperate, microclimates must be carefully selected or created. Usually the lack of heat, either in the growing season, the winter or both, limits what can be successfully grown in warm temperate regions.

Light: This category applies to mature, established plants. All cycad seedlings and those recovering from transplantation require 50% sun or less. In nature mature plants of many cycad species inhabit exposed rocky outcrops or cliffs and prefer full sun, indicated by dot (•) on left, especially those with bluish leaves. When deprived of adequate light sun-loving

Dioon edule in Veracruz, Mexico.
Cycads, like palms, are striking when planted near water.

species will produce overly elongated (etiolated) leaves that are prone to flopping over and breaking. In persistently overcast regions full exposure to available sun may be important to maintain a tidy, compact crown. Those species that naturally inhabit closed forest will continue to require shade or dappled sun as adults in cultivation, indicated by dot (•) on right. For the majority of species, sun in the morning and partial shade in the afternoon is ideal, indicated by dot (•) in center, especially if hot, dry conditions are frequently experienced in your area. Many problems with cycad cultivation can be avoided if the right planting locations are selected. The east side of a building is ideal for many shade loving cycads. In the northern hemisphere in a cool climate, a southern exposure provides necessary heat (conversely, if you are in the southern hemisphere, a northern exposure is needed). It must be emphasized, however, that with greater sun exposure, more irrigation is an absolute must to prevent drought stress.

Moisture: Proper irrigation is the key to successful cycad horticulture. Moisture, temperature and soil mix are critically intertwined and in pot cultivation these factors need to be manipulated so that roots remain in a narrow "golden zone": roots need to be moist, but well-aerated all the time and prefer temperatures between 72-95°F (22-35°C). Below this temperature range watering should to be cut back or root rot will ensue. In pot cultivation proper aeration and drainage can be created with this standard cycad mix: 1 part sharp, coarse sand, 1 part orchid bark, 1 part Canadian peat moss, 1 part pumice (1/8-1/4 inch). Water should drain from this mix as quickly as it is poured in. Ingredients that are not locally available can be substituted. For example pumice can be replaced with perlite or even limestone. An additional layer of pumice or limestone can be placed in the bottom of a pot to keep soils evenly moist.

Young plants can also be successfully grown in raised beds. This encourages rapid drainage and with more space to roam, taproots of seedlings are less likely to suffer root rot and likely to grow more quickly.

In the landscape, fine soils with poor drainage such as clay or marl, cannot provide the aeration required by cycad roots and are therefore unsuitable. Merely placing the cycad on a mound of poor-draining soil will not be enough to solve this problem, instead the soil needs to be replaced

LEFT: Taproots of cycad seedlings will bend to conform with the shape of the pot. RIGHT: Raised beds at Nong Nooch Garden.

or amended to improve drainage. Gypsum (cat litter) is very effective as an amendment, but gravel or sand can also be used, albeit in larger quantity, to improve aeration and drainage. In the wild, cycads tend to grow on slopes in stony soils and their roots may form dense mats when they encounter pockets of organic matter or richer soil. Cycads usually have a great tolerance for drought when they are grown in shady conditions. In dry shade they can remain in a stasis, not growing, but not declining, for long periods. Sun loving species with an established root system, can also tolerate drought. For these reasons cycads are a good selection for low maintenance landscape designs. They remain green and lush-looking longer than most other landscape plants during water shortages.

Since rain rarely falls in the right quantity or frequency, supplemental irrigation is almost always required for optimal growth. For small or

Emerging leaves of *Dioon argenteum* with white tomentum. Irrigation is critical during leaf emergence.

diverse cycad collections with varying needs hand watering is best so that each plant gets regularly checked to know its specific water demands. In large plantings, species with similar water needs should be grouped together and automated sprinkler systems can be employed. Automated systems can either be drip irrigation or overhead sprinklers. Using drip irrigation is best when the collection is composed of larger individuals, in windy or arid regions and where mornings are regularly cold. When growing numerous seedlings and subadult plants overhead irrigation provides better coverage. Overhead irrigation should be employed mid-morning or mid-afternoon. Avoid regular water on the foliage at night and watering in the heat of the day since leaf damage can occur from standing water droplets when there are temperature extremes above or below normal growing temperatures. For each of the three irrigation methods calibrate the irrigation events to supply enough water to wet the media completely. Water should percolate through the pot and be visible exiting the drain holes of the pot to wet all the roots and avoid fertilizer salts from accumulating in the growing media.

Stem height: In this table cycads are separated into three height categories: 1) shrub with stem less than 0.5 meter in height [dot (•) on left], including species with subterranean stems; 53% of all cycad species never exceed this height category; 2) small tree with stem attaining 0.5-2 meters in height, 35% of species fall within this category [two dots (••) in left and center]; 3) medium tree with stems that can be expected to reach more than 2 meters in height from seedling stage during an owner's lifetime [three dots (•••)]. In general *Cycas* species exhibit the fastest trunk growth and dominant this last category. Many *Encephalartos*, *Lepidozamia* and *Microcycas* also reaching this height, but at a slower pace. Cycads are often used with palms in landscapes. Unlike most palms cycads will rarely outgrow their place in a landscape design. Taller specimens are useful as interesting shrubs or low trees in the background or as centerpieces. Lower growing species, especially those with unusual foliage color or shape can be placed in the foreground, with some species suitable as ground cover.

Stem character: An above-ground trunk is formed in most, but not all species of cycad and is considered one of the most ornamental parts of

Ceratozamia, *Dioon* and *Encephalartos* in the fern house at Garfield Park Conservatory, Chicago.

the plant. Trunks usually form a column, but may lean or branch with age and typically have a scale-like texture of remnant leaf-bases. The stem apex may be crowned with protruding scale leaves or covered with a cap of wool. In most *Zamia* species the stem forms an underground tuber, but when it forms an aerial trunk, the texture is smooth, bumpy, or faintly ribbed. *Cycas* species exhibit by far the greatest variety of texture—in some the base of the trunk is squat and swollen, some are smooth, while others are fissured. In a few Australian species, sharp scale leaves persist and cover the trunk with spines. In the wild these are often burnt off in wild fires, but in cultivation these ornamental spines may persists for years.

Cycad stems are usually covered with diagonal leaf base scars that give them a scaly texture, but with age, depending on species, they can become smooth, fissured, bulbous, ribbed and covered with lichens, moss and other epiphytes.

CLOCKWISE FROM TOP LEFT

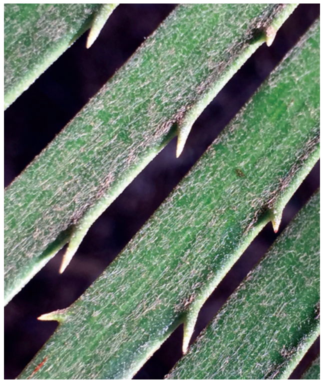
Zamia lindenii, Encephalartos transvenosus, E. sclavoi, Dioon spinulosum, D. purpusii, Cycas tansachana, Macrozamia moorei, C. siamensis.

Leaf length is useful in designing a landscape. Typically in most cycad plantings young cycad specimens are spaced too closely. It is a natural desire to take advantage of limited space and fill in gaps when planting a bed. As the crowded cycads mature, however, their foliage tangles and spiny leaves may protrude into walkways. Frequent pruning is then required or offending plants have to be removed; a usually laborious and thorny process. This can be avoided with proper planning. About 35% of cycad species typically have leaves less than 1 meter long (• on left); 1-2m of spacing is generally adequate for these. The majority of species have leaves between 1-2m long (• in center); for these 2-2.5m of space between plants is needed, more if you need to walk between plants. Only about 6% of species have leaves that typically exceed 2m in length (• on right).

Leaflet width is a measure of foliage texture. About 40% of cycad species have leaflets that are 1cm wide or less [dot (•) on left]. Another 40% of cycads possess leaflet widths between 1-4cm [dots (•) located in central positions]. A dot (•) in the far right indicates leaflets over 4cm in width; these are generally the most striking species when viewed from a distance. Some species may display a wide range of widths, spanning 3 three dots (•••) out of a possible four.

Leaflet character: Other decorative aspects of leaflets include corrugate texture (plicate), collar at the base of the leaflet, forking, lobes (forks of unequal length), persistent hair and wavy margins. The arrangement of leaflets often produces a striking pattern: imbricate (leaflets overlap in venetian blind-like pattern), bunched leaflets (producing a bamboo-like look), leaflets arranged in a spiral pattern along the rachis, opposing leaflets produce a keel shape to the leaf. Color: leaflets of *Macrozamia* species and some *Encephalartos* have a colored basal attachment to the rachis that may be yellow, orange or red; emerging leaves may be various shades of red ranging from pink to brown; some species have leaves and leaflets that have a persistent waxy bloom giving the foliage a bluish appearance.

CLOCKWISE FROM TOP LEFT: Color and texture choices exhibited by *Microcycas calocoma*, *Zamia obliqua*, *Z. dressleri*, *Encephalartos horridus*, *Dioon merolae*, *Z. neurophyllidia.*



Dioon spines.

Spines: prickles, teeth or spines can be located on various parts of a cycad leaf. Only 15% of cycad species are free of spines (• on left) and are thus user friendly. When there are teeth or spines on leaflets that are not wicked enough to draw blood from passing pedestrians or prickles are confined to the petiole this is indicated with (• in center); 63% of species fall into this category. In general pedestrians brushing these species when walking by will not be harmed. A gardener working near the petiole or trying to pollinate a cone, however, may receive serious scratches or jabs from this category of cycads species. When spines are located on leaflets and are sharp enough to draw blood in a passing pedestrian they are indicated by (• on right). Nearly a quarter of all species fall into this category, all belonging to *Encephalartos* or *Macrozamia*. Ironically these are often considered the most impressive species with the most interesting foliage that landscapers want to display. In some Florida theme parks poor placement of prickly specimens require frequent pruning and entail risk of poking out the eyes of careless tourists.

Unusual female cone in *Microcycas*.

Potted *Encephalartos nubimontanus* in a secluded landscape.

Cone character: Instead of flowers cycads produce cones. Large cones are always striking. They may be covered with felt, have interesting texture or dangle from stalks. The approximate color of the male cone is indicated in this column. When female cone color differs significantly from that of males this is indicated in column 19 under remarks. Female cones crack open when receptive to pollination with each genus displaying a different crack pattern.

Pollen: The months when male cones shed pollen are indicated in this column. Coning times may vary depending on your local climate. For example, when the commonly cultivated species, *Cycas revoluta*, is grown outside of its native climate zone coning may be many months off. Generally, receptivity in female cones occurs at the same time as pollen shedding, but tends to be a little later. Coning times for southern hemisphere species have been converted for the northern hemisphere. If you are living in the southern hemisphere, these coning months should be shifted six months.

Propagation: All species can be propagated from seeds (S), except those in which one sex (male or female) have become extremely rare or extinct. Some species commonly produce stem offsets, called "suckers" (C) that either emerge from the base or along the length of the stem. When suckers are more than 5 cm in diameter they can be removed with a clean, sharp knife and the cut end allowed dry and heal in a shady spot for several days before planting. The cut end can also be treated with a fungicide to inhibit decay and rooting hormone to induce adventitious roots.

ABOVE LEFT: Tools for removing offsets include a toothbrush for applying fungicide. Gloves should be worn to keep exudate and fungicide from skin contact. ABOVE RIGHT: Suckers on a stem. Significant force is required to detach offsets. OPPOSITE, CLOCKWISE FROM TOP LEFT: Untrimed cluster of suckers after removal. Clean cuts to remove torn and/or bruised tissue. Exposed vascular cambium. Treated offset ready for planting. Clean cuts with fungicide on wounds on parent plant. Parent plant ready for repotting.

CLOCKWISE FROM TOP LEFT:
Drought damage on emerging leaf of *Cycas micholitzii*; sunburn on *Ceratozamia chamberlainii*; freeze damage on *Zamia roezlii* and *Encephalartos ferox*.

Freezing tolerance: If you are in a warm temperate or subtropical climate, freezing temperatures are a major concern for cycads. Foliage will turn brown when leaves suffer freeze damage. A species may exhibit different tolerances for freezing temperatures depending on how temperatures drop in your area with the onset of winter. In some areas, such as California, winter temperatures gradually lower over many weeks or months and cycads acclimate to colder temperatures, that is to say their metabolism slows down or changes, so that they can withstand freezing temperatures when they finally arrive. In other areas, such as Florida, day temperatures may hover in the range of 70-80°F (21-27°C) continuously for many weeks and then suddenly drop to freezing. Without acclimation meristems and leaves are much more vulnerable. In the column for freeze tolerance, observations are gathered from the literature as well as growers for how species react to freezing temperatures. Due to various circumstances of acclimation explained above, cold tolerance is given as a range. In some cases they are predicted, but with a high degree of confidence. If leaves turn brown as temperatures merely approach 32°F (0°C) but do not reach freezing, they are considered highly vulnerable to freeze damage (• on left). Those species that show little to no leaf damage at temperatures 32°F or slightly below are considered freeze resistant (• in center). Those species showing little or no damage to leaves at temperatures below 27°F (-3°C) are considered highly resistant to freezing temperatures (• on right).

Flood tolerance: Cycads do not like to have roots, stems or leaves immersed in water. Most are tolerant of immersion for up to half a day or a day, but beyond this tissues will begin to turn brown and die. Actively growing tissues, such as root tips, growing tips of stems and emerging leaves are especially vulnerable. While risk of flooding may be low in your area, climatologists predict global increases in the frequency of storm surges and torrential rains, and it only takes a single flood to destroy a cycad collection. If this is a concern it is best to design your landscape or nursery so that vulnerable species are located on the highest ground available or are elevated on mounds, preferably with fast draining soil. Those species than die or suffer severe injury after 2-3 days of immersion are indicated by dot position (• on left). Those that show some damage

Recently transplanted *Encephalartos relictus* with leaves trimmed to reduce water demand.

to leaves, stems and roots after 2-3 days of immersion, but can recover within months are indicated by (• in center), indicating slightly stronger flood resistance. Those species that show little or no damage after more than 3 days of immersion are indicated by (• on right). Large plants are more tolerant than seedlings. Many *Zamia*, especially rainforest species, and those growing naturally along seashores or rivers and streams possess the greatest tolerance. The most flood tolerant of all species is *Zamia furfuracea*, which inhabits hurricane-prone shorelines in Mexico.

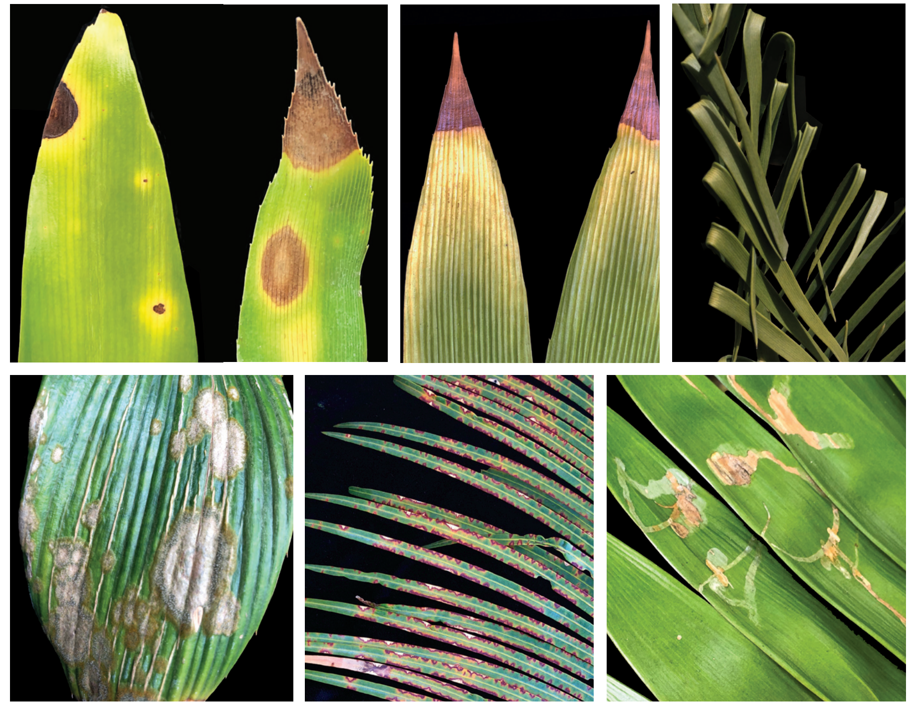
Salt tolerance: Some species inhabit dunes and cliffs along seashores and are splashed or flooded by seawater during storms. Blue-leafed *Encephalartos* irrigated from wells with salt water intrusion grow fine, but *Ceratozamia* exposed to such water do poorly. Based on such observations species are determined to have low salt tolerance (• on left), moderate tolerance (• in center) or high salt tolerance (• on right).

Encephalartos kisambo used as a focal point along a border.

Transplanting: Species that that have high mortality or show very slow recovery after they are dug up and replanted are indicated by (• on left); those with variable success, possibly depending on soil preferences or susceptibility to stem damage are indicated by (• in center); those that recover easily after they are dug up and replanted are indicated by (• on right). Cycad stems are filled with water and large plants are much heavier than they appear. They easily suffer fatal bruises during digging and lifting. Cycad plants are not furniture and should not be moved unless absolutely necessary! Every effort should be made, using the information in this manual, to plant a cycad in its proper place so that transplanting can be avoided.

Lepidozamia peroffskyana and *Macrozamia johnsonii* integrated with modern architecture at the Los Angeles County Museum of Art.

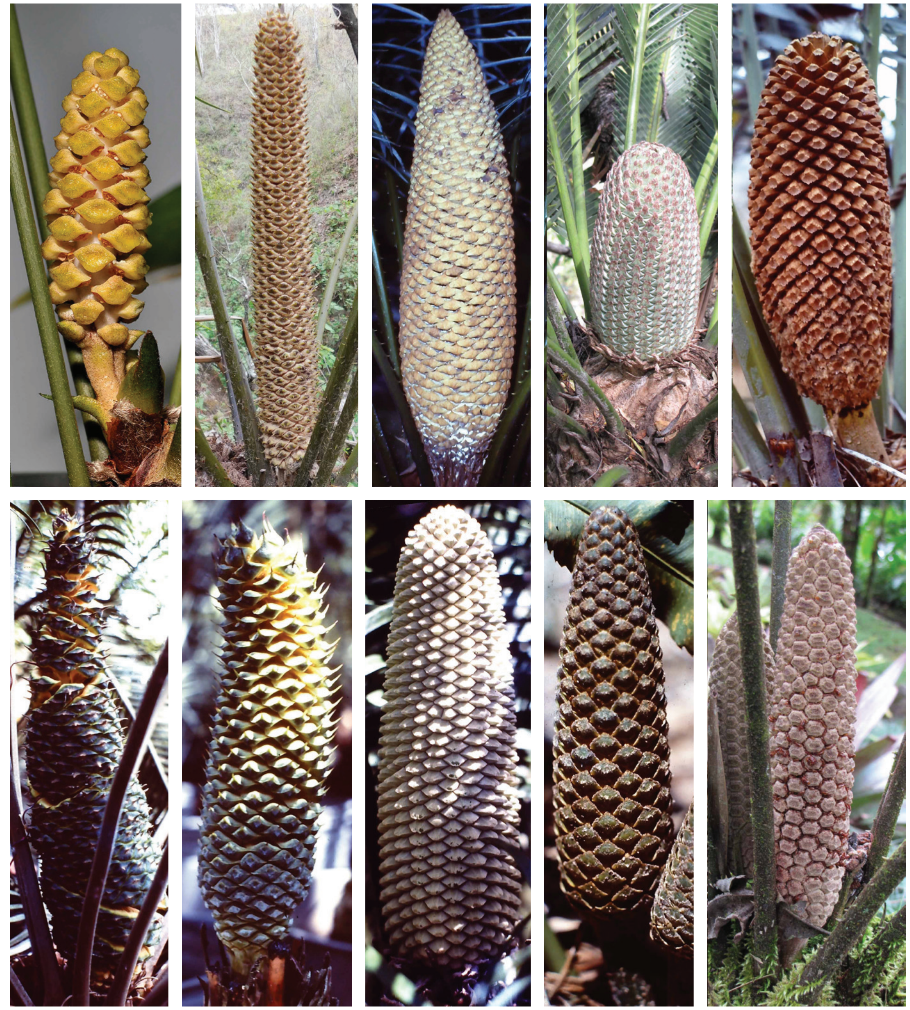
CAS resistance: Cycas aulacaspis scale (CAS) is an insect that infests leaves, stems and roots and is visible as white oval bumps about 2 mm wide. It is native to Southeast Asia, where natural predators as well as natural resistance in cycad populations appear to keep it in check in the wild. It is spreading globally and has killed thousands of cultivated *Cycas* and threatens the extinction of several species. Other genera are also vulnerable. Low resistance to CAS is indicated by (• on left). Moderate resistance is indicated by (• in center). High resistance is indicated by (• on right). This is a highly tropical pest, which will become inactive during winter months in the subtropics and appears to be of less concern in cooler, drier, more seasonal areas such as California.



CLOCKWISE FROM TOP LEFT: *Mycoleptodiscus indicus* progresses from dot to large lesion with halo. Fertilizer tip burn. *Macrozamia* leaf bending. *Cephaleuros virescens* parasitic algae. Drought induced nutrient deficiency. Leaf miner damage.

Other pests, remarks: Other pests include the Eubulus weevil borer which has been introduced to south Florida and attacks the stems and roots of Caribbean *Zamia*. Tranes weevil, *Melanotranes sp*., is also a borer, native to Australia, that will attack the stems of *Macrozamia* that are under stress or in poor health. There have been outbreaks of this weevil in South Africa and southern California. All *Encephalartos* appear highly susceptible, as is *Zamia furfuracea* and probably other *Zamia*. Both these weevils kill infected plants and are of extreme concern. A disease has appeared recently that causes the collapse of emerging leaves of *Encephalartos*: blue-leafed species appear to be highly susceptible. Preliminary study indicates it is caused by a species of *Colletotrichum* fungus. This fungal disease likely made a host shift from another type of plant onto cycads, possibly in a nursery setting where many plants are grown together.

Female cones during or near receptivity showing crack patterns. TOP, LEFT TO RIGHT: *Bowenia spectabilis*. *Ceratozamia mirandae*. *Cycas panzhihuaensis*. *Dioon purpusii* (opens only at base). MIDDLE, LEFT TO RIGHT: *Encephalartos paucidentatus*. *Lepidozamia peroffskyana*. *Macrozamia lucida*. BOTTOM, LEFT TO RIGHT: *Microcycas calocoma*. *Stangeria eriopus*. *Zamia pumila*.



Male cones during pollen shed (except where noted). TOP, LEFT TO RIGHT: *Bowenia spectabilis*. *Ceratozamia mirandae*. *Cycas hainanensis* with shed pollen accumulated at base. *Dioon purpusii* prior to pollen shed. *Encephalartos transvenosus* prior to pollen shed. BOTTOM, LEFT TO RIGHT: *Lepidozamia peroffskyana*. *Macrozamia plurinervia*. *Microcycas calocoma*. *Stangeria eriopus*. *Zamia pseudomonticola* with pollinator beetles entering crevices.

POLLINATION

Pollen collection and storage: In cycads male and female cones are produced on separate plants. Sex changes are extremely rare. To collect pollen, an emerging male cone needs to be identified. These are usually more elongated in shape and have smaller, more numerous scales than female cones, but in some species the two are similar. Using column 12 of the Decision Table you can identify the time of year when male cones are likely to emerge and then monitor the cone until it enters a phase of rapid elongation. For most species pollen shedding will occur within a 3-5 day interval. An elongating male cone can be cut just prior to pollen shed or during the shedding process and placed indoors on a smooth sheet of paper. As the pollen is released, tap the cone on a hard surface to facilitate the release of pollen. If there is debris, then shift the pollen and finally pour into a dry vial or an envelope and store in a Ziploc bag or plastic box in the refrigerator for up to several weeks until a receptive female cone is available. For long term storage the pollen needs to be frozen but must be dried prior to freezing.

Artificial pollination: In the wild most species have specialized beetles or thrips that transfer pollen from the male cone to a receptive female cone. If these beetles or thrips are present in your garden they will likely cause hybridization between different species. If genetically pure seeds are desired, it is best to exclude these pollinators from your collection and conduct artificial pollination by hand. This way you will have more control of the seed production process. Artificial pollination can be done with the dry or wet method. Dry pollen or pollen mixed with water can be squirted into the cracks that open in receptive female cones. Generally a slurry of water and pollen squirted into the top cracks will distribute the pollen more effectively through the cone by gravity and has a higher success rate than the dry method. The exception are blue-leafed *Encephalartos* where the wet method appears to result in the abortion of ovules/seeds. For these only the dry method is recommended.

A syringe is used to inject a slurry of pollen and water into a *Zamia* cone; a glass cup (lower left) is useful for mixing the pollen.

SEED PRODUCTION AND STORAGE

After pollination, developing seeds will be held by the cone for 4 months to 2 years. Most *Ceratozamia*, *Encephalartos* and *Macrozamia* hold seeds within the female cone for 4-8 months. In most *Zamia* species female cones will hold seeds between 7-12 months. *Stangeria* hold their seed for 10-11 months. For these genera, when seeds are released the embryos within may still be quite immature and will require a period of up to 4 months to grow before they can germinate. In any seed batch there will be variation in the amount of time required for germination. This appears to be an adaptation to the unpredictability of rains in many cycad habitats. During this time of development it is recommended that seeds be cleaned of their fleshy coats and be stored in a plastic bag with a bit of dry to slightly damp peat moss in a shady place, such as a closet, where there are no big fluctuations in temperature that may cause cycles of desiccation and condensation.

As the seeds reach maturity they will germinate in the bag and can be transferred to a germination bed with fast-draining soil (see page 26: Moisture). The closet and slightly damp peat moss simulates the shady, leaf litter habitat where many cycad seeds develop until the rainy season arrives. The acidity of slightly damp peat moss has the advantage of preventing the growth of fungi and bacteria that may infect and kill a germinating seed. *Dioon* species hold their seeds in the female cone for 12-16 months and *Zamia tuerckheimii* hold their seeds for 2 years. In these cases the embryos are usually fully formed at release and will germinate immediately when placed on a germination bed.

Seed germination: Germination beds should be moist as germinating seeds are prone to drying out. Seeds should be given at least 70% shade. Seeds in a shade house should be regularly misted. Alternatively, covering them with burlap and providing daily overhead watering will also fulfil these requirements. Cycad seeds should never be completely buried in a soil medium. This will cause rotting. They should be placed halfway into the soil, either flat or with the germinating end pointing down or up. In either case the emerging radical will bend downward toward gravity and then root in the soil. Placing seeds in a communal bed appears to promote higher survival rate of germinating seeds. Possibly emerging

seedlings growing close to one another absorb more water from the soil and prevent damping off fungus, however, the reason is unclear.

Long term seed storage: Cycad seeds of some species have been successfully stored in the vegetable compartment of a refrigerator for up to one year and still germinate. Beyond this time frame no techniques are currently known.

LEFT: *Dioon* seeds in a community pot, germination of *Cycas cairnsiana*, *Dioon* seedlings, *Zamia* seedlings. RIGHT: Transplanting *Cycas cupida.*

LANDSCAPING WITH CYCADS

The right plant in the right place is a basic application of horticulture that certainly pertains to cycads. In tropical to subtropical or conservatory settings there is a cycad to fit most conditions adding a dramatic statement to the landscape. The table is a useful guide to selecting species for criteria such as cold tolerance, sun/shade preference, mature size, growth rate and other characteristics. Although options abound for the look of a cycad, the decision should be based on the needs of the plant meeting your space and conditions.

Drainage is an important consideration since cycads cannot tolerate waterlogged soils or standing water. Even areas that have standing water only a few days each year can cause cycads to fail or under perform in the landscape. An easy and effective way to insure drainage is to plant the cycad above grade and mound soil or mulch around the exposed roots. Rocks or boulders can be used to create attractive mounds that are stable. Hillsides or slopes usually give cycads excellent drainage. Decorative containers of potted cycads can provide drainage in wet areas.

Since cycads live a long time they should be sited where they will not need to be moved. Competition for space and light over time should be considered when combining cycads with other plants. Often cycads take up to a year after being planted to produce new leaves and several years of good culture to obtain a full look. If sun, water, and fertilization are optimal, most cycads will keep leaves for one to five years and develop multiple flushes. Few plants can compare to a well-grown cycad.

Avoid damage to foliage by planting away from walkways and borders with mature size in mind. Prickly leaves can hurt people. All parts of cycads including seeds are toxic. Brightly colored cones may attract children or pets who might eat them. Potenial poisoning and fermenting seeds are easily avoided by cutting cones prior to dehiscence.

Designing with cycads is fun and easy. Often the cycad is the focal point and used to anchor the view. Groundcover looks great around a cycad and can virtually eliminate the need for weeding. Cycads benefit from mulching. Once planted, most cycads are trouble-free, requiring less water than those potted in containers. Landscape cycads tolerate drought as well as any irrigation necessary to make companion plants thrive.

TOP: Cycads, such as *Encephalartos* in foreground, can be used with stunning effect with rocks, as seen at Nong Nooch Tropical Garden. BOTTOM: Because they require good draininage, cycads do well in raised beds and rocks at Flamingo Gardens in Davie, Florida.

Building a raised bed with rocks using *Encephalartos ferox*. RIGHT: Set plant at desired elevation. BELOW: Position boulders to retain soil around the cycad rootball, making it the centerpiece among flowers, bromeliads and other plants.

CLOCKWISE FROM TOP: Cycads grow well on slopes. Statuary and cycads enhance each other in a landscape. Containers provide not only drainage but elevate a cycad near a walkway, as seen at Vizcaya Museum and Gardens, Miami.

TOP: Massed cycads can be used as an attractive landscape screen or border, in this case for a grassy field at Nong Nooch. BOTTOM: Cycads are as dramatic as the peacocks at Flamingo Gardens.

NOTES

Encephalartos woodii at Lotusland in Montecito, California. Cycads are wonderful by ponds and other water features because they rarely lose their leaves or make a mess.

NOTES

LEFT TO RIGHT: Ripe female cones and seeds of *Zamia pumila* and *Dioon edule*. *Zamia furfuracea* seeds are cleaned in a three step process: (1) abrade the seed coats using a metal brush attached to a drill; (2) place abraded seeds in a solution of pectinase enzyme and maintain at around 95°F (35°C) for about 1-2 weeks; (3) place seeds on a wire screen and spray off seed coat residues with high pressure water; repeat process if necessary.