Cycads Status Survey and Conservation Action Plan

IUCN

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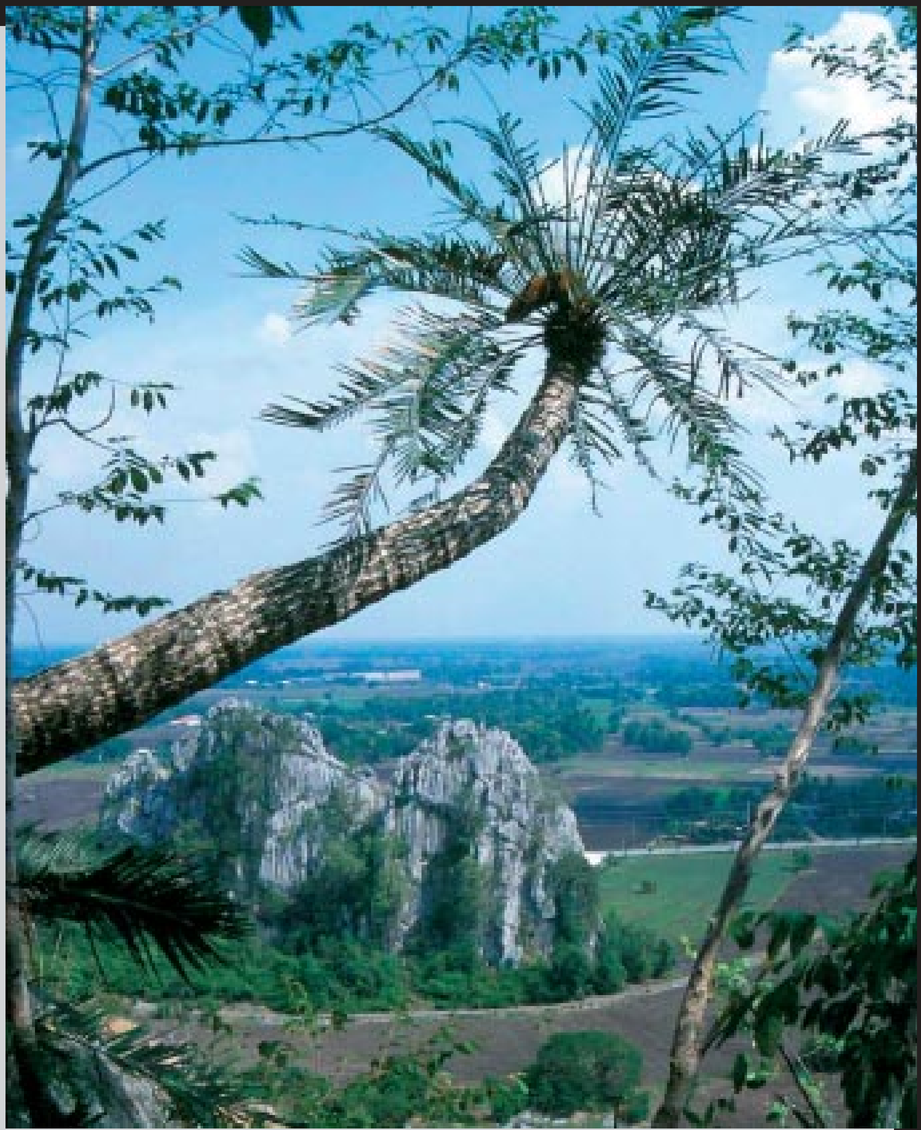
Cycads

Edited by John Donaldson



IUCN/SSC Cycad Specialist Group

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Status Survey and Conservation Action Plan

Cycads

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Dedication

The Cycad Action Plan is dedicated to the memory of Cynthia Giddy who died tragically in a car accident on 16 June 1998. Cynthia was the past Chair of the Cycad Specialist Group and a great champion of cycad conservation. She was amongst the first to realise that cycads would die out in southern Africa unless drastic steps were taken to protect them and she fought passionately for more effective legislation and conservation action. Cynthia was particularly concerned about trade in wild-collected plants and she campaigned tirelessly against the illegal trade, standing as an expert witness in numerous court cases, and participating in meetings of the CITES Plants Committee. In addition, she guided nature conservation officers through the confusing process of cycad identification, and she promoted the cause of cycads as plants that were worthy of conservation. Cynthia's passion for cycads led to the publication of her book, *Cycads of South Africa,* first published in 1974. Cynthia became involved with the Cycad Specialist Group soon after it was formed and served as Chair from 1994 to 1997.

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IUCN – The World Conservation Union
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Cover photo: The Critically Endangered *Cycas tansachana,* restricted to limestone outcrops in Thailand. Photo: J.S. Donaldson.

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Contents

Foreword

Cycads are the most ancient seed plants still living today, with fossils that date to the late Carboniferous period some 300–325 million years ago. I have sometimes used the analogy of the Rosetta Stone for the fund of information stored within the cycads and its importance to the interpretation of plant biology. You will recall that the Rosetta Stone was a slab found in 1799 near Rosetta, a town in Egypt near the mouth of the Nile, and which bore parallel inscriptions in Greek and Egyptian hieroglyphics. This discovery made it possible to decipher Ancient Egyptian writing and revealed many aspects of this great culture that were previously unknown. In a similar way, the very ancient structures and developmental pathways of cycads enable us to make connections between the early origins of seed plants and their present day counterparts. Losing these precious relics without ever having full knowledge of them would be a tragedy indeed.

We know about the physiology, reproductive structure and behaviour of only a handful of cycad species among the 11 extant genera and *c.*297 species and subspecies. But the potential store of information has been highlighted by studies of reproductive biology. Until very recently, cycads were thought to be wind-pollinated. Now we find many, and perhaps all, to be insect-pollinated, and we now know that insect pollination is of far greater age than that of flowering plants. Had cycads gone extinct in nature a few decades ago, we would never have had any inkling of this important and exciting bit of information for understanding plant biology. Even so, we remain ignorant about the biology of most cycad species and among those that have been studied we have more questions than answers.

Because cycads are often found as small populations in remote areas of undisturbed vegetation, exploration in recent years has taught us that there are most likely many new species of cycads that remain to be discovered. This is particularly true for Asia and the Neotropics where there are few botanists working on cycad taxonomy. Even when species have been described, population demographics are often poorly understood because many species appear to be composed of small disjunct populations, often as a result of habitat destruction that has left small fragments of once larger continuous populations. So, just as more fieldwork is necessary to understand the reproductive biology of cycads, fieldwork must also be extended just to determine what we have.

The unanswered questions and undiscovered cycads should strengthen our resolve to preserve the cycads in their natural habitats together with all their interactions. But, if cycads are going to be conserved, urgent action is required. Cycad populations are disappearing at an alarming rate and they stand out as one of the world's most threatened groups of plants. The publication of the IUCN Cycad Action Plan is therefore a critical step towards putting cycads on the global conservation agenda.

Knut Norstog
Idaho, USA

Acknowledgements

The Cycad Action Plan is a collaborative work that has involved numerous people all over the world who have generously given of themselves and their time, expertise, and data. Every contribution is greatly appreciated. We would particularly like to thank Wendy Strahm of IUCN/SSC for initiating the process, securing some essential funding to get the participants together, and for persistently nudging us towards the final product. De Wet Bösenberg and Chris Whitehouse are thanked for processing data for Red List assessments and De Wet Bösenberg for producing the maps. Janice Golding and Johan Hurter provided detailed assessments for some of the African cycads and valuable information and insights on plant distributions, threats, and CITES, were provided by Mossie Basson, Henk Beentje, Bennie Buytebier, Ricardo Callejas, Zhong Ye-Chong, Luciano Gaudio, Favio Gonzalez, Miguel Angel Perez Farrera, Morne Ferreira, Paul Foster, Douglas Goode, Tim Gregory, Peter Heibloem, Philip Ladd, Anders Lindström, Julie Lyke, Beatrice Mirungu, Aldo Moretti, Li Nan, Liu Nian, Roy Osborne, Lou Randall, Sergio Sabato, Rob Scott-Shaw, Tommy Steyn, Alberto Taylor, Mario Vasquez-Torres, Ger van Vliet, Carl Vernon, Piet Vorster, and Gary Wilson. We would like to thank John Caldwell for providing trade data from WCMC (World Conservation Monitoring Centre), Alain Mauric and Polly Phillpot for a great deal of editing, and Libbe Besse, Tom Broome, Paul Foster, Anders Lindström, Roy Osborne, Ingrid Nänni, and Piet Vorster for commenting on various drafts or sections of the Action Plan. We would also like to thank the following gardens for providing information on their collections: Cycad Gardens, Cycad Gardens Nursery, Durban Botanic Gardens, Escuela De Biologia, Universidad de Ciencias Y Artes Del Estado De Chiapas, Eudlo Cycad Gardens, Fairchild Tropical Garden, Ganna Walska Lotusland Foundation, Huntington Botanical Garden, Lowveld National Botanical Garden, Marie Selby Botanical Gardens, Montgomery Botanical Center, National Botanical Institute (South Africa), Orto Botanico Di Napoli, Plantation 2000 and Springs Garden. The management and staff of the Montgomery Botanical Center in Miami kindly hosted the second meeting of the authors of the Cycad Action Plan in 1997.

Executive Summary

The Cycad Action Plan brings together a collection of data and opinions on one of the world's most threatened groups of plants and presents a series of actions to promote their conservation. The coverage in the Cycad Action Plan provides substantially more information than has been made available in previous Red Lists and regional action plans. Even in the few years since the publication of the 1997 IUCN Red List of Threatened Plants (Walter and Gillett 1998), the number of species and subspecies that have been assessed has increased from 180–297. At the same time, the number of taxa that are Extinct in the Wild, or fall into one of the IUCN categories of threat, has risen from 149 (82%) in 1997 to 155 (53%). We have used the latest IUCN Red List Categories and Criteria (version 3.1, 2001) (available in Appendix 2), for evaluating threatened status and this has resulted in a more objective analysis than was previously possible. Cycads have been under severe threat for several decades and many attempts have been made to conserve the plants and their habitats with varying degrees of success. Part of the Cycad Action Plan is therefore an analysis of what has been done and its effectiveness, and part is a plan of action to build on past successes to reduce the impacts on wild cycad populations.

The Action Plan begins with an overview of all the cycads, describing the origins of the three families of living cycads (Cycadaceae, Stangeriaceae, and Zamiaceae) and their current distributions. It is encouraging to see that roughly 40% of the world's cycads fall into globally recognised biodiversity hotspots. This results in a considerable overlap between some of the objectives of this Action Plan and the goals of several international conservation organisations; that is, to conserve the last remaining habitat in areas of high diversity. In the case of cycads, this is an essential prerequisite for conservation since cycads have evolved numerous interactions with other organisms that will only survive in their native habitat.

The overview is followed by regional assessments for the four broad areas of cycad distribution; namely Africa and the Indian Ocean Islands, Australia, Asia (including Malesia – an area of tropical Australasia comprising Malaysia, Papua New Guinea, and the islands of Indonesia and the Philippines), and the New World. This geographical breakdown is convenient for regional planning but it also reflects the underlying biogeography of the cycads. With the exception of the widespread genus, *Cycas,* each of the other ten genera occurs in only one of the four regions. The chapter for each region deals with regional diversity and provides an analysis of local centres of diversity. The graphs provided for each region show that typically most of the cycads occur in a few countries while many countries have only one cycad species and these analyses are critical for regional planning. The regional overviews also highlight many of the differences between areas, with Africa having a high level of threat due to wild-collecting compared to Asia and the New World, where habitat destruction is a severe threat, and Australia where the levels of threat are generally lower.

Trade is a significant issue affecting cycads and a separate chapter has been included to deal with trade issues. CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) has provided an international mechanism to monitor and control trade in endangered species and all cycads are currently listed in the CITES appendices. The key question we try to address is whether CITES has been effective. One of the shortcomings that we identify is that CITES monitors trade but it does not monitor the impact on wild populations. The need to conserve cycad habitats means that trade has to be viewed in a broader context. The potential to satisfy trade through artificially propagated plants and through community based nurseries is evaluated.

With untold species facing extinction, many species may only survive in botanical gardens. We have therefore assessed the current status of cycad collections, with special emphasis on genebanks that represent specific populations. Activities over the past decade have already resulted in a large number of genebanks but there are still several Critically Endangered and Endangered species that are not adequately represented in genebanks.

Finally, the Cycad Action Plan presents a set of objectives and actions to reduce the threat to cycads in the wild and to provide *ex situ* conservation for those that almost certainly will die out in the wild. The actions focus on habitat conservation and species conservation and involve a wide range of stakeholders. Local communities, collectors, conservation organisations, policy makers, and researchers, can all influence the survival or extinction of cycad species and the final chapter outlines actions and activities that can be implemented by these stakeholders.

Donors to the SSC Conservation Communications Programme and the *Cycads Status Survey and Conservation Action Plan*

The IUCN Species Survival Commission is committed to communicate important species conservation information to natural resource managers, decision makers and others whose actions affect the conservation of biodiversity. The SSC's Action Plans, Occasional Papers, newsletter *Species* and other publications are supported by a wide variety of generous donors including:

The Sultanate of Oman established the Peter Scott IUCN/SSC Action Plan Fund in 1990. The Fund supports Action Plan development and implementation. To date, more than 80 grants have been made from the Fund to SSC Specialist Groups. The SSC is grateful to the Sultanate of Oman for its confidence in and support for species conservation worldwide.

The Council of Agriculture (COA), Taiwan has awarded major grants to the SSC's Wildlife Trade Programme and Conservation Communications Programme. This support has enabled SSC to continue its valuable technical advisory service to the Parties to CITES as well as to the larger global conservation community. Among other responsibilities, the COA is in charge of matters concerning the designation and management of nature reserves, conservation of wildlife and their habitats, conservation of natural landscapes, coordination of law enforcement efforts, as well as promotion of conservation education, research and international cooperation.

The World Wide Fund for Nature (WWF) provides significant annual operating support to the SSC. WWF's contribution supports the SSC's minimal infrastructure and helps ensure that the voluntary network and publications programme are adequately supported. WWF aims to conserve nature and ecological processes by: (1) preserving genetic, species, and ecosystem diversity; (2) ensuring that the use of renewable natural resources is sustainable both now and in the longer term; and (3) promoting actions to reduce pollution and the wasteful exploitation and consumption of resources and energy. WWF is one of the world's largest independent conservation organisations with a network of National Organisations and Associates around the world and over 5.2 million regular supporters. WWF continues to be known as World Wildlife Fund in Canada and in the United States of America.

Finally, funding provided by *WWF South Africa* and the *Mazda Wildlife Fund* to various contributors of this Action Plan greatly increased the quality of information contained in this publication. *The National Botanical Institute in South Africa* bore many of the staff costs associated with this publication. We are grateful for their support.

Chapter 1

Introduction

J.S. Donaldson

The world cycad flora of approximately 297 species and subspecies (referred to as taxa from here on) represents a small fraction of the earth's plant diversity. Yet, despite their small numbers, cycads are a group of global conservation significance. The 1997 IUCN Red List of Threatened Plants listed 12.5% of the world's vascular plants in one of the threatened categories (Walter and Gillett 1998). By comparison, a staggering 82% of the world's cycad species were listed as threatened. Even though the revised listings presented in this Action Plan are lower than previous estimates (52%), there is clearly a major extinction crisis facing the cycads, a group of plants that are recognised by scientists as the oldest seed plants still in existence with origins dating back to the late Carboniferous period 300 million years ago (MYA).

> "It was not only the sheer gigantism that seemed characteristic of the group – the biggest spermatozoids, the biggest egg cells, the biggest growing apices, the biggest cones, the biggest everything in the vegetable world. It was rather the sense that cycads were brilliantly adaptable and resourceful life-forms, full of unusual capacities and developments which had enabled them to survive for a quarter of a billion years, when so many of their contemporaries had fallen by the way".
> Oliver Sacks, *The Island of the Colorblind* (1996)

The reasons for the decline in cycad numbers are many and varied. Almost certainly, there are some species that are dying out naturally and, ideally, these should be left alone to allow the natural process of extinction to proceed. However, there is no doubt that human activities have significantly affected cycad populations and these factors are shaping the future survival or extinction of cycad populations far more than natural processes. The destruction and alteration of natural habitat, as well as the removal of plants from the wild in massive numbers for landscaping and plant collections, are frequently cited as the main reasons for the decline and disappearance of cycad populations. Other factors, such as the influence of alien plants and animals, and use in traditional practices, are also possible threats that need to be evaluated.

The problem facing the world's conservation community is how to conserve cycads. The remaining populations are spread through at least 60 countries on five continents and on numerous oceanic islands. Many species exist as relatively small isolated populations, often in transformed habitats that may not appear to warrant much attention for the conservation of biodiversity. Consequently, it is difficult to be optimistic that cycad species will be conserved as part of global initiatives that focus on hotspots of biodiversity or threatened habitats and ecosystems. Nevertheless, cycads are charismatic plants that have been identified as flagship species for conservation so that even single populations can be saved in some circumstances. To succeed, a broad framework for cycad conservation must be developed. This framework must range in focus from the ecosystem to the population, it needs to embrace the principle of sustainable utilisation and incorporate the potential value of off-site conservation in botanical gardens. Finally, the conservation framework needs must be realistic within the context of the social and economic driving forces that influence trade and habitat destruction. This is the aim of the current Action Plan that has been compiled by the IUCN/SSC Cycad Specialist Group.

The Cycad Specialist Group forms part of the IUCN Species Survival Commission and was formed in 1987 as an international network to promote cycad conservation. Since its inception, the Specialist Group has promoted cycad conservation through ongoing interaction with the CITES secretariat to curb the non-sustainable trade in wild-collected cycads; by regularly updating the taxonomy of the world's cycads and producing a world list of cycads; by undertaking a census of the numbers of plants both in nature and in collections; by motivating and supporting conservation actions in various parts of the world; and by strengthening the network of individuals and institutions involved in cycad conservation. An Action Plan for cycads was first discussed at the Cycad Specialist Group's meeting in Panzhihua (China) in 1996 and was further developed at a workshop in Miami in 1997. The objective is to update the current status of the world's cycads, identify the conservation needs, and specify the actions required to conserve cycads in their natural habitat and thus avert the extinction crisis that now seems inevitable. The Cycad Action Plan is meant to be a working document that identifies priorities, guides cycad conservation actions internationally, and serves as a technical resource for national and regional planning. Cycads are mostly long-lived and their response to specific conservation actions may be slow. It is therefore appropriate for the Action Plan to provide a framework for action over the next 10–20 years. However, the threat of extinction for many cycad species is so great that short-term objectives and actions must form part of the Cycad Action Plan.

The multiple scales at which action is required to conserve cycads (international, regional, national and local) has made it impossible to involve all stakeholders in the process. In many respects, the Cycad Action Plan focuses on technical criteria and analyses of various problems and strategies. The analysis of the current status of the world's cycads as well as the major threats will have to be reconciled with stakeholder needs and preferences as part of ongoing actions. To make this process easier, separate accounts are given for each of the major regions where cycads occur; Africa, Asia, Australia and the Pacific islands, and the New World (Americas). Trade has been such a central issue for cycad conservation that a separate chapter has been included to discuss the impact of trade on wild populations. We have also included a separate chapter on the role of botanical gardens because so many cycads are on the brink of extinction in the wild that botanical gardens may be the only place where some species will survive. In the final part of the Action Plan, we present a conceptual model for evaluating various conservation actions and we present a conservation strategy and series of actions to ensure that cycads continue to exist in the wild.

The key word for the success of the Action Plan is 'action'. Early visible results are critical both to ensure that the most endangered cycads survive and to sustain the process of participation and action. We have therefore drawn up a list of key objectives and activities in the final chapter and, when the cycad account is finally balanced, it is the success or failure of these actions that will make the difference.

Chapter 2

Cycads of the World: An Overview

J.S. Donaldson, K.D. Hill, and D.W. Stevenson

2.1 Cycad taxonomy, diversity and distribution

2.1.1 Taxonomy and classification

The cycads are a natural group of plants that have been clearly shown to have a single evolutionary origin (i.e., they are monophyletic) by both morphological and molecular studies (Stevenson 1990; Chase *et al*. 1993). We don't know the exact ancestors of the cycads, and we are uncertain about their relationships with other plants, but we do know that they are an extremely ancient group of plants. The cycad fossil record extends back to at least the Early Permian period, 280 million years ago (MYA) (Zhifeng and Thomas 1989), and possibly to the late Carboniferous period 300–325 MYA (Norstog and Nicholls 1997). The cycads are now generally thought to be the sister group to all other living seed plants (Nixon *et al*. 1994).

Relationships among the cycad genera are now fairly well understood and Stevenson (1992) presented a detailed classification of the genera and higher groupings. Based on this classification, the living cycads can be divided into three families, Cycadaceae, Stangeriaceae, and Zamiaceae, with 11 genera and about 297 species and subspecies. These taxa are distributed through the warmer areas of North and South America, Africa, Asia, and Australia, as well as a large number of oceanic islands (Figure 2.1).

The family Cycadaceae contains only one genus, *Cycas*, and is regarded as an early offshoot from the rest of the cycads. This family apparently originated in the ancient landmass of Laurasia with *Cycas* fossils known from the Eocene deposits (38–54 MYA) of China and Japan (Yokoyama 1911; Liu *et al*. 1991). *Cycas* has relatively recently dispersed to the Australasian region and the east coast of Africa, but the major evolutionary events giving rise to new species have occurred in Indochina and Australia, where most of the living species now occur (Figure 2.1).

The Stangeriaceae is a small family that appears to have originated on the ancient supercontinent of Gondwana. The existing plants in this family belong to two genera, *Stangeria* occurring in Africa, and *Bowenia* in Australia (Figure 2.1). Fossil Stangeriaceae have also been found in Lower Cretaceous deposits (70–135 MYA) in Argentina (Artabe and Stevenson 1999). There are only three living species, with a single species of *Stangeria* and two species of *Bowenia*.

Male plants of *Cycas panzhihuaensis*, China.

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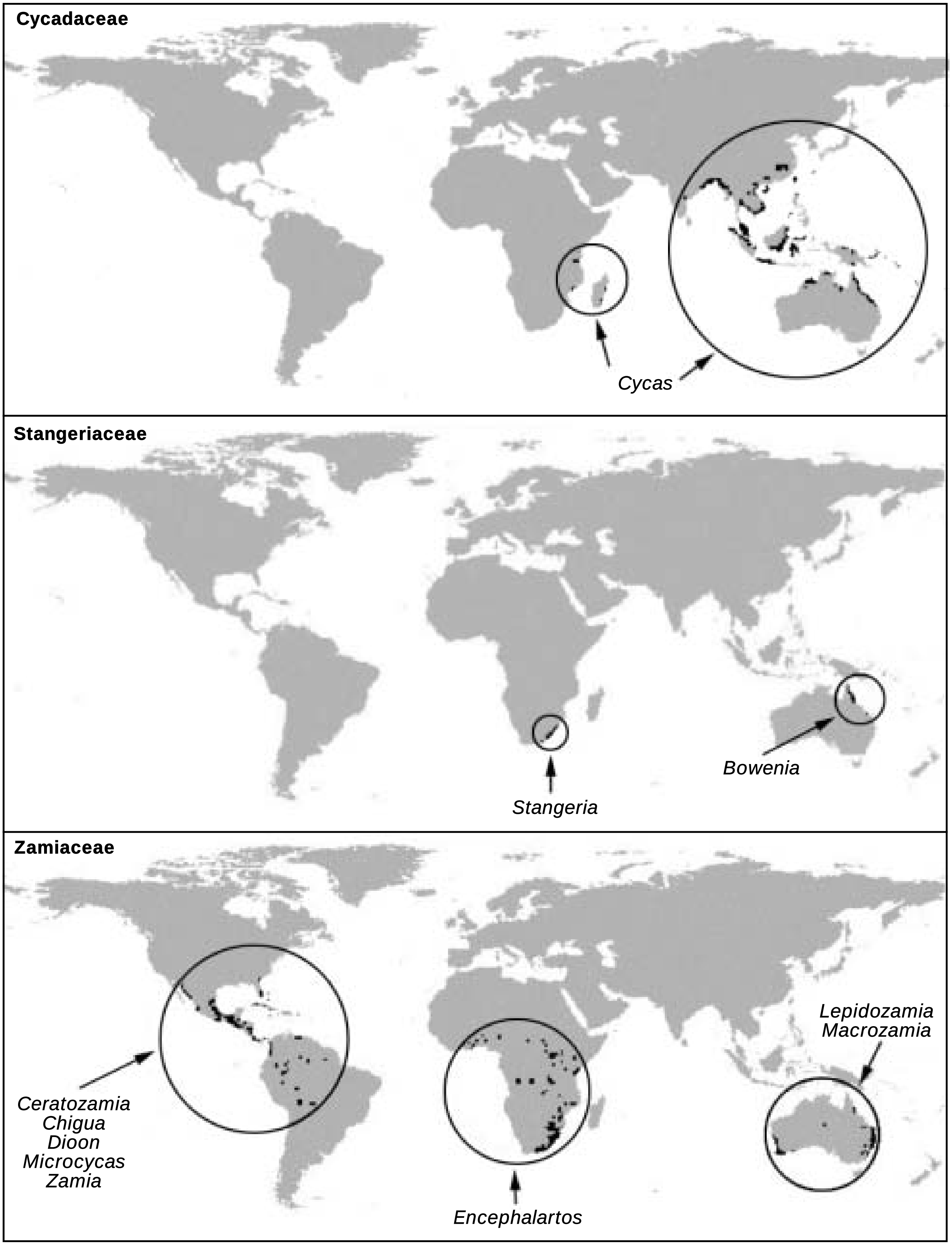
The diminutive *Bowenia spectabilis* growing in the rainforests of northern Queensland, Australia.

© J.S. Donaldson

Figure 2.1. The distribution of the three cycad families and 11 genera.



Encephalartos latifrons, a spectacular member of the Zamiaceae growing in South Africa.

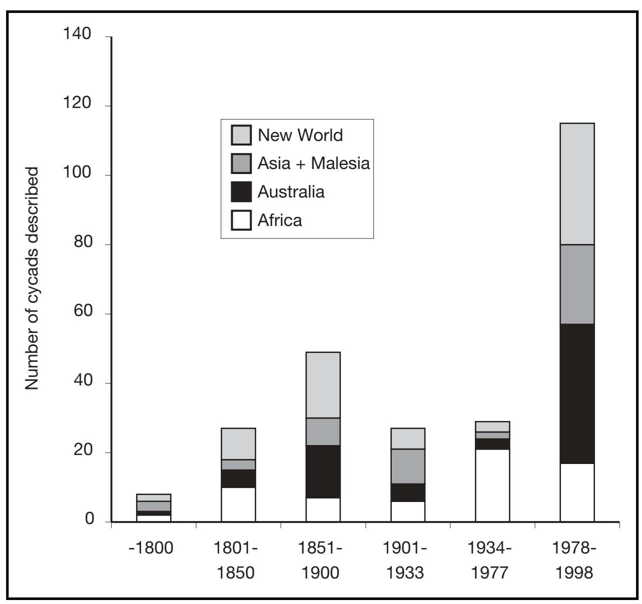
The Zamiaceae is by far the most diverse and widespread cycad family. Fossils of extinct Zamiaceae (dating from the Middle Triassic to the Eocene [54–200 MYA]) have been found in North America, Europe, Australia, South America, and Antarctica (Taylor and Taylor 1993), indicating that the family existed before the break-up of the ancient landmass of Pangaea. Today the Zamiaceae is represented by *Encephalartos* in Africa, *Macrozamia* and *Lepidozamia* in Australia, and *Zamia*, *Ceratozamia*, *Dioon*, *Chigua,* and *Microcycas* in the New World.

The number of recognised cycad species, worldwide, has increased dramatically in the last 20 years (Figure 2.2), especially in Australia, Asia, and the New World, and to a lesser extent in Africa. This is the direct result of increased study and an improved understanding of the group. Despite increased study, our knowledge of cycad diversity is still quite poor, especially for Asian species of *Cycas* (Chapter 5) and the American genera *Zamia* and *Ceratozamia* (Chapter 6). Continuing fieldwork and taxonomic studies are likely to result in additional new species, particularly in *Zamia*, and substantial changes to the taxonomy of these cycads.

In contrast, extensive field surveys and taxonomic revisions of Australian cycads have already been undertaken in the past 10–20 years (Chapter 4) and it is unlikely that many new species will be discovered in this region. A similar situation exists in southern Africa where the taxonomy of *Encephalartos* and *Stangeria* is expected to remain relatively stable (Chapter 3). However, cycads occurring elsewhere in Africa have been less well surveyed and recent fieldwork has shown that there are several new species of *Encephalartos* that need to be formally described (Heibloem 1999; P.J.H. Hurter pers. comm.; D. Goode pers. comm.).

To accommodate ongoing changes in cycad taxonomy, members of the IUCN/SSC Cycad Specialist Group have routinely published a "World List of Cycads", giving an up-to-date record of all the recognised species. The first list was published in the journal of the Cycad Society of South Africa (Osborne and Hendricks 1985) with minor amendments in a subsequent issue of the same journal (Osborne and Hendricks 1986). Several updates have followed to reflect changes in taxonomy and interpretation, especially for the genera *Cycas, Encephalartos*, *Macrozamia,* and *Zamia.* Complete revised lists have been presented at a series of International Conferences on Cycad Biology and published in the proceedings of these conferences (Stevenson *et al.* 1990; Stevenson and Osborne 1993a; Stevenson *et al.* 1995; Osborne *et al.* 1999) and elsewhere (Stevenson and Osborne 1993b). Advances in the electronic media have made it relatively easy to access the latest information and an up-to-date list of cycad species is maintained by K.D. Hill of the Royal Botanic Gardens in Sydney and can be accessed on the PlantNet website at http://PlantNet.rbgsyd.gov.au/PlantNet/cycad.

Figure 2.2. Number of known cycad species described by region and year.



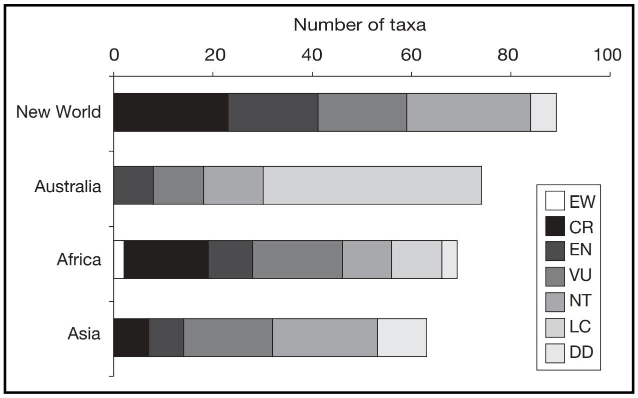


Figure 2.3. The diversity and threatened status of the world's cycad flora, ranked according to the four main regions of diversity.
EW = Extinct in the Wild, CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, DD = Data Deficient.

2.1.2 Centres of diversity and endemism

Centres of cycad diversity occur in southern Africa, Australia, and the tropical New World (Figure 2.1), although the extent of diversity varies at family, genus, and species level. All three cycad families are represented in Australia and Africa whereas Asia and the New World each have only one family (Cycadaceae and Zamiaceae respectively). At the generic level, the New World has the greatest diversity with five genera (*Ceratozamia, Chigua, Dioon, Microcycas,* and *Zamia*) while Australia has four genera (*Bowenia, Cycas, Macrozamia,* and *Lepidozamia*). Three genera occur in Africa (*Cycas, Encephalartos,* and *Stangeria*) and only *Cycas* occurs in Asia.

Cycad diversity is much more evenly distributed at the species level (Figure 2.3) with wide evolutionary radiations in *Cycas, Encephalartos, Macrozamia, Zamia, Ceratozamia,* and *Dioon*. As a result, Australia, Asia, Africa, and the New World each have more than 60 species. Notwithstanding the wide distribution at the species level, a few regions stand out as critical centres of species diversity, notably Australia, South Africa (Figure 3.1), Mexico (Figure 6.1), China and Vietnam (Figure 5.1), which together account for more than 70% of the world's cycads.

2.2 Cycads and global biodiversity hotspots

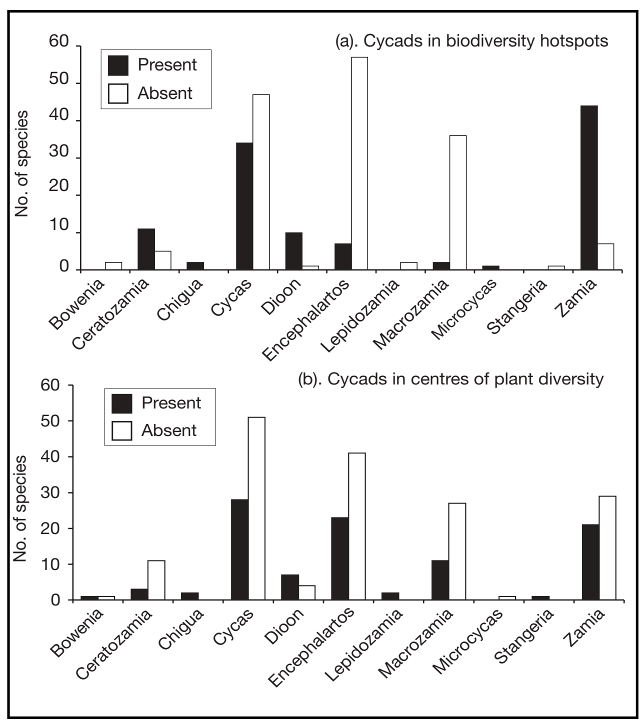
Geographical areas that have an exceptional number of plant or animal species, combined with a high proportion of endemic species, have been variously referred to as 'priority conservation areas' (ICBP 1992), 'Centres of Plant Diversity' (WWF-IUCN 1994; 1994–1995; 1994–1997), or biodiversity 'hotspots' (Myers 1988; 1990; Mittermeier *et al*. 1998; Myers *et al*. 2000). Different criteria have been used to define the boundaries of these areas, but the common theme is that a considerable proportion of terrestrial biodiversity occurs in a relatively small proportion of the earth's total land surface.

These areas of concentrated biodiversity provide one mechanism for achieving economies of scale in global conservation initiatives and there is a growing global trend towards using such megadiversity areas as focal points for conservation actions. A global conservation plan for cycads must take these trends into consideration so that cycad conservation measures can be better organised in terms of broad conservation initiatives.

In a recent study, Donaldson and Bösenberg (MS) examined cycad distributions in relation to priority conservation areas identified by the Centres of Plant Diversity project (CPD) (WWF-IUCN 1994; 1994–1995; 1994–1997) and biodiversity hotspots (*sensu* Mittermeier *et al*. 1998). The comparison of cycad distributions with the geographical limits of first order CPD sites showed that 100 cycad species (37%) occurred within these sites while 112 species (40.5%) occurred in hotspots and tropical wilderness areas identified by Mittermeier *et al.* (1998).

The proportion of cycad species occurring in global hotspots (40.5%) is close to the proportion of all plant species that occur in these areas (44%) (Myers *et al*. 2000) and there is considerable overlap between centres of cycad diversity and general centres of plant diversity. However,

Figure 2.4. Cycad distributions in relation to (a) biodiversity hotspots and (b) centres of plant diversity. Modified from Donaldson and Bösenberg (MS) using the 271 species recognised in 1999.



despite similar numbers of cycads occurring in CPD areas and hotspots, Donaldson and Bösenberg (MS) point out that there are significant differences in the actual species that occur in these areas (Figure 2.4). The CPD sites included many areas of high cycad species richness in Africa and Australia but covered fewer areas in South and Central America and Southeast Asia. Conversely, the hotspot analysis identified far larger areas of Central and South America and Southeast Asia but included only one site in Australia (south-west Australia) and four sites on the African continent (excluding Madagascar and Indian Ocean islands). As a result of these differences, the African genera, *Encephalartos* and *Stangeria,* and the Australian genera *Bowenia, Lepidozamia,* and *Macrozamia* are consistently better represented in CPD sites than in hotspots (Figure 2.4). In contrast, the predominantly Asian genus, *Cycas*, and the American genera, *Ceratozamia, Dioon*, *Microcycas,* and *Zamia* are better represented in hotspots. The two described species of *Chigua* are represented in both hotspots and CPD sites.

The plight of highly threatened cycad species is of particular concern for this Action Plan. Donaldson and Bösenberg (MS) show that threatened cycad species are slightly better represented in hotspots than cycads in general, but that there is very poor coverage for species of *Encephalartos* (<10%). Conservation plans need to ensure that cycad species that occur within global priority conservation areas benefit from the funding and actions that will focus on these areas. At the same time, we should avoid a triage approach that ignores the species that fall outside global hotspots. Cycads are ideal subjects for a range of conservation actions including ecotourism opportunities, sustainable use nurseries, and involvement by botanical gardens, and all of these options need to be explored.

2.3 Cycad interactions

Cycads do not exist in isolation and it is important, wherever possible, to consider their interactions with other organisms as part of a Cycad Action Plan. During the past few decades, research has shown that cycads have evolved symbiotic interactions with nitrogen fixing cyanobacteria, arbuscular mycorrhizae, bird and mammal dispersal agents, and with various insect pollinators (Norstog *et al.* 1986; Tang 1987; Donaldson *et al.* 1995; Donaldson 1997; Vovides *et al.* 1997; Mound and Terry 2001). There is an equally rich and complex set of non-symbiotic interactions with other insect groups (Donaldson 1991; Ackery *et al.* 1993; Donaldson and Bösenberg 1995). In all likelihood, still more interactions remain to be discovered, especially with lesser known organisms such as fungi and bacteria.

Many of the known interactions are specific to one or a few cycad species (Oberprieler 1995a, 1995b) and have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Tranes beetles massing on a male cone of *Lepidozamia peroffskyana* in Australia.

influenced the evolution of unique chemical, morphological, and behavioural attributes (e.g., Rothschild *et al.* 1986; Donaldson 1991; Ackery *et al.* 1993; Stevenson *et al.* 1999). These interactions must be viewed as specialised 'cycad interactions' and treated as such in conservation plans. Obviously, cycad conservation plans will need to ensure the continued existence of key interactions with root symbionts, pollinators, and dispersal agents, but it is equally important to conserve cycads because they have a key function in the life histories of other organisms.

2.4 Diversity and threat

Cycad conservation needs to be viewed within the dynamic context of ongoing evolution and extinction. Some cycad species occur as small relict populations of species that may once have been more widespread. However, other groups are clearly actively evolving with separate populations emerging as new species. In both cases, the result is a large number of taxa that have restricted geographical distributions and relatively small population sizes, which predisposes them to a high risk of extinction from habitat destruction, wild-collecting, and stochastic environmental events.

The 1997 IUCN Red List of Threatened Plants listed the three cycad families as amongst the most threatened plant families in the world (Walter and Gillett 1998). Certainly, the cycads rank as one of the most threatened plant groups where the majority of species occur on

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A dense stand of *Macrozamia communis* near Batemans Bay, Australia.

continental landmasses and are not restricted exclusively to islands. The global analysis shows that at least two cycads are Extinct in the Wild (studies of plants in collections suggest that there may be more) and 52% of all cycads appear in one of the IUCN Red List Categories of threat (version 3.1, 2001). The threats are dealt with in each of the regional chapters of this Action Plan, but it is important to note here that they vary in their nature and impact between regions (Figure 2.3). Ignorance of this fact has caused confusion in past attempts to deal with global cycad conservation issues. The regional analyses show that cycads in the New World, Africa, and Asia are far more threatened than those in Australia (Figure 2.3). Several Australian cycads are under threat from habitat destruction and collecting, but Australia represents a peculiar situation where many cycad species are locally common and are therefore inherently less vulnerable to extinction than those in other parts of the world. The possible reasons for this situation have not been explored, although they could offer insights into the environmental factors that influence cycad abundance. In other parts of the world, it is important to recognise that there are many threatening processes. In the past, wild-collecting has been viewed as the main threat to wild cycads but the regional chapters show that habitat destruction and even habitat modification are possibly greater threats in some parts of the world. The Action Plan therefore needs to make appropriate recommendations for each area.

Chapter 3

Regional Overview: Africa

J.S. Donaldson

3.1 Introduction

There are currently 69 recognised cycad species and subspecies in Africa and the adjacent Indian Ocean islands (this excludes at least five apparently new species that need to be described). The largest genus, *Encephalartos* (with 67 species and subspecies), and the smallest genus, *Stangeria* (with one species), are both endemic to Africa, while *Cycas thouarsii* is the only representative of the more widespread genus, *Cycas*. Cycads are distributed through 16 countries on the African continent (excluding unconfirmed reports of cycads in Togo). They occur mainly along the eastern side from South Africa to Sudan, but their distribution extends through central Africa (Uganda and Democratic Republic of the Congo) to Angola, Nigeria, Benin and Ghana in the west (Figure 3.1). Populations also occur on the oceanic islands of Madagascar, Comores, Seychelles and Zanzibar along the east coast of Africa.

Osborne *et al.* (1999) regarded the taxonomy of *Encephalartos* as almost complete. There is no doubt that *Encephalartos* is one of the better known cycad genera, but there are many aspects of the taxonomy and systematics of this genus that need to be resolved. Recent travels by cycad biologists and collectors, especially to countries in central Africa, have revealed several apparently new species (Pòcs *et al.* 1990; Slabbert and Hurter 1994; Heibloem 1999; D. Goode pers. comm.). Even among the known species, there are several species complexes that need to be revised (P. Vorster and J.H. Hurter pers. comm.) and molecular systematic studies may lead to different interpretations of these species groups. Some taxonomists also believe that

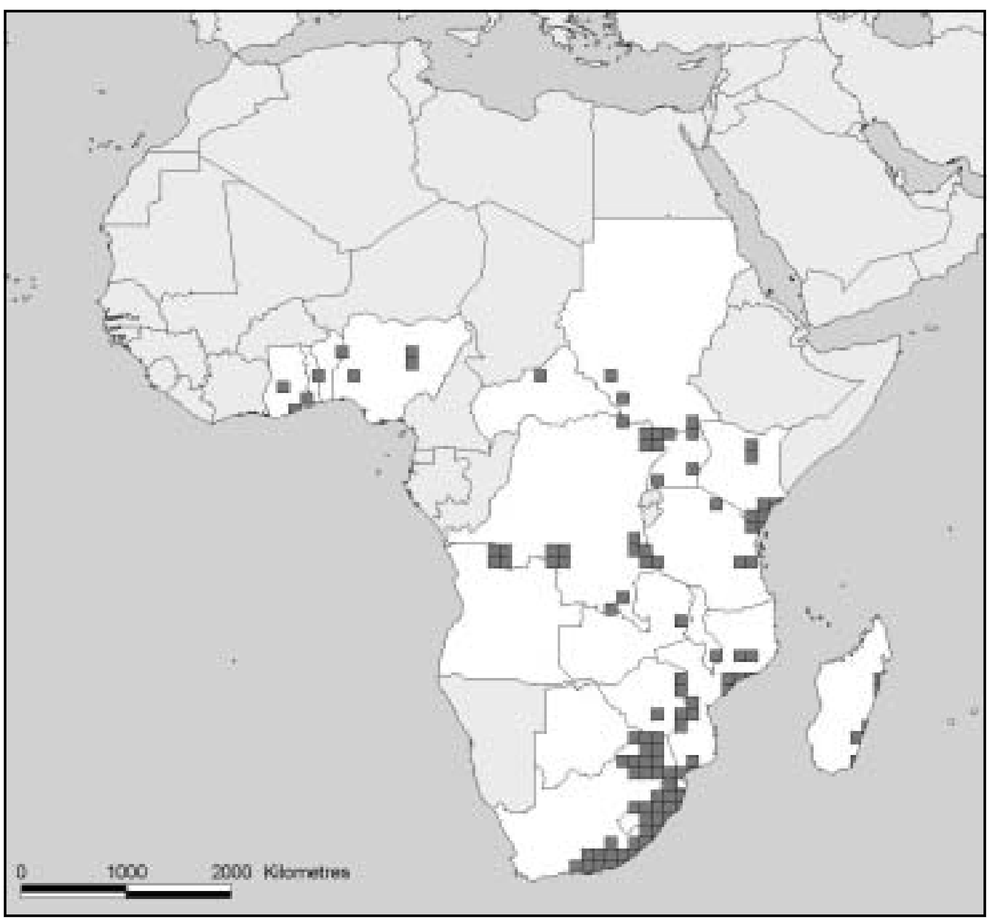
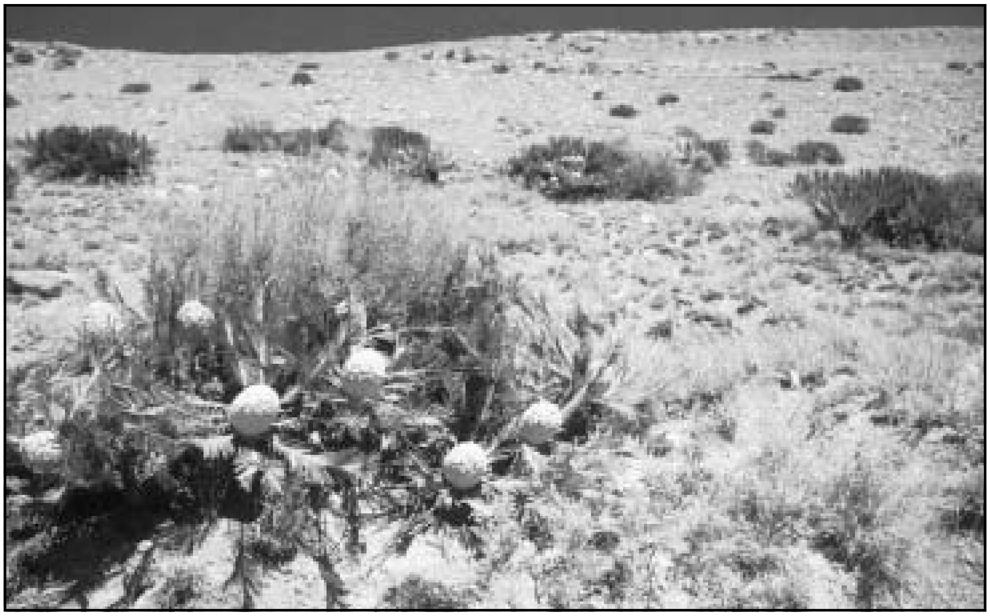


Figure 3.1. Distribution of cycads in Africa and Indian Ocean islands.



Encephalartos cycadifolius, South Africa.

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several plants in living and herbarium collections belong to undescribed species that may be Extinct or Extinct in the Wild (J.H. Hurter pers. comm.). Nevertheless, these changes are not expected to result in a substantial increase in the number of species of *Encephalartos*.

The taxonomy of *Stangeria* has been stable for many years. There are two recognised forms of *S. eriopus,* a grassland form and forest form (Dyer 1965), and there has been some debate about the meaning of these differences. Most taxonomists seem content to accept the current taxonomy in which only one species is recognised. Similarly, *C. thouarsii* is accepted as a single widely distributed species and this status is unlikely to change.

Despite the broad geographic range of cycads throughout sub-Saharan Africa, most cycad species are quite localised. Forty-five taxa occur in only one country, 18 are found in two countries, and only five occur in three or more countries. South Africa stands out as the most important centre of diversity with more than half the known African cycads (Figure 3.2). Other countries with relatively high cycad diversity (5–14 taxa) are Mozambique, Swaziland, Democratic Republic of Congo, Kenya, Tanzania, and Uganda. At the other extreme, there are ten countries each having only one cycad species (Figure 3.2). An important question to ask is whether the high diversity in South Africa is simply the result of more fieldwork and taxonomic study in this region. Cycads from South Africa are certainly better known than those from most other parts of Africa, but the relative importance of South Africa is unlikely to change as more cycads are discovered and described. There has been a sharp increase in fieldwork in Africa in recent years and, though several new species have been discovered, this has not changed the overall pattern of species richness. The known pattern of cycad species richness therefore seems to provide a reasonable base for conservation planning.

3.2 Threats to African cycads

Over the past several decades, botanists and conservationists have repeatedly warned that Africa's cycads are disappearing from the wild and that many species are threatened with extinction (Dyer 1965; Giddy 1974; Goode 1989; Osborne 1990a; Grobbelaar 1992; Osborne 1995a, 1995b). The threatened status of African cycads was recently revised as part of a global revision by Osborne (1994a, 1995a) and as part of the 1997 IUCN Red List of Threatened Plants (Walter and Gillett 1998). Southern African cycads were also evaluated for the Red Data List of Southern African Plants (Hilton-Taylor 1996a, 1996b), and the threatened status of cycads from the KwaZulu-Natal province of South Africa was revised by Scott-Shaw (1999). Southern African cycads are currently being re-evaluated as part of the SABONET (Southern African Botanical Diversity Network) project that will produce a Red List of threatened plants for ten southern African countries (J. Golding pers. comm.). Data from these publications have been updated for the Cycad Action Plan to reflect the latest information that is available for cycad populations. According to these most recent data (Table 3.1), two African cycad species are Extinct in the Wild (EW) (2.8%), 18 taxa are classified as Critically Endangered (CR) (26%), eight are classified as Endangered (EN) (12%), and 18 are classified as Vulnerable (VU) (26%). A further 11 taxa are listed as Near Threatened (NT) (16%) and nine have been categorised as Least Concern (LC). There were insufficient data to classify three species (Table 3.1). This means that, overall, two species are Extinct in the Wild and 64% of the remaining African cycads are classified in one of the threatened categories (CR, EN, or VU).

The threatened status of African cycads arises partly from natural rarity and decline. For example, several species occur as small isolated populations (e.g., *Encephalartos brevifoliolatus, E. dolomiticus, E. dyerianus, E. latifrons, E. nubimontanus, E. tegulaneus* ssp. *powysii*) that probably had relatively small populations long before humans wrought any major changes to their environment. Pearson (1916) mentioned that *E. latifrons* was scarce at a time when large scale collecting for botanical gardens was only starting to occur and several decades before intensive collecting by private plant collectors began to decimate wild populations. Similarly, *E. woodii* was described from a single multi-stemmed individual located in 1895, indicating that it was naturally rare in the Ngoye Forest (South Africa) or that it had declined for some unknown reason before collecting and habitat destruction became widespread. Notwithstanding the evidence for natural rarity, there is considerable circumstantial evidence showing that human activities have greatly accelerated the decline in cycad populations, most especially those species that were already scarce.

Identifying the causes of decline is difficult because there are few if any monitoring data for most cycad populations over a long enough period. Nevertheless, combined data from various sources, including reports of cycad trade, permit records, and the study of matched photographs (only available for South Africa and Swaziland), give some indication of the major causes of decline (Figure 3.3). These are discussed in greater detail.

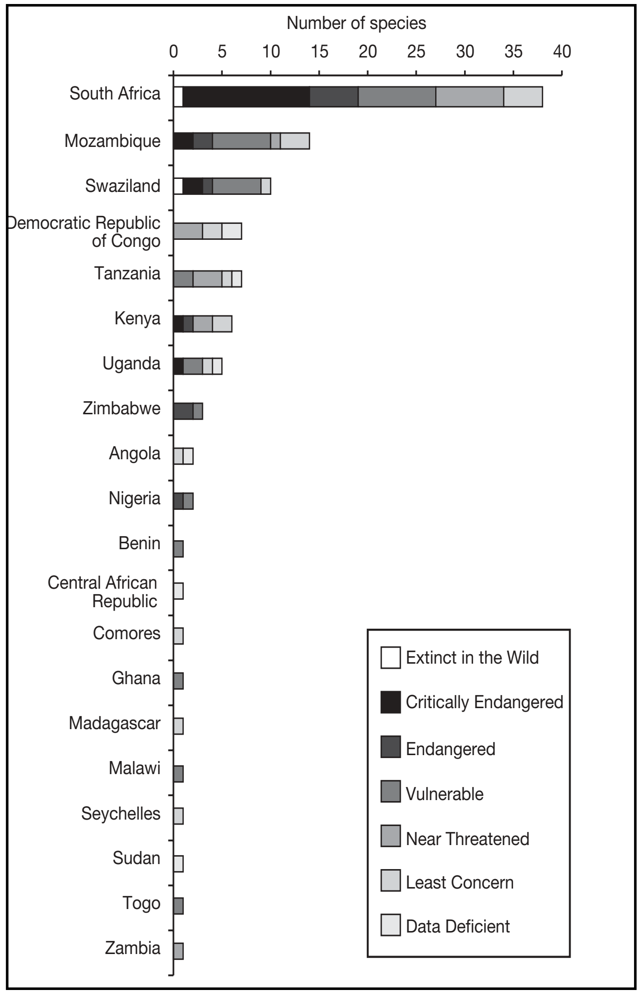

Figure 3.2. Diversity and threatened status of African cycads.

A picture of decline: matched photographs of cycad populations

There are very few records of cycad numbers in the wild before the 1970s and this makes it difficult to estimate the decline in cycad populations over time. However, there are many photographs of cycad populations and it is possible to compare the current population with the historical photograph. John Donaldson and de Wet Bösenberg found over 200 historical photographs of cycads in southern Africa and they managed to re-photograph 130 of these populations. From these matched photographs, it was possible to identify plants that had disappeared as well as new plants that had become established. When taking the matching photograph, it was possible to look for signs of removal, mortality, or habitat destruction, to explain the disappearance of specific plants (Donaldson and Bösenberg 1999).

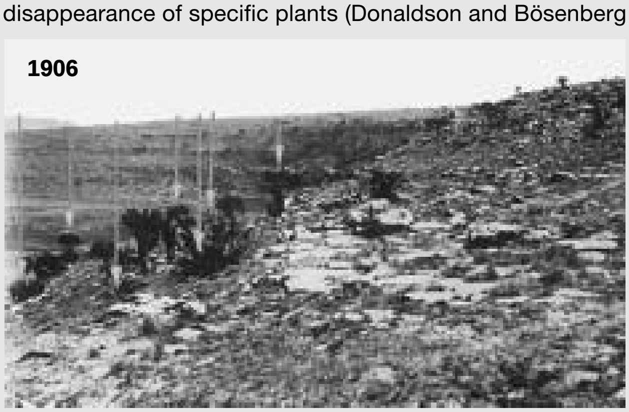

Table 3.1. The distribution and threatened status of cycads in Africa and the adjacent Indian Ocean islands[1]. Causes of threat are abbreviated as HD = habitat destruction, OC = over collecting, TU = traditional use, and RF = reproductive failure. Decline and habitat reduction represent trends within the past 30 years. See Appendix 2 for explanation of current IUCN Categories and Criteria (2001). For explanation of status in 1997 IUCN Plant Red List see Walter and Gillett (1998).

Taxon	Country	Reserve	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Source of threat	Habitat reduction
Extinct in the Wild									
E. relictus	Swaziland	N	–	EW	–	0	–	–	–
E. woodii	South Africa	N	Ex	EW	–	0	–	–	–
Critically Endangered									
E. aemulans	South Africa	N	E	CR	A2acd; B1ab(v) +2ab(v); C1	65–200	high	OC,RF	moderate
E. brevifoliolatus	South Africa	N	E	CR	B1ab(i,ii,iii,iv,v) +2ab (i,ii,iii,iv,v); C2a(ii); D	5	high	OC,RF	none
E. cerinus	South Africa	N	E	CR	A2acd; B1ab(i,ii,iii,iv,v) +2ab(i,ii,iii,iv,v); C2a(ii)	70	high	OC,RF	minor
E. cupidus	South Africa	Y	E	CR	A2acd; B1ab(ii,iii,iv,v) +2ab(ii,iii,iv,v)	500–950	high	OC,RF	moderate
E. dolomiticus	South Africa	N	E	CR	A2acd; B1ab(i,iii,iv,v); C1	175–250	high	OC,RF	minor
E. dyerianus	South Africa	Y	E	CR	A2acd; B1ab(iii,iv,v) +2ab(iii,iv,v)	500–800	high	RF	minor
E. equatorialis	Uganda	N	I	CR	B1ab(ii,iii,v) +2ab(ii,iii,v)	100–375	high	OC,HD,RF	moderate
E. heenanii	South Africa, Swaziland	Y	E	CR	A2acde; B1ab(ii,iv,v) +2ab(ii,iv,v)	300–600	high	OC,HD, TU,RF	moderate
E. hirsutus	South Africa	N	V	CR	A4acd; B1ab(iii,iv,v) +2ab(iii,iv,v)	<300	high	–	minor
E. inopinus	South Africa	N	E	CR	A2acd; B1ab(i,ii,iii,iv,v); C2a(i)	250–300	high	OC,RF	minor
E. laevifolius	South Africa, Swaziland	Y	E	CR	A2acde; B2ab(i,ii,iii,iv,v)	700–820	high	OC,HD,RF	moderate
E. latifrons	South Africa	N	E	CR	A2acd; C1+2a(i)	70–100	high	OC,RF	high
E. middelburgensis	South Africa	Y	E	CR	A2acd	420–450	high	OC,RF	high
E. msinganus	South Africa	N	E	CR	A2acd; B1ab(ii,v); C1+2a(ii)	100–200	high	OC,RF	moderate
E. munchii	Mozambique	N	E	CR	A2d; B1ab(ii,iv,v); C1+2a(i);D	17	high	OC,RF	none
E. nubimontanus	South Africa	N	E	CR	A2acd; B2ab(i,iii,iv,v); C1+2a(ii)	50–100	high	OC,RF	none
E. pterogonus	Mozambique	N	E	CR	A2cd; B1ab(ii,iv,v) +2ab(ii,iv,v); C1+2a(i);D	10	high	OC,RF	minor
E. tegulaneus ssp. *powysii*	Kenya	N	–	CR	B1ab(v)+2ab(v)	200–400	moderate	OC	minor

Table 3.1 ... continued. The distribution and threatened status of cycads in Africa and the adjacent Indian Ocean islands[1].

Taxon	Country	Reserve	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Source of threat	Habitat reduction
Endangered									
E. arenarius	South Africa	Y	E	EN	A2acd; B1ab(ii,iii,iv,v) +2ab(ii,iii,iv,v); C1	850–1,500	high	OC,HD	moderate
E. barteri ssp. *allochrous*	Nigeria	?	–	EN	A2cd; B1ab(ii,iii,iv,v); C1	300–1,000	high	OC, HD	minor
E. chimanimaniensis	Mozambique, Zimbabwe	N	E	EN	A2ad; B1ab(i,ii,iv,v) +2ab(i,ii,iv,v); C1	500–1,000	high	OC,RF	moderate
E. concinnus	Zimbabwe	Y	E	EN	A2acd; B1ab(iii,iv,v) +2ab(ii,iv,v); C1	300–1,000	high	OC,TU,RF	moderate
E. eugene maraisii	South Africa	N	V	EN	A2acd; C1	600–4,500	high	OC,RF	moderate
E. horridus	South Africa	Y	V	EN	A4cd; B1ab(i,iii,iv,v)	3,000–7,000	high	OC,HD	moderate
E. kisambo	Kenya	N	V	EN	A2cd; B1ab(ii,iii,v) +2ab(ii,iii,v)	5,200	high	OC,HD,TU	moderate
E. lebomboensis	South Africa, Swaziland, Mozambique	Y	R	EN	A2acd; B1ab(ii,iii,iv,v) +2ab(ii,iii,iv,v)	5,000	high	OC,HD	moderate
Vulnerable									
E. altensteinii	South Africa	Y	V	VU	A2cd; B2ab(i,ii,iii,iv,v)	8,000–10,000	low	OC,HD,TU	moderate
E. aplanatus	Mozambique, Swaziland	N	–	VU	A2acd; B1ab(i,ii,iii,iv,v) +2ab(i,ii,iii,iv,v); C1	2,000–4,000	high	OC,RF	moderate
E. barteri ssp. *barteri*	Benin, Ghana, Nigeria, Togo	?	–	VU	A2cd	10,000–15,000	moderate	OC,HD	minor
E. delucanus	Tanzania	?	V	VU	B1ab(iii,iv,v) +2ab(iii,iv,v); C2a(i)	<1,000	low	RF	high
E. ghellinckii	South Africa	Y	V	VU	C1	9,000–10,000	stable	OC	none
E. gratus	Malawi, Mozambique	N	V	VU	A4cd	100,000	moderate	OC,HD,RF	minor
E. humilis	South Africa	N	V	VU	A2acd; C1	4,500–10,000	high	OC,HD	high
E. macrostrobilus	Uganda	?	–	VU	B1ab(iii,iv,v); C2a(i)	300	low	HD,RF	moderate
E. manikensis	Mozambique, Zimbabwe	Y	R	VU	A2acd	10,000	moderate	OC	minor
E. ngoyanus	Mozambique, South Africa, Swaziland	Y	V	VU	A4acd; B1ab(iii,v) +2ab(iii,v)	4,300–5,000	high	OC,HD,RF	moderate
E. paucidentatus	South Africa, Swaziland	Y	V	VU	A2acd	8,000–12,000	low	OC,HD	minor
E. princeps	South Africa	N	V	VU	A4acd; C1	3,500–5,000	moderate low	OC,HD	moderate
E. schaijesii	DR of Congo	?	–	VU	B1ab(i,ii,iii,iv,v) +2ab(i,ii,iii,iv,v)	1,000–5,000	high	HD	minor
E. sclavoi	Tanzania	N	R	VU	B1ab(iii,iv,v); C1	5,000–6,000	low	HD,TU	moderate
E. senticosus	Mozambique, South Africa, Swaziland	Y	–	VU	A2acd	5,000–10,000	high	OC	none
E. trispinosus	South Africa	Y	V	VU	A4cd; C1	3,500–10,000	high	OC	minor

Table 3.1 ... continued. The distribution and threatened status of cycads in Africa and the adjacent Indian Ocean islands[1].

Taxon	Country	Reserve	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Source of threat	Habitat reduction
E. umbeluziensis	Mozambique, Swaziland	Y	V	VU	A4cd; B1ab(i,ii,iii,iv,v) +2ab(i,ii,iii,iv,v); C1	1,000–1,500	high	OC,HD	moderate
E. whitelockii	Uganda	?	E	VU	B1ab(iii,v) +2ab(iii,v); D2	5,000–10,000	low	–	minor
Near Threatened									
E. caffer	South Africa	Y	V	NT	–	10,000	low	OC,HD	moderate
E. friderici-guilielmi	South Africa	Y	V	NT	–	5,000–10,000	low	OC	minor
E. hildebrandtii	Kenya, Tanzania	Y	R	NT	–	10,000–20,000	low	HD	moderate
E. ituriensis	DR of Congo, Uganda	N	–	NT	–	>1,000	low	–	minor
E. lanatus	South Africa	Y	R	NT	–	70,000–80,000	stable	–	none
E. lehmannii	South Africa	Y	R	NT	–	5,000–7,000	low	OC	minor
E. longifolius	South Africa	Y	V	NT	–	7,000–15,000	low	OC	minor
E. marungiensis	DR of Congo, Tanzania	?	E	NT	–	>1000	low	HD	moderate
E. natalensis	South Africa	Y	R	NT	–	8,300–12,000	low	–	moderate
E. schmitzii	DR of Congo, Zambia	1?	E	NT	–	5,000–10,000	high	OC	minor
Stangeria eriopus	Mozambique, South Africa	Y	R	NT	–	100,000	high	OC,HD,TU	moderate
Least Concern									
Cycas thouarsii	Comores, Kenya, Madagascar, Mozambique, Seychelles, Tanzania	Y	–	LC	–	–	–	HD	moderate
E. bubalinus	Kenya, Tanzania	?	V	LC	–	>20,000	low	–	minor
E. cycadifolius	South Africa	N	V	LC	–	15,000–30,000	low	OC	minor
E. ferox	Mozambique, South Africa	Y	R	LC	–	100,000	low	OC,HD	moderate
E. poggei	Angola, DR of Congo	N	–	LC	–	50,000	stable	–	minor
E. tegulaneus ssp. *tegulaneus*	Kenya	?	R	LC	–	5,000–10,000	low	TU	minor
E. transvenosus	South Africa	Y	R	LC	–	20,000–50,000	low	–	minor
E. turneri	Mozambique	N	E	LC	–	10,000	low	TU	none
E. villosus	South Africa, Swaziland	Y	?	LC	–	100,000	low	OC,HD	minor
Data Deficient									
E. kanga (*ined*)	Tanzania	N	–	DD	–	–	–	–	–
E. laurentianus	Angola, DR of Congo	N	R	DD	–	–	–	–	–
E. septentrionalis	Central African Republic, DR of Congo, Sudan, Uganda	Y	–	DD	–	–	–	–	–

[1] Based on personal accounts and literature (Bamps and Lisowski 1990; Beentje 1994; Crosiers and Malaisse 1995; Dyer 1956; Dyer and Verdoorn 1969; Giddy 1990; 1992; Heenan 1977; Heibloem 1999; Hurter 1994a,b; 1995; Hurter and Claassen 1996a,b; Hurter and Glen 1995; 1996; Hurter and Whitelock 1998; Jones and Wynants 1997; Kemp 1985a,b,c; 1986a,b; 1987; 1988; 1989; 1990; 1991; 1993; Lavranos and Goode 1985; Lisowski and Malaisse 1971; Malaisse *et al.* 1993; Melville 1957; Osborne 1986; 1987a,b,c; 1988a,b,c; 1989a,b,c; 1990b,c; 1991a,b; 1992; 1993a,b; 1994a,b; 1995c; Robbertse *et al.* 1988; 1989; Slabbert and Hurter 1993; 1994; Turner 1995; 1998; Vorster 1990; 1992a,b; 1995; 1996a,b,c; Vorster and Vorster 1985; 1986).

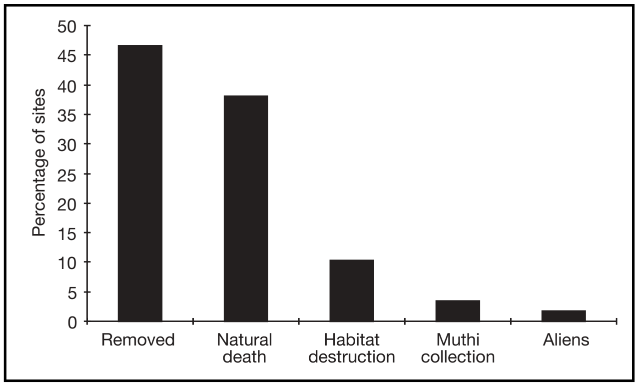

Figure 3.3. Causes of decline in cycad populations as determined from a series of 130 matched photographs **(modified after Donaldson and Bösenberg 1999).**

3.2.1 Trade in wild-collected plants

This is the most frequently cited cause of decline in African cycad populations (Dyer 1965; Giddy 1974; Goode 1989). Large numbers of cycads in gardens originated from wild populations and, based on the number of permits, former nature conservation officials in South Africa estimate that there may be over one million plants in private collections. Reports from law enforcement agencies indicate that trade in wild-collected plants is still the most important threat to cycad populations. Osborne (1995b) has challenged this view and argued that the emphasis on trade overlooks other causes of decline such as habitat destruction and the impact of traditional use (e.g., medicinal and magical use). Whilst other causes may be overlooked, a study of matched photographs from South Africa and Swaziland (Donaldson and Bösenberg 1999, MS) indicated that 60% of decline in populations of *Encephalartos* species could be attributed to trade in wild-collected plants (Figure 3.3).

3.2.2 Habitat destruction

African cycad populations are typically very localised and dispersal takes place over short distances. As a result, habitat destruction could potentially be one of the greatest threats to cycad populations. There are numerous examples where cycad numbers have declined as a direct result of habitat destruction. Urban expansion and coastal resort developments have destroyed populations of *E. hildebrandtii* along the east coast of Zanzibar, and *E. horridus* and *E. altensteinii* populations in South Africa. Bush clearing for agriculture has altered the habitat or directly reduced populations of *E. kisambo* in Kenya, *E. arenarius* and *E. latifrons* in South Africa, *E. gratus* in Mozambique, and *E. schmitzii* in Zambia. Afforestation with exotic tree species such as pines and eucalypts is a further form of habitat destruction that is affecting grassland cycads such as *E. laevifolius* and *E. humilis*. Large numbers of *E. senticosus* were removed from the wild to save them from the site where the Jozini Dam was built along the border between South Africa and Swaziland, although this has not been a major threat to the survival of the species.

Once again, there is no easy way to measure the overall impact of habitat destruction. The study of matched photographs suggests that decline in *Encephalartos* populations as a direct result of habitat destruction has occurred at *c.*12% of sites throughout southern Africa.

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Replanted specimens of *Encephalartos altensteinii* after they were illegally harvested from a wild population in the Eastern Cape province of South Africa.

A population of *Encephalartos hildebrandtii* being cleared for a resort development in eastern Zanzibar.

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Habitat destruction may also indirectly affect cycad populations by making them more visible (when surrounding vegetation is removed) and more accessible to plant collectors. It is not clear whether habitat destruction has had a greater or lesser impact elsewhere in Africa.

3.2.3 Traditional use for magical/ medicinal purposes and for food

Traditional usage for medicine and magic (collectively referred to as muthi plants, Figure 3.3) or food can be divided into three main activities; 1) the collection of bark from *Encephalartos* species for magical/medicinal purposes, 2) the use of entire stems of *Encephalartos* spp. to make a flour or paste, 3) the collection of entire *Stangeria eriopus* plants to use the stem and roots for medicinal purposes. These practices appear to be confined to specific regions and their impact therefore also varies between regions. Bark is usually harvested by slicing 10–15cm wide sections from the stems of arborescent species of *Encephalartos*. This practice has been recorded mostly from the Eastern Cape and KwaZulu-Natal provinces of South Africa. On a small scale, collection of bark probably does not have a significant impact on cycad populations because the wounds heal and the plant recovers. However, intensive collecting removes the protective layer of old leaf bases from large sections of the stem and ultimately kills the plant. Some cycad populations have declined substantially as a direct result of bark-collecting (e.g., *E. friderici-guilielmi* at Tsolo in the Eastern Cape, and several *E. natalensis* populations in KwaZulu-Natal). Results from the study of matched photographs show that bark-collecting has probably resulted in a significant decline in *Encephalartos* populations at 5% of sites. Of real concern is the observation that bark-collecting is taking place even from Critically Endangered species such as *E. latifrons* where there are fewer than 100 plants left in the wild.

Thunberg, who travelled through parts of South Africa in 1772 and 1773, first recorded the practice of harvesting cycad stems to obtain a starch-rich flour. There are no recent published accounts of this practice in South Africa, but a local chief from the Honde Valley on the border between Mozambique and Zimbabwe related how they used *E. manikensis* stems in a similar way to obtain starch during times of famine (pers. comm.). *E. hildebrandtii* stems have been used in the same way in Zanzibar (pers. obs.). The overall extent of such cycad use throughout Africa is unknown, but it is probably restricted to times of famine because the low numbers of plants, slow growth rates, and inaccessible locations make them unsuitable for more frequent use.

The harvesting of *S. eriopus* stems is a potentially serious threat. The whole plant is harvested and Osborne *et al*. (1994) recorded trade of more than 3000 plants per month from medicinal plant markets in the vicinity of Durban (South Africa). Although *S. eriopus* is still abundant throughout its original range, the level of exploitation appears to be unsustainable. However, no research has been done on plant population dynamics to determine the impact on wild populations (Chapter 7 for more details on trade).

3.2.4 Alien vegetation

Alien plants have invaded many regions where cycads occur and, in some cases, present a potential threat to existing cycad populations. For example, dense stands of *Lantana camara* L. have invaded farmlands in the Eastern

Cape province of South Africa where *E. princeps* and *S. eriopus* occur. In addition to the weeds smothering younger plants, chemical control using herbicides may also destroy plants if spraying is not carried out in a selective manner. Stands of guava (*Psidium guajava* L.) have become so dense in parts of Swaziland that it was impossible to locate cycads photographed there earlier this century (pers. obs.). Other weeds invading areas where cycads occur include prickly pear, (*Opuntia ficus-indica* L. (Mill.)), and *Acacia* spp. Despite these examples, at present alien vegetation appears to have caused population decline in relatively few instances (2% of *Encephalartos* sites according to data from matched photographs). The major impact of alien plants will probably be on cycad recruitment because of reduced coning frequencies due to shading (Donaldson, unpublished data) and the altered environment for germination and recruitment. This means that invasion by alien plants may initially be difficult to detect and will need to be carefully monitored.

3.2.5 Critically small populations

A decline in population numbers (both natural and human-induced) can lead to problems associated with small population size. Such problems include genetic effects (inbreeding depression and genetic bottlenecks), ecological effects (such as the breakdown of pollination and dispersal mutualisms and the elimination of root symbionts), and increased vulnerability to stochastic events (drought, flood). Little is known about these effects on cycad populations but all of the Critically Endangered and most of the Endangered species have less than a few hundred individuals left in the wild. Because cycads are dioecious (plants are either male or female), have a long juvenile phase, and may cone infrequently, the effective population size is likely to be much lower than the number of individuals actually recorded from the wild. As a result, the negative effects of small population size are likely to be a major factor influencing the survival of cycad populations.

The effects of small population size on cycad populations are poorly studied. A low number of fertile seed does however appear to be a common phenomenon in small cycad populations in southern Africa and elsewhere (Vovides *et al*. 1997; Donaldson 1999; Heibloem 1999). In addition to possible genetic causes of poor seed set, three significant influences on seed set are pollen limitation due to increased distances between male and female plants, the local extinction of insect pollinators, and skewed sex ratios. Recent research has shown that several species of *Encephalartos* are insect-pollinated (Donaldson *et al.* 1995; Donaldson 1997) and that many of the known or suspected pollinators are associated with only one or a few species of cycad (Oberprieler 1995a, 1995b; 1996). Surveys of cycad insects in South Africa, Zimbabwe, Zanzibar, and Kenya indicated that insect pollinators are already extinct in some cycad populations and there is very low seed production in these populations (Donaldson 1999). Sex ratios also seem to change as cycad populations decline. Large vigorous populations have a sex ratio approaching 1:1 (Grobbelaar 1999; Raimondo 2001) but small populations of *Encephalartos* appear to be dominated by males, (e.g., the male:female ratio for *E. latifrons* is 4:1, the few remaining specimens of *E. brevifoliolatus* are all males, and the only known plant of *E. woodii* is also male). In addition to differential mortality of males and females, skewed sex ratios could also arise because plant collectors target female plants.

3.3 Addressing the threats

3.3.1 Trade restrictions

Trade restrictions are dealt with in detail in Chapter 7 but a summary for African species is provided here. All species of *Encephalartos* and *Stangeria* are listed on CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) Appendix I. This means that international trade in wild-collected plants is prohibited. Garden propagated material can be traded and, in most instances, is subject to the conditions that apply to Appendix II plants. There has been no attempt to evaluate the effect of CITES listings on trade in African cycads or the benefits for cycad conservation. It is known that illegal shipments do still occur and many legitimate collectors and nursery owners regard CITES as ineffective and obstructive. Nevertheless, local conservation and law enforcement agencies still regard CITES regulations as a significant deterrent to international trade in wild-collected plants.

Although CITES allows trade in seeds of Appendix I species, South Africa and several importing countries have implemented a restriction on trade in seeds of *Encephalartos* and *Stangeria*. The rationale for this restriction is that wild-collected seeds cannot be distinguished from cultivated seeds. This is a controversial decision because it places restrictions on legitimate trade in seeds and probably has limited conservation value (Anderson 1993). Members of the IUCN Cycad Specialist Group have advocated lifting restrictions on trade in *Encephalartos* seeds to allow seeds to become more widely available to collectors. The rationale is that this would satisfy demand and eliminate the involvement of smuggling syndicates. Deterministic population simulation models indicate that seed harvesting will not have a significant negative impact on populations of *Encephalartos* (Raimondo 2001).

Effective implementation of laws to restrict trade in wild-collected cycads is one of the major problems facing customs and law enforcement agencies in Africa. Law enforcement agencies are often understaffed and lack the capacity to deal with cycad poaching. Even when they are apprehended, plant collectors may avoid prosecution because of technicalities in the law that require proof from the state that the plants were indeed collected in the wild. To overcome this problem, conservation agencies in South Africa have experimented with the use of microchips to provide a unique identity for cycads that are at risk. Microchipped plants can be used to trace the movements of plants in trade and provide evidence in the case of illegal transactions in wild-collected plants.

3.3.2 The protected area network

At least 25 African cycad species are included in one or more reserves. However, 13 Critically Endangered taxa and a further four Endangered and eight Vulnerable species do not appear to occur in any protected area. There is also a need to distinguish between different types of reserve and the way they are likely to function in cycad conservation. All reserves are important for reducing the effects of habitat destruction, but not all reserves will effectively reduce illegal trade in wild-collected plants. Collecting is likely to be eliminated only in reserves that have restricted access and tightly controlled entry and exit points. Osborne (1995b) listed reserves for 24 southern African cycad species, but 16 of these reserves do not have adequate access controls and plants have disappeared from several of these reserves. Probably the most spectacular example is the massive decline in numbers of *E. laevifolius* in the Starvation Creek area in Mpumalanga (South Africa), where 80% of the known plants in one population were illegally removed between 1989 and 1996. Nevertheless, 19 cycad species do occur in reserves with appropriate protection.

There is a strong correlation between initial rarity and population decline, due to collectors focusing on rare species (Donaldson and Bösenberg 1999). This means that strict access controls to reserves may only be necessary in the case of the most threatened and sought after species (e.g., *E. laevifolius*) where there is a strong incentive to collect plants even from within protected areas. It also highlights the extreme vulnerability of threatened species that are not included in reserves (Table 3.1).

3.3.3 *Ex situ* collections in botanical gardens

An overview of the role of botanical gardens and the status of garden collections is presented in Chapter 8. Only aspects that are specific to African cycads are dealt with here.

African cycads are relatively well represented in six gardens belonging to the National Botanical Institute (NBI) in South Africa, the Durban Botanic Garden (South Africa), Ewanrigg Botanic Garden and the Harare Botanic Garden (Zimbabwe), and the National Museums of Kenya in Nairobi. In some instances, these collections are not well documented and comprise only a few plants of each species, but the number of well documented and genetically representative collections of African cycads is steadily increasing. The NBI and Durban Botanic Gardens in South Africa have developed genebanks for several of the more threatened species and complementary genebanks are being developed at the Montgomery Botanical Center in the USA and Nong Nooch Tropical Garden in Thailand. It is particularly important to ensure that species that are already extinct in the wild are present in collections (for scientific and educational purposes) and that genebanks are set up for the most threatened species. At present, *E. relictus* (EW) is present in only one botanical garden collection, and genebanks for *E. brevifoliolatus, E. heenanii, E. hirsutus, E. latifrons, E. msinganus, E. munchii, E. pterogonus,* and *E. tegulaneus* ssp. *powysii* (all CR) either do not exist or need to be strengthened. The same is true for several Endangered species.

One of the challenges for *ex situ* collections in Africa is the maintenance of specific mutualisms within botanical gardens. If one of the goals of *ex situ* genebanks is to provide material for reintroductions, then it is important to also preserve beetle pollinators that have specific relationships with certain African cycads (Donaldson *et al*. 1995; Donaldson 1997). However, cycads in southern Africa are also colonised by cycad weevils that destroy the seeds (Donaldson 1991, 1993). *Ex situ* genebanks therefore have to be carefully managed to ensure that control of seed feeding weevils does not destroy beetle pollinators.

3.3.4 Sustainable use and community projects

The concept of sustainable utilisation has been applied to cycad conservation in parts of Africa. Community projects are discussed in more detail in Chapter 8 and are only summarised here. Cycad nurseries based on wild-collected seeds have been set up in South Africa either under the control of provincial nature conservation departments or in collaboration with rural communities (e.g., the *E. transvenosus* nursery at Modjadji and the *E. lebomboensis* nursery at Mananga). In some cases, licences/permits are issued to individual farmers to enable them to harvest small quantities of seeds. Despite these initiatives, sustainable utilisation of wild-collected seeds has not been fully investigated or used as a conservation tool. As a result, landowners often feel that they have no ownership of the cycads on their land and there is no incentive for them to conserve the plants. This can have serious consequences for cycad conservation because so many threatened species occur on private or communal farmland outside the reserve system.

Seed harvesting schedules and monitoring procedures need to be established to enable landowners to exploit this resource if they so desire. Further sustainable use projects in rural communities also need to be investigated. In the case of rural communities it may be necessary to provide infrastructure and training to make it possible to utilise seed on a sustainable basis.

3.3.5 Species recovery programmes

For cycad species with critically small populations, some form of intervention may be required to promote population persistence. Reinforcement (adding individuals to an existing population), reintroductions (re-establishing a species in an area where it has died out) and introductions (establishment of a species outside its natural distribution) have all been attempted in various parts of Africa. In some cases, these interventions have been proactive attempts to limit population decline and have used plant material specifically grown for this purpose. In other instances, these interventions have happened reactively when wild-collected plants have been confiscated. One of the most comprehensive cycad conservation programmes was established by the former Transvaal Provincial Administration (TPA) in South Africa that included a monitoring programme, an *ex situ* nursery, and several reintroduction projects. The nursery was later closed and the plants of conservation value were transferred to the National Botanical Institute. The entire programme effectively came to an end when the provincial boundaries were altered in 1994 although the Parks Board in Mpumalanga (one of the provinces established in 1994) continued with much of the work. There are important lessons that emerge from this effort that should inform future recovery programmes; 1) Cycad recovery programmes are often difficult to implement, 2) *ex situ* collections need to be carefully documented and maintained, 3) the success rate of introductions varied considerably (Boyd 1995) and further research is required to identify the most successful methods and stages for reintroduction, 4) projects need support from the local community when they occur outside reserves, and 5) the main factors limiting population increase need to be identified. This last point may seem quite obvious but most recovery plans in the past have been implemented without taking limiting factors into consideration.

Due to the overwhelming impact of trade in wild-collected plants on cycad survival in Africa, cycad conservation has tended to focus on trade issues. Other essential elements of conservation such as the biological processes that underpin population survival or the sociological context in which conservation actions take place have received less attention. This has contributed to the perception that conservation actions are ineffective. Integrated conservation programmes are essential to overcome this problem, especially for the most threatened species. Integrated plans will almost certainly require several actions, which may include: protection from collecting; identifying other threatening processes; reinforcement; reintroductions or some other form of intervention to counteract the threatening process; and interaction with the parties affected by conservation actions.

In several countries, such as Kenya, Zimbabwe, Swaziland, and South Africa, there is a growing realisation that effective cycad conservation requires partnerships between law enforcement agencies, conservation departments, scientists, and local communities. These partnerships may be difficult to establish and often rely on one or two committed individuals, but they seem to be a necessary prerequisite for successful species recovery programmes. It is essential that proactive interventions are undertaken for the most endangered species and that guidelines are drawn up for planting cycads in the wild. In the case of confiscated wild-collected plants, these guidelines should also establish under what conditions it would be of greater conservation value to use the plants in an *ex situ* breeding programme from which seeds can be obtained for reintroduction purposes. There are many countries in Africa where the capacity to undertake these activities is severely limited. The only obvious way around this problem is to develop regional programmes so that resources can be shared and to develop partnerships with international organisations.

Chapter 4

Regional Overview: Australia

K.D. Hill

4.1 Introduction

Australia has a rich cycad diversity with 76 species and subspecies in 4 genera and 3 families (Table 4.1). This represents approximately 25% of the world cycad flora, including some genera that also occur in other regions. Although cycad diversity is high, distribution is far from uniform (Figure 4.1) and many species occur only in restricted areas. The four different genera also show markedly different patterns of distribution that partly reflects their historical biogeography – Zamiaceae and Stangeriaceae were both present on the ancient supercontinent of Gondwana whereas Cycadaceae originated in Laurasia. Species within the same genus seldom occur together so that species replace each other in different localities. Sometimes species in different genera do occur together, but this happens infrequently.

The number of species recorded for Australia has increased dramatically over the past two decades (Chapter 2, Figure 2.2). This has been the result of detailed taxonomic scrutiny and comprehensive field surveying. Many of the new taxa are new discoveries, with the first herbarium collections made only in the last 10–20 years. Botanical exploration of Australia has been extensive during this period, driven by the Flora of Australia project, and it now seems unlikely that many new taxa remain to be discovered.

The greatest diversity within Australia exists along the eastern and northern coastal zone, not extending inland more than 100–200km. Within this broad region, "hot spots" occur in Cape York Peninsula, the north of the Northern Territory, and the Queensland–New South Wales border region (Figure 4.1).

4.2 Threats to Australian cycads

Australia has an exceptional diversity of cycads and it appears to be a region where there are relatively few threats to their survival. Low human population numbers and a relatively affluent industrialised society have resulted in few of the land-use or traditional use threats that occur in

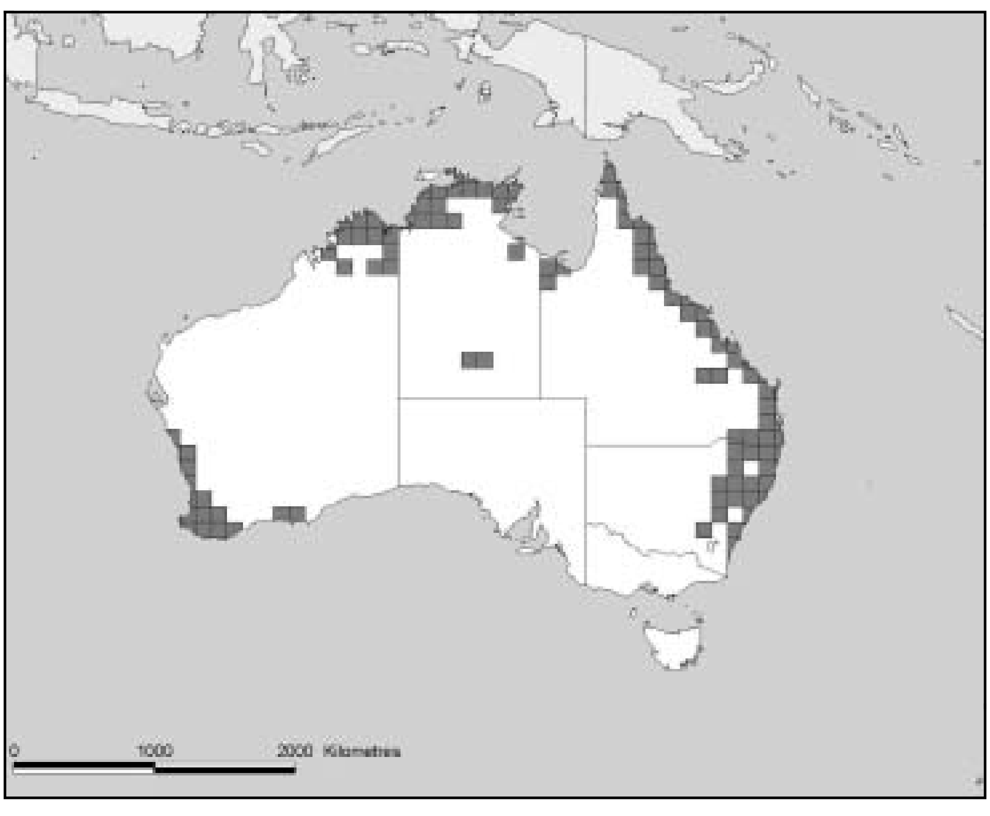

Figure 4.1. Cycad distribution in Australia.

Africa, Asia, and the New World. Threats to cycad habitat, when they occur, are usually from industrialised agriculture or residential development. Australian cycads have also not been targeted by collectors to the same extent as those in Africa and Mexico although collecting does represent an increasingly important threat to some populations.

Australian cycads often occur in large and healthy populations although detailed population data are not available for all species. Few of the Australian species would qualify as threatened following the methods used by Hilton-Taylor (1996a, 1996b) for African taxa. However, within Australia, rare or threatened status has been assigned using the Australian ROTAP (Rare or Threatened Australian Plants) system that was devised by Briggs and Leigh (1988, 1996) independently of the IUCN system. Under this system, two Australian taxa are treated as Endangered, 17 as Vulnerable, and 9 as Rare (Table 4.1). Note that these determinations are based on now outdated taxonomies. The IUCN Red List Categories and Criteria (version 3.1) provide quantitative assessments that make comparisons with other taxa and other regions more meaningful. A number of taxa have suffered notable population decline in the past (Table 4.1), and even though the causes for decline have now been reduced, they would still qualify for threatened status. Eight taxa are now classified as Endangered and 11 as Vulnerable using the IUCN Criteria, and the remainder fall into the Near Threatened or Least Concern Categories. The majority of the Endangered and Vulnerable taxa are species of *Cycas* or small species of *Macrozamia* in the section *Parazamia,* especially species that occur on agricultural land in southeast Queensland and northern New South Wales.

4.2.1 Fire

Fire is a significant threat to some populations in the long term, particularly in the monsoon woodlands of the Australian tropics. Although the plants occurring in these regions are remarkably well adapted to fire, fire frequency has increased as a result of land management practices. In many instances, seeds are killed by fire before they can germinate and this has disrupted regeneration.

4.2.2 Collection from the wild

There is evidence of cycads being removed from the wild for cultivation at many sites in Australia. In the past, usually only small numbers of plants were removed because Australian cycad species had lower value for collectors when compared with taxa from other parts of the world. In most species, regeneration from seed seems to have been sufficient to replace harvested individuals, but the impact of collecting will need to be monitored in populations now classified as threatened. A recent awareness of native flora, and an appreciation of the

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Cycas calcicola resprouting after fire in the Northern Territory of Australia.

Macrozamia dyeri near Cape Arid in Western Australia.

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horticultural usefulness of certain *Macrozamia* species, is leading to an increased demand from landscapers for these plants. As a result, pressure on wild populations of these slow- growing plants is likely to increase. Some taxa have already been removed in commercial quantities, but this is usually restricted to land destined for development and is regulated by a licence system that is monitored by conservation authorities.

Table 4.1. The distribution and threatened status of Australian cycads (*Bowenia, Cycas, Lepidozamia,* and *Macrozamia*). ROTAP refers to the Australian categories applied by Briggs and Leigh (1988, 1996). In the reserve column, taxa that occur on aboriginal lands are denoted by AL. Decline and habitat reduction represent trends within the past 30 years. See Appendix 2 for explanation of current IUCN Categories and Criteria (2001). For explanation of status in 1997 IUCN Plant Red List see Walter and Gillett (1998).

Taxon	Reserve	ROTAP status	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Extent of occurrence (km^2)	Habitat reduction (%)
Endangered									
C. canalis ssp. *canalis*	AL	*2V	–	EN	A2c; B1ab(iii,iv,v) +2ab (iii,iv,v)	>10,000	high	50	20–50
C. megacarpa	Y	3VC-	V	EN	A2c	2,500–10,000	high	200	20–50
C. platyphylla	N	3V	V	EN	A2c	2,500–10,000	low	50	20–50
M. conferta	N	2V	V	EN	A2ad	2,500–10,000	low	50	20–50
M. elegans	Y	*2VC-	–	EN	A2ad	2,500–10,000	high	50	20–50
M. flexuosa	N	2K	–	EN	A4c	2,500–10,000	high	100	20–50
M. pauli-guilielmi	N	2E	–	EN	A2c	1,000–2,500	high	100	50–80
M. spiralis	Y		–	EN	A2c	1,000–2,500	high	100	50–80
Vulnerable									
C. conferta	Y	2VCi	V	VU	C1	2,500–10,000	low	100	20–50
C. desolata	N	*2V	–	VU	D2	1,000–2,500	stable	20	<10
C. silvestris	N	2V/2R	V	VU	D2	2,500–10,000	stable	50	<10
M. cranei	N	2K	–	VU	D2	1,000–2,500	low	50	10–20
M. crassifolia	N	2R	R	VU	D2	1,000–2,500	low	50	10–20
M. humilis	Y	*2VC-t	–	VU	D2	1,000–2,500	stable	10	20–50
M. lomandroides	Y	2EC-	E	VU	A2c	2,500–10,000	high	50	50–80
M. occidua	Y	2VC-t	V	VU	D2	1,000–2,500	stable	50	<10
M. parcifolia	Y	2RC-	R	VU	C1; D2	1,000–2,500	high	20	20–50
M. secunda	Y	–	–	VU	A2c	>10,000	low	500	20–50
M. viridis	Y	2VC-/2RC-	V	VU	D2	1,000–2,500	stable	50	20–50
Near Threatened									
C. arenicola	AL	2K/2RI	–	NT	–	2,500–10,000	stable	50	<10
C. badensis	AL	*2R	–	NT	–	1,000–2,500	stable	20	? <10
C. brunnea	Y	3RC-	R	NT	–	2,500–10,000	stable	100	<10
C. cairnsiana	N	2V	V	NT	–	2,500–10,000	low	50	10–20
C. couttsiana	N	2R	R	NT	–	2,500–10,000	stable	50	<10
C. maconochiei ssp. *maconochiei*	N	*2V	–	NT	–	>10,000	high	50	20–30
C. ophiolitica	Y	2V	V	NT	–	2,500–10,000	high	100	20–30
C. semota	AL	*2V	–	NT	–	2,500–10,000	stable	50	<10
C. tuckeri	N	*2V	–	NT	–	2,500–10,000	stable	10	<10
C. yorkiana	N	*2R	–	NT	–	>10,000	stable	100	<10
M. plurinervia	Y	–	–	NT	–	1,000–2,500	low	50	20–30
Least Concern									
B. serrulata	Y	–	–	LC	–	>10,000	stable	30	10–20
B. spectabilis	Y	–	–	LC	–	>10,000	stable	500	10–20
C. angulata	N	–	–	LC	–	>10,000	stable		10–20

Table 4.1 ... continued. The distribution and threatened status of Australian cycads (*Bowenia, Cycas, Lepidozamia,* and *Macrozamia*).

Taxon	Reserve	ROTAP status	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Extent of occurrence (km²)	Habitat reduction (%)
C. armstrongii	N	–	–	LC	–	>10,000	low	150	10–20
C. arnhemica ssp. *arnhemica*	AL	–	–	LC	–	>10,000	stable	100	<10
C. arnhemica ssp. *muninga*	AL	–	–	LC	–	2,500–10,000	stable	40	<10
C. arnhemica ssp. *natja*	AL	–	–	LC	–	2,500–10,000	stable	100	<10
C. basaltica	Y	–	–	LC	–	–	stable	100	<10
C. calcicola	Y	–	–	LC	–	2,500–10,000	stable	200	10–20
C. canalis ssp. *carinata*	N	–	–	LC	–	>10,000	stable	150	<10
C. furfuracea	Y	–	–	LC	–	>10,000	stable	150	<10
C. lane-poolei	N	–	–	LC	–	>10,000	stable	50	<10
C. maconochiei ssp. *viridis*	AL	–	–	LC	–	2,500–10,000	stable	50	<10
C. maconochiei ssp. *lanata*	AL	–	–	LC	–	>10,000	stable	200	<10
C. media ssp. *banksii*	Y	–	–	LC	–	>10,000	low	200	20–30
C. media ssp. *ensata*	N	–	–	LC	–	2,500–10,000	stable	100	<10
C. media ssp. *media*	N	–	–	LC	–	>10,000	low	300	20–30
C. orientis	N	–	–	LC	–	>10,000	stable	200	<10
C. pruinosa	Y	–	–	LC	–	>10,000	stable	600	<10
C. xipholepis	Y	–	–	LC	–	>10,000	stable	200	<10
L. hopei	Y	–	–	LC	–	>10,000	stable	400	20–30
L. peroffskyana	Y	–	–	LC	–	>10,000	low	600	20–30
M. cardiacensis	Y	*2RC-t	–	LC	–	1,000–2,500	stable	10	<10
M. communis	Y	–	–	LC	–	>10,000	low	600	20–30
M. concinna	N	–	–	LC	–	1,000–2,500	high	300	20–30
M. diplomera	Y	–	–	LC	–	>10,000	low	200	20–30
M. douglasii	Y	–	–	LC	–	>10,000	stable	100	<10
M. dyeri	Y	–	–	LC	–	>10,000	low	100	20–50
M. fawcettii	Y	–	–	LC	–	>10,000	high	200	20–30
M. fearnsidei	Y	2VC-/-	V	LC	–	>10,000	low	200	20–30
M. fraseri	Y	–	–	LC	–	2,500–10,000	low	400	20–30
M. glaucophylla	N	–	–	LC	–	2,500–10,000	stable	100	20–30
M. heteromera	Y	–	–	LC	–	>10,000	stable	50	10–20
M. johnsonii	Y	2RC-	R	LC	–	>10,000	stable	50	<10
M. longispina	N	–	–	LC	–	2,500–10,000	low	100	20–30
M. lucida	Y	–	–	LC	–	>10,000	high	200	20–30
M. macdonnellii	Y	3VCa*	V	LC	–	>10,000	stable	200	<10
M. miquelii	N	–	–	LC	–	>10,000	low	400	20–30
M. montana	Y	–	–	LC	–	>10,000	low	300	20–30
M. moorei	Y	–	–	LC	–	>10,000	low	200	20–30
M. mountperriensis	Y	–	–	LC	–	>10,000	low	200	50–80
M. platyrhachis	Y	2EC-/2RCat	E	LC	–	2,500–10,000	stable	50	<10
M. polymorpha	N	–	–	LC	–	>10,000	low	100	20–30
M. reducta	Y	–	–	LC	–	>10,000	low	400	20–30
M. riedlei	Y	–	–	LC	–	>10,000	low	400	20–30
M. stenomera	Y	–	–	LC	–	2,500–10,000	stable	200	10–20

4.2.3 Habitat loss

In Australia the greatest damage to cycad populations in the past and the greatest threat in the future is from habitat loss. Large-scale clearing of land has removed entire populations of *Macrozamia communis*, *M. moorei*, *M. pauli-guilielmi, M. lomandroides*, *Cycas media*, *C. ophiolitica*, *C. canalis,* and *C. armstrongii*. However, most of these species remain in viable populations and in numbers of tens of thousands or even millions.

Cycads contain powerful toxins that can cause substantial losses to stock farmers. As a result, a number of cycad species were once regarded as problem species in Australia and were the target of selective eradication programmes. However, this practice seems now to have virtually disappeared.

4.2.4 Other threats

Additional threats to wild cycad populations that have been recorded in other parts of the world include; suppression of reproduction due to loss of pollinating organisms, reduction of viability in critically small populations due to accumulation of genetic abnormalities, and reduced regeneration due to competition from introduced invasive weedy species. None of these factors have been identified as a threat in any of the Australian populations.

4.3 Addressing the threats

All Australian states in which cycads occur have enacted new or revised plant protection legislation in the last 10 years, or are doing so at the moment. The legislation addresses all current threats to Australian cycads, providing that they are adequately monitored and enforced. Most Australian species also occur in part or in total on land that is protected or reserved in some way (Table 4.1).

In view of the large and healthy populations of most Australian cycads, and the comprehensive statutory protection of these plants, many of the conservation strategies discussed for other regions would seem unnecessary or inappropriate. Some species are not adequately reserved, and action is required to improve this situation. The most significant remaining threat in Australia is illegal removal from the wild by growers. This does not occur in sufficient quantity to be of great concern in the short term, but presents the potential of cumulative long-term damage to the populations, especially for the rarer taxa. The demand for these plants among collectors must be acknowledged, and any comprehensive conservation strategy must address this, (e.g., most state legislation allows limited and monitored collection of plants or seeds from the wild, but this does not cover all species).

In summary, current legislation appears to be sufficient to protect Australian cycads and laws seem to be adequately enforced. Plans to ensure the inclusion of the 24 species not yet found in protected areas should be developed. *Ex situ* conservation programmes such as those advocated for African cycads seem to be unnecessary for almost all Australian cycads. A framework for sustainable use of cycad populations is in place in most states and it is now necessary to ensure that harvesting limits and practices are properly monitored. The actions that are required to conserve Australia's cycad diversity are mostly additional population surveys and detailed assessments of decline in the species now classified as Endangered.

Chapter 5

Regional Overview: Asia

K.D. Hill, C.J. Chen, and P.K. Loc

5.1 Introduction

Cycads are represented throughout Asia by a single genus, *Cycas*, and *c.*63 species are thought to occur in the region (Table 5.1). Cycad abundance and diversity is not uniformly distributed throughout Asia and a number of centres of diversity are evident (Figure 5.1). These evolutionary "hotspots" require careful and specific attention in order to maximise the effectiveness of conservation actions in Asia. The main centres of diversity are Vietnam (24 species), China (21), Thailand (10), Indonesia (7), Papua New Guinea (PNG) (6), Philippines (5), and Malaysia (3) (Figure 5.2). Fourteen of these cycads (*c.*25%) are widespread taxa that occur in more than one country but the remainder have more restricted distributions. The cycad floras of Myanmar, Laos, and Cambodia are not well known, but no cycad species appear to be endemic to these countries and levels of threat are thought to be similar to adjacent countries where the cycads occur (Table 5.1). Although the number of species in any one country may not be high, the level of variation within species is very high, so that even countries with low diversity may contain distinct gene pools of widespread species.

As in most other regions with indigenous cycads, the number of recognised species in Asia has increased dramatically in the last 20 years (Chapter 2, Figure 2.2). This is the natural result of increased study and improved understanding of the group. However, there are numerous problem areas within the genus *Cycas* and many species still need to be described. We can therefore anticipate

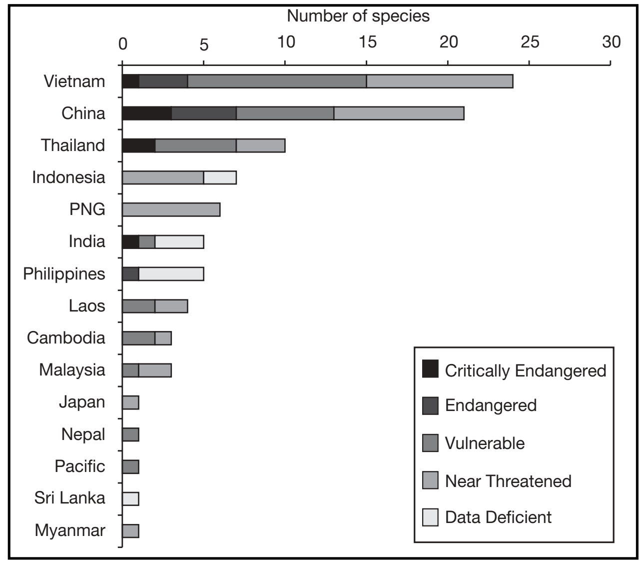

Figure 5.2. Diversity and threatened status of Asian cycads.

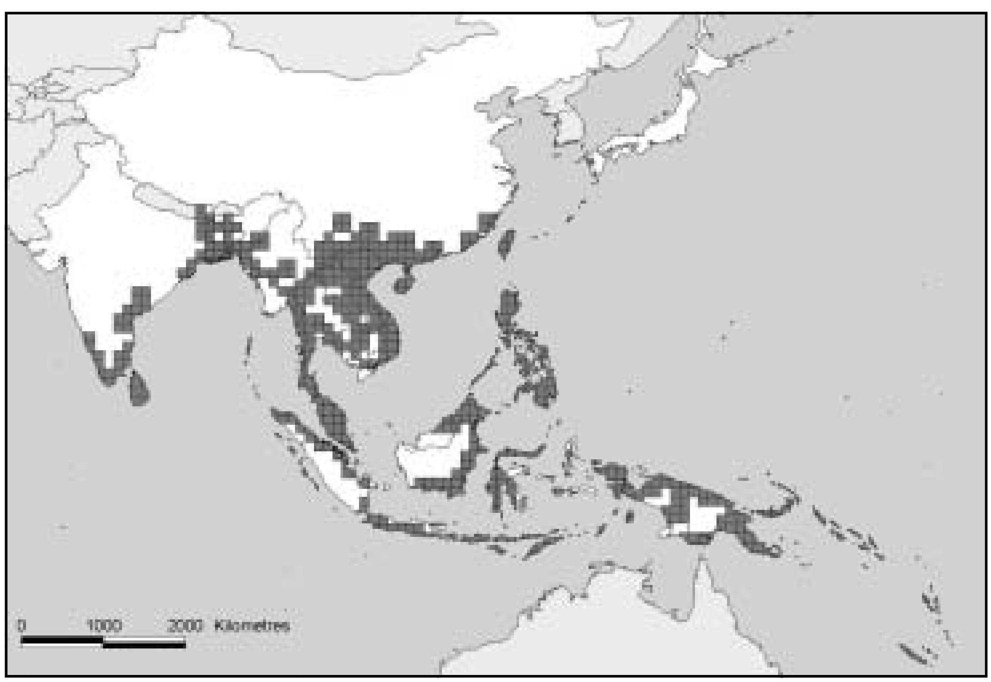

Figure 5.1. Distribution of cycads in Asia.

substantial changes to the taxonomy of the Asian cycads. In general, species-level taxonomy is still unclear and confused. Many new species that have been described in recent years by various authors have doubtful taxonomic status, whereas in other cases perfectly valid species have been reduced to synonymies without any apparent justification. For the purposes of this document, 63 species and subspecies are treated separately, although the status

Table 5.1. The distribution and threatened status of cycads in Asia. The cycad floras of Myanmar, Laos and Cambodia are not well known but the listings for adjacent countries are expected to also cover these floras. Names in quotation marks have not been formally described. Habitat reduction represents loss of habitat in the past 30 years. PNG = Papua New Guinea. See Appendix 2 for explanation of current IUCN Categories and Criteria (2001). For explanation of status in 1997 IUCN Plant Red List see Walter and Gillett (1998).

Taxon	Country	Reserve	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Extent of occurrence (km^2)	Habitat reduction (%)
Critically Endangered									
C. beddomei	India	N	E	CR	B1ab(i,ii,iv) +2ab(i,ii,iv)	<1,000	low	50	?
C. chamaoensis	Thailand	Y	–	CR	B1ab(i,iii,iv,v) +2ab(i,iii,iv,v)	2,500–10,000	high	10	?
C. debaoensis	China	Y	–	CR	B1ab(i,iii,iv,v) +2ab(i,iii,iv,v)	500	high	3	50
C. “fugax”	Vietnam	N	–	CR	A4acd	250–2,000	high	200	80
C. hongheensis	China	N	E	CR	B1ab(i,ii,iii,iv,v) +2ab(i,ii,iii,iv,v); C1	100	high	5	50
C. szechuanensis	China	N	Ex[*1]	CR	A2ac; B1ab(i,iii,v) +2ab(i,iii,v); C1	<100	high	1	?
C. tansachana	Thailand	N	–	CR	A2c; B1ab(i,ii,iii,iv,v) +2ab(i,ii,iii,iv,v)	2,500–10,000	high	10	80
Endangered									
C. “aculeata”	Vietnam	N	–	EN	B1ab(iii,iv,v) +2ab(iii,iv,v); C1	250–2,500	low	20	30–50
C. chamberlainii	Philippines	Y	V	EN	B1ab(i,iv) +2ab(i,iv)	<1,000	low	30	20–40
C. changjiangensis	China	Y	–	EN	A4acd; B1ab(i,iii)	2,000	low	20	50
C. hainanensis	China	N	V	EN	A2abc	10,000	low	200	50
C. “hoabinhensis”	Vietnam	Y	–	EN	A4c	2,500–10,000	high	50	50–80
C. multipinnata	China, Vietnam	Y	E	EN	A2c	1,000–2,500	low	250	50
C. taiwaniana	China	Y	V	EN	A2acd	5,000	high	400	50–80
Vulnerable									
C. “condaoensis”	Vietnam	Y	–	VU	D2	2,500–10,000	stable	20	<20
C. “collina”	Laos?, Vietnam	N	–	VU	A2c	2,500–10,000	low	200	30–50
C. diannanensis	China	N	–	VU	A2c	5,000	high	300	50
C. “dolichophylla”	China, Vietnam	Y	–	VU	A2c	>10,000	low	500	30–50
C. elongata	Vietnam	N	–	VU	A2c	>10,000	high	100	30–50
C. inermis	Vietnam	Y	–	VU	A2acd	>10,000	high	200	30–50
C. lindstromii	Vietnam	N	–	VU	A2c	>10,000	high	200	30–50
C. macrocarpa	Malaysia, Thailand	N	–	VU	A2c	>10,000	high	1000	30–50
C. micholitzii	Vietnam	Y	V	VU	A2c	>10,000	high	200	30–50
C. “bifida”	Vietnam, China	Y	E	VU	A2c	>10,000	high	100	30–50
C. nongnoochiae	Thailand	N	–	VU	A2c; D2	>10,000	low	20	30–50
C. pachypoda	Vietnam	N	–	VU	D2	2,500–10,000	low	20	?

Table 5.1 ... continued. The distribution and threatened status of cycads in Asia.

Taxon	Country	Reserve	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Extent of occurrence (km^2)	Habitat reduction (%)
C. pectinata	China, Cambodia, India, Laos, Nepal, Thailand, Vietnam	Y	–	VU	A2c	>200,000	low	3,000	30–50
C. pranburiensis	Thailand	Y	–	VU	D2	2,500–10,000	stable	10	–
C. seemannii	Pacific	N	R	VU	A2c	>10,000	low	2,000	30–50
C. segmentifida	China	Y	–	VU	A2c	>10,000	low	500	30–50
C. siamensis	Cambodia, Thailand, Vietnam	Y	–	VU	A2c	>10,000	low	1,000	30–50
C. taitungensis	China	Y	V	VU	A2ac	10,000	low	50	30–50
Near Threatened									
C. apoa	Indonesia, PNG	N	–	NT	–	>10,000	?	1,000	–
C. balansae	China, Vietnam	Y	–	NT	–	>10,000	low	400	<30
C. bougainvilleana	PNG	N	–	NT	–	>10,000	low	1,000	–
C. "brachycantha"	Vietnam	–	Y	NT	–	>10,000	low	50	–
C. campestris	PNG	N	–	NT	–	>10,000	low	500	–
C. chevalieri	Laos?, Vietnam	N	–	NT	–	>10,000	low	100	<30
C. clivicola	Cambodia, Malaysia, Thailand, Vietnam	N	–	NT	–	>10,000	low	1,000	<20
C. ferruginea	China, Vietnam	Y	–	NT	–	>100,000	low	150	20
C. guizhouensis	China	Y	Ex[*1]	NT	–	>10,000	high	500	20–50
C. litoralis	Indonesia, Malaysia, Thailand, Vietnam	N	–	NT	–	>10,000	low	1,000	<30
C. panzhihuaensis	China	Y	–	NT	–	>200,000	high	150	20–50
C. papuana	Indonesia, PNG	N	–	NT	–	>10,000	?	200	–
C. revoluta	China, Japan	Y	–	NT	–	>10,000	stable	1,000	<20
C. rumphii	Indonesia	N	–	NT	–	>10,000	low	1,000	–
C. schumanniana	PNG	Y	–	NT	–	>10,000	low	300	–
C. scratchleyana	Indonesia, PNG	N	–	NT	–	>10,000	low	1,000	–
C. sexseminifera	China, Vietnam	N	–	NT	–	>10,000	low	500	<20
C. simplicipinna	Laos, Myanmar, Thailand, Vietnam	Y	–	NT	–	>10,000	low	1,000	<30
C. tanqingii	China	N	–	NT	–	>100,000	stable	100	<20
C. "tropophylla"	Vietnam	Y	–	NT	–	>10,000	low	50	<20
C. yunnanensis	China	Y	–	NT	–	>10,000	low	200	<20
Data Deficient									
C. circinalis	India	N	–	DD	?	?	500	–	–
C. curranii	Philippines	N	–	DD	–	–	–	–	–
C. edentata	Philippines	N	–	DD	–	–	–	–	–
C. falcata	Indonesia	N	–	DD	?	?	50	–	–
C. javana	Indonesia	N	–	DD	?	?	1,000	–	–
C. nathorstii	Sri Lanka	N	–	DD	?	?	?	–	–
C. riuminiana	Philippines	N	–	DD	–	?	?	–	–
C. spherica	India	N	–	DD	?	?	?	–	–
C. wadei	Philippines	N	E	DD	–	–	?	?	–
C. zeylanica	India, Sri Lanka	N	–	DD	?	?	?	–	–

[*1] *C. szechuanensis* was incorrectly classified as Ex in the 1997 IUCN Red List. At that time it was thought to be known only from cultivation (EW), but it was later thought to be conspecific with *C. guizhouensis.* We consider it to be a valid species and new populations have been discovered in China. *Cycas guizhouensis* is regarded as a distinct taxon, widespread in eastern Yunnan, south-western Guizhou and north-western Guangxi provinces.

of many of these is still unclear (Table 5.1). The recent taxonomic revision of *Cycas* by de Laubenfels and Adema (1998) makes little useful contribution to the knowledge of Asian cycads at any level and in many cases adds to the confusion. We have therefore ignored this revision except in nomenclatural matters that have priority under the ICBN (International Code of Botanical Nomenclature).

5.2 Threats to Asian cycads

Twelve species of Asian cycads were listed in the 1997 IUCN Red List of Threatened Plants (Walter and Gillett 1998). This list is now out-of-date for the region due to the large number of new species and it has also been necessary to apply the 2001 IUCN Criteria. Populations of many Asian species appear to have declined, sometimes dramatically, over the past century. However, it is difficult to quantify these changes as there are no comparative data to support the impression of decline. Evidence for decline is mostly anecdotal and circumstantial. Nevertheless, several causes of decline can be observed in action today and it is therefore possible to evaluate some of the threatening processes. Of the 63 species and subspecies recognised for this report, seven are regarded as Critically Endangered, seven as Endangered, 18 as Vulnerable, and a further 21 as Near Threatened. Ten taxa are insufficiently known to even guess at their status (Data Deficient). This is either as a result of confused taxonomy (six taxa) or a lack of information on their population distributions and abundance (four taxa).

Cycas szechuanensis was originally thought to be Extinct in the Wild (Chen 2000) as it was known only from cultivated plants (classified as Ex in the 1997 IUCN Red List of Threatened Plants). Subsequently it was thought to be synonymous with *C. guizhouensis* or *C. taiwaniana*. It is regarded here as a distinct species but a few plants have been discovered in the wild. As a result, *C. szechaunensis* comprises a small number of plants whereas *C. guizhouensis* is widespread in eastern Yunnan, south-western Guizhou and north-western Guangxi provinces in China, and *C. taiwaniana* is also restricted to China but is classified as Endangered. Given this interpretation, no Asian species have been classified as Extinct or Extinct in the Wild. At one stage it was thought that *C. tansachana* in Thailand would be EW by the time of writing due to the rapid destruction of the limestone outcrops where it occurs. However, new populations have since been discovered and it is currently classified as Critically Endangered.

For effective conservation action, the main threatening processes need to be identified so that remedial actions can be implemented, even before monitoring data can be gathered. The two principal threats to cycads in Asia at present are habitat loss and selective removal of plants from the wild for trade.

5.2.1 Habitat loss

Cycad habitats in Asia have suffered severe reduction and degradation over the centuries, and these pressures will inevitably continue and even increase in the near future (Pant 1996). Many species are now known to occur as fragmentary populations in remote areas with rugged topographies. Historical records suggest that cycads have always been somewhat restricted to such habitats and, if so, habitat loss in the more distant past may not have been extensive. Habitat damage by the shifting agricultural practices of some minority groups would probably have been less frequent and more scattered in the past due to lower population numbers, and would have allowed the forest (and cycads) time to regenerate between planting cycles.

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Cycas tansachana, a Critically Endangered species growing on limestone outcrops in Thailand.

The prime cause of habitat loss or damage is the clearing of land for agriculture, often in areas that are marginal in terms of their potential for agricultural productivity. The large and rapidly increasing rural poor and minority group population in Asia (and in many other parts of the world) depend on such land for survival and place ever increasing pressure on this land. It is clearly impractical to halt such land-use, at least in the short term, since many of these people have no alternative livelihood. Compromises on land-use and the development of alternative livelihoods will be essential to preserve the cycads and forests in these areas.

Although the primary pressure on land is from agriculture, minor and localised damage is also caused by road building, dam construction, mining, and quarrying. At present, only *C. tansachana* in Thailand is known to be directly threatened by mining operations.

5.2.2 Selective removal

Cycads have been selectively removed from the forests of Asia for centuries and for a variety of reasons. Collection for horticulture is now the major reason and poses a significant threat to a number of species. The collection is carried out mostly by local villagers, but the reasons for removing plants and their ultimate destinations vary. Most cycads are used locally, either grown by the collector or sold in local markets, and often purchased locally as ornamental plants. Larger nurseries will buy large numbers of wild-collected cycads from villagers or in markets for shipment and sale elsewhere when this is an economic proposition. CITES regulations usually restrict international trade so most of the trade occurs within the country of origin. Dedicated cycad collectors will move cycad plants internationally, sometimes illegally, but this group is small and probably only a small volume of Asian cycads enter this trade. Nevertheless, this type of trade does present a disproportionately large threat to the rarest species that are of particular interest to dedicated cycad collectors.

Local people have also selectively removed cycads for a number of other purposes in the past (e.g., as pig food, as a source of starch for liquor production, for food in famine times, and for traditional medicines). In all of these cases, the current impacts on conservation are probably minimal since there are limited opportunities to use cycads for food and it tends to occur on a small scale except where cycads are abundant. Once populations begin to decline and cycads become less accessible, usage also declines and often stops altogether.

5.2.3 Other threats

Poor reproduction as a result of the loss of pollinating organisms, reduction of viability in critically small populations due to accumulation of genetic abnormalities, and reduced regeneration due to competition from introduced invasive weedy species have an impact on cycad populations elsewhere in the world (Chapters 3 and 6). There have been no experimental studies of pollination in Asian cycads and very little is known about pollination in the genus *Cycas*. The release of volatile compounds from the cones, and the presence of insect groups that are involved in cycad pollination in other cycads, suggests that at least some Asian cycads will be insect-pollinated. However, there have been no reports of reproductive failure, genetic decline, or decline due to alien weeds for any of the Asian cycad populations. A few species of *Cycas* occur on islands where seeds are dispersed by bats. The decline in bat populations on many islands is therefore a cause of concern.

Pile of wild-collected *Cycas* (probably *C. sexseminifera*) along a street in Zhanzhou, China. These plants were imported from Vietnam.

5.3 Addressing the threats

5.3.1 Legislation

Conservation legislation has been enacted in many parts of Asia. Protective legislation for cycads was enacted in China in 2000.

5.3.2 Trade restrictions

The family Cycadaceae, of which the genus *Cycas* is the only living genus, was listed on Appendix II of CITES in 1977. At the time, the listing was based largely on the fact that there was no internationally agreed classification system for cycads and it would have made little sense to list only some groups of cycads. Even though there is now a widely accepted higher classification system for cycads, the high impact of trade on Asian cycads means that there is probably sufficient justification for listing *Cycas* on CITES Appendix II in its own right. This means that exporting countries need to provide a permit to show that trade is not detrimental to wild populations. The only exception within the Cycadaceae is *C. beddomei* from India, which was transferred to Appendix I in 1985.

5.3.3 Species conservation plans

For an effective overall conservation strategy to be devised, threats to each species in its habitat must be considered and addressed individually and separately, and a conservation action plan formulated for each species. Individual species plans will be different because threats differ among species and among populations.

5.3.4 Taxonomic studies

An essential prerequisite for effective conservation is a sound understanding of the species' taxonomy and of the present conservation status of each species. There is still considerable uncertainty and some confusion at this level throughout Asia. Improving the knowledge base must be regarded as a foremost priority in developing an overall cycad conservation action plan.

5.3.5 *In situ* protection

Many cycad habitats remain under threat in Asia, and a programme of ensuring that threatened species are included in reserves is also necessary. Twenty of the 63 taxa dealt with in this report are known to occur within protected areas (national parks or nature reserves), leaving 43 taxa with no known populations in protected areas. The species outside reserves include five species classified as CR, one as EN, and eight as VU, and these species should receive the highest priority.

5.3.6 *Ex situ* conservation

Establishment of genetically representative collections of threatened species in a network of botanical gardens would provide a source of material for reintroduction and restoration programmes, and could satisfy horticultural demands. *Ex situ* conservation is dealt with in Chapter 8, but it should be noted here that several gardens around the world already hold good collections of documented Asian material and have a commitment to acting as an *ex situ* conservation resource (Chapter 7). This programme should be expanded and directed in order to cover all species classified as Critically Endangered, Endangered and Vulnerable (about 32 taxa). Gardens already holding good representative collections of Asian cycads are the Montgomery Botanical Center (USA), Nong Nooch Tropical Garden (Thailand), and Fairy Lake Botanical Garden in Shenzen (China). It would be desirable to attract additional gardens to the project.

5.3.7 Sustainable harvest programmes

The principal threat to Asian cycads remains collection for horticulture. A ready supply of artificially propagated nursery grown plants at competitive prices would effectively neutralise this threat. The village nursery conservation model, as discussed elsewhere in this report (Chapter 7), is seen as an essential part of the ongoing conservation of the Asian cycads.

Chapter 6

Regional Overview: New World

D.W. Stevenson, A. Vovides, and J. Chemnick

6.1 Introduction

Five genera of cycads; *Ceratozamia*, *Chigua*, *Dioon*, *Microcycas*, and *Zamia*, representing a total of 89 species (Table 6.1), are distributed through 21 countries in the tropical to subtropical regions of the New World (Figure 6.1). Many of the New World cycads have restricted distributions and four of the genera occur either entirely or mostly within one country. *Microcycas,* with one species, is endemic to Cuba. *Chigua,* with two species, is endemic to north central Colombia. *Dioon,* with 11 species, is found mostly in Mexico but one species also occurs in Honduras and Nicaragua. *Ceratozamia,* with 18 species, occurs mostly in Mexico with three species also occurring in the neighbouring countries of Belize, Guatemala, and Honduras. Only *Zamia,* with 57 species, is widespread in the Neotropics ranging from the extreme south-eastern United States to Bolivia. However, even within *Zamia,* there are high levels of endemism and 68.5% of all the species occur in only one country (Table 6.1).

Cycads are not distributed evenly throughout the New World. Mexico has an exceptional diversity of cycad species and contains roughly half of the New World species (Figure 6.2). This is followed by Colombia, Panama, Guatemala, Peru, and Cuba (Figure 6.2). The remaining countries have relatively few cycads and six countries have only one cycad species.

Generally speaking, cycad populations of any given species in the Neotropics are small and scattered, and they are often composed of less than a thousand individuals. There are exceptions such as populations of *Dioon edule* in Mexico, *Zamia integrifolia* in Florida, and surprisingly, the epiphytic species *Zamia pseudoparasitica* in Panama. The scattered nature of the populations is such that they are very often many kilometres apart, even as much as 100km. These disjunct populations make it difficult to assess the health of individual species without extensive fieldwork. This is particularly critical in South America where there are only two botanists working on the biology of indigenous cycads. Thus, most estimates of population

Figure 6.1. Cycad distributions in the New World.

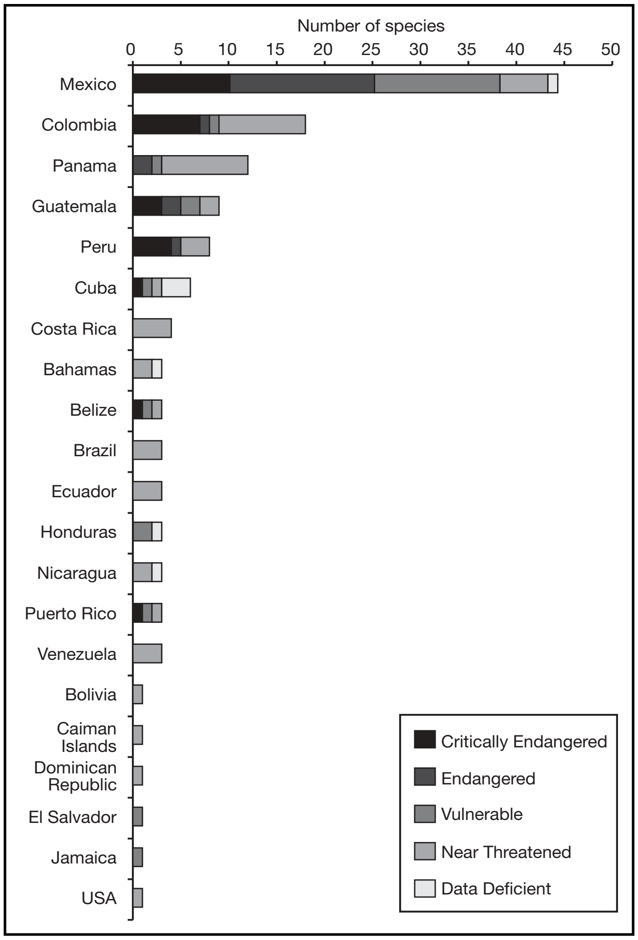

Figure 6.2. Diversity and threatened status of New World cycads.

size are just that, rough estimates based upon limited field observations and herbarium collections.

6.2 Threats to New World cycads

The 1997 IUCN Red List of Threatened Plants (Walter and Gillett 1998) listed 64 of the Neotropical cycads. The revised threatened status is given in Table 6.1. In line with other regional summaries (Chapters 3, 4, and 5), the revised list takes into consideration changes in taxonomy since 1997 and is based on the IUCN Red List Categories and Criteria version 3.1 (see Appendix 2). Fifty-nine species (65%) are classified as threatened, 25 species as Near Threatened (28%) and five species as Data Deficient. We tried to avoid excessive use of the Data Deficient category even though the exact status of many cycads is poorly known. Table 6.1 shows that habitat destruction is the major cause of decline in New World cycads. Deforestation for logging and expanding agriculture has occurred throughout the region and this has had a dramatic effect on many cycad species, especially those that grow in the forest understorey. Even if they are not destroyed during the process of deforestation, many of the understorey cycads with small subterranean stems cannot survive in the altered landscape. Collecting of plants from the wild has been less severe than in parts of Africa (Chapter 3), but has nevertheless contributed to the decline of many species (Table 6.1). This is especially true in Mexico where collectors have systematically decimated populations of cycads such as *Dioon sonorense, D. merolae, D. spinulosum, Ceratozamia norstogii*, *C. miqueliana,* and *Zamia furfuracea.*

As a result of habitat destruction and collecting, there are now 23 species listed as Critically Endangered, 18 as Endangered, and 18 as Vulnerable (Table 6.1). The Critically Endangered species typically have fewer than 250 mature individuals, often in a single population or in a number of small isolated fragments. Such critically small population sizes create significant problems for cycad survival, particularly because, (1), they are all dioecious (male and female plants), (2), individual plants tend to reproduce infrequently, and (3), many species rely on specialised beetles for effective pollination. This means that the chances of failed reproduction are high and any further decline in mature plants will hasten the path to extinction. For this reason, we have included reproductive failure as one of the factors contributing to decline in cycad populations (e.g., in *Microcycas calocoma*) (Table 6.1). Due to differences in diversity and threats (Figure 6.2), it is appropriate to summarise the situation in the three broad regions of the New World before discussing more general aspects of cycad conservation.

6.2.1 United States and the West Indies

Within the continental United States, *Zamia integrifolia* is represented by numerous populations in Florida. Many of these populations occur in national forests, experience little or no disturbance and have healthy breeding populations. Little is known about the wild populations of cycads in parts of the West Indies, particularly in Cuba and the Bahamas. In Puerto Rico, the endemic species, *Z. portoricensis* is known from only two localities. Visits to these localities every year, for the past decade, have revealed no seed set or any indication of the presence of a pollinator. Thus, this species should be considered Critically Endangered. Apparently the same is true for *Microcycas calocoma* in Cuba where seed set in the wild is minimal. Up until about 1920, *Zamia pumila* was common in south central Puerto Rico as revealed by numerous herbarium collections. However, extensive searches for this species in Puerto Rico in recent years have proven futile and the species must be assumed to be extinct in Puerto Rico.

6.2.2 Mesoamerica

There are three genera of cycads in Mesoamerica. Two of these, *Ceratozamia* and *Dioon,* only occur north of Costa

Villagers loading lopped off stems of *Dioon edule* near Monte Oscuro, Mexico.

Rica, whereas *Zamia* spreads into South America. In the past, overcollecting significantly contributed to the demise of once large populations of some species such as *C. norstogii* in Mexico, but the greatest threat in Mesoamerica today is extensive habitat destruction. The effects are particularly severe north of Costa Rica and the impact has been greatest on species that originally had narrow ranges, such as *C. kuesteriana* in Mexico. In contrast, the cycad species of *Zamia* in Panama and Costa Rica are faring better because most of the species occur in at least one reserve (Table 6.1) where habitat destruction is now minimal. Exceptions do occur and particular attention should be paid to establishing reserves that would include populations of *Z. dressleri*, *Z. skinneri*, and *Z. obliqua* within Panama where the first two are endemic. The habitat of *Z. obliqua* is being destroyed at a rapid pace and there are very few documented plants in cultivation. Although threatened by habitat destruction, *Z. skinneri* is also threatened by overcollection in undisturbed habitats.

In Mexico, special attention is needed with respect to narrowly endemic *Ceratozamia* spp. where the expansion of coffee plantations is encroaching on habitats of *C. zoquorum* in Chiapas, and *C. mexicana* and *C. morettii* in Veracruz. Even though *c.*50% of the species occur in reserves (Table 6.1), there is no long-term guarantee of their survival because of clandestine deforestation and other human-related activities. However, *Ceratozamia matudae, C. mirandae, Dioon merolae,* and *Zamia soconuscensis* in the El Triunfo and La Sepultura Biosphere Reserves of Chiapas are being sustainably managed in campesino cycad nurseries, as are *D. edule, C. mexicana,* and *Z. furfuracea* in Veracruz. These nursery-managed species have a better long-term survival prospect as long as the nurseries can provide a sustainable livelihood for campesino farmers. The Mexican national cycad action plan published in December 2000 highlights priorities such as *ex situ* and *in situ* conservation, sustainable management, education, and law enforcement. A special sub-committee has been set up to coordinate these activities. Cycads are listed, amongst other threatened flora and fauna, as a national conservation priority.

Dioon edule is a very attractive cycad that is ideal for cultivation.

6.2.3 South America

Very little is actually known about the distribution, population sizes, and reproductive health of the South American cycads. Most available information is from herbarium specimens and limited fieldwork done over the past 20 years by K. Norstog and D. Stevenson. Clearly, habitat destruction is of prime concern but it is even difficult to assess the extent of habitat destruction because it is not possible to conduct fieldwork in many areas. Despite the lack of data, we know that there are several Critically Endangered species that are most likely on the very verge of extinction and these are outside any national parks or reserves. Particularly vulnerable are *Zamia montana*, *Z. wallisii*, *Chigua bernalii*, and *C. restrepoi*. Both species of *Chigua* (known populations being less than 50 plants each), occur in the same very limited area, which is now being flooded as the result of a new hydroelectric dam. This is an excellent example of where a rescue operation to remove all plants to a new but compatible area would seem to be the most appropriate action. Habitat destruction during the past 15 years has reduced populations of both *Z. wallisii* and *Z. montana* to critically low numbers, and *Z. montana* has also been subject to intensive collecting.

Perhaps one of the most critical areas in South America is the border area between Colombia and Peru, stretching all the way to Iquitos in Peru. Some of the most unusual and interesting species of *Zamia* occur in this area and were only recently discovered. The recently described *Zamia macrochiera* is known from only two very small populations in this region. The species appears to have populations of ants that live in special tunnel-like flaps at the leaflet bases, highlighting the need for *in situ* conservation to protect such specific interactions.

Table 6.1. The distribution and status of cycads in the New World. Known threats are listed as HD=Habitat Destruction, OC=Over Collecting, RF=Reproductive Failure. Habitat reduction represents loss of habitat within the past 30 years. See Appendix 2 for explanation of current IUCN Categories and Criteria (2001). For explanation of status in 1997 IUCN Plant Red List see Walter and Gillett (1998).

Taxon	Country	Reserve	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Source of threat	Habitat reduction
Critically Endangered									
Ceratozamia euryphyllidia	Mexico, Guatemala	N	E	CR	B1ab(i,ii,iii,iv,v) +2ab(i,ii,iii,iv,v)	450	high	HD,OC	severe
C. fusco-viridis	Mexico	N	–	CR	B1ab(i,iii,iv,v); C1	<250	high	HD	severe
C. kuesteriana	Mexico	Y	V	CR	B1ab(ii,iii,iv) + 2ab(ii,iii,iv)	250–500	high	HD,OC	severe
C. norstogii	Mexico	Y	V	CR	A2abd; B1ab(iii,iv,v)	<600	high	HD,OC	severe
C. zaragozae	Mexico	N	E	CR	A2acd; B1ab(iii,iv,v)	<200	high	HD	severe
Chigua bernalii	Colombia	N	E	CR	A2acd; C1	<250	high	HD,OC	severe
Chigua restrepoi	Colombia	N	E	CR	A2acd; C1	<250	high	HD,OC	severe
Dioon caputoi	Mexico	Y	E	CR	A4acd; B1ab(iii,iv,v)	200–400	high	–	moderate
Microcycas calocoma	Cuba	Y	V	CR	B1ab(iii,iv,v) +2ab(iii,iv,v)	300–500	stable	RF,HD,OC	moderate
Zamia amplifolia	Colombia	N	R	CR	B1ab(i,iv) + 2ab(i,iv)	<1,000	stable	HD	severe
Z. disodon	Colombia, Peru	N	–	CR	A2abd; B1ab(i,ii,iii)	<400	high	OC,HD	minor
Z. hymenophyllidia	Colombia, Peru	N	–	CR	B1ab(i,ii,iv); C1	<200	high	HD	moderate
Z. inermis	Mexico	N	V	CR	A4abcd	300–500	high	HD	severe
Z. macrochiera	Peru	N	–	CR	A2abd; B1ab(i,iv,v); C1	<100	high	HD	severe
Z. montana	Colombia	N	V	CR	A2abd, B1ab(i,iv,v); C1	<100	high	HD	severe
Z. monticola	Guatemala	N	Ex	CR	C2a(ii)	<250	?	HD	severe
Z. picta	Mexico, Guatemala	Y	R	CR	B1ab(i,ii,iv,v) +2ab(i,ii,iv); C1	<250	high	HD,OC	severe
Z. portoricensis	Puerto Rico	Y	V	CR	B1ab(iii,v)+2ab(iii,v)	<500	low	RF	minor
Z. prasina	Belize	Y	–	CR	A2abd; B1ab(ii,iii,iv,v); C1	<100	high	HD	none

Table 6.1 ... continued. The distribution and status of cycads in the New World.

Taxon	Country	Reserve	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Source of threat	Habitat reduction
Z. spartea	Mexico	N	E	CR	A2abd	500–2,000	high	HD	severe
Z. urep	Peru	N	–	CR	B1ab(i,ii,iv) +2ab(i,ii,iv)	<250	stable	HD	minor
Z. vazquezii	Mexico	N	E	CR	B1ab(i,ii,iv) +2ab(i,ii,iv)	<1,000	high	HD,OC	severe
Z. wallisii	Colombia	N	V	CR	A2abd; C1	<100	high	HD,OC	severe
Endangered									
C. alvarezii	Mexico	Y	–	EN	B1ab(i,iii)+2ab(i,iii)	600–1,000	low	HD	moderate
C. beccarae	Mexico	N	–	EN	B1ab(i,iii,iv) +2ab(i,ii,iv)	300–450	high	HD	severe
C. hildae	Mexico	Y	E	EN	A2abcd; B1ab(ii,iii,iv)	500–1,000	high	HD,OC	severe
C. matudae	Mexico, Guatemala	Y	R	EN	B1ab(iii,v)+2ab(iii,v)	1,200–1,600	moderate	–	moderate
C. morettii	Mexico	N	–	EN	B1ab(i,iv,v) +2ab(i,iv,v)	500–1,000	low	HD,OC	minor
C. sabatoi	Mexico	Y	V	EN	B1ab(i,ii,iv) +2ab(i,ii,iv)	700–1,500	low	HD	moderate
C. whitelockiana	Mexico	N	–	EN	B1ab(i,ii,iii,v) +2ab(i,iii,v); C1	2,000–2,500	high	HD	severe
D. holmgrenii	Mexico	N	V	EN	B1ab(iii,iv) +2ab(iii,iv)	10,000– 20,000	low	HD,OC	moderate
D. sonorense	Mexico	N	R	EN	A2abe; C1	500–1,000	low	HD,OC	moderate
D. tomasellii	Mexico	N	R	EN	A2abd; B1ab(ii,iv,v) +2ab(ii,iv,v)	3,000–5,000	moderate	HD,OC	moderate
Z. cremnophila	Mexico	N	V	EN	B1ab(i,ii,iv) +2ab(i,ii,iv); C1	<1,000	high	HD	moderate
Z. dressleri	Panama	N	E	EN	C1	<1,000	high	HD	severe
Z. fischeri	Mexico	N	V	EN	A2abd	1,000–2,000	high	HD	moderate
Z. lacandona	Mexico	Y	–	EN	B1ab(i,iv,v) +2ab(i,iv,v); C1	<500	high	HD,OC	severe
Z. melanorrhachis	Colombia, Peru	N	–	EN	A2cd; C1	1,000– 1,300	high	HD	severe
Z. purpurea	Mexico	N	E	EN	A4abcd; C1	<2,000	high	HD,OC	severe
Z. skinneri	Panama	Y	R	EN	A2acd; C1	<500	high	HD,OC	severe
Z. variegata	Mexico, Guatemala	N	–	EN	B1ab(i,iii,iv,v) +2ab(i,iii,iv,v); C1	250–500	high	HD	severe
Vulnerable									
C. latifolia	Mexico	N	V	VU	A2cd; C1	6,000–10,000	high	HD,OC	severe
C. mexicana	Mexico	N	I	VU	A2cd; C1	5,000 –10,000	high	HD	severe
C. microstrobila	Mexico	N	E	VU	A2abe; C1	5,000 –10,000	low	HD	moderate
C. miqueliana	Mexico	Y	V	VU	A2acd; C1	600–800	high	HD,OC	moderate
C. robusta	Mexico, Belize, Guatemala	Y	R	VU	A2acd; C1	2,500 –6,000	high	HD,OC	moderate
D. califanoi	Mexico	Y	E	VU	B1ab(i,ii,iv) +2ab(i,ii,iv)	3,000–5,000	low	HD,OC	moderate
D. merolae	Mexico	Y	V	VU	B1ab(iii,iv,v) +2ab(iii,iv,v); C1	3,000–5,000	high	HD,OC	severe
D. purpusii	Mexico	Y	V	VU	B1ab(iii,iv,v); C1	2,500–3,000	moderate	HD,OC	moderate

Table 6.1 ... continued. The distribution and status of cycads in the New World.

Taxon	Country	Reserve	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Source of threat	Habitat reduction
D. rzedowskii	Mexico	Y	V	VU	B1ab(i,iv)+2ab(i,iv)	10,000	stable	HD	minor
D. spinulosum	Mexico	N	R	VU	A2acd	>10,000	high	HD	severe
Z. amblyphyllidia	Puerto Rico, Cuba, Jamaica	Y	–	VU	C1	2,000–3,000	moderate	HD	moderate
Z. encephalartoides	Colombia	N	–	VU	A2acd; C1	5,000	high	HD	moderate
Z. furfuracea	Mexico	N	V	VU	A2acd	10,000	stable	HD,OC	moderate
Z. gentryi	Ecuador	N	–	VU	C1; D2	<500	high	HD	?
Z. herrerae	Mexico, El Salvador, Honduras, Guatemala	Y	R	VU	C1	500–1,000	stable	HD	severe
Z. ipetiensis	Panama	Y	V	VU	B1ab(i,iv,v) +2ab(i,iv,v)	2,000	low	HD	moderate
Z. soconuscensis	Mexico	Y	V	VU	C1	<5,000	moderate	HD	moderate
Z. standleyi	Honduras	N	R	VU	C1	<1,000	moderate	HD	moderate
Near Threatened									
D. edule	Mexico	Y	R	NT	–	>10,000	low	HD	moderate
Z. acuminata	Nicaragua, Panama, Costa Rica	N	R	NT	–	2,000–5,000	stable	HD	minor
Z. amazonum	Colombia, Venezuela, Brazil, Peru	N	–	NT	–	>10,000	stable	HD	minor
Z. boliviana	Bolivia	Y	R	NT	–	5,000	stable	–	minor
Z. chigua	Colombia, Panama	Y	R	NT	–	7,000	stable	–	minor
Z. fairchildiana	Costa Rica, Panama	Y	–	NT	–	5,000–7,000	low	HD	minor
Z. integrifolia	USA, Bahamas, Cuba, Caiman Is.	Y	–	NT	–	>10,000	low	HD	moderate
Z. lecointei	Colombia, Brazil, Peru, Venezuela	N	–	NT	–	10,000 –15,000	high	HD	moderate
Z. loddigesii	Mexico, Guatemala	N	–	NT	–	>20,000	low	HD	moderate
Z. lucayana	Bahamas	N	–	NT	–	<1,000	low	HD	moderate
Z. manicata	Colombia, Panama	N	R	NT	–	4,000	low	HD	moderate
Z. muricata	Colombia, Venezuela	N	R	NT	–	7,500	low	HD	moderate
Z. neurophyllidia	Nicaragua, Costa Rica, Panama	Y	–	NT	–	4,000–5,000	low	HD	moderate
Z. obliqua	Colombia, Panama	Y	I	NT	–	5,000–7,000	low	HD	moderate
Z. paucijuga	Mexico	N	R	NT	–	<10,000	low	HD	severe
Z. poeppigiana	Colombia, Ecuador, Peru	N	–	NT	–	10,000 –15,000	stable	HD	moderate

Table 6.1 ... continued. The distribution and status of cycads in the New World.

Taxon	Country	Reserve	Status in 1997 IUCN Plant Red List	Current status	Criteria	Population size	Present decline	Source of threat	Habitat reduction
Z. polymorpha	Mexico, Belize	Y	–	NT	–	10,000	stable	HD	moderate
Z. pseudomonticola	Costa Rica, Panama	N	V	NT	–	3,500–4,000	stable	HD	minor
Z. pseudoparasitica	Panama	Y	V	NT	–	3,000–5,000	low	HD	none
Z. pumila	Dominican Republic, Puerto Rico, Cuba (Extinct)	N	–	NT	–	5,000–10,000	low	HD	severe ?
Z. roezlii	Colombia, Ecuador	N	R	NT	–	4,000	stable	–	minor
Z. tuerckheimii	Guatemala	N	R	NT	–	1,000	low	HD	moderate
Z. ulei	Brazil, Colombia, Ecuador, Peru	N	–	NT	–	4,000–5,000	low	–	minor
Z. verschaffeltii	Mexico	N	E	NT	–	<1,000	low	OC	minor
Z. cunaria	Panama	Y	V	NT	–	3,000	low	HD	minor
Data Deficient									
C. mixeorum	Mexico	N	–	DD	–	–	–	–	–
D. mejiae	Honduras, Nicaragua	N	V	DD	–	–	–	–	–
Z. angustifolia	Bahamas, Cuba	N	R	DD	–	–	high	HD	severe
Z. kickxii	Cuba	N	R	DD	–	–	–	–	–
Z. pygmaea	Cuba	N	R	DD	–	–	–	–	–

6.3 Addressing the threats

Habitat destruction has such a large affect on New World cycads that conservation measures will only succeed if they can halt the ongoing deforestation. Setting up reserves for the most threatened species would seem to be one of the only ways to protect them from rampant habitat destruction. However, at present, an inadequate number of the New World cycads occur in reserves (Table 6.1). This is particularly true in the six countries with the highest cycad diversity. Panama has the highest proportion of cycads in reserves (58%), followed by Mexico with 50%. Only 14% of the Cuban cycads occur in reserves and none of the cycads in Colombia, Peru, or Guatemala occur within reserves (Table. 6.1). Efforts are underway to establish reserves and parks in both Colombia and Guatemala.

Where reserves are not feasible, sustainable use nurseries linked to rural villages (village nurseries) are a possible alternative. These nurseries are dealt with in more detail in Chapter 8 and they appear to have been successful in Mexico. The village nursery conservation programme enables villagers to make an income while conserving cycad habitat and therefore provides a sustainable basis for cycad conservation. It would be wise to establish such a nursery system in the Chocó of Colombia for *Z. obliqua*, *Z. chigua*, and *Z. amplifolia* before the current levels of threat increase. Other cycads from Colombia and Ecuador seem to be of little interest in cultivation and would therefore not be suitable for village nurseries.

Ex situ collections are not an alternative to conserving plants in their wild habitat. However, the high number of Critically Endangered species in the New World means that there is a high probability that some species will die out in the wild. It is therefore essential to make sure that these species are represented in properly managed *ex situ* collections. The current status of *ex situ* collections is dealt with in Chapter 7, but it should be noted that the Montgomery Botanical Center in the USA already has representative genebanks for many New World cycads and the National Cycad collection of Mexico at the Jardín Botánico Fco. J. Clavijero in Xalapa has been a source of germplasm for tissue culture projects on Critically Endangered species such as *Ceratozamia euryphyllidia* (Chavez *et al*. 1998).

6.4 Gaps and priorities

The absence of data on the cycads of the New World reflects an underlying lack of fieldwork and local scientific capacity in the region. There are exceptions, such as in Mexico where several scientists have made substantial progress in terms of the taxonomy and ecology of cycad species and the development of local action plans (Anon. 2000), but many regions remain poorly studied. Experience in Australia (Chapter 4), South Africa (Chapter 3) and, more recently, Asia (Chapter 5) has shown that there is a substantial increase in the number of known species after periods of intensive fieldwork. Such studies are clearly needed in the New World, especially South America.

Most of the areas where New World cycads occur have been identified as global biodiversity hotspots (Chapter 2). In Mexico, for instance, a good number of cycads from the south and south-east of the country are in Pleistocene refuges that harbour relict floras of great age (Toledo 1982; Wendt 1987). Deforestation is a common threat in all these areas, providing a unique opportunity to link cycad conservation with broader initiatives to conserve habitats in the Neotropics. One priority for New World cycad conservation will therefore be to determine how cycad conservation can be integrated with these other initiatives.

Chapter 7

Cycads in Trade and Sustainable Use of Cycad Populations

J.S. Donaldson, B. Dehgan, A.P. Vovides, and W. Tang

7.1 Introduction

A simple definition for wildlife trade is the use and exchange of a species for any purpose. In this context, trade in cycads has a long and fascinating history in almost all countries where they occur naturally. Historical accounts (e.g., Thunberg 1793) as well as some excellent recent records, reviews, and syntheses (Whiting 1963; Gilbert 1984; Jones 1993; Sacks 1996; Norstog and Nicholls 1997) reveal a rich tapestry of interactions between people and cycads. These records tell how people have used cycad leaves in local ceremonies in Mexico, Honduras, South Africa, the Philippines, Solomon Islands, New Hebrides, and Indonesia (Jones 1993), and how indigenous people have used cycad leaves, stems, roots, and seeds for food in Africa, the New World, Asia, and Australia (Thunberg 1793; Whiting 1963; Jones 1993; Sacks 1996; Norstog and Nicholls 1997). Cycad stems, roots and leaf bases have been harvested for magical and medicinal use (Whiting 1963; Jones 1993; Osborne *et al.* 1994; Norstog and Nicholls 1997) and leaves have been used for the construction of baskets and traps (Donaldson pers. obs.). Some cultures have probably been using cycads since prehistoric times (Jones 1993) and it is remarkable how different cultures have independently developed the technology to prepare food from cycads which contain several powerful toxins. At one stage, eating cycad starch was thought to be the cause of lytigo-bodig disease among Pacific islanders (Kurland 1993; Sacks 1996).

Very little information is available on the historical impact of these traditional practices on cycad populations and we can only assume that levels of utilisation would have been within the carrying capacity of wild populations. There is at least some evidence for careful stewardship of cycad populations. Tessier (1793) (quoted by Whiting 1963) noted that cycads were so highly regarded as food for soldiers in Japan that it was not permitted to remove the plant from the island "on pain of death". In other countries, eating cycad starch has occurred mostly in times of hardship arising from drought, war, or the aftermath of typhoons (Thunberg 1793; Whiting 1963; Jones 1993), or has been reserved for chiefs and special occasions (Whiting 1963; Sacks 1996). Cycad starch is used more frequently in parts of Asia and Melanesia where cycads are locally abundant (Jones 1993), but even here the large and abundant seeds may be used instead of stems (Jones 1993; Sacks 1996), possibly because they can be harvested continuously without destroying the cycad population.

7.2 Current trade in cycads and cycad products

During the 19th and 20th centuries, cycad trade changed dramatically from the historical patterns of use. In some cases, the reasons for using cycads have remained unchanged but levels of exploitation have greatly increased. One of the best examples is commercial starch extraction. From about 1845, mills were set up in Florida (USA) to extract starch from the Coontie (*Zamia integrifolia*) and this enterprise intensified the long-standing practice among Seminole Indians of extracting starch from cycad stems. At the peak of production, one mill was said to have had a production of 24,000 pounds of flour per week (Clevenger 1922) which would have required a weekly harvest of 8000–12,000 *Zamia* plants (Norstog and Nicholls 1997). The increase in use, combined with urbanisation and the destruction of cycad habitat, led to a decline in cycad populations and the industry had completely collapsed by 1925 (Jones 1993). A similar commercial venture was started in 1921 in Australia using the abundant *Macrozamia communis,* but this industry failed for technical reasons (Jones 1993).

The use of cycads for medicine and magic continues in various parts of the world and has even intensified in some areas as a result of progressive urbanisation and population increase. Osborne *et al.* (1994) estimated that more than 3000 *Stangeria eriopus* plants were being traded each month from two markets in Durban (South Africa). A separate study in South Africa listed *S. eriopus* as a species that was highly priced because traditional medicine practitioners experienced shortages in supply (Manders 1997; Marshall 1998).

Close links between rural people and wild cycad populations, where negative feedback systems might have resulted in sustainable harvesting practices, have been increasingly replaced by a diffuse network of supply from wild cycad populations to urban markets. As people move and plant populations decline, the network is likely to extend further across regional and international boundaries. Manders (1997) estimated that, in parts of South Africa, harvesters were travelling 45% further in 1996 than they were in 1988 to collect popular plants such as *S. eriopus*. Clearly these changes in harvesting patterns reflect a decline in cycad populations and there is an urgent need to determine the impact of medicinal trade on wild populations and to determine what yields are sustainable. Marshall (1998) also pointed out that *S. eriopus* could be propagated to supply the medicinal plant market. The Durban Botanic Garden and the National Botanical Institute in South Africa have initiated a project to supply cultivated plants for medicinal use.

CITES records from 1983 to 1999 (WCMC database, World Conservation Monitoring Centre) show that there has been a substantial trade in leaves of species of *Cycas* (413,027 leaves plus 164 bags of leaves) and *Bowenia* (25,328 leaves plus 14,640 boxes of leaves) and in *Cycas* 'flowers' (1,904,301). Cycads do not produce flowers and the records probably refer to the male cones that are used together with leaves for floral arrangements. The bulk of the trade in leaves is from cultivated plants in Japan (the principal exporter) and there is no evidence that leaf harvesting has a detrimental effect on wild populations.

The most dramatic and potentially destructive change in the pattern of trade during the 20th century was brought about by the demand for cycads as feature plants in urban landscapes and as specimen plants for plant collections.

A medicinal plant market in South Africa where large quantities of *Stangeria eriopus* stems and *Encephalartos* bark are traded.

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Local villagers prepare to send a consignment of wild-collected *Cycas* downstream to nearby urban centres.

Cycads such as *Cycas revoluta* and other *Cycas* species have probably been used for centuries as decorative plants in Japan, China, Vietnam, India, and some other countries, but the large scale exploitation of cycads by urban landscapers and plant collectors occurred mostly in the latter half of the 20th century. Collecting from wild cycad populations to satisfy this demand is widely considered to be one of the main causes for the decline of cycad populations (e.g., Giddy 1993; Whitelock 1995; Donaldson and Bösenberg 1999). Despite the apparent importance of trade, there has been no recent analysis of the extent of cycad trade or its impact on wild populations. However, it is clear that cycad trade is influenced by at least five identifiable groups with different interests in cycads, different trade patterns, and different impacts on wild populations. It therefore makes sense to look at these groups separately and to deal with their impacts in an appropriate way.

- **Landscapers who require large numbers of a single species**

Relatively few cycads are presently used on a massive scale in urban landscapes. Two that stand out are *Cycas revoluta* and *Zamia furfuracea*. *Cycas revoluta* has been widely cultivated and there is no need for trade from wild populations. *Zamia furfuracea* was initially collected from wild populations in Mexico and there have been reports of 40 tons per month being imported into the USA. However, *Z. furfuracea* is now widely cultivated in both Mexico and the USA and there are sufficient plants in cultivation to make wild-collecting both unnecessary and uneconomical. Other species such as *C. taitungensis* are becoming more popular for large-scale plantings, but generally when cycads are required for large-scale planting, there is sufficient economic incentive to stimulate artificial propagation. However, it is important to note that, in this case, any restrictions on trade in seeds may need to be lifted to increase the availability of cultivated plants (Tang 1995).

> **Technology traps: microchips to protect South African cycads**
>
> How do you prove that a cycad has been illegally collected from the wild? This has been a major problem for law enforcement officers in South Africa where there has been substantial trade in wild-collected plants. Initially conservation officials kept a photographic record of plants that were at risk so that these photographs could be compared with plants that might have been illegally collected. This, of course, was quite tedious and could easily be disputed in court. The next step was to embed nails in the cycad stem so that these could be detected using a metal detector. Once again, there were many ways to get around this technology.
>
> More sophisticated technology has been used since the early 1990s in which a microchip is embedded in the cycad stem. The microchip can be detected only by a specific transponder and each microchip has a unique identity. Nature conservation officials have been microchipping threatened populations and there is a national register of all these plants including information on the exact geographical position of the plant. If law enforcement officials suspect that someone has removed a threatened cycad from the wild, they can scan the plant to see if it contains a microchip and then check the details in the national register. In this way, it is easy to identify plants that have been collected from the wild.

- **Landscapers requiring large feature plants**

Cycads are ideal feature plants in landscaped gardens or even as pot subjects in small gardens. In this case, it is not the volume of plants that is a problem but the size of the plants required. Large plants are often not available from nurseries, thus creating a market for wild-collected plants. In parts of China, large numbers of *Cycas panzhihuaensis* and *C. hongheensis* have been removed from the wild to provide feature plants (Chen 1999) and the same is true of *C. litoralis* in Thailand. In South Africa, one of the largest single instances of illegal collecting involved the removal of over 300 stems of *Encephalartos altensteinii* to provide large plants for a casino development.

A villager removing a plant of *Cycas panzhihuaensis* in China.

- **Urban gardeners who want cycads in their gardens**

As cycads have gained in popularity, more people have wanted them in their gardens. In general, these gardeners require a plant for a specific place in the garden but they are not necessarily looking for a particular species. As a result, they will take whatever is available at nurseries. Gardeners may be tempted to buy wild-collected plants if they are offered for sale, but they are unlikely to collect plants from the wild themselves or seek out wild-collected plants.

- **Hobbyist collectors who want a full or partial set of all described species**

There are many hobbyist collectors who would like to assemble a full or partial set of all the known species of cycad. These collectors will buy plants from specialist cycad nurseries, swap plants with other collectors, and join cycad societies so that they can exchange plants and information. Hobbyist collectors may collect seeds from accessible wild populations or be tempted to purchase rare species that may be wild-collected. However, they are unlikely to invest large amounts of time and money searching for rare cycads.

- **Serious collectors who want plants of known provenance**

There is probably no clear line to separate the hobbyist collector from the serious collector except for a difference in mindset. Serious collectors will invest a lot of time and money in their collections and will go to a great deal of trouble to acquire rare species and plants of known provenance. It should be emphasised that there are many serious collectors who have an entirely legitimate interest in cycads. It is most probably within this group of collectors that there will be individuals who collect and trade in plants taken from wild populations. This creates a market for wild-collected plants and opens up opportunities for participation by organised crime, such as in South Africa where several crime syndicates have been implicated in the illegal trade in cycads.

There is no simple way to assess the overall trade in cycads or its impact on wild populations. Concern about the impact of trade on wild cycad populations led to the listing of all cycad genera in either Appendix I or II of CITES and the annual reports submitted by the parties to CITES provide one of the few measures of cycad trade. Trade data from 1983 to 1999 (Figure 7.1) show that more than 50 million cycad seeds and 13 million cycad plants were exported by CITES parties during this period (WCMC database). Exports of cultivated specimens and seeds reported as Cycadaceae (probably mostly *Cycas revoluta*) and *Zamia furfuracea* accounted for more than 90% of all recorded trade (Tables 7.1 and 7.2). Japan was the most important exporter (nearly 90% of all seed exports and 65% of exports in cycad plants) (Figure 7.1). For taxa other than *C. revoluta* and *Z. furfuracea*, the recorded trade in

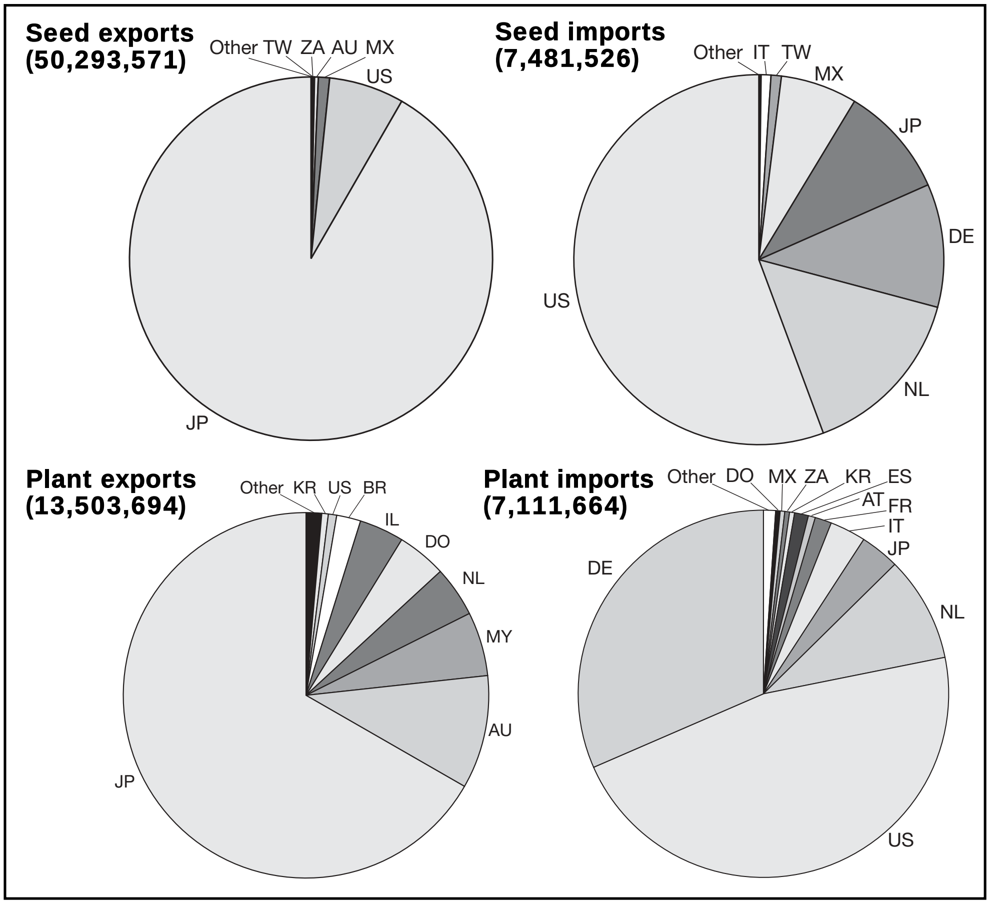

Figure 7.1. Number of cycad seeds and plants exported and imported by CITES parties between 1983 and 1999.
Abbreviations are:
AT = Austria, AU = Australia, BR = Brazil, DE = Germany, DO = Dominican Republic, ES = Spain, FR = France, IL = Israel, IT = Italy, JP = Japan, KR = Republic of Korea, MX = Mexico, MY = Malaysia, NL = Netherlands, TW = Taiwan, US = United States of America, ZA = South Africa.

seeds was relatively low (Table 7.1), but this is due more to the absence of reporting than an absence of trade. Even the CITES reports for trade in plants do not really provide an objective view of the way trade is impacting wild populations. Given the low numbers of plants in the wild, a relatively large number of *Encephalartos* plants have been traded. CITES records only document that they were 'live' plants of a particular genus, so it is not possible to determine how big they were (i.e., if they were artificially propagated) or which species were being traded. We have not had an opportunity to analyse seizure records of illegal imports, for this would give some indication of the level of illicit trade. What is really required is an in-depth analysis of the availability of certain species in cultivation, coupled

Table 7.1. The number of cycad seeds exported by CITES parties between 1983 and 1999. Exports have been grouped according to genus unless trade volumes of a single species exceeded 10,000 seeds. Exports of Cycadaceae have been listed separately as they could mean the genus *Cycas* or all cycads (if the family was recorded incorrectly).

Taxon	Number of seeds exported
Cycadaceae	46,106,915
Zamia furfuracea	3,312,512
Cycas revoluta	212,150
Encephalartos	107,521
Cycas spp.	9932
Zamia	6811
Dioon	3087
Stangeria	1546
Macrozamia	1250
Ceratozamia	903
Microcycas	162
Bowenia	115

Table 7.2. The number of cycad plants exported by CITES parties between 1983 and 1999. Exports are listed by genus except where a large number of a single species has been traded. The family Cycadaceae is listed separately as it is frequently cited on export permits without details of the genus or species involved.

Taxon	Number of plants exported
Cycadaceae	9,250,530
Cycas revoluta	2,263,009
Zamia furfuracea	987,451
Macrozamia	651,864
Zamia	130,002
Encephalartos	52,200
Cycas	49,822
Bowenia	41,028
Lepidozamia	2587
Ceratozamia	2522
Stangeria	1428
Microcycas	30

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A botanist implores local villagers not to remove cycads from the wild in China.

to an analysis of the volumes in trade. This, at least, would provide an estimate of the threat posed by international trade and the level of non-compliance with CITES regulations.

7.3 The restriction of trade by CITES

CITES is the best known and most widely applied mechanism for regulating trade in endangered species. The convention seeks to reduce the impact of international trade on wild species by; (1), prohibiting trade in wild-collected specimens where there is reasonable evidence that this trade will contribute to a high threat of extinction, or by (2), promoting the development and application of suitable harvest methods and quotas that will lead to sustainable harvests from wild populations. CITES came into effect in 1973 and the genera *Encephalartos, Microcycas,* and *Stangeria* were listed in CITES Appendix I (for species in immediate danger of extinction) in July 1975, followed in February 1977 by the listing of the entire families of Cycadaceae and Zamiaceae in Appendix II. The genus *Bowenia* was originally listed in the Zamiaceae but when the genus was included in the Stangeriaceae in 1990, *Bowenia* was listed separately in Appendix II. The genus *Ceratozamia* was upgraded to Appendix I in August 1985 and the genus *Chigua* was listed in Appendix I in January 1990.

Under CITES regulations, an Appendix I listing prohibits trade in wild-collected plants except for scientific or conservation purposes, whereas a listing on Appendix II allows trade in wild-collected plants or seeds as long as there is no detrimental impact on the survival of wild populations. Artificially propagated plants of species on either Appendix I or II can be traded. Parties to the CITES convention can implement stricter control measures and South Africa has applied stricter control measures on trade in seeds of Appendix I cycads. The rationale for this additional regulation (in South Africa) was firstly, that wild-collected seeds could not be distinguished from cultivated seeds making it impossible to enforce quotas and, secondly, that trade in seeds reduced the effectiveness of community-based nurseries in the country of origin.

It is difficult to evaluate the overall effectiveness of CITES or any of the national trade mechanisms in terms of their contribution towards the conservation of wild cycads. There are no reliable trade figures for cycads before CITES listings that could be used for before and after comparisons. Similarly, data on wild populations are generally so poor for many species that we hardly know what is there now and we can only guess about past population numbers. Even the annual CITES reports provide only a crude estimate of legitimate trade and will not be sufficient to determine whether CITES has contributed to saving species that are threatened by trade. Nevertheless, if we accept that the most basic criterion for success would be the prevention of extinction through trade, then trade restrictions have made a contribution. There is no doubt that many African and American cycad species would now be extinct in the wild if there were no trade restrictions. On the other hand, there is ongoing illegal trade in several Critically Endangered and Endangered species of cycad which illustrates that CITES alone will not stem the trade in wild-collected plants. CITES must therefore be seen as only one conservation tool and other actions must be taken to facilitate legal trade and to supply the demand for cycads from cultivated sources.

7.4 The potential for artificial propagation

It has often been suggested (Dehgan 1983, 1996a, 1996b; Dehgan and Almira 1993; Giddy 1993) that if the demand for cycads could be met through artificial propagation and large-scale commercial production, there would be no need for collectors to decimate wild populations. In terms of our categorisation of collectors into landscapers, gardeners and collectors, it would seem that nursery-grown plants could satisfy most of the demand. The obvious exceptions would be landscapers, who require large plants (at least in the short term), and some serious collectors, who specifically want rare species or plants from known localities. Our aim here is to determine whether the necessary methods and technologies exist to produce superior plants that would make collection of wild specimens unnecessary and economically unjustifiable.

Although some success in micropropagation of cycads has been reported (Chavez *et al*. 1992a, 1992b; 1998; Jager and van Staden 1996a, 1996b), no commercially practicable protocols have yet been implemented. As a result, seed propagation is currently the most practical method of large-scale commercial cycad production although an increasing number of plants can be produced from suckers and offsets obtained from stock plants in nursery plantations. Cycads are dioecious and many species do not produce seed unaided in cultivation either because their specific insect pollinators are absent or male and female plants produce cones asynchronously. However, there are several well established methods of artificial pollination that produce consistently good results and research has shown that even asynchronous coning can be overcome because pollen can retain 50% viability for up to two years when stored at 0°C (Osborne *et al.* 1992).

Seeds of most species of *Bowenia, Ceratozamia, Dioon, Lepidozamia, Macrozamia*, and *Stangeria* germinate easily, as long as their embryo is fully developed and the sarcotesta is removed before planting (Dehgan unpublished data). *Microcycas calocoma* seeds have been successfully germinated by the staff of Fairchild Tropical Garden and the Montgomery Botanical Centre (Hubbuch 1987). There have been reports that *Encephalartos* seeds are difficult to germinate (Hubbuch 1987), but this is almost certainly due to the unique situation in *Encephalartos* where the infertile seeds have the same external appearance as fertile seeds when the cone is mature (Donaldson and Bösenberg in prep.). Fertile seeds are therefore easily confused with infertile ones. Fertile seeds from hand pollinated cones of *Encephalartos* species germinate readily without any treatment, although, faster and more uniform germination can be achieved using gibberellic acid (Dehgan and Almira unpublished data).

The major difficulty with seed germination seems to be with some of the commonly cultivated genera. *Zamia,* and especially *Cycas,* experience what is referred to by Nikolaeva (1977) as "morphophysiological complex dormancy" (Dehgan and Johnson 1983; Dehgan and Schutzman 1989). Even here, horticultural research has overcome some of these difficulties. In some species of *Zamia,* dormancy does not develop if cones are allowed to disintegrate before the seeds are collected. Research has also shown that treatment with H_2S0_4 and growth regulators produces excellent germination in several species of *Zamia* (Dehgan and Johnson 1983; Dehgan and Schutzman 1983). Similarly, techniques using cold storage, growth regulators, scarification and different maturation periods have improved germination rates for several species of *Cycas* (Dehgan and Schutzman 1989; Dehgan and Almira unpublished data; Fiorino and Rinaldi 1989).

In general, cycads can be propagated from seeds relatively easily and the supply of plants in trade does not appear to be constrained by seed germination technology. The main constraints are more likely to be a source of seeds for the rarer species and the demand for large plants.

7.4.1. Obtaining larger plants

There is a perception that most cycad species develop much too slowly for either large-scale production, or the production of large plants, to be economically viable. However, stem growth in cycads is primarily dependent on annual leaf production, which in turn appears to be directly related to healthy root growth. Horticultural research on cycads has shown that root pruning and treatment with hormones can greatly increase the number of roots (Dehgan and Almira unpublished data; Dehgan and Johnson 1987; Osborne and Walkley 1997) so that plants grow more quickly. Adding fertiliser, maintaining soil moisture, and adjusting the pH of soil mixes can all stimulate growth in cycad plants (Dehgan 1983; Dehgan *et al.* 1994; Dehgan and McConnell 1984).

Large plants can also be obtained more quickly by propagating offsets or suckers from the main stem. These adventitious branches are usually limited in number and therefore cannot be used for large-scale production unless there are a large number of stock plants. However, research has shown that localised application of certain growth regulators (e.g., Promalin) can greatly increase the number of shoots in some species (Dehgan and Almira 1995). The induced branching and unusually rapid development of the caudex after treatment with growth regulators produces much larger plants than could be obtained from plants of a similar age in the wild. This technique seems to offer some hope for greater production of rare cycad species where seeds may be hard to come by, but it also has the potential for increasing the commercial production of larger plants.

7.5 Sustainable trade from wild populations

The sustainable use of wild cycad populations has two potential benefits for conservation. The first benefit is obvious because it increases the supply of cycads to world markets and thereby decreases the need for *ad hoc* collecting from the wild. In this sense, sustainable harvesting achieves the same goal as cultivation in nurseries except that it provides plants of known provenance (important for some collectors) and it could provide access to rare species. An additional benefit is that the wise use of wild populations provides a mechanism to protect cycad habitat.

Analyses in previous chapters showed that habitat destruction was a major cause of cycad decline in parts of Asia and the New World and also affected some species in Africa and Australia. In many cases, cycads occur on marginal land that is unsuitable for agriculture, but large areas of cycad habitat have nevertheless been destroyed due to the expansion of subsistence farming, commercial agriculture, grazing and non-agricultural developments. The sustainable use of cycad populations provides an alternative use for otherwise marginal land. Various models for sustainable use have been attempted in Costa Rica, Mexico, South Africa, Australia, and China. Currently there are not enough data available to provide an in-depth assessment of these different approaches, but it is worth documenting them so that conservation and development agencies can learn from the positive and negative experiences associated with these projects.

7.5.1 Mexico

Descriptions of sustainable use projects in Mexico have been given by Vovides (1993, 1997) and Vovides and Inglesias (1994). The use of wild fauna and flora in Mexico is governed by the General Law of Ecological Balance and Protection of the Environment that was passed by Congress in 1986. Threatened species are also included in an act passed in 1994 (NOM-059-ECOL-1994) that makes provision for artificial propagation in registered sustainable management nurseries known as UMAS (Unidad de Manejo de vida Silvestre). The first sustainable management nursery for cycads was initiated in 1990, initially without formal financing, for a population of *Dioon edule* at Monte Oscuro in the Chavarillo district. Here, subsistence farmers (campesinos) were clearing sections of cycad habitat and also lopping the crowns off large cycads, which they sold off as apparently well-established large plants.

The setting up of the nursery was preceded by studies of population structure, regeneration, phenology, and germination trials to come up with a workable protocol that could be used by peasant farmers. The need for such detailed studies had been identified in a project on *Zamia skinneri* in Costa Rica, where a low frequency of coning in deep shade rainforest led initially to the use of an inefficient method of vegetative reproduction. It was later found that higher coning frequencies could be obtained in secondary forest with higher light levels in the understorey (Ocampo pers. comm.). In Monte Oscuro, talks were given to the local community and the community agreed to set up a nursery using wild-collected seed on the understanding that they would (1), conserve the natural habitat as a seed source and (2), carry out reintroduction of nursery produced plants to compensate for seed removal. The community has generated some income from the sale of plants and the conservation benefit has been to protect about 80 hectares of tropical thorn-forest habitat.

Two further nurseries have been established in Veracruz province under the leadership of researchers from the Universidad Veracruzana. The first was established in 1992 at Cienega del Sur on the coast of Veracruz near Alvarado where substantial illegal harvesting of *Z. furfuracea* had taken place. An agreement was made with one campesino family who set up a low infrastructure nursery using seeds derived from the wild. Plants had reached a saleable size within two years and nursery-grown plants have subsequently started to produce seeds. The second project was initiated with a campesino community at Tlachinola, near Xalapa, for the management of *Ceratozamia mexicana*. Initial financing for both nurseries was obtained from Consejo Nacional de Ciencia y Tecnologia (CONACYT), GTZ-Germany and local authorities under the Solidaridad programme. Four additional nurseries have been started in the state of Chiapas for the management of *Dioon merolae* and *Ceratozamia* cf. *norstogii*, situated in the buffer zone of the La Sepultura biosphere reserve, and *C. matudae* and *Zamia soconuscensis* situated in the buffer zone of the El Triunfo biosphere reserve. Financing for the Chiapas nurseries has been obtained from a number of international sources including GTZ-Germany, MAB-UNESCO, and Fauna and Flora International, as well as national sources such as Comisión Nacional para el Conocimiento y Uso de la

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Zamia furfuracea propagated by local villagers as part of a conservation programme near Cienega del Sur on the coast of Veracruz where substantial illegal harvesting of *Z. furfuracea* had taken place.

Biodiversidad (CONABIO) and Fondo Mexicano para la Conservación de la Naturaleza (FMCN).

One of the major difficulties with all the nurseries in Mexico, as well as similar nurseries elsewhere, is the need to develop an effective marketing system to ensure that local communities can sell the plants they grow. If communities are not able to sell their plants within a reasonable timeframe, the community nurseries will collapse. Identifying target markets and developing trading partners in importing countries is therefore crucial to the success of these nurseries. At the same time, this means that nurseries must be equipped to produce a consistent supply of quality plants that are correctly labelled and packed, and that are accompanied by the correct phytosanitary and CITES documentation. In Mexico, GTZ has financed a three year marketing project in collaboration with ProTrade and a private nursery to develop markets for plants derived from sustainable management nurseries, and an agency has been created to coordinate the export of plants from GTZ-financed nurseries. It is not yet clear whether this mechanism will lead to continued benefits for local communities involved in sustainable-use projects.

7.5.2 South Africa

Cycads are classified as protected or specially protected plants in South Africa. There are no special provisions for the sustainable use of wild populations but the concept of sustainable utilisation has been adopted at both national and provincial levels. Regulated harvesting of seeds from wild populations has taken place since the 1970s and nature conservation departments set up nurseries for a number of *Encephalartos* species. Nurseries that were closely linked to rural communities were established for *E. transvenosus, E. lebomboensis,* and *E. paucidentatus.* The initial nurseries were run mostly by nature conservation staff and employed people from the local community, but later projects have given greater ownership to local communities. These projects have much in common with those in Mexico where the objective is to achieve greater *in situ* conservation by allowing local people to benefit from cycad populations. Such projects are critical in the case of species such as *E. lebomboensis* which has been ravaged by cycad collectors and where a community nursery has now been established.

Not all cycads occur on community lands in South Africa and a slightly different approach is required for cycads on commercial farms. *Encephalartos latifrons* is Critically Endangered and is scattered across a number of commercial farms in the Eastern Cape province of South Africa. Plants are so widely distributed that seed set can only be achieved by artificial pollination. A project is therefore being developed to involve commercial farmers who will set up a seed nursery based on wild plants that have been artificially pollinated. Once again, the rationale is that propagation of this rare cycad provides an economic incentive for farmers to conserve the last few remaining adult plants.

7.5.3 China

Two projects have been initiated in China. In the city of Panzhihua, a nursery has been established for the propagation of *C. panzhihuaensis.* The nursery is operated

A cottage industry to save *Cycas debaoensis* in China

Based on experiences in Mexico, in which the establishment of nurseries in villages near wild cycad populations has led to a greater awareness of their value as a renewable resource, a similar project is being developed in China. In this project, Prof. Liu Nian of South China Botanical Garden, William Tang, an associate of Fairchild Tropical Garden, and Anders Lindstrom of Nong Nooch Tropical Garden are applying the model developed in Mexico to the conservation of *Cycas debaoensis.*

Cycas debaoensis is a newly discovered species that has not yet been destroyed by plant collectors. Negotiations with the headmen of the village that is closest to the population of this cycad have led to a tentative agreement for the establishment of a nursery and cooperation in a conservation project.

The initial goals of this project are (first 2 years):

1. Establish a village nursery: This is a seasonally dry area and the nursery requires a small water tower and pipes for irrigation.
2. Train nursery workers so that they can construct and operate the nursery and look after the plants.
3. Map and tag all plants in the wild population (approximately 500 individuals) to monitor reproduction, as well as decline or increase in the population. This information will help determine the number of seeds that can be sustainably harvested and determine if the project is helping to protect the natural population.
4. Develop a consistent market for nursery grown plants.

Cycas debaoensis in habitat in Guangxi, China. This species is being cultivated by local villagers as part of an experimental conservation project.

© W. Tang

by a government agency in association with a botanical garden. The local people are only peripherally involved and it has been necessary to establish a reserve with a perimeter wall to control fires caused by peasant farmers living on the edge of the reserve. In Southern China, a project is being developed for a newly discovered species of cycad, *Cycas debaoensis*. This project is based more on the Mexican model and a representative from an academic government agency has been working together with the headmen of the closest village to establish a nursery and to develop a conservation project with participation by the local community.

7.5.4 Australia

Many Australian cycad species are so abundant that it is possible to harvest plants from the wild. In the Northern Territory, the Parks and Wildlife Service has drawn up a management plan for the sustainable use of cycad populations. The regulations make provision for harvesting concessions for both seeds and mature plants that are based on quotas for particular species. The Australian situation is unique in that it provides a framework for the sustainable harvest of mature plants whereas most other harvest schemes involve only seeds.

7.5.5 The lessons learned

Sustainable use of cycad populations appears to offer one solution to the problem of habitat destruction. However, despite the current focus on this approach, past efforts to establish nurseries show that it is not a simple process with guaranteed results. We need to take note of the lessons that have been learned from these pilot projects to increase the success rate of future projects.

1. The demand for a particular cycad species needs to be carefully evaluated. Some cycads are quite common in cultivation and are easy to propagate. In this case, community nurseries will have to compete against commercial nurseries that may have more direct access to markets (e.g., with *Zamia furfuracea*). In the case of rare species, there may be a limited market among collectors and this will not develop into a high volume market. The way the nursery is set up needs to be carefully thought through for each species, as regards the marketing strategy and financial planning.

2. A thorough understanding of the biology, life history and population structure of the species to be managed is required at the start of the project. Propagation methods should be worked out beforehand and developed to a point that is appropriate for the level of education and technology available to the user group. Botanical gardens can play a vital role in developing suitable methods.

3. It is important to understand the sociological context in which projects are developed and to work with an appropriate social structure. Projects developed so far have devolved responsibility to different social structures ranging from an individual family (e.g., at Cienega del Sur), the heads of families (men) with no participation by women or children (e.g., Monte Oscuro), commercial farmers (e.g., *E. latifrons*), and nature conservation authorities. It would be enormously helpful for future projects to determine which systems have been most successful.

4. Continuous assessment is necessary with inputs from technical specialists who communicate easily with local people.

5. Legislation and permits need to be revised to facilitate trade by sustainable-use nurseries. It may also be necessary to develop mechanisms that create a trading benefit for nurseries linked to the sustainable use of wild populations. In Mexico there has been a proliferation of peasant nurseries for the propagation of *Z. furfuracea* in areas away from the natural habitat and this reduces the incentives for habitat protection.

6. Effective marketing is essential for these projects. Linked to this is the need for further training to ensure a continuous supply of quality plants that meet the buyers' specifications.

7. Start-up funding and long-term support for marketing appears to be essential for the continued survival of sustainable-use nurseries.

Chapter 8

Off-site collections

T. Walters

8.1 Introduction

The successful long-term conservation of the world's cycads will only be achieved through the combination of two main activities: on-site (*in situ*) activities, which are conducted in the original habitat, and off-site (*ex situ*) activities, which preserve the genetic diversity outside of the plant's native habitat. The overall objective of this Action Plan is to conserve cycads on-site in their native habitat where evolutionary processes will continue to shape their development. However, the perilous position of many cycad populations means that conservation objectives can only be realised with the addition of an off-site activity programme for these species. Despite some of the problems associated with off-site collections (e.g., the artificial selection of plants that are suited to garden conditions, or the loss of collections due to natural disasters, poor maintenance, and changes in institutional policy), there seems to be no other way to preserve representative genetic material of cycads when so many species are threatened with extinction in the wild. This chapter provides an overview of the role of off-site collections in cycad conservation and an evaluation of the current status of these collections. The further development of cycad collections in botanical gardens is dealt with as one of the actions (Chapter 10).

8.2 The requirements for off-site preservation

Off-site collections are important genetic libraries for plant taxa. Esser (1976), Brown and Briggs (1991), Walters and Hubbuch (1992, 1994), and Given (1994) have provided several justifications for developing, managing, and financially investing in off-site collections of threatened plants, including:

- To arrest the potential genetic erosion of wild populations by providing a protective and managed site for growing plants
- To provide a gene reservoir for basic and applied research
- To provide plants and material to the nursery trade, as well as other individuals, organisations, and institutions so that the pressure is taken away from wild populations
- To provide plants and material for display collections and education
- To provide source material to restore plants to extinct or critically endangered populations in their native habitat (Barrett and Kohn 1991).

The educational and display objectives of off-site collections can be met by even modest collections in gardens that do not require any specific management. The situation is quite different when the objective is to preserve a representative gene pool for either scientific or restoration purposes. These collections need to represent specific populations and must be carefully documented and maintained. At present there are no proven methods for the long-term storage of cycad seeds or tissues (although cryopreservation techniques offer a lot of promise) and the only option is to develop collections of living plants.

Population genetic studies show that cycads typically have low levels of heterogeneity (Ellstrand *et al.* 1990; Walters and Decker-Walters 1991; Walters *et al.* n.d.) and that a sample of as little as ten plants can give a good representation of genetic diversity within a population. Propagation from seeds has proved to be the most appropriate way to develop such collections for threatened cycads and the genetic diversity within a cycad population can be represented by obtaining two seeds from five widely scattered mother plants within a population (Walters and Decker-Walters 1991; Walters *et al.* n.d. and citations within). This assumes that the seeds will all germinate, seedlings will grow to maturity, all the resulting plants will produce cones, and that at least half of the ten plants will be female. The odds of meeting all of these requirements is small so that the minimum requirement to build up an off-site collection of cycads should be increased to at least five seeds from five widely scattered mother plants (i.e., 25 seeds) for each population.

Seeds are often not available in wild cycad populations. Suckers have proved to be a viable alternative for some species although it is important to ensure that removing suckers does not damage the source plant, and that the wound is properly sealed with a protective fungicide paste. For species that do not produce suckers, the only option may be to collect wild plants, but this should be viewed as a last resort. The total number of suckers or plants that are removed will depend on many factors but the objective should be to obtain a collection of 15 viable plants.

The Center for Plant Conservation (1991) recommends that where there are more than five known populations, the core collection should contain samples from four to

The impressive male cones of *Encephalartos woodii.* No female plant has ever been found.

Lonely batchelors

Wood's cycad (*Encephalartos woodii*) was discovered in the Ngoye Forest in South Africa in 1895 as a single male plant with a number of stems. Botanists feared that this single plant would be destroyed so they removed some of the stems and propagated them in botanical gardens. The last wild plant died in the early 1900s, and despite several attempts to find additional plants, no other specimens of Wood's cycad have been discovered. So far, all attempts to induce a sex change in male plants have also failed. The initial plants were taken to Durban Botanic garden and they have supplied suckers to other gardens who, in turn, have also distributed suckers as their plants matured. The actual number of plants in collections is not known, but there are probably several hundred *E. woodii* in cultivation. A specimen of *E. woodii* in the Kirstenbosch National Botanical Garden (Cape Town) had to be enclosed in an iron fence to prevent collectors from illegally removing the suckers. The sight of this specimen prompted Oliver Sacks (1996) to write that "Seeing the magnificent solitary specimen at Kirstenbosch, unlabelled and surrounded by an iron fence to discourage poachers, reminded me of the story of Ishi, the last of his tribe. I was seeing here a cycad Ishi, and it made me think of how, hundreds of millions of years ago, the numbers of tree lycopods, tree horsetails, seed ferns, once so great, must have diminished to a critical extent until there were only a hundred, only a dozen, only a single one left – and finally, one day, none at all; only the sad, compressed memory held in the coal".

five populations covering the geographic range of the species. If less then five populations of a species are known, collections should be made from all populations. Replication (duplication) of critical off-site collections is also of vital importance. Even with the most carefully managed and planned collections, catastrophes can occur and several cycad collections have been lost through hurricanes, overheating in greenhouses, theft, and disease. The ideal situation is therefore to have duplicate collections either from the same initial wild sample or at least from the F1 generation of cultivated plants. A recommended practice is to collect enough initial material (only if the population can handle this) so that half stays with an institution within the country of origin and the other half goes to an institution elsewhere.

The value and success of off-site collections also depends on the amount of information available. It is particularly valuable to have information on geographic distribution, ecological range, population sizes, breeding system, seed dispersal mechanism, mode of pollination, and age structure of the populations (Holtsford and Hancock 1998). Excellent sources for understanding the biology of many cycads, as it relates to conservation, can be found in Donaldson (1995) and Norstog and Nicholls (1997). This information will give some indication of the short- and long-term management needs, the financial requirements, and the amount of land that needs to be set aside for the collections.

Seed orchards

In the early 1980s, the Lowveld National Botanical Garden in Nelspruit, South Africa, began to assemble a collection of the endangered species of *Encephalartos.* Johan Kluge, the curator of the garden, realised that a display collection could not meet the need for the production of seed, conservation, or research. Cones were being stolen from display collections, bags used for artificial pollination detracted from the garden's aesthetic appearance, and more plants of a species were needed to represent the genetic diversity of threatened species. This required a completely new approach to the management of endangered plant species. A decision was taken to establish seed orchards of approximately 50–100 individuals of a species in a section of the garden that was closed to the public. Seed orchards were established from seeds of known origin, or from seed produced by plants of known origin. This pioneering work led to the production of similar collections in other parts of the world. Cycad collections at Lowveld National Botanical Garden, the Montgomery Botanical Center in Miami (USA), and Nong Nooch Tropical Garden (Thailand) represent some of the most comprehensive and genetically representative collections of any plant group.

Nature conservation officials planting out seedlings of *Encephalartos latifrons* in South Africa.

Finally, since cycads are extremely long-lived perennials, off-site collections require a long-term commitment from botanical gardens. The core (original) collection for each species is the most valuable part of an off-site collection, and plants within the core collection should be clearly labelled so that they are never confused with future generations. A suitable site must therefore be identified and the institution must be committed to a healthy maintenance schedule for the original collection. Seed production should be carried out in such a way that it preserves genetic diversity (e.g., parents should include a male and a female plant originally collected from different mother plants within the same population). Seeds derived from these collections should always be labelled with full documentation of the parents along with the pollination methods used to produce the seeds. In some cases, the institution may need to make a commitment to preserve the pollinator along with the off-site collection as this may be the only way to conserve some of the species-specific pollination mutualisms. This provides an additional challenge for botanical gardens as it requires careful management of collections and could lead to hybridisation.

8.3 Priorities for conservation

The substantial requirements for the effective development and maintenance of off-site collections mean that it is simply not possible to cover all threatened species. Specific criteria have therefore been suggested to identify priority species that should be preserved in off-site collections. Those recommended by the Center for Plant Conservation (CPC 1991) are:

- A high degree of endangerment
- A rapid decline in population numbers or size
- Taxonomic and evolutionary uniqueness

Cycads as a group satisfy all these criteria. Although there are only *c.*297 infrageneric cycad taxa, this still represents a considerable challenge for botanical gardens if the objective is to adequately represent the full gene pool in cultivation. We therefore need to determine which cycads should receive priority. If we apply the CPC criteria to cycads (i.e., a high level of endangerment and taxonomic uniqueness) then we can rank cycads according to the degree of threat at the highest taxonomic level using the data provided in Chapters 3 to 6. The cycad family with the smallest number of species (and therefore potentially the greatest threat) is the Stangeriaceae. However, the single species of *Stangeria* and the two species of *Bowenia* that make up the family are still relatively abundant and none of them are classified in a threatened category. Similarly, within the Cycadaceae, some members of the genus *Cycas* are so abundant that there is currently no danger that the family will become extinct. It is also highly unlikely that all members of the Zamiaceae will die out. As a result, there is no clear priority for cycad conservation at the family level.

In contrast, at the genus level, the single species of *Microcycas* and the two species of *Chigua* are all listed as Critically Endangered and there is a high probability that these genera could become Extinct in the Wild. Although *Ceratozamia* is a much larger genus, all the species are listed in one of the threatened categories, again indicating a high level of threat. *Encephalartos* and *Zamia* have a high proportion of threatened species, but it is extremely unlikely that all species in these large genera will die out in the wild. Many species within the genus *Macrozamia* are common in the wild and there appears to be no threat to the two known species of *Lepidozamia*. As a result, the three genera that should receive the highest priority are *Chigua, Microcycas,* and *Ceratozamia*.

The priority for cycad conservation should therefore be to first ensure that *Chigua, Microcycas,* and *Ceratozamia* are adequately represented in collections. For the remainder of the cycads, priority should be based on the level of threat.

8.4. Current status in off-site collections

Osborne (1995a) carried out a census of cycads in private and public gardens but these figures are now out of date due to changes in cycad taxonomy, changes in threatened status, and substantial changes in the species represented in key botanical gardens. The results of a revised census, focusing on threatened cycad species, are presented here (Table 8.1). The majority of threatened species are represented in at least one collection but many of these collections comprise one or a few plants and do not constitute a true “off-site” collection as defined above. Three institutions house a substantial proportion of the world’s off-site cycad collections, namely the National Botanical Institute in South Africa, the Montgomery Botanical Center in Miami (USA), and Nong Nooch Tropical Garden in Thailand. These organisations have developed genebanks based on the guidelines outlined here and they account for most of the ‘genebank’ collections listed in Table 8.1. Other gardens such as Jardin Botanico Fco J. Clavijero in Xalapa (Mexico) and Fairy Lake Botanical Garden in Shenzen (China) have important collections. The expertise and the network of gardens involved in cycad conservation needs to be developed still further.

In terms of the priorities for off-site collections, *Microcycas* is well represented in at least one collection and seeds from this collection have been distributed to gardens all over the world. However, there are no genebanks for the two species of *Chigua* and they are poorly represented in collections. Suitable collections need to be developed as a

Table 8.1. Cycads known to be represented in off-site collections. 'General collection' means that one or more specimens have been reported in the collections of a botanical garden or public institution. Similarly, 'Private collection' means that one or more plants are known to occur in private collections. 'Genebank' means that a collection represents a significant genetic sample of a known population and it is maintained and managed as a genebank.

Taxon and Status	General collection	Gene bank	Private collection
Extinct in the Wild			
Encephalartos relictus	Y	–	–
Encephalartos woodii	Y	–	Y
Critically Endangered			
Ceratozamia euryphyllidia	Y	–	Y
Ceratozamia fusco-viridis	–	–	–
Ceratozamia kuesteriana	Y	–	Y
Ceratozamia norstogii	Y	–	Y
Ceratozamia zaragozae	Y	–	–
Ceratozamia zoquorum	Y	–	–
Chigua bernalii	Y	–	–
Chigua restrepoi	Y	Y	Y
Cycas beddomei	Y	–	–
Cycas chamaoensis	–	Y	–
Cycas debaoensis	–	Y	–
Cycas "fugax"	Y	–	–
Cycas hongheensis	Y	–	–
Cycas szechuanensis	Y	–	–
Cycas tansachana	Y	Y	–
Dioon caputoi	Y	–	–
Encephalartos aemulans	Y	Y	Y
Encephalartos brevifoliolatus	Y	–	–
Encephalartos cerinus	Y	Y	Y
Encephalartos cupidus	Y	Y	Y
Encephalartos dolomiticus	Y	Y	Y
Encephalartos dyerianus	Y	Y	Y
Encephalartos equatorialis	Y	Y	–
Encephalartos heenanii	Y	–	–
Encephalartos hirsutus	Y	–	–
Encephalartos inopinus	Y	Y	Y
Encephalartos laevifolius	Y	Y	Y
Encephalartos latifrons	Y	–	Y
Encephalartos middelburgensis	Y	Y	–
Encephalartos msinganus	Y	–	–
Encephalartos munchii	Y	Y	–
Encephalartos nubimontanus	Y	Y	–
Encephalartos pterogonus	Y	Y	–
Encephalartos tegulaneus powysii	Y	–	–
Microcycas calocoma	Y	Y	–
Zamia amplifolia	Y	Y	–
Zamia disodon	–	–	Y
Zamia hymenophyllidia	–	–	–
Zamia inermis	Y	–	Y
Zamia macrochiera	Y	–	–
Zamia montana	–	–	–
Zamia monticola	Y	–	–
Zamia picta	Y	–	Y
Zamia portoricensis	–	Y	Y
Zamia prasina	Y	–	Y
Zamia spartea	Y	–	–
Zamia urep	–	–	Y
Zamia vazquezii	Y	–	Y
Zamia wallisii	Y	–	Y
Endangered			
Ceratozamia alvarezii	Y	–	–
Ceratozamia beccarae	Y	–	–
Ceratozamia hildae	Y	–	Y
Ceratozamia matudae	Y	–	Y
Ceratozamia morettii	Y	–	–
Ceratozamia sabatoi	Y	Y	–
Ceratozamia whitelockiana	Y	–	–
Cycas canalis ssp. *canalis*	Y	–	–
Cycas chamberlainii	Y	–	–
Cycas changjiangensis	–	Y	–
Cycas hainanensis	–	Y	–
Cycas "hoabinhensis"	Y	–	–
Cycas megacarpa	Y	–	–
Cycas multipinnata	Y	Y	–
Cycas platyphylla	Y	–	–
Cycas taiwaniana	Y	–	–
Dioon holmgrenii	Y	–	Y
Dioon sonorense	Y	–	–
Dioon tomasellii	Y	–	–
Encephalartos arenarius	Y	–	Y
Encephalartos barteri ssp. *allochrous*	Y	–	–
Encephalartos chimanimaniensis	Y	Y	–
Encephalartos concinnus	Y	Y	–
Encephalartos eugene maraisii	Y	Y	–
Encephalartos horridus	Y	Y	–
Encephalartos kisambo	Y	–	–
Encephalartos lebomboensis	Y	Y	–
Macrozamia conferta	–	Y	–
Macrozamia elegans	–	Y	–
Macrozamia flexuosa	Y	–	–
Macrozamia pauli-guilielmi	Y	–	–
Macrozamia spiralis	Y	–	–
Zamia cremnophila	Y	–	–
Zamia dressleri	Y	Y	Y
Zamia fischeri	Y	–	–
Zamia lacandona	Y	–	–
Zamia melanorrhachis	Y	–	–
Zamia purpurea	Y	–	Y
Zamia skinneri	Y	Y	Y
Zamia variegata	Y	–	Y
Vulnerable			
Ceratozamia latifolia	Y	–	–
Ceratozamia mexicana	Y	Y	Y
Ceratozamia microstrobila	Y	–	Y
Ceratozamia miqueliana	Y	–	–
Ceratozamia robusta	Y	Y	–
Cycas "collina"	–	–	–
Cycas "condaoensis"	–	Y	–
Cycas conferta	Y	–	–
Cycas desolata	–	Y	–
Cycas diannensis	–	–	–
Cycas "dolichophylla"	–	Y	–

Table 8.1 ... continued. Cycads known to be represented in off-site collections.

Taxon and Status	General collection	Gene bank	Private collection
Vulnerable ... continued			
Cycas elongata	–	Y	–
Cycas inermis	–	Y	–
Cycas lindstromii	–	Y	–
Cycas macrocarpa	–	Y	–
Cycas micholitzii	Y	Y	–
Cycas "bifida"	Y	–	–
Cycas nongnoochiae	–	Y	–
Cycas pachypoda	–	Y	–
Cycas pectinata	Y	Y	–
Cycas pranburiensis	–	Y	–
Cycas seemannii	Y	Y	–
Cycas segmentifida	Y	–	–
Cycas siamensis	–	Y	–
Cycas silvestris	Y	–	–
Cycas simplicipinna	–	Y	–
Cycas taitungensis	Y	–	Y
Dioon califanoi	Y	–	Y
Dioon merolae	Y	–	Y
Dioon purpusii	Y	–	Y
Dioon rzedowskii	Y	–	Y
Dioon spinulosum	Y	Y	Y
Encephalartos altensteinii	Y	Y	Y
Encephalartos aplanatus	Y	–	Y
Encephalartos barteri ssp. *barteri*	–	–	–
Encephalartos delucanus	Y	–	–
Encephalartos ghellinckii	Y	–	Y
Encephalartos humilis	Y	Y	Y
Encephalartos macrostrobilus	Y	–	–
Encephalartos manikensis	Y	Y	Y
Encephalartos ngoyanus	Y	Y	Y
Encephalartos paucidentatus	Y	–	Y
Encephalartos princeps	Y	Y	Y
Encephalartos schaijesii	–	–	Y
Encephalartos sclavoi	Y	–	Y
Encephalartos senticosus	Y	Y	Y
Encephalartos trispinosus	Y	Y	Y
Encephalartos umbeluziensis	Y	Y	Y
Encephalartos whitelockii	–	Y	–
Macrozamia cranei	Y	–	–
Macrozamia crassifolia	Y	–	–
Macrozamia humilis	Y	–	–
Macrozamia lomandroides	–	Y	–
Macrozamia occidua	Y	–	–
Macrozamia secunda	Y	–	–
Macrozamia viridis	Y	–	–
Zamia amblyphyllidia	Y	–	Y
Zamia encephalartoides	–	Y	Y
Zamia furfuracea	Y	Y	Y
Zamia gentryi	–	–	–
Zamia herrerae	Y	–	Y
Zamia ipetiensis	Y	Y	Y
Zamia soconuscensis	Y	–	Y
Zamia standleyi	Y	–	Y
Data deficient			
Ceratozamia mixeorum	–	–	–
Cycas circinalis	–	Y	–
Cycas curranii	Y	Y	–
Cycas *diannanensis*	Y	Y	–
Cycas falcata	Y	–	–
Cycas javana	Y	–	–
Cycas nathorstii	–	Y	–
Cycas riuminiana	–	Y	–
Cycas spherica	Y	–	–
Cycas tanqingii	Y	–	–
Cycas wadei	Y	Y	–
Cycas zeylanica	–	Y	–
Dioon mejiae	Y	–	Y
Encephalartos kanga	–	–	Y
Encephalartos laurentianus	Y	–	–
Encephalartos septentrionalis	–	Y	–
Zamia angustifolia	Y	–	Y
Zamia kickxii	Y	–	–
Zamia pygmaea	Y	–	–

matter of urgency. Genebanks have been developed for several species of *Ceratozamia* so the needs within this genus are less urgent. At the species level, there are several Critically Endangered and Endangered taxa for which there are no genebanks and these collections should also receive a high priority (Table 8.1).

8.5 The role of private collections

Some of the world's most threatened cycad species are found in relatively large numbers in private collections and there is no doubt that these collections hold valuable material. With extinction becoming a very real possibility for many cycad species, the dilemma is to determine the actual conservation value of plants in private collections. Plant collectors often justify the removal of cycads from the wild by arguing that cycads are becoming extinct in the wild and that they are therefore contributing to cycad conservation by incorporating plants into their collections. This may indeed be a self-fulfilling prophecy since collecting of cycads from the wild constitutes one of the main causes of decline in cycad populations. The result is also an ethical dilemma because conservationists do not want to give undue recognition to collections that have contributed to the process of decline. However, many plants in private collections were obtained before the level of threat was fully appreciated and it may be useful to look at a collector's recent record to determine whether they should be included in conservation projects. At a more functional level, there are two additional constraints that limit the value of private collections.

8.5.1 Plant records

Very few private collectors maintain accurate records of their plant collections because this is a time-consuming and costly exercise, that many botanical gardens do not even undertake properly. It can be a very frustrating experience to walk through a cycad collection, knowing the potential scientific and conservation value of the plants, but finding out that there are no written records for any of the plants. For species that are known from only one locality this may not be a problem, but it can be a serious impediment when species occur in several different places or when there is some doubt about the taxonomic status of plants from different localities. There may be further complications when plants in collections represent the second or later generations of plants that have been grown from seeds. Without accurate records, there is no easy way to determine whether plants in collections still represent the gene pool of any particular wild population. Molecular techniques (e.g., DNA fingerprinting) can be used to match garden plants with wild populations thereby overcoming some of the problems associated with poor record keeping. At present, these techniques are expensive and time-consuming but they are likely to become more affordable and will therefore make it possible to use plants with poor provenance data in conservation work.

8.5.2 Conservation vs commercial objectives

Rare cycads typically have high commercial value and some Critically Endangered cycads are enormously valuable. Even seeds and seedlings can be worth over a hundred dollars each. Cycad conservation projects often work on small budgets and it is therefore difficult to pay commercial rates for material of rare cycads. In this instance, it is difficult to know beforehand whether conservation projects can rely on genetic material that forms part of private collections. There was a recent attempt to involve collectors in a project to restore populations of the Critically Endangered *Encephalartos latifrons* in South Africa. Despite the fact that hundreds of plants exist in private collections, very few private collectors became involved. One reason may be the potential financial loss if seedlings are used in restoration projects (instead of being sold), but there are almost certainly other reasons as well, such as concern about the questions that may be asked regarding the origin of the plants.

We cannot and should not exclude the potential role of private collectors but we need to recognise the problems that exist. Ultimately, the responsibility for conservation management lies with governments and botanical institutions, and private collections need to be integrated into their activities where it is appropriate.

8.6 Priorities for action

1. In countries where native cycad populations occur, botanical gardens, field stations, arboreta, and other related institutions must evaluate the status of their cycad populations, decide which institution should develop off-site collections and for which taxa, and immediately begin the development of the core collection. If the range state is unable to do this independently, it should be carried out in collaboration with a foreign institution under the guidelines of the Convention on Biological Diversity (CBD) and national biodiversity action plans.

2. The Cycad Specialist Group must work together with botanical garden organisations to develop a network of botanical gardens that meet the needs of cycad conservation programmes. Appropriate institutions need to offer and commit to providing long-term space and financial support for off-site cycad collections.

3. Botanical gardens can play an important role in education. Although cycad collections in many gardens have no provenance data, any cycad can be used to tell stories about cycad conservation. As a result, virtually any botanical garden with cycads can support the Cycad Action Plan (Chapter 10).

4. Regulations, permits, and the logistics of obtaining material for off-site collections place very strong constraints on the development of good collections. Governments need to facilitate the process of developing these collections and the further exchange of seeds between botanical gardens. It is particularly important for CITES Management and Scientific authorities to become involved in the process so that there are no undue delays in the issue of permits.

Chapter 9

A Unifying Framework for Cycad Conservation

W. Tang, J.S. Donaldson, and T. Walters

9.1 Introduction

Perhaps the most serious limitation of past cycad conservation measures has been their failure to identify all the forces that impact on the survival of cycads in the wild and to respond to them in an appropriate way. As a result, many cycad conservation policies and actions have had only limited success. Conservation measures have often seemed to contain all the right ingredients, including; reserves to conserve the remaining populations, listing on the CITES appendices to limit trade, or undertaking a research project to look at some aspect of population ecology, but they have not been wholly effective. It is true that plugging gaps in the existing system may resolve some of these problems, but equally, it is unrealistic to expect a different outcome when we persist in applying the same methods. There is a growing realisation that cycad conservation policies and actions need to be based on a broader understanding of the biological, social, and economic factors that impact on cycad populations.

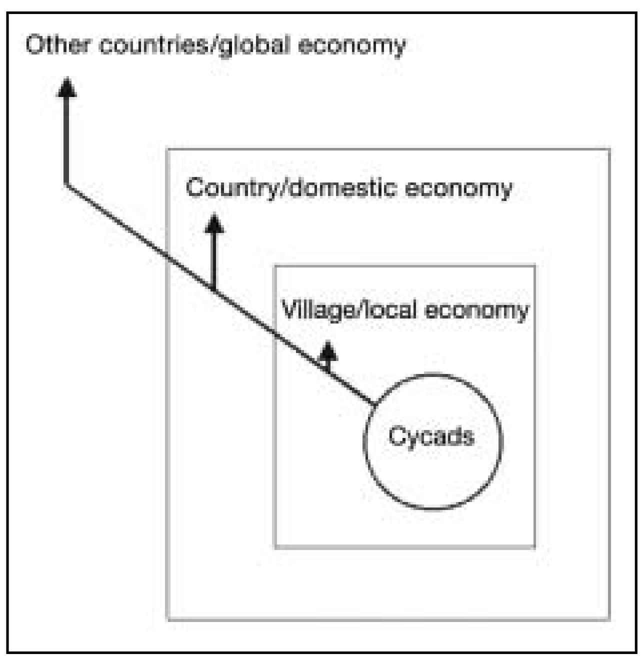
The preceding chapters of this Action Plan show that the main threats to wild cycad populations are habitat destruction and the extraction of wild plants for the horticultural and collector trade. It is easy to see these threats only as a result of the actions taken by local communities living near wild cycad populations, or the isolated actions of plant collectors. However, these actions are often influenced by the broader society where the demand for natural resources, through mining and agriculture, results in habitat destruction and the international trade in cycads creates a demand for wild-collected plants. The challenge for cycad conservationists is to identify these forces and to develop and implement conservation strategies that will be effective within the context of these local, national, and international dynamics. The conceptual framework presented here is an attempt to place cycad conservation in this broader socio-economic context so that it can be used as a tool to develop effective conservation measures and to test the likely effectiveness of different conservation measures. The ideas developed here are based on the pilot projects and information outlined in the previous chapters of this Action Plan.

9.2 Developing a conceptual framework for cycad conservation

The forces that impact on wild cycad populations can be arranged within a series of concentric boxes (Figure 9.1). Each of these boxes represents a geographic source of pressure on a wild population of cycads. For instance, a destructive force impinging on a population may arise from a local village, or it may be driven by demands within the national boundaries of the country where the cycads occur, or it may arise from an international source. Arrows connecting the wild population of cycads with each of these boxes represent these forces. The boundaries of each box may be viewed as political boundaries, and the forces that affect the population of cycads may be subject to various international, national or local regulations when they move from their source to their destination. This obviously has implications for cycad conservation policies and actions since an important first step for any conservation measure would be to identify the various forces affecting the cycad population in question.

The forces acting on wild cycad populations can also be represented as a simple economic model (Figure 9.2). Virtually all human threats to cycads are economic in origin, whether it is a farmer ploughing up land to grow crops, the extraction of plants for the horticultural trade, or the mining or lumbering activities of a large corporation. Purely spiritual or artistic activities have relatively little or

Figure 9.1. The different levels of political and economic influence on cycad populations.



no impact on wild cycad populations. Figure 9.2 illustrates how a population of wild cycads exists within the realm of the human economy. The immediate relationship is with local land-users, whether this is a single farmer or a rural community, where decisions about land-use and resource-use will be based on the benefits derived from the various options available to land-users. To simplify the situation, we have separated the relationship with cycads from all other competing forms of land-use.

There are relatively few instances where cycad populations provide direct benefits to land-users other than for horticultural use (but see Chapter 7 for examples of starch extraction and medicinal use). The low utility value of cycads means that the status of cycad populations within the local economy will depend largely on the needs of the local land-user. If there are sufficient resources to meet the needs of the land-user without encroaching on cycad habitat, the relationship with cycads may be positive or neutral. However, if there are insufficient resources, there will be a greater need to intensify competing forms of land-use that may have a negative impact on cycad populations.

Beyond the immediate neighbourhood of wild cycad populations, external forces operating on the local economy will strongly influence the relationship between local land-users and cycad populations. Increased external demand for farm produce or natural resources will result in the loss of cycad habitat or damage to the cycads themselves. However, if land-users are able to derive some benefit from cycad populations by meeting the external demand for cycad plants or by providing ecotourism opportunities for external markets, then destructive forms of land-use may be less attractive.

Within this basic model, cycads can be viewed as an economic resource. Even if conservation actions explicitly try to remove cycads from the economic arena, these conservation measures will probably have economic consequences that need to be addressed. Often, the cycads are not themselves the economic resource, but are threatened in the exploitation of another resource. In Australia and the Dominican Republic there have been government-sponsored programmes to eradicate cycads, because of toxicity to livestock. In these cases, the cycads were destroyed because they were barriers to the exploitation of pastureland for raising cows and sheep. Similarly, arborescent and epiphytic cycads may be destroyed during lumbering operations even when they are not the objects of exploitation themselves.

9.3 Applying the general model to cycad conservation problems

The basic conceptual model provides a template for developing and evaluating conservation policies and actions. As such, it needs to be worked into a particular context to be of any use. Only once the model has been applied to a specific environment, can conservation plans be intelligently proposed and their merits debated. For instance, we may ask whether a conservation plan can deal with pressure from local villagers who want to expand their farms to generate cash, or whether a particular conservation plan will be effective against a large strip mining operation that will destroy not only the cycad population but all vegetation and soil in its habitat? In such an analysis it is not enough to merely recognise the

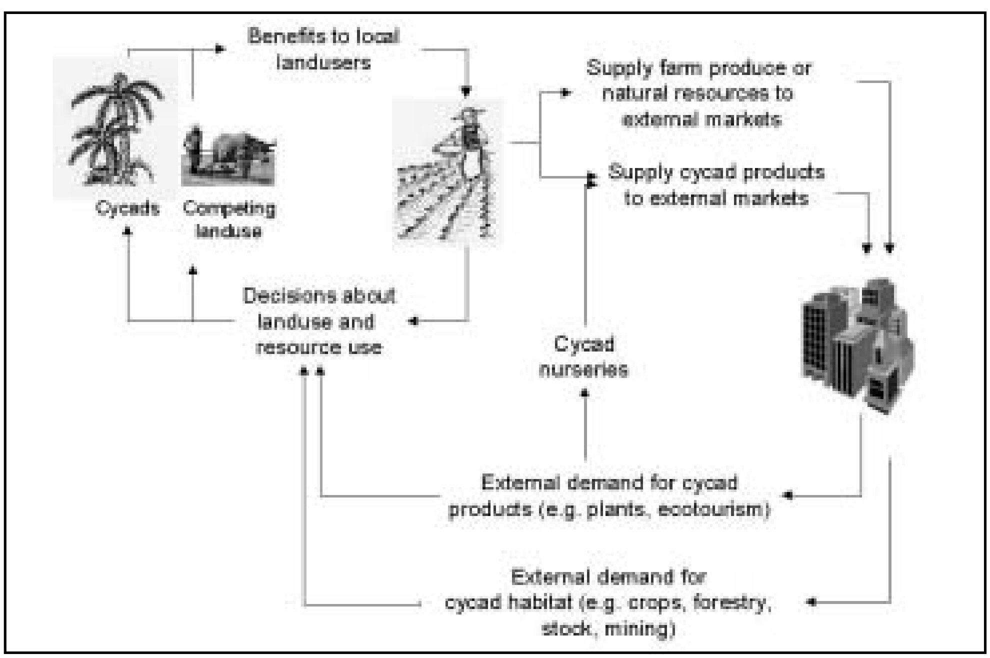


Figure 9.2. A simple conceptual model of the economic forces that influence the survival of cycad populations.

broad global picture, it demands an in-depth understanding of local culture, law, and customs.

It is also important to note that the conceptual model is not dependent on a particular conservation philosophy. Past conservation policies and actions have arisen mostly from a strong protectionist philosophy, based on the principle that natural resources need to be protected from over-exploitation or, in many cases, from any form of exploitation. As a result, policies have been formulated that put conservation in a gatekeeper role to restrict access to cycad populations, to develop barriers to trade in wild-collected plants, and to regulate the legal trade in plants. Over the past few decades, there has been a shift towards the alternative philosophy of sustainable utilisation based on the principle that natural resources can best be conserved if people are allowed to exploit wild populations at a level that is not detrimental to the population. The benefits derived from using the resource are presumed to act as a strong incentive for conservation actions. Conservation therefore acts to facilitate sustainable use. There may be reasons to apply either philosophy in a particular situation and the conceptual model presented here can be used to evaluate the outcomes of these applications.

Although the model needs to be adapted and tested in each specific context, there are certain factors that are likely to have a dominant effect on the outcomes of the model. These factors are discussed in more detail to highlight their likely impacts on conservation plans.

9.3.1 Regulations to limit trade and access to wild populations

Regulations to restrict trade in wild-collected plants (Chapter 7) can have a profound effect on the outcome of the model. However, such restrictions don't always have a positive outcome in terms of wild cycad populations. First, it is necessary to make a distinction between regulations that may restrict trade (e.g., those associated with a listing on CITES Appendix II) and those that prohibit trade in wild-collected material (e.g., listing on CITES Appendix I). It should be clear from the model that a total ban on trade in wild-collected material could completely exclude local land-users from any benefits derived from wild cycad populations (except for ecotourism). In this case, conservationists need to make sure that land-users will not destroy the cycad habitat in order to generate income from competing forms of land-use. The need to contextualise cycad conservation issues means that trade bans cannot be applied according to a simple formula derived from the plant's threatened status and trade volumes (as may have happened with past CITES listings). The missing dimension that needs to be considered is what effect a trade ban will have on cycad habitat.

Wild-collected *Cycas* being potted up for sale in a village in China.

Alternatives to a complete ban on cycad trade should always be considered. Existing population studies suggest that seed harvesting is likely to have a low impact on cycad populations. Nurseries based on wild-collected seed, especially those involving local people (Chapter 7) can meet both conservation and community upliftment objectives.

To facilitate sustainable trade, the listing of cycads on CITES appendices must be reviewed, especially in the context of the type of conservation plans proposed here. A listing on CITES Appendix II should be used to encourage trade practices that protect the resource (in this case cycads); in many countries CITES is implemented in a way that inhibits trade and therefore provides no incentive for local people to preserve cycad habitat. An inflexible set of regulations may not only hinder the development of new conservation measures, but actually work against the preservation of the very species they were intended to preserve.

9.3.2 Changing markets and market perceptions

In economic terms, cycads are simply another commodity subject to the laws of supply and demand. So far, this process has been seen mostly in a negative way where collectors have been vilified as the culprits responsible for the endangerment of wildlife. However, notwithstanding some of their destructive activities, collectors and enthusiasts typically represent a knowledgeable, well educated, and relatively wealthy (by global standards) group of individuals with a strong interest in cycads. In fact, many of the most ardent cycad conservationists and scientists are drawn from this group and most collectors would probably prefer to support conservation rather than contribute to the demise of wild populations. Therefore, instead of merely trying to suppress the market created by collectors and enthusiasts, the market could be steered to benefit conservation.

There are at least two ways that cycad enthusiasts can contribute to conservation of wild cycads simply by satisfying their interest. The first is by encouraging enthusiasts to buy plants from community-based nurseries in the country of origin, and the second is to develop ecotourism opportunities that enable enthusiasts to see cycads in the wild. Both of these activities can prevent habitat destruction by local people unaware of the plight of cycads and other endangered plants and animals. To achieve this, there will need to be a rigorous review of existing regulations to facilitate trade and access to ecotourism opportunities.

9.3.3 Research

Cycads are inherently interesting plants that have attracted the attention of various researchers. Nevertheless, there needs to be a specific focus on those aspects of cycad biology that can influence the outcome of economic models. On the one side, we need to know more about sustainable levels of harvesting from wild populations. Existing data suggests that seeds could be harvested from most wild populations without affecting population growth, thus greatly increasing the availability of seeds and seedlings for trade. However, suitable criteria for wild harvesting will need to be developed (e.g., before or after natural dispersal) based on cycad life-history strategies.

Research can also influence how competing forms of land-use impact on cycad populations. We need to know which land-use practices have a low impact on cycad populations and how to modify other land-use practices to reduce their impact on wild cycads. Already, studies of wild populations have started to identify critical factors that are impacted by land-use (e.g., direct loss of plants, changes in microclimate for seedling establishment, lower persistence of mature plants, extinction of both generalist and specialist insect pollinators, and loss of dispersal agents). However, more research is required in this area, and results need to be synthesised to identify appropriate 'best practices' for cycad conservation.

9.3.4 Education and publicity

Publicity and education can have a strong influence on the outcomes of the economic model. For example, if rural communities realise the need to conserve cycad populations despite their lack of economic or utility value, it becomes increasingly possible to conserve cycads outside reserves even when there is a strong external demand for wild-collected plants. Similarly, farmers, lumber companies and other land-users could be educated to use practices that are compatible with cycad conservation so that competing forms of land-use become less of a threat to cycad populations. Consumer groups can be educated to choose products that do not endanger cycad populations through programmes of publicity and certification. To achieve this, cycad conservation issues must be clearly communicated to a wide range of interested and affected parties, including land-users, government agencies, and consumers. In addition, suitable educational and informational products need to be developed so that they can be used to change public perceptions about cycad conservation issues.

9.3.5 Involving local people

Local people have a strong effect on the outcome of the model. Except in the few instances where cycads occur entirely in reserves, local people will end up being either the agents of protection or destruction for wild cycad populations. Local peoples therefore need to be involved in the process of developing conservation policies and actions. Sustainable use may often be the key to ensuring the participation of local people in a conservation project, but it is not only the economic rewards that need to be considered. If spiritual or cultural traditions are upheld by the preservation of cycads and their habitat, these will help to ensure the long-term success of a conservation plan. If the local people derive social status from national or international recognition of their participation in a conservation project, this will also promote long-term cooperation.

9.4 Summary

The model outlined here represents a very simplified view of how cycad populations may be impacted by various actions. In our view, such a simple visual model is adequate to allow decision makers to foresee the possible consequences of their policies or actions. At its most basic level, the model could be translated into a series of key questions:

- Will the policy/action result in the continued survival of the cycad population/s?
- Will the policy/action result in the continued existence of suitable cycad habitat/s?
- Is the policy/action sustainable given the available resources?

These questions have also guided the development of the actions that form part of this Action Plan.

Chapter 10

Action Proposals

10.1 The conservation of cycad habitats

Objective: *To establish effective protection for remaining cycad populations and habitat, especially in Asia and the New World.*

10.1.1 Develop links with organisations focusing on biodiversity hotspots

Cycad conservation is very strongly linked to habitat conservation, especially in Asia and the New World. These areas are often congruent with areas of general plant diversity (e.g., Mexico, China, Vietnam) which means that conservation organisations focusing on global hotspots will be trying to conserve some of the same habitats. We must therefore ensure that cycad conservation actions complement other actions to save threatened habitats. Cycads could be effectively used as flagship species in some areas.

Activities and responsibility

- Designate a member of the Cycad Specialist Group to liaise with organisations such as Conservation International, WWF, and the IUCN Species Survival Commission.
  Responsibility: Cycad Specialist Group.
  Timeframe: should take place when group is reconstituted for the 2001–2004 period.
- Circulate a list of cycads associated with designated biodiversity hotspots.
  Responsibility: Cycad Specialist Group.
  Timeframe: 2003–2004.
- Develop profiles on cycad species that could be used by Conservation International, WWF, or IUCN as flagship species for specific biodiversity hotspots. Animal and bird species have been used in this way and cycads could be used to highlight problems in specific hotspots.
  Responsibility: Cycad Specialist Group, together with CI, WWF, and IUCN.
  Timeframe: 2003–2004.

10.1.2 Evaluate and promote cycad nurseries linked to wild populations

The prime reason for promoting local cycad nurseries is that they provide an incentive for local communities to preserve cycad habitat. Existing nurseries have shown that involving local people does have benefits, but there are several key activities that are required to promote this activity.

Activities and responsibility

- Critically evaluate the successes and failures of pilot projects in Mexico and South Africa to determine whether nurseries do offer sustainable benefits to local communities.
  Responsibility: development agencies and conservation organisations such as GTZ, Fauna and Flora International, CONABIO, and Mpumalanga Parks Board (South Africa) who have invested in the development of nurseries, with collaboration by the Cycad Specialist Group.
  Timeframe: 2004.
- Identify cycad taxa that are suitable for community nurseries based on ease of propagation, market demand, and potential supply rates.
  Responsibility: Cycad Specialist Group together with cycad societies and the nursery industry.
  Timeframe: 2003.
- Develop criteria for the accreditation of cycad nurseries. The criteria should be based on the extent to which nursery activities benefit wild cycad populations and should form part of a marketing strategy for plants from sustainable use nurseries.
  Responsibility: Cycad Specialist Group together with development and conservation agencies.
  Timeframe: 2004.
- Develop a marketing strategy for community nurseries. This is one of the weaknesses in the current nursery programme where nurseries linked to wild populations have to compete with nurseries elsewhere.
  Responsibility: conservation and development agencies involved with local nurseries.
  Timeframe: ongoing.
- Develop additional nurseries based on the analysis of suitable taxa and the outcomes of the evaluation of existing nurseries.
  Responsibility: Cycad Specialist Group together with development agencies and local communities.
  Timeframe: 2003–2010.

10.2 *Ex situ* conservation

Objective: *To develop and promote a network of botanical gardens that (i) will ensure that all Critically Endangered cycad taxa are represented in genebanks within 3 years and all Endangered taxa within 5 years, and (ii) can provide the expertise and plant material required to support community nurseries and reintroduction programmes.*

10.2.1 Obtain more comprehensive coverage of cycad taxa in genebanks

Although the few gardens now involved have built up collections of many threatened species, there are still species that are not in genebanks and there are inadequate backup collections. Such backup collections are crucial to deal with natural disasters and mishaps. Additional gardens need to be encouraged to develop genebanks, even if they focus on only one or a few species. There is a special need to develop genebanks within cycad range states because it will be easier to maintain mutualisms in these collections and they can form part of local conservation programmes. The facilities and expertise that exist in the current network of gardens involved in cycad conservation can form the framework for a broader network of gardens.

Activities and responsibility

- Set up genebanks for priority taxa. The emphasis for developing additional collections should be given to priority taxa (*Chigua, Ceratozamia* and *Microcycas*) and the Critically Endangered and Endangered species that are not represented in genebanks.
  Responsibility: botanical gardens together with the Cycad Specialist Group.
  Timeframe: 2003–2005.
- Develop a protocol for duplicate collections and exchange of material between gardens housing cycad genebanks.
  Responsibility: botanical gardens together with the Cycad Specialist Group.
  Timeframe: 2003.
- Expand the number of gardens involved in cycad conservation by identifying gaps and communicating with botanical gardens, especially in range states.
  Responsibility: Cycad Specialist Group together with Botanic Gardens Conservation International.
  Timeframe: 2005.

10.2.2 Develop species recovery programmes linked to *ex situ* collections

The *ex situ* genebanks housed in botanical gardens represent the best material for restoring extinct populations or those that are collapsing. The gardens involved need to develop proper species recovery programmes that identify and deal with the main threatening processes, as well as the obstacles associated with restoring plants to the wild.

Activities and responsibility

- Review the data on past attempts to reintroduce cycads to identify successful methods.
  Responsibility: botanical gardens and Cycad Specialist Group.
  Timeframe: 2005.
- Set up experiments to test the success of different reintroduction methods.
  Responsibility: botanical gardens, restoration ecologists, Cycad Specialist Group, IUCN Reintroduction Specialist Group.
  Timeframe: 2003–2008.

10.3 Trade monitoring and control

Objective: *To reduce the destructive collection of wild plants by promoting and facilitating trade in artificially propagated plants and the sustainable harvest of seeds from wild populations.*

10.3.1 Review current trade and its impact on wild populations

A CITES trade review is required to establish which species are being traded internationally on a regular basis and whether this trade poses any threat to wild populations. There are several key elements to this review process. First, we need to acknowledge that data on legal trade in cycads provides only a limited perspective because there is a substantial illegal trade. A comprehensive review must therefore include an assessment of the illegal trade. This is not going to be easy but there should be data on illegal shipments entering importing countries. In addition, Range States (countries of origin), or cycad biologists, will often know which populations are being targeted by collectors and the levels of harvesting can be compared with levels of trade recorded by CITES. Second, it is imperative to assess all cycads on CITES Appendix I and Appendix II and not simply those on Appendix II. The most threatened cycads are those on Appendix I and it is only by looking at these species that we can evaluate the effectiveness of CITES and the impact of trade on cycads species that are threatened by trade. The current listings of cycads on the CITES appendices have been in place for nearly thirty years with only a few minor changes. The initial listings took place when the state of cycad taxonomy was far more muddled than it is now and there is a clear need to review the species listed on the CITES appendices. Specific attention needs to be paid to *Stangeria*, which is currently listed on Appendix I despite apparently low levels of international trade, and *Encephalartos* where all species are listed on Appendix I.

Activities and responsibility

- CITES Significant Trade review. The 10th meeting of the Plants Committee agreed to review the trade in cycads and this needs to be initiated as soon as possible.
  Responsibility: CITES Secretariat with support from the Cycad Specialist Group.
  Timeframe: 2003.
- Revision of CITES listing for cycads. The Significant

Trade review will almost certainly show that the current listings do not reflect the degree of threat through international trade. The appendices should therefore be modified accordingly.
Responsibility: CITES Secretariat, Cycad Specialist Group, and Range States.
Timeframe: submission to the COP in 2005.

10.3.2 Facilitate sustainable trade in cycad seeds

Propagation of cycads from seeds represents one way of reducing the threat to wild populations. Restrictions on trade in seeds can therefore end up jeopardising attempts to conserve cycads in the wild. One of the necessary actions is to facilitate trade in seeds. For species listed on CITES Appendix I, Management Authorities often require a non-detriment finding from their Scientific Authority, even for exports from non-range states. It is essential that this process does not impede legitimate trade in cycad seeds. Information needs to be disseminated to Management and Scientific Authorities in the main trading countries so that they are aware of the latest information and can make decisions quickly.

Activities and responsibility

- Review current research data on the impacts of seed harvesting on cycad population dynamics.
  Responsibility: Cycad Specialist Group.
  Timeframe: 2003.
- Evaluate extent of trade in seeds of wild origin, especially for CR and EN taxa. This should form part of the CITES Significant Trade review.
  Responsibility: CITES Secretariat, Cycad Specialist Group, exporting and importing countries.
  Timeframe: 2004.
- Undertake research on seed production and recruitment in cycad populations, focusing on species with representative life histories.
  Responsibility: population biologists, Cycad Specialist Group.
  Timeframe: 2003–2008.

10.3.3 Develop a conservation culture among cycad collectors

The global community of cycad enthusiasts represents a considerable potential resource for conservation. At present, collectors are one of the major threats and their impact needs to be reduced. At the same time, the interests of enthusiasts could be channelled in a positive way.

Activities and responsibility

- Encourage the major cycad societies to appoint a conservation officer and to develop conservation programmes.
  Responsibility: International Cycad Society, Cycad Society of South Africa, Palm and Cycad Society of Australia together with Cycad Specialist Group.
  Timeframe: 2003.
- Elect a representative of the cycad societies on to the Cycad Specialist Group.
  Responsibility: Cycad Specialist Group and cycad societies.
  Timeframe: elected for the 2001–2004 period.
- Promote conservation projects through the society journals.
  Responsibility: Cycad Specialist Group, local conservationists, cycad societies.
  Timeframe: ongoing.

10.4 Research

Objective: *To develop and promote a research programme that provides a better basic understanding of cycad diversity, distribution, threats, and recovery.*

10.4.1 Survey cycad populations in poorly known areas

In general, taxa that are poorly known come from areas that have been poorly surveyed. Experience has shown that good fieldwork results in many new species and more accurate assessments of threatened status. Field surveys of cycads in poorly studied regions are therefore an essential activity. The priority areas are parts of the New World, Asia, and Central Africa.

Activities and responsibility

- Identify priority areas and organise field surveys.
  Responsibility: Cycad Specialist Group, cycad biologists, conservation agencies.
  Timeframe: 2003–2010.
- Encourage cycad enthusiasts to record and submit data on cycad distributions and cycad numbers.
  Responsibility: cycad societies, Cycad Specialist Group, conservation agencies.
  Timeframe: 2003–2010.

10.4.2 Develop a consistent taxonomy for cycads

Cycad taxonomy has been confused and there has been considerable debate about the exact identity of certain taxa. This has resulted in problems for determining the threatened status. It is therefore important to resolve these problems as soon as possible.

Activities and responsibility

- Hold a workshop to develop principles and

recommendations for a consistent, practical, and informative taxonomy of the living cycads.
Responsibility: Montgomery Botanical Centre, cycad taxonomists.
Timeframe: 2003.

10.4.3 Promote horticultural research to increase the availability of artificially propagated plants

It is clear that when demand for plants exceeds the supply from cultivated sources, there is more pressure to remove plants from the wild. Recent research has shown that it is possible to improve germination, increase growth rates of seedlings, and develop plants from tissue culture for species with low seed set, which all contribute to more plants in cultivation. These research activities need to be continued, especially for species under threat in the wild, and the results need to be more widely applied by specialist growers and conservation agencies.

Activities and responsibility

- Identify the best methods for the propagation and cultivation of species that are threatened by trade.
  Responsibility: research community.
  Timeframe: 2003–2010.
- Disseminate the results of existing and future research work on cycad propagation and cultivation to enthusiasts, growers, botanic gardens, and conservation agencies.
  Responsibility: cycad societies, Cycad Specialist Group.
  Timeframe: 2003–2005.

10.4.4 Study the persistence of small populations and identify the key factors influencing decline and recovery

Many cycads now exist as small isolated populations but we have very little understanding of how this affects their survival. Population studies are required to determine whether these populations are doomed to die out or whether cycads are adapted to survive as small populations.

Activities and responsibility

- Determine whether cycad populations are limited by the local extinction of pollinators.
  Responsibility: research community, Cycad Specialist Group.
  Timeframe: 2003–2005.
- Determine whether insect pollinators can be reintroduced to cycad populations.
  Responsibility: research community, Cycad Specialist Group.
  Timeframe: 2003–2005.
- Determine whether small populations are capable of natural recovery and determine the threshold below which recovery is unlikely to occur.
  Responsibility: research community, Cycad Specialist Group.
  Timeframe: 2003–2005.

10.5 Provision of information

Objective: *to make information on cycads and their conservation accessible to policy makers, conservationists, and enthusiasts.*

10.5.1 Update and disseminate information on cycads

This Action Plan brings together information that may not previously have been accessible. The value of the current information will depend on how effectively it reaches the people who make decisions that affect cycads in the wild. It is therefore essential to package this information in various ways so that it reaches a wide range of decision makers. At the same time, the information provided here will soon be out-of-date and plans must be put in place to provide regular updates.

Activities and responsibility

- Provide an up-to-date taxonomy of cycads. The electronic media has made it possible to disseminate an up-to-date list of recognised cycad species. A list has been set up at http://PlantNet.rbgsyd.gov.au which will provide the latest information on cycad species.
  Responsibility: Ken Hill, Royal Botanic Gardens, Sydney.
  Timeframe: ongoing.
- Revise and publish the results of the Red List assessments of all cycad species. The Cycad SG has accepted responsibility to act as the Red List Authority for cycads. This means that the SG will need to undertake regular revisions of the threatened status of cycads which will be included in revisions to the IUCN Red List.
  Responsibility: Cycad Specialist Group.
  Timeframe: ongoing.
- Compile and publish a Top 50 booklet and website as part of the SSC Top 50 series. The series is to be used as a campaigning and marketing tool to raise awareness on plant conservation issues. The cycad Top 50 booklet should be a compilation of 50 seriously threatened species for which good stories (with illustrations) are available so that they can be used as an effective PR product targeted by the media at the general public and decision-makers.
  Responsibility: Cycad Specialist Group and SSC Plant Programme Officer.
  Timeframe: 2003.

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Appendix 2

IUCN Red List Categories and Criteria Version 3.1

Prepared by the IUCN Species Survival Commission
As approved by the 51st meeting of the IUCN Council, Gland, Switzerland, 9 February 2000

I. Introduction

1. The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. The general aim of the system is to provide an explicit, objective framework for the classification of the broadest range of species according to their extinction risk. However, while the Red List may focus attention on those taxa at the highest risk, it is not the sole means of setting priorities for conservation measures for their protection.

Extensive consultation and testing in the development of the system strongly suggest that it is robust across most organisms. However, it should be noted that although the system places species into the threatened categories with a high degree of consistency, the criteria do not take into account the life histories of every species. Hence, in certain individual cases, the risk of extinction may be under- or over-estimated.

2. Before 1994 the more subjective threatened species categories used in IUCN Red Data Books and Red Lists had been in place, with some modification, for almost 30 years. Although the need to revise the categories had long been recognised (Fitter and Fitter 1987), the current phase of development only began in 1989 following a request from the IUCN Species Survival Commission (SSC) Steering Committee to develop a more objective approach. The IUCN Council adopted the new Red List system in 1994.

The IUCN Red List Categories and Criteria have several specific aims:

- to provide a system that can be applied consistently by different people;
- to improve objectivity by providing users with clear guidance on how to evaluate different factors which affect the risk of extinction;
- to provide a system which will facilitate comparisons across widely different taxa;
- to give people using threatened species lists a better understanding of how individual species were classified.

3. Since their adoption by IUCN Council in 1994, the IUCN Red List Categories have become widely recognised internationally, and they are now used in a range of publications and listings produced by IUCN, as well as by numerous governmental and non-governmental organisations. Such broad and extensive use revealed the need for a number of improvements, and SSC was mandated by the 1996 World Conservation Congress (WCC Res. 1.4) to conduct a review of the system (IUCN 1996). This document presents the revisions accepted by the IUCN Council.

The proposals presented in this document result from a continuing process of drafting, consultation and validation. The production of a large number of draft proposals has led to some confusion, especially as each draft has been used for classifying some set of species for conservation purposes. To clarify matters, and to open the way for modifications as and when they become necessary, a system for version numbering has been adopted as follows:

Version 1.0: Mace and Lande (1991)
The first paper discussing a new basis for the categories, and presenting numerical criteria especially relevant for large vertebrates.

Version 2.0: Mace *et al.* (1992)
A major revision of Version 1.0, including numerical criteria appropriate to all organisms and introducing the non-threatened categories.

Version 2.1: IUCN (1993)
Following an extensive consultation process within SSC, a number of changes were made to the details of the criteria, and fuller explanation of basic principles was included. A more explicit structure clarified the significance of the non-threatened categories.

Version 2.2: Mace and Stuart (1994)
Following further comments received and additional validation exercises, some minor changes to the criteria were made. In addition, the Susceptible category present in Versions 2.0 and 2.1 was subsumed into the Vulnerable category. A precautionary application of the system was emphasised.

Version 2.3: IUCN (1994)
IUCN Council adopted this version, which incorporated changes as a result of comments from

IUCN members, in December 1994. The initial version of this document was published without the necessary bibliographic details, such as date of publication and ISBN number, but these were included in the subsequent reprints in 1998 and 1999. This version was used for the *1996 IUCN Red List of Threatened Animals* (Baillie and Groombridge 1996), *The World List of Threatened Trees* (Oldfield *et al.* 1998) and the *2000 IUCN Red List of Threatened Species* (Hilton-Taylor 2000).

Version 3.0: IUCN/SSC Criteria Review Working Group (1999)
Following comments received, a series of workshops were convened to look at the IUCN Red List Criteria following which, changes were proposed affecting the criteria, the definitions of some key terms and the handling of uncertainty.

Version 3.1: IUCN (2001)
The IUCN Council adopted this latest version, which incorporated changes as a result of comments from the IUCN and SSC memberships and from a final meeting of the Criteria Review Working Group, in February 2000.

All new assessments from January 2001 should use the latest adopted version and cite the year of publication and version number.

4. In the rest of this document, the proposed system is outlined in several sections. Section II, the Preamble, presents basic information about the context and structure of the system, and the procedures that are to be followed in applying the criteria to species. Section III provides definitions of key terms used. Section IV presents the categories, while Section V details the quantitative criteria used for classification within the threatened categories. Annex I provides guidance on how to deal with uncertainty when applying the criteria; Annex II suggests a standard format for citing the Red List Categories and Criteria; and Annex III outlines the documentation requirements for taxa to be included on IUCN's global Red Lists. It is important for the effective functioning of the system that all sections are read and understood to ensure that the definitions and rules are followed. (**Note:** Annexes I, II and III will be updated on a regular basis.)

II. Preamble

The information in this section is intended to direct and facilitate the use and interpretation of the categories (Critically Endangered, Endangered, etc.), criteria (A to E), and subcriteria (1, 2, etc.; a, b, etc.; i, ii, etc.).

1. Taxonomic level and scope of the categorisation process
The criteria can be applied to any taxonomic unit at or below the species level. In the following information, definitions and criteria the term 'taxon' is used for convenience, and may represent species or lower taxonomic levels, including forms that are not yet formally described. There is sufficient range among the different criteria to enable the appropriate listing of taxa from the complete taxonomic spectrum, with the exception of micro-organisms. The criteria may also be applied within any specified geographical or political area, although in such cases special notice should be taken of point 14. In presenting the results of applying the criteria, the taxonomic unit and area under consideration should be specified in accordance with the documentation guidelines (see Annex 3). The categorisation process should only be applied to wild populations inside their natural range, and to populations resulting from benign introductions. The latter are defined in the IUCN *Guidelines for Re-introductions* (IUCN 1998) as '... an attempt to establish a species, for the purpose of conservation, outside its recorded distribution, but within an appropriate habitat and eco-geographical area. This is a feasible conservation tool only when there is no remaining area left within a species' historic range'.

2. Nature of the categories
Extinction is a chance process. Thus, a listing in a higher extinction risk category implies a higher expectation of extinction, and over the time-frames specified more taxa listed in a higher category are expected to go extinct than those in a lower one (without effective conservation action). However, the persistence of some taxa in high-risk categories does not necessarily mean their initial assessment was inaccurate.

All taxa listed as Critically Endangered qualify for Vulnerable and Endangered, and all listed as Endangered qualify for Vulnerable. Together these categories are described as 'threatened'. The threatened categories form a part of the overall scheme. It will be possible to place all taxa into one of the categories (see Figure 1).

3. Role of the different criteria
For listing as Critically Endangered, Endangered or Vulnerable there is a range of quantitative criteria; meeting any one of these criteria qualifies a taxon for listing at that level of threat. Each taxon should be evaluated against all the criteria. Even though some criteria will be inappropriate for certain taxa (some taxa will never qualify under these however close to extinction they come), there should be criteria appropriate for assessing threat levels for any taxon. The relevant factor is whether *any one* criterion is met, not whether all are appropriate or all are met. Because it will never be clear in advance which criteria are

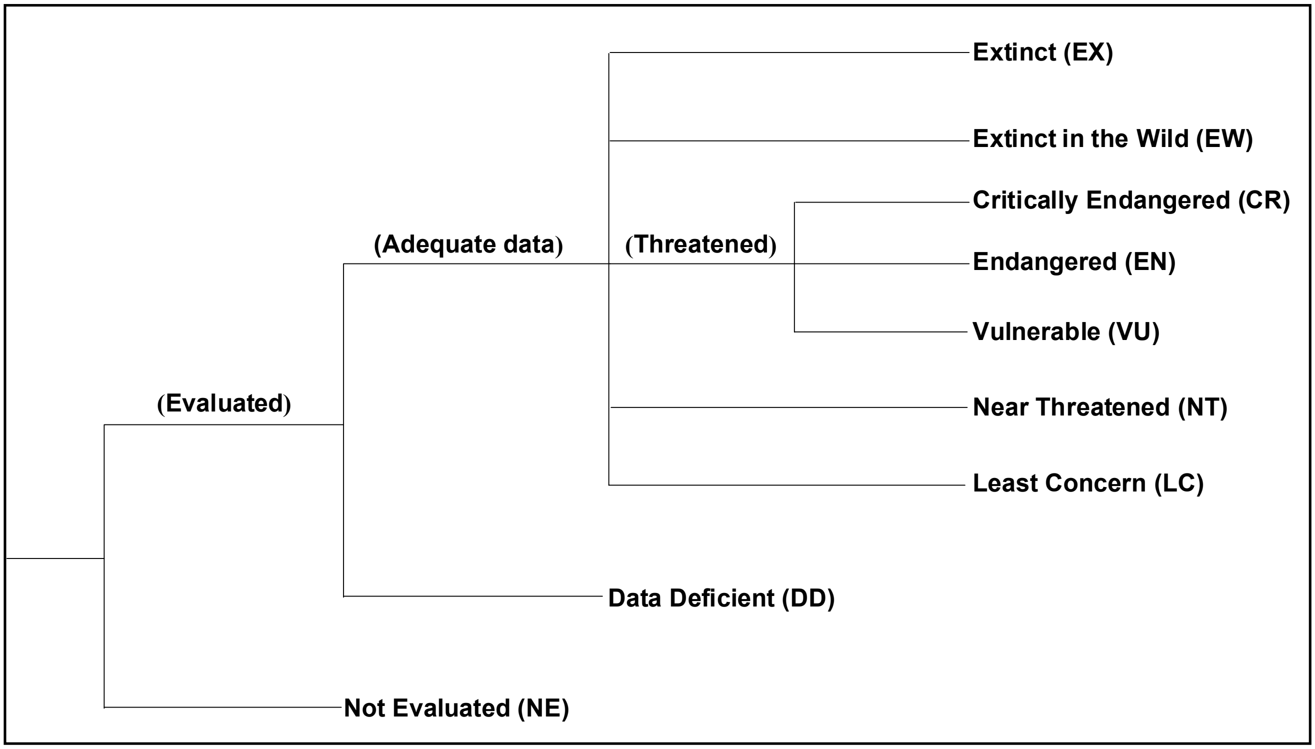


Figure 1. Structure of the categories.

appropriate for a particular taxon, each taxon should be evaluated against all the criteria, and *all* criteria met at the highest threat category must be listed.

4. Derivation of quantitative criteria

The different criteria (A–E) are derived from a wide review aimed at detecting risk factors across the broad range of organisms and the diverse life histories they exhibit. The quantitative values presented in the various criteria associated with threatened categories were developed through wide consultation, and they are set at what are generally judged to be appropriate levels, even if no formal justification for these values exists. The levels for different criteria within categories were set independently but against a common standard. Broad consistency between them was sought.

5. Conservation actions in the listing process

The criteria for the threatened categories are to be applied to a taxon whatever the level of conservation action affecting it. It is important to emphasise here that a taxon may require conservation action even if it is not listed as threatened. Conservation actions which may benefit the taxon are included as part of the documentation requirements (see Annex 3).

6. Data quality and the importance of inference and projection

The criteria are clearly quantitative in nature. However, the absence of high-quality data should not deter attempts at applying the criteria, as methods involving estimation, inference and projection are emphasised as being acceptable throughout. Inference and projection may be based on extrapolation of current or potential threats into the future (including their rate of change), or of factors related to population abundance or distribution (including dependence on other taxa), so long as these can reasonably be supported. Suspected or inferred patterns in the recent past, present or near future can be based on any of a series of related factors, and these factors should be specified as part of the documentation.

Taxa at risk from threats posed by future events of low probability but with severe consequences (catastrophes) should be identified by the criteria (e.g. small distributions, few locations). Some threats need to be identified particularly early, and appropriate actions taken, because their effects are irreversible or nearly so (e.g. pathogens, invasive organisms, hybridisation).

7. Problems of scale

Classification based on the sizes of geographic ranges or the patterns of habitat occupancy is complicated by problems of spatial scale. The finer the scale at which the distributions or habitats of taxa are mapped, the smaller the area will be that they are found to occupy, and the less likely it will be that range estimates (at least for 'area of occupancy': see Definitions, point 10) exceed the thresholds specified in the criteria. Mapping at finer scales reveals more areas in which the taxon is unrecorded. Conversely, coarse-scale mapping reveals fewer unoccupied areas, resulting in range estimates that are more likely to exceed the thresholds for the threatened categories. The choice of scale at which range is estimated may thus, itself, influence the outcome of Red List assessments and could be a source of inconsistency and bias. It is impossible to provide any strict but general rules for mapping taxa or habitats; the most appropriate scale will depend on the taxon in question, and the origin and comprehensiveness of the distribution data.

8. Uncertainty

The data used to evaluate taxa against the criteria are often estimated with considerable uncertainty. Such uncertainty can arise from any one or all of the following three factors: natural variation, vagueness in the terms and definitions used, and measurement error. The way in which this uncertainty is handled can have a strong influence on the results of an evaluation. Details of methods recommended for handling uncertainty are included in Annex 1, and assessors are encouraged to read and follow these principles.

In general, when uncertainty leads to wide variation in the results of assessments, the range of possible outcomes should be specified. A single category must be chosen and the basis for the decision should be documented; it should be both precautionary and credible.

When data are very uncertain, the category of 'Data Deficient' may be assigned. However, in this case the assessor must provide documentation showing that this category has been assigned because data are inadequate to determine a threat category. It is important to recognise that taxa that are poorly known can often be assigned a threat category on the basis of background information concerning the deterioration of their habitat and/or other causal factors; therefore the liberal use of 'Data Deficient' is discouraged.

9. Implications of listing

Listing in the categories of Not Evaluated and Data Deficient indicates that no assessment of extinction risk has been made, though for different reasons. Until such time as an assessment is made, taxa listed in these categories should not be treated as if they were non-threatened. It may be appropriate (especially for Data Deficient forms) to give them the same degree of attention as threatened taxa, at least until their status can be assessed.

10. Documentation

All assessments should be documented. Threatened classifications should state the criteria and subcriteria that were met. No assessment can be accepted for the IUCN Red List as valid unless at least one criterion is given. If more than one criterion or subcriterion is met, then each should be listed. If a re-evaluation indicates that the documented criterion is no longer met, this should not result in automatic reassignment to a lower category of threat (downlisting). Instead, the taxon should be re-evaluated against all the criteria to clarify its status. The factors responsible for qualifying the taxon against the criteria, especially where inference and projection are used, should be documented (see Annexes 2 and 3). The documentation requirements for other categories are also specified in Annex 3.

11. Threats and priorities

The category of threat is not necessarily sufficient to determine priorities for conservation action. The category of threat simply provides an assessment of the extinction risk under current circumstances, whereas a system for assessing priorities for action will include numerous other factors concerning conservation action such as costs, logistics, chances of success, and other biological characteristics of the subject.

12. Re-evaluation

Re-evaluation of taxa against the criteria should be carried out at appropriate intervals. This is especially important for taxa listed under Near Threatened, Data Deficient and for threatened taxa whose status is known or suspected to be deteriorating.

13. Transfer between categories

The following rules govern the movement of taxa between categories:

A. A taxon may be moved from a category of higher threat to a category of lower threat if none of the criteria of the higher category has been met for five years or more.
B. If the original classification is found to have been erroneous, the taxon may be transferred to the appropriate category or removed from the threatened categories altogether, without delay (but see Point 10 above).
C. Transfer from categories of lower to higher risk should be made without delay.

14. Use at regional level

The IUCN Red List Categories and Criteria were designed for global taxon assessments. However, many people are interested in applying them to subsets of global data, especially at regional, national or local levels. To do this it is important to refer to guidelines prepared by the IUCN/SSC Regional Applications Working Group (e.g. Gärdenfors *et al.* 2001). When applied at national or regional levels it must be recognised that a global category may not be the same as a national or regional category for a particular taxon. For example, taxa classified as Least Concern globally might be Critically Endangered within a particular region where numbers are very small or declining, perhaps only because they are at the margins of their global range. Conversely, taxa classified as Vulnerable on the basis of their global declines in numbers or range might be Least Concern within a particular region where their populations are stable. It is also important to note that taxa endemic to regions or nations will be assessed globally in any regional or national applications of the criteria, and in these cases great care must be taken to check that an assessment has not already been undertaken by a Red List Authority (RLA), and that the categorisation is agreed with the relevant RLA (e.g. an SSC Specialist Group known to cover the taxon).

III. Definitions

1. Population and Population Size (Criteria A, C and D)
The term 'population' is used in a specific sense in the Red List Criteria that is different to its common biological usage. Population is here defined as the total number of individuals of the taxon. For functional reasons, primarily owing to differences between life forms, population size is measured as numbers of mature individuals only. In the case of taxa obligately dependent on other taxa for all or part of their life cycles, biologically appropriate values for the host taxon should be used.

2. Subpopulations (Criteria B and C)
Subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less).

3. Mature individuals (Criteria A, B, C and D)
The number of mature individuals is the number of individuals known, estimated or inferred to be capable of reproduction. When estimating this quantity, the following points should be borne in mind:

- Mature individuals that will never produce new recruits should not be counted (e.g. densities are too low for fertilisation).
- In the case of populations with biased adult or breeding sex ratios, it is appropriate to use lower estimates for the number of mature individuals, which take this into account.
- Where the population size fluctuates, use a lower estimate. In most cases this will be much less than the mean.
- Reproducing units within a clone should be counted as individuals, except where such units are unable to survive alone (e.g. corals).
- In the case of taxa that naturally lose all or a subset of mature individuals at some point in their life cycle, the estimate should be made at the appropriate time, when mature individuals are available for breeding.
- Re-introduced individuals must have produced viable offspring before they are counted as mature individuals.

4. Generation (Criteria A, C and E)
Generation length is the average age of parents of the current cohort (i.e. newborn individuals in the population). Generation length therefore reflects the turnover rate of breeding individuals in a population. Generation length is greater than the age at first breeding and less than the age of the oldest breeding individual, except in taxa that breed only once. Where generation length varies under threat, the more natural, i.e. pre-disturbance, generation length should be used.

5. Reduction (Criterion A)
A reduction is a decline in the number of mature individuals of at least the amount (%) stated under the criterion over the time period (years) specified, although the decline need not be continuing. A reduction should not be interpreted as part of a fluctuation unless there is good evidence for this. The downward phase of a fluctuation will not normally count as a reduction.

6. Continuing decline (Criteria B and C)
A continuing decline is a recent, current or projected future decline (which may be smooth, irregular or sporadic) which is liable to continue unless remedial measures are taken. Fluctuations will not normally count as continuing declines, but an observed decline should not be considered as a fluctuation unless there is evidence for this.

7. Extreme fluctuations (Criteria B and C)
Extreme fluctuations can be said to occur in a number of taxa when population size or distribution area varies widely, rapidly and frequently, typically with a variation greater than one order of magnitude (i.e. a tenfold increase or decrease).

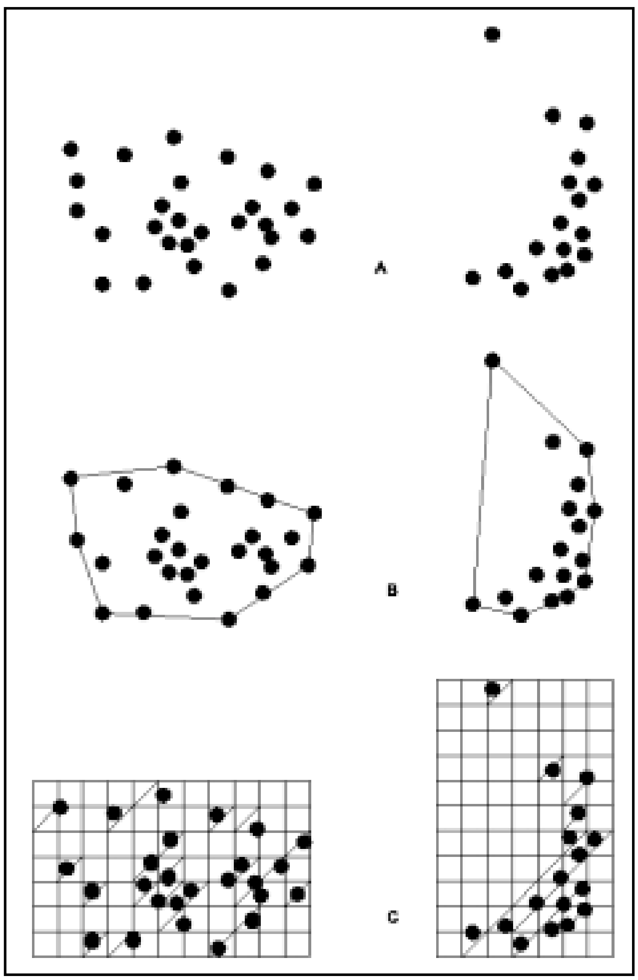
8. Severely fragmented (Criterion B)
The phrase 'severely fragmented' refers to the situation in which increased extinction risk to the taxon results from the fact that most of its individuals are found in small and relatively isolated subpopulations (in certain circumstances this may be inferred from habitat information). These small subpopulations may go extinct, with a reduced probability of recolonisation.

9. Extent of occurrence (Criteria A and B)
Extent of occurrence is defined as the area contained

within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy (see Figure 2). This measure may exclude discontinuities or disjunctions within the overall distributions of taxa (e.g. large areas of obviously unsuitable habitat) (but see 'area of occupancy', point 10 below). Extent of occurrence can often be measured by a minimum convex polygon (the smallest polygon in which no internal angle exceeds 180 degrees and which contains all the sites of occurrence).

10. Area of occupancy (Criteria A, B and D)
Area of occupancy is defined as the area within its 'extent of occurrence' (see point 9 above) which is occupied by a

Figure 2. Two examples of the distinction between extent of occurrence and area of occupancy. (A) is the spatial distribution of known, inferred or projected sites of present occurrence. (B) shows one possible boundary to the extent of occurrence, which is the measured area within this boundary. (C) shows one measure of area of occupancy which can be achieved by the sum of the occupied grid squares.



taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats. In some cases (e.g. irreplaceable colonial nesting sites, crucial feeding sites for migratory taxa) the area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon. The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon, the nature of threats and the available data (see point 7 in the Preamble). To avoid inconsistencies and bias in assessments caused by estimating area of occupancy at different scales, it may be necessary to standardise estimates by applying a scale-correction factor. It is difficult to give strict guidance on how standardisation should be done because different types of taxa have different scale-area relationships.

11. Location (Criteria B and D)
The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat.

12. Quantitative analysis (Criterion E)
A quantitative analysis is defined here as any form of analysis which estimates the extinction probability of a taxon based on known life history, habitat requirements, threats and any specified management options. Population viability analysis (PVA) is one such technique. Quantitative analyses should make full use of all relevant available data. In a situation in which there is limited information, such data as are available can be used to provide an estimate of extinction risk (for instance, estimating the impact of stochastic events on habitat). In presenting the results of quantitative analyses, the assumptions (which must be appropriate and defensible), the data used and the uncertainty in the data or quantitative model must be documented.

IV. The Categories[1]

A representation of the relationships between the categories is shown in Figure 1.

EXTINCT (EX)
A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat,

at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

EXTINCT IN THE WILD (EW)
A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

CRITICALLY ENDANGERED (CR)
A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.

ENDANGERED (EN)
A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.

VULNERABLE (VU)
A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.

NEAR THREATENED (NT)
A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

LEAST CONCERN (LC)
A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

DATA DEFICIENT (DD)
A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified**.**

NOT EVALUATED (NE)
A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

1 Note: As in previous IUCN categories, the abbreviation of each category (in parentheses) follows the English denominations when translated into other languages (see Annex 2).

V. The Criteria for Critically Endangered, Endangered and Vulnerable

CRITICALLY ENDANGERED (CR)
A taxon is Critically Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing an extremely high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥90% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
   a) direct observation
   b) an index of abundance appropriate to the taxon
   c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
   d) actual or potential levels of exploitation
   e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of ≥80% over the last 10 years or three generations, whichever is the longer**,** where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible**,** based on (and specifying) any of (a) to (e) under A1.

3. A population size reduction of ≥80%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥80% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 100km^2 and estimates indicating at least two of a–c:
   a. Severely fragmented or known to exist at only a single location.
   b. Continuing decline, observed, inferred or projected, in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) area, extent and/or quality of habitat
      iv) number of locations or subpopulations
      v) number of mature individuals.
   c. Extreme fluctuations in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) number of locations or subpopulations
      iv) number of mature individuals.

2. Area of occupancy estimated to be less than 10 km^2, and estimates indicating at least two of a–c:
   a. Severely fragmented or known to exist at only a single location.
   b. Continuing decline, observed, inferred or projected, in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) area, extent and/or quality of habitat
      iv) number of locations or subpopulations
      v) number of mature individuals.

   c. Extreme fluctuations in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) number of locations or subpopulations
      iv) number of mature individuals.

C. Population size estimated to number fewer than 250 mature individuals and either:

1. An estimated continuing decline of at least 25% within three years or one generation, whichever is longer (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a–b):
   a) Population structure in the form of one of the following:
      i) no subpopulation estimated to contain more than 50 mature individuals, OR
      ii) at least 90% of mature individuals in one subpopulation.
   b) Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 50 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations, whichever is the longer (up to a maximum of 100 years).

ENDANGERED (EN)

A taxon is Endangered when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a very high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥70% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
   a) direct observation
   b) an index of abundance appropriate to the taxon
   c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
   d) actual or potential levels of exploitation
   e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of ≥50% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have

ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

3. A population size reduction of ≥50%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥50% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 5,000 km^2, and estimates indicating at least two of a–c:
   a. Severely fragmented or known to exist at no more than five locations.
   b. Continuing decline, observed, inferred or projected, in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) area, extent and/or quality of habitat
      iv) number of locations or subpopulations
      v) number of mature individuals.

   c. Extreme fluctuations in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) number of locations or subpopulations
      iv) number of mature individuals.

2. Area of occupancy estimated to be less than 500 km^2, and estimates indicating at least two of a–c:
   a. Severely fragmented or known to exist at no more than five locations.
   b. Continuing decline, observed, inferred or projected, in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) area, extent and/or quality of habitat
      iv) number of locations or subpopulations
      v) number of mature individuals.
   c. Extreme fluctuations in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) number of locations or subpopulations
      iv) number of mature individuals.

C. Population size estimated to number fewer than 2,500 mature individuals and either:

1. An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a–b):
   a) Population structure in the form of one of the following:
      i) no subpopulation estimated to contain more than 250 mature individuals, OR
      ii) at least 95% of mature individuals in one subpopulation.
   b) Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 250 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years

VULNERABLE (VU)
A taxon is Vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing a high risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of ≥50% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are: clearly reversible AND understood AND ceased, based on (and specifying) any of the following:
   a) direct observation
   b) an index of abundance appropriate to the taxon
   c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
   d) actual or potential levels of exploitation
   e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

2. An observed, estimated, inferred or suspected population size reduction of ≥30% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

3. A population size reduction of ≥30%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.

4. An observed, estimated, inferred, projected or suspected population size reduction of ≥30% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) OR B2 (area of occupancy) OR both:

1. Extent of occurrence estimated to be less than 20,000 km^2, and estimates indicating at least two of a–c:
   a. Severely fragmented or known to exist at no more than 10 locations.
   b. Continuing decline, observed, inferred or projected, in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) area, extent and/or quality of habitat
      iv) number of locations or subpopulations
      v) number of mature individuals.
   c. Extreme fluctuations in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) number of locations or subpopulations
      iv) number of mature individuals.

2. Area of occupancy estimated to be less than 2,000 km^2, and estimates indicating at least two of a–c:
   a. Severely fragmented or known to exist at no more than 10 locations.
   b. Continuing decline, observed, inferred or projected, in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) area, extent and/or quality of habitat
      iv) number of locations or subpopulations
      v) number of mature individuals.
   c. Extreme fluctuations in any of the following:
      i) extent of occurrence
      ii) area of occupancy
      iii) number of locations or subpopulations
      iv) number of mature individuals.

C. Population size estimated to number fewer than 10,000 mature individuals and either:

1. An estimated continuing decline of at least 10% within 10 years or three generations, whichever is longer, (up to a maximum of 100 years in the future) OR

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of the following (a–b):
   a) Population structure in the form of one of the following:
      i) no subpopulation estimated to contain more than 1,000 mature individuals, OR
      ii) all mature individuals are in one subpopulation.
   b) Extreme fluctuations in number of mature individuals.

D. Population very small or restricted in the form of either of the following:
1. Population size estimated to number fewer than 1,000 mature individuals.
2. Population with a very restricted area of occupancy (typically less than 20 km^2) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming Critically Endangered or even Extinct in a very short time period.

E. Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years.

Annex 1: Uncertainty

The Red List Criteria should be applied to a taxon based on the available evidence concerning its numbers, trend and distribution. In cases where there are evident threats to a taxon through, for example, deterioration of its only known habitat, a threatened listing may be justified, even though there may be little direct information on the biological status of the taxon itself. In all these instances there are uncertainties associated with the available information and how it was obtained. These uncertainties may be categorised as natural variability, semantic uncertainty and measurement error (Akçakaya *et al.* 2000). This section provides guidance on how to recognise and deal with these uncertainties when using the criteria.

Natural variability results from the fact that species' life histories and the environments in which they live change over time and space. The effect of this variation on the criteria is limited, because each parameter refers to a specific time or spatial scale. Semantic uncertainty arises from vagueness in the definition of terms or lack of consistency in different assessors' usage of them. Despite attempts to make the definitions of the terms used in the criteria exact, in some cases this is not possible without the loss of generality. Measurement error is often the largest source of uncertainty; it arises from the lack of precise information about the parameters used in the criteria. This may be due to inaccuracies in estimating the values or a lack of knowledge. Measurement error may be reduced or eliminated by acquiring additional data. For further details, see Akçakaya *et al.* (2000) and Burgman *et al.* (1999).

One of the simplest ways to represent uncertainty is to specify a best estimate and a range of plausible values. The best estimate itself might be a range, but in any case the best estimate should always be included in the range of plausible values. When data are very uncertain, the range for the best estimate might be the range of plausible values. There are various methods that can be used to establish the plausible range. It may be based on confidence intervals, the opinion of a single expert, or the consensus opinion of a group of experts. Whichever method is used should be stated and justified in the documentation.

When interpreting and using uncertain data, attitudes toward risk and uncertainty may play an important role. Attitudes have two components. First, assessors need to consider whether they will include the full range of plausible values in assessments, or whether they will exclude extreme values from consideration (known as dispute tolerance). An assessor with a low dispute tolerance would include all values, thereby increasing the uncertainty, whereas an assessor with a high dispute tolerance would exclude extremes, reducing the uncertainty. Second, assessors need to consider whether they have a precautionary or evidentiary attitude to risk (known as risk tolerance). A precautionary attitude will classify a taxon as threatened unless it is certain that it is not threatened, whereas an evidentiary attitude will classify a taxon as threatened only when there is strong evidence to support a threatened classification. Assessors should resist an evidentiary attitude and adopt a precautionary but realistic attitude to uncertainty when applying the criteria, for example, by using plausible lower bounds, rather than best estimates, in determining population size, especially if it is fluctuating. All attitudes should be explicitly documented.

An assessment using a point estimate (i.e. single numerical value) will lead to a single Red List Category. However, when a plausible range for each parameter is used to evaluate the criteria, a range of categories may be obtained, reflecting the uncertainties in the data. A single category, based on a specific attitude to uncertainty, should always be listed along with the criteria met, while the range of plausible categories should be indicated in the documentation (see Annex 3).

Where data are so uncertain that any category is plausible, the category of 'Data Deficient' should be assigned. However, it is important to recognise that this category indicates that the data are inadequate to determine the degree of threat faced by a taxon, not necessarily that the taxon is poorly known or indeed not threatened. Although Data Deficient is not a threatened category, it indicates a need to obtain more information on a taxon to determine the appropriate listing; moreover, it requires documentation with whatever available information there is.

Annex 2: Citation of the IUCN Red List Categories and Criteria

In order to promote the use of a standard format for citing the Red List Categories and Criteria the following forms of citation are recommended:

1. The Red List Category may be written out in full or abbreviated as follows (when translated into other languages, the abbreviations should follow the English denominations):

Extinct, EX
Extinct in the Wild, EW
Critically Endangered, CR
Endangered, EN
Vulnerable, VU
Near Threatened, NT
Least Concern, LC
Data Deficient, DD
Not Evaluated, NE

2. Under Section V (the criteria for Critically Endangered, Endangered and Vulnerable) there is a hierarchical alphanumeric numbering system of criteria and subcriteria. These criteria and subcriteria (all three levels) form an integral part of the Red List assessment and all those that result in the assignment of a threatened category must be specified after the Category. Under the criteria A to C and D under Vulnerable, the first level of the hierarchy is indicated by the use of numbers (1–4) and if more than one is met, they are separated by means of the '+' symbol. The second level is indicated by the use of the lower-case

alphabet characters (a–e). These are listed without any punctuation. A third level of the hierarchy under Criteria B and C involves the use of lower case roman numerals (i–v). These are placed in parentheses (with no space between the preceding alphabet character and start of the parenthesis) and separated by the use of commas if more than one is listed. Where more than one criterion is met, they should be separated by semicolons. The following are examples of such usage:

EX
CR A1cd
VU A2c+3c
EN B1ac(i,ii,iii)
EN A2c; D
VU D1+2
CR A2c+3c; B1ab(iii)
CR D
VU D2
EN B2ab(i,ii,iii)
VU C2a(ii)
EN A1c; B1ab(iii); C2a(i)
EN B2b(iii)c(ii)
EN B1ab(i,ii,v)c(iii,iv)+2b(i)c(ii,v)
VU B1ab(iii)+2ab(iii)
EN
A2abc+3bc+4abc;B1b(iii,iv,v)c(ii,iii,iv)+2b(iii,iv,v)c(ii,iii,iv)

Annex 3: Documentation Requirements for Taxa Included on the IUCN Red List

The following is the **minimum** set of information, which should accompany every assessment submitted for incorporation into the *IUCN Red List of Threatened Species*™:

- Scientific name including authority details
- English common name/s and any other widely used common names (specify the language of each name supplied)
- Red List Category and Criteria
- Countries of occurrence (including country subdivisions for large nations, e.g. states within the USA, and overseas territories, e.g. islands far from the mainland country)
- For marine species, the Fisheries Areas in which they occur should be recorded (see http://www.iucn.org/themes/ssc/sis/faomap.htm for the Fisheries Areas as delimited by FAO, the Food and Agriculture Organisation of the United Nations)
- For inland water species, the names of the river systems, lakes, etc. to which they are confined
- A map showing the geographic distribution (extent of occurrence)
- A rationale for the listing (including any numerical data, inferences or uncertainty that relate to the criteria and their thresholds)
- Current population trends (increasing, decreasing, stable or unknown)
- Habitat preferences (using a modified version of the Global Land Cover Characterisation (GLCC) classification which is available electronically from http://www.iucn.org/themes/ssc/sis/authority.htm or on request from redlist@ssc-uk.org)
- Major threats (indicating past, current and future threats using a standard classification which is available from the SSC web site or e-mail address as shown above)
- Conservation measures, (indicating both current and proposed measures using a standard classification which is available from the SSC web site or e-mail address as shown above)
- Information on any changes in the Red List status of the taxon, and why the status has changed
- Data sources (cited in full; including unpublished sources and personal communications)
- Name/s and contact details of the assessor/s
- Before inclusion on the IUCN Red List, all assessments will be evaluated by at least two members of a Red List Authority. The Red List Authority is appointed by the Chair of the IUCN Species Survival Commission and is usually a sub-group of a Specialist Group. The names of the evaluators will appear with each assessment.

In addition to the minimum documentation, the following information should also be supplied where appropriate:

- If a quantitative analysis is used for the assessment (i.e. Criterion E), the data, assumptions and structural equations (e.g. in the case of a Population Viability Analysis) should be included as part of the documentation.
- For Extinct or Extinct in the Wild taxa, extra documentation is required indicating the effective date of extinction, possible causes of the extinction and the details of surveys which have been conducted to search for the taxon.
- For taxa listed as Near Threatened, the rationale for listing should include a discussion of the criteria that are nearly met or the reasons for highlighting the taxon (e.g. they are dependent on ongoing conservation measures).
- For taxa listed as Data Deficient, the documentation should include what little information is available.

Assessments may be made using version 2.0 of the software package RAMAS® Red List (Akçakaya and Ferson 2001). This program assigns taxa to Red List Categories according to the rules of the IUCN Red List Criteria and has the advantage of being able to explicitly handle uncertainty in the data. The software captures most of the information required for the documentation above, but in some cases the information will be reported differently. The following points should be noted:

- If RAMAS® Red List is used to obtain a listing, this should be stated.
- Uncertain values should be entered into the program as a best estimate and a plausible range, or as an interval (see the RAMAS® Red List manual or help files for further details).
- The settings for attitude towards risk and uncertainty (i.e. dispute tolerance, risk tolerance and burden of proof) are all pre-set at a mid-point. If any of these settings are changed this should be documented and fully justified, especially if a less precautionary position is adopted.
- Depending on the uncertainties, the resulting classification can be a single category and/or a range of plausible categories. In such instances, the following approach should be adopted (the program will usually indicate this automatically in the Results window):
  - If the range of plausible categories extends across two or more of the threatened categories (e.g. Critically Endangered to Vulnerable) and no preferred category is indicated, the precautionary approach is to take the highest category shown, i.e. CR in the above example. In such cases, the range of plausible categories should be documented under the rationale including a note that a precautionary approach was followed in order to distinguish it from the situation in the next point. The following notation has been suggested e.g. CR* (CR–VU).
  - If a range of plausible categories is given and a preferred category is indicated, the rationale should indicate the range of plausible categories met e.g. EN (CR–VU).
- The program specifies the criteria that contributed to the listing (see Status window). However, when data are uncertain, the listing criteria are approximate, and in some cases may not be determined at all. In such cases, the assessors should use the Text results to determine or verify the criteria and sub-criteria met. Listing criteria derived in this way must be clearly indicated in the rationale (refer to the RAMAS® Red List Help menu for further guidance on this issue).
- If the preferred category is indicated as Least Concern, but the plausible range extends into the threatened categories, a listing of 'Near Threatened' (NT) should be used. The criteria, which triggered the extension into the threatened range, should be recorded under the rationale.
- Any assessments made using this software must be submitted with the RAMAS® Red List input files (i.e. the *.RED files).

New global assessments or reassessments of taxa currently on the IUCN Red List, may be submitted to the IUCN/SSC Red List Programme Officer for incorporation (subject to peer review) in a future edition of the *IUCN Red List of Threatened Species*™. Submissions from within the SSC network should preferably be made using the Species Information Service (SIS) database. Other submissions may be submitted electronically; these should preferably be as files produced using RAMAS® Red List or any of the programs in Microsoft Office 97 (or earlier versions) e.g. Word, Excel or Access. Submissions should be sent to: IUCN/SSC Red List Programme, IUCN/SSC UK Office, 219c Huntingdon Road, Cambridge, CB3 0DL, United Kingdom. Fax: +44-(0)1223-277845; Email: redlist@ssc-uk.org

For further clarification or information about the IUCN Red List Criteria, documentation requirements (including the standards used) or submission of assessments, please contact the IUCN/SSC Red List Programme Officer at the address shown above.

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