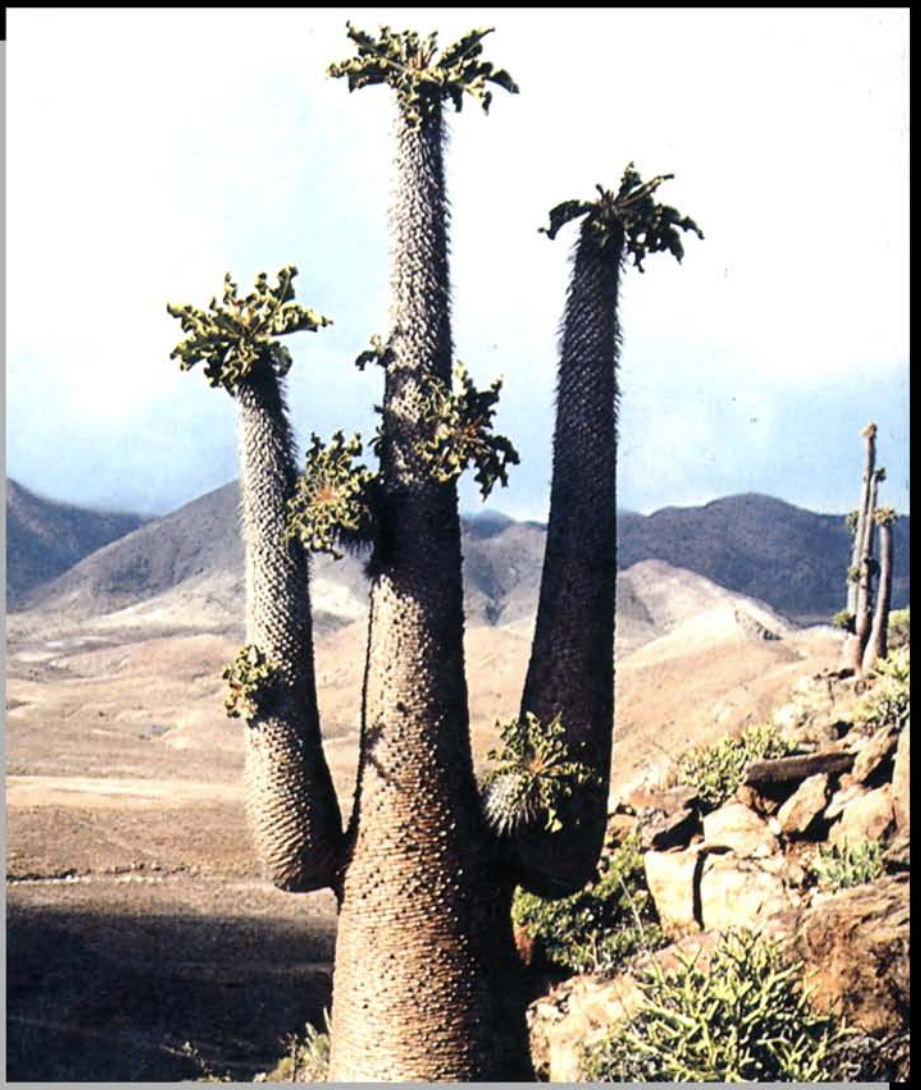
Status Survey and Conservation Action Plan

Cactus and Succulent Plants

Compiled by Sara Oldfield



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Significant in kind support for the development of this Action Plan was provided by the World Conservation Monitoring Centre, Desert Botanical Garden, and Royal Botanic Gardens Kew.

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Cover photo: *Pachypodium namaquanum,* the renowned 'Half Mens' from the Richtersveld, at one time listed on CITES Appendix I; now considered relatively safe, but still Vulnerable in parts of its range. (National Botanical Institute)

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Contents

Foreword

The sight was depressing. We looked closely at the huge pile of dead cacti to see if any had survived, but none were found. Commercial collectors had dug up these hundreds of plants, but for some reason had simply left them behind to die. I had seen the destruction of cactus populations in other places, where whole hillsides of cacti had been removed and carried away, but nowhere nearly as many plants had been ruthlessly removed and left to die as in this remote area of the Chihuahuan Desert. Devastation of populations of cacti and succulents has occurred in many parts of the world, sometimes through greed and selfishness of people who wish to make money from the plants, but at other times as land is converted to agriculture, bulldozed for houses or highways, or flooded to create dams.

For 40 years I have travelled throughout the arid regions of both North and South America doing research on cacti. I have been fortunate to see some of the rarest cacti known, but have also witnessed their pillage by people who fail to understand their importance in the wild and who do not care if they are destroyed, thus depriving future generations of the experience of seeing them. The same things are happening in areas of Africa and Madagascar. Cacti and succulents face terrible threats as the human population grows and land is converted from its natural state. Scientists are struggling to learn what they can before some of these populations of plants disappear, but it is discouraging to see tagged plants removed from study sites by unscrupulous collectors, or a study area bulldozed to make a wider road. At times the frustration has been so great that one is led to wonder if conservation activities are worth the time and effort. But then one hears the statement that "if only people knew what was happening, then they might stop this needless destruction." Or we see a piece of countryside that has been set aside specifically to protect and preserve a population of rare plants. We may read a report that collectors have been arrested for illegally removing plants. These are what give us hope; perhaps we can inform and educate people of the importance of preserving cacti and succulents in the wild, and, as a result, species can be saved from extinction.

This Action Plan is a much-needed publication on cacti and succulents, for it brings together data that have never been compiled before, which should help greatly in conservation efforts of cacti and succulents throughout the world. Included is information on eight succulent families, as well as nine geographic regions of the world, plus conservation strategies including trade control. However, the most important part of the Action Plan is the section dealing with proposals for conservation actions. These are both timely and practical, for experts from various regions have described how conservation efforts can be carried out. It is hoped that these proposals will stimulate governments, foundations, other organisations and individuals to respond to this ever-increasing crisis concerning the conservation of cacti and succulents.

It has been my privilege to serve as Chair of the Cactus and Succulent Specialist Group of the Species Survival Commission for nearly ten years. The conception and writing of this Action Plan is clearly the most significant contribution of this Group. It has been a challenge developing this work, for the Group wanted the expertise of the world's authorities, who are often heavily committed to other projects. Those that responded with contributions have made this Action Plan unique and of considerable value. Their willingness to contribute chapters or sections is greatly appreciated. Special thanks go to Sara Oldfield, Secretary of the Group, for overseeing and compiling the material as it was submitted. The project would never have been possible without her efforts. Wendy Strahm and Robin Sears of the Species Survival Commission also deserve many thanks for seeing the Plan through to its final production.

As one looks at this Action Plan, I ask that it be read with deep appreciation, not only of the plants described, but also for the contributions of so many who work with them. Hopefully, this publication will facilitate conservation efforts on behalf of the cacti and succulents, a remarkable group of plants that must be preserved for eternity.

Dr. Edward F. Anderson
Chair, IUCN/SSC Cactus and Succulent Specialist Group

Acknowledgements

The preparation of this SSC Action Plan has been a collaborative and largely voluntary venture to which many specialists have given freely of their time and expertise. Authors and contributors to the Plan are listed in Annex 17. Their work on this document, both in the initial preparation of the manuscripts, and subsequent help with additional information, review, and provision of illustrations is greatly appreciated. In turn, the authors have consulted widely in the preparation of their accounts and acknowledgements are given at the end of individual sections as appropriate. All members of the SSC Group have been involved in the preparation of the SSC Action Plan in some way, together with many members of the IOS and experts in conservation organisations. Sincere thanks to everyone involved. Special thanks are due to Ted Anderson, Susan Carter-Holmes, Craig Hilton-Taylor, Gideon Smith, Diedrich Supthut, and Nigel Taylor for guidance and encouragement in developing the Action Plan, and to Wendy Strahm and Robin Sears for ensuring its completion. Robin Sears played a particularly important role in assisting with the final editing, picture research and preparation of the report for publication. Thanks also go to Gary Lyons and Rob Wallace for final review of the text; and to Juan Manuel López Ramírez for the Spanish translation, and Paul Strahm and Bertrand de Montmollin for the French translation of the Executive Summary. Institutional support is acknowledged from the Desert Botanical Garden, Phoenix; Royal Botanic Gardens, Kew; and World Conservation Monitoring Centre. Financial support for preparation of the Action Plan was provided by the Peter Scott IUCN/SSC Action Plan fund.

Sara Oldfield
Secretary, IUCN/SSC Cactus and Succulent Specialist Group

Executive Summary

The often bizarre growth-forms and attractive flowers of cacti and other succulents have promoted widespread interest in this group of plants and horticultural popularity worldwide. Succulent plants are also of great ecological and economic significance, particularly in arid and semi-arid parts of the world. Although the definition of succulence as applied to plants is constantly under debate, about 10,000 plant species are generally recognised as succulent, within thirty plant families.

Of these succulent plant species, an estimated 2000 species are threatened with global extinction in the wild, and many more are regionally or nationally threatened. Habitat destruction is the major threat, and in common with other horticulturally desirable plant groups, over-collection for international trade remains a significant problem. The Cactus and Succulent Plants Action Plan, produced by members of the Species Survival Commission of IUCN-The World Conservation Union, brings together current information, never before compiled, on the population status, threats, and conservation of this group of important plants from around the world. From this compilation, priorities for conservation action are emphasised, providing direction for funding in plant conservation work. Conservationists, scientists, government officials, protected area managers, educators, and grant awarding bodies alike should find this document helpful in their work to conserve global and local flora. The contributors to this Action Plan encourage collaborative work among these interested parties.

The publication comprises four chapters and a series of annexes that provide readers with concise information on the current status of cactus and succulent populations. The extensive bibliography provides a comprehensive resource for more information on this group of plants. The Plan begins with overviews, written by botanists who specialise in the study of these particular plant families, of the distribution, diversity, threats, and status of eight main taxonomic groups of succulents including the Agavaceae, Aizoaceae, Aloaceae, Asclepiadaceae, Cactaceae, Crassulaceae, Euphorbiaceae, and Portulacaceae. Some of these groups are of great economic importance, many in the ornamental trade industry, and others, such as the Agavaceae, in the fibre and food industries.

Chapter 2 of the Action Plan describes and reviews existing conservation measures for succulent plants around the world with information on legislation, controlling the trade, and *in situ* and *ex situ* conservation. The intention of this chapter is to identify successful conservation activities which can be used as models elsewhere, and also to highlight priorities for further action. It is particularly important in reviewing international conservation measures to show how succulent plant conservation needs can be linked into broader initiatives and frameworks for biodiversity conservation.

Action for succulent plant conservation must take place primarily at the national and local levels and be implemented as far as possible by in-country agencies and local experts. This is accepted throughout the Action Plan, and Chapter 3, the regional accounts, has been largely prepared by experts within the regions concerned. Chapter 3 concentrates on the regions of the world which have the major concentrations of succulent plants.

The final chapter of the Plan describes the priority conservation action proposals, developed by the members of the SSC Cactus and Succulent Plant Specialist Group, for succulent plants around the world. Implementing these proposals will save the maximum diversity of succulents based on our present knowledge.

The SSC Cactus and Succulent Specialist Group calls for:

- Field research to support understanding of the taxonomy and conservation status of succulent plants,
- Increased *in situ* protection for succulent plant species through the development of protected area networks,
- Coordinated *ex situ* protection of threatened succulent species to support the conservation of species in their natural habitats wherever possible,
- Effective national legislation for all threatened succulent plant species,
- Effective trade controls for all wild succulent plant species threatened by exploitation for international commerce,
- Education on the value of succulent plants and the need for their conservation and sustainable use.

Resúmen

Las a menudo extrañas formas de crecimiento y las flores atractivas de cactus y otras plantas suculentas han logrado un interés general por este grupo de plantas y una popularidad para su utilización en horticultura en todo el mundo. Las plantas suculentas son también de gran importancia ecológica y económica particularmente en las zonas áridas y semiáridas de todo el mundo. Aunque la definición de suculencia aplicada a las plantas está constantemente en debate, cerca de unas 10.000 especies de plantas, clasificadas en unas 30 familias, son reconocidas generalmente como suculentas.

De estas especies de plantas suculentas, unas 2.000 están globalmente amenazadas en la naturaleza con la extinción, y muchas otras en peligro regional o nacional. La destrucción del hábitat es la mayor amenaza, y es compartida con otros grupos atractivos de plantas de jardinería, en donde su sobreexplotación para el comercio internacional es un problema de gran trascendencia. El Plan de Acción para Cactus y Plantas Suculentas, que elaboraron los miembros de la Comisión de Supervivencia de Especies (CSE) de la UICN - Unión Mundial para la Naturaleza, unifica la información actual, que nunca antes se había recopilado, sobre el estado de las poblaciones, amenaza y conservación de este grupo tan importante de plantas de todo el mundo.

A partir de esta compilación, se ponen de relieve las prioridades para la acción de conservación, y se brindan directrices para el financiamiento del trabajo de conservación de las plantas. Conservacionistas, científicos, funcionarios, gestores de áreas protegidas, educadores y organismos financiadores, del mismo modo, podrían encontrar ayuda en este documento para sus trabajos de conservacíon de la flora local y global. Los contribuidores a este Plan de Acción animan al trabajo de colaboración entre estos grupos interesados.

La publicación consta de quatro capítulos y una serie de anexos que proporcionan a los lectores una información concisa sobre el estado actual de las poblaciones de cactus y suculentas. La extensa bibliografía proporciona una amplia fuente de información suplementaria sobre cactus y plantas suculentas. El Plan comienza con resúmenes, que escriben botánicos especializados en el estudio de estas familias específicas de plantas, acerca de la distribución, diversidad, amenazas y el estado de ocho grupos taxonómicos principales de cactus y suculentas entre las que se encuentran las familias Agavaceae, Aizorceae, Aloaceae, Asclepiadaceae, Cactaceae, Crassulaceae, Euphorbiaceae, y Portulaceae. Algunos de estos grupos son de gran importancia económica, muchos de ellos incluidos en el comercio de ornamentales, y otros como las Agavaceas, en las industrias alimentaria y textil.

El Capítulo 2 de este Plan de Acción describe y examina las medidas de conservación existentes para las plantas suculentas de todo el mundo, con información sobre legislación, control del comercio y conservación *in situ* y *ex situ*. El objetivo de este capítulo es identificar las actividades exitosas de conservacíon que pueden ser usadas como modelos en otros lugares y muestra además las prioridades para una acción más completa. Es particularmente importante en el análisis de las medidas de conservación internacional, mostrar como las necesidades de conservación de las plantas suculentas pueden ser unidas dentro de las iniciativas generales de conservación y en los marcos para la conservación de la biodiversidad.

La acción para la conservación de las plantas suculentas debe tomarse ante todo en los niveles locales y nacionales y ser llevada a cabo tanto como sera possible por agencias estatales y locales especializadas. Esto es aceptado en todo el Plan de Acción, y en el Capítulo 3, los informes regionales han sido preparados por expertos de las propias regiones. El Capítulo 3 se concentra en las regiones del mundo que tienen el mayor número de plantas suculentas.

El capítulo final describe las propuestas de acciones prioritarias para la conservación para las plantas suculentas de todo el mundo. Lo elaboraran miembros del Grupo Especialista de la CSE/UICN en Cactáceas y Suculeantas. Haciendo efectivas estas propuestas, basadas en nuestros conocimientos actuales, salvaremos al máximo la diversidad de las suculentas.

El Grupo Especialista CSE en Cactus y Suculentas pide:

- Una investigación de campo para apoyar el entendimiento de la taxonomia y el estado de conservación de las plantas suculentas,
- Aumento de la protección *in situ* de las especies de plantas suculentas a través del desarrollo de redes de áreas protegidas,
- Coordinación de la protección *ex situ* de las plantas suculentas para apoyar la conservación de especies en sus hábitats naturales dondequiera que sea posible,
- Una legislación nacional eficaz para todas las especies de plantas suculentas amenazadas,
- Controles efectivos sobre el comercio de todas las plantas suculentas silvestres amenazadas por la sobreexplotación en el comercio internacional,
- Educación sobre el valor de las plantas suculentas y la necesidad de conservación y uso sostenible.

Résumé

L'aspect souvent particulier ainsi que la beauté des fleurs des cactus et d'autres plantes succulentes suscitent beaucoup d'intérêt de la part du public pour ce type de végétation dont la culture est très répandue. Les plantes succulentes ont également une grande importance écologique et économique à travers le monde, particulièrement dans les régions arides ou semi-arides. Bien que la définition de ce qu'est exactement une plante "succulente" fasse toujours l'objet de discussions, on peut considérer que quelque 10,000 espèces, subdivisées en trente familles, font partie de ce groupe de plantes.

Au niveau mondial, on estime que près de 2,000 espèces de plantes succulentes sont menacées d'extinction dans leur habitat naturel. Un nombre bien plus élevé est menacé de disparition à une échelle régionale ou nationale. La menace la plus importante pour les plantes succulentes est la destruction de leurs habitats, puis, comme pour beaucoup d'autres groupes de plantes attractives, une récolte trop intensive pour satisfaire les besoins du commerce international constitue un problème tout particulier.

Le Plan d'Action pour les cactus et les plantes succulentes publié par les membres de la Commission de la sauvegarde des espèces (CSE) de l'Union mondiale pour la nature (UICN) réunit toutes les informations au niveau mondial - ce qui n'avait encore jamais été fait - au sujet de la répartition, des menaces et de la conservation de cet important groupe de plantes. Sur la base de cette compilation, des priorités de conservation sont dégagées, en indiquant les directions à suivre pour rechercher des financements pour les actions de conservation. Ce document constitue une base de travail pour la conservation de la flore au niveau mondial ou local à l'intention des acteurs de la conservation, des scientifiques, des dirigeants gouvernementaux, des gestionnaires d'espaces protégés, des enseignants et des organes de subventionnement. Les auteurs du Plan d'Action encouragent une collaboration étroite entre toutes les parties concernées.

Cet ouvrage, constitué de quatre chapitres et d'une série d'annexes, offre au lecteur des renseignements concis sur l'état actuel de conservation des populations de cactus et de plantes succulentes. Une abondante bibliographie offre une liste très complète de références sur ce groupe de plantes. Dans la première partie du Plan d'action, des botanistes spécialistes des différentes familles, décrivent la répartition, la diversité, les menaces et l'état de conservation des huit principaux groupes taxonomiques de cactus et de plantes succulentes, notamment les Agavaceae, Aizoaceae, Aloaceae, Asclepiadaceae, Cactaceae, Crassulaceae, Euphorbiaceae et Portulacaceae. Certaines de ces familles ont une grande importance économique, principalement dans le cadre du commerce de plantes ornementales, d'autres, telles que les Agavaceae, sont utilisées dans les industries des fibres et des aliments.

Le second chapitre du Plan d'Action décrit et évalue les mesures de conservation des plantes succulentes existant à travers le monde, y compris la réglementation relative à leur commerce et les mesures de conservation *in situ* ou *ex situ*. L'objectif de ce chapitre est d'identifier les actions de conservation réussies qui pourraient servir de modèles dans d'autres situations et de mettre en évidence des priorités pour la poursuite des activités de conservation. En analysant les mesures de conservation prises au niveau international, il est particulièrement important de montrer comment les exigences de la conservation des plantes succulentes peuvent être intégrées dans le cadre plus général de la conservation de la biodiversité.

Les actions de conservation pour les plantes succulentes doivent être planifiées en priorité au niveau national et local et être réalisées autant que possible par des acteurs des pays concernés et des experts locaux. Ce principe s'applique à tout le Plan d'action et, par conséquent, dans le troisième chapitre du Plan d'Action, les comptes rendus régionaux, ont été préparés principalement par des experts des régions concernées. Ce troisième chapitre met l'accent sur les régions du monde qui sont les plus riches en plantes succulentes.

Le dernier chapitre du Plan d'Action décrit les actions de conservation prioritaires proposées à l'échelle mondiale par les membres du Groupe de spécialistes des cactus et des plantes succulentes. Basée sur nos connaissances actuelles, la mise en oeuvre de ces propositions permettra de sauvegarder la plus grand diversité possible de plantes succulentes.

En conclusion, les recommandations du Groupe de spécialistes des cactus et des plantes succulentes de la CSE sont les suivantes :

- Effectuer des recherches sur le terrain pour vérifier la taxonomie et l'état de conservation des plants succulentes,
- Améliorer la protection *in situ* des plantes succulentes en développant le réseau d'aires protégées,
- Coordonner la conservation *ex situ* des espèces menacées de plantes succulentes pour renforcer, quand cela est possible, leur conservation dans leur habitat naturel,
- Mettre en oeuvre des réglementations nationales efficaces pour toutes les espèces de plantes succulentes menacées,
- Contrôler de manière stricte le commerce de toutes les plantes succulentes sauvages menacées par le commerce international,
- Sensibiliser le public et les autorités sur la valeur des plantes succulentes, le besoin de les conserver pour le futur et l'importance de leur utilisation durable.

Acronyms used in this Action Plan

AGUAT	Universidad de San Carlos [Guatemala]
AIAS	Italian Succulent Plant Society
ANAE	National Association for Environmental Actions [Madagascar]
ANGAP	Agence Nationale pour la Gestion des Aires Protégées [Madagascar]
ANPC	Australian Network for Plant Conservation
BCMEX	Universidad Autónoma de Baja California [México]
BGCI	Botanical Gardens Conservation International (formerly BGCS)
CAMPFIRE	Communal Areas Management Programme for Indigenous Resources
CBHL	The Council on Botanical and Horticultural Libraries
CEA	Centro de Educación Ambiental [Puerto Rico]
CHIP	Instituto de Historia Natural de Chiapas [México]
CIAC	Centro de Información Ambiental del Caribe [Puerto Rico]
CIB	Centro de Investigaciones Biológicas [México]
CIIDIR	Centro Interdisciplinario de Investigación para el Desarrollo Integral [México]
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COMARNA	Comisión para la Proteccion de la Flora, la Fauna y el uso racional de los Recursos Naturales [Cuba]
CONABIO	La Comisión Nacional de la Biodiversidad [México]
CONACYT	Consejo Nacional de Ciencias y Technología [México]
CPC	Center for Plant Conservation [USA]
CPD	Centres of Plant Diversity
DEF	Direction des Eaux et Forêts [Madagascar]
DES	Desert Botanical Garden [USA]
DNP	Dirección Nacional de Parques [Dominican Republic]
DRN	Departamento de Recursos Naturales [Puerto Rico]
EC	European Community
FSA	Flora of southern Africa region
HNT	Huntington Botanic Gardens [USA]
IABG	International Association of Botanic Gardens
IBUG	Universidad de Guadalajara [México]
IES	Instituto de Ecologia y Sistemática [Cuba]
INE	Instituto Nacional de Ecología [México]
IPGRI	International Plant Genetic Resources Institute
ISI	International Succulent Institute
IOS	International Organization for Succulent Plant Study
IUCN	International Union for Conservation of Nature and Natural Resources - The World Conservation Union
JBN-RMM	Jardín Botánico Nacional "Rafael M. Moscoso" [Dominican Republic]
MEXU	Universidad Nacional Autónoma de México
MINAGRI	Viceministerio Forestal, Ministerio de Agricultura [Cuba]
MNHN	Museo Nacional de Historia Natura [Cuba]
NBI	National Botanical Institute [South Africa]
NHS	Natural History Society [Jamaica]
NRCD	Natural Resource Conservation Department [Jamaica]
NTCI	National Trust for the Cayman Islands
NYBG	The New York Botanical Gardens
OAX	Instituto Politécnico National, CIIDIR [México]
RDP	Reconstruction and Development Programme [South Africa]
RPS	*Repertorium Plantarum Succulentarum*
SADC	Southern African Development Community
SARH	Secretaria de Agricultura y Recursos Hidráulicos [México]
SEDESOL	Secretaria de Desarrollo Social [México]
SEMARNAP	Secretaria de Medio Ambient, Recursos Naturales y Peces [México]
SLPM	Universidad Autónoma de San Luis Potosí, [México]
SPAW	Protocol on Specially Protected Areas and Wildlife for the Caribbean Region of the Cartagena Convention
SSC	Species Survival Commission [IUCN]
TRAFFIC	Trade Records Analysis of Flora and Fauna in Commerce
UAT	Universidad Autónoma de Tamaulipas [México]
UNCED	United Nations Commission on Environment and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
USFWS	United States Fish and Wildlife Service
WCMC	World Conservation Monitoring Centre [United Kingdom]
WWF	World Wide Fund for Nature
ZSS	Städtische Sukkulenten-Sammlung Zürich [Switzerland]

Introduction

Succulent plants have a global distribution and are represented in nearly all habitat types. Over 30 botanical families have succulent plant species, ranging from tiny annual plants to huge trees. The Cactaceae is the largest and perhaps the best known of the succulent plant families. The unifying characteristic of succulent plants is their ability to store water in one or more organs of the plant, giving rise to stem succulents, leaf succulents, and root succulents — the so-called caudiciform plants.

> "A succulent (or succophyte) is a plant possessing at least one succulent tissue. A succulent tissue is a living tissue that, besides possible other tasks, serves and guarantees an at least temporary storage of utilisable water, which makes the plant temporarily independent from external water supply when soil water conditions have deteriorated such that the root is no longer able to provide the necessary water from soil." von Willert et *al.* (1992)

Succulents, with their often bizarre growth-forms and attractive flowers have long attracted the attention of botanists, both amateur and professional, and horticultural enthusiasts. Despite the widespread interest in succulent plants, and their ecological and economic importance, relatively little attention has been paid to their conservation needs, outside the confines of the specialist societies. The International Organization for Succulent Plant Study (IOS) has been instrumental in promoting conservation mainly through the publication of a Code of Conduct. First published in 1973, the IOS Code of Conduct has been widely publicised through national cactus and succulent societies and has provided a model for use by other specialist plant societies. The Code of Conduct was updated in 1990 (Oldfield 1990).

E. F. Anderson

Strombocactus disciformis, Mexico.

The IOS Conservation Section provided the basis for the formation of the IUCN/SSC Cactus and Succulent Specialist Group in 1984, and the two groups continue to work together sharing a common membership and regular meetings. The SSC Cactus and Succulent Specialist Group has undertaken important conservation fieldwork in Chile, Mexico and Ecuador, has acted as an expanded network for conservation discussion and exchange of information, and has contributed to CITES matters. The idea for an SSC Action Plan for cacti and succulents was first discussed by the Specialist Group in 1990 at the Group's meeting held in Bonn, Germany. There was general agreement that preparation of the Plan should proceed as rapidly as possible. There is a sense of urgency in all plant conservation matters and particularly so for groups of plants where information, although by no means complete, is sufficient to prioritise and initiate long overdue conservation activities.

Arrangements for the preparation of the Action Plan were confirmed in 1993 at the Group's meeting in Malta and a first draft was prepared in time for the 1994 Group meeting, coincident with the 23rd IOS Congress and 24th AETFAT Congress held in Wageningen. The taxonomic accounts for the Action Plan were prepared in 1993 together with the general sections on legislation and controlling the trade. Preparation of the regional accounts, which generally necessitated information gathering from diverse sources and wider consultation amongst local organisations and experts, was finalised at the end of 1995. The Wageningen meeting provided a particularly useful opportunity to discuss the African and Madagascan accounts for the Action Plan, and the CITES Plants Committee meeting held in San Miguel de Allende, Mexico in May 1994, provided an opportunity to review the Mexican account. The timespan involved in preparation of the Action Plan already means that updates will be necessary for certain sections with regard particularly to taxonomic references now published and CITES trade information. However, the Group's main priority, following this period of information gathering, is now to implement the Action Plan.

The Action Plan aims to bring together current information on the conservation of cacti and succulents from around the world in order to provide a summary of the present situation. This provides the background against which to set priorities for conservation action. In preparing an overview Action Plan of this nature it has not proved possible to be fully comprehensive in the species and areas covered. The north temperate regions of Europe and Asia, for example, which are not covered specifically in the Action Plan, are by no means without succulents but do not have the same diversity, degree of endemism, and urgency for succulent plant conservation as, for example, Madagascar, Mexico, and Namibia. The Specialist Group is keen to learn of other succulent plant species and other areas of succulent plant diversity which are in need of conservation attention and also of ongoing conservation initiatives to which it can contribute.

The annexes to this Plan provide various regional taxonomic lists of succulents. Unless otherwise noted, the conservation status given for each taxon follows the IUCN Red List categories. With the exception of the Brazil Cactaceae reported by Nigel Taylor, all of the lists follow the old criteria (pre-1994). Work is ongoing by specialists to apply the new criteria which offer a more objective and detailed evaluation of these species' threat of extinction. Annex 16 details both versions of the IUCN Red List categories.

A precise definition of the term 'succulent' has not been attempted for the purposes of the Action Plan and some doubtfully succulent species have been included where these are of conservation concern. Some of the caudiciform plants, for example, are marginally succulent, but are fashionable at present with succulent plant collectors and subject to trade pressures. Cycads and some orchids can also be considered succulent, but these are not included in the Action Plan because they fall within separate SSC Action Plans (for Orchids see IUCN/SSC Orchid Specialist Group 1996; IUCN/SSC Cycad Action Plan, in prep). Certain genera of the Bromeliaceae are included within the Action Plan because plants of this family often have similar lifeforms, grow in similar habitats, and face the same threats as plants more commonly treated as succulents. It is, however, hoped that the Bromeliaceae will soon have an SSC Conservation Action Plan of their own.

Further field research and taxonomic studies are urgently needed as a preliminary conservation activity for succulent plant species is various parts of the world. The need for further information should not, however, hold up the implementation of in situ and *ex* situ conservation activities as outlined in the Action Plan. Members of the SSC Group have expertise in succulent plant taxonomy, ecology, conservation planning, conservation legislation, information management, development of recovery plans and cultivation of succulent plants. Integration of different approaches and methodologies for conservation will be important to ensure the conservation of maximum succulent plant diversity. The preparation of the Action Plan is not an end in itself but a beginning. The SSC Cactus and Succulent Specialist Group is committed to implementation of the Plan and offers its assistance to all who are in a position to take the action proposals forward.

Chapter 1

Taxonomic Groups

Agavaceae

Wendy Hodgson

The Agave family (Agavaceae Endlicher) is a group of economically important succulent plants with a natural distribution in the drier regions of the tropics and subtropics. The botanical limits of the family are undecided, but for the purposes of this Action Plan the Agavaceae is considered to comprise 18 genera and approximately 625 species. Many of these species remain poorly known in the wild. Herbaria and field surveys are urgently needed to determine conservation status for the species. Despite lack of detailed field information, progress has been made towards developing a conservation programme, particularly for the American species, for example through the SSC Agavaceae Action Plan Workshop held at the Desert Botanical Garden, Phoenix, in 1992.

Box 1.1 Botanical characteristics of Agavaceae

The Agave Family is characterised by stout, simple or sparingly branched, arborescent shrubs (or sometimes trees), or short-stemmed, somewhat herbaceous plants with a short rhizome or erect caudex; leaves simple, alternate, sessile, tending to be crowded in dense rosettes at ends of stems or branches or at ground-level on a short stem, generally thickened, leathery or firm-succulent (in contrast to soft-succulent as in Aloaceae), often prickly on margins and spine-tipped; flowers in dense racemes or panicles or heads terminating the stem (plants are monocarpic, as in *Agave*), or axillary and subterminal (plants are polycarpic, as in Yucca); perfect, sometimes unisexual, perianth consisting of tepals arranged in 2 whorls of 3, petaloid, often thick and fleshy, distinct or fused below to form a tube, stamens 6, filaments distinct, fused to tepals or base of tube, ovary superior or inferior, 3-carpeled, usually with nectaries style usually terminal with 3 stigmas, ovules l-many, fruit a loculicidal capsule or berry, seeds flattened; chromosome counts vary from x=16-30+.

Systematic treatment

The Agavaceae has undergone many changes since it was proposed by Endlicher in 1841. Cronquist (1981) maintains the Agavaceae as a family distinct from the Liliaceae and Amaryllidaceae based on the specialised growth habit. Agavaceae are characterised by being stout, simple or branched shrubs or trees, or herbaceous plants arising from a caudex, often forming succulent rosettes as opposed to Liliaceae and Amaryllidaceae which are herbaceous perennials, usually dying back to the ground. *Yucca* and *Agave* share the karyotype of 20 small and 5 large chromosomes. This trait was considered unique at one time and provided the incentive to remove *Yucca* from the Amaryllidaceae to the Agavaceae. However, the presence of few large and many small chromosomes is more common throughout the Liliaceae than once thought. *Hosta,* a genus with a very different habit and included within the Liliaceae, resembles yuccas and agaves in this respect while other genera now considered in Agavaceae *(Nolina* and *Dracaena)* do not. Cronquist (1981) considered the Aloaceae and Agavaceac as parallel derivatives from the Liliaceae with only slight differences.

McVaugh (1989) points out that unless some basis other than plant habit can be found, it is impossible to distinguish between the Agavaceae and Liliaceae in the Nueva Galicia flora of western Mexico. In *Manfreda, Polianthes,* and *Prochynanthes,* genera generally considered to be closely related to *Agave,* plants are herbaceous, commonly have fleshy roots developed from a short rhizome, and have soft, thin, slightly succulent leaves which in most species die back annually; marginal teeth, if present, are soft. McVaugh (1989) suggests one solution might be to include all herbaceous genera in the Liliaceae, and only the more woody groups in Agavaceae. However, the problem is more complicated in that there are obvious similarities (and presumed relationships) between *Agave* and *Manfreda.* In addition, *Manfreda* is closely related to *Polianthes* and *Prochynanthes.* He then justifiably asks that if *Agave* and *Manfreda,* and *Manfreda* and *Polianthes,* are so closely related that they could even be considered congeneric, then can *Agave* and *Polianthes* be assigned to different families?

Various subdivisions of the family have been made. Hutchinson (1934) divided Agavaceae into six tribes: Yucceae *(Yucca* and *Hesperaloe*), Dracaeneae (*Cordyline, Cohnia, Dracaena,* and *Sansevieria),* Phormieae *(Phormium),* Nolineae *(Nolina, Calibanus, Beaucarnea,* and *Dasylirion),* and Polyantheae *(Polianthes, Prochynanthes, Bravoa,* and *Manfreda*). Cronquist (198 1) also recognised 18 genera but conceded that so treated the Agavaceae may not form a natural group. *Phormium* and *Doryanthes,* usually included in this family, may not properly belong with other genera. Serologically *Agave* and *Yucca* seem to stand apart from a group consisting of

Dracaena, Nolina, Sansevieria, and *Cordyline.* Dahlgren *et al.* (1985) recognise Agavaceae with eight genera subdivided into two subfamilies: Yuccoideae *(Yucca* and *Hesperaloe)* and Agavoideae (*Agave, Manfreda, Polianthes, Prochynanthes, Beschorneria,* and *Furcraea),* based on cytological, anatomical, and embryological studies.

Recent studies at the University of Texas, Austin, support recognising the Nolinaceae as a monophyletic group including, among others, *Beaucarnea, Nolina, Dasylirion,* and *Calibanus (see* Hernandez and Simpson 1992). Recent studies on the molecular and morphological phylogeny of the Agavaceae by David Bogler at the University of Texas support the treatment of Hutchinson and Dahlgren and the findings of Hernandez and Simpson. Preliminary work, which included chloroplast DNA restriction site analysis, suggests that two distinct major lineages occur (D. Bogler, pers. comm., 1994). The first group includes *Hosta, Camassia,* and Agavaceae. Within the Agavaceae are the seemingly closely related *Agave, Manfreda, Polianthes,* and *Prochynanthes; Beschorneria* and *Furcraea* appear more closely related to the more primitive *Agave dasylirioides* and *A. striata,* while *Yucca* appears to be more closely related to *Camassia* than to *Agave.* The second lineage includes the Convallariaceae, Dracaenaceae and Nolinaceae, the latter a monophyletic group including *Nolina, Dasylirion, Calihanus,* and *Beaucarnea.* In this group, *Calibanus* appears most closely related to *Beaucarnea.*

In this account, the Agavaceae is recognised *sensu lato,* following Cronquist's more inclusive, albeit unnatural treatment. Most scientists, at least in the USA, recognise this treatment and the Flora of North America includes *Dasylirion* in the Agavaceae. As defined here, the Agavaceae includes 18 genera and approximately 625 species.

Distribution and diversity

Naturally distributed through the American and Caribbean arid and tropical climes, agaves and their relatives have been widely dispersed since 1492 to other continents, where they are viewed as having considerable economic and horticultural importance. The origins of these genera and species appear to be related to the evolution of the Neotropical flora in the cordilleras of Mexico and Central America. Best known is the considerable adaptive radiation of the genus *Agave* that has occurred in the Sierra Madre Occidental of Mexico (Gentry 1972, 1982), undoubtedly associated with the development of the Madro-Tertiary flora (Axelrod 1958).

Through secondary adaptive radiation, members of the Agave family have adapted to habitats ranging from the temperate woodlands and prairies of eastern North America to the wet tropics and subalpine habitats of South America. Nevertheless, most species in the family occur presently in arid, semi-arid, and dry subtropical vegetation zones in both coastal plains and adjacent montane landforms. The predominance of CAM metabolism and succulence among these species allows them to remain dormant during extended seasonal droughts and periods of high temperatures. The extremely high water use efficiencies that have been recorded among agave cultivars (Nobel 1988) are also characteristic of the wild species and not simply a product of domestication.

Of the 18 genera in the Agavaceae, species richness is highest in the genus *Agave* (200+ species) and then descends in roughly the following order: *Pleomele (140,* Old World tropics and subtropics, if treated as distinct from Dracaena), *Dracaena (50,* Old World tropics), *Sansevieria (50-60,* South Africa, Madagascar, and Arabia), *Yucca* (35-40, south USA, Mexico, Guatemala, and Cuba), *Nolina (25-30,* south-west USA to central

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Agave collection, Desert Botanical Garden, Arizona.

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Collection of centre of *Agave* plant for fibres, Peñita, Tamaulipas, Mexico.

Mexico), ***Manfreda (25,*** south and south-east USA to Honduras), ***Furcraea (c. 20,*** central Mexico to South America), ***Dasylirion*** (14-17, south-west USA to Oaxaca), *Cordyline* (10-15, Old World tropics), *Polianthes* (including Bravoa 20, Mexico), ***Beschorneria*** (10, Mexico and north Guatemala), ***Beaucarnea (9,*** Mexico to South America), ***Hesperaloe (4,*** central Texas and north Mexico), ***Doryanthes (3,*** Australia), ***Phormium (2, New*** Zealand), ***Prochynanthes*** (1, Mexico), and ***Calibanus*** (1, Mexico).

The following centres of Agavaceae diversity have been identified by Gentry (1982), Reichenbacher (1985), and Garcia-Mendoza (1987, 1989): the Apachean woodlands and grasslands of the Deming Bridge between the Sonoran and Chihuahuan Deserts; the subtropical Cape region of Baja California; the northern and central Sierra Madre Occidental, including temperate and semi-arid woodlands and dry subtropical thornscrub; the ecotone between the semi-arid highlands of central Mexico and the wetter Sierra Madre Oriental; the more tropical montane belt of ranges in Michoacan and adjacent states; the Chiapan and Oaxacan highlands of south-western Mexico and adjacent Guatemala, including semi-arid valleys in the rain-shadow of the Sierras, and adjacent humid uplands. Oaxaca has the greatest diversity of Agavaceae in the Mexican Republic with 42 taxa.

The species list of Agavaceae in Annex 1 indicates species which are currently considered to be narrow endemics, inhabiting zones of less than 100 km in length and width (10,000 km^2). Here high levels of endemism in areas of high species diversity are expected. Indeed, of the 42 taxa in the State of Oaxaca, Mexico, 32 are endemic to the Republic of Mexico and six are endemic to the state. Hybridisation, polyploidy, and vegetative reproduction are important processes in species formation in Agave (Pinkava and Baker 1985), and probably other members of the family. For example, ***Yucca campestris,*** a sand-dune endemic of south-western Texas, may have originated from hybridisation between Y. *elata* and Y. ***constricta*** (Powell 1988). Peninsular floras such as that of Baja California also contain high levels of endemism. Of the 25 taxa of *Agave* that occur in Baja California, 20 are endemic (Gentry 1972).

Species richness is also affected by the local diversity and abundance of their pollinators; for example, Oaxaca has nine species of nectar-feeding bats specialising on *Agave* (A. Garcia-Mendoza and H. Arita, pers. comm.). The interactions between certain members of the Agavaceae, e.g. *Agave*, ***Manfreda,*** and ***Yucca,*** and their pollinators ***Leptonycteris*** and ***Tegeticula,*** have been widely discussed as classic examples of pollination syndromes between mutualistic species which generate and maintain certain aspects of the structure of their biotic communities (Webber 1953; Howell 1974; Arita and Martinez del Rio 1990). Several genera of nectar-feeding bats, bees, hummingbirds, wasps, moths, and hawkmoths may have co-evolved mutualistic relationships with some agaves; yucca moth co-evolution with ***Yucca*** species has also been documented in intricate detail. The population reduction or local extirpation of these pollinators may lead to reduced fertility and seed set in individual plants (Equiarte and Burquez 1988), but there is as yet no evidence that populations of long-lived polycarpic perennials have been severely reduced (Nabhan and Fleming 1992). However, reintroduction and translocation efforts of species in the Agavaceae are likely to fail if pollinators are no longer present in sufficient abundance to sustain populations.

Local uses and commercialisation

The Agavaceae is of considerable economic importance. Fibrous leaves provide cordage and are used in making mats, baskets, hats, thatches, paper, fans, sacks (*Nolina,* ***Dasylirion, Beaucarnea,*** *Agave*, ***Hesperaloe*** *funifera*, ***Phormium, Furcraea, Sansevieria, Yucca),*** flower arrangements (*Agave*), brooms (*Dasylirion*), and pack saddles ***(Furcraea).*** Trunks, stems, and flower stalks

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Cut *Agave lechuguilla*, San Luis Potisi, Mexico.

provide food for humans and cattle (*Agave,* ***Dasylirion, Nolina)*** and alcoholic beverages (*Agave,* ***Dasylirion*** including ***D. cedrosanum, Yucca).*** Flowers of ***Yucca elephantipes*** are eaten by people in south-east Mexico. Fruits provide food for humans (the baccate-fruited species of ***Yucca,*** including the more restricted Y. ***endlichiana,*** *Y.* ***arizonica, Y.*** *grandiflora,* and Y. ***madrensis).*** Trunks provide fuel (*Dasylirion*), while trunks and old stalks are used for the construction of temporary shelters, posts, porches, and corrals (*Agave,* ***Dasylirion, Nolina, Yucca).*** Some taxa are grown as living fence rows (*Agave* and ***Yucca).*** Rhizomes (usually erroneously referred to as roots) and, to a lesser extent, leaves, were or still are used to produce soaps, shampoos and detergents ***(Yucca*** including Y. ***madrensis, Manfreda, Prochynanthes, Polianthes, Furcraea*** *longaeva,* and ***Nolina palmer-i,*** a Baja California endemic), as insect repellents ***(Prochynanthes),*** and as medicines (*Aga* ***ve, Yucca, Manfreda, Prochynanthes).*** Flowers are used in perfumery ***(Polianthes tuberosa,*** known only from cultivation). Flowers of ***Polianthes*** *tuberosa* are used as cut and garden flowers while other species of ***Pohanthes*** are sometimes sold as cut flowers in Mexican markets. Many taxa are now grown as ornamentals: *Agave,* ***Calibanus, Dasylirion, Doryanthes,*** arborescent ***Nolina, Hesperaloe, Yucca*** including the Joshua tree Y. *brevifolia* and Y. ***rostrata*** collected from the wild for landscaping, ***Manfreda, Pleomele, Polianthes,*** and ***Beaucarnea.***

Rare and threatened taxa

It is difficult to determine whether specific taxa within the Agavaceae are threatened, or if so, to what degree. Despite recent field work, taxa are still poorly known or collected, particularly in south-central Mexico. In addition, interspecific hybridisation is a relatively common phenomenon within the family and there occurs much variability within and intergradation between

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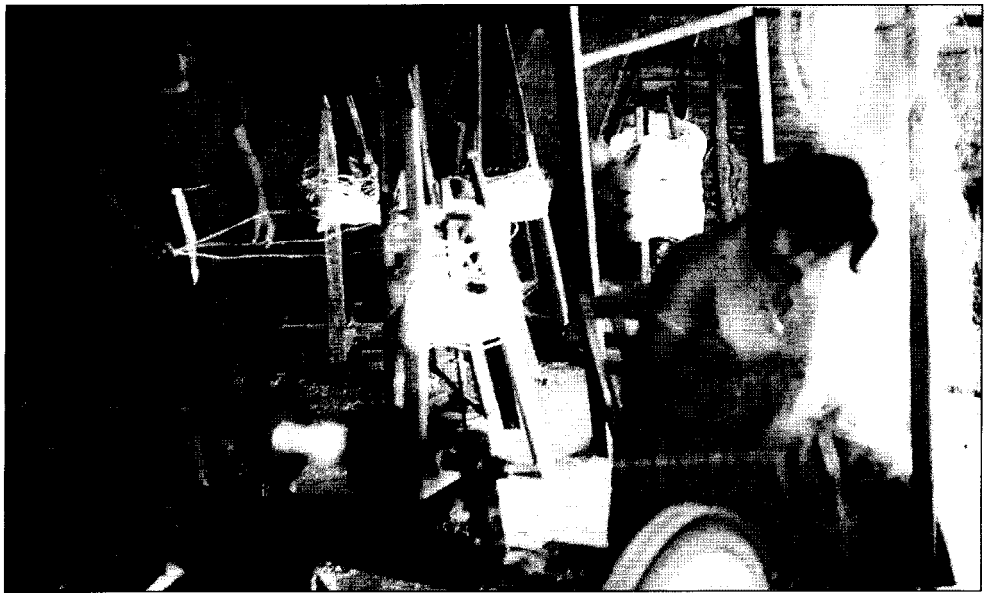
Machine preparing *Agave* fibres, Ecuador.

populations. As a result, defining taxa becomes more problematic and adds to the difficulty in determining rarity.

In the Republic of Mexico the native habitat for seven percent of *Agave* species is unknown, while 15 percent are known from three or fewer herbarium collections at the time of Gentry's (1982) monograph (Reichenbacher 1985). Approximately 50 percent of the entire genus is either poorly known, potentially rare, or occur as fairly restricted endemics (Annex 1), and therefore of considerable conservation concern. Of the 25 known species of ***Manfreda, 14*** have limited ranges or few collections. Of these 14 species, six are known from six or fewer collections. Of the 13 species of ***Pohanthes*** at least nine have limited ranges within which populations are scattered (S. Verhoek, pers. comm. 1993). Until there is a revision of ***Furcraea*** identification of all species (with the exception of ***F. bedinghausii)*** is doubtful. Authors point



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Making cordage of *Agave* fibres, Ecuador.

out that some *Furcraea* species have limited ranges, with some native to only a few Caribbean Islands. At the time of Standley's (1920) text, of the 22 or so species of *Nolina,* five were known only from their type localities and seven were endemic to a state or small part of a state. Likewise, of the approximately 17 species of *Dasylirion,* five were known only from their type localities and an additional six were endemic to one state. Subsequent studies of *Dasylirion* will result in taxonomic changes and range extensions for Mexican species; in addition, it appears that none of the (approximately 10) well defined species are rare (D. Bogler, pers comm.1993), although they may still be endemic to one state. All members of the genus *Hesperaloe* are considered to have limited ranges, with the exception of *H. funifera.* Hernandez (1993) considers the whole genus *Beaucarnea* as threatened, with five species being particularly sensitive.

Regionally, Agavaceae taxa are often poorly known or limited in distribution. For example, over 30 percent of the agaves in Oaxaca are represented by only a few specimens. Little or no information is available for seven *Agave* species endemic to the Bahamas and they may be very rare. Within Guatemala, eight species of *Agave,* one species of *Beaucarnea,* and three species of *Furcraea* are considered to have limited distributions.

Recognised threats

Threats to agave family members can be classified as global (climate change, air contamination), habitat-specific (overgrazing, land conversion, competition with exotics), taxon-specific (vulnerability to introduced pests and diseases, loss of pollinators, economic overexploitation), and population-specific (collection by hobbyists, depletion for local, traditional uses). Because many species in the agave family are characterised either by few populations, low numbers of individuals per population, or both of these factors, they are vulnerable to environmental and demographic stochasticities. In addition, little information is available on the majority of species within the family thereby reducing the chances of appropriate management of their populations.

By far, the three most common pressures on Agavaceae taxa are: 1) land clearance and conversion of native vegetation for agriculture; 2) direct and indirect effects of overgrazing by livestock; and 3) overcollection for ornamental purposes, and to a lesser extent, fibre and alcohol. For example, the very beautiful *Agave wercklei* is endemic to the Rio Grande region on the Pacific slope of Costa Rica. At present, their populations are being adversely impacted by the development of coffee plantations (A. Mendoza, pers. comm. 1993).

Livestock, particularly goats, eat young plants and emerging flowering stalks which limits sexual reproduction and reduces genetic variation. *Agave peacockii* is known from only a small area in the vicinity of Tehuacan, Puebla, where Gentry (1982) observed only 40-50 plants in the mid-1960s. Local people believe it has the finest, strongest fibre of any of the numerous agaves growing in the region, and use it for making rope and nets. Its use may account for its scarcity, but Gentry observed several flowering stalks bitten off by cattle. A similar situation exists for the fibre-producing *A. potrerana* in central Chihuahua.

Fortunately, with the availability of commercial alcoholic beverages, the desire and need to produce 'bootleg' alcohol from *Agave* and *Dasylirion* have become less important. There have, however, been dramatic local declines in *Agave* abundance in parts of Sonora where *Agave angustifolia, A. palmeri,* and *A. shrevei* have been intensively harvested for illicit mescal production (G. P. Nabhan, pers. comm. 1993).

Overcollection for ornamental purposes continues to pose serious threats to various genera within the Agavaceae. The fact that all species of *Beaucarnea* are considered threatened, mainly by overcollection, raises serious concerns. Illegal collectors have made it profitable for campesinos to collect material which is said to go to either the United States or Germany (Hernandez 1993). Hernandez (1993) points out that overcollection of seeds and seedlings are affecting natural repopulation of the species. As members of the genus are dioecious, overcollection of young and adult plants is changing the sex ratios and reducing the production of seeds, thereby lowering the size and genetic variability of the populations. The need to regulate the export of these and other overcollected plants is critical. The interest and demand for particular genera, including *Agave, Hesperaloe, Yucca,* and *Beaucarnea,* in the horticultural trade has increased dramatically over the last 10 years and is expected to continue. However, only five out of over 180 potentially rare or restricted taxa within the Agavaceae *sensu Zato* are listed in the Appendices of CITES.

Actions for conserving genetic diversity

There are four current activities which directly or indirectly conserve the genetic diversity found within this family: 1) efforts to resolve the causes of threats to habitat; 2) efforts to protect selected habitats where rare or otherwise threatened taxa occur through establishing biosphere reserves, sanctuaries, parks, or other protected areas where their populations can be maintained, translocated, or enhanced; 3) efforts to establish and enforce laws limiting the extraction from the wild and transport and commerce of rare, threatened, or vulnerable taxa; and 4) efforts to establish *ex situ* samples of the genetic variation of each species for propagation in botanical gardens, *in vitro* laboratories, or for storage as seeds or tissue cultured germplasm in gene banks. Only the Desert Botanical Garden, Phoenix, has developed a gene bank specialising in the Agavaceae, although over 40 botanical gardens contain CITES-listed endangered species from this family. The principal *ex situ* collections of the agave family occur at the Desert Botanical Garden

Box 1.2 *Ex* situ conservation of Agavaceae at Desert Botanical Garden, Phoenix

During 1991 and 1992, a systematic review of the Agavaceae collection was carried out at the Desert Botanical Garden as part of an Institute of Museum Services grant (Ecker and Burgess 1992). The review and subsequent report addressed I) the determination of the scientific value of the Agavaceae collection and verification of the identity of as many species as possible, 2) identification of rare species in the collection which were noted in the database, 3) creation of a priority list of species to be propagated, and 4) development of a Long Range Conservation Plan which identified species requiring propagation and/or acquisition. Strategies for propagation and collection of plants were developed on a species-by-species basis. A conservation plan outlining the status of each taxon in the Agavaceae collection and a plan for the long term conservation of each taxa were developed. Genetically representative seed collections have been established from several populations of Arizona taxa. Pollen is collected and stored from live plant material for controlled pollination. Seed produced from controlled cross-pollination is made available to other institutions via the Index *Seminum* program. Although still improving, the Desert Botanical Gardens ex situ program for Agavaceae can provide a template for other institutions considering the development of such a program.

(Arizona), the Jardín Botánico of the Universidad Autónoma de Mexico (UNAM) (Mexico City), and Huntington Botanical Garden (California).

With regard to significant in situ conservation efforts which include rare or threatened populations of Agavaceae, the following UNESCO-recognised biosphere reserves contain several species: Rancho El Cielo, Tamaulipas; Bolsón de Mapimi, Coahuila; Big Bend, Texas; El Pinacate, Sonora; Isla Tiburón, Sonora; Desierto de Vizcaino, Baja California; La Michilia, Durango; Sierra de Manantlan, Jalisco; and Selva Lacandona, Chiapas. None of these protected areas, as far as is known, has developed action plans specific to managing and conserving local members of the Agavaceae.

A conservation strategy for the Agavaceae of central Mexico to northern South America was presented at the SSC Agavaceae Action Plan Workshop held at the Desert Botanical Garden, Phoenix in 1992 (Mendoza and Bye 1992). The strategy is incorporated into the Action Proposals in Chapter 4 of this Action Plan.

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Aizoaceae

Steve Hammer

The Aizoaceae Rudolfi, the Mesembryanthema, is the second largest family of succulent plants after Cactaceae. The family is currently divided into five subfamilies, of which two, Mesembryanthemoideae and Ruschioideae, comprise the bulk of the succulent species within the family as a whole. The Mesembryanthemoideae and Ruschioideae form a clade known informally as Mesembryanthema *sensu* H.E.K. Hartmann. Only the plants of this group, known colloquially as 'mesembs', are considered here. The remaining three subfamilies have few, if any, true succulents and have thus escaped the collector's zeal, although they do include plants of agricultural importance.

For two centuries Mesembryanthema or 'mesembs' have been intensely studied both by professionals and amateurs, resulting in 'taxonomic chaos'. Now, through work at the University of Hamburg, some accord is being reached. As presently understood the clade (the former Mesembryanthemaceae Fenzl) comprises some 120 genera informally arranged into 15 groups (Hartmann 1991) based on fruits, flower, and vegetative characters.

Among the succulent subfamilies the two basic divisions, Mesembryanthemoideae and Ruschioideae, are separated by nectary form, by the axile or basal-parietal placentation of their gynoecia, and by different types of expanding structures in their fruits. Mesembryanthemoideae comprises perhaps 100 species in about 10 genera. Only a few of its species are suited to or are attractive under cultivation. In the wild, thev do have some importance for grazing.

Box 1.3 Botanical characteristics of Mesembryanthema

Mesembryanthema are characterised by a high degree of leaf succulence, and especially by their hydrochastic capsules (more or less persistent dried fruits, remarkable in structure and highly responsive to moisture). Other characteristics are the (frequent) possession of bladder idioblasts, bright petals (petaloid staminodes) of androecial origin meronectaria, well-developed valve wings in the fruits and a basic chromosome number of x=9. The monophyllum comprises mainly perennials, some biennials, and a few annuals. In their growth form, species range from tiny geophytes which produce only small tufts of barely visible leaves annually, to long-lived shrubs 3m tall.

Ruschioideae, by far the larger group, comprises about 110 genera with perhaps 1200 species. Revisions of the larger genera are not complete. Many more species have been described, especially in the 1920s and 1930s; tautologies resulted from the independence and conflicting concepts of distant authors. As a general rule, the described species will probably be reduced to one-third of their former number. On the other hand, many of the less attractive species in both the subfamilies are undercollected, overlooked, and undescribed even though many of them are biologically fascinating. It is probable that many geophytes and very narrowly endemic dwarf species are still unknown. Only a few extinctions, however, have been suspected.

The most compact species in the Ruschioidaeae, members of the so-called highly-specialised or 'stemless' genera, have attained a degree of diversity and adaptation (such as dimorphic and or fused leaves, fenestration, riddling patterns, hair coverings) unknown in their long-stemmed leafier allies. It is these bizarre forms which have attracted so much attention from collectors. Only a few species in Mesembryanthemoideae, chiefly both species of *Dactylopsis* have attracted as much notice, though some geophytic 'mesemboids' might do so once their ornamental potential is better understood.

Centres of diversity

The main centres of diversity occur within South Africa and, to a lesser extent, Namibia. The occurrence of Mesembryanthema in northern Africa and the Mediterranean rim involves a few species of natural origin; the majority have, however, been introduced into this area.

W. Strahm

Cheiridopsis derenbergiana, Karoo Botanical Garden, South Africa.

C. Hilton-Taylor

Dactylopsis digitata, an unusual member of the Aizoaceae; its finger-like appearance gives rise to its local name of 'bobbejaans vingers' or 'baboon fingers'.

Within South Africa, the highest concentration of genera occurs in the so-called 'Vanrhynsdorp centre' as defined by Nordenstam (1969) with *31* genera within one quarter-degree square. The 'Gariep centre' has 30 genera, and the 'Little Karoo centre' has 27 (Hartmann 1991). The first two centres constitute southern and northern extremes of the area long known as Namaaualand. All the centres are extremely rich in endemic species, and it should be emphasised that many endemics occupy very small habitats. This is particularly true for the Gariep centre, complex and rough in its geology. Many species are restricted to single hilltops or hill groups and this, of course, has strong conservation implications.

In many areas mesembs form the dominant flora; this is particularly the case in the so-called Knersvlakte (the Vanrhynsdorp centre) and in some similar areas characterised by eroded, quartz-covered shales. In such areas the soils are poor in humic content and often high in salts. Many habitats are extremely sensitive and specialised. Unfortunately, many of the more peculiar habitats also harbour valuable mineral deposits such as copper, nickel, titanium, diamonds and gold, and mining has led to the eradication of several plant formations.

Trade

Within the Mesembryanthema, the ornamental species are the most important economically. Creepy or shrubby mesembs excel as ground cover plants in temperate areas; some, such as *Delosperma* spp., are exceptionally hardy, and some species are wonderfully colourful bedding plants. The highly succulent species in *Lithops* and *Conophytum* are valued as pot plants, though world sales are small compared with figures for Cactaceae.

Illicit trade in field-collected plants is hard to measure, but it seems that the current market is small. This might be partly due to a virtuous green consciousness among

sellers and collectors, but it can also be attributed to the fact that mesembs are not currently popular or fashionable with succulent collectors. The strongest factor is that almost all ornamental mesembs are now cheaply available as seeds, seedlings, or cuttings. The price of *Conophytum burgeri,* a peculiar endemic, fell from US$300 per wild-collected plant in 1978 to US$3.50 for a five-year old nursery seedling in 1992. It is the intention of certain specialist nurseries to widely propagate them, in effect driving prices down, thus eliminating most of the market for wild-collected plants.

Threats

The mountainous areas of Namaqualand are not amenable to cultivation, but they are grazed by goats which have a damaging impact on the succulent plant flora. The fertile and comparatively moist southern Cape, home to some of the more tender mesembs, including the fynbos species, has experienced great destruction from agricultural activities. This has had the greatest effect on Aloaceae, but mesembs have not entirely escaped, which might account for the apparent extinction of *Circandra.* The greatest threats to the mesembs are certainly those which are hardest to deflect: farming, mining, and urbanisation.

The threat of collecting is generally adequately controlled. In many respects the most attractive plants are fortunate: all can be easily and quickly propagated from seed, and almost all are already in cultivation in the USA and the UK. Moreover, most plants grow rapidly, so the appeal of the big, old wild plant is absent. The activities of the few private field collectors are, however, notoriously difficult to control. The nature conservation laws in South Africa are very stringent, but easily circumvented by anyone with the requisite boldness, as the country is too large for adequate policing. The best hope is to convince collectors that "digging them up" damages the plants that they claim to love. If specialists are to glamorise and popularise the plants by publishing attractive articles and tempting descriptions, they must simultaneously provide a legal quick and convenient method for distributing seeds and seedlings from material already in horticulture.

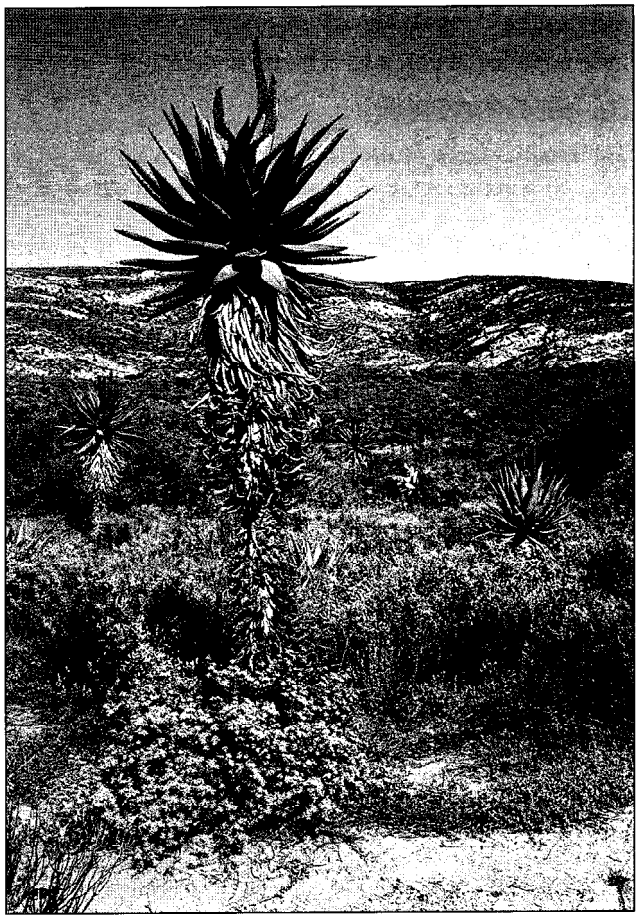
Protection

CITES protection is probably not appropriate for rare species of mesembs such as *Muiria hortenseae.* This particular species is threatened in habitat, occupying a tiny but conspicuous roadside site of about one hectare. Trade controls on *Muiria* could arguably increase the notoriety and market value of a species which is already overvalued. Furthermore, a well-grown *Muiria* seedling would be impossible to distinguish from a wild plant. Purchase and preservation of the most sensitive tracts of land may be the only option to protect mesembs in the Knersvlakte region.

Aloaceae

Ernst J. Van Jaarsveld and Gideon F. Smith

Although distributed through a large part of the Old World, the Aloe family, a fairly small taxonomic group of monocots, has its major centre both in evolutionary depth and in total number of species and genera in southern Africa. Of the approximately 436 species in about seven genera in the family, there are some 233 species in six genera in the area covered by the Flora of southern Africa (FSA) project. This project aims to provide a taxonomic account of all known indigenous and naturalised plant taxa of the subcontinent south of, but excluding, Angola, Zambia, Zimbabwe, and Mozambique. In terms of number of species, the Aloaceae is more or less eighteenth largest family in the subcontinent, and the sixth largest monocot family (cf. Table 4 in Goldblatt 1978, and assuming fragmentation of the Liliaceae into several smaller families). However, on a world scale the Aloaceae is the largest monocotyledonous family of succulent plants and the second largest succulent plant family in southern Africa (cf. Asphodelaceae in Tables 1



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Aloe ferox, a species which is intensively used commercially to obtain bitter aloes and other products for use in the pharmaceutical and cosmetic industries.

D. J. Supthut

Aloe *helenae,* listed on CITES Appendix I.

and 2 in Smith *et al*. 1993, excluding *Bulbine* and *Bulbinella,* but including *Lomatophyllum).* The family has both horticultural and medicinal value. Pharmaceutical products derived from especially Aloe *vera* and A. *ferox* are widely used (Kent 1980; Bloomfield 1985).

Systematic treatment

From a modest beginning in 1753 as a single lillioid genus, Aloe (1753), this taxon rapidly gained more genera and species. In recent years the Liliaceae, where the alooid genera have been traditionally classified, has been subjected to significant taxonomic reassessment in terms of its constituent infrafamilial taxa. The different interpretations of the circumscription of the Liliaceae by various taxonomists have resulted in, amongst others, the tribe Aloineae *sensu* Hutchinson (1959) being removed from the family (Dahlgren and Clifford 1982; Dahlgren *et al.* 1985). However, the circumscription of the Aloineae, one of 28 tribes recognised by Hutchinson (1959) in the Liliaceae, has undergone comparatively little change. The major controversies surrounding the taxonomy of the Aloineae have rather centred on genus and species concepts. In line with the classificatory interpretation of Brummitt (1992) of this natural group, we regard the alooid genera as warranting segregate familial status in the Aloaceae. The family includes the following seven genera: *Aloe* (333 species; Reynolds 1966, 1982), *Haworthia (68* species; Bayer 1982), *Gasteria* (16 species; Van Jaarsveld 1991), *Lomatophyllum (12* species; Jacobsen 1986), *Astroloba (7* species; Roberts Reinecke 1965), and two monotypic genera, *Chortolirion* (Smith 1991b) and *Poellnitzia* (Smith and Van Wyk 1992a). The generic status of the two monotypes has been disputed from time to time and they are sometimes included in *Haworthia.* Although the boundaries of many of the alooid genera and some of the species are still being debated, general agreement exists over the question of familial monophyly. A number of synapomorphies can be listed for this natural entity (Smith and Van Wyk 1991), thus confirming their common origin. It is unlikely that the combination of the distinctive alooid karyotype (x=7, four long and three short chromosomes), and the characteristic leaf morphology have arisen more than once. Furthermore, the vascular bundles of leaves of Aloaceae typically have a well developed cap of thin-walled parenchyma cells at the phloem pole. These are often referred to as aloin cells (Smith and Van Wyk 1992b).

General characteristics

All species of Aloaceae are slow-growing, petaloid, rosulate or distichous perennials. They differ in size from miniatures barely 10 mm high *(Haworthia parksiana)* to trees of massive bulk up to 20 m tall *(Aloe barberae).* Almost all species are long-lived succulents that have above-ground storage organs (leaves, stems), but a few have subterranean storage and perennating organs (e.g. *Chortolirion).* Very few are deciduous in the sense that they die down and become dormant for part of the year (usually the cold, dry season). Floral morphology is variable and some basic forms occur repeatedly in different genera, which adds another dimension to the interpretation of the patterns of variation in reproductive morphology. In general, representatives of the family Aloaceae are easily recognised by their rosettes of usually spiny or tuberculate leaves that with age wither from below. The adventitious root system is usually shallow and utilises the upper leaf litter layer of the soil. In some species the roots may be fusiform and deeper. The racemose or paniculate inflorescence appears to be axillary but is in fact borne apically, bearing fleshy tubular flowers. The fruit is a three-angled, oblong, loculicidal woody capsule. In this regard *Lomatophyllum* with its fleshy berries is an exception.

The aloes often form a conspicuous feature of the southern African landscape and are popular garden subjects with their tough, thorny leathery leaves. Most species of Aloe have large, colourful, tubular flowers which are pollinated mainly by birds. Flowering is usually in the dry season and the seeds ripen just before the rainy season. Representatives of the other alooid genera are usually cryptic dwarf plants which occur in the shade of nurse plant species. *Haworthia* and *Astroloba* have small insect pollinated flowers, whilst bird pollination predominates *Gasteria* and *Poellnitzia.*

The genera of Aloaceae differ from the closely related Asphodelaceae in their conspicuous succulent leaf

consistency, crescentiform or cymbiform leaf outline in cross-section, and the markedly bimodal karyotype consisting of 2n=14 chromosomes (Smith 1991a). In this regard *Bulbine* and *Kniphofia* appear to be problematic, particularly since some of the species of *Bulbine* have karyotypes and morphologies similar to that of certain taxa of Aloaceae (Rowley 1954). However, *Bulbine* can be easily distinguished from genera of the Aloaceae on the basis of its open, yellow (only very rarely white or orange) flowers, free perianth-segments, bearded filaments, lack of nectar production and the annual nature of some of its species (for example *B.alata*). Furthermore, *Bulbine* has an African-Australian distribution whereas the Alooideae is absent from Australia. Mainly for these reasons *Bulbine* was not considered to be a constituent of the Aloaceae. In contrast to representatives of Bulbine and the Aloaceae, leaf succulence is absent in *Kniphofia,* the leaf outline (cross-section) is V-shaped and it has a chromosome base number of six.

Aloe occurs over much of sub-Saharan Africa, ranging from the southern tip of Africa to the Arabian Peninsula. It is also found on Madagascar and Socotra. The genus is ecologically heterogeneous within its range of distribution and has diversified into almost every possible habitat, ranging from deserts, grassland and savanna to comparatively high rainfall coastal forest types. The fleshy-fruited *Lomatophyllum* is restricted to the Mascarene Islands. The general distribution patterns of *Astroloba, Gasteria,* and *Haworthia* closely resemble one another. These three genera are endemic to southern Africa and are more or less restricted to the summer-dry, semi-arid coastal regions below the inland escarpment of the subcontinent. *Gasteria* and *Haworthia* have outliers in the arid river valleys of Natal, Swaziland, and the eastern Transvaal, with a single species of *Haworthia (H.venosa* ssp. *tessellata)* occurring in the climatically severe central-southern Africa. The distribution of *Astroloba* is more restricted than those of *Gasteria* and *Haworthia* and it is usually found in slightly more arid environments of the Fynbos and Succulent Karoo Biomes of southern Africa. These three genera and *Aloe* have relatively large numbers of species indigenous and endemic to the arid subtropical transitional thickets of the eastern Cape where they show signs of active speciation. Of the genera of Alooideae, the monotypic *Poellnitzia* has the most restricted distribution. This genus is found only in the Robertson and Bonnievale districts of the south-western Cape Province. In contrast, the other monotype, *Chortolirion,* is widely distributed in the summer rainfall grasslands of southern Africa. The genus does, however, enter the winter rainfall region in southern Namibia.

Most species of Aloaceae use chemical (bitter leaf sap) or mechanical (pungent, acuminate leaf tips and prickles) strategies to prevent predation (Van Jaarsveld 1987). Many taxa occur in grassland and savanna habitats where natural fires are common. In the case of arborescent species fire adaptation is usually through the retention of a continuous cover of persistent, dead leaves around the stems, which acts as an insulator. Smaller species are geophytic or semi-geophytic with subterranean stolons. A few species have true bulbs. Many species of Aloe of the dry Mediterranean Fynbos regions are also subject to regular fires and often have resprouting abilities (e.g. the shrubby *A. commixta* group which have lignotubers). The arborescent *A. plicatillis* has a corky bark. *A. pearsonii* of the dry, winter rainfall Richtersveld and Namib regions has functional persistent leaves for most of the height of the plant. These become turgid during a good rainy season. Species of *Gasteria* occur mostly in dense vegetation, and with their green, mottled leaves are well camouflaged. When browsed they will resprout from broken leaf fragments. Species of *Haworthia* are usually small and frequently occur in specialised habitats.

The southern African alooid genera

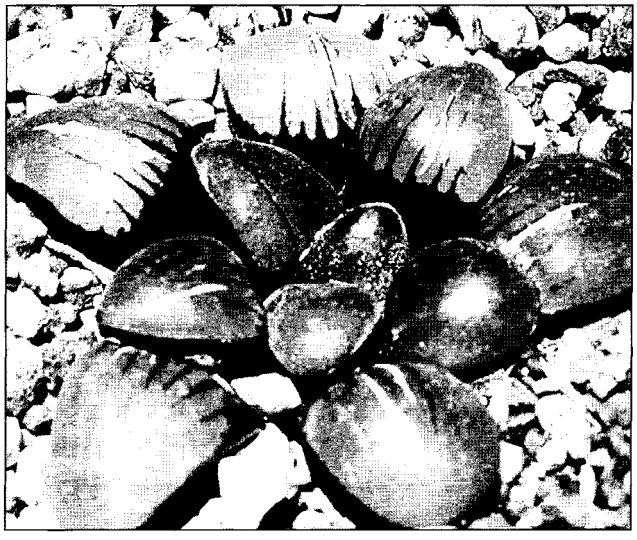
Aloe L. The genus *Aloe* has been thoroughly treated by Reynolds (1966, 1982). A revision of the South African species has recently been undertaken by Dr. H. F. Glen and Mr. D. S. Hardy. Aloes have tremendous horticultural appeal in South Africa. The bright flowers and interesting leaf ornamentation, and the horticultural hardiness of most species of *Aloe* make them attractive for cultivation even under less favourable hot and dry conditions. Though the majority of species are well adapted to arid environments, few can survive low temperatures and frost, and severely cold spells will occasionally lead to the demise even of individuals of species that occur naturally above the climatically severe inland escarpment (e.g. *Aloe greatheadii* var. *davyana;* pers. obs. by G. F. Smith). To many South Africans aloes are what roses and rhododendrons are to Europeans, and these rosulate succulents will always be horticulturally important in that country. An *Aloe* craze was sparked off in South Africa in the 1960s and 1970s by the seminal works of Groenewald (1941) and Reynolds (1966, 1982), resulting in the publication of numerous popular works on the genus. These include the works of Beyleveld (1973), Bornman and Hardy (1971), Jankowitz (1975), Jeppe (1974, 1977), Judd (1972), and West (1974). In addition, the Aloe Breeders Association is an active group of amateurs that continuously register new cultivars. Interest in the genus eventually resulted in legislation brought forward to protect species in their habitats, especially to prevent indiscriminate collecting. Nowadays, as a result of their horticultural appeal, most African states impose strict legislation to protect species of *Aloe (see* section on Conservation Measures, Southern Africa, Chapter 3).

Unfortunately, some *Aloe* habitats have been destroyed by agricultural activities and urban expansion, and to a lesser extent by collectors and for ethnic uses. Fortunately, some species have restricted habitats not suited for agricultural purposes, and species have been successfully introduced into cultivation and seeds are

freely available. Rarest and most threatened of all is A. *polyphylla*, the species having novelty and ornamental appeal. Its numbers have drastically been reduced by collectors. However, the probability of it becoming extinct even in habitat appears to be slight. Unfortunately, few specimens of *A. polyphylla* survive *ex situ* due to its specialised habitat requirements. Smith (1989) showed the destruction of the natural habitat of A. *bowiea* and *A. myriacantha* in the south-eastern Cape, and emphasised the importance of the acquisition of land for its immediate protection. *A. ferox* is of economic importance and is one of the most common of all species. It is easily cultivated and readily establishes from seed. Commercial plantations of *A. ferox* have been started at Albertinia, South Africa. Concern has been expressed on the effect that the removal of the leaves has on survival of the species in the wild, since the dried leaves protect it against fires. The local *Aloe* sap tappers industry was worth R2.5 million in 1992 (Newton 1993).

Haworthia Duval. The genus has been taxonomically treated by Bayer (1982) and Scott (1985). The treatment of Bayer (1982) reflects a more natural dispensation.

Haworthia consists mostly of dwarf rosulate succulents, often proliferating from the base and forming dense clusters with smooth to tuberculate (rarely pubescent) leaves. The lax racemose inflorescences bear insignificant, bilabiate, whitish flowers. Of the alooid genera, *Haworthia* is under most threat due to habitat destruction. These usually cryptic plants are often confined to Renosterveld (sclerophyllous shrublands), Succulent Karoo, and arid savanna regions. The Renosterveld regions are of agricultural importance in the southern Cape and most have been transformed to wheat fields, with the result that many populations have been drastically reduced and a few species could become extinct if drastic measures are not implemented. Smith (199lc) drew attention to the reduction in size of populations of *H. fasciata* in its south-eastern Cape habitat. Most species have tremendous horticultural value and because of their small size and relative ease of cultivation are popular container plants and highly prized, especially in Japan, Europe, and the USA. Some collectors have also played a role in reducing numbers. This is, however, minimal in comparison to agricultural damage to their habitats. Under the leadership of Mr. Kobus Venter, two *Haworthia* localities *(H. magnifica* var. *maraisii* and *H. mirabilis* var. *badia)* within the Napier village municipal region have been declared national heritage sites. Furthermore, many species of *Haworthia* are being multiplied by seeds and leaf cuttings by interested members of the Succulent Society of South Africa. *H. limifolia* is used medicinally by various African tribes and its numbers have been reduced considerably in the wild. However, this species is cultivated at the Silverglen Nursery in Durban and plants are supplied at affordable prices to traditional healers. Other threatened species in the southern Cape include *H. emelyae* var. *multifolia*, *H. magnifica* var. *atrofusca*, *H. serrata*, and *H. poellnitziana.*



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Haworthia springbokvlakensis, a highly sought after and very scarce member of the genus.

Gasteria Duval. The genus has been revised (Van Jaarsveld 1991) and a more complete account is found in Van Jaarsveld (1994). It is a well defined, monophyletic group with brittle, mottled, keeled leaves which are often tuberculate and usually without spines. It has pendulous pedicels and gasteriform, trichromatic, curved flowers. The black, winged seeds are wind dispersed. The genus has centres of endemism in arid savanna regions and to a lesser extent in the Succulent Karoo of the south-eastern Cape. All species have horticultural potential and they are popular container plants. A number of species are confined to the fertile inter-montane valleys of the eastern Cape which is overgrown with subtropical thicket vegetation or grassland or, to a lesser extent, renosterveld. This region is of agricultural importance and large areas have been cleared for crop farming. This region is the habitat of G. *bicolor* var. *bicolor*, *G. nitida* var. *nitida*, *G. nitida* var. *armstrongii*, *G. pulchra*, and G. *excelsa.* Of these, G. *nitida* var. *armstrongii* is endemic to the lower Gamtoos River Valley and is under threat. Fortunately the species is represented in a nearby nature reserve. G. *bicolor*, although still common, has been reduced considerably by agricultural development. G. *excelsa* occurs on forested, well-drained rocky banks, but due to overgrazing and firewood collecting has become much rarer. G. *baylissiana* is another very rare species from the summit of the Zuurberg. The reason for its *in situ* decline is unknown but the numbers of the species have recently been increased by reintroductions to its habitat. Stocks of the species have been increased ex *situ* by seed and various clones originally distributed by Col. R. D. Bayliss to botanical gardens were used in the project. G. *croucheri* from Natal has became rare due to medicinal and ethnic

uses in that region. Seed of this *Gasteria* have been made available to Silverglen Nursery, Durban, whence plants are provided to traditional doctors. Fortunately, the remaining species occur in habitats not under immediate threat. All species of *Gasteria* are being increased from seed as well as vegetatively at the Kirstenbosch Botanical Garden, especially the rare endemics, and seeds are made available on an annual basis.

Astroloba Mitewaal. The genus is closely related to *Haworthia*, but for some reason has never appealed to collectors and species of this genus are not under immediate threat.

Poellnitzia Mitewaal. At present urbanisation does not pose a threat to populations of *Poellnitzia rubriflora*. In the entire Succulent Karoo Biome it occurs in only two medium-sized towns (Worcester and Oudtshoorn) and various smaller centres, for example Robertson and Bonnievale. Cultivation of especially wine grapes is limited to fairly narrow strips alongside water courses, such as the Breë River. The colonies of *P. rubriflora* are mostly confined to rocky hillocks and appear to be in no immediate danger of agricultural activities. However, due to its small world population and its confinement to a restricted geographical area, *Poellnitzia* has been removed from the Indeterminate (I) category designated to it by Hall *et al.* (1980) (under the name *Haworthia rubriflora* in Hall and Veldhuis (1985) and reclassified as Rare (R) in Hilton-Taylor (1996b) (see Annex 16 for definitions of the Red List categories).

Chortolirion A. Berger. The genus has a very effective defence mechanism in that, in its natural grassland habitat, casual succulent plant collectors are likely to mistake its linear leaves with those of a grass species. The inflorescence and flowers of *Chortolirion* are also very inconspicuous. In pristine and well-managed pastures grazing pressure is minimal since the abundance of palatable grass species associated with it will certainly be utilised preferentially. Therefore, at least at present, *Chortolirion* is Not threatened. Where possible, populations should be monitored for decline or expansion, especially since *Chortolirion* occurs in some of the most densely populated areas of South Africa.

Asclepiadaceae

Focke Albers and Ulrich Meve*

The family Asclepiadaceae R.Br. is characterised by its unique complicated flower morphology and highly evolved pollination system. The family comprises various lifeforms including herbs, shrubs, twiners, succulents, and trees. The species mainly occur in the subtropics and tropics around the world, and only occasionally in temperate regions.

Economically the family is of little value. Some genera are of horticultural interest, but most species are not of significant value in terms of horticultural production. Asclepias, Hoyas and related species are grown as outdoor or pot plants, Dischidias, stapeliads, and *Ceropegia* species can be found all over the world in special hobbyist collections. Other uses of the family are few. The hairs of *Asclepias* and *Calotropis* seeds were sometimes used as a substitute for down, and in India ropes are produced from the stem fibres. In Africa and India some species are used medicinally by local people. Species of *Caralluma* and *Ceropegia* are eaten in India (see Annex 10) and, in extreme dry areas of southern Africa, succulents are eaten by Nama people and Bushmen.

Systematic treatment

Brummit (1992) compiled 315 genera in this large family. Today the number of species is estimated at more than 2000. In an intensive study of the family, Liede and Albers (1994) determined that about 500 correctly described genera exist. These are arranged in taxonomic order and discussed below. The family is divided into three subfamilies (Periplocoideae, Secamonoideae, Asclepiadoideae), the latter one comprises four tribes (Marsdenieae, Asclepiadeae, Gonolobeae, Stapelieae) according to Bruyns and Forster (1991). A fifth tribe Fockeae is added to this subfamily by Kunze, Meve and Liede (1994).

The subfamily Periplocoideae is a well-defined taxon, which is sometimes excluded from the Asclepiadaceae and treated as a family of its own (Periplocaceae) (Schlechter 1905; Bullock 1956). Most of the species are shrubs and twiners occurring in the Old World. Only two of the described genera, *Raphionacme* and *Petopentia*, have fleshy root stocks. Raphionacme is becoming of increasing interest for the hobbyist growers. Venter and Verhoeven (Bloemfontein, RSA) have contributed several valuable papers on this taxon since 1983 and Goyder (Kew) is also dealing with this group.

The subfamily Secamonoideae (five genera) is dominated by the great palaeotropic genus *Secamone* (Australia, Forster and Harold 1989; Africa, Goyder 1992; Madagascar region, Klackenberg 1992). Many species are known only from one or a few specimens, and 84 per cent are endemic to Madagascar (Klackenberg 1992). The twiners and herbs are not important in cultivation.

The largest subfamily is the Asclepiadoideae. Within this grouping, the tribe Fockeae contains three genera which are excluded from the tribe Marsdenieae. The small African genus *Fockea* consists of well-known caudiciform succulents. Research on this genus has been carried out by Court (Grahamstown, RSA). One species, *Fockea sinuata*, is considered to be Endangered. In general, the Fockeae species are of no importance for amateur growers.

The tribe Marsdenieae contains attractive leaf

* *Manuscript submitted in 1993*

succulents. Many of these are epiphytes of East Asia, Australia, and Oceania: *Dischidia, Dischidiopsis,* and *Hoya.* Some common species of these genera are grown as house plants, but most of the species in collections are cuttings of plants of natural origin, which are traded by a few professional horticulturists. Rain forest species in the centres of diversity in Malaysia, Indonesia, Philippines, and New Guinea are extremely threatened by forest destruction. Research is being carried out by de Koning (Leiden) and H. and R. Donkelaar (Werkendam), both from the Netherlands, and by Forster and Liddle, from Australia.

The largest tribe, Asclepiadeae, has a world-wide distribution in temperate, subtropical, and tropical regions. Lifeforms represented include herbs, shrubs, twiners, and trees, with succulents relatively uncommon. Large genera of this tribe are *Asclepias, Cynanchum/Vincetoxicum,* and *Oxypetalum.* The first genus is better known (e.g. Woodson 1954), whereas the others have been neglected for a long time. *Cynanchum* and related groups are being studied now by Liede (Ulm, Germany) and Nicolas (South Africa). The species of the genera which occur in the New World are quite different from those living in the Old World.

Succulents in the Asclepiadeae include species of *Cynanchum* with fleshy leaves, and species of *Asclepias, Aspidonepsis, Cynanchum, Sta tmostelma,* and *Stenostelma* with succulent subterranean parts. Stem succulents include species of *Sarcostemma, Cynanchum, Folotsia, Karimbolea,* and *Platykeleba,* all of which, with the exception of *Sarcostemma,* exist in the semi-arid parts of south-west Madagascar. Some of these are extremely localised or rare. Liede (pers. comm.) listed 48 species of *Cynanchum,* five of *Folotsia,* two of *Karimbolea,* and *Platykeleba insigne* as Rare and Endangered succulent Malagasy species. Several of them have apparently declined rapidly in numbers as their habitat is gradually being destroyed. The stem-succulents are of interest to hobbyists, but other species are not considered desirable and therefore they have not been additionally endangered by professional collectors.

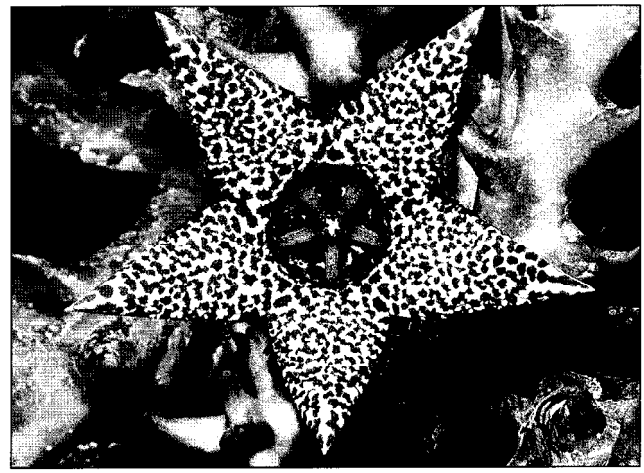
The species of the tribe Gonolobeae are restricted to the warmer parts of Central and South America. The herbaceous species often belong to monotypic genera which are poorly known in the wild and in herbarium collections. Several species are represented by single herbarium sheets and some species have never been re-collected since they were first described. Stevens (Missouri Botanic Garden) is working on this very difficult and poorly known group.

The Stapelieae is by far the best-known tribe and the most important one for hobbyist growers. All species are of palaeotropical origin, and many have evolved lifeforms with fleshy subterranean parts or stem succulence. The tribe Stapelieae includes the genus *Ceropegia* and a group of 30 other genera which collectively are commonly known as stapeliads.

The distribution area of *Ceropegia* covers Africa, Madagascar, Arabia, India, Southeast Asia, the Indonesian Archipelago, and Northern Australia. Although the genus is so widespread, most of the approximately 200 species are endemics with restricted distributions. Due to this fact, and the horticultural appeal of *Ceropegia* spp., the genus as a whole is listed in Appendix II of CITES. Within the Stapelieae, this genus has the highest rate of insufficiently known species (20 per cent). Since Huber's revision of the genus in 1957, several new species have been described which are highly attractive to hobbyists. Most, except for the geophytcs, can be easily propagated by cuttings, and have been in cultivation for many years.

The species of the genus *Brachystelma* (about 120), as well as those of *Riocreuxia* and *Tenaris,* all have developed geophytic forms and are well-adapted to grassland. The species of *Brachystelma* have a similar distribution area as those of *Ceropegia* to which they are closely related, but they avoid wetter areas. The habitats of *Bnrchystelma* are under extreme grazing pressure. The species do not grow well on their tubers in cultivation, and can bc propagated only by seed. According to the species listed in the "Checklist of *Brachystelma, Ceropegia, Riocreuxia,* and the Stapelieae" (Boele, Kroesen, and Noltee 1987) 72 per cent of the approximately 120 species are Endangered. Six species are already Extinct or have not been found for a long time. These are *B. gemmeum, B. glenese, B. gracillium, B. longifolium, B. na talense,* and *B. occiden tale.* Valuable information is given by Dyer (1983). The genus *Macropetalum* is insufficiently known.

The thirty genera of stapeliads contain approximately 400 species. As stem succulents, with often large and attractive flowers, they are very well known to hobbyist growers and can be found in collections all over the world. In the wild, most of the species are confined to the more arid parts of Africa, but there are also several species occurring in Arabia, India, and Myanmar. Two European species are closely related to those of North Africa. The



U. Meve

Orbeopsis gerstneri ssp. *gerstneri,* a South African asclepiad.

species mainly form small, widely scattered or sometimes solitary populations. It is becoming increasingly apparent that stapeliads are a comparatively old plant group, in which plate tectonics and changes of climate have led to several migratory processes. The present distribution pattern comprises not only various centres of diversity, but also very restricted areas of retreat (Albers and Meve, in prep.). This perspective allows for the introduction of a relatively large number of genera in the stapeliads, a view supported by most of the recent studies. Research work so far, however, has mainly been limited to morphological characters and unfortunately has led to divergent concepts of species and even genera. Experts are far from an acceptable agreement like the one reached by the IOS consensus group for the Cactaceae.

Northeast Africa is assumed to be the centre of evolution for the stapeliads, but most of the species occur in southern Africa today. This secondary centre (Albers 1983) has evolved its own genera: *Hoodia, Huerniopsis, Lavrania, Notechidnopsis, Ophionella, Orbeanthus, Orbeopsis, Pectinaria, Quaqua, Stapelia, Stapeliopsis, Tavaresia, Trichocaulon, Tridentea,* and *Tromotriche.* The genus *Stapelianthus* is endemic to Madagascar. Only a few genera, like *Huernia* and *Duvalia,* are known on both sides of the equator, the vast majority of the North African species belongs to the genus *Caralluma.* The species from India and Myanmar are included here. Despite intensive research which has been done by Gilbert (1990) the genus still needs attention. With the aid of modern methods it seems to be possible to elucidate this complex (Albers and co-workers, in prep.).

Most of the other large genera of the stapeliads have been revised recently or revisions are in preparation *(Duvalia, 14* spp., Meve, in press; *Echidnopsis,* 31 spp., Bruyns 1988; *Hoodia, 13* spp., Bruyns 1993; *Huernia, 69* spp., Leach 1988; *Lavrania, 5* spp., Bruyns 1993; *Orbea, 21* spp., Leach 1978; *Orbeopsis,* 11 spp., Leach 1978; *Pachycymbium sensu* Gilbert, 31 spp., Gilbert 1990; Piaranthus 7 spp., Meve 1994; *Quaqua 24* ssp., Bruyns 1983; *Stapelia, 45* spp., Leach 1985; *Tridentea, 20* ssp., Leach 1980). Valuable information on the distribution and ecology of the species is included in most of the revisions.

The *Hoodia/Trichocaulon* complex, which has also been studied by Plowes (1992), still needs a satisfactory nomenclature. Lavranos has contributed to the knowledge of most of the taxa in a valuable way by describing new species and introducing new genera which he had found and collected on field trips in Africa and Arabia (mainly published in the *Cactus and Succulent Journal* (US).

Little is known about the population behaviour of the stapeliads. Observations on *Hoodia* spp. in Namibia indicated that some specimens have a lifespan of approximately 60 years (Jurgens ex Erb, pers. comm.). Albers and Meve (1991) demonstrated, in contrast, that some karroid species with creeping lifeform behave like ephemerals, e.g. within nine years a large *Duvalia caespitosa* population was substituted by a *Stapelia pillansii* population. Further long-term studies, of enormous importance for studying conservation status, are needed for other taxa.

The myiophilous pollination syndrome of the stapeliads is now being investigated more carefully (Meve and Liede 1994). The knowledge of pollinators of the other taxa is still very poor. A literature review is presented by (Meve and Liede 1994).

Species of the stapeliads can be quite readily propagated by seed, but most of the specimens which arc cultivated by specialists are of wild origin or from material exchanged among colleagues. Many of the species are not easy to grow on their own roots, so grafting seems to be a very successful way to keep them alive and make them bloom sooner.

Threats

The destruction of the natural habitat is by far the most threatening danger for the species. In the winter rainfall area of South Africa, as well as in East and North Africa, overgrazing and the spreading of agriculture is the most important cause of this destruction. The karroid regions of South Africa seem to be rather stabilised, whereas some Fynbos species are known to be threatened by agricultural activities and housing development on the coast. Species threatened in this way include those of *Duvalia, Orbea,* and *Stapelia.* The problems facing succulents of the arid regions of Madagascar are described in the Madagascar account in Chapter 3. Most of the *Stapelianthus* spp. of Madagascar are under enormous pressure except **S.** *decaryi* and *S. madagascariensis.* The Indian *Caralluma* species are all considered to be threatened due to spreading agriculture and population pressure. The monotypic *Frerea indica* of India (often only accepted as *Caralluma frerei*), together with the genus *Ceropegia,* are the only stapeliads listed in CITES (Appendix II). *Caralluma europaea* is threatened by the increased building of holiday villages in Spain. The

D. J. Supthut

Stapelianthus pilosus

endemic C. *burchardii* of the Canary Islands seems to be sufficiently protected. This species, the two European Carallumas and the Ceropegias of the Canaries are protected by EC legislation.

Although the field collecting of amateurs should not be underestimated, as a threat it is secondary to habitat destruction. It is controlled by governmental restrictions in several countries.

Conservation status

Using the updated "Checklist" (Boele, Kroesen, and Noltee 1987), which is mentioned already, Meve (pers. comm.) compiled all data available for the Stapeliads. Following the old IUCN Red List categories (see Annex 16), he found out that no species is Extinct, but that 12.6 per cent of the species are Endangered, 1.8 per cent are Vulnerable, 29.5 per cent are Rare, and 7.5 per cent are Indeterminate. That means that half of the Stapeliad species are threatened today. The same percentage is found with *Ceropegia* if the rather high number of insufficiently known species is included. A list of the Asclepiadaceae with conservation categories is given in Annex 2.

To summarise, the Asclepiadaceae comprises more than 2000 species with most occurring in the subtropics and tropics. The more arid, as well as the wetter areas of these zones, contain very sensitive ecosystems which are under considerable pressure or have already been destroyed. Many species of Asclepiadaceae are therefore threatened with extinction, including many species which are poorly known. Long-term studies are needed nearly everywhere. Within the best-studied tribe Stapelieae, half the species are considered to be threatened. In other groups the percentage is even higher. In general, the reasons affecting the conservation status of Asclepiadaceae are increasing agricultural development, forest destruction, housing, and road development.

Cactaceae

Nigel P. Taylor

The Cactus family (Cactaceae Juss.) is characterised botanically by the presence of stems bearing specialised, felted short-shoots termed areoles, which usually develop the spines (modified leaves) that represent the familiar hallmark of this plant group. Except for one species of *Rhipsalis (R. baccij'era* - Neotropics eastwards to Sri Lanka), the family is endemic to the New World, although various economically important and weedy species have been introduced and become naturalised in warmer parts of the Old World. In the Americas they range from southern Canada to Patagonia, being most frequent in the dry climatic zones between 35" N and S latitude and outside the moist equatorial (Amazonian) region. The family has very considerable value in terms of horticultural production, with millions of artificially propagated specimens traded across international borders each year.

Taken as a whole the Cactus family has a surprisingly wide climatic and ecological spectrum, encompassing almost rainless desert such as parts of the western Atacama in northern Chile at one extreme to tropical rain forest receiving more than 2000 mm of rain per year at the other. They range from sea level to a reported 5200 m altitude in the Andes and vary considerably in their resistance to frost. None is parasitic, but epiphytes, lithophytes, 'cactus geophytes', mound-forming caespitose, decumbent, scandent and erect, free-standing tree and shrub species are frequent. Apart from the 'cactus geophytes', amongst the most remarkable arc dwarf species restricted to cliffs, such as *Aztekium, Strombocactus,* and *Blossfeldia,* which have dustlike strophiolate seeds. In contrast, *Opuntia (Brasiliopuntia) brasiliensis* is adapted to life in high, dense, dry to very humid forest, where it forms a tree to 20 m, with a cylindrical trunk and flattened leaflike ultimate stem-segments (southern Neotropics). At least four Mexican species appear to be restricted to gypsum, and isolated outcrops of particular rock types account for a significant part of the narrow endemism seen in the family. Some species are able to grow on, or are restricted to, extremely oligotrophic substrates, for example, *Uebelmannia* and *Discocactus* spp. Seed dispersal is effected by various means including mammals, birds, lizards, insects (especially ants), fish (Amazonia), wind (*Eriosyce* spp., *Pterocactus),* and water (*Frailea*). Bats are a particularly important group of associated organisms (Dobat and Peikert-Holle 1985) on whose conservation the survival of some cactus species may well depend. Nurse plants of various shapes and sizes are often important for establishment of delicate cactus seedlings (Cactoideae).

Although amateur horticulturists continue to play a significant role in describing and classifying cacti, the past 20 years have seen the family subjected to fairly intense

E. F. Anderson

Aztekium hintonii, Nuevo León, Mexico.

morphological and taxonomic scrutiny by professional botanists and it is now probably one of the better understood major succulent plant groups. The Cactaceae comprises four subfamilies, namely the primitively leaf-bearing Maihuenioideae and Pereskioideae (2 genera / c. 19 species), the highly derived Opuntioideae (5 or more genera /185-265 spp.) with barbed spines and glochids, and the leafless, morphologically complex Cactoideae (c. 97 genera /> 1000-2000 spp.). The last of these, containing the bulk of the family, is divisible into at least eight tribes, each of which has a characteristic geographical range.

Collaborative study of the family's classification at generic level by a broad group of botanists and knowledgeable amateurs (under the auspices of the IOS) has resulted in two published reports listing the genera accepted by a consensus of systematists (Hunt and Taylor 1986, 1990). Following these reports, a checklist of species names and their synonyms in current usage has been compiled for the family on a consultative basis. This includes distribution data at country level and country by country species lists with details of endemism (Hunt 1992). This checklist, prepared at the behest of the CITES Secretariat, distinguishes between species fully *accepted* as such according to certain primary sources (botanical monographs, floristic treatments, and in the opinions of authors of a few unpublished taxonomic revisions) and those only *provisionally accepted,* which include taxa whose status awaits expert botanical study and also those treated as subspecies or geographical varieties in the primary sources consulted. In total, the Cactus family comprises about 105 genera and, following the CITES Checklist, 1208 *accepted* and a further 1300 *provisionally accepted* species. If infraspecific taxa are excluded from the latter figure, leaving those whose taxonomic status is least understood, then it becomes clear that the greatest concentrations of taxonomically doubtful species are found in Peru and Bolivia. It is this region of the central Andes where competent field study is most needed to resolve questions of taxonomic and conservation status. Nevertheless, it is probable that a significant proportion of such taxa will prove to be 'good' endemic species and so their numbers should be taken into consideration when analysing this Andean region from a conservation perspective.

Centres of diversity

In spite of the above-mentioned uncertainties, it is a relatively simple matter to identify the geographical centres of diversitv and of endemism for cacti. In first place by far comes Mexico and the immediately adjacent south-western United States (southern California, Arizona, New Mexico, and south-west Texas) where some 27 per cent of all cactus genera are endemic and at least 570 *accepted* species are native, 430 being endemic to Mexico alone (27 cactus species have been reported sympatric in a single locality in north-east Mexico, Fitz Maurice, pers. comm.). The region is notable for the high number of endemic tree-like or columnar species belonging to tribe Pachycereeae, which are characteristic of the dry tropical forest and Sonoran Desert floras, where they sometimes dominate or are so conspicuous as to be worthy of description as forming 'cactus forest'. Many are of local economic importance for their edible fruits, woody skeletons used in house construction, and for planting as impenetrable living fences. Bats are known to be important pollinators and seed dispersers of these columnar cacti. Mexico and the bordering Rio Grande valley region of the USA (especially the Chihuahuan Desert and its margins) have many remarkable small or monotypic genera from tribe Cacteae, which exhibit unique and sometimes extraordinary morphology, for example, *Ariocarpus (7* spp.), *Astrophytum (4* spp.), *Aztekium (2* spp.), *Epithelantha (2* spp.), *Geohintonia* (1 sp.), *Leuchtenbergia* (1 sp.), *Lophophora (2* spp.), *Mammilloydia* (1 sp.), *Obregonia* (1 sp.), *Ortegocactus* (1 sp.), *Pelecyphora (2* spp.), *Stenocactus (8* spp.), and *Turbinicarpus (14* spp.). Most of these include species which are either of very restricted distribution or found only in very unusual habitats, and some are known to be under threat from collecting for horticultural purposes, which has required their protection from commercial over-exploitation by inclusion in Appendix I of CITES. Other low-growing genera, which are particularly diverse and species rich in the south-west USA and Mexico, include *Mammillaria* (> *150* spp.), *Coryphantha* (>50 spp.), and *Echinocereus* (> *50* spp.), each with threatened taxa, some of which are included in Appendix I of CITES in view of horticultural demand. Apart from collecting pressure the most threatened taxa are those 'cactus geophytes' that inhabit fertile land undergoing agricultural development (e.g. *Echinocereus pulchellus*). Opuntioideae, i.e. *Opuntia* spp., make up a very important component of this cactus flora and some are of considerable local economic importance for their edible fruits and stem-segments. Southern Mexico has a significant number of species belonging to the primarily epiphytic tribe Hylocereeae (e.g. *Disocactus* s.l.), inhabiting moister tropical forest and mountainous regions, but in comparison with tribes Cacteae and Pachycereeae, a smaller proportion of these is endemic, with ranges frequently extending into the adjacent countries of Central America, where they represent the most important component of the cactus flora.

The second most diverse region for cacti is that of the central Andes comprising the countries of Peru and Bolivia, with the addition of southern Ecuador, north-east Chile, and north-west Argentina. About 18 per cent of all cactus genera are endemic to this region and there are about 420 taxa named as species endemic to Peru and Bolivia, but most of these are only *provisionally accepted* by the CITES Checklist. The cacti of southern Ecuador, north-east Chile, and north-west Argentina are better known and comprise about 115 *accepted* species. As in the

case of Mexico, cactus forest vegetation with large shrubs and columnar or tree-like forms occurs, but highly specialised and unique growth habits are less common, exceptions being represented by *Blossfeldia* (1 sp.) and an unusually diverse array of *Opuntia* spp. However, there are numerous species of globose habit from tribes Notocacteae and Trichocereeae. Genera containing many species include *Parodia, Rebutia, Gymnocalycium, Echinopsis, Cleistocactus, Oreocereus,* and *Matucana.* The commonest pollination syndromes in this region are those for bees, hawkmoths, and hummingbirds.

The third most diverse region is that here loosely described as eastern Brazil, comprising the segment of that great country east of a line drawn between the states of Maranhao and São Paulo (north-east and south-east Brazil plus eastern Goiás and eastern Tocantins). About 80 per cent of its cactus flora is endemic, including 11 per cent of all cactus genera and having a total of approximately 145 taxonomically acceptable native species (plus numerous taxa recognisable as subspecies). Its cacti are perhaps the best understood after those of the USA and northern Mexico (Chihuahuan and Sonoran Deserts). Columnar, shrubby and sometimes tree-like forms (tribe Cereeae and *Pereskia)* and epiphytic forms (tribe Rhipsalideae) predominate, the former being particularly diverse in the dry interiors of Bahia and Minas Gerais states, the latter characteristic of the coastal Mata Atlantica and mountains of Rio de Janeiro and São Paulo (and also the states of southern Brazil). Much of the Mata Atlantica has now been destroyed and with it the habitat of these epiphytic cacti. *Rhipsalis pentaptera,* for example, although common in cultivation, is probably Extinct in the Wild, since its only known habitat formerly occurred in what is now a built-up area within the city of Rio de Janeiro. The east Brazilian cereoid cacti are notable for the frequent development of diverse kinds of woolly lateral cephalia, which in some cases are thought to be adaptations connected with pollination by bats, the commonest cactus pollen vector in the region. Hummingbird and hawkmoth pollination syndromes are also frequent. The fewer species of globose habit include the taxonomically isolated *Uebelmannia (3* spp. restricted to a small area in Minas Gerais state) and *Melocactus (* 15 spp.) and *Discocactus (6* spp.), with flowers borne in peculiar inflorescence structures called terminal cephalia. Representatives of each of these three genera arc regarded as severely threatened and are currently the only South American cacti listed in Appendix I of CITES (Braun and Esteves Pereira 1988; Taylor 1992). Members of Opuntioideae are diverse at generic level, but represented by very few species when compared with other areas within the family's range.

The geographical region that is fourth in order of importance comprises central-western and southern Brazil, Paraguay, Uruguay, and Argentina (excluding the north-west and southern parts). There are approximately *85 accepted* species (about half of these endemic) and a greater number of endemic but only *provision ally accepted* taxa. Columnar, shrubby, or semi-scandent cacti are mainly represented by species from the genera *Cereus, Harrisia, Opuntia,* and *Pereskia,* most of which are endemic, but the greater representation of the family is in the form of low-growing or globular members of *Parodia* s.l. (incl. *Notocactus* etc.), *Frailea,* and *Gymnocalycium,* each with numerous named species and in need of taxonomic revision. Habitats of various of these smaller cacti are shrinking due to agricultural development and field studies are required to determine their conservation and taxonomic status. There is also a high number of epiphytic species from tribe Rhipsalideae, whose habitat is shrinking through deforestation, as in eastern Brazil.

Smaller, but nevertheless important, centres of

A. Areces-Mallea

Dry savanna in Haïti.

endemism include the Caribbean region with northern South America (north Venezuela, north and west Colombia and Panama), where the most notable genera with endemic species are *Melocactus* with 9 and *Cereus* with 5, and central to north-western Chile (especially the western edges of the Atacama Desert), where an isolated flora has developed. The Caribbean islands have relatively small cactus floras, exceptions being Cuba and Hispaniola, but are notable for peculiar endemics such as the Consolea group of *Opuntia, Leptocereus* (including the giant *Neoabbottia), Harrisia* subg. *Harrisia,* the massive *Dendrocereus* (now included in *Acanthocereus* by some authors), and a unique group of dioecious *Pereskia* spp., some of which are very rare and of particular conservation concern (Leuenberger 1986).

If the north-easternmost corner of Chile is excluded (see above), the remainder of the country has an almost exclusively endemic cactus flora of about 60 *accepted* species. The coastal fringe of the Atacama Desert in northern Chile is home to many remarkable cacti whose existence depends to a large degree on moisture derived from fogs which roll in from the cold Pacific Ocean. Various remarkable life forms have evolved in this region, including extreme 'cactus geophytes' and certain members of the endemic genus *Copiapoa* (about 25 spp.) with stems covered in dense white or grey wax. Excepting a few hummingbird-syndrome species, nearly all the endemic Chilean cacti are thought to have flowers adapted for pollination by hymenoptera. Cacti found in the regions of Santiago, Valparaiso, and southward include species under threat from urban and agricultural expansion, and at least one member of the largest Chilean genus, *Eriosyce (27* spp. endemic), is now believed to be Extinct in the Wild *(E. aspillagae*; *see* Kattermann 1994).

Towards the extremities of the family's range, and near its equatorial centre, few species are represented due to obvious climatic constraints. In the north, in the USA, should be mentioned the Rare, narrowly endemic species of *Pediocactus* and *Sclerocactus,* some of which are protected by CITES Appendix I listing. To the south, in Argentinian Patagonia and adjacent Chile, there are peculiar representatives of the Maihuenioideae *(Maihuenia, 2* spp.), Opuntioideae *(Pterocactus* spp.), and tribe Notocacteae *(Austrocactus* spp.), but none of these is regarded as particularly threatened at present. In the constantly humid Amazonian region there are only a few widespread epiphytic species, plus some poorly known endemics (*Melocactus* and Cereus spp.), the most notable cactus being *Selenicereus wittii,* which inhabits flooded forest (igapó), climbing up the trunks of trees by means of aerial roots (Mee 1988). Farther west, in the Galapagos archipelago, is a small but entirely endemic cactus flora comprising the monotypic genera *Jasminocereus* (a close relative of *Armatocereus* from the South American mainland) and *Brachycereus,* and various unusual *Opuntia* spp.

Threats

The major pressures affecting the conservation status of cacti are, in decreasing order of severity, (1) agricultural development and deforestation, (2) urbanisation and infrastructural development including road building/widening and hydroelectric dam projects, (3) collection for horticulture, (4) mining of stone for construction (especially threatening to species restricted to limestone or granitic rock outcrops, for example, in eastern Brazil and Mexico).

Crassulaceae

Henk t'Hart

The Stonecrop family (Crassulaceae DC.) comprises herbaceous, and sometimes shrubby, leaf succulents with regular, hermaphrodite flowers which have an equal number (commonly five) of sepals, petals, and carpels. With few exceptions, the carpels are many-seeded and completely free. The distribution of the family is nearly cosmopolitan, but most taxa are restricted to the subtropical and temperate regions of the Northern hemisphere and southern Africa. The family is very rare in Australia and South America. The Crassulaceae comprises a large number of species of great horticultural value, most of which can be easily propagated and are produced commercially.

As with other succulent plant groups, the taxonomy of the Crassulaceae is hampered both by the difference in the appearance of herbarium specimens compared to that of live plants, and by a lack of clear-cut discontinuities in morphological features. The latter is probably due to strong morphological constraints resulting from their highly specialised habit. Consequently botanical opinion strongly diverges with respect to the number of species and genera in the family as well as to the delimitation of infrageneric and infrafamilial taxa. The use of living plant material in systematic studies may to a large extent help to solve these disputes (as demonstrated, for example, by Praeger 1921, 1932; Frôderstrôm 1930-1936; Walther 1972), but at the higher taxonomic levels, especially concerning the delimitation of genera, there is still much disagreement among professional botanists. Recently a joint study by a small group of Crassulaceae experts, under the auspices of IOS, has resulted in the first draft of a list of genera accepted by consensus (Eggli *et al.* 1994).

Crassulaceae occurring in regions which have been extensively explored botanically are fairly well-known. The exact number of species within this family is, however, still uncertain, as knowledge is incomplete for Central and South America, the Near East, southern Central Asia (the Himalayas), East Africa, and Madagascar. Despite these gaps in our knowledge, the evolution and systematics of the family are now beginning to be understood. Combined cytological and morphological studies of plants cultivated under uniform conditions have greatly improved our understanding of the significance of infraspecific variation and speciation in

the family and has considerably improved species delimitation (for references see t'Hart 1991). Recent DNA studies, however, have most of all enhanced our understanding of the evolutionary relationships within the family and have helped to verify earlier tentatively proposed evolutionary trends (van Ham 1994).

The Crassulaceae family comprises 1200-1500 species. In the most recent monograph covering the whole family Berger (1930) distinguished 6 subfamilies. However, the family comprises only 2 major evolutionary lines and consequently the number of subfamilies has been reduced accordingly (van Ham 1994; t'Hart 1994). The subfamilies are the Crassuloideae *(sensu* Berger 1930), which is distinguished from all other Crassulaceae by a combination of haplostemonous flowers and opposite leaves (2 genera / c. 200 species), and the Sedoideae which is characterised by predominantly obdiplostemonous flowers and spiral phyllotaxis (c. 30 genera / 1000-1200 species).

The family probably evolved about 100-60 million years ago in Eastern Africa or the Mediterranean region (van Ham 1994). From this primeval centre of origin two lineages, the Crassuloideae, and the *Cotyledon* and *Kalanchoe* lineage of the Sedoideae, migrated into southern Africa, whereas the other lineages of the Sedoideae spread over Europe, Asia, and North and Central America in four or more successive migration waves.

Centres of diversity

With the exception of the large genus ***Sedum*** (about 500 species), which is widely distributed in the subtropical and temperate regions of the Northern Hemisphere, and the semi-aquatic, cosmopolitan genus *Tillaea* (about 20 species), the genera of Crassulaceae are generally confined to a single continent or subcontinent. Four main geographical centres of diversity and of endemism can be readily distinguished, one in southern Africa and three in the Northern Hemisphere. These four centres differ largely with respect to the species and the genera they comprise. The three centres in the Northern Hemisphere, do however, each contain a unique section of *Sedum* (t'Hart 1982).

C. Hilton-Taylor

Tylecodon *paniculatus,* a member of the Crassulaceae which is removed from the wild in southern Africa because it causes stock poisoning.

The southern Africa centre of diversity has approximately 450 species in six major genera, *Crassula, Adromischus, Cotyledon, Bryophyllum, Kulanchoe,* and *Tylecodon.* Altogether they constitute the larger parts of the subfamily Crassuloideae and the entire *Kulanchoe* and *Cotyledon* lineage of the subfamily Sedoideae (t'Hart 1994), which, with few exceptions, are all characterised by opposite leaves. South Africa is by far the richest region with over 140 species of *Crassula* (Tolken 1977), and most of the species of *Adromischus, Cotyledon,* and *Tylecodon. Crassula* s.l. comprises some highly specialised, systematically isolated forms which are sometimes treated as separate genera (small or monotypic), e.g. *Dinacria, Pagella, Rochea,* and *Vauanthes. Crassula* also occurs in tropical East Africa and Madagascar, but it is outnumbered there by *Kalanchoe* (over 100 spp.). *Bryophyllum* (incl. *Kitchingia)* is endemic to Madagascar. The systematics of the East African *Kalanchoe* species has recently been reviewed in a series of local Floras, but the Madagascan species of *Kalanchoe* and *Bryophyllum,* most of which are probably endangered, are urgently in need of revision. They show a remarkable series of physiological and morphological adaptations to different habitats and pollinators. Some *Bryophyllum* species produce bufadienolides, (cyto)toxic secondary compounds which are regarded as potent, novel antitumor agents (Yamagishi *et al.* 1989).

In East Africa, from Madagascar to Ethiopia, some 15 rare and aberrant Sedoideae of uncertain affinities are found. These include *Afrovivella, Crassularia, Hypagophytum,* and *Perrierosedum,* and may be relicts of an ancient (Tertiary), African Sedum flora.

The second centre of diversity is central Mexico with about 300 endemic species in five major genera *(Echeveria, Graptopetalum, Pachyphytum, Sedum, Villadia).* The states of Puebla, Hidalgo, and Oaxaca are extremely rich in species, containing over 60 species of *Echeveria* alone (Walther 1972). This region adjacent to and including the eastern section of the Transmexican Volcanic belt also comprises a wide variety of other Crassulaceae. The central Mexican Crassulaceae all belong to a single evolutionary line (van Ham 1994). The taxa are relatively young and show little evolutionary divergence, which may explain why they can still be hybridised forming a single huge comparium (a group of species which have the potency to hybridise) of more than 200 species (Uhl 1992). Many of the Mexican Crassulaceae are very local and known only from the type collection or a few locations. Northwards along the Sierra Madre the number of species gradually diminishes. The

adjacent regions of Baja California and the USA states of California and Oregon constitute a secondary American centre of diversity independent of the central Mexican lineage. The region comprises another 80 endemic species most of which belong to *Dudleya* and ***Sedum.*** Most Mexican and western American Crassulaceae have large, rosulate or semirosulate, very succulent, thick leaves and are often shrubby. In the USA a few annual Sedoideae occur, which are usually separated from ***Sedum,*** i.e. ***Diamorpha*** (1 sp.) and ***Parvisedum (4*** spp.). Some species of ***Echeveria*** and a few species of ***Sedum*** and ***Villadia*** occur in South America as far as north-western Argentina.

The third centre of diversity is the Eurasian-Mediterranean region with about 220 endemic species in seven major genera ***(Aeonium, Aichryson, Monanthes, Rosularia, Sedum,*** *Sempervivum,* ***Umbilicus).*** A general feature of Eurasian Crassulaceae is the large number of taxa with polymerous flowers, most notably Berger's subfamily Sempervivoideae and some groups of ***Sedum.*** The genera ***Aeonium,*** *Aichryson*, and *Monanthes* are confined to Macaronesia, except for four species of ***Aeonium*** occurring in north-west Africa, eastern central Africa, and on the Cape Verde Islands. The Canary Islands are notable for the high number of endemic species of these three genera, with over 60 spp. in total. ***Sempewivum (c. 40*** spp.) is confined to the montane and alpine zones of the mountains of southern Europe and the Near East. All species of ***Sempewivum*** are rosulate and much sought after as ornamentals. *Rosularia* agrees with ***Sempewivum*** in habit and ecological preference. It is mainly confined to the Near East. The Eurasian-Mediterranean ***Sedum*** flora is further characterised by a large number of annual or hapaxanth species (over 40 percent). ***Umbilicus*** is notable for its distinctly pedunculate, peltate leaves, racemose inflorescences, and sympetalous flowers. ***Umbilicus, Pistorinia (2-3*** spp. with a tubular corolla), and a few sympetalous species now included in ***Sedum,*** used to be classified in Berger's otherwise strictly South African subfamily Cotyledonoideae.

The fourth centre is located in eastern Asia and comprises about 200 endemic species in five major genera ***(Hylotelephium,*** *Orostachys,* ***Rhodiola, Rosularia, Sedum).*** A remarkable feature of the Asian Crassulaceae is the predominance of taxa with annual, leafy, flowering shoots in combination with a rhizome *(Rhodiola,* ***c. 40*** spp., ***Sedum*** sect. ***Aizoon,*** ***> 15*** spp.) or tuberous roots ***(Hylotelephium, c. 30*** spp.). ***Rhodiola*** is mainly found at high altitudes in the Himalayas, whereas ***Hyloptelephium*** and ***Sedum*** sect. ***Aizoon*** occur at less elevated and more mesic habitats from south-western China to eastern Asia. Many species of ***Rhodiola*** are dioecious, though their sexual differentiation is apparently not based on chromosomal differences (sex chromosomes).

Crassulaceae generally occupy arid and semi-arid, usually rocky habitats. Only very few taxa are, secondarily,

W. Strahm

Aeonium manriqueorum, Gran Canaria.

adapted to a mesic or aquatic environments, the most striking example of which are the semi-aquatic species of *Tillaea.* Although Crassulaceae are generally well-adapted to survive extended periods of drought, they are, rather surprisingly, largely absent from true desert regions. Throughout their area they are most abundant in sub-montane and montane regions, although they can be found from sea-level to over 4000 m in the tropics (*Sedum ruwenzoriense* in East Africa). Apart from their horticultural value, Crassulaceae are of little or no economic importance. The succulent leaves are sometimes prescribed for healing wounds in folk medicine and the rhizomes of *Rhodiola rosea* have some use in folk medicine. A few species have found odd applications, for example, decoctions of ***Aeonium*** *glutinosum* have been used to reinforce fishing nets on Madeira. Nowadays Crassulaceae are not used for food, though ***Sedum*** *rupestre* was recommended for salad in medieval herbals. The juicy appearance of the leafy parts of many Crassulaceae may appear rather attractive in arid environments, however, the succulent leaves are completely tasteless or bitter-tasting and are generally even avoided by cattle. "Not even the goats eat it" as an Anatolian peasant once told me pointing to ***Sedum*** *pallidum.* The species which contain alkaloids or bufadienolides, are generally unpalatable or even poisonous.

Threats

Most species of Crassulaceae occur in rocky places which are not prone to the threats of habitat destruction. Reforestation of montane habitats may locally reduce their area, but is in general of little consequence. Development of mass-tourism in fragile alpine habitats or on small oceanic islands is a more acute threat and could seriously imperil the narrow endemics frequently occurring in these places. For example, of the three accessible populations of *Sedum fusiforme* on Madeira, two sites have fallen prey to extension of tourist accommodations. The few Crassulaceae occurring in arable places are all very much endangered. In addition to the aforementioned Madagascan *Bryophyllum* species, some rare annual Sedoideae occurring in seasonally wet habitats could be endangered by increased cultivation, for example, *Sedum assyriacum* of the Near East.

Euphorbiaceae

Susan Carter-Holmes

The Euphorbia Family (Euphorbiaceae Juss.) is a very large family, the sixth largest among flowering plants, consisting of over 300 genera and 5000 species in several tribes. It is distributed throughout the temperate and tropical regions, but with the greatest representation in the humid tropics and subtropics of both hemispheres. In habit the family is very diverse, with plants ranging from prostrate, erect, or scandent annual or perennial herbs, to shrubs and trees, with leaves compound or simple, large or minute. It is nevertheless characterised by small, unisexual flowers, and a superior, usually 3-celled dehiscent fruit with each cell containing 1 or 2 seeds.

The tribe Euphorbieae contains genera with many succulent-stemmed species, some of these also with succulent leaves, native in the tropics and subtropics of the Old World, with a few from the New World. The only genus outside the tribe with species that could be called succulent is *Jatropha*, a large genus confined almost exclusively to the tropics. A few species, primarily from Central America, have been introduced into cultivation and have become naturalised in some parts of the Old World. A few are caudiciform, possessing enlarged fleshy stems and usually brilliant red flowers, the most widely cultivated of which is *J. podagrica*. A limited interest in the more woody, xerophytic species from the semi-desert areas of east tropical Africa, including Somalia, where they form a major part of the flora, has currently been aroused among hobbyists, after several recent introductions and the publication of treatments by Radcliffe-Smith (1987a, 1987b). However, these forms are usually difficult to propagate except by seed and are unlikely to become popular.

Systematic treatment

The Euphorbieae is a well-defined tribe, including the very large genus *Euphorbia*, with a world-wide distribution in temperate and tropical zones; and 10 other small genera confined to tropical and subtropical regions. It is characterised by a specialised inflorescence termed a 'cyathium', consisting of a cup-like involucre enclosing numerous male flowers surrounding a solitary female flower; the male flowers are reduced to single stamens, and the female flower to an ovary with the perianth reduced to a rim, occasionally lobed. The cyathia are further arranged in usually dichotomous cymes. Milky latex, which is often extremely caustic, is always present. Several genera are composed entirely of succulent species, namely *Pedilanthus*, *Synadenium*, *Monadenium*, and *Elaeophorbia*, all of which are of interest to the hobbyist grower.

Pedilanthus is a genus of shrubs and small trees with leafy, fleshy branches and extremely zygomorphic, beak-like cyathia usually coloured red. A thorough treatment by Dressler (1957) includes 14 species centred in the drier regions of Central America, and extending into the northern part of South America and the West Indies. One species, *P. tithymaloides* has been introduced as an ornamental, and has become naturalised in many parts of the Old World. This and P. *macrocarpa* from Baja California are the most widely cultivated.

The genus *Synadenium*, characterised by an entire, spreading glandular rim on the involucre, is confined in distribution to east and southern tropical Africa consisting of about 20 closely related species, difficult to identify, the majority of which are centred in Kenya and Tanzania. An account of the East African species has been given by Carter (1988a) for the Flora of Tropical East Africa, and Leach worked on the southern species for Flora Zambesiaca. All are shrubs or small trees with semi-succulent branches and large fleshy leaves. Their taxonomy is difficult to work out, differences between them relying primarily on leaf and cyme-branching characters. Branch-cuttings are readily rooted, and red-leaved forms are commonly cultivated as ornamentals in tropical regions world-wide, as well as less popularly by the hobbyist. A few species appear to have limited distributions, but most are fairly widespread, usually in deciduous woodland, and are threatened only by increasing human population pressures.

Monadenium contains over 50 species, distributed throughout the eastern tropical regions of Africa, from northern Somalia southwards to the Transvaal, the majority endemic in Kenya and Tanzania. All are limited in distribution, occurring in dry grassland and open deciduous woodland or scrub, as small, widely scattered or sometimes solitary populations. A monographic account was given by Bally (1961), with the east African and Somali species later revised by Carter (1988b,c, 1993). Leach worked on the fewer southern species for Flora Zambesiaca. The genus is distinguished by an entire

horseshoe-shaped involucral gland with a deep rim extended to protect the ovary which is exserted through the notch. Persistent bracts envelope the involucre and are sometimes large and showy. Habit ranges from small geophytes with large fleshy roots, to herbs with thick, succulent stems covered in tubercles, and small trees with often spiny stems and large fleshy leaves. All species are attractive to the hobbyist. Most are easily propagated vegetatively, and have been in cultivation for many years, often from the original introductions made by Bally during research for his monograph. Several species were described from single specimens and are insufficiently known, especially the small, often insignificant geophytes from the *Brachystegia* woodlands of southern Tanzania, Zambia, and Malawi. These are not threatened in the wild, but the thickly succulent stemmed species from drier areas farther north are increasingly vulnerable from habitat destruction by a growing population, or by overgrazing.

By far the largest genus is *Euphorbia,* with nearly 2000 species world-wide. Because of the unifying structure of the cyathium, classification of this large and otherwise diverse aggregate of species has always been difficult and no system proposed so far has proved entirely satisfactory on a world-wide basis. About 650 species are truly succulent, confined to the tropics and subtropics, and with relatively few exceptions, occur in the drier regions of the Old World, well adapted to survive in often extreme habitat conditions. Their growth habit is very diverse, from small herbs to shrubs and large trees. Many more species are semi-succulent, with somewhat fleshy stems, or fleshy leaves, or with a more-or-less fleshy or tuberous rootstock. These are being increasingly adopted by the hobbyists as 'succulents' worthy of culture, but if they were included in any overall treatment of succulent members, then all related species, covering the majority in the genus, would have to be taken into account. Since all succulent *Euphorbia* species are listed under Appendix II of CITES, with a few geophytes from Madagascar on Appendix I, this borderline leads to problems in deciding which species should be included as succulent in the true sense.

Distribution

Succulent species in the New World, specifically Central and South America, are relatively few, and not related to those of the Old World. Several species, with erect, more-or-less cylindrical stems, small leaves and often large cyathial bracts, are mostly long established in cultivation, such as *Euphorbia pteroneura* from Mexico, and *E. sipolisii* and *E. phosphorea* from Brazil. Several distinct species related to the latter have recently been discovered in Brazil but are not yet generally known in cultivation. *E. misera* from Baja California, Mexico, is a woody xerophyte which has nevertheless long been accepted by the hobbyists as a 'succulent'.

There are a number of tree species with paired spines, and a small group of geophytes related to *E. fusiformis*, from India and Southeast Asia that are finding increasing popularity. The tree species are not well known taxonomically, but work is currently being done on them for the Botanical Survey of India. The geophytes, with several probably distinct taxa, each have a limited range except for *E. fusiformis* itself, but are reported to be reasonably common. So far, there seems to be very little artificial propagation of these, with most plants in circulation among hobbyists in India and elsewhere being of wild origin. This is a group on the borderline of succulence, the only really succulent part of the plants being their semi-woody or somewhat fleshy root. They are usually listed as caudiciform.

Madagascar has its own endemic group of species in the subgenus *Lacanthis,* typified by stipules flanking the usually large leaf-scars, and modified as spines which are often much divided into bristly fringes. They range in habit from fleshy, thick-stemmed, shrubby herbs to geophytes. All are of interest to the hobbyist, and numerous forms have recently been described as distinct species by Rauh in the journals of the German and American cactus and succulent societies. Almost all are restricted in distribution, mostly in the dry deciduous woodland of the southern part of the island. They have apparently been declining rapidly in numbers from habitat destruction, as well as being collected for export. There is no excuse for this, as they all seem easy to propagate, especially from seed, and several have been well established in cultivation for many years. The most endangered are the geophytes, which are now listed on Appendix I of CITES.

Another group are the 'pencil' euphorbias, with succulent, cylindrical, leafless branches related to *Euphorbia tirucalli,* and all trees or shrubs. The only species of any significant interest to the hobbyist is *E. stenoclada,* in cultivation for many years. Species are endangered only from habitat destruction. Rauh has given a good account of all the Madagascan succulent species in various issues of *The Euphorbia Journal (1983-1993).*

One species related to this last pencil group is *E. sarcostemmoides,* which is reported to be a Rare endemic of the drier regions of Australia, with a scattered distribution, and is sometimes found in hobbyist collections. There are no other succulent species in Australia, but *E. tannensis,* a fairly common, weedy herb, is beginning to find popularity by virtue of its tuberous root. It has been adopted by hobbyists as a succulent, but should not legitimately be included.

On the African continent there are three main types of succulent *Euphorbia:* the tuberculate stemmed species, the pencil stemmed species, and the pair-spined species. The tuberculate-stemmed species are confined almost entirely to southern Africa in Cape Province, with a high incidence of endemism. They range in form from tall, leafy stems to dwarf and much-branched plants forming domed cushions, to solitary or sparsely branched

individuals with very thick stems sometimes reduced to a globose body. The inflorescences are persistent on many species with the peduncles hardening into woody spines. In this group are some of the first succulents to be introduced into cultivation, including *E. obesa, E. meloformis,* and *E. bupleurifolia,* all represented in almost every nursery and hobbyist collection but limited in distribution and endangered in the wild. Overcollection has been, and possibly still is, a factor here, but habitat destruction due to farming, mining operations, and road-building plays a major role. In many instances it is not possible to determine conservation status, as habitats are known to be on land where entry is restricted and in some cases forbidden. This is especially true of the mineral-rich areas to the west into Namibia. In this area many of the cylindrical, pencil stemmed, leafless, spineless species occur, usually as shrubs, the smaller ones, often endemic, finding some favour in the horticultural trade. They are probably not vulnerable except perhaps from habitat destruction, as propagation from cuttings is generally easy. There are also numerous pair-spined species in this region, mostly large, slow-growing shrubs, endemic in this extremely arid zone which extends northwards into Angola.

For all species of this southern African region, White, Dyer and Sloane's two volumes on the succulent Euphorbieae (1941) is still the major work. More recently, Leach produced a number of papers describing many more species, especially from the western areas, including Angola. Several articles have also appeared in The *Euphorbia Journal,* with valuable information on distribution and conservation status (1981-1993).

Farther north, into tropical Africa and the Arabian Peninsula, there are some species in the pencil group, all of which are common and widespread, especially in the drier regions. *Euphorbia tirucalli* itself is the most common endemic in central tropical Africa but introduced and naturalised throughout the tropics world-wide. It is used extensively for hedging purposes since cuttings root readily and quickly grow to form an impenetrable hedge. It is not easily eradicated and in some places has spread to the detriment of the natural vegetation, not only in Africa but also elsewhere in tropical regions. As a succulent species it is listed under Appendix II of CITES and thus protected, but can always be easily distinguished from 'look-alike' species by its distinctively striated branches.

However, the pair-spined succulents provide the greatest number of species north of South Africa. The range in habit is very wide from trees and shrubs, to succulent-stemmed herbs. They are found in abundance throughout the drier regions, from Angola eastwards to Mozambique, and northwards through East Africa to Ethiopia and Somalia, with a few peripheral representatives in the Arabian Peninsula and West Africa, including the Canary Islands, as well as in southern Africa and those tree species already mentioned in India and Asia. Trees are generally less specialised for survival in an arid environment, and as such have the widest distribution, being found from just above sea level to its highest altitudes of over 3000 m (E. *ampliphylla*). A genus of tree species, with large, fleshy leaves, *Elaeophorbia,* should be mentioned here, distinguished from *Euphorbia* by its indehiscent drupaceous fruit, which has a thick, persistently fleshy exocarp and no sign of a perianth below the ovary. Two distinct species occur along forest edges, from West Africa eastwards to Uganda. Many authors consider the genus to be synonymous with *Euphorbia.*

Shrubs of this pair-spined group occur mostly in deciduous bushland, with fewer, usually leafy species in the more humid regions of West Africa, but in semi-desert areas characterised by the development of an extremely robust spinescence. The majority of the smaller, succulent-stemmed herbs, often with a large, fleshy or tuberous root, occur mostly in exposed situations, usually among rocks, and colonising the most extreme habitat conditions. It is this group which contains the greatest number of species and the greatest number of endemics with extremely limited distributions. Many of these species occur in East Africa, particularly in central Tanzania and the Rift Valley region of Kenya, but the greatest concentration is undoubtedly in the Horn of Africa in Somalia and the Ogaden region of eastern Ethiopia.

Threats

Throughout these tropical regions, the greatest danger to the survival of all these species lies in habitat destruction for spreading agriculture, for charcoal burning, or in Somalia especially, by overgrazing. Overcollecting is apparently not, and is unlikely to be because of local government restrictions, a hazard in any of these areas.

The remainder of the succulent species from areas north of southern Africa, number a very few non-spiny, caudiciform members related to *Euphorbia longituberculosa*, or to the southern African species *E. trichadenia,* occurring in sparse, open grasslands, and all of which are widespread and unlikely to be endangered. Apart from these, most of the fleshy-stemmed herbaceous or sometimes shrubby, leafy species from the Canary Islands, related to *E. atropurpurea, E. mellifera,* and *E. balsamifera* are generally considered as succulents. Several of these are endemic in the Canaries, and endangered, so warranting protection, but whether they should be regarded as succulent species, when other more common but closely related species are not, is open to question.

The most recent account for west African species is given by Keay in the Flora of West Tropical Africa (1925) and accounts of the East African and Somali species are given by Carter in the Flora of East Tropical Africa (1988) and the Flora of Somalia (1993). M. G. Gilbert's account for the Ethiopian species will appear in Volume 4 of the Flora; and L. C. Leach worked on the species

covered by Flora Zambesiaca. The Arabian species will appear in the Flora of Arabia, edited in Edinburgh; and an account of the Canary Island species, with their conservation status, is given in D. and **Z.** Bramwell's pocket flora (1974) and the recently published Red List of the Canary Islands (Gómez-Campo 1997).

Portulacaceae

Maike Gerbaulet

The Portulacaceae Juss. is a medium-sized family comprising annual or perennial herbs and subshrubs to very large shrubs. Most genera are more or less leaf-succulent, but some also have succulent stems (*Portulacaria, Ceraria*). The main characteristic feature of the family is the 2-phyllous floral involucre (sometimes considered as sepals). Some genera show scales or hairs at the leaf bases (regarded as stipules by some authors), namely *Anacampseros, Grahamia, Portulaca, Talinaria, Talinopsis, Talinum,* and *Xenia*. The mostly bisexual flowers are usually ephemeral and self-fertile, but some species are dioecious (e.g. *Ceraria* spp.). The ovary is mostly superior, but semi-inferior in *Portulaca.*

The major centres of distribution are North and South America, Africa, and Australia. In addition, some species occur in areas of tropical Asia with well established African biogeographic affinities, or in arctic Asia. One genus is restricted to New Zealand and Kerguelen Island. Furthermore, there are several cosmopolitan weeds.

Several genera or species are cultivated as ornamentals, *Anacampseros* spp. and *Portulacaria afra* are often found in succulent collections. *Claytonia virginica* (spring beauty), some *Calandrinia* s.l. spp., and *Portulaca grandiflora* are common garden ornamentals. *Lewisia* spp. are grown in rock gardens. Some species serve as food or in the preparation of medicine, the roots of some *Anacampseros* spp. are used to brew beer; the leaves of some species are sometimes enjoyed as a snack. The starchy roots of *Lewisia rediviva* (bitter root) are eaten as a vegetable. *Montia fontana, M. perfoliata* (winter purslane), *Portulaca oleracea* ssp. *sativa* (purslane), *Talinum fruticosum,* and *T. triangulare* (with a purslane-like taste) are used as potherbs. *Portulaca oleracea* is locally also used as a medicinal plant. *Portulacaria afra* is cultivated as a fodder plant in South Africa.

Systematic treatment

Several treatments of single portulacaceous genera or parts thereof have been published during the past decades, McNeil1 (1975) revised the *Montia* and *Claytonia* generic complex. The more recent account on *Montia* by Lourteig (1991) focuses on the species of the southern hemisphere. *Lewisia* has been revised by Mathew (1989). Several authors worked on *Portulaca;* the treatment by Legrand (1962) covered mainly the American species with many new names published. Geesink (1969) studied the Indo-australian and Pacific species. The latest investigation was by Nyananyo (1987) who again confined himself to selected species. A group of portulacas restricted to Australia, Africa, and some areas in between is currently under investigation by Gilbert and West. Several papers have been published concerning the status of single species. The infrageneric classification as well as the delimitation of species remain unresolved.

Concerning the systematic position of the endemic African and Madagascan genera *Calyptrotheca, Ceraria, Portulacaria,* and *Talinella* and the small genera *Hectorella* and *Lyallia* (sometimes segregated under the name Hectorellaceae) several papers have been published by Nyananyo (1986a, b, c, 1989, 1990). As a result, both latter genera were united and (re)included in the Portulacaceae. The remaining genera were suggested to belong to the Portulacaceae rather than to the Basellaceae. Nevertheless, their position within the Portulacaceae remains unresolved.

The southern African species of *Talinum* have been revised by Tolken (1969). However, a revision of the whole genus, or even the American species, is wanting. Besides, the new genus *Amphipetalum* recently described from Argentina (Bacigalupo 1988) seems to be closely related to *Talinum*. Also, the relationship between *Calyptrotheca* and *Talinum* should be re-evaluated.

In recent years, there have been several attempts to re-examine the generic relationship within the family. A synoptical classification of Portulacaceae was proposed by McNeil1 (1974). This showed, however, that many questions concerning the systematics of portulacaceous genera still remain to be answered. The starting point for thorough changes in the classification and circumscription of genera within the Portulacaceae was the cladistic analysis of Carolin (1987). One of the most important results of his analysis was that the large and most diverse portulacaceous genus *Calandrinia* s.l., is unnatural. Hershkovitz (major publications concerning the taxonomy, 1991, 1992, 1993) revised the whole generic complex and assigned the species to five genera, *Schreiteria, Rumicastrum, Calandrinia* s.str., *Cistanthe,* and *Montiopsis.* Furthermore, Carolin's cladogram served as a basis for a revision of the genus *Anacampseros* and related genera including a thorough evaluation of their systematic position within the Portulacaceae (Gerbaulet 1992a). As a corollary, the monotypic Argentinian genus *Xenia* was segregated from *Anacampseros.*

At present, most of the generic relationships within the Portulacaceae are unresolved. Also the circumscription of the family must be reconsidered. Various authors pointed out that the Portulacaceae, as presently understood, are in all probability paraphyletic and that. the Basellaceae, Didiereaceae, Hectorellaceae, and presumably even Cactaceae have to be considered to resolve the phylogenetic relationship within the first.

Generic distribution

The main distribution areas of the Portulacaceae are North and South America, Africa, and Australia, although some genera are also found elsewhere. These areas can be sorted into two groups: the first mainly comprises areas in North and South America east of the cordilleras, in eastern and southern Africa, and/or in Australia. The second group mainly includes areas in North and South America west of the cordilleras.

The major members of the first group are *Anacampseros, Portulaca,* and *Talinum,* the latter being restricted to America and Australia. *Portulaca,* showing a more tropical distribution, is also found in those areas of tropical Asia with well established African biogeographical affinities, like tropical Arabia, southern India, and Sri Lanka. Furthermore, some weedy species of *Portulaca* and *Talinum* are cosmopolitan (e.g. *P. oleracea, T. paniculatum*). Some smaller genera are confined to certain parts of the first set of distribution areas: *Talinaria* and *Talinopsis* are endemic to Mexico. *Amphipetalum, Grahamia, Schreiteria,* and *Xenia* occur in eastern South America. *Calyptrotheca* (eastern Africa), *Ceraria, Portulacaria* (both southern Africa), and *Talinella* (Madagascar) are native to Africa including Madagascar. *Rumicastrum* is endemic to Australia.

Calandrinia s.str. (including *Monocosmia), Cistanthe (sensu* Hershkovitz 1992, including *Calyptridium, Lewisia tweedyi, Philippiamra,* and *Sparguea),* and *Montia* are the main genera of the second distribution block. Some *Montia* species are cosmopolitan weeds (e.g. *M. fontana).* *Claytonia* and *Lewisia* are native to western North America including Alaska. They share an arctic to temperate distribution with *Claytonia* extending into arctic Asia. *Lenzia* and *Montiopsis* occur in western South America.

Lyallia (including *Hectorella*) is endemic to New Zealand and Kerguelen Island. At present, no agreement has been reached whether to sort these to the first or the second set of distribution areas.

Threats and conservation status

Of all the Portulacaceae, *Anacampseros* spp., *Cistanthe* (formerly *Lewisia) tweedyi, Lewisia cotyledon, L. maguirei,* and *L. serrata* are protected by the CITES Appendix II listing.

Regarding the genera endemic to or showing a major distribution centre in Africa and Madagascar, only little is known about the conservation status of the East African *Calyptrotheca* and the Madagascan *Talinella.* The endangered or threatened southern African taxa are listed in the *Red Data List of southern African plants* (Hilton-Taylor 1996b).

In Africa, *Portulaca* and *Talinum* consist mainly of widespread species. Some species of both genera are probably not endemic to Africa but became naturalised after being introduced as garden ornamentals or weeds. *Talinum* species are not threatened in Africa. *Portulaca* appears to comprise a few very widespread species complexes which are often segregated into several to many minor species. Some of these microspecies are recorded to be threatened (e.g. *Portulaca trianthemoides* in South Africa), but the species complexes as a whole are not.

The genera *Ceraria* and *Portulacaria* consist only of a few species each. Although 'real succulents', most of them have not been very popular among horticulturists until recently. An exception is *Portulacaria afra* which has been in cultivation for decades. Most of the species have only a rather limited distribution area. This is especially true for *Portulacaria armiana* which is known from a couple of localities only. Since this recently described species seems to have become the fashion among collectors, it should be classified as Vulnerable. The other species, however, are fairly common and not threatened.

Conversely, all African *Anacampseros* species (22 currently recognised) have tremendous horticultural value. Although single species are fairly widespread, many species show a restricted distribution. Generally, the more widespread species occur only sporadically, whereas the restricted ones may be locally abundant. Since the main distribution area of *Anacampseros* is not subject to large-scale agricultural activities, the major threat is imposed by collectors. In the eastern parts of South Africa, however, agriculture does have an impact on the conservation status of *Anacampseros.* In this region, *Anacampseros* species are nowadays more or less restricted to rocky outcrops or mountainous habitats, but herbarium records show that they have been far more widespread in the recent past. In northern Namibia, overgrazing by cattle leads to the spreading of thornbush savanna (Walter 1964; Walter and Breckle 1984) which in turn threatens the endemic *Anacampseros* species (Gerbaulet 1992b). On the whole, most species should be classified as Rare or Vulnerable, some even as Endangered (14 in total), while the remaining eight do not seem to be threatened.

Chapter **2**

Conservation Measures

National legislation

Sara Oldfield

In general succulent plants are relatively distinctive within national floras, and due to their horticultural attraction, wild populations have been widely sought after and exploited. As a consequence, where the laws relate to collection and trade, succulents may be quite well represented in national conservation legislation for plants. Nevertheless, the lack of basic inventory and assessment of conservation status for succulent plant species limits the development of species conservation legislation in many countries. This is particularly the case in South America where, in general, laws protecting plant species restrict collection and export of a wide range of plants but rarely protect individual succulent plant species. Madagascar is another important succulent-rich country which has no specific legislation protecting rare and threatened succulent species. The USA currently has the most comprehensive legal protection for succulent plant species in the wild. The Endangered Species Act (1973) (ESA) currently protects 24 native cacti and two succulent taxa, listed as Threatened or Endangered as shown in Table 2.1. The ESA prohibits interstate or international trade in listed plants without a permit. The removal of listed plants from lands under federal jurisdiction is also prohibited without a permit.

Habitat conservation is covered by section 7 of the ESA. Federal agencies are required to ensure that any actions they fund, authorise, or undertake are not likely to jeopardise listed species. Another legal requirement under ESA is the preparation of recovery plans for individual species. These include positive measures to enhance the survival of listed species in the wild through management of wild populations and reintroduction

Table 2.1 Threatened succulents and cacti listed on the US Endangered Species Act (as of 30 September 1996)

Taxon	Common name	Distribution	Listing[1]
Agavaceae			
Agave arizonica	Arizona agave	U.S.A. (AZ)	E
Cactaceae			
Ancistrocactus (= Echinocactus = Mammillaria) tobuschii	Tobusch fishhook cactus	U.S.A. (TX)	E
Cereus eriophorus var. *fragrans*	Fragrant prickly-apple	U.S.A. (FL)	E
Astrophytum (= Echinocactus} as terias	Star cactus	U .S.A. (TX) , Mexico	E
Coryphantha (= Cochiseia = Escobaria) robbinsorum	Cochise pincushion cactus	U.S.A. (AZ), Mexico (Sonora)	T
Coryphantha (=Escobaria = Mammillaria) minima (= C. nellieae)	Nellie cory cactus	U.S.A. (TX)	E
Coryphan tha ramillosa	Bunched cory cactus	U.S.A. (TX), Mexico (Coahuila)	T
Coryphantha scheeri var. *robus tispina*	Pima pineapple cactus	U.S.A. (AZ), Mexico (Sonora)	E
Coryphantha sneedii (= Escobaria = Mammillaria) var. *leei*	Lee pincushion cactus	U.S.A. (NM)	T
Coryphantha (= Escobaria = Mammillaria) sneedii var. *sneedii*	Sneed pincushion cactus	U.S.A. (NM, TX)	E
Echinocac tus horizon thalonius var. *nicholii*	Nichol's Turk's head cactus	U.S.A. (AZ)	E
Echinocereus chisoensis (=reichenbachii) var. *chisoensis*	Chisos Mountain hedgehog cactus	U.S.A. (TX)	T
Echinocereus fendleri (=hempelii of authors, not Fobe*)* var. *kuenzleri*	Kuenzler hedgehog cactus	U.S.A. (NM)	E
Echinocereus lloydii (= *E. roetteri* var. *lloydii)*	Lloyd's hedgehog cactus	U.S.A. (NM, TX)	E

Echinocereus reichenbachii var. *albertii (= E. melanocen trus)*	Black lace cactus	U.S.A. (TX)	E
Echinocereus triglochidiatus var. *arizonicus (= E. arizonicus)*	Arizona hedgehog cactus	U.S.A. (AZ)	E
Echinocereus viridiflorus var. *davisii (= E. davisii)*	Davis' green pitaya	**U.S.A. (TX)**	**E**
Echinomastus (= Echinocactus, = Sclerocac tus, = Neolloydia) mariposensis	Lloyd's Mariposa cactus	U.S.A. (TX), Mexico (Coahuila)	T
Harrisia (= Cereus) portoricensis	Higo chumbo	U.S.A. (PR)	T
Leptocereus grantianus	None	U.S.A. (PR)	E
Opun tia treleasei	Bakersfield cactus	U.S.A. (CA)	E
Pediocactus (= Echinocactus, = Utahia) sileri	Siler pincushion cactus	U.S.A. (AZ, UT)	T
Pediocactus (= Echinocactus, =Navajoa , = Toumeya, = Utahia) peeblesianus var. *peeblesianus*	Peebles Navajo cactus	U.S.A. (AZ)	E
Pediocactus (= Toumeya) bradyi	Brady pincushion cactus	U.S.A. (AZ)	E
Pediocactus (= Toumeya) knowltonii (= P. bradyi var. *knowltonii)*	Knowlton cactus	U.S.A. (CO, NM)	E
Pediocactus despainii	San Rafael cactus	U.S.A. (UT)	E
Pilosocereus (= Cereus) robinii	Key tree-cactus	U.S.A. (FL), Cuba	E
Sclerocactus (= Coloradoa, = Echinocactus, = Pediocactus) mesae-verdae	Mesa Verde cactus	U.S.A. (CO, NM)	T
Sclerocactus (= Echinocactus, = Pediocactus) glaucus (= whipplei var. *glaucus, =subglaucus, = franklinii)*	Uinta Basin hookless cactus	U.S.A. (CO, UT)	T
Sclerocactus (= Pediocactus) wrightiae	Wright fishhook cactus	U.S.A. (UT)	E
Dudleya se tchellii	Santa Clara Valley dudleya	U.S.A. (CA)	E
Dudleya traskiae	Santa Barbara Island liveforever	U.S.A. (CA)	E
Sedum in tegrifolium ss p . *leedyi*	Leedy's roseroot	U.S.A. (MN, NY)	T

[1] E = Endangered: any species in danger of extinction throughout all or a significant portion of its range.
T = Threatened: any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

schemes, recovery meaning restoration of the population to a point where it is a "viable self-sustaining componant of their ecosystem so as to allow downlisting" (US Fish and Wildlife Service 1990). A 1988 amendment to the ESA requires that recovery plans for listed species be developed and implemented by the Department of the Interior. Reports are made to Congress every two years. These recovery plans are intended to provide a blueprint for private, Federal and State interagency cooperation on implementation.

At present the ESA is under some threat. In 1995 a moratorium on new listing was called, but a year later certain cases were pushed through. Several bills have been introduced to Congress that aim to weaken the protection of national endangered plants; these will make it more difficult for the USA to fulfil its obligations with CITES (De Ferrari 1996).

Another Federal law in the USA, the Lacey Act, gives Federal support to state conservation laws. Since 1981, the Lacey Act has prohibited interstate trade or export of wild native plants collected or possessed in contravention of the State or, in the case of Indian lands, the Reservation, of origin. States which have legislation regulating the collection of cacti and succulents are Arizona, California, New Mexico, Nevada, and Texas.

Zimbabwe is another country which has good legal provisions protecting succulent plants both from collection pressures and habitat destruction. The Parks and Wildlife Act, 1975, as amended lists the genus Aloe and ten other succulent species as specially protected. The Act also allows for the constitution of botanical reserves to protect rare or endangered indigenous plants or representative plant communities growing naturally in the wild.

Unfortunately, protective legislation for succulent plants is not enforced in Zimbabwe due to lack of personnel and the absence of any active and full-time inspectorate. No reserves have yet been created specifically to protect representative communities of succulent plants which are specially protected by law. A recommendation to create a network of succulent reserves under the Parks and Wildlife Act, 1975, is given in Chapter 4 of this Plan, the Action Proposals.

In South Africa, the Forest Act 122 of 1984 is a

national statute which gives protection to a number of listed succulents. The most important legislation for the protection of native plant species is, however, provided by the four provincial ordinances (Glavovic 1993). Under these ordinances, plants on or along public roads are protected and no native plant can be picked without the landowner's permission. Possession and trade in indigenous plants is generally regulated and certain species are given special protection.

In Natal all native flowering plants are regulated with certain species classified as specially protected. The Transvaal also has a list of specially protected species, together with lists of endangered and rare species. Importation and exportation of endangered and rare species is controlled. The Cape legislation lists endangered flora and protected flora. Succulent species given special protection under the South African state ordinances are listed in Table 3.8 in the Southern Africa Regional Account in Chapter 3.

A recent review of plant conservation legislation in South Africa has pointed out that the existing laws do not take into account traditional rights and harvesting practices. Controlled access to plants used, for example, for medicinal purposes should be part of policy to encourage sustainable utilisation. Furthermore, it is pointed out that an integrated national legal system for flora conservation is needed with consistency throughout the regions. Perhaps of most importance, greater emphasis should be placed on in situ conservation so as to preserve representative and important plant communities wherever possible.

The development of conservation legislation protecting rare and threatened succulent species remains a priority in many countries, particularly in Madagascar. Ideally, legislation should aim to enhance the conservation status of individual species through the development of recovery programmes, as well as limiting habitat destruction and overexploitation. Implementation and enforcement of existing legislation also need to be addressed. One catalyst for improving national legal protection for succulents is the development of increasingly comprehensive international legal obligations to protect threatened species and their habitats.

International legislation

The Convention on Biological Diversity

The Convention on Biological Diversity (Biodiversity Convention) was signed by 153 States, together with the European Community, during the UNCED meeting in June 1992. The objectives of the Convention are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources. Parties to the Biodiversity Convention are required to identify components of biological diversity important for conservation and sustainable use; develop national strategies, plans or programmes for the sustainable use of biodiversity; establish protected area systems; develop or maintain threatened species legislation; and further biodiversity conservation by various other specified means.

The Biodiversity Convention will enhance the conservation of cacti and succulents in various countries through the identification of threatened species and development of the conservation measures outlined above. Country biodiversity studies have been produced for a range of countries including Kenya and Uganda as a preliminary step in implementation of the Convention. These form the basis for the development of the national strategies or action plans to protect biodiversity.

The Berne Convention

This Convention, applicable to the Council of Europe member states, was signed in 1979. The Convention provides for the conservation of wildlife and wildlife habitats in general and for the special protection of listed species. Appendix I of this convention lists 490 specially protected plants including the succulents listed in Table 2.2, all of which occur in the Canary Islands except for *Euphorbia stygiana* which is endemic to the Azores.

Table 2.2 Threatened succulent species in Appendix I of the Berne Convention

Agavaceae	*Dracaena draco*
Asclepiadaceae	*Caralluma burchardii*
	Ceropegia chrysantha
Crassulaceae	*Aeonium gomeraense*
	Aeonium saundersii
Euphorbiaceae	*Euphorbia handiensis*
	Euphorbia lambii
	Euphorbia stygiana
Leguminosae	*Lotus kunkelii*

The EC Habitats Directive

Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats of Wild Fauna and Flora, the European Community Habitats Directive, aims to contribute to the protection of biodiversity through the conservation of habitats and wild fauna and flora within EC countries. Under the Directive a network of protected habitats is being created through the designation of Special Areas of Conservation. The network will include the habitats of species listed in Annex II of the Directive. Annex IV (b) designates plant species in need of strict protection and Annex V lists plant species whose taking in the wild and exploitation may be subject to management measures. Macaronesian succulent plant species protected by the Habitats Directive are listed in Table 2.3.

Table 2.3 Succulent species in the Annexes of the EC Habitats Directive

ANNEX II	
Asclepiadaceae	*Caralluma burchardii*
	Ceropegia chtysantha
Crassulaceae	*Aeonium gomeraense*
	Aeonium saundersii
	Aichtyson dumosum
	Monanthes wildpretii
	Sedum brissemoretii
Euphorbiaceae	*Euphorbia handiensis*
	Euphorbia lambii
	Euphorbia stygiana
Leguminosae	*Lotus kunkelii*
ANNEX IV (b)	
Contains the succulent species listed above together with:	
Agavaceae	*Dracaena draco*
ANNEX V	
No succulent species listed at present.	

The SPAW Protocol of the Cartagena Convention

The Protocol on Specially Protected Areas and Wildlife (SPAW) was developed under the Cartagena Convention on the Protection of the Marine Environment of the Wider Caribbean Region. Annex I of the Protocol lists 56 vascular plant species which are protected from all forms of destruction or disturbance, including picking, collection, or commercial trade. As far as possible, activities which adversely affect the habitats of these species will be subject to regulation. Annex III of the protocol lists 'harvestable' species of flora and fauna, exploitation of which will be regulated according to management plans. With respect to the selected cacti and other succulent taxa, these Annexes are far from complete and up to date (Table 2.4). Conservation of species on both Annexes will require not only protection but also measures to enable the recovery of wild populations.

Table 2.4 Succulent species listed in the Annexes of the SPAW Protocol

ANNEX I	
Cactaceae	*Echinocereus reichenbachii* var. *albertii*
	Harrisia fragrans
	Harrisia portoricensis
	Leptocereus grantianus
	Leptocereus wrigh tii
	Melocac tus guitartii
	Melocactus harlowii s. l.
	Pilosocereus deeringii
	Pilosocereus robinii
ANNEX III	
Agavaceae	*Nolina brittoniana*
Asclepiadaceae	*Asclepias viridula*
Cactaceae	*Melocactus intortus*

In addition to the regionally protected species listed in these Annexes, parties are required to "identify endangered or threatened species of flora or fauna within areas over which it exercises sovereignty, or sovereign rights or jurisdiction, and accord protected status to such species".

The SPAW Protocol also sets out a cooperative programme for protected areas in the Caribbean region. This will support the selection, establishment, planning, management, and conservation of protected areas and buffer zones, where necessary, and the creation of a protected areas network.

Controlling the trade

Sara Oldfield*

Cacti and other succulent plants are of major horticultural importance forming the basis for a multi-million dollar international industry. They are sold both as general houseplants and as botanical specimen plants for specialist collectors. Collection of plants from the wild for international trade has been one of the main threats to certain species, and despite the development of sophisticated propagation techniques this threat remains a significant problem.

CITES

The principal means by which international trade in succulent plants is controlled is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). This convention first came into force in 1976 and has now grown to become one of the largest and best known of all conservation conventions, with over 130 member states. The general aim of CITES is to regulate trade in threatened wild species as listed in three appendices.

The Appendices

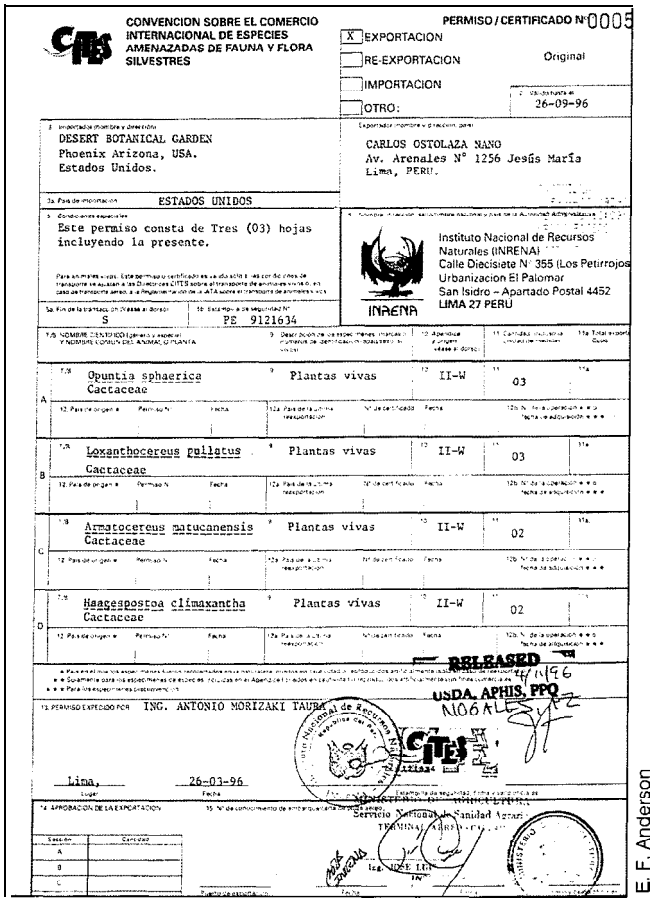
Species listed on Appendix I of CITES (Annex 3) arc considered to be at serious risk from any commercial trade and thus all international trade in wild plants between countries who are members of the convention is banned under the terms of the Convention. Species listed on Appendix II of the Convention are those which may be threatened by excessive levels of trade without appropriate regulation. Species may also be included in Appendix II because of their similarity to more threatened species, as an aid to enforcement. International trade in wild specimens of Appendix II species is permitted under the convention but is controlled and monitored through a licensing system. Appendix III is used by countries which may want to control trade in particular species of their own flora and fauna which are not listed on the other Appendices. It is not currently used for any succulent plants.

**Account prepared in 1993*

The Appendices of CITES are amended by agreement of the member states. Normally changes are made following consideration of detailed proposals at the Conference of the Parties which is held every two years. Changes may also be made through postal votes between the meetings.

A list of the succulent plants included in the Appendices of CITES is given in Annex 3. The listing is not fully comprehensive for horticulturally desirable succulents or fully representative of species threatened by trade. Some succulents were included in the original Appendices of the Convention drawn up in 1973 before detailed justifications were required for each taxon listed. Subsequent amendments to the Appendices have been based on more thorough compilation of information, but, in general, the data available on which to base CITES proposals for succulent genera has been, and remains, incomplete.

Many succulents do not yet benefit from international trade controls through CITES. These include many rarities native to Madagascar and Africa which are sought by collectors. There is currently a fashion within the trade for caudiciform or swollen-stemmed plants, which occur in a wide range of families and genera. During the past decade caudiciform plants, such as *Kedrostris, Raphionacme, Cyphostemma, Dioscorea, Adenium,* and *Fockea,* all non-CITES, together with *Pachypodium* and *Euphorbia* caudiciforms, have become popular houseplants. Many of these plants are slow-growing in cultivation and wild-collected plants are regularly offered. Certain genera and species warrant CITES listing and a recommendation for development of proposals is given in Chapter 4. Further research is necessary to determine the impact of trade on other succulents and their suitability for CITES listing.



CONVENCION SOBRE EL COMERCIO INTERNACIONAL DE ESPECIES AMENAZADAS DE FAUNA Y FLORA SILVESTRES

PERMISO / CERTIFICADO N° 0005

[X] EXPORTACION
[ ] RE-EXPORTACION
[ ] IMPORTACION
[ ] OTRO:

Original

26-09-96

DESERT BOTANICAL GARDEN
Phoenix Arizona, USA.
Estados Unidos.

CARLOS OSTOLAZA NANO
Av. Arenales N° 1256 Jesús María
Lima, PERU.

ESTADOS UNIDOS

Este permiso consta de Tres (03) hojas incluyendo la presente.

Instituto Nacional de Recursos Naturales (INRENA)
Calle Diecisiete N° 355 (Los Petirrojos
Urbanizacion El Palomar
San Isidro – Apartado Postal 4452
LIMA 27 PERU

INRENA

S

PE 9121634

A	Opuntia sphaerica Cactaceae	Plantas vivas	II-W	03	
B	Loxanthocereus pallatus Cactaceae	Plantas vivas	II-W	03	
C	Armatocereus matucanensis Cactaceae	Plantas vivas	II-W	02	
D	Haageospostoa climaxantha Cactaceae	Plantas vivas	II-W	02	

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ING. ANTONIO MORIZAKI TAURA

Lima, 26-03-96

Servicio Nacional de Sanidad Agraria

E. F. Anderson

CITES export permit, Peru.

Artificially propagated plants

CITES defines artificially propagated plants as grown from seeds, cuttings, or propagules under "controlled conditions", where the stock has been established and maintained in such a way that does not damage the survival of the species in the wild. The material should be managed in a manner designed to maintain the artificially propagated stock indefinitely.

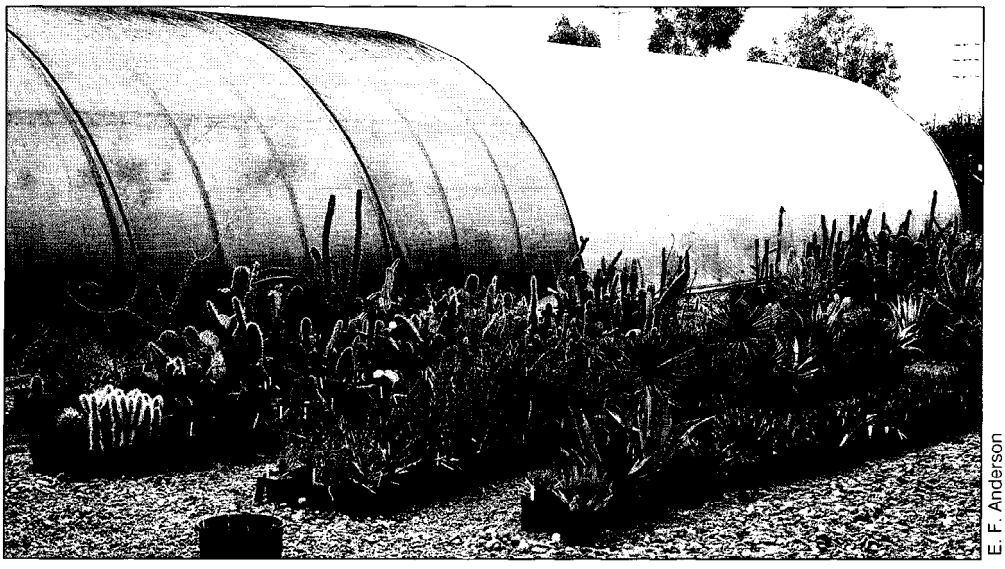
Artificially propagated Appendix I species may be treated in the same way as Appendix II species under the terms of the Convention. Artificially propagated Appendix II species are effectively treated as if they were non-CITES by some countries, although permitting requirements vary. It is generally considered that some minimum documentation needs to accompany such Appendix II species in international trade to show that they are not taken from the wild. One option allowed by CITES is the use of phytosanitary certificates annotated for CITES purposes.

Millions of artificially propagated plants of both non-CITES and CITES-listed succulent species, including large numbers of those on Appendix I, are traded internationally. This legitimate trade does not impact on wild populations of the plants concerned and should be encouraged to stem demand for wild plants. Most nurseries trading internationally deal only with propagated material, but this is not always the case. There are frequent instances of wild plants being mislabelled as artificially propagated in order to escape CITES controls. Commercial succulent plant propagation in succulent-rich countries such as Madagascar and Mexico is not yet sufficiently well developed, as discussed in the regional sections of Chapter 3.

A resolution was passed on nursery registration at the CITES Conference of the Parties held in Fort Lauderdale in 1994. The intention of nursery registration is primarily to facilitate propagation and trade, is widely seen as a desirable means to simplify the licensing arrangements. This would ease the burden of paperwork for nurseries exporting only artificially propagated material.

Implementation of CITES

Implementation of CITES is through the national legislative and administrative procedures of member states. The text of the Convention and subsequent resolutions and recommendations agreed by the Parties provide the framework for national implementation and international cooperation. The convention requires Parties to appoint Scientific and Management Authorities



E. F. Anderson

Propagation at the Desert Botanical Garden.

who are responsible for carrying out the provisions of the convention.

Unfortunately, implementation of CITES has been generally weak for plants, and some countries have largely ignored the requirements of the Convention for plants. Few countries have allocated the resources to determine appropriate levels of trade in wild plant species on a scientific basis prior to issuing export permits. In others administrative procedures have hindered legitimate trade in artificially propagated CITES plants alienating *bona* fide nurseries from the CITES process. The intent of the CITES convention can be lost in excessively bureaucratic licensing procedures, especially where these are not clearly explained to importers and exporters.

Table 2.5 lists the main countries involved in the import and export of cacti and other succulents and provides examples of reported problems in implementation of CITES controls for these plants.

Certain general problems with enforcement of the Convention for plants are being addressed, but relatively limited attention is given to these problems compared with enforcement for animals. One major problem is that of plant identification. Few enforcement agents have specialist botanical training and even with such training it can be very difficult to recognise species listed under the Convention or to distinguish between Appendix-I and Appendix-II listed succulents in the same genus. A greater problem is to distinguish between artificially propagated and wild-collected plants of the same species.

Some identification guides have been produced to help enforcement. The Italian Succulent Plant Society (AIAS) has produced an identification manual for Appendix I cacti, for example, with colour photographs. The Swiss CITES Management Authority has also produced a guide, and draft identification sheets for CITES-controlled plants have been produced by the US CITES Agencies. In the UK the *CITES Guide to Plants in Trade* has also been published (Mathew 1994).

EC CITES regulation

In EC countries, CITES controls are implemented by means of Council Regulation 3626/82, which came into force on 1 January 1984. This Regulation goes beyond the basic requirements of CITES by imposing the necessity for import, as well as export, permits for CITES Appendices II and III species brought into the Community.

As both a major consumer of wild plants for horticulture and a major producer of artificially propagated CITES species for export, it is important that the EC has effective means to implement the Convention. Inconsistencies remain in the enforcement, with some European countries operating very lax controls on the plant trade. There is a need for a coordinated CITES inspectorate within the EC.

In order to improve implementation, the EC CITES Regulation has been subject to extensive review and a revised version has been prepared. The future of the revised legislation remains unclear. It has been proposed that a significantly increased list of plant species will be subject to trade controls if and when the new EC legislation comes into force. A new provision of the legislation may also be to introduce a list of plants (and animals) for which import into the EC would be monitored only, without a specific requirement for export documentation. The intention is to build up a clearer picture of the quantities of listed species entering the Community to provide an early warning system of potential trade threats.

Monitoring the trade in CITES succulents

One of the major successes of CITES for succulent plants has been to compile information on the volumes of trade in Appendix II species, providing information which is not available from any other source. All Parties to the Convention are obliged to submit annual reports on trade in CITES-listed species to the CITES Secretariat.

Table 2.5 Main countries involved in cactus and succulent trade with some specific problems relating to control

Country	Import/Export	Problems relating to control in trade of cacti and succulents
Austria	Import and export	Export of wild Appendix I species to Italy (Jenkins 1992). Confiscation of 49 kg of Mexican cacti in August 1993.
Belgium	Import and Export	Mexican Appendix I cacti available in trade (Jenkins 1992).
Bolivia	Export	Poor reporting of CITES plant trade. Collecting of rare plants by European enthusiasts.
Brazil	Export	Under-reporting of the cactus trade. Export of large quantities of seed is damaging certain wild populations.
Canada	Import and Export	A major trader in Cactaceae; few details of the trade.
Chile	Export	Wild-collected *Copiapoa* have been popular in European trade. Chilean plants exported via Peru.
Denmark	Import and Export	
Dominican Republic	Import and Export	Concern about 'laundering' of cacti and succulents collected in other countries.
France	Import and Export	Wild-collected Mexican Appendix I cacti available in trade (Jenkins 1992). Seizure of 390 wild collected Mexican cacti at Orly airport in February 1993.
Germany	Import and Export	Wild-collected Mexican Appendix I cacti available in trade (Jenkins 1992).
Italy	Import and Export	Relatively recent development of cactus hobby has led to strong demand for wild-collected rarities. Seizure of 1490, mostly wild-collected, cacti arriving from Peru.
Japan	Import and Export	Import of rare field-collected cacti.
Korea	Import and Export	A major trader in Cactaceae; few details of the trade.
Madagascar	Export	International demand for native succulents far exceeds nursery capacity to propagate the plants. Wild plants have been exported in bulk as artificially propagated specimens. Uncontrolled trade in non-CITES succulents.
Mexico	Export	Major source of illegally collected cacti in trade. National legislation has not been effective in preventing the export of rare wild plants from the country over the past 40 years. Recent improvements in enforcement but controls at the Mexico/USA border remain difficult and specialist collectors from Europe and Japan pose problems.
Namibia	Export	Export of wild plants is prohibited but European nursery catalogues indicate availability of both CITES and non-CITES succulent plants,
Netherlands	Import and Export	Major international trading country for succulents. Huge trade in artificially propagated plants but Mexican Appendix I cacti available in trade as wild plants (Jenkins 1992).
Peru	Export	Under-reporting of CITES trade in cacti and wild cacti traded as artificially propagated. Seizures of large consignments of wild cacti in USA and Europe recently. A shipment of 1491 plants investigated in Palermo in 1993, showed that more than 90% wild collected although all were claimed to be artificially propagated.
South Africa	Import and Export	Concern has been expressed about the export of wild *Euphorbia* spp. Many other genera of the rich succulent flora are in export trade but details are not known. Export of non-CITES succulents is a cause of concern. Seizures of wild-collected CITES succulents without permits by UK Authorities in 1994.
UK	Import	Licensing requirements have deterred some nurseries from export market.
USA	Import and Export	Delays and expense in obtaining permits has hindered legitimate export of artificially propagated plants.
Zimbabwe	Export	Inadequate enforcement of national legislation results in some illegal trade in rare plants.

However, the standard of reporting for plants is generally poor. Many countries, for example, report only to family or generic level for cacti and other succulent plants, and other countries do not report on the plant trade at all. Nevertheless, a significant body of data on the international succulent plant trade has been compiled since the Convention came into force.

Monitoring of the trade through review of licence applications and analysis of annual reports can provide an early warning system of trade on a scale likely to cause conservation problems. This happened, for example, with the import of CITES Appendix II Madagascan succulent species in the mid 1980s. One species, *Pachypodium brevicaule*, was imported in the tens of thousands from Madagascar to Germany in 1985 and 1986 for sale in general horticultural outlets. The plants were claimed to be artificially-propagated but subsequent investigation demonstrated that all were wild-collected. In the same way thousands of wild plants of the slow-growing species *Euphorbia cap-saintmariensis, E. cylindrifolia, E. moratii,* and *E. primulifolia* were imported into Europe in the mid-1980s, together with large numbers of *Didierea* and *Alluaudia* in the Didieriaceae. Concern about the volumes of trade lead to the transfer of certain Madagascan succulents to Appendix I of CITES in 1989 and to the temporary imposition of stricter importer controls on all species by the EC.

Data from the CITES annual reports is held on computer at WCMC in a form which allows for various analyses to be carried out. Comparisons can for example

Box 2.1 CITES trade data for cacti

Cacti are the most heavily traded group of plants recorded in CITES trade statistics. The average total number of cacti recorded in annual trade is over 13 million. This is unlikely to represent the total world trade in cacti. One wholesale nursery in the Netherlands for example, produces over *18* million cacti annually, mainly for the European market In the USA total cactus production has been estimated at up to 50 million annually, with over 20 million produced in nurseries of Vista, California alone (Fuller 1987).

The countries with the highest levels of reported average annual trade in cacti are the Netherlands (over six million), Japan (over five million), Brazil (over one million), Korea, Canada, Spain, and Dominican Republic. The high volume of trade in plants in most of these countries is predominantly in artificially propagated cacti produced domestically and does not give rise to any concern. The export of cacti from Brazil is different in that both artificially propagated specimens of indigenous and non-indigenous species are traded together with wild-collected plants.

Brazil has several major nurseries in the south of the country which are thought to deal entirely in artificially propagated plants. One nursery exports around five million cacti annually to a wholesale firm in the Netherlands. The Brazilian trade in Cactaceae is, therefore, clearly under reported. Some Brazilian cacti are relatively difficult to propagate and are still sought after as wild specimens. Concern about levels of trade in wild-collected plants of *Uebelmannia* and *Discocactus,* together with some species of *Melocactus,* led to the transferral of these species to Appendix I of CITES in 1992. There is also the possibility that wild-collected plants of other genera such as *Notocactus* are being exported in small quantities from Brazil.

It is thought that there is substantial under-reporting of cactus exports from other South American countries, The annual average reported trade for Peru, for example, is only 1037 plants, 55% of which are reported to be artificially propagated. There is an internationally known cactus nursery within the country which has regularly exported wild-collected plants in contravention of CITES during the past ten years.

The average annual number of cacti reported to be exported by Mexico is around 50,000. Of these, less than one percent are reported to be propagated. As the export of wild-collected cacti from Mexico has theoretically been banned for the past 50 years and many of the horticulturally desirable species are threatened in the wild, this scale of trade is obviously of considerable concern.

The most heavily traded cactus genus is *Mammillaria,* one of the largest genera in the Cactaceae with around 150 valid species and many other names in horticultural use. The centre of distribution for *Mammillaria* is Mexico and many species are confined to small areas within the country. Although the genus is very commonly cultivated, it has been reported that wild populations are exploited to fill the commercial demand for large specimens. Worrying levels of trade have been recorded in species such as *M. dixanthocentron* which is slow growing in cultivation and Vulnerable in the wild, and *M. guerreronis,* which is uncommon in cultivation. Newly described *Mammillaria* species are particularly vulnerable to collection. Several new species are described each year in Europe, possibly as a result of illegal export of field-collected material. Publication of locality details with description of new species attracts collectors and puts the plants at risk.

Other heavily traded cacti genera include *Gymnocalycium, Echinopsis,* and *Notocactus.* Despite their horticultural importance these South American genera are poorly known in the wild and are in need of taxonomic fieldwork. The region of southern Bolivia and north Argentina has the greatest diversity of small globular cacti after Mexico and they are subject to quite a strong demand from collectors.

Source: Oldfield (1 99 1)

be made of the data on transactions reported by exporting and importing countries. Discrepancies highlight problems which may be worthy of further investigation.

At the request of the Parties, a comprehensive review of all CITES Appendix II trade data was undertaken in 1991, reviewing all trade data for the period 1983-1989. The results of this 'Significant Plant Trade Study' were presented at the Eighth meeting of the Conference of the Parties in 1992. Particular attention was paid to the Cactaceae and a summary of the results is presented in Box 2.1. As part of the same project, trade in the genus Aloe and its parts and derivatives, has been subject to review. This concluded that the data on levels of trade in Aloe parts and derivatives contained within CITES Annual Reports currently have limited value for conservation purposes. The only significant trade in parts and derivatives from wild populations reported to the CITES Secretariat is the trade in Aloe *ferox* from South Africa. This trade is large but appears to be sustainable and does not currently have a detrimental impact on this widespread species. CITES monitoring has benefits for long-term management of A. *ferox*. Other countries which export Aloe products derived from indigenous species should report the trade in detail. Importing countries should also record and report the trade.

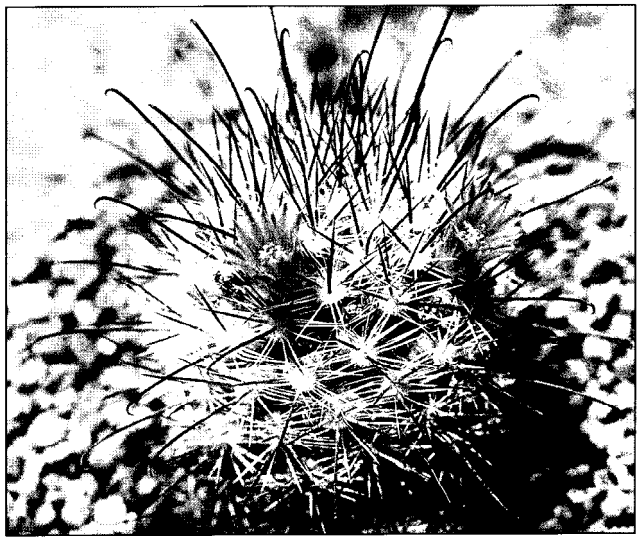
The data on levels of trade in live Aloe plants recorded in CITES statistics for the period 1983-1989, show that the most heavily traded species are generally 'not threatened' in the wild and are commonly artificially propagated. Relatively small-scale trade in rarer species may however be a cause for concern. Collector demand is thought to focus on South African and Madagascan rarities. A number of Madagascan species are strong candidates for Appendix I listing.

Improvement in national reporting of trade in CITES-listed succulents is a priority in increasing the effectiveness of the Convention. A review of national reporting procedures for trade in CITES plants is being carried out by WCMC in response to a recommendation of the 'Significant Plant Trade Study'.

Regular review of the CITES trade data for succulents is essential in monitoring the application of the Convention to trade in these plants. A long-term goal should be to relate trade data to biological data and information on nursery production for each species of conservation concern in order to determine management policies for sustainable trade. At present there are major gaps in the available information most notably on the impact of commercial trade on succulent populations in the wild. Under the ongoing CITES Significant Plant Trade process, projects are now being implemented which relate levels of trade to the status of rare species in the wild. Recent projects carried out in Madagascar and Mexico are examples referred to in the regional accounts.

Illegal trade

There is no doubt that illegal trade in wild succulent plants continues in contravention of CITES (see Table 2.5). Smuggling of small quantities of rare wild plants in suitcases or through the post, or mis-declaring of openly imported shipments are examples of the activities which continue and are extremely difficult to stop given the current level of resources. Surveys conducted by TRAFFIC in Europe, Japan, and South Africa in the past few years have revealed the widespread and often open availability of Appendix I listed wild plants in nurseries. The recent survey of European nurseries by TRAFFIC Europe revealed that wild plants of the Appendix I cacti *Ariocarpus, Aztekium, Obregonia, Pelecyphora,* and *Strombocactus* were all on sale in Italy. Austria has been a source of wild specimens of *Ariocarpus* on sale in Italy, but does not report in detail on its plant trade. Wild *Ariocarpus* plants have been sold openly in the Amsterdam flower market, and nurseries in Belgium and Germany continue to stock Appendix I rarities. Early in 1992 seventy cacti including *Ariocarpus* and *Strombocactus* were seized from a shop in Paris.



Can Te, A.C, S.A.

Mammillaria limonensis in cultivation at Can Te, A.C. gardens, Mexico.

A clear-cut example of illegal international trade in rare cacti is provided by the commercial availability of the recently described species *Aztekium hin tonii* and *Geohintonia mexicana.* The original descriptions of the new taxa were published in the Mexican journal *Cactaceas y Suculentas Mexicanas* at the end of 1991. Other specialist journals publicised the discovery of these new cacti *(Geohintonia* is a new genus). The following year the new taxa were already present in commercial nurseries and private collections within Europe. All specimens outside Mexico are illegal both under Mexican national legislation and under CITES, as no export permits have been issued.

At the CITES Conference of the Parties, held in Kyoto in 1992, Mexico called on importing countries to help with problems of illegal plant exports. In 1991, 18 foreigners were caught illegally collecting cacti in Mexico; in some cases these were pseudo-conservationists "saving"

E. F. Anderson

Geohintonia mexicana

wild plants. Recently, Mexican authorities have been studying where the collectors go to within the country and concentrating enforcement efforts in those areas.

Trade in non-CITES succulents

International trade in non-CITES succulents involves a wide range of species which frequently appear to be threatened in the wild and/or collected in contravention of national laws. This is the case, for example, with southern African succulents. A recent survey of German and Dutch succulent plant catalogues carried out for the German CITES Scientific Authority recorded the availability of threatened southern African succulents at 16 nurseries and noted indications of their wild status (Schippmann 1993). Although data on volumes of trade cannot be collected in this way, surveys of this kind can be a useful step in indicating species of potential concern.

In situ conservation

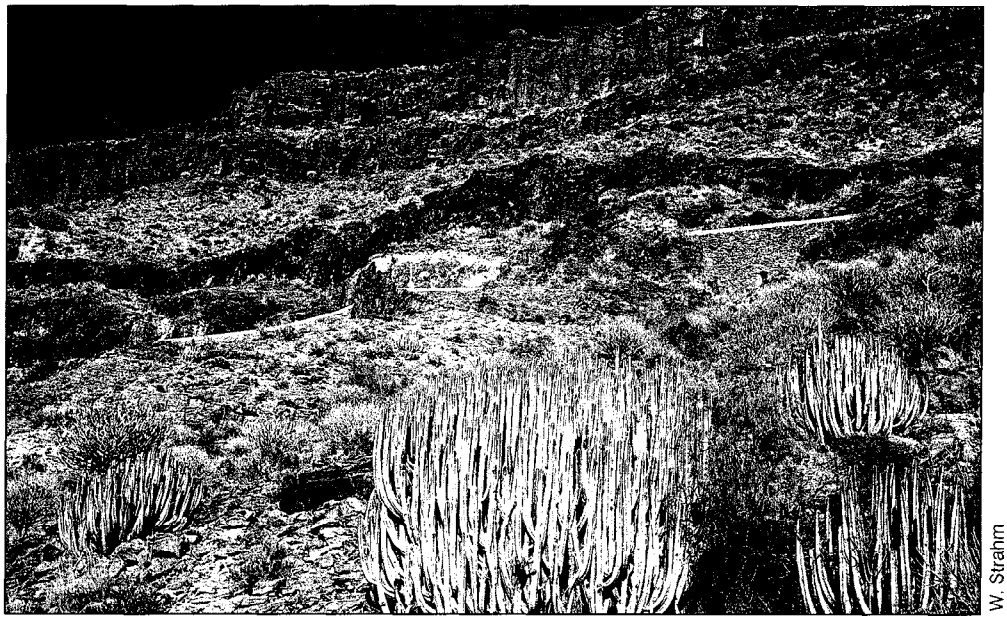
Sara Oldfield

Protecting wild plants in their natural habitats is generally considered to offer the best long term chance of survival for rare and threatened species. In situ protection can take various forms including legal protection of the habitat where the species occurs; designation of micro-reserves, nature reserves, national parks or other categories of protected area; land use controls or zoning restrictions; protection on private land; voluntary management agreements; habitat restoration; or the development of recovery plans for wild populations of threatened species. This section provides examples of different forms of in situ conservation for cacti and other succulents to supplement the information within the regional accounts.

Protecting the habitats of threatened species

Areas specifically protected for threatened species are relatively uncommon as most plant conservation legislation is concerned with protecting species from various forms of collection and disturbance. Habitat protection for threatened plants is, however, included in national conservation legislation for several European countries and also in the USA. The US Endangered Species Act gives protection to the 'critical habitats' of threatened species including various cacti and other succulents. Critical habitats are defined as areas which are essential to the conservation of the species concerned. These areas must be designated and their boundaries precisely described in the Federal Register. As of October 1987, of the 168 listed species of wild flora, there were 23 species for which critical habitats had been designated (Groombridge 1992).

Protection of the habitats of threatened plant species



W. Strahm

Habitat for *Euphorbia canariensis,* Los Palmitos Valley, Gran Canaria.

is also enshrined in regional conservation legislation. In Europe, for example, the EC Habitats Directive addresses the conservation of both natural habitats and habitats of threatened species by the establishment of a European network of Special Areas of Conservation (SACs) which collectively form the Natura 2000 network. New sites, identified by member states, in conjunction with the EC, include areas of natural habitat type listed in Annex I of Directive, with certain habitats given special priority, and habitats of the threatened species listed in Annex II. Habitat types included in Annex I which may be important for succulent plant protection include Mediterranean and pre-steppe brush (low formations of *Euphorbia* close to cliffs), various categories of rocky slopes, and Mediterranean montane forests.

Criteria for the selection of sites both at a national level (Stage 1) and EC level (Stage 2) are given in Annex III of the Directive. The criteria for selection of sites for species include size, density, and isolation of the population in relation to the national total, condition of the site, and global importance. All identified national sites of Annex II species will be considered as sites of EC Importance. Protection of the habitats of those endemic succulents of the Canary Islands included in Annex II (see Table 2.3) will therefore be protected under the Directive, reinforcing the protected area system outlined in Box 2.2.

The Habitats Directive obliges Member States to establish conservation measures for SACs with appropriate management plans, and to avoid the deterioration and disturbance of the protected sites. Environmental Impact Assessments are required for any developments which may adversely affect SACs.

Box 2.2 Protected areas in the Canary Islands

The Canary Islands have a number of protected areas which are important for succulent plant conservation. Examples of succulent species which are protected ***in situ*** are included in Annex 6. Major National Parks occur on Tenerife, La Palma, La Gomera, and Lanzarote. In contrast, Gran Canaria, the island which has experienced the greatest degree of habitat destruction and modification, had, until recently, a relatively poorly developed series of protected areas. In the late 1980s a comprehensive review of species and habitats was undertaken on Gran Canaria in order to select sites in need of protection. As a result of the review, PEPEN - A Special Plan for the Protection of the Natural Areas of Gran Canaria - was published in 1986.

The following year, the Regional Government passed an intermediate law putting most of the proposed areas of PEPEN in a schedule of protected areas. It is now the responsibility of the Dirección General de Medio-Ambiente to prepare management plans for these sites. Despite the progress in protecting the unique succulent plant flora of the Canary Islands, there are however, still significant gaps in the protected area coverage. Lowland plant communities are, for example, not adequately covered. A new National Park is currently proposed to protect a large sector of the *Euphorbia* communities and eroded volcanic landscapes of Gran Canaria.

Source: Synge 1991

Protected areas

The more common form of in situ protection for succulent plants is inclusion within the boundaries of land set aside for general conservation purposes. A protected area is defined as:

An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means. (IUCN 1994a)

At a global level, a recent study of habitat protection carried out by WCMC indicates that overall 7.7 per cent of tropical regions are conserved within protected areas. Protected area coverage of different habitat types is uneven with wet and moist major habitats better represented in protected areas than dry major habitats. This probably reflects national and foreign policies to promote the conservation of tropical rain forests as well as the fact that drier habitats are more prone to agricultural conversion (Green *et al.* 1995). The lack of protection for drier areas may indicate that succulent plant diversity is not adequately protected in the tropics. Green *et al.* (1995) note particularly the restricted protection for lowland dry and arid habitat types in Central America, the Caribbean, and South America. The study also notes the need to carry out similar quantitative assessment of the representation of centres of species diversity, speciation, and endemism within protected areas.

For plants, the Centres of Plant Diversity (CPD) project coordinated by IUCN has identified some of the most important sites for species diversity and endemism worldwide. These are the global priority areas for conservation of plant biodiversity. Individual CPDs which are particularly noteworthy for succulent plant species are listed in Table 2.6, which also indicates the extent to which the sites are currently protected. It is apparent that many CPDs are not legally protected, or are only protected in part. A considerable proportion of those sites which are officially protected are not effectively managed (WWF and IUCN 1994).

International designations

At an international level various mechanisms exist to protect globally important ecosystems and the species occurring within them. One such mechanism is the Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention). This Convention provides for the designation of areas of "outstanding universal heritage" as World Heritage sites, with the principal aim of fostering international cooperation in safeguarding these important sites. Few World Heritage sites are important

Table 2.6 Centres of Plant Diversity - Conservation status of succulent rich sites

Site	Vegetation	Conservation status
Cal Madow, Somalia	Dry montane forest	Daalo Forest Reserve, no protection in practice.
Hobyo area, Somalia	Deciduous bushland, woodland, dunes	No protected areas, extremely vulnerable to overgrazing.
Ogaden, Somalia / Ethiopia / Kenya	Deciduous bushland, woodland	No protected areas.
Socotra, Yemen	Semi-desert, shrubland, thicket, grassland	No protection, but traditional practices have prevented serious exploitation.
Cape Floristic Region, South Africa	Fynbos, shrubland, montane	Reserves cover 19% of region but mainly in mountains.
Karoo-Namib Region, South Africa/Namibia	Succulent shrubland	National Park and a few other reserves covering about 2% of region.
Madagascar	Predominantly forests and thicket	Protected areas cover less than 2% of the island.
Canary Islands	Coastal vegetation, *Euphorbia*-rich vegetation, scrub, woodland, forest	Many protected areas with some notable gaps for succulent rich sites.
Pinar del Rio, Cuba	Seasonal forests, succulent and thorn scrub	National Park; lowlands at risk.
Cockpit Country, Jamaica	Subtropical forest, scrub thicket	No protected areas.
Tehuacan Valley, Mexico	Dry scrub, deciduous forest	Small botanic garden.
Edwards Plateau, Texas, USA	Forest, grassland, semi-desert scrub	Protected areas cover less than 0.5% .
California Floristic Province	Forests, woodlands, coastal scrub, grasslands	About 11% of land protected, mostly montane, lowland habitats threatened.
Atacama Desert, Chile	Mixture of annual, short-lived perennial and woody scrub	Two protected areas cover 468 km^2, many endemics need more extensive protection.
Lomas, Peru/Chile	Islands of low montane desert scrub and thorny steppe	Lachay Nature Reserve, protected area coverage inadequate.

for succulent plant conservation. Exceptions are the Reserve naturelle intégrale du Tsingy de Bemaraha in Madagascar inscribed as a World Heritage site in 1990, the Grand Canyon National Park in Arizona, USA, and the Galapagos Islands.

Biosphere reserves are created under the UNESCO Man and the Biosphere (MAB) Programme. The objective of this Programme is to develop a scientific basis linking the natural and social sciences for the rational use of and conservation of the biosphere and for the improvement of the relationship between humans and their environment. Biosphere reserves are multipurpose areas dedicated both to the conservation of characteristic ecosystems and species, and to sustainable development to meet human needs. Currently the international network consists of over 285 biosphere reserves.

Various biosphere reserves are particularly important for succulent plant conservation. Mexico has six internationally recognised biosphere reserves including the Pinacate Biosphere Reserve covering 480,000 ha of the Sonoran Desert and adjoining the Organ Pipe National Monument in the USA (see below). The Mapimi Biosphere Reserve, established in 1977, covers over 100,000 ha of Chihuahuan Desert with more than 20 species of cacti (Box 2.3).

In the USA, an area of succulent plant diversity is protected in the Big Bend National Park, which is one of 47 biosphere reserves in the country. This National Park protects a large area of Chihuahuan Desert in Brewster County, Texas. Rare cacti occurring within Big Bend include *Ancistrocactus tobuschii, Coryphantha ramillosa, Epithelantha micromeris* var. *bokei,* and *Sclerocactus mariposensis.*

Box 2.3 Reserva de la Biosfera de Mapimi, México

Location Situated north-east of the town of Ceballos on the boundaries of the states of Durango, Chihuahua, and Coahuila. The reserve lies in a hollow or basin surrounded by small mountain ranges running more or less parallel from north to south, in the large catchment area known as Bolson de Mapimi.

Area 103,000 ha (expanded from original 100,000 ha; core area 38,000 ha)

Land tenure There are various common public lands, private ranches, and small peasant properties.

Physical features The reserve is part of the riverine basin (endorheic) system of the Mapimi Bolson of the North Mexican Central Tableland and part of the Chihuahuan Desert. Alluvial deposits predominate, consisting of recent Pleistocene gravels, clays and muds, Outcrops of igneous rock from the Tertiary period and volcanic rocks (rhyolites, andesites, and basalts) are also found. The landscape consists of isolated mountains and extensive interconnected plains.

Vegetation The reserve is located in the Chihuahua arid zone, typically represented by a restricted flora with a large number of endemics. There are five vegetation types, all generally open and xerophytic. Microphyllous matorral scrub is the most representative vegetation community, as characterised by *Larrea divaricata, Agave* spp., *Hechtia* spp., *Pastinaca* spp., *Euphorbia antisyphilitica,* and *Opuntia* spp.

Local human population In the early 1980s there was a total population of approximately 100 people. Of the main ranch and farm units in the reserve at this time, three were privately owned while eight were ejidos in which the land was entrusted by the government to a local community. Nine of the units were devoted to stockraising, one to the extraction of wax from candelilla, whilst 11 extracted salt from a lagoon to the north of the reserve. Agricultural development is limited.

Scientific research and facilities Research facilities include the Desert Laboratory, established in 1978 by the Instituto de Ecologia and located on 20 ha of land in the centre of the reserve. Research includes studies on amphibians and reptiles, raptor biology, the regeneration of desert vegetation after over-grazing, fire, and various types of human activity.

Conservation management Established primarily to protect the Bolson tortoise and the fragile arid habitat. When the reserve was first established there was no zonation, but a core and buffer zone system has subsequently been established. The scientific management of the biosphere reserve is coordinated by the Instituto de Ecologia. The local people are involved in a legally constituted association to assist in management of the reserve. This group includes representatives of the cattle ranches, small land owners ejidos, the National Council of Science and Technology (CONACYT), and the Instituto de Ecologia.

Source: *WCMC Protected Areas Database*

National designations

Protected areas, defined as sites with an area of 1,000 ha or more in IUCN categories I-V (see Box 2.4), have been established in over 160 countries and play an essential role in the conservation of biodiversity worldwide (Groombridge 1992). In general, protected areas designated by national legislation have been developed to protect scenic landscapes, representative ecosystems, or

Box 2.4 IUCN Categories of protected areas (I-V) with their management objectives

I *Scientific Reserve/Strict Nature Reserve:* to protect nature and maintain natural processes in an undisturbed state in order to have ecologically representative examples of the natural environment available for scientific study, environmental monitoring, education and for the maintenance of genetic resources in a dynamic and evolutionary state.

II *National Park:* to protect natural and scenic areas of national or international significance for scientific, educational and recreational use.

III *Natural Monument/Natural Landmark:* to protect and preserve nationally significant natural features because of their special interest or unique characteristics.

IV *Managed Nature Reserve/Wildlife Sanctuary:* to assure the natural conditions necessary to protect nationally significant species, groups of species, biotic communities, or physical features of the environment where these require specific human manipulation for their perpetuation.

V *Protected Landscape:* to maintain nationally significant natural landscapes which are characteristic of the harmonious interaction of man and land while providing opportunities for public enjoyment through recreation and tourism within the normal life style and economic activity of these areas.

Source: *IUCN (1994a)*

animal populations rather than to protect individual plant species or botanical diversity. There are a few notable exceptions. Two protected areas in Arizona, USA, have been designated specifically to protect cacti. These are the Organ Pipe Cactus and Saguaro National Monuments. The former of the two protects an important example of Sonoran desert vegetation with, in addition to the organ pipe cactus *Lemaireocereus thurberi,* 28 other taxa of cacti occurring within the protected area.

In many other countries succulent plants occur within protected areas designated for general conservation purposes (see Box 2.2), but often full botanical inventories have not been compiled for these sites. Often it is unclear which succulent species occur within a particular protected area, and also to what extent particular rare or threatened species are actually protected in situ in various parts of their range.

At a national level, some countries have not yet developed protected area networks, and in others important areas of succulent-rich vegetation are not yet adequately represented. Most of the countries reviewed in the Action Plan have important areas of succulent plant diversity which are not yet included in protected area systems. These include Brazil, Madagascar, Mexico, Caribbean islands, Somalia, South Africa, and Zimbabwe. Recommendations for priority sites for protected areas are given in Chapter 4.

With increasing threats to succulent species in the wild and increasing land demands, implementation of recommendations for in situ protection will be particularly challenging. Novel approaches may be required. One such approach is the creation of micro-reserves specifically designed to protect endangered or endemic plant species. An example of this approach is being pioneered for endemic species in Valencia, Spain. In 1994, the Regional Government of Valencia created a new kind of legal protection, with the aim of establishing small permanent reserves for plants in need of habitat protection (Laguna 1997). More than 60 small reserves have already been created, with an individual area of less than 20 ha, and in the next few years a total of 150 micro-reserves will be established protecting 280 endemic species. The small size of each protected area is expected to reduce the risks of problems with land users. Management of the micro-reserves in Valencia is coordinated with the development of recovery plans and *ex* situ conservation measures. It is clearly resource and management intensive and will not be appropriate in all succulent rich areas requiring protection. Such an approach may however be appropriate, for example, for narrow endemics in parts of the Caribbean, Madagascar, Mexico, and South Africa.

The increasing availability of distribution data for succulent plant species and computerised mapping systems make it easier, in theory, to select and design areas for the protection of succulent diversity, although the actual designation of national parks and reserves remains challenging because of conflicting landuse demands. The use of geographic data from literature, herbarium specimens, and other sources to plan for the conservation of plant genetic resources is discussed by Maxted *et al.* (1995). Similar techniques can be used to plan conservation strategies and protected areas for rare and threatened plant species.

In Mexico, the distributions of endangered cacti in the Chihuahuan Desert Region have been mapped on a grid square basis to show the areas of maximum diversity of the species (Hernhndez and Barcenas 1995). In this way the areas of particular importance for cactus conservation are identified, as discussed further in the Mexican Regional Account in Chapter 3. Other factors would need to be taken into account in the selection of formally protected areas such as habitat diversity, presence and diversity of other species groups, and land use pressures. However, the study of the Chihuahuan Desert Region vividly highlights the fact that none of the critically important species rich quadrants identified for endangered cacti are included in protected areas.

Increasingly it is recognised that designation and management of protected areas must take into account the views and requirements of local people. The Richtersveld National Park in South Africa, briefly described in Box 2.5, was established in 199 1 following nearly 20 years of consultation with local people.

Box 2.5 Richtersveld National Park, South Africa

The Richtersveld National Park in the north-western Cape of South Africa protects an internationally important area of succulent plant diversity. The protected area was designated in 1991 after extensive local consultation. Management involves recognition of local needs with local communities involved in the decision-making process. The Park covers 1,624 km^2 of attractive desert scenery and unique endemic vegetation. It is particularly important for the conservation of South Africa's mesembs, together with distinctive *Aloe pillansii, A. dichotoma, A. meyeri,* and *Pachypodium namaquanum.* Threats to the succulent plants have included mining, stock farming, and collection for horticulture. Tourism is now a growth industry and this in itself places pressures on the succulent plant species.

Private land

Acquisition and management of land for conservation by NGOs and individual land owners are important means of ensuring in *situ* conservation. In the USA, for example, The Nature Conservancy Council administers over 1300 reserves covering 650,000 ha; the National Audubon Society owns or leases over 100 sanctuaries covering over 60,000 ha; and Operation Stronghold is an alliance of 800-900 private landowners who have undertaken conservation measures on private land estimated to cover 2-2.5 million ha (WCMC 1992).

In Mexico, the NGO Can Te, A.C. has a programme, 'Comprar para Conservar' or 'Purchase to Preserve',

which encourages people to contribute financially toward the purchase of threatened habitats. Can Te, A.C. considers that most threatened species of cacti and other succulents do not grow in areas appropriate for national protection. In these cases, purchase of the land may be the only viable option to preserve the sites. Realistically, this can be best achieved by non-governmental organizations or by private individuals. Can Te, A.C. has purchased the terrain of *Mammillaria albiflora* on a barren hillside in north-eastern Guanajuato. Collectors have not appreciably reduced the population, even though it is the main known locality for the taxon. Recently, the plant was put in jeopardy when the owner of the property offered it for sale for agricultural use. However, purchasing land is not always practical. For example, the expansion of the city of Queretaro threatens to eliminate the only known remaining habitat of *Mammillaria mathildae*, a cactus little in demand and not threatened by collectors. An attempt by Can Te, A.C., in cooperation with the Queretaro campus of the Instituto Tecnológico y Estudios Superiores de Monterrey (ITESM), to purchase the habitat was unsuccessful due to the high prices demanded by the speculating owners.

Species management

Within areas set aside for conservation, management of the plant communities will frequently be required. Protected areas generally have management plans which set out the requirements for maintenance of the site in broad terms. For populations of individual rare or threatened species, particular management prescriptions may be necessary. As Given (1994) points out, "Particular species may be threatened or in decline because of factors that are independent of the ecosystem as a whole. Examples include harvesting, predation and the consequences of small population size. Some species may require specific habitat manipulation independent of that applied to the whole system where they occur."

Species management within protected areas may involve protection from unwanted human disturbance, with periodic monitoring or more active manipulation. Unfortunately knowledge of the biology and ecology of succulent plants species is frequently very limited, and management where it is applied is likely to be based on trial and error. Research from *ex situ* situations can be particularly helpful for succulent plants. Conservation of succulent plant species in the long-term will be most successfully achieved by an integrated approach involving both *in situ* and *ex situ* conservation measures.

Box 2.6 Recovery plan for Pediocactus *knowltonii*

Pediocactus *knowltonii* is an Endangered cactus of the USA, with only one viable population on a single hill, south of La Boca in northern New Mexico. The species was listed as Endangered under the Endangered Species Act in 1979 when only about 1000 individuals were known to remain. The decline of the naturally rare species has been caused by habitat loss, collection for horticulture and, in 1960, a misguided "rescue" operation when thousands of plants were collected from the proposed site of a dam. The *Know/ton Cactus Recovery Plan* approved on 29 March 1995, called for restoration of the La Boca population to approximately 100,000 cacti, long-term protection of the site, and reintroduction of the species at other suitable localities, The site is owned by The Nature Conservancy. It has been fenced to keep out cattle and in an attempt to deter collectors. The development of detailed recovery goals have been hindered by lack of biological data for the species.

Source: *Endangered Species Technical Bulletin 10 (12). 1995.*

Ex situ conservation

Edward Anderson

As seen in the introductory chapters of this Action Plan, many succulent taxa are in serious trouble, and may be lost unless immediate conservation efforts are undertaken. Cultivation of plants in botanic gardens, arboreta, private collections, and nurseries is an ex *situ* conservation method that is used by biologists to assure, at least, some protection of species 'away from danger'. Plant material in ex *situ* cultivation may be used for reinforcing existing wild populations or in the re-establishment of wild populations following the IUCN *Guidelines for Re-Introductions* (IUCN 1995).

In 1985 an international conference was held in Las Palmas de Gran Canaria, in which the organisations present adopted a series of 13 recommendations dealing with 'Botanic Gardens and the World Conservation Strategy.' Recommendation 4 dealt specifically with *ex situ* conservation. It stated (IUCN 1986):

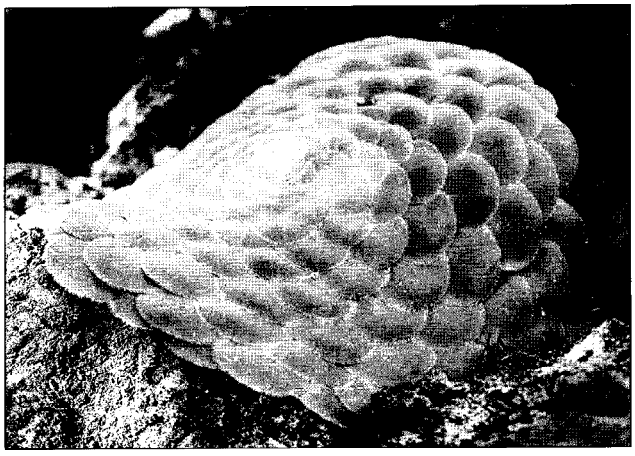
"While recognising that no single approach to the conservation of endangered species can be relied upon; appreciating that ex *situ* conservation is a necessary adjunct to *in situ* conservation; and acknowledging the importance of seed banks in the long-term conservation of genetic resources, The International Conference on Botanic Gardens and the World Conservation Strategy:

- Urges Botanic Gardens to recognise their responsibility to maintain, propagate and make available stock of critically threatened species for scientific and horticultural research, for reintroduction (where appropriate) and to provide suitable stock for horticulture;
- Recommends that exploration and collection of species be based on concepts of infraspecific diversity so that ecogeographical diversity and diversity between and within populations be sampled in such a way that a maximum of genetic diversity be captured and stored;

- Urges Botanic Gardens to become involved with seed conservation and recommends that the International Board for Plant Genetic Resources (IBPGR) (now the International Plant Genetic Resources Institute - IPGRI) be approached so as to establish closer collaboration on the conservation of threatened species;
- Recommends that every effort be made to maintain minimal international standards for seed storage and rejuvenation;
- Recommends IUCN to continue and expand the monitoring and co-ordination of *ex* situ conservation, presently carried out by the Botanic Gardens Conservation Co-ordinating Body, as an integral part of the implementation of the Botanic Gardens Conservation Strategy;
- Recommends Botanic Gardens and other relevant institutions to support this essential work and to provide the necessary finance for it."

As a response in part to these recommendations and because of the important succulent collections that exist around the world that could contribute significantly to the conservation of succulents, this section deals with various forms of ex situ conservation presently available for succulents. It also describes several actions that might be taken to facilitate *ex* situ conservation.

Conservation collections have been defined as "living collections of rare or endangered organisms, established for the purpose of contributing to the survival and recovery of a species" (Center for Plant Conservation 1991). There are four important types of succulent plant collections that may be utilised in *ex* situ conservation activities: botanic gardens and arboreta, seed banks, private collections, and, to some extent, commercial nurseries. Each of these plays a significant, though different role in conservation. Nonetheless, careful networking among these different collections and their managers or owners will provide botanists and conservationists with an effective tool for the long-term preservation of germplasm of rare and endangered succulents. Additionally, plant material in *ex situ* cultivation may be used for reinforcing existing wild populations or in the re-establishment of wild populations following the IUCN *Guidelines for Re-in troductions* **(IUCN 1995).**



W. Strahm

Aeonium tabuliforme, a Rare Crassulaceae of the Canary Islands.

Botanic garden networks

The International Association of Botanic Gardens (IABG) is an umbrella organisation for all the 1600 botanic gardens and arboreta worldwide. Some arc the traditional botanic gardens, whereas others are nature reserves, small private gardens, nurseries, and agricultural experimental stations. These institutions combined provide more than 100,000 hectares (247,100 acres) of *ex* situ habitat for the cultivation of plants. There are also regional associations of IABG in Latin America and the Caribbean, Asia, and Europe. In North America the American Association of Botanical Gardens and Arboreta is also active.

Following the recommendations of the Las Palmas conference, IUCN established the Botanic Gardens Conservation Secretariat, BGCS, (which later became Botanic Gardens Conservation International - BGCI), to co-ordinate botanic gardens' conservation work worldwide. In 1985 the Secretariat published two reports of significance to succulent plant conservation: Report No.13 of the Rare and Threatened Species of Mexican Cacti and Report No.15 of the Succulents of Africa and Madagascar. *The Botanic Gardens Conservation Strategy* was published in 1989 (IUCN-BGCS 1989) and provides a rationale and basic guidelines for plant conservation work through botanic gardens. Today over 450 gardens and other institutions from 90 countries are members, and BGCI has an active programme to enhance the conservation and environmental education efforts of botanic gardens worldwide. BGCI maintains a database of rare and endangered species currently (1995) holding about 200,000 records of plants in botanic gardens, many of which are succulents.

In 1993 the IABG and BGCI signed a wide-ranging agreement "for the purposes of fostering the development of the world network of botanic gardens and arboreta, towards researching, documenting, conserving and utilising the plant resources of the world. .." *(Botanic Gardens Conservation News 1994).*

The World Conservation Monitoring Centre (WCMC), in Cambridge, UK, maintains a database of over 100,000 rare and threatened plant taxa worldwide. Conservation biologists, particularly members of the IUCN/SSC Specialist Groups, provide data to WCMC, which in turn compiles, analyses, and supplies value-added information regularly to Botanic Gardens Conservation International (BGCI), the IUCN Species Survival Commission, and many other international and national organisations and institutions involved in monitoring rare plants.

In the United States the Center for Plant Conservation (CPC) was founded in 1984 at the Arnold Arboretum. Currently headquartered at the Missouri Botanical Garden, the Center is a consortium of botanic gardens and arboreta in the USA whose purpose is to preserve critically endangered plant taxa of the USA by establishing a national *ex* situ collection of rare plant germplasm. This National Collection is held in the Center's 25 participating institutions across the country, and is primarily composed of stored seeds which have been collected in a manner to capture the genetic diversity of a taxon to the fullest extent possible. The collection, and others like it, serves several functions: 1) as an insurance policy against extinction in case of a catastrophic loss in the wild; 2) as a source of material for research and education programs which can contribute to the conservation of a species; and 3) as a source of germplasm for potential re-introduction and ecological restoration projects, which are carried out on a cooperative basis.

Over 450 plants are currently represented in the National Collection. Of these, approximately 25 species are succulents, with the majority at the Desert Botanical Garden in Phoenix, Arizona. Genetically representative seed collections of the rare succulents have been placed in long term storage at the Desert Botanical Garden, Rancho Santa Ana Botanic Garden (California), San Antonio Botanical Garden (Texas), and Fairchild Tropical Garden (Florida). Research is conducted on germination and viability testing, propagation methods, and reproductive biology. These botanic gardens are often involved in surveying, monitoring, and re-introduction projects with federal and state agencies, as well as other partners.

National networks of botanic gardens exist in many other countries. For example, the Australian Network for Plant Conservation (ANPC) has established a programme in *ex* situ conservation demonstrating how botanic gardens can network effectively in conservation matters. An Endangered Species Collection was started in 1986 at the Australian National Botanic Gardens, Canberra, for research, education, display, and possible re-introduction. This collection possibly will become available to the nursery industry as well (Richardson 1992). In the Netherlands, the Dutch Botanic Garden Foundation co-ordinates a Decentralised National Collection amongst the Dutch botanic gardens, including very significant numbers of cacti and other succulents. Active botanic garden networks involved in conservation also operate in many countries, including Brazil, China, Colombia, Cuba, France, Germany, Indonesia, Italy, Japan, Mexico, Russia, Spain, and Portugal (Wyse Jackson 1993).

Databases

The development of the *International Transfer Format for Botanic Garden Plant Records* (IUCN-BGCS 1987) and computer-based plant collection software systems have provided the means for, and been influential in, the development and improvement of plant records and collection documentation worldwide.

One of the most serious problems facing conservationists is that of nomenclature. Some rare succulents are referred to by a variety of names; for example, the Office of Scientific Authority of the US Fish and Wildlife Service and the CPC continue to use the nomenclature of Benson (1982) for cacti in the USA, although CITES has now published an updated checklist of the most commonly accepted names of cacti based on recent research (Hunt 1992). In an effort to assist scientists and horticulturists in dealing with the perplexing problems on nomenclature, the contents of all issues of the *Repertorium Plantarum Succulentarurn* (RPS) have been compiled by the Stadtische Sukkulenten-Sammlung Zurich (ZSS), creating the *RPS/ZSS Database.* Not only does this database contain thousands of names, but it also contains curatorial information as needed for living and herbarium collections. The following custom-designed printouts are available: taxonomic data by family, taxonomic data by genus, and synonymy of a genus. Such synonymy lists are available for most succulent families. Additional lists are published in the annual issues of the *IOS Bulletin.*

Collecting

The CPC (1991) has published guidelines for collectors of rare plants in response to some concern about inadequate genetic representation of endangered species in *ex situ* collections. The guidelines address five questions which constitute a natural hierarchy covering species, populations (and ecotypes), individuals, and alleles. The work of the collector may also be influenced by the degree of genetic difference among populations, time and money considerations, the survival rate of propagules, and the intended use of the collections. The Center's five sampling questions are:

1) *Which species should be collected?* The two most important criteria here are the probability of loss of a unique genepool, and the potential for restoration or recovery.
2) *How many populations should be sampled per species?* As a rule, one to five ecotypes or populations should be sampled, depending on the population history and the degree of difference among the groups.
3) *How many individuals should be sampled per popula tion ?* Ten to fifty individuals should be sampled per population, but this depends on population size and genetic mobility.
4) *How many propagules should be collected from each individual?* From one to twenty should be obtained, depending on the survival rate of the propagules and the long-term needs of the collection.
5) *Under what circumstances is a multiyear collection plan indicated?* More than one year is recommended,

especially if the desired number of propagules cannot be removed safely without affecting the reproductive capabilities or demography.

Developing techniques, particularly for DNA study, for the analysis of genetic variability of plant populations in the wild and maintained *ex* situ provide valuable means for improving the genetic representation in garden collections. Such techniques are also becoming useful for conservation, to study material from garden sources (from botanic gardens, private growers, and commercial sources) that has lost its documentation.

Seed banks

There is an increasing number of seed banks being developed for wild plants worldwide, particularly by botanic gardens, although there is still relatively little co-ordination between them. A 1994 survey by BGCI indicated that there are currently over 150 such seed banks in botanic gardens. The extent to which succulent species are contained within their collections is unknown, however. One such collection specialising in the storage of arid land species is held at Wakehurst in the UK, and a second by members of the CPC in the US where seeds from the National Collection of endangered plants are desiccated and frozen for long term storage of the germplasm.

The collection and *ex* situ storage of seeds of rare plants present several significant conservation problems. The first concerns the impact of collecting seeds on the natural populations. This is of special concern with respect to succulents occurring in arid regions, for the severe climatic fluctuations in deserts frequently lead to sporadic reproduction. Thus, collection of seeds from plants with low levels of reproduction during periods of stress can be highly detrimental to the long term survival of that population. IUCN-BGCS (1989) recommends that never more that 10 per cent of the seed available in a wild plant population should be collected.

A second concern, expressed by Richardson (1994), involves the exchange of seeds in *Index Seminum* programs in which weedy plants are distributed with insufficient controls. Thus, exchange programs by botanic gardens with good intentions may result in the introduction of potentially dangerous exotic plants. The CPC has recognised the problems, both potential and real, of seed banks and the exchange of seeds, and has published extensive guidelines for the management of "orthodox" seeds (those that tolerate severe desiccation or dehydration and which can usually be stored for long periods of time) (Wieland 1995). These guidelines deal with the collection, storage, and shipment of seeds. Much information on the management of seeds has also been published by IPGRI.

Seed collections are a significant aspect of *ex situ* conservation, for they provide a source of germplasm other than from the field. If care is taken and guidelines are followed, seed banks and *Index Seminum* exchanges can play an important role in perpetuating rare succulents, as well as providing research and horticultural materials. The National Botanical Institute of South Africa (NBI), including its network of botanic gardens has a seed exchange programme with other institutions; seeds are exchanged "on the understanding that it is not used commercially." These seed collections can also be valuable to some *in situ* conservation projects which involve re-introduction of plants into habitat. Those organisms placed in habitat may have originated from seeds propagated in either botanic gardens or commercial nurseries. Guidelines for such plant re-introductions have been produced by several organisations, including the IUCN-SSC Re-introductions Specialist Group (IUCN 1987 and 1995), and the *Handbookfor Botanic Gardens on the Re-introduction of Plants to the Wild* has been published by BGCI (Akeroyd and Wyse Jackson 1995).

Botanic gardens

A wide range of botanic gardens maintain very extensive collections of succulent plants. Compared to many other plant groups, the rare and endangered species of cacti and succulents are well represented in many collections. A few of these gardens grow collections of the succulent members of their own flora, e.g. the Jardín Botánico Canario 'Viera y Clavijo', Gran Canaria, Spain; the National Botanic Institute, South Africa; and the Kings Park and Botanic Garden, Perth, Western Australia. However, the succulent collections of most botanic gardens are of exotics. There are also many regions of natural succulent vegetation, such as Ethiopia, Somalia, Chile, where there are no functioning *ex situ* conservation facilities. The development of local facilities and expertise should be emphasised in plans to establish new collections. Collaborative training programmes between the larger international botanic gardens and local facilities should occur.

The following eight examples are from botanic gardens that have already shown leadership in managing collections of succulents, and are actively involved in conservation work.

1. University of California Botanical Garden U C Berkeley, Centennial Drive, Berkeley, California 94720, USA. Telephone: (510) 6438040. FAX: (510) 642-5045.

Founded in 1890, this state supported garden is part of the largest university campus in the USA. The garden, located in Sycamore Canyon above the main campus, has an area of 13 hectares (32 acres). The succulent collection comprises a fifth of the total collection. There are 2570 taxa, comprising 4046 accessions, with 2293 species of the families Agavaceae, Aizoaceae, Cactaceae, Crassulaceae, and Aloe (included in Liliaceae in their data base). Of these, 69 per cent of the taxa are documented (78 per cent at the species level). The Berkeley garden also has living material of 45 species of CITES Appendix I succulents. It

is a participating member of the CPC. Living material of the following collectors of succulents are present in the garden: M. Cardenas, S. B. Hogan, P. C. Hutchison, A. Lau, R. Moran, M. Kimnach, W. Krahn, F. Ritter, R. Rodin, and J. West.

2. **Desert Botanical Garden 1201** North Galvin Parkway, Phoenix, Arizona 85008-3490, USA. Telephone: (602) 941-1225. FAX: (602) 481-8124.

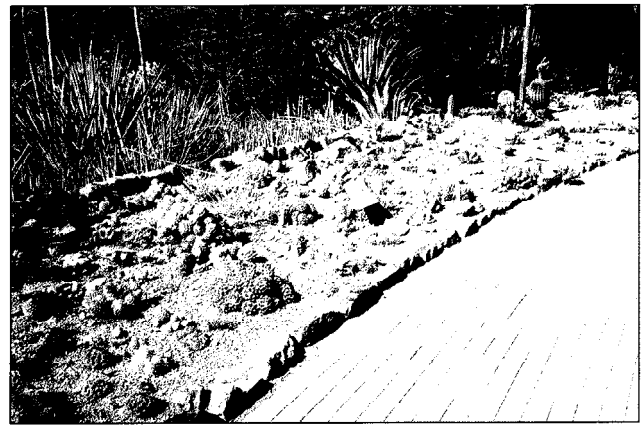
This garden is a private institution and was founded in 1937. It covers an area of 53 hectares (145 acres), with most specimens planted outside. There are also three glasshouses and an extensive shade house. The Garden's succulent collection contains the following specimens:

Family	No. taxa	No. taxa documented
Agavaceae	267	204 (76%)
Aizoaceae	274	205 (75%)
Aloaceae	253	117 (46%)
Asclepiadaceae	88	65 (74%)
Cactaceae	1296	841 (65%)
Crassulaceae	102	55 (54%)
Didiereaceae,	13	1 (8%)
Euphorbiaceae	124	68 (55%)
Fouquieriaceae	14	8 (57%)

There are 38 species of CITES Appendix I succulents in the collection in the Agavaceae, Apocynaceae, Cactaceae, Euphorbiaceae, Fouquieriaceae, and Aloaceae. Significant collectors at the Desert Botanical Garden have included E. F. Anderson, M. Baker, R. Engard, H. S. Gentry, W. Hodgson, P. C. Hutchison, F. Kattermann, G. Lindsay, B. Parfitt, D. Pinkava, J. Rebman, L. Slauson (Ecker), and A. Zimmerman.

The Desert Botanical Garden is a member of the CPC, and is responsible for protecting many of the threatened and endangered succulents of the south-western USA. The Garden has established a seed bank and living *ex* situ collections of the following succulents:

Agave arizonica
A. parviflora
Coryphantha recurvata
C. ramillosa
C. scheeri var. *robustispina*
Echinocactus horizonthalonius var. *nicholii*
Echinocereus chisoensis
E. viridiflorus var. *davisii*
Epithelantha bokei
Escobaria minima
E. robbinsorum
E. sneedii var. *sneedii*
Mammillaria thornberi
Peniocereus greggi var. *transmontanus*
Sclerocactus erectrocentrus var. *acunensis*



E. F. Anderson

Mammillaria and *Coryphantha* collection, Desert Botanical Garden, Arizona.

S. erectrocentrus var. *erectrocentrus*
S. mariposensis

The Garden has also established permanent *in situ* monitoring sites and is carrying out extensive field studies for several of the above taxa.

3. **Huntington Botanical Gardens** The Huntington, 1151 Oxford Road, San Marino, California 91108, USA. Telephone: (818) 4052160. FAX: (818) 405-0225.

The Huntington Botanical Gardens, founded in 1919, has a succulent plant collection, as well as other major plant collections and an important arts and humanities collection and library. Plant records were begun in 1930. The desert plant collection covers an area of 6 hectares (15 acres). Most of the collection is outdoors, but the garden also has several glasshouses. The succulent collection consists of nearly 20,000 accessions, representing more than 8000 taxa, of which one-third are documented. Some of the most important succulents in the collection consist of:

Family	No. taxa	No. taxa documented
Agavaceae	490	304 (62%)
Aizoaceae	728	255 (35%)
Aloaceae	780	304 (39%)
Asclepiadaceae	429	249 (58%)
Asteraceae	74	34 (46%)
Bromeliaceae	196	53 (27%)
Cactaceae	3125	812 (26%)
Crassulaceae	1293	427 (33%)
Didiereaceae	11	1 (1%)
Euphorbiaceae	483	97 (20%)
Fouquieriaceae	13	8 (62%)

The Huntington has 60 CITES Appendix I taxa in its living collection. It is responsible for growing and distributing the International Succulent Institute (ISI)

materials each year. The list of succulents offered is published annually in the *Cactus and Succulent Journal* (US).

Succulent collectors include E. F. Anderson, W. Baker, G. Barad, J. Bauml, J. Berdach, J. Betzler, J. Bleck, F. Boutin, S. Brack, F. Brandt, M. Cardenas, J. Clements, S. Collenette, J. Dice, J. Dodson, H. Earle, U. Eggli, A. Ellert, C. Fleming, J. Folsom, R. Foster, E. Gay, H. S. Gentry, C. Glass, S. Hammer, D. Hardy, A. Hoffman, I. Hoffmann, F. Horwood, P. Hutchison, E. van Jaarsfeld, F. Katterman, R. Kiesling, M. Kimnach, K. Knize, D. Koutnik, A. Lau, J. Lavranos, B. Leuenberger, S. Linden, H. Y. Liu, J. Lomeli-Sencion, G. Lyons, T. Mcdougall, N. Martinez, W. Minnich, R. Moran, L. Newton, F. Otero, D. Plowes, W. Rauh, H. Sanchez-Mejorada, R. Thompson, J. Trager, V. Turecek, C. Uhl, M. Vassar, and M. Wilkins.

4. **Jardín Botánico del Instituto de Biologia de UNAM** Instituto de Biologia, Universidad Nacional Autónoma de Mexico. Ciudad Universitaria, Apartado Postal 70-614, 04510 Coyoacan, Mexico D.F., Mexico. Telephone: 52-915-6-22-9046, 6-16-1297. FAX: 52-915- 6-22-9046, 6-16-2326.

This major Mexican botanic garden is part of the National University of Mexico and is funded by the government. The botanic garden consists of an area of 10 hectares (24.7 acres). A major portion of the garden is dedicated to Dra. Helia Bravo H. and contains the succulent collection. It consists of 148 Agavaceae species, with 120 (81%) documented (1 species of CITES Appendix I); 455 Cactaceae species, with 300 (66%) documented (23 species of CITES Appendix I); 65 Crassulaceae species, with 60 (92%) documented; 25 Nolinaceae species, with 15 (60%) documented. Important collectors of succulents have been H. Bravo H., A. Garcia M. (active), D. B. Gold, U. Guzmán C. (active), E. Matuda, F. Miranda, J. Reyes S. (active), H. Sanchez-Mejorada R., and S. Arias M. (active).

5. **Jardín Botánico "El Charco del Ingenio"** Can Te, A.C, Mesones *71, 37700,* San Miguel de Allende, Guanajuato, Mexico. Telephone: 52-415-2-2990. FAX: 52-515-2-4015.

This private garden was founded in 1990 in an area north-west of the colonial city of San Miguel de Allende. At present much of El Charco is in the form of a nature reserve, but an area of 64 hectares (158 acres) is being developed into a more formal botanic garden. This new garden is emphasising the Agavaceae, Cactaceae, and Crassulaceae of the Mexican flora. Most of the collection is outside, but there are two large glasshouses on the grounds of the garden and a major propagation facility on a farm a few kilometres away. Significant collectors are C. Glass and W. A. Fitz Maurice. A seed exchange programme with other institutions has not yet been formally approved by the Mexican government, but it is the intention of Can Te, A.C. to develop a major seed exchange programme for the Mexican government. Hopefully, this will reduce the pressure on wild populations from illegal collectors.

Can Te, A.C. has also been involved in several rescue and salvage operations in Mexico. *Mammillaria aurilanata, Pelecyphora aselliformis,* and *Echinocactus grusonii* are examples of cacti which have been removed prior to major habitat changes, such as road and dam construction. Can Te, A.C. has also established a nature reserve for the protection of *Mammillaria albiflora.* The staff is also heavily involved in rare cactus monitoring projects in many parts of Mexico.

6. **Jardin Exotique** B.P.105, Monte Carlo 98002, Monaco. Telephone: 33-93-30-33-65. FAX: 33-93-30-60-74.

Founded 1933, this municipally operated garden, with an area of one hectare (2.5 acres), has long specialised in succulents. It contains 4000 succulent plant taxa, of which 800 (20%) are documented. The collection contains about 30 CITES Appendix I taxa in *Pachypodium, Euphorbia, Aloe, Ariocarpus, Astrophytum, Discocactus, Mammillaria, Melocactus, Obregonia, Pediocactus, Turbinicarpus,* and *Uebelmannia*. The most important succulent groups represented are the Agavaceae, Aizoaceae, Aloaceae, Amaryllidaceae, Apocynaceac, Asclepiadaceae, Asteraceae, Boraginaceae, Bromeliaceae, Cactaceae, Crassulaceae, Dracaenaceae, and Euphorbiaceae. Collectors of succulents who have deposited material in the Jardin Exotique include M. Kroenlein, W. Rauh, R. Kiesling, and C. Backeberg.

7. **National Botanic Gardens of South Africa** National Botanic Institute, Kirstenbosch, Private Bag X7, Claremont 7735, South Africa. Telephone: 27-2 1-797-2090. FAX: 27-021-797-2376.

The National Botanical Institute of South Africa has eight National Botanical Gardens strategically located in the major natural regions of the country: Harold Porter, Karoo, Kirstenbosch, Lowveld, Natal, Orange Free State, Pretoria, and Witwatersrand National Botanical Gardens. The role of these gardens is to cultivate, protect, display, research, and utilise South Africa's floral wealth, for the education and enjoyment of all. While all of these gardens have succulent plants in their collections, three of the gardens have succulent collections of international importance.

Kirstenbosch National Botanical Garden The Kirstenbosch National Botanical Garden, located on the slopes of Table Mountain near Cape Town, was founded in 1913. The garden occupies 528 hectares (1305 acres), of which some 36 hectares (89 acres) is cultivated, while the remainder is maintained as a natural flora reserve. Approximately 6000 indigenous species are grown in the garden, of which 1500 are succulents. There are a few individual plants of three CITES Appendix I species: *Aloe pillansii, A. polyphylla,* and *A. thorncroftii.*

Approximately 95 per cent of all the succulent plants grown at Kirstenbosch are documented in that all their accession details and location within the garden are fully computerised. Voucher specimens of a number of the plants in cultivation are placed in the Compton Herbarium, which is also at Kirstenbosch. The system could use some improvements on information accessibility.

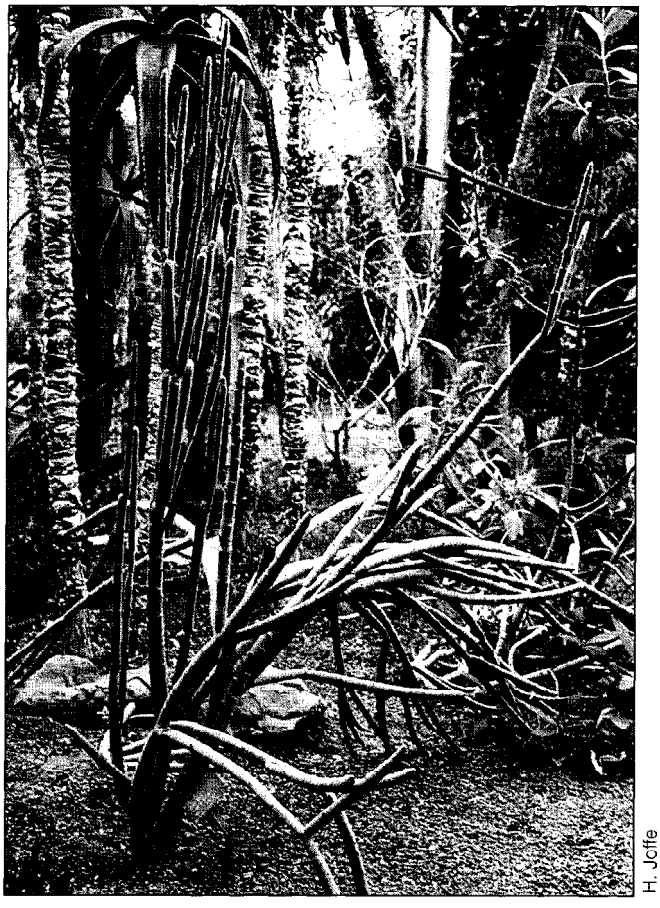
Part of the succulent collection is grown outdoors in two main areas, namely the Mathews Rockery and the Mesem Banks (covering an area of approximately 3000 m^2), while the remainder, especially the smaller species and the research collections, are grown in glasshouses in the nursery area. The winters in Cape Town are far too wet for many of the succulent species to be grown outdoors. As a result, a display glasshouse is being built (covering 1400 m^2), the main feature of which will be the succulent flora of southern Africa.

Many of the plants grown at Kirstenbosch are the result of staff collecting activities, but other collectors who have made significant contributions to the collection include M. B. Bayer, H. Hall, C. A. Smith, F. Stayner, and W. Wisura.

The Karoo National Botanical Garden, at the foot of the Brandwacht Mountains near Worcester, was founded in 1921 but transferred to its present location in 1945. This garden concentrates on plants from the arid semi-desert areas of southern Africa, particularly the succulents. Approximately 11 hectares (27 acres) of the garden have been developed for the cultivation of plants, and the remaining 143 hectares (353 acres) are being retained as a flora reserve, protecting a typical example of the local Karoo vegetation, which includes over 80 species of succulents.

The lower part of the garden is devoted to summer rainfall arid-area plants, while in the upper part of the garden their winter rainfall counterparts are grown. There are plantings of related species, such as the aloes and mesembs, and elsewhere there are plantings that reflect the floras of different regions, such as Namibia, the Richtersveld, the Knersvlakte, Tanqua Karoo, Little Karoo, etc. In all, some 6400 plant species have been established, of which over 2500 are succulents.

There are a number of important reference collections, e.g. the *Haworthia* collection, the *Conophytum* collection, the *Euphorbia* collection, and the collection of succulent asclepiads, which are grown under controlled conditions in shade and glasshouses. Over 300 species of rare or endangered succulents are cultivated in the garden, including two CITES Appendix I species: *Aloe pillansii* (40 plants) and *Pachypodium baronii* (only 1 plant and which comes from Madagascar). Approximately 80 per cent of the collections are fully documented. A small reference herbarium is maintained at the garden, but most of the specimen vouchers are sent to the Compton Herbarium at Kirstenbosch.



H. Joffe

Madagascan plant collection at the Pretoria National Botanical Garden.

Significant contributors to the collection include M. B. Bayer, P. V. Bruyns, D. Kotze, L. C. Leach, A. Mitchell, I. Oliver, P. L. Perry, F. Stayner, and E. J. van Jaarsveld.

Pretoria National Botanical Garden The Pretoria National Botanical Garden, situated eight kilometres from the centre of Pretoria, was established in 1946. This garden, which covers approximately 77 hectares (190 acres), is mostly cultivated, although a small portion of natural vegetation is preserved along the rocky ridge which runs through the garden. Over 5000 species are grown in the garden, of which over 2000 are succulents. Most of the succulents are grown as group plantings, such as aloes, crassulas, mesembs, euphorbias, and caudiciforms, but there are also geographic plantings for Namib Desert and Karoo plants, plus a recently developed Madagascan area with species of Didiereaceae and *Pachypodium*.

The garden is particularly famous for its glasshouse collections (covering an area of 3200 m^2) of succulent plants, especially from Namibia and Namaqualand — including the Desmond Cole *Lithops* collection, and a unique collection of Madagascan succulents established by David Hardy. In the glasshouses and in the garden plantings there are also a number of succulent species (particularly aloes) from east and north-west Africa.

Accession data for all the species in cultivation are available. Unfortunately, the plant records system has not been kept fully up-to-date and many plant labels have been lost or misplaced, making it difficult to relate some plants to their accession data. Attempts are being made to rectify this situation. Specimen vouchers of many of the plants in cultivation in the garden are placed in the National Herbarium located within the garden. This is the largest herbarium in Africa, with over 1.3 million specimens; all the specimen label information is fully computerised. The Herbarium also includes the Mary Gunn Library, which has an excellent collection of works on succulent plants.

There are a large number of threatened plants in cultivation at this garden, including 20 CITES Appendix I species: 15 species of Aloe, 2 species of Madagascan *Euphorbia,* and 3 species of Madagascan *Pachypodium.* In most cases there are only one or two plants in cultivation, but for some species there are large numbers; for example, there are 10 plants of *Aloe descoingsii,* 18 of *A. parvula, 12* of *A. rauhii,* and 55 of *A. suzannae.*

The major collectors who have made significant contributions to the Pretoria collection include D. Cole, R. A. Dyer, D. S. Hardy, D. de Kock, J. Lavranos, G. Prinsloo, H. Toelken, and J. van Zanten.

8. Städtische Sukkulenten-Sammlung Zürich
Mythenquai 88, CH-8002 Zurich, Switzerland. Telephone: 41-l-201-45-54; FAX: 41-l-201-55-40.

The City of Zurich Succulent Plant Collection was founded in 1931 and is operated by the city. It consists of an area of 0.5 hectare (1.24 acres), with nearly all the collection being housed in glasshouses. The succulent collection numbers some 26,000 accessions, amounting to more than 50,000 individual plants. Approximately 20 per cent of the collection is from horticultural origin with no indication of locality. The other 80 per cent have some documentation; 45 per cent of all accessions are directly from the wild (many in the form of seeds); 10 per cent are later propagations of unknown status (mostly supplied by horticultural firms with a collection number); the remaining material is either from seed obtained through controlled pollination, or propagated from cuttings.

Although it has not been calculated, most (if not all) CITES Appendix I succulents are in cultivation. The collection also has 14,000 herbarium specimens and a Cactaceae seed collection, all of which are documented.

The Zurich Succulent Plant Collection is the official repository of the IOS, with its archives, library holdings, and voucher specimens of several research projects.

Collectors who have contributed substantially to the Zurich holdings include E. F. Anderson, P. Bally, U. Eggli, J. Lavranos, W. Rauh, W. Rausch, W. Reppenhagen, F. Ritter, and D. Supthut. In addition, numerous accessions have been received from the International Succulent Institute (ISI; see under The Huntington), as well as obtained or purchased from horticultural firms such as Köhres, Uhlig, Abbey Garden, and from private individuals.

Botanic garden libraries

Most of these botanic gardens have important succulent libraries, which also play a significant role in plant conservation. Plant sciences libraries and librarians in botanic gardens provide important data for plant conservation both through their own individual plant literature collections, as well as through the links of their libraries with records in other botany library collections. Bibliographies and records on both the literature of botany and seed catalogue collections are two important holdings in libraries. Two such works which pertain to rare plant conservation published by The Council on Botanical and Horticultural Libraries (CBHL) are:

1) *Nursery and Seed Catalogs: A Directory of' Collections (in North America). 1985.* Compiled by June Rogier and Mary Lou Wolfe, Librarians, Andersen Horticultural Library (Minnesota) and Pennsylvania Horticultural Society (Pennsylvania) in co-operation with the National Agricultural Library (USA) and Agriculture Canada (Canada).
2) *Endangered Plant Species of the World and Their Endangered Habitats: A Compilation of the Literature. 1985.* By Meryl A. Miasek and Charles R. Long, Library Director, Indiana University (South Bend) and Director of the Library, The New York Botanical Garden (New York).

As an example of the type of information available in botanic garden libraries, the Desert Botanical Garden in the USA maintains a collection in the Richter Library of all seed exchange programs in which they have participated since they began a seed exchange programme in 1965. That is also the first year of publication of the Desert Botanical Garden's *Index Seminum.* Also, its living plant and herbarium accession records are maintained in the Richter Library, dating back to the incorporation of the Garden in the 1930s. Most of these are now in a computer database.

Many botanic gardens also publish records of their collections, which are useful in *ex situ* research. Plant names, locations, old and new maps of plant discoveries, and other records are important information for *ex situ* research. The inclusion of botanic garden libraries and librarians in *ex situ* conservation activities helps insure that these records are preserved for future use.

Hobbyist collections and nurseries

Whereas traditionally one thinks only of botanic gardens and arboreta when considering conservation collections, private hobbyists and commercial nurseries also provide important *ex situ* collections of succulents. The combined activities of succulent plant growers and botanic gardens

with significant collections of succulents, in large part through the encouragement of the International Organization for Succulent Plant Study (IOS), are now resolving some of the impediments listed by Given (1987), namely inadequate documentation and conflicting aims. Moreover, co-operative efforts among institutions and individuals, where they do occur, are making these plants available for research and re-introduction.

Several hobbyists, who are not professional botanists, have significant collections of certain groups of succulents. These collections have extensive documentation and have been used in several cases for major taxonomic studies. The IOS has recognised the importance of these private collections, and has established a Section titled IOS Generic Reserve Collections. For many years the collections at Zurich, Switzerland and Linz, Austria have been recognised as such, and in 1978 four other gardens received this recognition. The IOS set up qualifications and objectives to be met by IOS Generic Reserve Collections (Taylor and Hunt 1988): "a collection must contain material of substantial scientific importance, especially with regard to systematic research and/or conservation in their widest senses." The objectives are (Taylor and Hunt 1988):

1) Emphasis on material of known wild origin; all accessions to be properly documented, with details of donor, field data, and recipients of propagations; secure labelling of plants and regular updating of records is essential.
2) Preservation of voucher material (dried or liquid) for study by taxonomists working with the group concerned, and a photographic record of specimens prior to preservation, or as an alternative to preservation. If the Reserve Collection lacks its own herbarium facilities, preserved materials should be deposited in a well known and responsible institution and a record kept of what has been deposited.
3) Representation of as comprehensive a range of species as possible and willingness to assist specialists who are members of IOS in their research by way of access or loan/gifts of material as appropriate.
4) Active propagation and distribution of rare, scientifically valuable, and endangered species.
5) Willingness to co-operate in studies of floral biology and vegetative growth under artificial conditions towards the objective of making rare or endangered species available to a wider public and thereby relieving the pressure on wild populations.

The following private collections have been approved or are under consideration by the IOS as Generic Reserve Collections (Taylor 1991a):

- Andrea Cattabriga, Bologna, Italy — dwarf Mexican Cactaceae
- Keith Grantham, Luton, UK — *Euphorbia*
- Ben Groen, Wageningen, The Netherlands — *Conophytum, Astroloba*
- Alan Hart, Cheshire, United Kingdom — *Ceropegia*
- Fred Kattermann, Sussex, New Jersey, USA — *Eriosyce, Copiapoa*
- Massimo Meregalli, Torino, Italy — *Copiapoa*
- Roy Mottram, Thirsk, UK — *Cleistocactus, Oreocereus*
- David Parker, Birmingham, UK — *Echinocereus*
- Hans Till, Attersee, Austria — *Gymnocalycium*
- Bernd Ullrich, Pohlheim, Germany — *Agave*
- Richard and Franziska Wolf, Wienderwald, Austria — *Mammillaria*

Fred Kattermann and his collection of *Eriosyce* is an example of a dedicated hobbyist performing exhaustive field work, making detailed records, and writing a noteworthy monograph of the genus (Kattermann 1994). Kattermann spent over 45 weeks in the field during 1977-94, legally collecting approximately 1500 plants from about 500 different populations. Living material was distributed to several institutions for propagation, and herbarium specimens were prepared and given to the Desert Botanical Garden and The New York Botanical Garden. In addition, he collected living plants of 20 other genera, most of which have been given to the Desert Botanical Garden. He has willingly provided material to researchers throughout the world.

E. F. Anderson

Astrophytum asterias in a cactus nursery, Kurashiki, Japan.

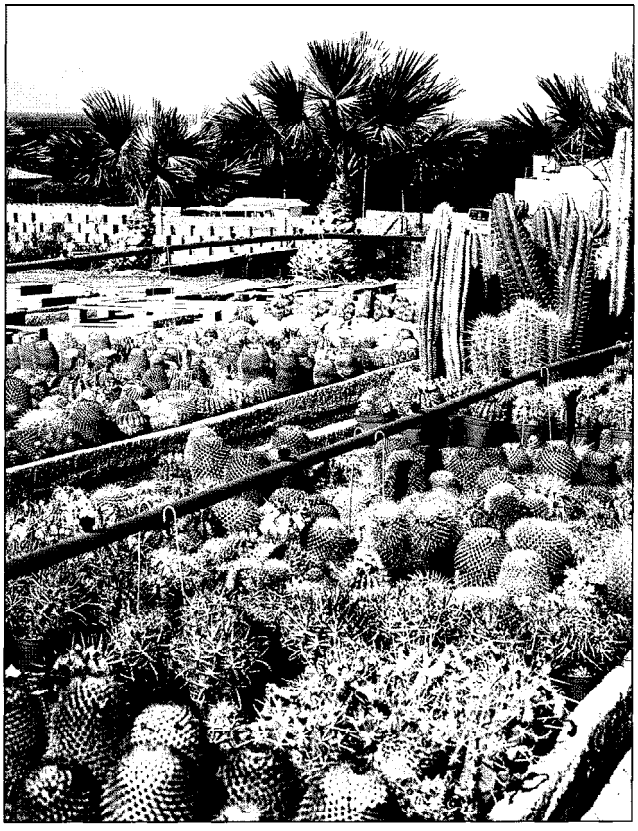
Other collections have been critical for taxonomic studies. The Meregalli collection was the basis for an extensive paper on *Copiapoa* (Meregalli 1991), and the *Echinocereus* collection of David Parker was used by Nigel Taylor to supplement his field work in his significant monograph of the genus (Taylor 1985).

Clearly, hobbyist collections are a significant source of germplasm of rare and endangered succulents. The programme established by the IOS to insure the proper maintenance and documentation of these collections must be encouraged, as well as the implementation of an effective networking among researchers, institutions, and the hobbyists.

Some commercial nurseries specialise in the propagation and sale of specific groups of succulents. Many of their propagated plants are derived either from seed or cuttings, from field collected, or documented material. These stock plants, and succeeding generations, can provide a significant source of germplasm for rare and endangered succulents. However, while sometimes reducing demand on wild stock, nursery collections do not necessarily contribute to the genetic and demographic management of threatened plants. Nursery collections of propagules and their artificial propagation for commercial purposes must go hand in hand with providing safeguards, through botanic gardens and seed banks, for tracking and insuring that propagules will be available for research and long-term preservation, and thus contributing to *ex* situ conservation.

Several commercial nurseries have stocks of rare succulents with documentation. Mesa Garden in Belen, New Mexico provides an example of the roles that some of these commercial businesses have in both in situ and *ex* situ conservation. This nursery arose from Steven Brack's strong interest in growing succulents from seeds, and was stimulated by his membership in the African Succulent Plant Society and its biennial seed distribution. In 1973 the nursery began using seeds collected from habitat primarily within the state and documenting their source for sales. Starting in 1975, he began to make extensive collections of seeds in Mexico. These collections form the core of Mesa Garden, and their first seed list of 1980 had approximately 1000 offerings.

In 1980 Brack joined with Steven Hammer, a specialist on Old World succulents, to collect seed, especially of the mesembs, in South Africa. They encountered the very rare *Conophytum angelicae* on one of their trips and were able to collect nine seeds. From those few propagules Mesa Garden has now produced several generations of the plant, with a production of several thousand seeds annually. This has significantly reduced the impact of collectors decimating the remaining *in situ* population of this species. Brack has also assisted the US Fish and Wildlife Service in the propagation of a rare cactus *Pediocactus knowltonii* for re-introduction back into its natural habitat.



W. Strahm

Guimar nursery, Tenerife, Canary Islands.

From its very beginning, the Mesa Garden nursery has emphasised the propagation and sale of seedlings and seeds with habitat data. In several instances seed of the same species are offered from different localities, thus providing germplasm variability. Mesa Garden now has a comprehensive collection of mesembs, as well as hundreds of cacti from both North and South America. This nursery has provided research materials to numerous scientists throughout the world.

It should also be noted that the cooperative *ex situ* activities of botanic gardens and nurseries have meant that several succulent species, now virtually extinct in the wild because of extensive habitat destruction, are widely represented in cultivation. Two examples are *Astrophytum asterias* and *Echinocactus grusonii.*

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Chapter 3

Regional Accounts

Tropical Africa

Sara Oldfield

The vegetation of Africa includes sixteen broad vegetation types recognised by White (1983). Woodland and grassland are predominant. Succulent plants are found in most vegetation types but are rare in the high forests of West Africa and uncharacteristic of miombo woodland.

White (1983) recognises ten regional centres of endemism for Africa. Succulent plants are particularly important in the Somalia-Masai, Cape, Karoo-Namib, East Malagasy, and West Malagasy regional centres of endemism. The Somalia-Masai region, covering Ethiopia, Somalia, Kenya, and northern Tanzania is the main area of succulent plant diversity in tropical mainland Africa. Between this region of East Africa and the rich southern Africa flora there is a marked decrease in succulent plant diversity determined primarily by climatic factors. In central Africa there is a much more marked summer rainfall allowing the build up of woody biomass and a long enough dry season to allow regular burning of the ground layer. As a consequence countries such as Tanzania, Zambia, and Zaire are relatively poor in succulents. In this region the Asclepiadaceae, for example, are poorly represented.

Box. 3.1 Main African vegetation types and their succulent diversity

Woodland
Open stands of trees at least 8 m tall, with a canopy cover of 40 percent or more, with a field layer usually dominated by grasses. Nearly all types are deciduous or semi-deciduous with some evergreen species. Woodlands are widespread in tropical Africa and are especially characteristic of the Sudanian and Zambezian regions with their continental climates and moderate precipitation falling in the summer. Succulents are relatively poorly represented.

Transitional Scrub forest
Intermediate between forest and bushland and thicket and often dominated by tree-like species of Aloe and *Euphorbia.*

Bushland and thicket
Bushland includes open stands of bushes, usually between 3 and 7m tall and with a canopy cover of 40 percent or more; in thicket the stands of bushes are closed. Both types are found under a wide range of climatic and edaphic conditions which are unfavourable for tree growth. They are most frequent in areas where annual rainfall is 250-500mm and of irregular occurrence or where there are two pronounced dry seasons. Deciduous bushland and thicket is extensively developed in the Somalia-Masai region; evergreen and semi-evergreen bushland and thicket is found in the Cape, coastal east and south-east Africa and associated with the drier types of montane forest.

Shrubland
Open or closed stands of shrubs up to 2m tall. The most extensive shrublands are in the Karoo-Namib region and in the Cape (fynbos). Shrublands also occur in montane and Afroalpine regions. In the latter they are typically dwarf and form but one component of a diverse range of communities.

Grassland
Land covered with grasses and other herbs, either without woody plants or the latter not covering more than 10 percent of the ground. Edaphic grasslands are widespread throughout Africa and include vast areas in the Serengeti (developed on volcanic deposits and maintained as grassland by grazing), grasslands associated with seasonally or permanently waterlogged soils and also secondary grassland, which has replaced forest or woodland after human intervention (such as burning and cultivation).

Wooded grassland
Land covered with grasses and other herbs, with woody plants covering between 10 and 40 percent of the ground. This is the most widespread vegetation in the Sahel and in the Kalahari part of the Kalahari-Highveld zone. It is also common in the Sudanian and the Zambezian regions.

Deserts and semi-deserts
Arid landscapes with a sparse plant cover, except in depressions where water accumulates. Semi-desert vegetation begins to occur when the mean annual rainfall drops below c. 250mm, e.g. in parts of the Karoo-Namib, Somalia-Masai, and the Sahel and on the margins of the Sahara Desert. True deserts include the Sahara, the floristically richer Namib Desert, and parts of northern Kenya.

In recent years tropical rain forest vegetation has received much conservation attention. Arid vegetation types, however, may also be very rich in plant species and under threat. The Karoo, for example, an area of semi-desert, contains a wealth of succulents and other xerophytic plants. Similarly, arid areas on the Somalia/Kenya/Ethiopia border and in the rainshadows of the Eastern Arc mountains in Tanzania (see Lovett 1988) exhibit high levels of endemism at the level of the plant species. Fynbos, the evergreen bushland and thicket of the Cape region, has the highest concentration of species per unit area in the world: 8550 vascular plant species in 89,000 km^2 (Goldblatt 1978).

The vegetation of Africa has been modified by human influence over many thousands of years. In recent years the scale of destruction of semi-arid, woodland, and forest ecosystems has assumed major proportions. The deterioration of dry lands may not perhaps be so immediately obvious as forest destruction, but it is nevertheless as serious, both for local inhabitants and for maintenance of plant species diversity. Generally, the best preserved semi-arid and arid vegetation types can now be found only in remote areas or in national parks, far from any artificial water supplies.

Somalia-Masai regional centre of endemism

The Somalia-Masai vegetation group of White (1983) includes virtually all Somalia, much of Kenya and Ethiopia, together with the arid northern portion of Tanzania and north-western Uganda. Within this section the succulent floras of Ethiopia, Kenya, and Somalia are considered further. The entire Somalia-Masai vegetation group is considered to be one of Africa's ten regional centres of endemism. There are about 4000 vascular plant species in the region with 31 per cent endemism. There are many endemic succulents (e.g. stapeliads).

The main vegetation type is deciduous bushland, dominated by *Acacia* and *Commiphora*. This can vary from open bushland 3-4 m tall to almost impenetrable thicket some 10 m tall. A subtype on limestone and gypsum includes many local endemics. Enclaves within this type are riparian forest and semi-evergreen bushland on hills and the lower slopes of mountains. Semi-desert grassland and shrubland occur in low rainfall areas.

Overgrazing caused by large-scale herding of animals (cattle, camels, goats) has transformed the original vegetation in many areas. This has become particularly severe in recent years due to increase in population and recurrent droughts. Areas near permanent wells or waterholes are the most affected. Also, over vast areas, the deciduous bushland has been converted to secondary bushed grassland by temporary agriculture or the cutting of fuelwood for charcoal-burning.

Less than five per cent of the unit is included in protected areas (MacKinnon and MacKinnon 1986). Many large national parks have been established in eastern Africa, mainly for the protection of spectacular concentrations of wildlife in savanna habitats. There are, however, no conservation areas in the Ogaden region of Ethiopia, Kenya, and Somalia, for example, which arc important for succulents.

Kenya

Kenya has in total about 6000 flowering plant species. Inventories of species are relatively complete with the major exception of the undercollected north-east region. The full distribution of most plant species is, however, not known. Three-quarters of Kenya's land area comprises arid or semi-arid ecosystems. Plant endemism is high, especially if regional endemics are included in the totals (National Biodiversity Unit 1992). Inselbergs in semi-arid areas are botanically important sites. There are 364 indigenous taxa of succulents in 22 plant families reported for Kenya (Wabuyele, in *litt.* 1997; see Box 3.2).

Threats to the succulent flora

Habitat destruction through processes such as agricultural development, building construction, and expansion is the main threat to succulent plants in Kenya (Newton 1995). Grazing is a particular threat to succulents such as *Caralluma* spp. which are not protected by spines or the presence of unpalatable substances such as the latex of *Euphorbia* spp.

Commercial exploitation is another significant factor affecting certain succulent species. Collection of Kenyan succulents for the export market is not thought to take place on a major scale, but there is some collection of rare and unusual succulents for specialist growers overseas. Undescribed species of *Raphionacme* are, for example, currently offered by a specialist succulent trader in Germany. Other species of Asclepiadaceae have also been threatened by overcollection including *Huernia* spp., *Caralluma* spp., *Echidnopsis dammanniana,* and *Edithcolea grandis.*

Exploitation of native *Aloe* spp. has also been a threat to wild populations. Plantations of *Aloe* spp. were first established near Mombasa in 1986 following the Presidential decree protecting wild populations from harvesting for leaf exudates. Unregulated initial stocking and restocking of these plantations is probably still depleting wild *Aloe* populations. A plantation in northern Kenya was established by transplanting wild plants resulting in considerable harm to wild populations (Newton 1991). Field observation has shown that the law is rarely observed and there is evidence of continuing illegal harvesting. In some areas of Kenya harvesting from the wild appears to do little harm to populations because almost all defoliated plants survive. In other areas, it has been reported that wild plants have been completely destroyed by harvesting activity. In the Baringo area of Kenya, collection of *Aloe* leaf is causing serious damage to wild populations. Local people are paid Ksh 20 for 20 litres of leaf extract (£1 = Ksh 66) which would involve harvesting several hundred plants (Newton, *in litt.* to S.

Oldfield, WCMC, 1992). The main *Aloe* species exploited in Kenya is *A. secundiflora*, although *A. turkanensis* is also thought to be used. Exploitation is all for export, with no company using *Aloe* exudate to manufacture products within the country (Newton, *in litt.* to S. Oldfield, WCMC, 1992).

The conservation status of Kenyan succulents

Various partial lists of threatened plants have been produced for Kenya. The most recent list compiled within the country includes succulent species in the families Crassulaceae, Aizoaceae, Portulacaceae, Euphorbiaceae, Asclepiadaceae, and Liliaceae (Luke 1991). WCMC holds records of 82 threatened succulent species of Kenya in the latter three families. Recent consultation with the National Museums of Kenya Plant Conservation and Propagation Unit resulted in a target list of species known to be under threat in their natural habitat, though the conservation status of many others are not known (Newton 1995). In this list 67 taxa have been given top priority status, in most cases because of threats to habitats (Annex 4). Data sheets on three Kenyan succulents are included in the *IUCN Plant Red Data Book* (Lucas and Synge 1978). These are *Caralluma distincta, C. tubiformis,* and *Euphorbia wakefieldii.* These remain top priorities for conservation attention.

Priority sites for conservation

Upland grassland areas, especially those with impeded drainage 'vleis', support interesting and very rare plant species such as *Brachystelma keniense* and should be protected.

Existing conservation measures

Kenya has a protected area network covering over seven per cent of the total land area. The protected areas are biased towards savanna/semi-arid areas with significant populations of large mammals. Most protected areas suffer damage through encroachment, poaching, pollution, or overuse by tourists (National Biodiversity Unit 1992). Desert areas are inadequately represented in the protected area system. Small areas of lava desert are protected in the Marsabit and S. Turkana National Parks. More areas for protection should be identified in the Chalbi and Koroli deserts (Mackinnon and Mackinnon 1986).

There are various categories of protected areas in Kenya. Under the Wildlife (Conservation and Amendment) Act 1976, as amended, the following may be designated:

- National Parks - vegetation is protected from cutting, injury, 0r setting fire; no clearance or cultivation is allowed.

Box 3.2 Kenya Succulent Species Conservation Project

This Project, initiated mid-1996 under the direction of the Plant Conservation Programme (PCP) of the East African Herbarium, holds as its objective to facilitate conservation of Kenya's succulent plant taxa. The working document for this project is a report by Prof. Len Newton (1995) entitled "Succulent Species in Kenya", prepared as a contribution to this Action Plan. In the report Newton documents 364 succulent taxa in 22 families in Kenya. Here 67 taxa, representing 12 families, are listed as being rare and /or endangered (Annex 4). These taxa comprise the target PCP list for formulation of conservation action. There are 23 taxa for which the conservation status is unknown and these will receive primary attention.

The project objectives, some tasks for which have already been completed, are as follows:

- Document type specimens and duplicates for succulent plant species in the East African Herbarium,
- Determine how many type localities have been destroyed and whether those remaining are threatened,
- Develop a specimen database for threatened taxa,
- Assess the pressure on wild populations and the present conservation status of taxa known from only one locality,
- Collect germplasm for ex *situ* conservation and propagate in cultivation those taxa that are rare and under threat in their natural habitat, and
- Document species in trade and / or cultivation as a guide to monitoring exploitation pressure.

Field surveys are aimed at verification of the extant populations of targeted taxa and evaluation of their current conservation status; documentation of threats to each of them; collection of stocks for ex *situ* conservation and collection of herbarium specimens for further research.

It has been noted from analysing the collection database that there is a lack of adequate and accurate information on distribution of most taxa. Collections occur mostly around Central Kenya, the lower Rift Valley, and Western Kenya. In order to reach any meaningful consensus on the conservation status of these taxa it will be important to take complete inventory of the under-collected regions and protected areas. Areas of high succulent diversity should be identified and subsequently conserved.

In relation to the trade of succulents, the Project wishes to develop a dataset of species in cultivation in nurseries, conduct a survey on international traded for the Kenyan taxa, and develop a list of rare and endangered taxa for CIT-ES in country policing.

Submitted by Emily Wabuyele, East African Herbarium.

- National Reserves - less strictly controlled with other land uses permitted, for example, traditional grazing rights and water rights are protected.
- Local Sanctuary - vegetation is not protected.
- Protection area - adjacent to national parks, national reserves, or local sanctuaries, they are legally declared to protect species, habitats, and ecology.

Under the Forests Act 1942, as amended, Forest Areas or Central forests are designated and also Nature Reserves which are strictly protected sites within forest reserves.

Succulent plants are represented within many of Kenya's protected areas. Usually, however, plant species inventories are not available, so it is difficult to assess to what extent rare and threatened species are protected.

Examples of protected areas important for succulent plant conservation include the following:

- Mount Kulal Biosphere Reserve - succulent *Euphorbia* spp.
- Amboseli National Park - four types of semi-arid vegetation.
- Hell's Gate National Park - situated south of Lake Naivasha in the Rift Valley. There is a wide variety of succulents in the area.
- Mount Suswa - proposed extension to Hell's Gate National Park, in Nalvasha District.
- Mutomo Plant Sanctuary - degraded site covering 16 ha in Kitul District. This was first established in 1964 as a joint enterprise between the County Council of Kitul and the Kenya Horticultural Society. The Sanctuary protects a range of interesting succulent plant species in situ and also provides a site for *ex* situ conservation of plants from other semi-arid parts of Kenya.

Ethiopia

The flora of Ethiopia consists of about 5765 flowering plant species of which 10-20 per cent are endemic. Endemism is particularly high in the sub-desert Ogaden in the south-east as well as in the forests of the south-west. There are also local centres of endemism in the mountains of Ethiopia.

Ethiopia shows a considerable variety of habitats, most of which have at least some succulents growing in them. In very simplistic terms the country can be divided into four main areas:

Central highlands — the Semien Mountains rise to 4600 m in the north and in the south there is an extensive plateau at over 4000 m. Convenient divisions can be made at very approximately 1500 m as the bottom limit, and at about 3500 m between a lower Afromontane area and an upper Afroalpine area.

The Afroalpine areas are occupied by *Erica* bushland at lower altitudes and moorland at higher altitudes and in areas of poorer drainage. Succulents are restricted to a few species of Aloe, all endemic, and a variety of Crassulaceae, with several endemic species of *Sedum, Umbilicus botryoides,* the very distinctive endemic *Rosularia simense, Aeonium leucoblepharum* and the endemic genus *Hypagophytum semiense.* The latter two also extend down into the Afromontane zone where conditions permit.

The Afromontane area is mostly densely populated and intensively cultivated with only remnants of the original vegetation below 3500 m. Many of the lower parts were probably at one time forested, but now only remnants of the original forest are left. These were probably mostly dominated by *Juniperus* procera and *Olea europea* ssp. *africana.* In the south and west the rainfall is higher and more reliable and *Podocarpus gracilior* is often a major component of the forests whilst in the extreme south-west, at rather lower altitudes and higher rainfall, a depauperate Guinean - Congolan forest type is still to be found characterised by various species of *Celtis* and *Trilepisium madagascariensis.* The forested areas are relatively poor in succulents though the consistently epiphytic endemic *Sedum epidendrum* is a notable exception and *Euphorbia ampliphylla* can be an important component tree, reaching a height of at least 24 m. *Euphorbia ampliphylla* is often used to form living hedges. Succulents are most common on rocky slopes and it seems rather clear that some groups, most notably various *Aloe* species have benefited from the creation of such habitats by forest clearance. *Kalanchoe,* including the endemics *K. schimperiana* and *K. petitiana,* are often common at thicket margins.

Western lowlands — The flora of these areas has very strong affinities with the flora of West Africa with many species reaching their easternmost limit in Ethiopia. The area is not well known, but the indications are that relatively few succulents occur. Much of the area is occupied by wooded grassland subject to regular burning which will kill the majority of succulent plants. *Portulaca foliosa s.* str. is one succulent that does occur and provides a good example of the western affinities of the area - the type was collected in Ghana. The name has been used in East Africa, but closer examination has shown that such material is not conspecific with the West African plant.

Eastern lowlands — The area between the highlands and the Red Sea is mostly occupied by the Afar Depression, a true desert with vast salt deposits and rather few plants of any kind. Ecologically, the most important group of succulents are members of the Chenopodiaceae which are often dominant in the moister, usually saline areas. Some stapeliads are found in suitable situations, but these are nearly all species much better represented to the south, only *Caralluma edulis* has not been recorded from elsewhere. Similarly, a few species of *Euphorbia* are found but only *E. triaculeata* is restricted to the area. There is a tendency for the eastern escarpment of the highlands to

receive a significant portion of their rainfall in winter and this is reflected in the occurrence of plants with distinct Mediterranean affinities. Amongst these is an ephemeral *Sedum* related to S. *hispanicum*.

Southern and south-eastern lowlands — These include a wide variety of deciduous bushland and woodland belonging to the Somali-Masai vegetation group. The vast majority of Ethiopian succulents are found in this area, with only the Crassulaceae and possibly *Aloe* better represented elsewhere in the country. The dominant trees and shrubs throughout the region are species of *Acacia* and *Commiphora,* but species of succulent *Euphorbia* are often dominant locally. There are many areas which are rich in succulents and even areas where stapeliads such as *Caralluma penicillata* are locally subdominant.

The succulent flora

The major problem in drawing up a list of Ethiopian succulents is deciding on what should be included, as there are large numbers of semi-succulent species. A list of some important genera within the families containing succulents is presented in Table 3.1.

Threats to the succulent flora

Commercial exploitation **—** To date there is relatively little evidence of specific commercial exploitation of succulents. The notable exception may be *Euphorbia abyssinica* which in the past was the primary source of matchwood in Ethiopia. The current situation is unclear but there are still large populations of this species over a major part of the country. The commercial collection of *Aloe* for the pharmaceutical industry appears to have been very restricted, in marked contrast to Kenya.

The biggest potential threat must be from succulent collectors. Some Ethiopian endemic succulents are amongst the most desirable of all collectors' plants, most notably *Euphorbia piscidermis* and *E. gymnocalycioides*,

Table 3.1 Succulent flora of Ethiopia

Aizoaceae	Seven genera and perhaps 13 species, only **3** or 4 species of *Delosperma* are of horticultural interest. Only 1 of these, *D. nakurense*, is relatively well known.
Aloaceae	**38** species of Aloe, 22 endemic, mostly at higher altitudes, some known from rather few localities, but none vulnerable and some extremely abundant.
Asclepiadaceae	Many non-succulent.
Cactaceae	*Rhipsalis baccifera* native to south-west forests; *Opuntia* at least 3 species growing as weeds, one exploited locally for fruits.
Crassulaceae	Ethiopia has the greatest number and diversity of *Sedum* spp. of any African country (Gilbert 1985).
Cucurbitaceae	Most species not succulent; *Momordica rostrata* and *Cephalopentandra ecirrhosa* with well-developed succulent caudexes, and *Mukia pallidinervia* a true leaf succulent.
Euphorbiaceae	Three genera include succulents: *Euphorbia, Monadenium,* and *Jatropha. Euphorbia* is the largest genus within Ethiopia, and also includes the largest number of succulents. The exact number depends largely on what definition is used for succulence, there being a number of marginal species. The largest group are the 45 species, 15 endemic, belonging to the all succulent subgenus *Euphorbia;* subgenus *Lacanthis* has 4 species, 3 endemic; subgenus *Esula* has 3 good succulents plus a number of marginal succulents,
Geraniaceae	Most species of *Pelargonium* at least slightly succulent; only one of the Ethiopian species, *P. boranense,* a local endemic from southern Ethiopia, of interest to general collectors because of the succulent stem and very large bright red flowers.
Passifloraceae	Two species of *Adenia* having true succulents - *A. venenata* and *A. aculeata;* others subsucculent, most notably *A. ellenbeckii*, or not succulent.
Piperaceae	Eight species of epiphytes, none endemic, all widespread in Africa and sometimes further afield.
Portulacaceae	*Talinum: 3* species, 7. *portulacifolium* common and widespread; *Calyptrotheca somalense* at least locally common in western Sidamo and Gamo Gofa - apparently with a short flowering period and probably under-recorded; *Portulaca:* 15 species, some rather poorly known, others widespread, including a troublesome pantropical weed.
Vitaceae	Most non-succulent, no succulents endemic, some species of *Cissus* leaf-succulents (C. *rotundifolia*) or stem succulents (C. *Cactiforme, C. quadrangulare, C. quinquangulare*); *Cyphostemma betiforme* a stem succulent restricted to gypsum areas of the south-east.

and there is no doubt that most these would be very vulnerable to any kind of commercial collecting. It is vital that such exploitation should be very strictly controlled.

Agriculture — Habitat degradation from agriculture is obviously a threat to many succulents, but it is probably not of very great importance within Ethiopia. Most species are found in areas not suitable for cultivation and indeed some species, most especially some of the more shrubby *Aloe* species, have probably extended their ranges in parts of the country where denudation by erosion following cultivation has created extensive open rocky slopes.

Overgrazing — Overgrazing is a problem in some areas, but in many cases succulent species survive surprisingly well wherever there is some protection by rocks and unpalatable shrubs.

Introduced species — *Opuntia* cf. *dillenii* and two or three other species are a major weed problem in some areas but there is some evidence to suggest that native succulents are at least sometimes able to benefit from the shelter these spiny plants can offer.

Conservation status of succulents

A comprehensive listing of the conservation status of Ethiopian succulent plants has not yet been prepared. WCMC holds records of 76 nationally threatened succulent species of Ethiopia.

Existing conservation measures

Most major conservation areas have been identified and provisional or nominal protection implemented. Ethiopia's protected areas consist of national parks, sanctuaries, wildlife reserves, and controlled hunting areas. Only two national parks, Awash and Simen Mountains, have been legally gazetted.

All the national parks contain some succulents. Political upheavals and lack of resources have made the effectiveness of these parks open to question, but there is no doubt that they will offer some protection from agricultural development, probably the greatest overall threat to succulents within Ethiopia. The Semien Mountain National Park includes the type localities of many Ethiopian high-altitude endemics including *Rosularia simensis, Hypagophytum semiense,* and probably *Aloe steudneri.* Awash National Park includes the type localities of *Pachycymbium sacculata* and *Euphorbia awashensis.* Quite a number of other succulents also occur within this park.

The Mago National Park, which is not yet gazetted, has *Euphorbia grandicornis, E. scoparia, Sansevieria* spp, and *Adenium obesum.* Nechisar National Park, also not yet gazetted, has fine stands of *Euphorbia tirucalli.*

Somalia

Somalia has approximately 3000 flowering plant species of which about 500 are endemic. Highly specialised vegetation types within the country support many endemic xerophytic plant species suggesting that arid climatic conditions have remained unchanged for long periods of time.

The vegetation of Somalia consists mainly of *Acacia-Commiphora* deciduous bushland and thicket particularly in the south. There are large areas of semi-desert grassland and deciduous shrubland in the north and extending south along the coast.

The north-east of Somalia (Cal Madow mountains) is particularly rich in succulent plant diversity and is considered to be an internationally important centre of plant biodiversity (WWF and IUCN 1994). Specialised limestone habitats, with outcrops of pure gypsum, harbour many endemic species. Some of these species have been known only from single collections by early naturalist explorers and many others have only been discovered in the past fifteen years. The bush-covered plains of southern Somalia have succulents in common with south-east Ethiopia and the better-known region of north-east Kenya. There are also local endemics confined to isolated coastal outcrops or coastal dunes.

Threats to the succulent flora

Desertification threatens species of the succulent scrub. Somalia has the greatest proportion of pastoralists in Africa, and livestock accounts for 40 percent of the country's GNP. Overgrazing is the dominant threat to natural habitats and the succulent species which they contain.

Some succulent species are able to withstand grazing pressures. *Aloe* spp. are, for example, generally unpalatable. *Aloe megalacantha* invaded extensive areas following removal of woody vegetation by livestock, for example, on the plains surrounding the war-stricken city of Hargeisa. Other species of *Aloe,* such as *A. pirottae* and *A. peckii* are, however, adversely affected by grazing pressures. These two species only grow in the shelter of bushes and once the vegetation is removed the species become progressively rarer. Other succulent species are particularly susceptible to grazing pressures, for example, Asclepiads which are not spiny or protected by poisonous substances. *Euphorbia columnaris,* endemic to a small area in north-east Somalia is almost extinct because overgrazing has led to soil erosion. Plants of the species have weak root systems which are unable to support mature plants once the soil is eroded.

War in the Horn of Africa has lead to the disruption of traditional grazing regimes leading to further environmental instability. The flow of refugees into northern Somalia has lead to destruction of vegetation for kilometres around the camps (Hutchison 1991).

Table 3.2 Succulent genera of Somalia

Family	Genus	No. of species
Aizoaceae	(Aizoon)	1
	Sesuvium	2
	Trian thema	5[1]
Aloaceae	Aloe	27
Apocynaceae	Adenium	3
Asclepiadaceae*	Calo tropis	1
	Caralluma	17+2 (7 endemic)
	Ceropegia	6
	Cryp tolepis	3+1
	Curroria	2
	Cynanchum	8
	Diplos tigma	1
	Dregea	3
	Duvalia	3
	Echidnopsis	12+1
	Edithcolea	1
	Glossonema	4
	Gomphocarpus	3
	Huernia	3
	Kanahia	1
	Leptadenia	3
	Odontan thera	1
	Orbea	1
	Oxys telma	1
	Pen tarrhinum	2
	Pen ta tropis	2
	Pergularia	2
	Periploca	3
	Pleuros telma	1
	Pseudolithos	4
	Pseudopectinaria	1
	Raphionacme	1
	Rhytidocaulon	2+1
	Sarcostemma	2
	Secamone	1+1
	Socotora	1
	Strobopetalum	1
	Tacazzea	1
	Tenaris	2
	Vince toxium	1
	Whitesloanea	1
Crassulaceae	Aeonium	1
	Cotyledon	1
	Crassula	3
	Kalanchoe	12
	Sempetvivum	1
	Umbilicus	1
Euphorbiaceae	Euphorbia	99+3[5] (>50% endemic)
	Monadenium	3
Portulacaceae	Anacampseros	+1
	Calyp tro theca	1
	Portulaca	9[1]
	Talinum	3+1

Note: * in need offurthertaxonomic work

Source: Kuchar 1985

Conservation status of succulents

Although a comprehensive listing of the conservation status of succulent plants of Somalia has not yet been prepared, IUCN categories have been applied to a number of succulent species, especially in the genera *Euphorbia* and *Aloe*. WCMC holds records of 61 nationally threatened succulent species for the country. Data sheets on *Euphorbia cameronii* and *Whitesloanea crassa* are included in the *IUCN Plant Red Data Book* (Lucas and Synge 1978). The genus *Pseudolithos* is endemic to Somalia. All four species of this genus are rare and severely threatened. In general, many of the asclepiads of Somalia are considered to be exceedingly rare (Kuchar 1986). The low representation of stapeliads in herbarium collections may be because the small populations initially located have been decimated by intensive grazing and erosion (Kuchar 1986).

Priority sites for succulent plant conservation

Four centres of endemism and plant diversity for Somalia are given in *Centres of Plant Diversity* (WWF and IUCN 1994). These are Hobyo, the Cal Madow mountain range, the fixed dune vegetation in southern Somalia, and the Nugaal Valley.

Hobyo — The area around Hobyo (Obbia) in the Mudug Region of central Somalia, covering around 3000 km^2, consists of a coastal plain with dunes and areas of limestone pavement, particularly in the north; a low limestone escarpment running more or less parallel to the coastline; and a low plateau further inland. The limestone escarpment reaches about 440 m south-west of Hobyo. It is dissected by deep gorges which run approximately east to west. The gorges contain seasonal streams. The vegetation of the coastal plain is open and treeless with a low vegetation of grasses, herbs, and shrublets. The limestone escarpment is covered with a species-rich *Acacia-Commiphora* bushland and the inland plateau also has bushland and woodland dominated by species of *Acacia* and *Commiphora*. The area is still relatively inaccessible and in need of further botanical study. Succulents are frequent. The threats to the flora are not particularly severe at present, although the effects of over-grazing and cutting of woody vegetation for fuelwood are damaging in some places. Fortunately, the most botanically interesting vegetation, that of the dunes and limestone gorges, is still largely intact. Parts of the area have been proposed as a Game Reserve.

Cal Madow — As mentioned above, the Cal Madow (Al Medu) mountain range, a large area which extends right up to the north-east corner of Somalia, is an internationally important centre of plant endemism. This remote area is relatively sparsely populated and was apparently untouched by the recent war. The region consists of a coastal plain bordering the Gulf of Aden, locally known as the "Guban", and an uplifted limestone plateau lying to the south and dipping to the south-east.

The plateau scarp reaches 2416 m at Shimbiris (the highest point in Somalia), to the north-west of Ceerigaabo.

The vegetation of Cal Madow varies greatly according to altitude and rainfall and includes coastal plain of desert or semi-desert, with little or no vegetation; the subcoastal zone with sparse to dense, primarily woody vegetation; slopes of the escarpment covered by a macchia-like evergreen or semi-evergreen scrub which, at higher elevations, grades into remnants of *Juniperus* forest degraded by logging. To the south of the escarpment, vegetation consists of severely degraded open woodlands.

Examples of phytogeographically interesting succulent species present in Cal Madow include *Aeonium leucoblepharum* and *Euphorbia balsamifera.* Several succulent *Euphorbia* spp. are endemic.

The most interesting vegetation along the escarpment is still largely intact and threats to the flora are not particularly severe at present. Daalo Forest Reserve, to the north of Ceerigabo, and the surrounding mountain area have been proposed for protection as a national park. However, at present there are no functioning nature reserves in Somalia.

Fixed dune vegetation in southern Somalia — This vegetation supports xerophytes and succulent species of many genera. Large, fixed and vegetated dunes occur in southern Somalia along the Indian Ocean from south of Hobyo to just south of the border with Kenya. These are mostly 10-15 km wide and between 20 and 60 m high. Some dunes have been deprived of their vegetation by overgrazing and are moving inland. The vegetation consists of *Acacia* bushland. There are more than 200 vascular plant species, with over 20 strict endemics and a number of endemic subspecies. Some of this vegetation should be protected by the proposed Lag Badana Bushbush National Park.

Nugaal Valley — An arid area along the Wadi Nugaal, about 250 km long. The western part consists of massive deposits of gypsum and anhydrites, while the coastal part is mainly limestone. The vegetation consists of open semi-desert grassland or bushland. The succulent flora is particularly rich with a number of local endemics. Priority sites associated with the Wadi Nugaal include the gypsum hills around Las Anod where the sparse degraded vegetation supports a rich endemic succulent flora with *Aloe inermis, Dorstenia gypsophila, Adenia aculea ta, Raphanocarpus stefaninii, Euphorbia columnaris, Pterodiscus,* and *Caralluma* spp. The Las Anod National Park has been proposed by Bally and Melville (1973) to protect fine scenery, rich and varied flora, and the Somali wild ass *(Equus asinus somalicus).* They also suggest that a fenced floral reserve be created for *Euphorbia columnaris.* The limestone plateau to the north of Eil is another area rich in succulent plants including many endemics and has been proposed as a national park by Bally and Melville (1973).

Other priority succulent sites include:

- Gaan Libah Forest Reserve — *Aloe jucunda, Aloe hildebrandtii, Euphorbia abyssinica, Kalanchoe* spp., *Echidnopsis* spp.; proposed as a national park by Bally and Melville (1973).
- Sheikh Pass area in the Golis Mountains — rich in endemic species; *Whitesloanea crassa, Pseudolithos cubiformis, Euphorbia phillipsiae, Aloe somaliensis, Aloe hemmingii, Euphorbia inculta, Edithcolea grandis, Monadenium ellenbeckii, Kleinia gunnisii,* and *Echidnopsis cilia ta.*
- Molidera Hills — two gypsum hills 58-62 km south of Erigavo on the road to El Dab; *Aloe molederana, Pelargonium christophoranum, Dorstenia gysophila,* and *Dracaena ombet;* floral reserve suggested by Bally and Melville (1973).
- Bulo Burti — limestone ridge with rich flora including *Monadenium stellatum;* floral reserve suggested by Bally and Melville (1973).

Existing conservation measures

Somalia lacks any organised protected area system to conserve its critical sites. Of the conservation areas established and proposed since 1969 only Balcad and Alifuuto Nature Reserves are currently functional, and plans have been prepared for the proposed Lag Badana-Bushbush National Park. The legal establishment of all conservation areas in Somalia would result in more than eight per cent of the total area being covered. In addition, there are 27 'protected forests' and grazing reserves established to protect grazing lands (WCMC 199 1).

The author would like to thank Mike Gilbert and Susan Carter-Holmes for the provision of information and suggestions for this account; the Plant Conservation Programme of the National Museums of Kenya has also provided valuable information. The Protected Areas Unit of WCMC is also thanked for the provision of information.

Madagascar

Sara Oldfield and Diedrich Supthut

Madagascar has an extraordinary flora, rich in endemic taxa. Out of an approximate total of 7600 endemic plant species, over 600 are succulent plants. The succulent flora of the island is of great value botanically, ecologically, and economically, and yet it is one of the most endangered succulent floras of the world.

The succulent plants of Madagascar are listed in Annex 7. The family Didiereaceae (see Box 3.3) is endemic to Madagascar and a number of succulent genera in other families are restricted to the island. New succulent species and varieties continue to be discovered and, despite the level of international botanical and horticultural interest in the group, the taxonomic status of many Madagascan succulents remains poorly known.

Box 3.3 Didiereaceae, a succulent family endemic to Madagascar

The Didiereaceae Drake is a small family endemic to Madagascar consisting of four genera, *Alluaudia, Alluaudiopsis, Decaryia,* and *Didierea,* with eleven species. The spiny cylindrical or conical pachycaul stems of the plants give a superficial resemblance to columnar species of *Euphorbia* or cacti and the Didiereaceae are sometimes known as "the cacti of the old world". The stems are woody, and scarcely succulent, with limited space for water storage. The plants have simple, deciduous leaves, except for *Alluaudia dumosa,* and small, unisexual flowers. Accounts of the family are given by Rauh (1963) and Rowley (1993).

Species of the Didiereaceae are ecologically important components of the dry thorny forest in the south and south-west of Madagascar. Much of this vegetation has been cleared for agriculture and most of the remaining stands are impenetrable or nearly so. Some remnant patches of dry thorny forest occur within protected areas. The Reserve naturelle integrale de Tsimanampetsotsa, for example, has vegetation dominated by Didiereaceae and Euphorbiaceae and covers part of the very restricted distribution of *Alluaudia montagnacii.* The Reserve naturelle integrale d'Andohahela has a good representation of *Alluaudia* and *Didierea* spp.

The whole family is threatened mainly by habitat destruction and utilisation of the wood for construction and charcoal production. The wood of *Alluaudia procera, A. ascendens,* and *A. montagnacii* is used locally in the areas where the species grow and is sold in the cities of Madagascar. Exploitation of the wood is a threat, for example, to the species and vegetation in the Reserve naturelle integrale d'Andohahela.

Another threat to Didiereaceae is collection for horticulture. All species are in demand by collectors, but they rarely flower in cultivation, and seed is in short supply. Some species are cultivated in Madagascar for export, but others such as *Didierea madagascariensis* and *D.trollii* are gathered from the wild and exported as seedlings. The whole family has been included in Appendix II of CITES since the Convention came into force in 1976. This has enabled the collection of trade data for the family, which revealed, for example, the import of thousands of wild plants of *Didierea* and *Alluaudia* into Europe in the mid-1980s erroneously labelled as artificially propagated plants.

Flore de Madagascar et des Comores (Humbert 1936) covers most of the major succulent families, but many of the early volumes are out of date. The genus *Euphorbia* has not yet been covered by the Flora. Some of the relatively well known succulent groups such as the genus *Aloe* and geophytic *Euphorbia* spp. are in need of taxonomic attention (Supthut and von Arx 1993). In the case of *Aloe* spp. their spatial separation on isolated inselbergs, long intervals of time between species description, and difficulty of access to sites have all contributed to taxonomic uncertainty. Professor Rauh has prepared the first volume of *Succulent and Xerophytic Plants of Madagascar (1995)* and volume two is expected in 1997. There is currently no local guide to the succulents of Madagascar, although a general identification guide to the common plants of the island is being prepared.

Madagascar can be divided into a number of phytogeographical regions reflecting local differences in topography, geology, soils, and climatic conditions. Within four broad regions — eastern, central highlands, western, and southern / south-western — seventeen vegetation types are recognised, within which there are many distinct plant communities. No systematic classification at the community level is available as yet. Most of Madagascar's vegetation has been extensively modified and only about 20 per cent of the natural vegetation remains.

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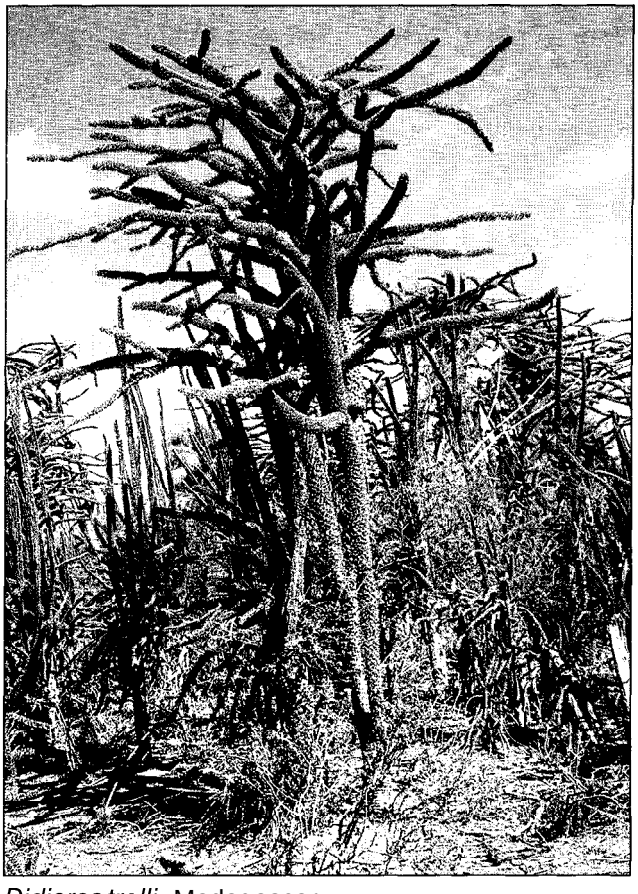
Inselberg on the Central Plateau, Madagascar.

The eastern escarpment to the central highlands all the way to the coast, characterised by high rainfall and a variety of soil types, is the richest botanically. Vegetation consists of a band of evergreen rain forest below 800 m and along the coast, now extensively deforested and replaced by 'savoka', or secondary lowland forest.

The undulating central plateau region, from 500-1500 m in elevation, is characterised by lateritic clay soils and montane and cloud forests. The plains have been overgrazed and burnt for centuries resulting in impoverished grasslands with their upper layers strongly eroded and are now very poor in succulent species (Rauh 1983b). Rupicolous vegetation occurs on the inselbergs which occur in the plateau area of central Madagascar. The inselberg rock formations of volcanic origin represent local ecological niches in the middle of a montane forest zone. The initial colonists, after lichens and mosses, are plants of the genus *Fimbristylis* which produce a pure black neutral to acidic humus carpet. This becomes completely desiccated in the dry season (Rauh 1983b). Succulents can tolerate the soil conditions and are well represented in the rupicolous vegetation with, for example, species of *Pachypodium, Aloe, Kalanchoe, Cynanchum, Euphorbia,* and *Tetradenia*. Most of the highland *Aloe* species are inhabitants of the inselberg rock formations: *A. haworthioides; A. parvula,* which grows in the quartz Itremo rocks in cushions of *Fimbristylis* or in cracks in the rocks; *A. laeta* in the Massif du Mont Ibity growing in association with *A. ibitensis; A. parallelifolia;* and *A. trachyticola* (Rauh 1983b). The floral composition of rupicolous vegetation on the western rocky outcrops is, in general, relatively poorly known.



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Didierea trolli, Madagascar.

The western region has climax vegetation of dry deciduous forest with woody endemic succulents of genera such as *Adenia, Adansonia, Uncarina, Pachypodium,* and *Euphorbia*. Most of the deciduous forest has been destroyed by human activity and is replaced by secondary or wooded grassland. The western escarpment of the central plateau consists of low evergreen sclerophyllous forest, and transitional forest in the Sambirano region of north-west Madagascar.

The southern and south-western region is characterised by arid climatic conditions. The climate is characterised by lack of seasonality with the slight precipitation (approximately 300 mm per year) falling irregularly throughout the year. Towards the coast high air humidity is a climatic feature, with heavy dew and fog precipitation. The vegetation consists of deciduous xerophytic thicket, sometimes known as spiny desert. This vegetation is dominated by Didiereaceae and *Euphorbia* spp. It has a sparsely developed ground layer consisting predominantly of succulents. Deciduous thicket has been replaced by grassland over much of its natural area of distribution.

Succulent plants are represented in all phytogeographical regions of Madagascar. The two most important regions are the Central Plateau, on the inselbergs, and the dry forests in the north-west, west, and south. The remarkable vegetation of the southern coastal region supports the highest percentage of endemic succulent plant species for the country as a whole.

Threats

Burning — Large areas of Madagascar have been burned since the first settlers arrived on the island 1500 years ago. The extensive areas of grassland are burned each year to provide pasture for zebu cattle. Some succulent species such as *Aloe macroclada* and various species of *Euphorbia* such as *E. primulifolia* are relatively fire-resistant, and the inselberg communities initially escape damage from fire, but in general burning is a major threat to the succulent plant flora. *Pachypodium* spp. are for example particularly susceptible to fire damage as are some rare *Aloe* spp.

Other Madagascan succulents considered to be endangered by fire include the asclepiads: *Ceropegia dimorpha, C. armandii,* both of which are also sought after by succulent collectors, C. *bosseri, C. leroyi,* and *Cynanchum rossii*. The latter two have not been seen in the wild for the past twenty years. The genus *Stapelianthus* which is confined to the south-west of the island, is also susceptible to fire, with the following species endangered by burning and clearance of the xerophytic forest: *Stapelianthus decaryi, S. pilosus, S. madagascariensis, S. montagnacii, S. insignis, S. hardyi, S. keraudrenae, S. arenarius,* and S. *calcarophilus.*

Grazing — The zebu cattle of Madagascar and their impact on the flora and fauna are well known. There are an estimated 10 million zebu on the island and the cattle are of great cultural importance.

Clearance for agriculture — Traditional agriculture in Madagascar consists of various forms of shifting and settled cultivation producing predominantly rice, with cassava, sweet potatoes, and maize. The main cash crops are coffee, grown mainly along the east coast and in the north-west; cocoa, also grown in the north-west; vanilla, grown mainly in the north; and cloves grown on the eastern coastal plains. Large plantations with oil palms, green peppers, cinnamon, and cloves are found in the area.

Agricultural development has been less important in the arid succulent-rich areas of southern Madagascar. Nevertheless, a large area of Didiereaceae vegetation has been cleared in the Amboasary region for sisal, *Agave sisalana,* plantations. Production of sisal declined until recently but is now expanding again and remains an important industry. Two new large sisal plantations have been laid out in the vicinity of Amboasary and another new sisal plantation exists north of Morandava. The rare species, *Euphorbia cylindrifolia*, *E. ambovombense*, *E. ampanihense,* together with some *Stapelianthus* and small *Aloe* species grow in *Alluaudia-Euphorbia* forests close to sisal plantations and could be destroyed through intensified agricultural development together with extensive clearance of forests for charcoal production. *Opuntia* plantations are also established in this region.

Introduced species — *Agave sisalana* is an invasive introduced species which continues to have a detrimental impact on the ecology of the xerophytic thicket vegetation. The species spreads by prolific vegetative reproduction, destroying primary vegetation.

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Euphorbia quartziticola, a Rare plant restricted to quartz substrates; threatened by habitat destruction.

The prickly pear, *Opuntia dillenii,* first introduced to Fort-Dauphin as fencing around houses in around 1770, quickly became established to the detriment of indigenous vegetation. Brought under control in the 1920s, the species is again established in southern Madagascar. Various other *Opuntia* spp. are planted for fodder throughout southern Madagascar.

Furcraea is another invasive, and increasingly common, introduced species, particularly on the Central High Plateau.

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Alluaudia-Euphorbia forest, since destroyed, featuring *E. plagiantha, A. ascendens,* and *A. procera.*

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Alluaudia montagnacii, used for construction and charcoal production.

Local use — Collection of fuelwood affects woody succulent species in the vicinity of towns such as Tulear, Sakahara, and Fort-Dauphin. The production of charcoal also consumes significant quantities of woody succulents particularly close to Tulear, where there is a commercial charcoal operation. Charcoal production is also common to the north of Tulear and at Ampanihy, Tsihombe, Amboasary, and Ambovombe. Species used for charcoal production include ***Euphorbia*** spp., ***Alluaudia*** spp., and ***Decaryia madagascariensis.*** Charcoal production is both for domestic consumption and export overseas.

Woody succulent species are utilised as timber for construction of dwellings. This places a strain on wild populations of various species, notably *Alluaudia* ***ascendens*** and ***A. montagnacii.*** Another species of Didiereaceae, ***Decaryia madagascariensis,*** is heavily exploited by local people. Its trunk forms dense, firm sections of charcoal which are highly valued, and the thinner twigs are used for hedging and corral building. Species of Didiereaceae are also used as live fencing.

A considerable number of succulent species are utilised locally for medicinal purposes as documented, for example, by Jenkins (1987). Certain species are rare, but it is not known to what extent collection for medicinal use has a detrimental impact on wild populations. Some succulent species are also considered to be sacred in some parts of Madagascar; for example, ***Pachypodium*** *brevicaule* is avoided by local inhabitants.

Collecting for horticulture — Madagascan succulents arc of horticultural interest to specialist collectors worldwide. The international demand for succulent species from Madagascar has led to the wholesale removal of wild plants for export primarily to Europe, Japan, and the USA. Around 100 succulent species have been exported on a fairly regular basis, the principal genera being ***Pachypodium, Aloe,*** and ***Euphorbia.*** It is clear that where there is a monetary value to plants as a result of international horticultural demand, there is a strong incentive to collect and export the material which is not seen as having any intrinsic value locally. Both bulk removal of common species for the 'supermarket' trade and collection of very rare species for the specialist market continue to take place. The latter is probably more threatening or damaging to local populations.

The actual species collected for export change according to fashions in succulent trade. At present there is a strong demand for caudiciform plants, most of which are not listed on the Appendices of CITES. At the same time newly described species of all genera will be subject to particular threat.

Conservation status

There has been no systematic attempt to categorise the conservation status of Madagascan succulent species. IUCN categories have been applied to various succulent groups during the 1980s based on the field knowledge of individual experts, and this information was recorded in the Plants Database now maintained by WCMC. Conservation categories are given for Madagascan succulents in Annex 7 where these are known. For the majority of species there is limited distribution data and even less site assessment information on which to base current conservation status. Taxonomic uncertainties add to the difficulties of applying conservation categories.

The main stimulus for field-based assessment of the

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Pachypodium rosulatum var. *stenanthu* sold along a tourist route.

conservation status of succulent species known to be rare has been the listing of certain species on Appendix I of CITES. During 1992 and 1993 two field surveys were carried out in Madagascar by D. Supthut and B. von Arx under the auspices of CITES (Project No. S52). The field work involved training of local conservation personnel in succulent species identification. Three sets of herbarium specimens were made for deposition at the DEF herbarium in Antananarivo; Stadtische Sukkulenten Sammlung, Zurich, and Conservatoire et Jardin botanique in Geneva. Further survey work of this nature is a priority for the conservation of the Madagascan succulent flora.

Priority sites for conservation

Madagascar's succulent species occur throughout the island in all major vegetation types. There are certain areas which are outstanding in terms of their succulent richness and diversity:

1) The whole area of southern xerophytic thicket community, dominated by Didiereaceae and shrubby or arborescent *Euphorbia* spp., and resticted to a small coastal region about 50 km wide, is an international conservation priority. According to Rauh (1978d), "All in all, the vegetation of the precipitation-poor south-west Madagascar is because of its numerous morphological, biological, floristic specialities and its wealth of endemism, something so unique in the world that all effort should be made not only to guard these plants but to preserve them for posterity." Not many untouched, coherent areas remain in the south and south-west, but within the area certain sites can be identified as particularly outstanding for succulent conservation. One good area is between Ampanihy and Ejeda (along Route Nationale 10) down to the coast at Itampolo and Androka.

2) Another important area of the southern xerophytic thicket community is that to the south of Tulear where the succulent flora is particularly diverse. One site identified as a priority for conservation is to the east of the coast road, from the Tulear exit to the junction with the road to the interior, towards Saint Augustin. Rare species of *Aloe, Euphorbia, Stapelianthus, Kalanchoe, Moringa,* and *Operculicarya* occur.

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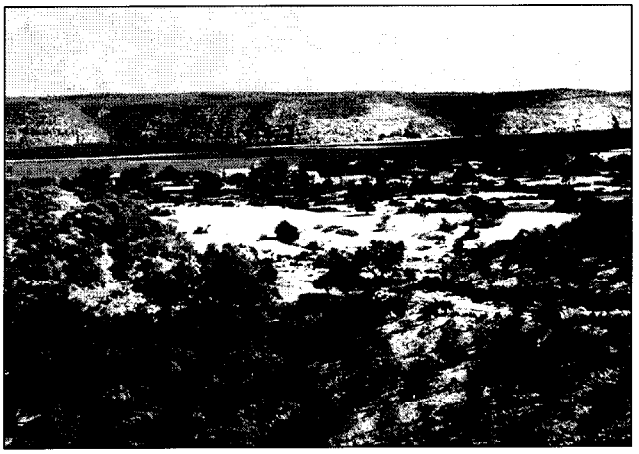
In 1992, this small population of *Aloe calcairophila* was totally removed by collectors.



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Saint Augustin, south-west coast, an important succulent habitat featuring *Uncarina, Moringa, Euphorbia,* and *Stapelianthus.*

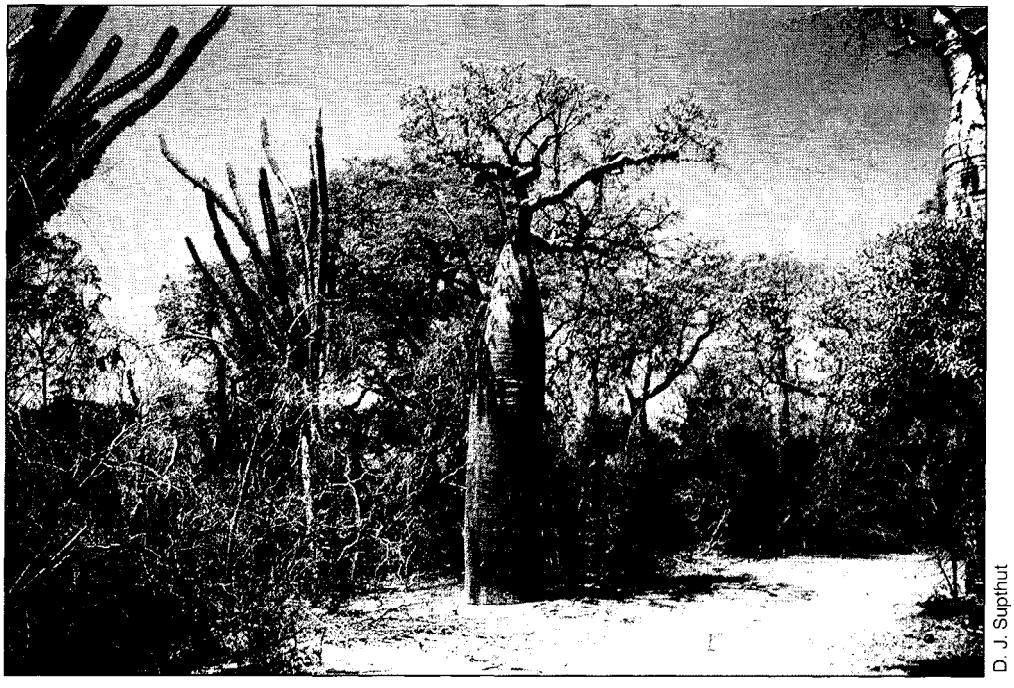
3) A third important area for this type of vegetation is Site d'interet biologique du Lac Anony. *Aloe suzannae* and *A. helenae* grow in this area, together with *Euphorbia cylindrifolia* and *E. francoisii* at the western end of their distributions. Succulent species of Cucurbitaceae such as the heavily traded *Xerosicyos pubescens* also occur.

4) Site d'interet biologique de Zombitse has a tropical dry climate with 750 mm annual precipitation. The forest is heavily exploited.

5) Mount Ibity in the Central Plateau is a very important site for succulent plant conservation with endemics such as *Aloe trachyticola, Pachypodium brevicaule,* and *Euphorbia primulifolia*. It is regularly visited by succulent plant collectors.

6) Cold'Itremo, another site in the Central Plateau, hosts an exceptionally rich flora and fauna due to its distinctive geology and soils. *Euphorbia quartzicola, Pachypodium brevicaule, P. densiflorum, Aloe calcairophila,* and *Aloe compressa* occur there.

7) Site d'interet biologique du Nord de Toliara PK 32 contains primary forest to the north of Mora-Mora - spiny forest with *Didiereaceae, Pachypodium,* and arborescent *Euphorbia* spp. Unfortunately, large areas of forest were cleared in Autumn 1994.



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Adansonia fony, Didierea madagascariensis, Euphorbia stenoclada, and *De/onyx floribunda;* type locality of *Alluaudiopsis mamierana.*

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Pachypodium baronii var. *windsori*

8) La Montagne des Français is important for populations of *Adansonia suarezensis,* an endemic to the north of Madagascar, which is threatened by habitat destruction at its other locations. The site also has *Pachypodium baronii* var. *windsori, P. decaryi, P. ruthenbergianum, Euphorbia viguieri, E. neohumbertii, Aloe suarezensis,* and *Impatiens tuberosum.*

Existing conservation measures

The conservation of Madagascar's biodiversity is widely recognised as being of outstanding importance particularly by international conservation agencies. Major programmes of conservation activities such as the Madagascar National Environmental Action Plan (NEAP) have, therefore, been developed, largely with outside funding. There has been, in general, remarkably little attention paid to the conservation needs of Madagascar's rich succulent flora.

Protected areas

Protected areas currently cover approximately 10,350 km^2 (1.76 per cent) of Madagascar's land area and Malagasy biodiversity is not fully represented. Of particular concern for succulent plant conservation is the gap in protected area coverage in the south-west. In total only around 50,000 ha of spiny forest vegetation is protected (Pollock 1986). Also of major concern is the fact that none of the succulent-rich inselbergs of the Central Plateau are protected. In general, the protected areas which do exist on paper are not adequately protected on the ground. Most do not have botanical species inventories, and these are urgently required.

Five different categories of protected area are recognised:

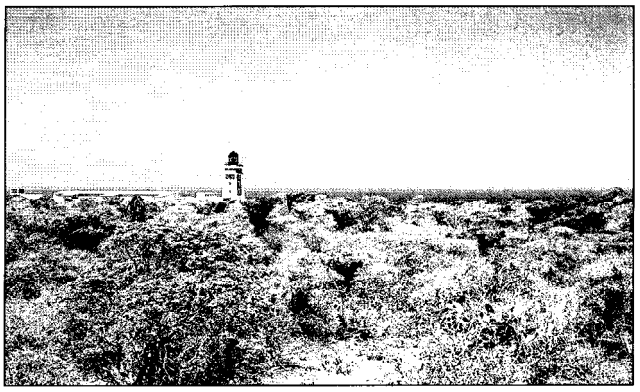
a) Reserves naturelles integrales (Strict Nature Reserves),
b) Parcs nationaux (National Parks),
c) Reserves speciales (Special Reserves),
d) Forêts classées (Classified Forests),
e) Perimetres de reboisement et de restauration (Reafforestation Zones).

The establishment of Strict Nature Reserves dates back to 1927. The relevant legislation is Decree 66-242. Under this legislation access to the sites is strictly forbidden other than for scientific research purposes. National Park legislation is contained in Decrees 58-07 and 62-371. Access to National Parks is controlled and exploitation of some forest products by local people is allowed. Special Reserves have been set up by a series of decrees and are designed to protect certain plant or animal species. Access to reserves is free but some damaging activities, including the collection of natural products, are forbidden.

A review of ecosystems, protected areas, and species conservation requirements carried out by WWF and Madagascan conservation authorities has recommended the expansion of the protected area system (Nicoll and Langrand 1989). The lack of adequate protected area coverage in the south-west is noted but no specific sites for conservation are identified. Out of 16 critical sites listed as meriting protection, only one in the north of Madagascar is an important succulent area: La Montagne des Français, an area of dry limestone forest with different vegetation to the nearby Montagne d'Ambre National Park. It is also planned to give the Site d'intérêt biologique de Zombitse and the Vohibasia forest, the status of Reserves speciales. These sites are transitional between western and southern vegetation and are remnants of the species rich Forêt de Sakaraha which has virtually disappeared.

Protected areas important for succulent conservation

1) Parc national de l'Isalo — encompasses part of the sandstone Isalo Massif, rupicolous vegetation is abundant with *Puchypodium rosula turn* var. *gracilius, Euphorbia primulifolia* var. *begardii, Ceropegia dimorpha, E. isaloensis,* and *Aloe isaloensis.* The area needs to be extended to include land south of the route national No. 7 and north of the Onilahy River.
2) Reserve naturelle integrale de L'Andringitra — rich endemic flora with *Aloe* and *Kalanchoe* spp. on the crags. A species list does not exist for this area.
3) Reserve naturelle integrale de l'Ankarafantsika — *Pachypodium rosulatum* var. *drakei, P. sofiense, Euphorbia cremersii, E. pauliani, E. pedilanthoides,* and *Adenia* spp.
4) Réserve naturelle intégrale du Tsingy de Namoroka — Many xerophytic and crassulacean plants with *Adansonia rubrostipa* and *Pachypodium ambongense.*
5) Reserve naturelle integrale de Tsimanampetsotsa — vegetation dominated by Didiereaceae, for example, *Decaryia madagascariensis, Alluaudia procera, A. montagnacii, A. humbertii,* tree *Euphorbiu* spp., *Pachypodium* spp., and *Adansonia fony.*
6) Reserve naturelle integrale d'Andohahela — has a good representation of *Alluaudia* and *Didierea* spp. with *Didierea trollii, A. procera, A. ascendens, A. humbertii,* and tree *Euphorbia* spp.
7) Reserve naturelle integrale du Tsingy de Bemaraha - *Euphorbia moratii (3* vars.), many *Aloe* spp., *Lomatophyllum* spp. and *Pachypodium* spp.
8) Reserve speciale Cap Sainte Marie - the limestone rocks support *Alluaudia comosa, Alluaudiopsis fiherensis, Aloe millotii, Euphorbia capsaintemariensis* and *Crassula humbertii.*
9) Reserve speciale Bezaha-Mahafaly - a 500 ha reserve protecting xerophytic vegetation in south-west Madagascar, with Didiereaceae, *Aloe, Euphorbia* and *Pachypodium* spp.
10) Reserve speciale d'Ankarana - *Pachypodium decaryi, Euphorbia ankarensis, E. herman-schwartzii, E. alfredii, E. pachypodioides, E. neohumbertii,* and *Cyphostemma laza.*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Juvenile *Alluaudia comosa* in typical habitat, Cap Sainte Marie.

Many of Madagascar's protected areas have received more intensive biological research than other parts of the country, but the more inaccessible sites are still poorly explored. The preparation of detailed inventories of the protected areas would help in the analysis of current protection given to threatened succulent species in Madagascar. Renewed inventory work is currently being carried out in actual or proposed protected areas, mainly under the auspices of Missouri Botanical Garden's Madagascar Research and Conservation Program. This, however, concentrates on wet forests with little work on the dry or high plateau flora.

National legislation

There is currently no legislation giving special protection to rare and threatened succulents in Madagascar. Protected area legislation has been discussed above. Conservation legislation relating to vegetation and flora

Box 3.4 Conservation agencies and botanical institutions in Madagascar

Direction des Eaux et Forêts (DEF): This government department, under the Ministere de la production animale (elevage et pêche) et des Eaux et forêts, has responsibility for forest management and protected areas. DEF is also the CITES Management Authority.

Office National de L'Environnement (ONE): ONE is a new Government body, created in 1991 . It is currently planning a cross-sectoral review of policies which relate to the environment.

Agence Nationale pour la Gestion des Aires Protégées (ANGAP): ANGAP is an NGO, established with funding from USAID, which works closely with DEF. ANGAP has taken responsibility for 34 out of 50 areas designated for protection and is investigating the development of management plans for protected areas.

National Association for Environmental Actions (ANAE): ANAE is a recently established NGO which serves to provide financing to communities, local NGOs and village organisations for watershed management, reforestation, and erosion control activities developed through local initiatives,

WWF-Madagascar: WWF representation in Madagascar was established in 1979 under a legal decree. Since that time WWF has implemented activities relating to education and public awareness and more recently implementation of field activities particularly relating to management of protected areas. Botanical work at present relates mainly to ethnobotany.

Jardin Botanique de la DRST Tsimbazaza: maintains important living collections of Madagascan plants, but does not have suitable climatic conditions for the cultivation of many of Madagascar's endangered succulents. There is a growing core of well trained and experienced botanical staff, supported by a strong reference library and herbarium. It has been suggested that a CITES Scientific Authority should be based at the Garden.

in general consists of: a law of 15 January 1930 protecting forests; an ordinance, No. 75.014-1975, bringing CITES into force. Law No. 91.008 of 25 July 1991, concerning animal protection, reinforces the importance of CITES banning the export of animal species listed in the Appendices, but does not refer to plant species.

Knowledge of the status in the wild of succulent plant species is essential in determining which plants should be listed for legal protection. At present this information is only partially available.

Review and additional information for this section were kindly provided by Blaise Du Puy, Martin Jenkins, and Bertrand von Arx.

Southern Africa

Craig Hilton-Taylor

Southern Africa (including Botswana, Lesotho, Namibia, South Africa, Swaziland, and Zimbabwe) has long been recognised as an area of remarkable plant diversity with extremely high levels of endemism (see Cowling *et al.* 1989; Cowling and Hilton-Taylor 1994; Gibbs Russell 1985; Goldblatt 1978; Good 1974). The high levels of diversity and endemism found in the flora in general, also extend to the succulent plant groups as has been shown by Barkhuizen (1978), Court (1981), Van Jaarsveld (1987) and Smith *et al.* (1993) (see Table 3.3). Considering that southern Africa is a predominantly warm-temperate, semi-arid region with an overall mean annual rainfall of less than 400 mm, it is not surprising that there are a large number of succulent plants in the flora. What is perhaps most astonishing, is the extent to which the major succulent families have speciated in southern Africa, particularly the Aizoaceae, Aloaceae, Asclepiadaceae, Crassulaceae, and to a lesser extent, the Euphorbiaceae (see Table 3.4). This diversity can in part be attributed to contemporary ecological conditions, particularly the subcontinent's transitional location relative to the subtropical summer rainfall and winter rainfall climatic zones, combined with a complex topography and heterogeneity of geology and soils which allow for steep ecological gradients (Cowling and Hilton-Taylor 1994). In addition the region's history of aridity (see Van Jaarsveld 1987) combined with a special genetic potentiality (Ihlenfeldt 1994) has also undoubtedly played a major role in promoting speciation in the succulent groups. The heterogeneity of southern Africa's flora is well illustrated by its classification into five phytochoria (Werger 1978; White 1983), seven biomes (Rutherford and Westfall 1986) and, in South Africa alone, 70 major vegetation categories or Veld Types (Acocks 1953).

Succulent plants have long been utilised by people in southern Africa; however, it was not until the start of the active botanical exploration of the region by the early seventeenth century explorers and naturalists, that this succulent wealth came to the attention of people in Europe and eventually the rest of the world (Smith *et al.* 1993). Despite the rises and falls in the popularity of southern African succulent plant species amongst horticulturists, botanists and hobbyists around the world, the demand for these plants has undoubtedly had a negative impact on the wild populations. This demand, together with the enormous impact of people in modifying and transforming virtually every ecosystem in southern Africa (Macdonald 1989) has resulted in a

number of southern Africa's succulent species becoming threatened with extinction. It is these rare and threatened species which form the focus of this section.

There have been several attempts to describe and catalogue the succulent flora of southern Africa. Some of the earlier descriptive works include those of Rawe (1968) and Barkhuizen (1978) which were followed by the more comprehensive work of Court (1981). Van Jaarsveld (1987) provided a review of all the succulent plant families in southern Africa including their distribution, reproductive and defence mechanisms, and adaptations to drought. This work was complemented by that of Smith *et al.* (1993) which focused largely on the taxonomic issues in southern African succulent families. Other publications which have helped document the southern African succulent flora include Jacobsen (1960, 1974), Percy-Lancaster and Richards (1991), and the recently published works of Eggli (1994) and Eggli and Taylor (1994). In addition to the above works there is a large number of books, scientific papers, and popular articles dealing with specific southern African succulent families and genera (see Smith *et al.* 1993 for references to some of these). All of the above publications are helping to bring us closer to compiling a complete 'register' of all southern African succulents (Smith *et al.*, in press).

A major inconsistency among many of the publications listed above is the definition of succulence. Some authors have followed a fairly broad definition, whereas others are very strict. The differences in numbers of succulent taxa cited in each work can therefore be attributed in part to the author's definition. The task of obtaining total numbers of succulent taxa is further complicated by the fact that all of the publications dealing with all the succulents in southern Africa, including the most recent, are taxonomically outdated and in addition there are many differences of opinion on which taxa are worth recognizing and consequently which names should be accepted. For the Flora of southern Africa (FSA) region (the area including Botswana, Lesotho, Namibia, South Africa, and Swaziland), the treatment of Smith *et al.* (1993) was followed, although it was not recognised that many of the numbers of species cited are incorrect, as they were based on outdated information in Arnold and De Wet (1993). For Zimbabwe, the checklist compiled by Percy-Lancaster and Richards (1991) was used. Even comparing Percy-Lancaster and Richards (1991) to Smith et *al*. (1993) poses problems due to the differing interpretation of succulence. Hence the results for the FSA region are presented and discussed separately to those for Zimbabwe.

Table 3.3 shows the numbers of succulent taxa (families, genera, species) recorded in the FSA region. These numbers were derived from Smith *et al.* (1993), however, all succulent species which have become naturalised in the region (e.g. many species of Cactaceae) were removed from the counts. There are therefore 3377 species (in 201 genera and 26 families) of succulent plants indigenous to the FSA region. (Note: these figures do not include the numbers of infraspecific taxa.) If one adds the semi-succulent species, the total rises to 3873, which represents some 17 per cent of the total flora of the FSA region (Arnold and De Wet 1993) and 39 per cent of the world's 10,000 succulent plant species (Rowley 1978). Table 3.4 gives a breakdown of the major succulent families in the FSA region, and the number of succulent genera and species in each family in comparison to the numbers which are non-succulent. From Table 3.4 it is clear that the Aizoaceae is the most important succulent family, contributing some 63.4 per cent of all the succulent species found in the region. The Asclepiadaceae, Aloaceae, Crassulaceae, and Euphorbiaceae all contribute significant numbers of succulent species to the flora. Further details on these families, their genera and species are provided by Van Jaarsveld (1987) and Smith *et al.* (1993).

Table 3.5 indicates that succulents are also an important component of the flora of Zimbabwe, with 336 taxa (species and infraspecific taxa) of succulents, pachycauls, and caudiciforms recorded (cycads and geophytes listed by Percy-Lancaster and Richards (1991) have been excluded). It is estimated that there are approximately 6500 species of flowering plants in Zimbabwe (Kimberley 1993), therefore some five per cent of these can be termed succulent or semi-succulent. The major families and genera in Zimbabwe which contain succulent or semi-succulent species are discussed in detail by Percy-Lancaster and Richards (1991) and Kimberley (1993). Comparing the taxa in the list compiled by Percy-Lancaster and Richards (1991) to those listed in Arnold and De Wet (1993), it is evident that there are 115 succulent taxa recorded from Zimbabwe which do not occur in the FSA region. Therefore the grand total for the whole of southern Africa (FSA region plus Zimbabwe) is 3988 succulent taxa, i.e. nearly 40 per cent of the world's succulents occur in southern Africa.

Table 3.3 Numbers of succulent taxa (families, genera, and species) in the Flora of southern Africa region

Column five is the percentage of the 10,000 succulent species in the world. (Source: Smith et al. 1993)

	families	genera	species	Per cent of species FSA	Per cent of species world
Succulent	**26**	**201**	3377	15	34
Semi-succulent	13	**55**	**496**	**2**	**5**
Total	**39**	**256**	**3873**	17	39

Table 3.4 A summary of southern African plant families with succulent species, arranged in decreasing number of succulent species per family

Note that some families are not restricted to southern Africa but, for the purposes of this table, only those species occurring in the Flora of southern Africa region were taken into account. (Source: Smith *et al.* (1993), but some numbers have been updated by this author.)

Family	Number of genera		Number of species		Percent total succulent flora	Largest succulent genus in the family (No. of species)
	non-succulent	succulent	non-succulent	succulent		
Aizoaceae	0	c. 117	0	c. 2141	63.4	*Ruschia (c. 350)*
Asclepiadaceae	39	27	415	c. 264	7.8	*Stapelia (c. 45)*
Aloaceae	0	6	0	c. 262	7.8	*Aloe (149)*
Crassulaceae	0	6	0	236	7.0	*Crassula (l 5 1)*
Euphorbiaceae	47	3	284	181	5.4	*Euphorbia (179)*
Asteraceae	233	IO	2232	58	1.7	*Senecio (30)*
Zygophyllaceae	4	4	8	c. 49	1.5	*Zygophyllum (c.* 44)
Asphodelaceae	2	2	107	43	1.3	*Bulbine (4 1)*
Portulacaceae	1	5	2	42	1.2	*Anacampseros (22)*
Geraniaceae	3	2	c. 263	29	0.9	*Pelargonium (15)*
Chenopodiaceae	15	3	157	14	0.4	*Sarcocornia (9)*
Vitaceae	3	2	41	11	0.3	*Cyphostemma (9)*
Apocynaceae	18	2	32	9	0.3	*Pachypodium (5)*
Pedal iaceae	6	2	24	7	0.2	*Pterodiscus* (4)
Passifloraceae	4	1	15	c. 5	0.2	*Adenia (c. 5)*
Piperaceae	1	1	1	4	0.1	*Peperomia (4)*
Dracaenaceae	1	1	2	4	0.1	*Sansevieria (4)*
Lamiaceae	37	1	233	4	0.1	*Plectranthus (4)*
Hyacinthaceae	24	3	c. 346	4	0.1	*Bowiea (2)*
Dioscoreaceae	0	1	11	3	0.1	*Dioscorea (3)*
Goodeniaceae	0	1	0	2	0.1	*Scaevola* (2)
Cactaceae	0	1	0	1	0.03	*Rhipsalis (I)*
Viscaceae	0	1	16	1	0.03	*Viscum (I)*
Brassicaceae	38	1	158	1	0.03	*Heliophila (I)*
Sterculiaceae	6	1	177	1	0.03	*Sterculia (1)*
Rubiaceae	61	1	235	1	0.03	*Phylohydrax* (I)
Total	543	c. 205	c. 4759	c. 3377	**100**	

Distribution in southern Africa

Although succulents are found in practically all parts of southern Africa, by far the greatest numbers of species, genera, and families are found in the western arid parts of the region (Hilton-Taylor 1994, 1996a; Van Jaarsveld 1978) (see also Chapter 1 for details on their distributions). In terms of phytochoria, biomes, and vegetation types, succulents within South Africa tend to predominate in the Karoo-Namib Region (see White 1983), the Desert, Succulent Karoo, and Nama-Karoo Biomes *(sensu* Rutherford and Westfall 1986), and in the various karroid and false-karroid Veld Types (vegetation types) described by Acocks (1953). Jürgens (1990) coined the term "leaf succulent zone" to describe part of this area which is extremely rich in leaf succulent species. High numbers of succulent species are also found in dry habitats along the east coast of South Africa, extending from the Eastern Cape along the coast of KwaZulu-Natal, through Swaziland into the Eastern and Northern Transvaal (see Figure 3.1). Succulents generally avoid the interior plateau above the Great Escarpment because of the occurrence of frost (Figure 3.1). Some species, however, are able to survive the harsh highveld winters by establishing themselves in relatively frost-free niches or by developing a degree of tolerance to frost as for example, in some of the *Aloe* species (see Hilton-Taylor and Smith 1994).

Table 3.5 Numbers of succulent, pachycaul and caudiciform taxa found in Zimbabwe

(Source: Totals modified from Percy-Lancaster and Richards, 1991.)

	Families	Genera	Taxa
Succulent	14	48	231
Pachycaul/caudiciform	23	8	105
Total	*37*	*56*	*336*

Succulent taxa occur in nearly all parts of Namibia except for the central dune field of the Namib Desert and the sandy and semi-humid eastern and north-eastern parts. Major centres of endemism with concentrations of succulent species in Namibia include the Southern Namib Desert (Sperrgebiet or Diamond Area No. 1), the Hunsberge, the Warmbad-Pofadder region, the Karasberge, Damaraland, and the Kaokoveld.

In Botswana, although succulents are mostly found in

the south-eastern and eastern parts of the country (to the east of the eastern edge of the Kalahari sands) where they occur on suitable rocky outcrops, a number of species, particularly members of the Asclepiadaceae, are able to survive in the Kalahari sands area under semi-desert conditions (see Hargreaves 1990 and Plowes *1989)*. Succulents occur all over Zimbabwe, but the greatest numbers are in the eastern highlands area (see Percy-Lancaster and Richards 1991).

Conservation status

Data on the conservation status of southern African succulent species were obtained from a variety of sources. The primary sources were the *Southern African Red Data Book: Plants — Succulent and Nama-Karoo Biomes* (Hilton-Taylor, in prep.) and the *Red Data List of southern African plants* (Hilton-Taylor 1996b) and the subsequent update (Hilton-Taylor 1996c). The latter is a collaborative project with information obtained from the threatened plants databases maintained by the various conservation agencies in southern Africa (Cape Nature Conservation: R. Stanvliet and T. Anderson; Natal Parks Board: R. Scott-Shaw; Orange Free State Directorate of Nature and Environmental Conservation: J. du Preez; Transvaal Directorate of Nature and Environmental Conservation: W. Boyd; Namibian Ministry of Tourism and Environment: M. Strohbach; National Herbarium of Namibia: G. Maggs; and the Swaziland National Trust Commission: K. Braun). A number of publications on the threatened plants of specific geographical or political regions also provided valuable baseline data, particularly on the past conservation status of certain taxa. These included Everard (1988); Fourie (1984, 1986); Hall *et al.* (1980); Hall and Veldhuis (1985); Hilton-Taylor and Smith (1994); Jankowitz (1975, 1977); Kimberley (1971, 1975, 1980, 1991) and Müller (1985). Information was also obtained from the Plants Database maintained by WCMC, particularly for Zimbabwe. In addition, a number of amateur and professional botanists were consulted and are listed in the acknowledgements.

All the data obtained is stored in a database (known as 'SARARES') developed at the Ecology and Conservation Research division of the National Botanical Institute in Kirstenbosch, Cape Town. This database is updated regularly, and it is hoped that it will provide the basis for the future development of a southern African threatened plants working group, which will enable better co-ordination of research and conservation activities concerning threatened plants across the subcontinent. Having all the data in one centralised database, also enables one to look at the conservation status of each species across its entire distribution range rather than in just certain political or geographical areas. This will help to prevent limited conservation resources being spent unnecessarily on species which are only locally threatened. The conservation status as listed in Annex 8, is therefore the global status for each taxon. Only seven of the 576 taxa listed are not endemic to the FSA region, and all of these are in effect endemic to the greater southern African region in that they occur in the adjoining countries of Angola, Mozambique, and/or Zimbabwe, where they are also under threat.

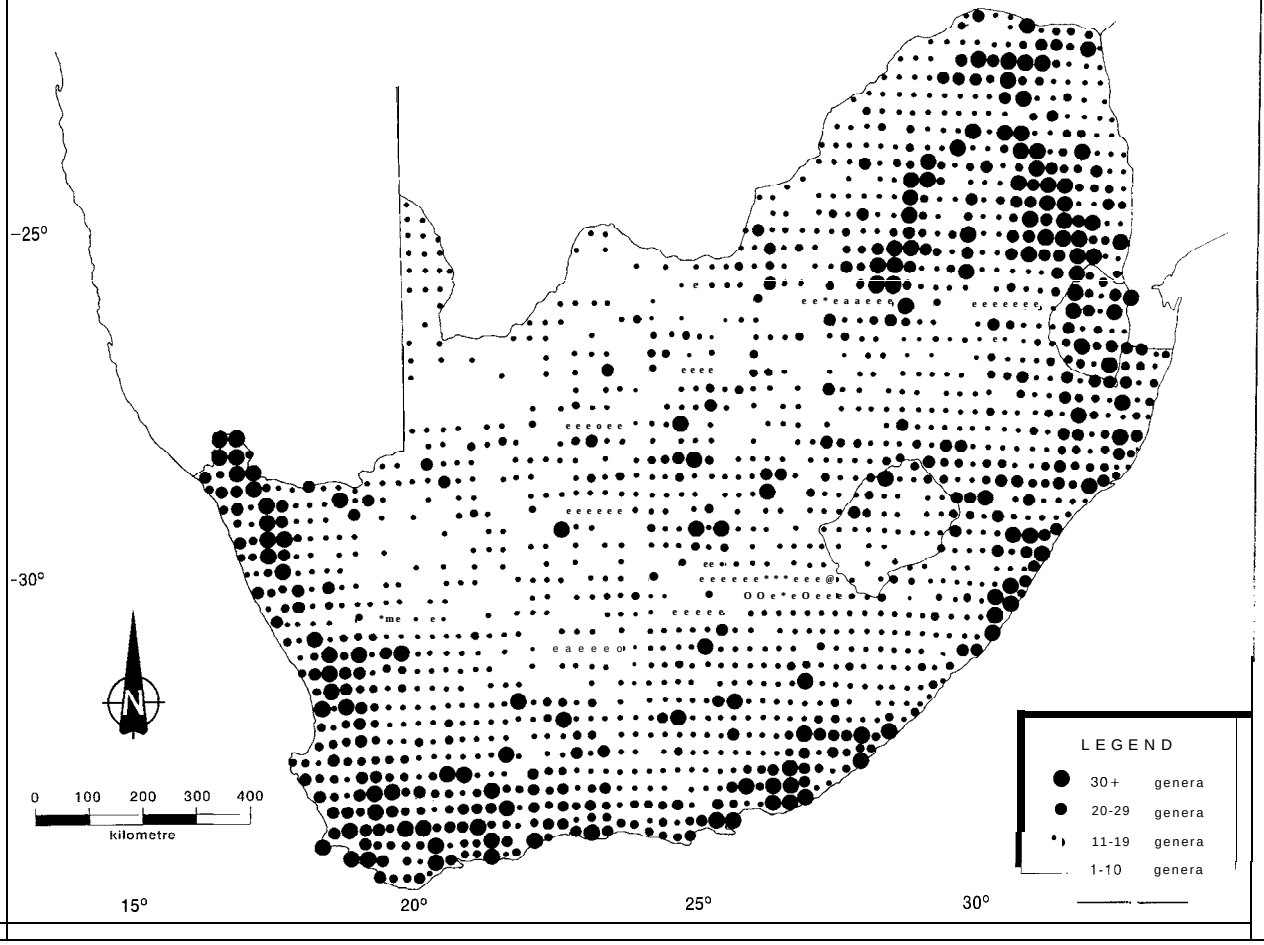
The IUCN Red List Categories (see Annex 16) were used in describing the conservation status of each taxon considered to be rare or threatened. In some cases where there was uncertainty as to which category was most appropriate hybrid categories as used by the WCMC were given. A new set of categories with rigorous quantifiable criteria has been developed (see Mace *et al.* 1993; Mace and Stuart 1994; IUCN 1994b) but have not been used here as much of the southern African data is too sparse to apply the new criteria at this stage. Once consensus has been reached on which taxa should be on the southern

Table 3.6 Numbers of globally threatened succulent taxa in the Flora of southern Africa region based on information in Annex 8

EX = Extinct in the Wild, **E =** Endangered, **V =** Vulnerable, **R =** Rare, **I** = Indeterminate, **K =** Insufficiently known, **Percent =** percentof total number of succulent species in that family in FSA region which are threatened.

Family	EX	E	V	R	I	K	Total	Percent
Aizoaceae	7	14	27	91	34	50	223	10
Aloaceae		20	31	42	4	8	105	40
Asclepiadaceae	2	3	19	52	8	9	93	35
Euphorbiaceae	2	6	17	28	2	13	68	36
Crassulaceae	2	1	4	39	3	13	62	26
Portulacaceae			2	17	1		21	50
Asteraceae			1	2		7	10	17
Asphodelaceae		1	2	7			11	26
Geraniaceae				4	1	2	7	24
Vi taceae				**3**		1	4	36
Apocynaceae					1		2	22
Passifloraceae				2			3	60
Brassicaceae				1				100
Zygophyllaceae				1			1	2
Total	14	45	104	**289**	54	**105**	**611**	18%

Figure 3.1. Map of the frequency distribution of succulent plant genera in South Africa, including Lesotho and Swaziland, showing the number of genera recorded per quarter degree grid square. Data extracted from the PRECIS (PREtoria Computerised Information System) database maintained at the National Herbarium (PRE), Pretoria, South Africa. (Map prepared by M.Môssmer and G.F. Smith).



African threatened list, all the taxa will be assessed using the new criteria and the new categories assigned. Future additions to the list will also be evaluated in terms of the new criteria.

The listings of all succulent taxa (excluding semi-succulents) considered to be rare and threatened in the FSA region and in Zimbabwe are given in Annexes 8 and 9 respectively. As the databases on which these annexes are based are constantly changing, the information presented for the FSA region was correct as of 31 November 1996 and for Zimbabwe as of 19 June 1995.

A summary of the information in Annex 8 is presented in Table 3.6 (for all taxa with hybrid conservation categories, the higher status was used). This summary reveals that 18 per cent (611 taxa) of the succulents in the FSA region are considered to be at risk or threatened. Of these, 14 taxa are thought to be Extinct in the Wild and 149 are seriously threatened. The overall extinction rate could in fact be considerably higher as many of the taxa classified as Indeterminate, may also be Extinct. Most of the extinctions are directly the result of habitat loss due to agricultural activities, while none can be attributed to removal by collectors, although many of the taxa in the Endangered and Vulnerable categories are facing extinction as a result of overcollecting. The most threatened families include the Aizoaceae (223 taxa threatened), Aloaceae (105 taxa), Asclepiadaceae (93 taxa), Euphorbiaceae (68 taxa), and Crassulaceae (62 taxa). Although the Aizoaceae shows the greatest extinction rate, it is the Aloaceae which are the most threatened with 51 taxa in the Endangered and Vulnerable categories. Table 3.7 shows the threatened status of the Aloaceae at generic level. From this it is apparent that although Aloe has the greater number of threatened taxa, it is the taxa within *Haworthia* which are under the most threat (see Hilton-Taylor and Smith 1994 for details).

Annex 9 shows that 48 succulent taxa are considered to be threatened in Zimbabwe. Twenty-one of these threatened taxa are endemic to Zimbabwe, while eight of

Table 3.7 Numbers of threatened alooid taxa in the Flora of southern Africa region

EX = Extinct, **E** = Endangered, V = Vulnerable, R = Rare, **I** = Indeterminate, **K =** Insufficiently known, **nt**/**ne =** not threatened or not evaluated, **Per cent =** percentage of taxa in that genus threatened. (Source: Hilton-Taylor and Smith 1994 and Annex 8.)

Genus	E	V	R	I	K	Total	nt/ne	Per cent
Aloe	4	11	31	2	6	54	123	31
Astroloba			1	-	-	1	4	20
Chortolirion				-	-	0	1	0
Gasteria	1	1	5	-	2	9	13	41
Haworthia	17	17	4	2	-	40	75	35
Poellnitzia			1	-	-	1	0	100
Total	**22**	**29**	42	**4**	**8**	**105**	**216**	**33%**

the non-endemic taxa are also globally threatened, although one of these is insufficiently known for complete evaluation. The Zimbabwe figures combined with those from the FSA region indicate that 603 of southern Africa's succulent taxa are considered to be globally threatened at present.

Threats

Botswana

Very few of the succulents in Botswana occur in conservation areas, and therefore they are all potentially under threat. Fortunately, due to the low population density and relatively undisturbed nature of much of the vegetation, few species are considered to be threatened, although an assessment of the situation is long overdue. Many succulents in Botswana are utilised for a variety of ethnobotanical purposes, e.g. *Euphorbia duseimata* is used to induce vomiting after poisoning and in the treatment of mental disease, stomach pains, and venereal disease; *Orbeopsis knobelii* is eaten raw or roasted and is a good source of water; and *Kleinia longiflora* is used in Bakgatla rainmaking ceremonies (Hargreaves 1990). An increasing demand for some of these species could have detrimental effects on the wild populations. As there are no laws protecting the flora of Botswana (see Existing conservation measures below) some plants may also be removed from the wild by avid collectors. A number of species are also affected by other human activities, such as expanding urbanisation, mining, and agricultural activities, particularly the planting of crops and grazing.

Namibia

Due to the low human population density in most of Namibia and the relatively large area covered by nature reserves (13 per cent according to Maggs *et al.* 1994), one can argue that there is little threat to the widespread succulent species. The situation is, however, somewhat different for those succulent species of more restricted distribution, particularly the local endemics. These species are largely found in the Namibian centres of plant endemism (see Maggs *et al.* 1994) where overexploitation of land can easily lead to the endangerment of locally or regionally endemic species. In Damaraland and the Kaokoveld very intensive exploitation of certain plant groups by international pharmaceutical companies has taken place including succulent taxa like species of *Commiphora*. This exploitation has apparently already lead to the complete destruction of some plant populations in Damaraland and the Kaokoveld (C. Hines, pers. comm.).

In the coastal mining area of Diamond Area No. 1 (the coastal strip between Luderitz and Oranjemund) large scale destruction of the area immediately adjacent to the coast has taken place over the last sixty years. Few botanists have been given permission to enter the mining area proper, and hence one can only speculate about the extent of the damage and the effect of this on the vegetation and the loss of species diversity, particularly amongst the succulent plant species. From the work done by Jurgens on the vegetation dynamics of the sandveld area to the south of the Orange River, one can predict that a similar pattern would be found further to the north, expecting under natural conditions a situation with high species turnover and rapid dynamics. The mostly sandy soils, comprising largely wind blown material, have resulted in the evolution of species with the ability to regenerate fairly quickly. However, the large scale and rapid nature of the destruction caused by the mining operations will have certainly resulted in the extinction (at least locally) of some species. The mining activities and rehabilitation plans for the area do not incorporate appropriate botanical expertise; this is largely because only Consolidated Diamond Mining personnel are allowed to work in the mining area itself, very few of whom have the appropriate training. Perhaps of greater concern than the mining activities, which are largely confined to the coastal strip, are the recreational activities of the local inhabitants, particularly four-wheel drive off-road driving (Maggs *et al.* 1994).

Along the lower Orange River valley (between Hunsberge/Richtersveld and the Atlantic Ocean), diamond mining activities have increased markedly during the last ten years. Large stretches of this extremely arid landscape have been destroyed by surface mining and the deposition of screened material (mine dumps). Jurgens (pers. comm.), who has a number of permanent plots in this area, has found that extremely long time scales are required for the regeneration of the destroyed vegetation.

This area, termed the West Gariep Circle, is a local centre of endemism (Jürgens 1991) which has been very poorly researched as a result of restricted access to the area (Sperrgebiet). Mining occurs on both sides of the Orange River, thus resulting in the destruction of vegetation and loss of species in both Namibia and South Africa. Here again, the exploitation techniques used do not take into consideration the dynamics involved in the regeneration of vegetation.

Succulent collectors also cause some destruction in Namibia, particularly in the Hunsberge area, where extremely rare species like *Tylecodon* ***singularis*** or attractive and highly sought after species like ***Pachypodium*** are 'hunted'. Of great concern are recent reports of wild-collected plants removed from the restricted diamond mining area of the Sperrgebiet being offered for sale in Europe (D. Newton, pers. comm.; Maggs ***et al.*** 1994). Progressive opening up of the more remote parts of southern and western Namibia for mining, farming, and tourism will undoubtedly result in increasing losses of plants in the populations of rare and endangered succulent plant species.

Lesotho

Talukdar (1994) presents a review of the botanical diversity of Lesotho and its conservation. Of the threats to the flora which Talukdar lists, the ones most likely to have an impact on succulent species include: a) expanding human settlements; b) an increasing dearth of arable land in the lowlands resulting in intensive cultivation of the foothills and some mountain areas, often on steep slopes unsuitable for agriculture; c) overstocking — it is estimated that there are currently 2.5 to 4 times the number of domestic animals than the grassland is capable of sustaining in good health; d) overgrazing resulting from overstocking causing degradation of pasture, loss of topsoil through removal of vegetation cover and soil erosion, and the loss of species; and e) inundation of more than one-third of Lesotho's total area once the Lesotho Highlands Water Project is completed. This project, together with its related activities of road construction etc., will certainly have an impact on the populations of ***Aloe polyphylla*** and ***Delosperma ashtonii.*** In the case of ***A. polyphylla,*** the greatest threat is the uprooting and sale of this popular spiral aloe. Despite the protected status of this species (see Legislation below) the removal of plants from the wild for sale to collectors continues unabated (Donnay and Meyer 1981; Talukdar 1983, 1994). This is possibly a case where too much publicity has been to the disadvantage of the species, as it has only made the plant more desirable (Talukdar 1994).

South Africa

Much has been written about the threats to the botanical diversity of South Africa in general (see chapters in Huntley 1989 and 1994), and in particular on some of the causal factors responsible for the rate of decline in the numbers of species (see Everard 1988; Fourie 1984; Hall 1987; Hall ***et al.*** 1984; and Nolte 1992). Although natural causes, such as climatic shifts, and genetic decline certainly account for some of the changes in species abundances and distribution, it is undoubtedly the modification and transformation of the landscape by people which is having the greatest impact, not only on localised succulent species but also on widespread species. In summary, these transformations include:

1) Industrial development, urbanisation, expanding rural settlements and their allied transport infrastructure. These activities have often taken place in areas of high diversity and endemism, particularly along the coast, affecting considerable numbers of rare species.
2) The invasion of natural areas by introduced alien plants which often out-compete and replace the indigenous flora (see chapters in Macdonald *et* ***al.*** 1986).
3) Approximately 70 per cent of southern Africa is utilised by domestic livestock for grazing purposes (Macdonald 1989). Much of the land has been, and in many places still is, overstocked far beyond its carrying capacity resulting in overgrazing. This overgrazing together with trampling results in the loss of vegetation cover, increased soil erosion and ultimately the loss of species. In addition some succulent species

N.R. Crouch

Vendors selling their wares in the medicinal plant market of Ezimbuzini near Durban, South Africa.

are actively eradicated from farms, e.g. many of the *Tylecodon* species are dug out, because they cause stock illness (krimpsiekte) and even death when eaten. Other species like *Euphorbia aggregata,* are viewed by farmers in the Eastern Cape as nuisance plants (Smith 1994).

4) Large portions of the country are planted under crops resulting in monoculture landscapes with a few remnant patches of natural vegetation on hill tops or areas unsuitable for ploughing such as along rivers and streams. Much of the Western Cape for example is a patchwork of wheat fields and vineyards, and many species of *Haworthia* are confined to road verges or small remnant patches of natural vegetation in the southern parts of this region. The continued survival of some of these species is entirely dependant on the whims of the local farmers and landowners.
5) Extensive afforestation with alien timber species such as pines, blue gums and wattles, is resulting in considerable loss of natural habitat for many succulent species.
6) Expanding urbanisation and agriculture both require increasing quantities of water. The building of dams to meet this demand has resulted in the flooding of valleys with the loss of plant populations and perhaps even the extinction of some species. No information is available as to how many succulents have been affected by inundation.
7) Mining for minerals and quarrying for building materials has a major impact as many succulent species are confined to these unusual substrates. Unfortunately, the laws governing mineral rights take precedence over conservation laws because of the economic importance of the minerals to the country, especially in terms of foreign exchange. Only through intense public pressure and considerable lobbying of the government can mining activities be stopped.
8) Removal of succulent plants from the wild is also having an impact on the continued survival of many species. The full extent of this impact has yet to be documented although a number of trade surveys conducted in Europe, Japan, and the USA reveal that wild collected plants are being exported from southern Africa (see Fuller and Fitzgerald 1987; Jenkins 1993; Oldfield 1991, 1993). The collectors can be classified into three groups: amateur hobbyists, commercial collectors, and herbalists. Although some amateurs undoubtedly collect plants and seeds from the wild, they seldom do this on a regular basis or remove large quantities of material, to be of any major concern. Commercial collectors, on the other hand, have a far greater impact as they dig out hundreds and sometimes thousands of plants, even removing whole populations. The number of prosecutions over the years and the evidence of wild-collected plants in trade on the overseas markets indicates that this is an ongoing problem.

National Botanical Institute

Adenium multiflorum, a species frequently wild-collected and sold on the roadsides in Zimbabwe.

The international trade in southern African succulent species is being investigated by the South/Eastern African branch of TRAFFIC (D. Newton, pers. comm.). Some succulent species are collected for their edible, medicinal, or magical properties. *Haworthia limifolia* for example, is removed from the wild in large quantities by traditional herbalists, for sale to people in towns and settlements. The only succulent with medicinal properties which is exploited commercially at present is *Aloe ferox* (see Oldfield 1993). The leaves of A. *ferox* are harvested to extract a mucilaginous gel and bitter exudate known as 'bitter aloes' which is used by the pharmaceutical and cosmetic industries. A report on this harvesting and its impact on the species is being prepared by TRAFFIC (Newton 1993).

Swaziland

In Swaziland, as with most of the rest of southern Africa, the main threat to the succulent species is habitat degradation and destruction due to human activities, mainly from expanding settlements and agricultural activities. At least one species, namely *Haworthia limifolia*, is collected extensively for use as a traditional medicine.

Zimbabwe

In Zimbabwe many of the habitats where the specially protected plants (see National Legislation) occur are seriously endangered or at risk. The principal risks arise out of mining development, the construction of roads and dams, the construction of high voltage power lines, and the settlement or resettlement of people (often large numbers) in environmentally sensitive areas containing numbers of threatened or high risk species (Kimberley 1991).

Collectors do not pose a major problem in Zimbabwe since the number of specialist collectors and cultivators in Zimbabwe is very small (Kimberley 1991). There is, however, a threat from the activities of itinerant plant sellers who hawk specially protected indigenous plant species at all the major shopping centres in Harare quite openly and with impunity (Kimberley 1991). Similarly, specimens of *Adenium multiflorum* are often openly offered for sale on road sides to passers-by (Kimberley 1991). Every specimen sold undoubtedly causes the seller to remove further specimens from the wild thus reducing the size and viability of these populations.

A number of Zimbabwe's succulents are utilised for traditional medicinal purposes (see Drummond *et al.* 1975). The demand for traditional medicines has increased as the population has grown. These demands combined with the various environmental changes described above will inevitably result in a number of succulent species becoming scarce and possibly even extinct. The same is probably true for other southern African countries, particularly South Africa and Swaziland.

Existing conservation measures

International legislation

Several international conventions regulate domestic and international trade in protected succulent plants. The most important is the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (De Klemm 1990). The Convention, which came into force in 1975, has been ratified by over 130 countries including the southern African states of Botswana, Namibia, South Africa, and Zimbabwe. Swaziland is not a signatory and Lesotho, although a signatory, has not as yet ratified the Convention. A number of southern African succulent and semi-succulent species and genera are listed in Appendices I and II of CITES (Table 3.8). None are listed on Appendix III. Trade in more than 498 (14.7 per cent) of southern Africa's succulent taxa is regulated by the Convention. CITES not only regulates international trade in the listed taxa but also in their respective parts and derivatives given various exceptions depending on the taxon concerned (see Newton and Bodasing 1994 for details on the South African plant trade).

The succulent species in trade varies considerably from year-to-year and is dependent on a number of factors such as the availability of plants, taxonomic status of the group, availability of good literature on the group, rarity, ease of cultivation, and the popularity of the group. As trends in the succulent industry change, a species in demand today may not be so tomorrow. CITES attempts to remain abreast of the trends by reviewing listing at ten-year intervals. The Convention of the Parties which meets every two years, also reviews and votes on proposals to list or downlist taxa. As mentioned above, TRAFFIC South/Eastern Africa is conducting a survey (1994/95) to see which southern African succulent species arc in trade. Although it is difficult to obtain exact figures on the numbers of plants traded, the survey information combined with data from field studies will hopefully indicate which species, if any, are threatened by the trade. Initial results show that almost 2600 taxa of southern African succulents are currently being offered for sale in nurseries, indicating that the total number of species in international trade is significantly higher than reflected by

Table 3.8 Southern African succulent and semi-succulent taxa listed on the CITES Appendices

The figures in brackets indicate the approximate number of species or taxa indigenous to southern Africa covered by the listing (Note: *Pachypodium namaquanum*, formerly listed on Appendix I, was downlisted at the recent 1994 Convention of the Parties to Appendix II in order to facilitate trade in artificially propagated plants.)

Family	Appendix I	Appendix II
Aloaceae	Aloe *albida* (Stapf) Reynolds *A. pillansii* L.Guthrie *A. polyphylla* Schonland ex Pillans A. *thorncroftii* Pole-Evans *A. vossii* Reynolds	All *Aloe* spp. (196 taxa)
Apocynaceae		All *Pachypodium* spp. (5 spp.)
Asclepiadaceae		All *Ceropegia* spp. **(67** taxa)
Cactaceae		All *Cactaceae* species (1 sp.)
Euphorbiaceae		All succulent *Euphorbia* spp. (199 spp.)
Portulacaceae		All *Anacampseros* spp. (29 taxa)
Welwitschiaceae		*Welwitschia mirabilis* Hook.f.

the CITES trade statistics (Newton and Bodasing 1994). The results of this survey will be used to make conservation recommendations and some additional species and/or genera may well be proposed for listing under CITES at a future meeting of the Parties.

In addition to the fact that two southern African countries are not parties to the Convention, all of the southern Africa members are contravening the terms of the Convention in that they do not have separate management and scientific authorities. In South Africa at present, although the Department of Environment Affairs (aided by the Department of Foreign Affairs) is the official management authority, responsibility for enacting CITES is devolved to the provinces. South Africa therefore has four management authorities and all four of these provincial conservation agencies also act as the scientific authorities. As can be seen from the provincial legislation described below, there are many discrepancies between the provinces as to how CITES is interpreted and enacted. In addition, the South African regulations for the inspection of plant exports need to be strengthened with regard to expert official viewing of samples of the species being exported, as at present this is either very superficially done or not done at all (Cowling and Olivier 1992). The division of South Africa into nine new provinces requires that the issue of management authorities and regulations be addressed.

Following the Earth Summit in Rio de Janeiro in June 1992, all the countries in southern Africa became signatories to the Convention on Biological Diversity. The objectives of this Convention include "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources" (Article 1, UNEP 1992). In terms of the Convention, Contracting Parties are required to "develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity or adapt for this purpose existing strategies, plans or programmes" (Article 6, UNEP 1992). Although a number of southern African countries still have to ratify the Convention, and those who have done so still have to start preparing a national strategy, the Convention has significant implications for the conservation of southern African succulent plant species.

The only regional treaty of international relevance is the 1968 African Convention on the Conservation of Nature and Natural Resources (the African Convention). Under this Convention, the semi-succulent *Welwitschia mirabilis* is the only succulent species to be listed for full protection. In addition, Swaziland is the only southern African country which is a party to this Convention.

National (country and provincial) legislation

Each country within southern Africa has numerous legal statutes which provide for the protection of the formally proclaimed conservation areas such as national parks, game reserves, nature reserves, forest reserves, water catchment areas, wilderness areas, etc., and for the flora, fauna, and historical objects they contain. In addition to these statutes, there are a number of laws which protect individual species of indigenous plants outside of the declared protected areas. It is this legislation which is of most relevance to the conservation of succulent species. The relevant laws and the succulent species they protect are briefly discussed here on a country-by-country basis.

Botswana

There are no specific protection laws for plants in Botswana (Hargreaves 1992; Moyo *et al.* 1993), although plants are protected in the national parks, game reserves, sanctuaries, wildlife management areas, controlled hunting areas and forest reserves by the Wildlife Conservation and National Parks Act No. 28 of 1992 and the Forest Act No. 29 of 1980. In terms of the National Parks Act any person found in or leaving a protected area in possession of an object of "scientific interest", e.g. a succulent plant, has committed an offence. Unfortunately very few of the conservation areas are in the southern and eastern parts of the country where most of the succulent species occur. In terms of the Forest Act a number of species are declared protected trees. However, under the Forest (Declaration of Protected Trees) Order of 198 1 (Section 11), those species which occur on state land, e.g. *Adansonia digitata* (a semi-succulent), may be utilised by the inhabitants of specified villages/towns or habitations. In order to provide some protection for severely endangered species, the National Museums of Botswana is investigating the possibility of declaring some of the sites where these species occur as "National Monuments" under the Monuments and Relics Act 15 of 1970 (the *Aloe marlothii* forest at Molepole will be the first test case). In terms of this act, a monument may be defined as "any area of land containing rare or distinctive or beautiful flora". However, even if this measure is successful it can only provide protection for a few individual specimens, not all the plants of a species. Therefore, there is an urgent need for the enactment and enforcement of suitable legislation to protect the flora of Botswana.

Lesotho

Threats to the survival of the national flower of Lesotho, *Aloe polyphylla*, prompted the development of national legislation to protect this and other threatened species. In 1938 a Proclamation was issued by the Resident Commissioner of Basutoland, prohibiting the removal, export, sale, or destruction of A. *polyphylla* (Talukdar 1983). This Proclamation was replaced by the Historical Monuments, Relics, Fauna and Flora Act No. 41 of 1967 which set out regulations protecting the flora of Lesotho. This Act also made provision for the formation of the Protection and Preservation Commission (PPC) whose responsibility it was to enforce the Act. On the advice of the PPC the government of Lesotho issued a Legal Notice

(No. 36 of 1969) in which the Protected Flora of Act 41 were defined. The first item in the schedule of protected flora provides for the protection of all Aloe species, but with particular reference to A. *polyphylla* including its seeds and flowers. *Cussonia* species were the only other succulent or semi-succulent group to be listed as protected flora. The PPC also published a Public Notice in 1970 which prohibited the removal and/or export of A. *polyphylla* (Talukdar 1983). As mentioned above, despite all these legal attempts to protect this species, protection has very rarely been enforced and populations of the species have continued to decline (Donnay and Meyer 1981; Talukdar 1994). Although this species is unlikely to become extinct within the next five years, an integrated conservation plan is required which includes traditional conservation measures, the involvement of local village chiefs and headman, combined with an active public education campaign. The flora protection laws, fines imposed, and law-enforcing arm also need to be strengthened in order to protect other succulent species in Lesotho, and the personnel involved must be made conversant with what is protected and why.

National Botanical Institute

Aloe *polyphylla*, the national flower of Lesotho and a highly Endangered species because of wild-collecting.

Namibia

The Constitution of Namibia makes provision for the conservation of its flora and fauna as part of government policy by stating that "The State shall actively promote and maintain the welfare of the people by adopting . . . policies aimed at . . . the maintenance of ecosystems, essential ecological processes and biological diversity in Namibia and utilisation of living natural resources on a sustainable basis for the benefit of all Namibians, both present and future..." (Article 95). At present this policy is enforced by the Nature Conservation Ordinance (No. 4 of 1975) as amended in 1986 (Act No. 27) and 1990 (Act No. 31). Under Schedule 9 of this Act, a large number of succulent species are listed as 'Protected Plants'; these are listed in Table 3.9. It is interesting to note that the fines and periods of imprisonment for offences relating to animals have been amended and substantially increased (Act No. 31 of 1990), while those for plants have remained unchanged. Such disparities between the laws concerning flora and fauna are a common feature of all southern African countries.

Despite the above legislation there are no adequate methods of law enforcement in place to protect individual species and the list of protected plants is desperately in need of revision (Maggs *et al.* 1994). The conservation laws in Namibia are currently being redrafted, and an environmental lawyer was recently appointed as a consultant to help in preparing the draft (M. Strobach, pers. comm.).

South Africa

With the establishment of the Union of South Africa in 1910, the responsibility for the protection of the flora and fauna was accepted by the four provincial administrations (Section 85, Paragraph 10 of the South Africa Act 1909), and this has remained virtually unchanged since then (see Fuggle and Rabie 1992 and Glavovic 1993). The most important legislation in terms of which indigenous plants outside protected areas are conserved are the various provincial nature conservation ordinances. The definition of the term 'indigenous plant' as used in the ordinances varies, but in general it means any species of plant which is indigenous to the Republic of South Africa and Namibia, irrespective of whether it is or has been cultivated, or whether it is no longer growing in the wild state, or has for some time not been growing in the wild state. The Orange Free State and Transvaal ordinances further specify that protection covers the flower, seed, fruit, cone, bulb, tuber, stem, root or any other part of such plant. The latter also specifies that the plant can be alive or dead. All the ordinances exclude those plants declared to be noxious weeds in terms of any law.

The provincial ordinances will all have to be reviewed and changed as a result of the political changes within South Africa (see discussion below on changes to the legislation). However, as these ordinances are still in operation they are discussed here and the succulent species they protect are listed in Table 3.10.

Cape — The Cape Nature and Environmental Conservation Ordinance 19 of 1974 provides for the protection of certain plant species indigenous to the Republic of South Africa and Namibia (see Table 3.10). Schedule 3 of the Ordinance lists the 'endangered flora', which includes those species in danger of extinction and those listed in Appendix I of CITES, but excludes those species listed in the Appendix which are specified in Schedule 4 (for example, Aloe *polyphylla,* an endangered species listed on CITES Appendix I, is not included in Schedule 3 because it is included under all *Aloe* species in Schedule 4). Schedule 4 of the Ordinance lists those species declared to be 'protected flora' and includes all species listed on CITES Appendix II, except for those specified in Schedule 3 ***(Pachypodium namaquanum*** is an example of this). Under the Ordinance no person may sell, donate, receive as a donation, pick, or import into, export from, or transport through the Province any 'endangered flora' without a permit issued by the Director of Cape Nature Conservation. Similarly no person may pick 'protected flora' without a permit or 'indigenous unprotected flora' without the written, dated and signed permission of the land owner or other authorised person. The sale of protected flora is also controlled by the registration and licensing of flora growers and sellers.

Natal — Under the Natal Nature Conservation Ordinance 15 of 1974, as amended in 1993, Schedules 10, 11 and 12 list 'unprotected indigenous plants', 'protected indigenous plants', and 'specially protected indigenous plants', respectively. No succulent species are included on the list of 'unprotected indigenous species'. Schedule 11 declares all plants indigenous to the Republic of South Africa and Namibia, except those listed in Schedules 10 and 12, to be protected. This list therefore includes the vast majority of succulent taxa listed in Table 3.4, except for those specified in Schedule 12 and 12A. The succulent taxa listed as specially protected plants on Schedule 12 are listed in Table 3.10. Schedule 12A refers to all plants on CITES Appendix I and Appendix II. In terms of the Ordinance, the Natal Parks Board is charged with the conservation of indigenous plants in Natal and it is their responsibility to issue permits or licenses which govern the picking, sale, possession, import, or export of 'protected indigenous plants' and 'specially protected indigenous plants'.

Orange Free State — In the Orange Free State, Section 30 of the Nature Conservation Ordinance 8 of 1969 declares all the species specified in Schedule 6 which are indigenous to the Republic of South Africa and Namibia to be protected plants. The succulent species specified are listed in Table 3.10. In terms of the Ordinance no person may pick any 'protected plant' without a permit issued by the Administrator and no person may pick any indigenous plant without the written permission of the land owner. In addition, no person may sell, donate, import into or export from the Province any 'protected plant' or a plant of an 'endangered species' (CITES Appendix I species) or 'scarce species' (CITES Appendix II species), except under the authority of a permit from the Administrator.

Transvaal — The Transvaal Nature Conservation Ordinance 12 of 1983 has two Schedules providing for the protection of plant species indigenous to the Republic of South Africa and Namibia. Schedule 11 (Section 86 (l)(a)) specifies 'protected plants' and Schedule 12 (Section 86 (l)(b)) specifies 'specially protected plants'. Schedule 11 excludes all plants which have been improved by selection or cross-breeding, and it excludes all species of *Aloe* which do not occur in the Transvaal and a number of relatively common Aloe species (see Table 3.10 for excluded species). The succulent species declared to be 'specially protected plants' are listed in Table 3.10. In terms of the Ordinance no person may possess, pick, sell, purchase, donate or receive as a donation, import into or convey within, or export or remove from the Province a 'protected plant' or 'specially protected plant' unless they have a permit authorising them to do so. No indigenous plants may be picked within a nature reserve without a permit nor on private land without prior written permission from the land owner or occupier. All nursery owners are required to be registered in order to sell any species of protected plant cultivated in their nurseries.

In addition to the 'protected' and 'specially protected' plants, all species listed on Appendices I and II of CITES, and any readily recognisable part or derivative thereof, is declared by the Transvaal Ordinance to be an endangered species or a rare species respectively. No person may import into or export or remove from the Province an endangered species or a rare species, unless they have a permit authorising them to do so.

Adequacy of provincial legislation

The current legislation for the conservation of South African flora is deficient in many respects:

1) There is no formal national policy on indigenous flora, a situation which is exacerbated by divided control and the lack of prescribed co-ordination between the various conservation agencies.
2) It is clear from the above provincial ordinances that the existing laws are fragmented, haphazard, and often inconsistent with each other, particularly concerning which plant species (even which parts of plants) are protected and what level of protection they have within various parts of South Africa.
3) There are a number of loopholes within the legislation which are easily exploited by unscrupulous plant dealers, particularly with regards to the transfer of plants between provinces.
4) Most of the ordinances are fairly old and as a result the taxonomy of the taxa listed in the schedules is out-dated.

5) The laws concerning plant species are generally far less stringent than those for animals, particularly for large mammals like elephant and rhino (this is true for all southern African countries).
6) Levels of enforcement vary considerably from province to province, and in many cases fall far short of what is desirable. This is not a reflection of the abilities of the law enforcers themselves but of their small numbers, budgetary shortages, and vast areas subject to their control (Cowling and Olivier 1992).
7) Even if an offender is apprehended and prosecuted, the fines imposed are often too low to act as a serious deterrent to commercially-minded plant collectors (Hilton-Taylor and Le Roux 1989).

The election of a new government, the development of a new constitution, the reincorporation of the former homeland areas into South Africa, and the division of South Africa into nine new provinces since April 1994 has many implications for conservation. All provincial legislation, including the conservation ordinances, will have to be either redrafted or drafted from new. This presents an ideal opportunity for the conservation community to become involved in the legal processes which provide protection for our flora and fauna. Ideally, there should be a national conservation statute with regional administration of it. If it is decided to maintain the present system, all disparities and inconsistencies between provinces must be removed, when the conservation ordinances are drafted or redrafted. The schedules of protected plants need to be recompiled and updated on a regular basis based on good scientific information (the national status of a species must be considered, not just its local provincial status). The fines for offences must also be adjusted so that they act as an effective deterrent. Adequate funding must be made available by government to ensure the efficient enactment and policing of this new legislation. At the same time, however, the new legislation will have to make allowances for aboriginal rights and the harvesting practices of indigenous people. It will be a long time, if at all, before the tribal cultures are assimilated into western society, hence their needs and traditional values have to be accommodated within the legal system. Controlled access to natural resources (including succulent plants) consistent with traditional harvesting practices and the principle of sustainable utilisation will have to be allowed. Although better control of trade in plants used for traditional healing and other traditional uses will be essential, the law must be sensitive to the needs of the people involved in such trade.

Swaziland

There is an assortment of legislation in Swaziland relating to the protection of its indigenous flora. The National Trust Commission Act of 1972, which created the Swaziland National Trust Commission to oversee nature conservation and the preservation of Swazi heritage, provides legislation concerning protected areas proclaimed under this Act (Braun and Prendergast 1992). For succulent species which occur outside of the protected area network, the Flora Protection Act No. 45 of 1952 (as amended by Government Notices 146 of 1974 and 32 of 1975) is of most importance. Under this Act a number of species are listed in a Schedule as 'protected indigenous plants'. The succulent species on the Schedule are listed in Table 3.9. In terms of the Act 'protected indigenous plants' means any plant, shrub or tree (all parts included) indigenous to southern Africa which is included in the Schedule. The Act prohibits any person from plucking, gathering, cutting, uprooting, injuring, breaking, destroying, selling, exporting, or possessing any 'protected indigenous plants' unless they have a permit from the Minister, or the plants have been specifically cultivated, or the land is required for cultivation or construction. In terms of the Act the Minister of Agriculture is enabled to establish one or more indigenous floral reserves.

Attempts were made in 1975 to amend the Flora Protection Act by means of a draft Amendment Order. The aim of this amendment was to make provision for better and more effective protection of the flora of Swaziland, and to increase the penalty for any contravention of the Act. Many of the clauses in the draft were unfortunately not accepted. Enforcement of the conservation legislation in Swaziland, as in most of southern Africa, is extremely difficult and many offences go unprosecuted (Braun and Dlamini 1994).

Zimbabwe

A number of plant species are specially protected indigenous plants in terms of the Zimbabwean Parks and Wildlife Act of 1975. The succulent species which are afforded protection by this Act are listed in Table 3.9. Under this Act, it is a criminal offencc to dig up, pick, tamper with, or remove 'specially protected indigenous plants' from habitat.

Land owners were exempt from the provision of the Act until 1985 when an amendment to the Parks and Wildlife Act of 1975 inserted a new Section 46A into the Act which empowers the Minister of the Environment and Tourism, if considered necessary or desirable to do so in the interests of preservation, conservation, propagation or control of any indigenous plants within Zimbabwe or any area of Zimbabwe, to prohibit (absolutely or subject to conditions, indefinitely or for a specified period) the land owner from picking or selling specified indigenous plants.

It is also an offence to sell a 'specially protected indigenous plant' except in terms of a permit issued by the Minister. Likewise, it is an offence to purchase a specially protected indigenous plant except from a permit holder or an authorised dealer in such plants.

Table 3.9 Succulent plants declared to be protected species in Namibia, Swaziland, and Zimbabwe

In some cases, the names of the taxa listed in the Acts have gone into synonymy; the currently accepted names are shown here with the synonyms in brackets or, if the species of a genus have been transferred to a number of genera, these genera are given in brackets, Genera followed by 'spp.' include all species.

Namibia

Aizoaceae
Aridaria noctiflora
Astridia spp.
Cephalophyllum spp.
Chasma tophyllum musculinum
Cheiridopsis spp.
Conophytum spp.
Dinteranthus spp.
Ebracteola spp.
Fenestraria rhopalophylla ssp. *aurantiaca*
Hereroa spp.
Jensenobotrya lossowiana
Juttadinteria spp.
Lapidaria margaretae
Lithops spp.
Nananthus aloides
Opthalmophyllum spp. (many of these are now *Conophytum* spp.)
Psammophora spp.
Ruschia spp.
Schwantesia spp.
Stoeberia spp.
Titanopsis spp.
Trichodiadema spp.

Aloaceae
Aloe spp.
Chortolirion angolense (= C. bergerianum)
Gasteria pillansii var. *ernesti-ruschii*
Haworthia venosa ssp. *tesselata (=H. tesselata* var. *engleri.)*

Apocynaceae
Pachypodium lealii
P. namaquanum

Asclepiadaceae
Caralluma spp. (transferred to either *Quaqua* or *Pachycymbium)*
Ceropegia spp.
Duvalia spp.
Hoodia spp.
Huernia spp.
Huerniopsis spp.
Piaranthus spp.
Stapelia spp.
Tavaresia barklyi (= Decabelone barklyi)
Trichocaulon spp. (transferred to either *Hoodia* or *Lavrania)*

Crassulaceae
Adromischus spp.
Crassula spp.

Moringaceae
Moringa ovalifolia

Portulaceae
Anacampseros spp.
Portulacaria pygmaea

Vitaceae
stem succulent *Cyphostemma* spp.

Welwitschiaceae
Welwitschia mirabilis

Swaziland

Aizoaceae
Lithops spp.
Frithia spp.

Aloaceae
Aloe spp.
Haworthia spp.

Apocynaceae
Adenium multiflorum
A. swazicum
Pachypodium saundersii
Brachystelma spp.
Caralluma spp. (transferred to *Pachycymbium)*
Ceropegia spp.
Duvalia spp.
Huernia spp.
Stapelia spp.
Stultitia spp. (transferred to *Orbea, Orbeopsis* or *Pachycymbium)*

Zimbabwe

Aloaceae
All species and varieties of Aloe, including the natural hybrids

Apocynaceae
Adenium multiflorum (=A. obesum) ssp. *multiflorum*
Pachypodium saundersii
Hoodia lugardii
Tavaresia barklyi

Euphorbiaceae
Euphorbia davyi
E. decidua
E. memoralis
E. wildii

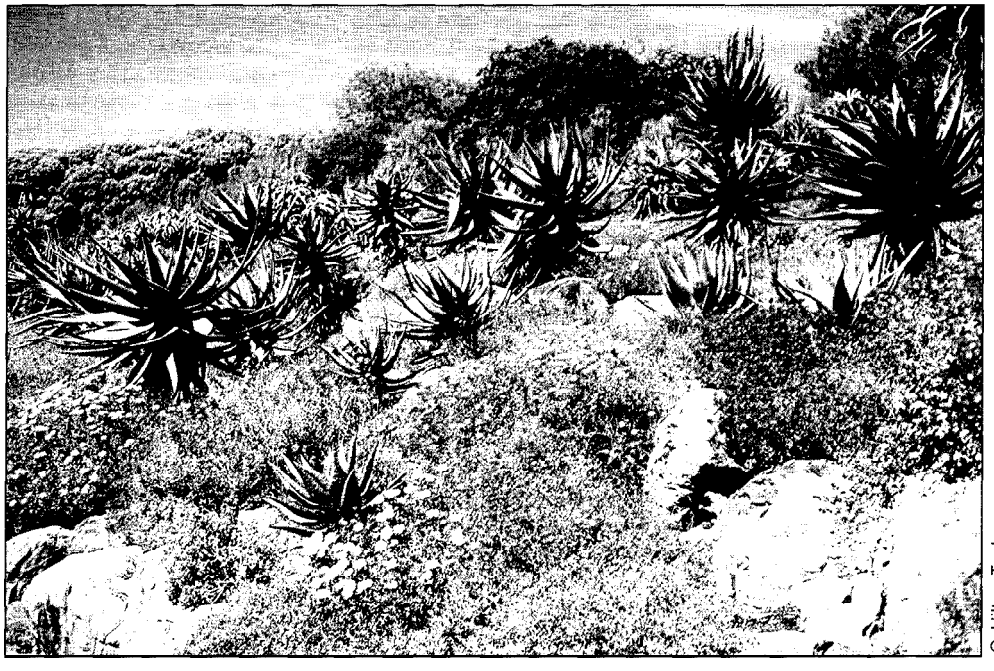
Passifloraceae
Adina fructicosa
A. spinosa

Protected area network

A large number and variety of protected areas such as national parks, game reserves, state forests, wilderness areas, local authority nature reserves, bird sanctuaries, water catchment areas, etc., have been established within the countries of southern Africa. The aim of most of these areas is principally to ensure that entire ecosystems, communities, or habitats are conserved, rather than just individual plant or animal species. A few reserves have been proclaimed specifically for the preservation of a single species (mainly mammals as for example in the case of the Addo Elephant National Park or Bontebok National Park), but in so doing much of the natural habitat is also conserved. The protected area network in each southern African country is described and reviewed by WCMC (1991), and additional details concerning the preservation of key South African ecosystems are given in Huntley (1989). The adequacy of the existing protected area network in relation to the preservation of the flora of each southern African country is reviewed in Huntley (1994). From that information it appears that some 30 million hectares (9.8 percent of the area of southern Africa) is included in state or semi-state conservation areas. This figure would be considerably higher if one were to include all the privately owned and local authority reserves, but as they have no long-term conservation value (in terms of current legislation) they have been ignored.

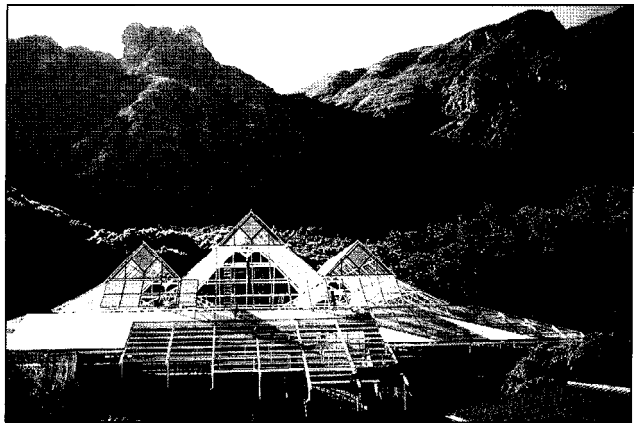
Many of the protected areas in southern Africa have been declared on an ad hoc basis or have been the result of the focus on suitable extensive areas for the conservation of large mammals, rather than the result of a preconceived design for maximising the preservation of biological diversity (Huntley 1978; Siegfried 1989). Given that six percent of South Africa is set aside for conservation, it is surprising to find that possibly 74 percent of South Africa's vascular plant species occur within the reserve system (Siegfried 1989). This result may be an artefact of the data used for the analysis, although the finding is supported by data for Swaziland which indicates that 60 percent of Swaziland's plant species are protected within two small nature reserves covering only two percent of the total area of that country (Braun and Dlamini 1994). Siegfried (1989) was only able to obtain complete plant checklists for 52 of South Africa's reserves and partial checklists for 153 reserves, whilst 377 had no lists at all. This situation is still true for much of southern Africa today and as a result it is impossible to say at this stage how many succulent species occur in the protected area network. However, given the facts that succulents are often highly localised to particular and often unusual habitats and that the areas with the highest diversity of succulents are the least conserved (see Hilton-Taylor and Le Roux 1989; Cowling and Hilton-Taylor 1994), it is reasonable to conclude that very few of our succulent taxa are conserved in the protected area network. The Succulent Karoo for example, an area with the greatest diversity of succulent plants in southern Africa, has less than two percent of its area set aside for conservation (see Hilton-Taylor and Le Roux 1989; Hilton-Taylor 1994).

In an attempt to identify the gaps in the southern African (excluding Zimbabwe) protected area network, Rebelo (1994) used iterative selection procedures to analyse data from PRECIS (the PRE (National Herbarium, Pretoria) Computerised Information System). The main aim of this analysis was to determine the optimal placement of nature reserves in relation to the centres of endemism. Rebelo (1994) has shown that 93 percent of southern Africa's plant taxa can be conserved optimally in just ten percent of southern Africa's area,



C. Hilton-Taylor

The Mathews Rockery at Kirstenbosch National Botanical Garden which contains a large variety of Aloe species and many species of Aizoaceae.



C. Hilton-Taylor

The new arid plants conservatory at Kirstenbosch National Botanical Garden will display to the public one of the largest collections of southern African succulents in the world.

require 22 per cent of the area. Comparing the existing protected area network to the optimal reserve configuration, Rebelo (1994) has indicated in which areas land needs to be set aside for conservation. The largest contiguous area requiring preservation that currently has the fewest reserves is the Succulent Karoo as discussed above. There are a number of problems with the PRECIS data set, including incompleteness (especially with regards to succulent taxa), incorrect data, uneven coverage (especially for the arid regions), and the coarse scale used for recording distributions (Rebelo 1994). In order to assess how effective the current reserve network is in preserving succulent plants and to identify gaps in the network, detailed distribution information would have to be obtained from all the main herbaria in the region and subjected to a similar analysis.

Although approximately 14 per cent of Zimbabwe has been set aside for conservation purposes, the complete range of vegetation types is not adequately conserved and there are many rare and/or endemic plant species which are not protected in the existing network (Timberlake and Muller 1994). It is also alarming to note that 11 of the 25 Botanical Reserves, established in 1975 under the Parks and Wildlife Act, were deproclaimed in 1979 presumably because of partial destruction or degradation (Timberlake and Muller 1994). Using a hierarchical approach, Timberlake and Muller (1994) have identified a number of areas important for the conservation of botanical diversity in Zimbabwe. They also stress that simply identifying these areas is not sufficient for conservation. Land-use planning and appropriate management techniques need to be developed as well (Timberlake and Muller 1994).

Ex situ conservation

Although regarded as the ideal option, there are significant drawbacks to *in* situ conservation of plant species in protected areas. These areas are vulnerable to natural disasters such as pests, fires, and storms; vulnerable to political whims and ever-increasing pressures for land; rapidly becoming more expensive to manage and protect; protect only a limited number of species and genotypes; and susceptible to the effects of global warming (Moss 1994). A complementary tool to in situ conservation is the use of *ex* situ gene banking methods. Gene banking includes the preservation of frozen seeds in conventional seed banks, the growing of plants in field gene banks such as in botanical gardens, arboreta and nurseries, and in vitro techniques such as tissue culture for micropropagation and cryopreservation (Hawkes 1992). The conservation of species by means of ex situ techniques also has many disadvantages, for example: only a very small portion of the total gene pool can be stored; it is a very expensive and labour intensive operation; evolution is effectively stopped; genetic shift and drift may occur in multiplication cycles, thus compromising genetic integrity; and very little is known about the long-term viability of seed of most wild species (Moss 1994). On the positive side, however, *ex situ* samples serve as an insurance policy or hedge against population extinction or catastrophic loss of habitat and they can also be used to enhance the probability of success of the irreplaceable *in situ* efforts.

Ex situ conservation of plant diversity by means of seed banks has been slowly getting under way in southern Africa since 1987 with the development of a regional genetic resources programme known as the SADC (Southern African Development Community) Regional Gene Bank (see Moss 1994). The main focus of this programme, which involves the establishment of national gene banks, has been on genetic resources which have economic value as agricultural crops, forages, medicinal plants, horticultural crops, traditional wild foods, etc. Unfortunately, very few succulent species have been considered to have enormous economic potential to warrant the collection and storage of their seed. Aside from a handful of succulent seeds collected during recent expeditions to Namibia and South Africa there is very little seed of southern African succulent species (there may be some seed of a few semi-succulents) stored in the national gene banks established so far, and it is doubtful whether there are any samples in overseas gene banks such as Wakehurst Place at the Royal Botanic Gardens, Kew (see Braun and Prendergast 1992; Prendergast 1994). Even the small gene bank established by the Bolus Herbarium of the University of Cape Town for endangered species contains no seed of any succulent species (A.V. Hall, pers. comm.).

Most of the countries in southern Africa (excepting Swaziland) have at least one botanical garden. Some of these gardens are very new such as the one being established near Gaborone by the National Museums of Botswana, and that being developed around the National Herbarium in Windhoek by the National Botanical Research Institute of Namibia. In Lesotho, the University

Table 3.10 Succulent plants declared to be Protected Species (*), Specially Protected Species (#) or Endangered Species (+) by the nature conservation ordinances of the four provinces of South Africa

In some cases, the names of the taxa listed in the Ordinances have gone into synonymy; the currently accepted names are shown here with the synonyms in brackets or, if the species of a genus have been transferred to a number of genera, these genera are given in brackets.

Cape

Aizoaceae
All species in the family formerly called the Mesembryanthemaceae*
Aloaceae
Aloe spp.* (except for A. *ferox)*
Aloe buhrii +
A. erinacea +
A. pillansii +
Gasteria nitida var. *nitida* * *(=G. beckeri)*
Haworthia spp. *
Apocynaceae
Pachypodium spp.*
P. namaquanum +
Asclepiadaceae
All species*
Crassulaceae
Crassula coccinea * *(=Rochea coccinea)*
C. columnaris * (presumably including the subspp.)
C. *petfoliata* var. *minor* * *(= C. falcata)*
C. perfoliata var. perfoliata *
C. pyramidalis *
Kalanchoe thyrsiflora *
Dioscoreaceae
Dioscorea eiephan tipes *
(= *Tes tudinaria elephantipes)*
D. *sylvatica* var. *syivatica* * *(=T. syivatica)*
Euphorbiaceae
Euphorbia bupieurifoiia *
E. fascicuiata *
E. *globosa* *
E. horrida * (presumably including the 3 varieties)
E. groenewaldii #
E. meloformis *
*E. obesa**
E. schoenlandii *
E. symmetrica *
E. valida *
Portulacaceae
Anacampseros spp. *
All families
All species on CITES Appendix I
All species on CITES Appendix II*

Natal

Aloaceae
Aloe spp.*
Gasteria spp. #
Haworthia spp.#
Apocynaceae
Adenium spp. #
Pachypodium saundersii #
Asclepiadaceae
Brachysteima spp. #
Caraiiuma spp. # (Natal species transferred to *Pachycymbium)*
Duvalia spp.#
Huernia spp. #
Stapeiia spp.#
Stuititia spp.# (transferred to *Orbea, Orbeopsis* or *Pachycymbium)*
Dioscoreaceae
Dioscorea spp.#
All families
Species indigenous to the Republic of South Africa or Namibia*, species on CITES Appendix I and CITES Appendix II*

Orange Free State

Aizoaceae
Lithops spp. *
Neohenricia sibbetii *
Pieiospiios spp. *
*Titanopsis calcarea**
Aloaceae
Aloe spp.#
Haworthia venosa ssp. *tesselata* * *(=H. venosa* ssp. *recurva)*
Apocynaceae
Pachypodium spp. *
Araliceaea
Cussonia spp.#
Asclepiadaceae
Stapelieae spp. *
Ceropegia spp.*
Trichocauion spp. * (transferred to *Hoodia* or *Lavrania)*
Begoniaceae
Begonia sutheriandii *
Dioscoreaceae
Dioscorea spp. *
Euphorbiaceae
Euphorbia spp. *
Portulacaceae
Anacampseros spp. *

Transvaal

Aizoaceae
Lithops lesliei # (presumably including the 7 varieties)
Frithia puichra # (presumably including the variety)
Aloaceae
*A/i Aloe** *species excluding (a) those not occurring in the Transvaal and (b) the following: A. acuieata, A. ammophiia, A. arborescens, A. ctyptopoda (=A. wickensii), A. grea theadii* var. *davyana (=A. barbetfoniae), A. castanea, A. davyana, A. mutans, A, globuligemma, A. grandiden ta ta, A. iutescens, A. mariothii* , A. *parvibracteata, and A. transvaaiensis*
Gasteria spp. *
Haworthia spp. *
Apocynaceae
Adenium multifiorum # (=A. obesum)
A. oleifolium #
A, swazicum #
Pachypodium saundersii#
Araliceaea
Cussonia spp.*
Asclepiadaceae
Brachysteima spp.#
Ceropegia spp. #
Duvaiia spp. #
Hoodia currorii ssp. iugardii # (=H. lugardii)
Huernia spp. #
Huerniopsis spp.#
Orbea spp. #
Orbeanthus spp.#
Orbeopsis spp. #
Pachycymbium spp.#
Stapeiia spp. #
Begoniaceae
Begonia spp. #
Bombacaceae
Adansonia digita ta #
Dioscoreaceae
Dioscorea spp.#
Euphorbiaceae
Euphorbia barnardii #
E. ciivicola #
E. grandiaiata #
E. knobelii #
E. perangusta #
E. restricta #
E. rowiandii #
E. tortirama #
E. waterbergensis #

of Roma has a garden in Maseru, and there are at least four gardens in Zimbabwe. South Africa has the greatest number and diversity of gardens ranging from eight National Botanical Gardens — under the auspices of the National Botanical Institute (NBI) whose primary focus is the growing of indigenous flora — to a large number of university, municipal, and privately owned gardens.

Practically all of the gardens in southern Africa grow succulent species; however, not all of these gardens maintain accurate records about the sources of their plant material, the location of this material in their garden, and the history of these plants, especially the genetic integrity of their progeny. More importantly, few of these gardens maintain succulent collections with the goal of conservation of species; most of the gardens are primarily intended for recreational purposes. All of these gardens can, however, play an important role in succulent plant conservation (see Heywood 1992). One of the stated objectives of the National Botanical Gardens (NBI) in South Africa is to establish collections of threatened plants and to promote the *ex* situ conservation of rare and endangered species. All of the NBI gardens grow succulent plants; however, it is the Kirstenbosch, Pretoria, and Karoo National Botanical Gardens which have the largest collections, particularly the latter (see *Ex* situ conservation in Chapter 2). No attempt has been made so far to determine accurately how many species of succulents in total are in cultivation at these gardens, or how many plants there are (especially of different genetic origin) of each species. Some attempts have been made to determine the number of threatened species being grown in each garden, but there has been no comparison between gardens. It is therefore difficult to determine exactly how many threatened species in total there are in cultivation. The new *Red Data List of Southern African Plants* (Hilton-Taylor 1996b) provides the opportunity to assess the numbers of threatened succulent species in cultivation.

Table 3.11 provides a preliminary assessment of the southern African (FSA region only) Aloaceae taxa in cultivation at three of the National Botanical Gardens of South Africa (Karoo, Kirstenbosch, Pretoria) in 1994. The overall results are very encouraging with 88 per cent and 95 per cent of the *Aloe* and *Haworthia* taxa, respectively, in cultivation. All of the taxa in the remaining genera which occur in the region, namely *Astroloba (5* taxa), *Chortolirion* (1 taxon), *Gasteria (22* taxa), and *Poellnitzia (1* taxon), are also in cultivation in at least one of the three gardens. Looking at the threatened species, 91 per cent of the threatened *Aloe* taxa and 85 per cent of the threatened *Haworthia* taxa are in cultivation. Unfortunately, what these figures do not indicate are the exact numbers of plants of each species being grown. In many cases this is a single individual or a few plants, often of the same clone. So while the results are good in terms of species diversity, in terms of conservation of genetic diversity the results are very poor. More attention needs to be paid to this problem by the gardens if they wish to continue their role in *ex situ* conservation.

Despite the various drawbacks and problems in maintaining species in gardens, this method of conservation is of considerable value as is clearly illustrated by Foster (1993) in describing how the collection of Aloaceae is utilised at the Royal Botanic Gardens, Kew. The collections of Aloaceae in the botanical gardens of southern Africa are an important international scientific and conservation resource. The Pretoria National Botanical Garden, for example, has not only one of the most comprehensive collections of southern African aloes, but includes 139 *Aloe* taxa from

Table 3.11 The numbers of southern African *Aloe* and Haworthia taxa in cultivation at the Kirstenbosch, Karoo, and Pretoria National Botanical Gardens, South Africa (figures for Haworfhia were not available for Pretoria) in 1994

The figures for each garden are indicated separately and then a combined total for each genus is shown. Column one indicates the number of plants in cultivation column two the per cent of southern plants[a] in cultivation, column three the number of threatened taxa in cultivation, and column four the per cent of the total number of threatened taxa in that genus[b] which are in cultivation.

	In cultiv.	Per cent	Threatened	Per cent
Aloe				
Kirstenbosch NBG	115	71	35	67
Karoo NBG	7-t	44	20	39
Pretoria NBG	125	77	44	85
Total	**143 (163[a])**	**88**	**49 (54[b])**	*91*
Haworthia				
Kirsten bosch N BG	58	50	15	38
Karoo NBG	101	**88**	**33**	**83**
Total	**109 (115a[a])**	**95**	**34 (40[b])**	**85**

[a] Total number of taxa in the FSA region.
[b] Total number of taxa in the region considered to be threatened.

east Africa, north-east Africa, and Madagascar, plus five species of *Lomatophyllum* from Madagascar and the Mascarene Islands.

Proposed conservation strategy

Despite all the international and national legal protection measures, despite the existing protected area network, and despite attempts to establish *ex situ* conservation measures, the current development patterns and continued exploitation of resources in southern Africa are resulting in the increasing depletion of the region's succulent plant diversity. To prevent the loss of this diversity a multi-faceted conservation strategy involving all the stake-holders is required (see Nolte 1992 who presents such a strategy for the conservation of succulent plants). Incorporated into the Action Proposals in Chapter 4 are a number of suggestions and actions which are required as part of this strategy. The list is by no means comprehensive and the actions are not listed in any order of priority. Although suggestions are given as to who the key players for each action are, the proposals are not intended to be prescriptive or binding in any way. Also, as many of the key players have not been fully identified or consulted about their involvement, no attempt has been made to cost or timetable any of the proposals. Many of the actions are also not once-off events, but rather on-going exercises.

The dramatic political transition that has occurred in South Africa since the start of the reform programme, initiated in 1990 and culminating in the inauguration of Mr Nelson Mandela as the President of a democratic South Africa on 27 April 1994, is having a profound influence on conservation policy within South Africa and which may have repercussions for the adjoining states (Huntley 1996). The new government of national unity has placed the highest priority on its Reconstruction and Development Programme (RDP) to redress the legacy of apartheid. The RDP, which focuses primarily on socio-economic disparities, will also be addressing environmental issues, and policy outlines indicate that new approaches need to be developed by the existing conservation agencies (Huntley 1996). The conservation strategy included in Chapter 4 (certainly for South Africa) needs to be carried out within the constraints of the RDP. An important policy change required by the RDP is the participation of local communities in the decision-making process concerning environmental issues such as land tenure and access to natural resources. Such transparent procedures concerning resource utilisation (Huntley 1996) and the development of good neighbour relations in the management of protected areas (Fourie 1994) will hopefully dispel the view held by most of southern Africa's black majority that saving succulent plants (along with rhinos, elephants, and other internationally popular species) is an indulgent pursuit of the affluent minority.

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North America

Edward F. Anderson

The continent of North America has a land mass of 24,700,000 km^2 (9,500,000 mi^2), which makes up 16.2 percent of the earth's surface. It extends from 14°30'N at the Mexico-Guatemala border to 70°N latitude near the Arctic Circle. Virtually all types of biomes are present, from arctic tundra to tropical rain forest. Topography is also highly variable, ranging from sea level to nearly 6000 m elevation. The countries of Canada, the USA, and The Republic of Mexico form the political and geographic boundaries of this continent.

Table 3.12 lists the plant families of North America which contain native succulent members. Some of these families, such as the Burseraceae and Fouquieriaceae, have relatively restricted habitats, whereas others, such as the Crassulaceae, occur in virtually all regions of North America. Nonetheless, the succulent flora of North America tends to be concentrated in the arid regions of Mexico and the south-western USA, and it is within these areas that the main conservation problems exist.

The Agavaceae, Cactaceae, Crassulaceae, and

Table 3.12 The main plant families of North America which contain native succulent members

	No. genera	No. species
Agavaceae *(sensu lato)*	12	360
Aizoaceae	3	15
Burseraceae	1	12
Cactaceae	79	1170
Commelinaceae	12	100
Crassulaceae	6	>300
Dioscoriaceae	1	63
Fouquieriaceae	1	11
Portulacaceae	5	many spp.

Fouquieriaceae have representatives that are either listed in Appendix I of CITES, the SEMARNAP Diario Oficial (Mexico), or in the US Endangered Species Act. The two families containing the most vulnerable taxa are the Agavaceae and Cactaceae.

North America can be most conveniently divided into two regions: 1) Canada and the United States of America, and 2) The Republic of Mexico. Canada currently has no succulent plant populations under threat. Because the USA and Mexico differ so greatly in vegetation types, development of conservation programs, and protected regions, the two political units will be considered separately.

Succulent plant flora in the United States

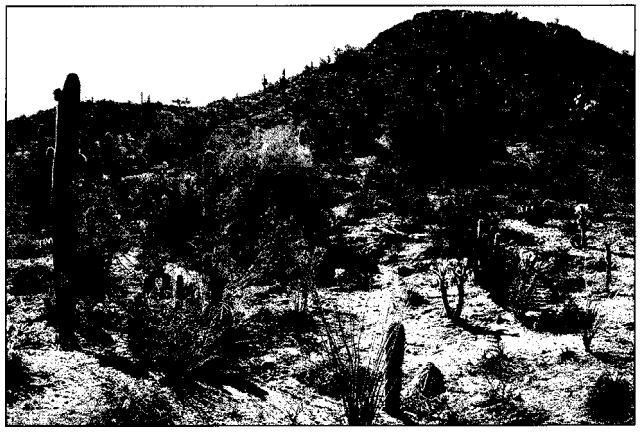
Most succulents are located in the western USA, although members of the Cactaceae are found virtually throughout the country, as well as in much of Canada. The genus *Sedum* of the Crassulaceae is widespread in numerous vegetation types in both countries.

The main succulent plant families in the USA are the Agavaceae, Cactaceae, and Crassulaceae. The Aizoaceae, Burseraceae, Commelinaceae, Fouquieriaceae, and Portulacaceae are also present, but not in large numbers as compared to in Mexico. The Agavaceae has five genera and 70 species in the USA. The Cactaceae has 29 genera (2 endemic) and 246 species. The Crassulaceae has 3 genera with more than 100 species.

The main vegetation types with succulent plants are the Sonoran Desert, Mohave Desert, Great Basin (Sagebrush) Desert, Chihuahua Desert, Desert Grassland, Coastal Desert Scrub, and Chaparral.

Threats

The most serious threats to succulent populations in the USA are collectors, off-road vehicles, urban development, agricultural development, the effects of mining and road construction, and the removal of forests or other natural vegetation. Those regions most seriously threatened are desert areas near major urban centres in California, Arizona, and New Mexico. One such example is the Mohave Desert of California in which off-road vehicles have destroyed extensive areas of native vegetation. The development of natural gas lines in New Mexico has also impacted several populations of *Sclerocactus* and *Echinocereus.* The construction of dams, such as the Glen Canyon dam in Arizona, has also led to the loss of some important desert habitat. Several large local populations of S. *papyracanthus* have been destroyed by urban growth in Albuquerque, New Mexico. The rapid growth of desert communities, such as Palm Springs, California, has also destroyed large areas of the Sonoran Desert in that state. Agricultural development in desert regions of Arizona and California have also heavily impacted desert plants. Livestock grazing and the accompanying trampling by hooves has resulted in some localised damage to succulents in the south-west. Collectors have impacted many small populations of species in *Sclerocactus* and *Pediocactus,* especially in the states of Arizona and New Mexico.



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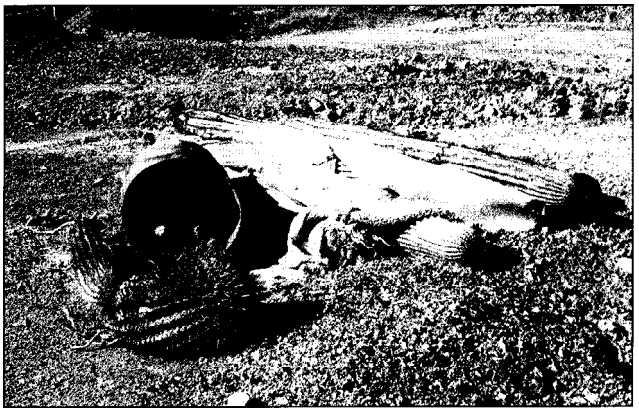
Sonoran Desert

Local uses and commercialisation

Succulents are most adversely affected in the USA by collectors and people involved in arid landscaping and horticulture. Despite laws regulating their collection, specimens of *Carnegiea gigantea* (saguaro) continue to be illegally removed from habitat to be sold in the commercial landscaping trade. Likewise, specimens of *Fouquieria splendens* (ocotillo) and numerous barrel cacti



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Carnegiea salvage operation, Arizona.

(Ferocactus spp. and *Echinocactus* spp.) are subjected to collecting from the field for horticulture. In some regions of Texas the spines of *Opuntia* spp. are burned off and livestock allowed to browse on the plants. Throughout the south-western USA Native Americans and hispanics collect the fruits of *Opuntia* spp., *Carnegiea gigantea,* and other cacti for food. Populations of *Lophophora williamsii* (peyote) have also been affected by the extensive collecting of 'heads' or tops by Native Americans for religious purposes or others for personal use or sale. Some other cacti with similar physical characteristics, such as *Astrophytum asterias,* have also been mistakenly collected by those who wished to use peyote for its hallucinogenic effects.

Existing conservation measures

Protected areas

Several federal and state parks and monuments have been set aside in the south-western USA to protect the native flora and fauna, as well as other natural phenomena. Those protected areas which have numerous succulents are:

Arizona
- Grand Canyon National Park
- Organ Pipe Cactus National Monument
- Saguaro National Monument

California
- Joshua Tree National Monument
- Anza-Borrego State Park

New **Mexico**
- Carlsbad Caverns National Park

Texas
- Big Bend National Park
- Big Bend Ranch State Park

Utah
- Capitol Reef National Park

Several Native American (Indian) reservations also have restrictions on collecting plants.

Legal protection for succulents

Succulents are protected at three levels in the USA. Most states in the south-west have laws controlling the collection of plants, particularly cacti and succulents. The state of Arizona has an Arizona Native Plant Law which specifically protects all Cactaceae, Crassulaceae, and Fouquieriaceae. California has a Desert Native Plant Act which requires permits, tags, and seals to collect desert plants on public land. Nevada, New Mexico, and Texas have similar regulations or laws requiring permits for collecting any plant within the state on private or public land. At present Utah has no plant protection laws.

The second level of protection is the Endangered Species Act, administered by the US Fish and Wildlife Service, in which numerous taxa, including several

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Echinocereus triglochidiatus, New Mexico.

succulents (see Table 2.1), are listed as threatened or endangered. Their collection (or destruction) in the wild is strictly controlled by this legislation, especially on public land.

The third level of protection is CITES (see Controlling the trade), of which the USA, Canada and Mexico are member nations. This treaty controls the international trade in many succulents, some of which are native to the USA.

Ex situ conservation

Efforts at *ex situ* conservation are being made by several botanical gardens through the coordination of the Centre for Plant Conservation (CPC), located in St. Louis, Missouri, which includes provision for the long term storage of seed of endangered plants. The Desert Botanical Garden in Phoenix, Arizona currently has primary responsibility for most succulents from the arid regions of the south-western USA and also propagates threatened Mexican species. They are presently propagating a total of 16 different threatened and endangered succulent taxa as listed in Table 3.13. Other botanic gardens are also propagating rare and endangered succulents as part of their regular operations. These include the Rancho Santa Ana Botanic Garden,

Claremont, California; the Huntington Botanical Garden, Pasadena, California; and the Botanic Garden of the University of California, Berkeley. As noted in Chapter 2, some commercial nurseries are also making a significant contribution to *ex* situ conservation efforts.

Nursery development

Major commercial nurseries which specialise in succulents are found in southern California, Arizona, and Texas. Few grow CITES Appendix I plants because of cumbersome federal regulations. However, millions of seed-grown cacti and other succulents are produced there for the world trade.

Main agencies involved in succulent plant conservation

There are both governmental and non-governmental agencies involved in conservation activities. The primary federal agency is the US Fish and Wildlife Service, which has primary responsibility for both the US Endangered Species Act and CITES. The US Department of Justice is also involved in apprehending and prosecuting those who violate federal regulations on international trade in succulents.

The CPC is closely involved in coordinating conservation activities of more than 20 botanic gardens and other institutions in the USA. The Cactus and Succulent Society of America and its numerous affiliate branches are also advocates of succulent plant conservation. The national organisation has a Conservation Committee. The influence of the International Organization for Succulent Plant Study (IOS) is strongly felt within the USA, not only through the efforts of individual members, but also through its international voice in matters concerning succulent plant conservation. The IOS Code of Conduct has also been widely distributed throughout the USA.

Assessment of existing conservation measures

In general, effective legislation exists at both the state and federal levels to protect and control the trade in recognised rare and endangered succulents. Unfortunately, prosecution and the ensuing litigation are both time-consuming and costly. Thus, government agencies sometimes are forced to use their limited resources in dealing with more critical issues, such as the drug trade and illegal immigration. Education on plant conservation is still needed among many groups of Americans. For example, a number of property owners in west Texas have organised the Trans-Pecos Heritage Association to prevent what they perceive to be a federal effort to 'lock up' their private land because a rare plant or animal may occur on it. They actively patrol their fenced property and arrest trespassers who come onto their land for any reason. Unfortunately, most of these people are misinformed of what the government can and cannot do on private land. In fact, the avid protection of their land from trespassers is also protecting the succulents that grow there from collectors.

Conservation education must be more creatively presented to the public and in schools; for too many people the terms 'conservation' and 'environment' are pejorative ideas rather than goals to be sought. Economic impacts of the Endangered Species Act have tended to polarize people against long-term protective efforts to conserve threatened or endangered species. Often such fears, though with a real economic basis, are founded on a lack of comprehensive understanding of the environmental situation.

There must also be support for continuing research on the plants that are currently listed or are candidates for

Table 3.13 Threatened and endangered North American succulents in cultivation at the Desert Botanical Garden, Phoenix, Arizona, USA

(CPC National Collection, CITES listing (Appendix I or II), or threatened (T) or endangered (E) under the US Endangered Species Act).

Taxon	CPC	CITES	ESA
Agave *arizonica*	*	I	E
A. *parvi flora*	*	I	
Ariocarpus *fissura tus* var. *lloydii*		I	
A. *kotschoubeyanus*		I	
A. *retusus*		I	
Aztekium *ritteri*		I	
Coryphantha *ramillosa*	*		T
C. scheeri var. *robustispina*	*		E
Echinocactus *horizonthalonius* var. *nicholii*	*		E
Echinocereus *chisoensis*	*		T
E. *ferreirianus*	*	I	
E. schmollii		I	
E. triglochidia tus var. *arizonicus*			E
E. viridiforus var. *davisii*	*		E
Escobaria *minima*	*	I	
E. robbinsorum	*		
E. sneedii var. *sneedii*	*	I	
Fouquieria *columnaris*		II	
F. fascicula ta		I	
F. purpusii		I	
Leuchtenbergia *principis*			
Mammillaria *pectinifera*		I	
M. plumosa			
M. solisioides		I	
Obregonia *denegrii*		I	
Pachycereus *militaris*		I	
Pelecyphora *aselliformis*		I	
P. s tro biliformis		I	
Sclerocactus *erectocentrus*	*	I	
S. *mariposensis*		I	
S. *papyracanthus*		I	
Tumamoca *macdougalii*	*	I	
Turbinicarpus *klinkerianus*		I	
T. lophophoroides		I	
T. schmiedickeanus		I	
T. schmiedickeanus var. sc hwarzi i		/	

listing as endangered or threatened species. The public requires clear demonstration that a plant is indeed threatened or endangered.

Also, the federal government needs to work closely with commercial nurseries in facilitating the propagation of and trade in rare and endangered succulents. The availability of propagated plants will almost certainly reduce the pressures from collectors on plants in the wild.

Mexico

W. A. Fitz Maurice and Edward F. Anderson

Succulent plant flora

The Republic of Mexico has a great diversity of habitats and flora. Succulents are found throughout the country, from the tropical forests in the south and south-east to the arid regions along the international border of mainland and Baja California with the United States to the north. Two main mountain chains run down through the mainland of the Republic: the Sierra Madre Occidental in the west through the states of Sonora, Chihuahua, Durango, Sinaloa and Nayarit; and the Sierra Madre Oriental to the east through the states of Puebla, Hidalgo, Veracruz, San Luis Potosi, Nuevo León, and Tamaulipas. Below this is the Trans-Mexican volcanic belt, and in the region between these three ranges the high plateau of north-central Mexico. All of these broad geographical zones have a rich succulent flora, as do the arid and semi-arid zones of Puebla and Oaxaca, and the Baja California peninsula. Although less diverse, there is also a unique succulent plant component in the vegetation of the low, hot, humid coastal regions and the southern and south-eastern tropical forests.

The extensive desert zones of Mexico consist of the Chihuahuan Desert, including parts of the states of Chihuahua, Coahuila, Durango, Zacatecas, San Luis Potosi, Nuevo León, Tamaulipas, Guanajuato, Querétaro, and Hidalgo; the Sonoran Desert of Sonora and northern Baja California; and the Vizcaino Desert, including parts of the states of Baja California and Baja California Sur.

The main vegetation zones in which succulent groups are found are the Chihuahuan Desert, Sonoran Desert, Vizcaino-Magdalena Desert, Desert Shrubland, Tropical Shrubland, Tropical Forests, and the Oak-Pine Forest. However of the 32 types of vegetation in Mexico (Rzedowski 1986) all but the aquatic, semiaquatic, and páramo types contain succulents. The Matorral Xerófilo and its subdivisions probably have the greatest diversity of

Box 3.5 Estimated number of succulent genera and species per family in Mexico

Cactaceae: There is some disagreement in the number of taxa of Mexico in this family. Bravo-Hollis and Sánchez-Mejorada (1978, 1991) recognise 1080 taxa (854 species and 226 varieties and forms), whereas Hunt (1992) lists 925 provisional and fully accepted species. According to Hernández and Godinéz (1994), following Hunt's taxonomic framework, there are 563 well recognised species. Cactus nomenclature here follows Hunt, with the addition of new discoveries and published varieties.

Crassulaceae: Following Walther (1972), together with recent discoveries, there are over 150 taxa of Mexican *Echeveria.* Jacobsen (1960) lists 29 Mexican taxa of *Dudleya,* more than 30 of *Villadia* and 89 of *Sedum.* Additionally, using Jacobsen and including recent discoveries, there are 13 species of *Pachyphytum,* 14 of *Graptopetalum,* 4 of *Lenophyllum,* 3 of *Thompsonella,* 1 of *Tacitus* and 3 of *Kalanchoe.* Thus, there are of the order of 350 Mexican taxa of Crassulaceae.

Agavaceae: Gentry (1982) recognises over 140 taxa of *Agave.* In addition, there are approximately 21 species of *Manfreda* (Piña-Luján 1978) together with 11 of *Furcraea,* 3 of *Hesperaloe,* and 23 of Yucca (Standley 1920-1926 and Jacobsen 1960). This gives a total on the order of 200 taxa for the family in Mexico.

Fouquieraceae Henrickson (1969) lists 12 species of the single genus in this family, *Fouquieria,* all of which are found in Mexico.

Other families: Other families with succulent representatives in Mexico, so-called caudiciform succulents, or species considered 'succulent' by collectors, include:

Aizoaceae: *Carpobrotus* (1) and *Mesembryanthemum* (1) . **Anacardiaceae:** *Pachycormus* (1) . **Apocynaceae:** *Plumeria* (5). **Asclepiadaceae:** *Gonolobium* (several), **Asteraceae: Senecio** (at least 2). **Begoniaceae: Begonia** (several). **Bombacaceae:** *Ceiba* (4) and *Bombax* (2). **Bromeliaceae:** *Hechtia* (several). **Burseraceae:** *Bursera* (2 or 3) and *Beiselia* (1). **Commelinaceae:** *Tradescantia* (several), **Convolvulaceae:** *Ipomoea* (at least 3). **Cucurbitaceae:** *Ibervillea* (at least 2). **Dioscoreaceae:** *Testudinaria* (1). **Euphorbiaceae:** *Euphorbia* (at least 4), *Jatropha* (several) and *Pedilanthus* (several). **Fabaceae:** *Erythrina* (several). **Lentibulariaceae:** *Pinguicula* (several). **Li l iaceae:** Aloe (1) . **Moraceae:** *Dorstenia* (several) and *Ficus* (at least 3). **Nolinaceae:** ***Beaucamea*** (6), *Dasylirion* (15), *Nolina* and *Calibanus* ***(18)***. **Oxalidaceae:** *Oxalis* (several). **Piperaceae:** *Peperomia* (at least 1). **Portulacaceae: Portulaca** (several) and *Talinum* (several). **Urticaceae:** *Pilea* (1) . **Vitaceae:** *Cissus* (at least I).

Totals: Overall, aside from the cacti and excluding orchids, this gives a minimum of 750 succulent taxa, and, including plants as yet unnamed, there are possibly as many as 1000. Thus, there is probably a total of between 1600 and 2000 Mexican cacti and other succulent plants. The total number varies according to the definition of 'succulent' followed.

Table 3.14 Main vegetation types and cactus diversity (Source: *Arias 1993)*

Vegetation type	Extent of land coverage (approx.) percent	No. of genera	Percent of genera
Xerophytic scrub	45	39	34
Tropical deciduous forests	17	24	21
Conifer forests	21	7	6
Tropical perennial forests	11	6	5
Moist montane forests	1	4	3

Table 3.15 Uses of succulents in Mexico

Family	Main uses
Agavaceae	food, fibre, beverages, ornamentals, animal food, medicine, ceremony
Cactaceae	food, fodder, fencing, ornamentals, medicine, ceremony
Crassulaceae	ornamentals, medicine
Fouquieriaceae	fencing, ornamentals

succulents, particularly of the families Cactaceae, Agavaceae and Fouquieriaceae. (Table 3.14)

There are at least 28 plant families in Mexico which include taxa that could be described as succulent (Box 3.5). Of these, the four most important are the Cactaceae, Crassulaceae, Agavaceae, and Fouquieriaceae.

Local uses

Many succulent plants are utilised by Mexicans, as summarised in Table 3.15, and commercialisation of various species is an important economic factor, especially in northern Mexico. The utility of succulent species can provide an incentive for their propagation and conservation. There are, however, some instances of overexploitation of wild populations for local use as shown in the section on threats below.

The genus *Opuntia* (Cactaceae) is widely cultivated for its fruits (tunas), both in commercial orchards and on subsistence farms. In addition, *Opuntia (Platyopuntia)* fruits are extensively collected from wild plants for sale along roads or in local markets. These species are also grown for 'nopales' (the new stems or 'pads' are skinned and sliced to provide the basic green vegetable for subsistence farms) and for cattle feed. The fruits of other cactus genera, including *Escontria, Myrtillocactus, Polaskia, Stenocereus,* and *Hylocereus,* are also harvested.

Various species of cacti are in demand for their traditional medicinal use. *Mammillaria limonensis,* for example, is acclaimed in its habitat area as a remedy for sore throats; *Opuntia fulgida* is used to make a treatment for diarrhoea and other species of *Opuntia* have been used as a treatment for diabetes; *Pachycereus pecten-aboriginum* and *Lophophora* spp. are used to treat rheumatism and other inflammatory ailments; and *Ariocarpus kotschoubeyanus,* and other species, as a pain killer.

The genus *Agave* (Agavaceae) is of considerable commercial value both for the production of alcoholic beverages (mescal, pulque, tequila) and as a source of fibres (istle, sisal, henequen). The sisal industry, declining in the face of competition from plastics, usually involves commercially grown plants and does not destroy the plant. Likewise *Agave tequilana,* produced for tequila in Sonora, Nayarit, and Jalisco, is derived exclusively from cultivated stands.

Cuttings from *Fouquieria* species and *Stenocereus marginatus* are widely used as barriers, often becoming living fences. The latter is so widely used throughout Mexico that its geographic origin is uncertain. Species of *Agave* are also used as living barriers. Cuttings from *Opuntia (Cylindropuntia)* species are often used on the top of low stone walls to make existing barriers more formidable.

Threats

Habitat modification and conversion — Generally, the greatest threat to succulent plant populations is changing land use. This is a side effect of the long term rapid growth of the Mexican economy, which has also resulted

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Stenocereus fence, San Luis Potisi, Mexico.

in population migration to cities to meet the needs of expanding industries.

Amongst the numerous factors involved in the disturbance of succulent plant populations, the conversion of land for both commercial and subsistence agricultural purposes is the most significant. For example, large areas of the succulent-rich Valley of Jaumave are being converted to agriculture, including the commercial growing of Aloe *vera.* In other areas of northern and central Mexico succulent habitat is converted to maize cultivation as in San Luis Potosi where *Ariocarpus kotschoubeyanus* has become threatened. Agriculture is being increasingly practised on marginal desert land. A common practice throughout Mexico is the burning of grasses and low brush at the height of the dry season, in the belief that nutrients are thus being returned to the soil, and to avoid a build-up of tinder that could result in a more devastating fire. Many cacti and other succulent plants are lost or badly damaged in these brush fires, and this practice of periodic burning of grazing areas does not appear to be controllable.

Land development for livestock production follows the demands of the growing economy. While the major impact is from commercial use, there is a substantial impact on the land from the goats, sheep and, to a lesser extent, cattle kept by the rural population. Plants are destroyed in land preparation, and by trampling and grazing by animals, as well as by chemical changes in the soil. The resulting erosion causes further damage.

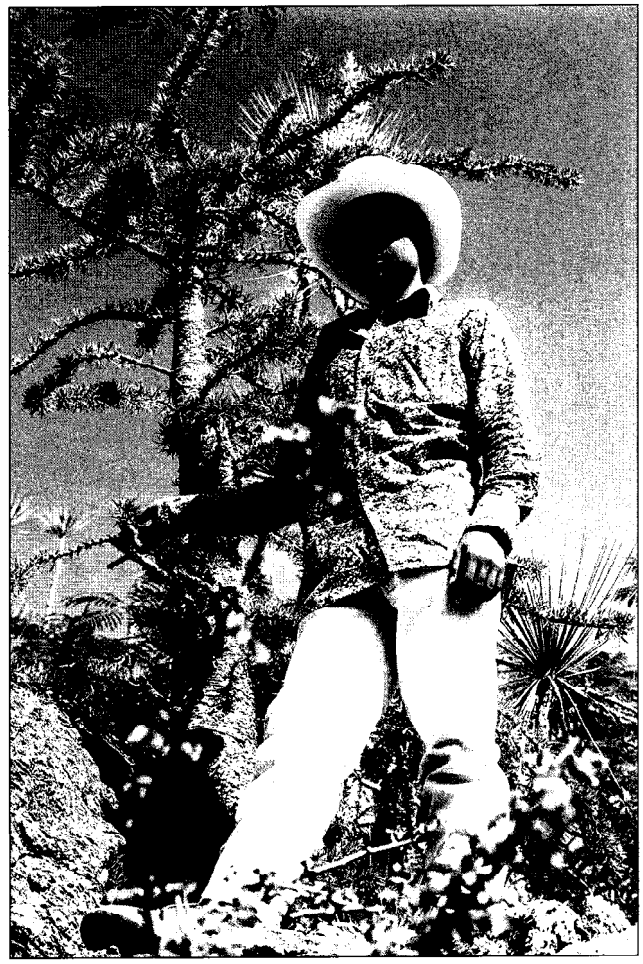
Destruction of habitat is also caused by road building, mining, the construction of dams, expansion of urban areas, and industrial development, all of which lead to the loss of succulent plant populations. The new dam in the Rio Moctezuma Valley has destroyed most of the remaining habitat of *Echinocactus grusonii.* Considerable habitat destruction is also occurring in Baja California as a result of all-terrain vehicles. This, in addition to expansion of irrigated agriculture and tourism developments on the Magdalena Plain and the Cape region, has led to the loss of some critical succulent plant sites.

In the Valley of Tehuacan-Cuicatlan between the states of Puebla and Oaxaca, the construction of a new highway from Mexico City to Oaxaca has destroyed part of the habitat of *Cephalocereus hoppenstedtii, Agave titanota,* and *Fouquieria purpusii.* The habitat of *Ariocarpus agavoides* near Tula, Tamaulipas, is threatened by the expansion of an urban garbage dump. UNAM performed a rescue operation prior to the construction of this new super-highway.

Indirect, and less easy to define, universal problems concomitant to economic growth also threaten succulent plant populations. These problems include industrial, residential and vehicular pollution, diversion of natural water, and soil erosion.

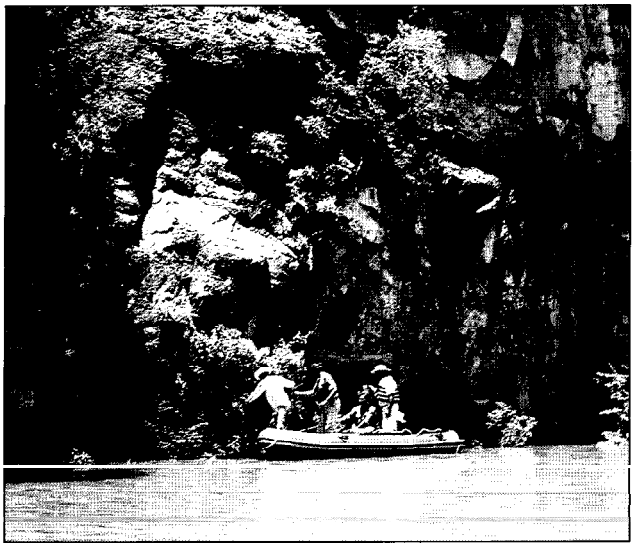
Illegal plant ***collection*** — Amateur and commercial collecting of cacti and other succulents has been one of the major threats to wild species in Mexico, and remains a significant problem. The commercial exploitation of cactus populations in particular has led to the virtual extinction of several local populations of plants. Examples include the cacti *Turbinicarpus viereckii, Pelecyphora strobiliformis, Mammillaria pectinifera, Lophophora diffusa,* and *Astrophytum asterias.* Repeated collecting at fairly well-known sites in Mexico led to the near disappearance of several of these species. There is some evidence that the seed reservoirs, given sufficient time and protection, may allow the populations to return. This may be occurring, for example, at one of a number of sites of *Pelecyphora strobiliformis* that had all the adult and juvenile plants removed by commercial collectors in the 1960s.

The market in the USA for illegally-collected Mexican cacti has declined recently as a result of stricter enforcement of legal controls at the Mexico-USA frontier and within the USA. Collecting for commercial gain by central Europeans remains a significant threat however. As an example, following the publication of the



Can Te, A.C.

Marcos Sierra, horticulturist with Can Te, A.C, beside *Fouquieria purpusii* at the edge of the new toll road.



Can Te, A.C.

Part of the Can Te, A.C. crew participating in a two week rescue operation with rising waters of Aguamilpa dam in Nayarit.

rediscovery of *Mammillaria schwarzii,* dedicated collectors backtracked the deliberately vague site location data and found the plant at its only known habitat. This information was then distributed among collectors with the result that a population of around 1000 plants has been decimated to about 100 individuals in five years, entirely due to collecting. This has happened despite the fact that artifically propagated plants of the species have been widely and legally available.

Although Mexican laws, international treaties, and increased international border cooperation are reducing the collection and illicit export problems, action on the part of international conservation organisations is still needed to help control all aspects of the trade.

The problem of overcollection is aggravated at some rare plant sites, for example, those of *Ariocarpus agavoides, Astrophytum asterias,* and *Mammillaria herrerae*, where local people realised the financial rewards to be gained by selling plants to foreigners. Collected plants are removed from their habitat in quantities well in excess of demand, and are poorly cared for. Similarly, the demand for rare plants has given rise to local guides well known to the foreign collecting community.

Collection of cacti and succulents for use within Mexico also threatens wild populations of some species. Small succulent plants are collected and potted and are widely available in Mexican nurseries for decorative purposes. Large cacti such as *Ferocactus* are sold as garden plants. In rural Mexico, as well as in some cities, it is the custom to make up a nativity scene or 'nacimiento' each Christmas. Traditionally, this includes small *Mammillaria* species such as *M. plumosa, M. bocasana, M. albicoma, M. dumetorum,* and *M. aureilanata.* These plants are collected commercially and shipped to markets throughout Mexico. Often the children in rural areas are sent into the hills to collect suitable plants for their own family's use. The plants are generally discarded after the holidays although they are sometimes cultivated.

Although agaves are commercially grown on a large scale to supply distilleries, many small mescal and pulque operations use agaves gathered from the wild, and this is resulting in local depletions. Mescal production in Sonora has markedly reduced the number of native agaves reaching flowering age. As a consequence, the bats, which are the chief pollinators of those agaves and many important cacti in the area, have become significantly threatened.

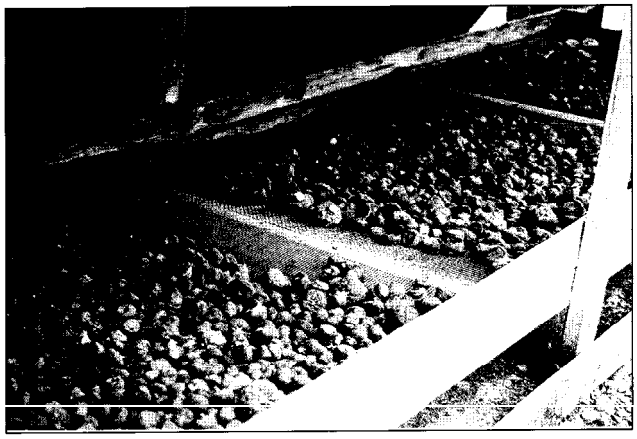
Species of *Ferocactus, Melocactus, Echinocactus,* and other similar cactus forms are widely collected for small operations making 'crystallised fruit' (the plant bodies are cut into cubes and boiled in syrup). A group of producers in the Queretaro area recently approached the organisation Can Te, A.C. asking for assistance in large scale propagation of *Ferocactus histrix,* as this principal source of material for their industry was becoming increasingly difficult to find in habitat.

Species of barrel cacti, for example *Echinocactus platycanthus* and *Ferocactus pilosus,* are used extensively in northern Mexico as forage and as a water source for goats and, less frequently, cattle especially during the dry season. This practice along with other uses of the plants has resulted in a dramatic decline of the population densities of these species. The same has happened with wild *Opuntia (Platyopuntia)* collected for cattle feed in northern Mexico.

The use of *Lophophora williamsii* or 'peyote' is well known. The species is listed in Mexico as a narcotic with multi-year prison terms awarded for possession. Its status as a narcotic has given rise to destruction of both *L. williamsii* and other, often rarer species of similar appearance by zealous officials. Educational materials dealing with identification of the species involved are currently in preparation for widespread distribution to local authorities. The government allows the collecting

Can Te, A.C.

Lophophora williamsii, the true 'peyote', in flower in habitat, San Luis Potosi.



E. F. Anderson

Drying peyote, Texas.

and use of peyote in the religious ceremonies of some indigenous peoples.

Conservation status

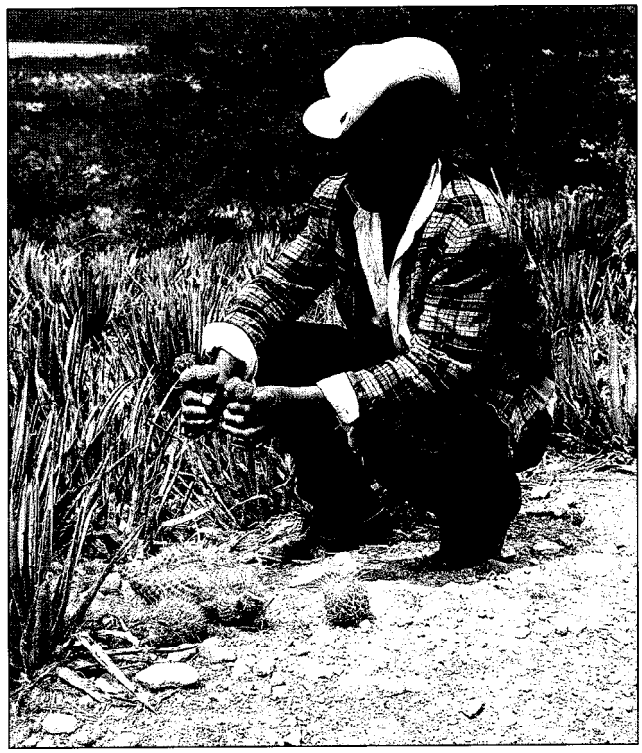
The impact of all the various threats on Mexican cacti and other succulents depends on the population characteristics of individual species. The majority of Mexican endangered cacti occur in small, disjunct populations, primarily in arid and semi-arid regions of the country, and a significant proportion of them are represented only by one or a few populations. Most of these species have a combination of biological and ecological attributes making them extremely vulnerable to any form of disturbance. These plants usually have slow growth rates, long life cycles, and the recruitment of new individuals in the population is extremely low. These inherent characteristics, along with the peculiar biogeographical patterns of these plants, determine a slow demographic response of the populations after disturbance. Unfortunately, accurate plant population information is generally not available and so it is often difficult to evaluate the precise degree of threat to individual species.

Various preliminary studies of the conservation status of Mexican succulents have been carried out over the past fifteen years. The Threatened Plants Committee (TPC) of IUCN undertook a survey of the conservation status of Mexican Cactaceae in the early 1980s mainly by correspondence with experts in Mexico and elsewhere. IUCN categories of threat were applied to all Mexican species and this formed the basis for the data on Mexican cacti held by WCMC. Data holdings at WCMC have recently been revised by harmonising with the CITES *Cactaceae Checklist* (Hunt 1992) and information on threatened Mexican cacti and other succulents published by SEDESOL and subsequently SEMARNAP".

Concern about the situation in the wild of Mexican CITES Appendix I cacti led to the field survey work conducted by members of the SSC Group and Mexican conservation trainees from 1986 to 1988, funded by WWF-US. The results of this field work (Sánchez-Mejorada *et al.* 1986; Anderson 1990; and Anderson *et al.* 1994) confirmed the conservation status of a range of 52 rare and threatened species.

More recently, a newly formed group working at the Institute of Biology, UNAM, has centred its research activities on the study of the biogeographical patterns of the Mexican endangered species, particularly those growing in the Chihuahuan Desert Region (Hernandez and Godinez 1994; Hernandez and Barcenas 1994). Over the past few years this same group has assembled a database of herbarium collections from North and Central American Cactaceae containing so far (September 1994) over 9500 records from 37 Mexican, USA, and European herbaria (Hernandez *et al.* 1993). This is the largest available database containing geographical data on cacti species, and is proving invaluable to determine the areas of species concentration of endangered cacti in Mexico.

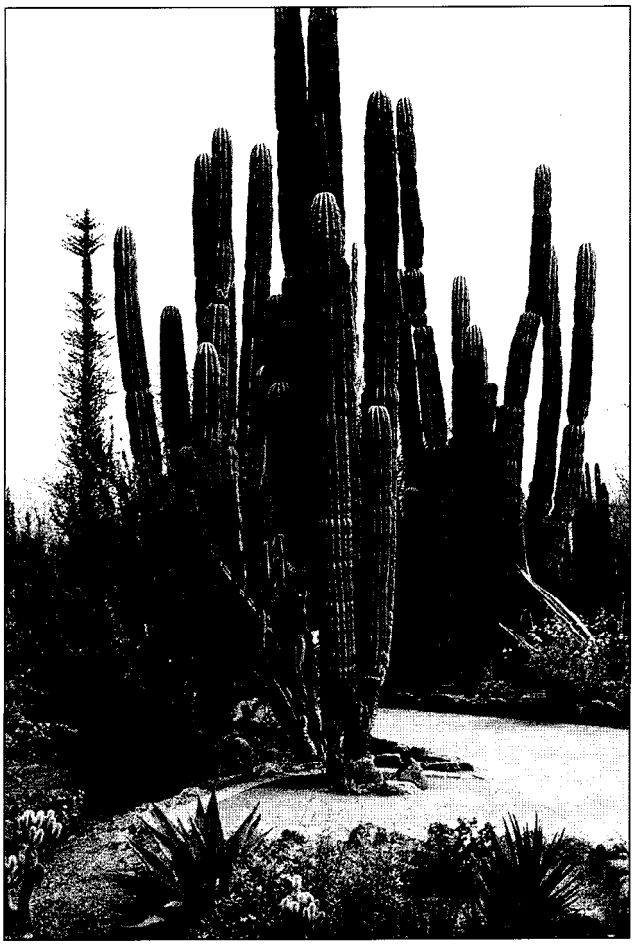
It has been estimated (Hernandez and Godinez 1994) that 73 per cent of the genera and 78 per cent of the species of cacti occurring in Mexico are endemic, and that 35 per cent (197 species) are somewhat endangered. In absolute terms, the country possesses the highest numbers



E. F. Anderson

Mexican cactus and plant collector with *Pelecyphora strobiliformis*, Tamaulipas, Mexico.

* SEDUE (Secretary of Urban Development and Ecology) was superceded in the area of ecology, in the early 1990s, by SEDESOL (Secretary of Social Development). Under the new President, Ernesto Zedillo, SEDESOL was further refined to SEMARNAP (Secretary of the Environment, Natural Resources and Fish). Within that organisation, INE (National Institute of Ecology) is the institution most actively involved with threatened species and collecting permits.



E. F. Anderson

Pachycereus pringlei, Desert Botanical Garden, Arizona.

of endemic and endangered cacti, comparing with other countries such as Chile, Ecuador, Cuba, and Brazil which also have highly significant proportions of endemic and endangered species.

Currently field surveys to assess the status of Mexican cacti are being undertaken by scientists from various botanical gardens and universities within Mexico. Botanists at UNAM are, for example, working on ecological and population studies in the Chihuahuan Desert area in the Tehuacan-Cuicatlan Valley and have been studying the conservation status of cacti in the State of Queretaro for over ten years. At a recent conference on population studies held at Can Te, A.C. in San Miguel de Allende, Guanajuato presentations were given on work in progress by researchers at the Universidad Autónoma de Tamaulipas, the Centro de Investigaciones Biologicas de Baja California Sur and the ITESM, Campus Queretaro. Can Te, A.C. is continuing to work with these institutions and others to pull together the diverse information available. A comprehensive program of detailed population studies is urgently needed to build on the work already in progress. It is clear that this must be coordinated and implemented locally.

Few detailed studies have been made of the long-term fluctuations of cacti and other succulent plant populations in habitat. These are necessary to understand the natural behaviour of populations and the reasons for their rarity, and, via comparative studies, to assess the basis of their vulnerability. Can Te, A.C. started such investigations in 1991 and currently has 50 ongoing studies with others in preparation. Concomitant with further population studies, additional long term studies can and need to be initiated.

A CITES-financed project is currently in progress to carry out population studies on Mexican cacti and to evaluate the impact of legal and illegal trade on wild populations of these species. The work is being carried out by Can Te, A.C. and the Desert Botanical Garden, Phoenix, with the assistance of several local botanic institutions.

Information on the conservation status of Mexican Agavaceae is included in Annex 1. A list of threatened Mexican cacti and other succulents as prepared by SEMARNAP is given in Annex 11. The cactus information within that list is based on Hernandez and Godinez (1994) which modified Hunt's (1992) CITES *Cactaceae Checklist.*

Priority sites for conservation

The Chihuahuan Desert Region, which is the largest and least understood North American Desert, contains the largest assemblage of endangered cacti in the whole continent. Hernandez and Barcenas (1995) have evaluated the major areas of concentration in this region in terms of their species richness along with their abundance of rare, geographically restricted cacti. Within the Chihuahuan Desert the species are aggregated in areas of moderate altitude, particularly towards the south-eastern, and to a lesser extent, the eastern margins of this desert, in northern San Luis Potosi, and in southern Coahuila (including the Bolsón of Cuatro Cienegas), Nuevo Leon and Tamaulipas. Another area of similar importance is the Queretaro-Hidalgo Arid Zone which includes areas such as the Rio Extorax Basin and the Metztitlan Valley.

The richest area within the Chihuahuan Desert is located in northern San Luis Potosi, around a locality known as Huizache, where a total of 14 endangered species are recorded. Towards the north and north-east of Huizache there are several other areas where an important number of endangered species occur. These correspond to regions near Matehuala, Doctor Arroyo, Galeana, Aramberri, Jaumave, and Cuatro Cienegas. Another area of similar importance as the Huizache is the Rio Extorax Basin, in the State of Queretaro. This area which is separated from the main body of the Chihuahuan Desert, corresponds to the Queretaro Arid Zone and is surrounded by several cactus-rich regions located in Guanajuato, Queretaro, and Hidalgo.

Major areas of succulent diversity in Mexico include the following:

1) **Chihuahuan Desert Region,** including disjunct portions in the Jaumave and Tula valleys, and the Queretaro-Hidalgo Arid Zone. According to the studies of Hernandez and Barcenas the areas within this region that merit inclusion within Mexico's National System of Protected Areas are:

   a) Toliman (Extorax Basin, Queretaro),
   b) Huizache (San Luis Potosi),
   c) Metztitlan, (Hidalgo),
   d) The valleys of Tula and Jaumave, Tamaulipas - these have a high percentage of rare and threatened cacti which are very popular with foreign collectors, including *Ariocarpus agavoides, Turbinicarpus saueri, Tysabelae, Obregonia denegrii, Pelecyphora strobiliformis,* and *Mammillaria zubleri.*

   Another site in this region identified as being important for conservation is Doctor Arroyo north to Galeana and Rayones, including Aramberri Valley, in Nuevo Leon State.

2) **Sonoran Desert** including the Cape Region of Baja California Sur, the islands of the Gulf of Baja California together with the Pacific Ocean West Coast of Baja California. The area around Cataviñá in the southern part of Baja California State is especially rich with *Fouquieria (Idria) columnaris, Pachycormus discolor,* and other important species such as *Ferocactus gracilis, Pachycereus pringlei, Washingtonia robusta,* and *Dudleya* spp.

3) **Tehuacán-Cuicatlán Valley,** Puebla-Oaxaca: dense wooded sites of arborescent cacti with *Cephalocereus hoppenstedtii, Escontria chiotilla, Ferocactus flavovirens, F. haematacanthus, F. robustus, Mitrocereus fulviceps, Myrtillocactus geometrizans, Neobuxbaumia macrocephala, N. mezcalaensis, N. tetetzo, Pachycereus hollianus, P. weberi, Pilosocereus chrysacanthus,* as well as *Mammillaria napina, M. pectinifera,* and other succulents such as *Agave spp., Fouquieria purpusii,* and *Beaucarnea gracilis.* UNAM has studied the area in detail and proposes that the least disturbed area, south of the city of Tehuacan, should be protected.

4) **La Mixteca Alta** (Oaxaca)

5) **Balsas Basin** (Oaxaca, Puebla, Guerrero, and Michoacan)

6) **Isthmus of Tehuántepec** (Oaxaca)

Other succulent rich sites of outstanding importance are:

7) **Barranca de Metztitlán,** Hidalgo: spectacular habitat for unique "viejitos" *Cephalocereus senilis,* with *Astrophytum ornatum, Echinocactus platyacanthus, Fouquieria fasciculata, Mammillaria geminispina, M. humboldtii.*

8) Habitat of *Aztekium hintonii* and *Geohintonia mexicana* with *Mammilloydia candida* var. *caespitosa, M. picta, M. winterae, Thelocactus tulensis* var. *matudae, Yucca* sp. cf. *carnerosana,* and others.

9) **Pedregal de Cuernavaca** (Chichinautzin), Morelos: one of the most beautiful natural succulent gardens in the Mexican Republic with *Agave horrida, Echevcria gibbiflora, Sedum frutescens, S. oxypetalum,* many orchids, begonias, and bromeliads.

These areas, rich in succulent taxa and of outstanding beauty and interest, merit inclusion within the National System of Protected Natural Areas. In addition, the following succulent-rich areas have also been identified as critical for the protection of their native flora:

a) El Canon del Zopilote, Guerrero State
b) The Desierto de Altar, Sonora State
c) Viesca-Saltillo area, Coahuila State
d) Piedras Negras-Sabinas area, Coahuila State
e) Mapimi region between Durango, Chihuahua and Coahuila States
f) Bolsón de Cuatrocienegas, Coahuila State
g) Cumbres de Monterrey, Nuevo Leon State
h) Barranca de Tolantongo, Hidalgo State
i) Mesa del Nayar, Nayarit State
j) Huayacocotla, Veracruz State
k) Llanura del Rio Verde, San Luis Potosi State

Existing conservation measures

Mexico has made major progress in succulent plant conservation activities in the past decade. Existing laws are being effectively enforced, and scientists are actively engaged in research related to conservation. The effects of these activities are already noticeable on wild populations of succulents. Illegal collecting and the wanton destruction of plants have been greatly reduced.

The decline of many succulent plant populations continues, however, and sustained efforts on a broad front will be necessary to prevent further extinctions. As far as possible, local inhabitants need to be involved in conservation planning to ensure full support for conservation decisions.

Protected areas

The Mexican National System of Protected Natural Areas, under the direction of various ministries, includes 73 protected areas. These areas fall into nine categories: Biosphere Reserve, Special Biosphere Reserve, National Park, Natural Monument, Aquatic Park, Area of Protected Natural Resources, Area of Protected Wild Flora and Fauna, City Park, and Ecological Protection Zone. A total of over six million hectares or 60,000 km^2 are currently under protection. About half of the total area covers arid land, but relatively few protected regions exist in the northern part of Mexico where there is the greatest diversity of succulents.

The existing protected areas on paper are generally neither staffed nor fenced on the ground, but they offer the potential to provide special protection where a high threat category has been identified. Greater financial support for the existing federal protected areas is needed. Protected areas with numerous succulents include:

a) El Pinacate Reserve
b) Mapimi Biosphere Reserve
c) Canon de la Huasteca
d) Parque Internacional del Rio Bravo
e) Isla Cedros Sanctuary
f) Sierra de Manantlan Biosphere Reserve
g) Isla Isabel National Park
h) Rio Lagartos Ecologic Reserve
i) Canon del Sumidero National Park
j) Lagunas de Chacagua National Park
k) San Pedro Martir National Park

In addition, a large region near Cuatro Cienegas has been proposed as a protected area.

The habitats of threatened species, *Cremnophila nutans* (Crassulaceae) and the yellow-spined variant of *Mammillaria spinosissima* fall within the confines of the Tepozteco National Park in the state of Morelos. *Ferocactus tiburonensis* is endemic to the island of Tiburon and the entire island is a special reserve. The best known habitat of *Agave victoriae-reginae* lies within the area of Cumbres de Monterrey, the largest national park in Mexico.

At present La Comision Nacional de la Biodiversidad (CONABIO) is preparing a list of the additional areas in Mexico appropriate for designation as protected areas. Several areas with populations of succulent plants need to be protected, provided such action does not create heavy economic and social burdens on the people living in the vicinity. Local inhabitants, if included in decisions involving regions near their villages, may provide the greatest security for the plants. Perhaps financial incentives might enable them to steward these areas as wardens or guards.

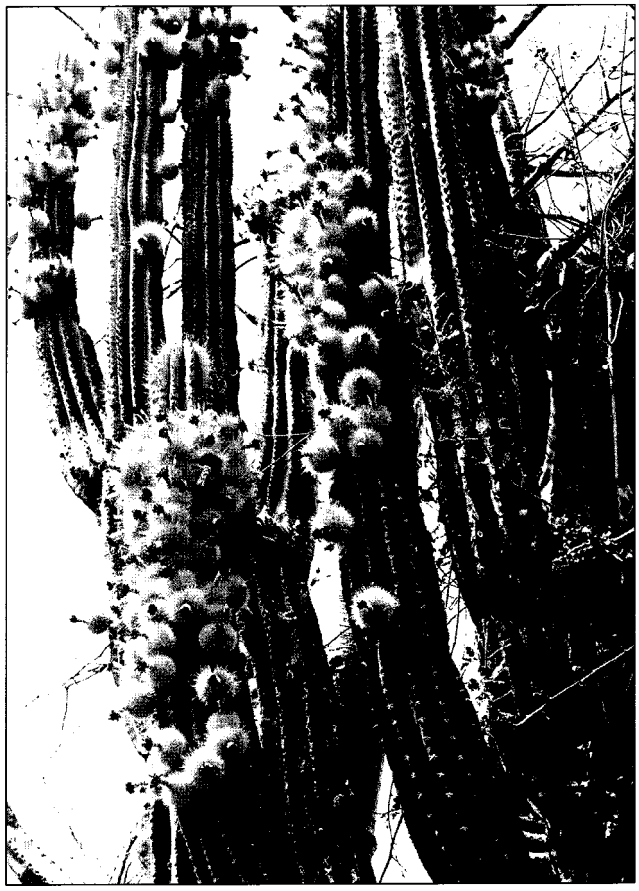
Legal protection for succulents

The General Law of Ecological Balance and Protection of the Environment, passed by Mexico's Congress in 1986, establishes the principles and regulations by which all species of wild flora should be treated and used in Mexico. All uses of wild flora are covered by this law and require authorisation of the Secretary of Environment, Natural Resources and Fish (Secretaria de Medio Ambient, Recursos Naturales y Peces or SEMARNAP), specifically of the National Institute of Ecology (Instituto Nacional de Ecología or INE) through its General Administration of Ecological Use of Natural Resources (Dirección General de Aprovechamiento de los Recursos Naturales or DGAREN). Permits for the collection of any wild plants are required by the Mexican government, which the head of DGAREN must personally sign.

Infractions of the law range from misdemeanors to felonies. It is the responsibility of SEMARNAP to bring suit in the case of misdemeanors and to refer suspected felonies to the Federal Attorney General (Procuraduria General de la Republica or PGR). The law also allows an individual to bring suit where it is believed the law has been violated.

Another law which has relevance to succulent plant conservation is the Federal Forestry Law (Ley Federal Forestal). This law was recently amended (late 1996) and now, once again, includes and regulates non-woody plants. Perhaps even more significant is the typification in the Penal Code of illegal removal of plants, including cacti and other succulents, making such illegal removal a 'delito ambiental' (an environmental crime) with jail sentences now possible of three to six years.

Existing legislation is sufficient to protect the native flora and fauna of Mexico, but greater efforts are needed to educate the public about federal regulations. SEMARNAP is required to list the species of flora and fauna to be regulated (Annex 11). In addition, violators of the law should be prosecuted to emphasise that the Mexican government is serious about preserving its natural wealth. Table 3.16 provides examples of some enforcement acts.



Can Te, A.C.

Pachycereus pecten-aboriginum, a cactus of Mexico used in local medicine.

CITES

Mexico is a recent signatory of CITES, and SEMARNAP, as the Managment Authority, has the responsibility of enforcing regulations pertaining to the international trade in succulents.

At present there appear to be misunderstandings by many people about the purpose of CITES. Many Mexicans and foreigners do not understand the permit system presently in operation by SEMARNAP, and nearly all foreign collectors have ignored the system. In addition, inspectors at the international borders need training in the identification of plants currently controlled by Mexican law.

More effective and timely means must be found for repatriating Mexican plants confiscated at foreign borders or seized in foreign countries. This will require putting pressure on the authorities in the countries where the plants are confiscated to assign responsibility for repatriation costs.

Ex situ conservation

Mexico has 42 registered botanic gardens listed by SEMARNAP (Annex 13). Coordination of the conservation activities of Mexican Botanic Gardens is facilitated by the Asociacion Mexicana de Jardines Botanicos. The Asociacion is promoting the formation of national collections for various groups of plants. The national collection for Agavaceae is already maintained by the Jardín Botánico del Instituto de Biologia, UNAM. The collection currently holds 80 per cent of the Mexican species in the family.

Botanic Gardens are playing an important role in 'rescuing' succulent plants from sites threatened by development projects. In 1990, UNAM conducted an intensive rescue operation in the Rio Moctezuma valley, the habitat of *Echinocactus grusonii,* as well as other rare plants, prior to the major dam project. In 1992, Can Te, A.C. conducted a rescue effort at a well known site of *Pelecyphora aselliformis* and *Mammillaria aureilanata* threatened by construction of a highway. At the request of the Mexican government in 1993, plants were rescued from a 10,000 ha area about to be flooded by a new dam at Aguamilpa, Nayarit. This rescue operation was undertaken by Instituto de Botánica de la Universidad de Guadalajara, and La Escuela de Biologia de la Universidad de Guadalajara, together with Can Te, A.C.

Can Te, A.C.

Site of rescue operation with *Pelecyphora aselliformis* and *Mammillaria aureilanata.* From left: Gabriel Solano of SEMARNAP in Mexico City; Biol. Emilio Baltazar Cuellar Jimenez from the San Luis Potosi office of SEDUE; W. A. and Betty Fitz Maurice, investigators with Can Te, A. C.; and Charles Glass, Curator of Plants for Can Te, A.C.

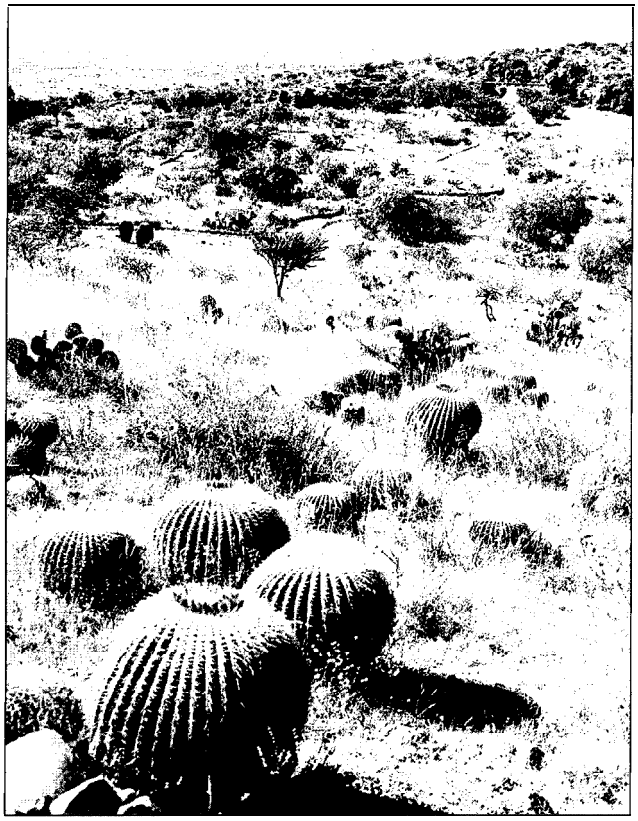
In another important rescue operation UNAM relocated specimens of around 50 species from the site affected by the construction of the Tehuacan-Oaxaca highway. The plants were placed in the Botanic Gardens of UNAM, the Centro Interdisciplinario de Investigación para cl Desarrollo Integral Regional-Unidad Oaxaca (CIIDOR-Oaxaca), and African Safari Parque Zoológico en Valsequillo, Puebla.

In addition to caring for and propagating the rescued plants in botanic gardens in Mexico, consideration is also being given to reintroduction of plants to suitable habitats, as UNAM has done at the Rio Moctuzema site. For example, UNAM's tissue culture work has allowed the reintroduction of *Mammillaria san-angelensis* in Mexico City.

Botanic gardens also act as rescue centrcs for cacti and other succulent plants confiscated from collectors at various frontiers and occasionally within Mexico. Seized plants are sometimes sent to Mexican institutions, and collections are being maintained, for example, by Jar-din Botánico del Instituto de Biologia, UNAM; Instituto de

Table 3.16 Enforcement actions by Mexican authorities 1991 and 1992

People prosecuted	Plants collected	Penalty
4 Austrians	878 Appendix I and II specimens	each fined US$1200
4 Belgians	1569 Appendix I and II specimens	each fined US$800
1 German	Appendix I and Appendix II cacti	prison sentence
1 German	423 Appendix I and II specimens	US$425
3 Italians	c. 400 Appendix I and II specimens	each fined US$400
1 American	28,624 Appendix I and II specimens	returned to USA before the case was decided in court



Can Te, A.C.

Part of a plantation at the Botanic Garden, El Charco del Ingenio, San Miguel de Allende, of 500 golden barrels *(Echinocactus grusonii)* whose natural habitat is currently under the waters of the new Zimapan dam on the border between Querétaro and Hidalgo.

Botanica, Universidad de Guadalajara; Universidad Autónoma Agraria Antonio Narra; and Can Te, A.C., but this has so far been on a somewhat random basis. The sheer number of plants involved can place a strain on existing resources of the botanic gardens.

Nursery development

In Mexico there is extensive nursery production of plants for the domestic market, but little of this has been devoted to cacti and other succulent plants. Until recently there were only two commercial nurseries propagating succulents from seed and cuttings. The situation is now changing with a rapidly increasing consumer interest in native succulents. This coincides with intensified efforts by the Mexican authorities to control the trade in wild-collected plants. Sixteen nurseries have made application to the authorities for permission to propagate succulent plants (see Annex 12). Although still small, the industry shows good growth potential.

Main agencies involved in conservation

The main governmental agency responsible for conservation in Mexico is the Consejo Nacional de Ciencias y Technologia (CONACYT). Both SEMARNAP and the Secretary of Agriculture (Secretaria de Agricultura y Recursos Hidraulicos or SARH) are responsible for the control of the use of Mexico's natural flora; the direct concern lies with SEMARNAP. Many other governmental agencies are directly and indirectly involved.

In addition to the governmental agencies a number of universities and many non-governmental organisations are active in conservation efforts relating to succulent plants. These include:

Departamento de Botánico, Instituto de Biologia de la Universidad Nacional Autónoma de México (UNAM) houses the National Herbarium of Mexico, which has the largest collection of Mexican plants (over 550,000 specimens), including an important set of herbarium specimens of Cactaceae, Agavaceae, Crassulaceae, and several other succulent plant families. A research group at this institution is devoted to generate basic information on the taxonomy, biogeography, and ecology of rare and endangered cacti, particularly from the Chihuahuan Desert Region. Also this group has developed the largest database of herbarium collections of North and Central America, currently containing over 9500 records from 33 institutional herbaria.

Jardín Botánico del Znstituto de Biología de la Universidad Nacional Autónoma de México (UNAM) in Mexico City has a well-established and active conservation programme relating to the study and conservation of cacti and other succulents. Activities include:

- study of the cactus flora of Meso-America, including field collections for the National Herbarium;
- study of the biogeography, distribution and conservation status of the cacti of the Tehuacan Valley, and the development of a proposed protected area;
- publication of scientific materials on succulents;
- maintenance of the national collection for Agavaceae;
- propagation of endangered cacti including the development of tissue culture techniques;
- development of educational materials relating to cacti and agaves.

Can Te, A.C., a non-governmental, not-for-profit organisation dedicated to conservation, has a newly formed botanic garden that is taking a lead in succulent conservation work. Several important salvage operations have been carried out, and rescued plants are now being propagated. Can Te, A.C. also provides information on propagation to producers and collectors, for example, to the crystallised fruit manufacturers mentioned above. Can Te, A.C. also has a program, 'Comprar para Conservar' or 'Purchase to Preserve', encouraging people to contribute financially toward the purchase of threatened habitats.

Universidad Autónoma de Tamaulipas - botanists from this university have been carrying out detailed population studies on endangered cacti in the Jaumave area.

Sociedad Mexicana de Cactdceas, the main specialist society for succulent plants in Mexico. It is involved in the dissemination of information on Mexican cacti and other succulents and their conservation.

Centro de Investigaciones Biológicas (CIB) in La Paz - carries out ecological studies of cacti in the Baja California area.

Universidad de Guadalajara, where studies are carried out on the cactus flora of Jalisco and the propagation of endemic species.

ITESM-Campus Querétaro carries out studies on the cacti of Queretaro, undertakes propagation activities, maintains a small gene bank, and has an education programme about cacti of the state.

The authors would like to acknowledge the following people for kindly providing additional information and review of this section: Salvador Arias, Helia Bravo H., Robert Bye, Federico Gama, Abisai Garcia Mendoza, Keith Gardner, Charles Glass, Kenneth Heil, Hector M. Hernandez , Wendy Hodgson, George Lindsay, Reid Moran, and Gary Nabhan.

The West Indies

Alberto Areces-Mallea

The Caribbean islands form an archipelago of over 1000 islands of considerable range in size, altitude, soil types and environmental niches. Exposed land surfaces cover a distance of 2700 km from Barbados on the east, to the western tip of Cuba, while the distance from Grenada in the Lesser Antilles to the northern tip of the Bahamas is 1900 km. The islands range in size from Cuba, with 114,500 km^2 and a vascular flora of over 6000 species, to islets of small rocks of a few square metres and a flora of a dozen species.

The diversity of the West Indies is seen in such factors as altitude of the islands, temperature range, soil types, and units of vegetation on each island. Hispaniola has the greatest range in altitude where the Enriquillo Basin is 30 m below sea level and Pico Duarte reaches 3000 m. Volcanic peaks in the Lesser Antilles range from 900 m to approximately 1500 m. The major part of the land surface within the archipelago is below 300 m in altitude.

The average (mean) temperatures of the area at elevations of less than 90 m range from 24.9" (Havana) to 26.1 °C (Dominica). Neither annual nor daily variations in temperature are great. Day-length range is nearly two hours greater in Nassau in the north than it is in Trinidad just south of the area under consideration. With respect to rainfall, many areas of the West Indies receive less than 1000 mm of annual precipitation, while rainfall exceeding 5000 mm has been suggested for several areas. Sometimes there are six or seven months of reduced rainfall occurring as two dry periods, while many mountain areas show no months of rainfall of less than 100 mm. Succulents and low spiny shrub vegetation are characteristic of coastal areas with seasonally higher temperatures and rainfall under 700 mm, often falling in one short annual period.

The West Indies show a variety of soil types which offer a relatively large number of ecological niches. There are siliceous savannas in western Cuba and on the north coast of Puerto Rico. The central portion of Cuba has a nearly uninterrupted serpentine savanna. Areas of gypsum and salt concentrations, often in bands, occur in Hispaniola. A belt of aluminous lateritic soil extends through most of the island of Jamaica and occurs also in

A. Areces-Mallea

Cactus scrub with *Stenocereus hystrix* and *Pilosocerus royenii* with *Plumeria obtusa* in the foreground, Mona Island, Puerto Rico.

the southern peninsula of Hispaniola; areas of volcanic activity occur in the Lesser Antilles. Outcrops of limestone as sedimentary rock or elevated coral reefs are abundant, and areas of intrusive igneous rock could be added to the chart as additional specialised habitats. The vegetation of the various soil types is often distinctive in composition or habit and is frequently high in endemic species. In general, geologic and edaphic features combine with climate and topographic factors such as high relief and alternation of lowlands and mountains, to determine the unique characteristics of the plant communities and the floristic diversity of each individual, isolated island.

The Caribbean Islands have a natural vegetation consisting of lowland and montane tropical forest, evergreen thicket, savanna, cactus-thorn scrub, marsh or swamp, mangrove, beach, and riverine communities. The total flora of the region consists of about 13,000 vascular plant species with around 6550 regional endemic species. About half of the endemics occur only in Cuba.

Institutional bases for the study of the West Indian flora locally are patchy and most of them are limited in physical resources and capabilities. Fortunately, interest is growing and there is current activity in, for example, Cuba, Dominican Republic, Puerto Rico, St. Lucia, and Barbados. In recent years, Floras covering both flowering plants and ferns have been published for the Bahamas, Cayman Islands, Jamaica, and the Lesser Antilles. A flowering plant Flora for Hispaniola is well advanced in production, although the Cactaceae has not yet been covered. New Floras of Cuba and Puerto Rico are being prepared. There is no current guide to the succulents of the West Indies.

A general Flora, to include all cryptogamic and phanerogamic groups, is proposed for the Greater Antilles under the direction of The New York Botanical Garden. Most of the current research on floristics in Cuba and Hispaniola is published in those islands, but for other territories, investigations and publication are institutionally based in North America and Europe.

The succulent flora

The succulent flora of the West Indies consists mainly of plants in the Agavaceae, Apocynaceae, Cactaceae, Euphorbiaceae, Moraceae, Portulacaceae, and Vitaceae. Also included here are marginally succulent species such as the West Indian Bombacaceae, a Sterculiaceae *(Hildegardia)* with a bulky, greenish trunk, all *Dorstenia* (Moraceae), and many of the native Euphorbiaceae with somewhat thick stems or leaves more fleshy or thicker than normal. However, no Burseraceae, Begoniaceae, Piperaceae, Rubiaceae, Urticaceae, aroids, or orchids other than the succulent vinelike *Vanilla,* well represented in the dry areas, are considered. Out of 324 so defined succulent plant species recorded here for the West Indies*, 243 (75 per cent) are endemic. Succulents comprise about 2.5 per cent of the total number of flowering plants of this region. The remaining 81 species (25 per cent) extend to continental landmasses in North, Central, and South America, and even sometimes to the Old World tropics and/or subtropics. This latter group is not of primary conservation concern. It is made up of many species occurring along the seashore, some within beach areas, coastal salt marshes, dunes or flats, and others on maritime rock exposures.

The families containing succulent plants in the West Indies are listed in Table 1 of Annex 14 with the number of succulent species in each genus and an indication of endemic taxa. No subspecific taxa are considered due to the yet insufficient knowledge of the Caribbean flora. New succulent species continue to be discovered (Areces-Mallea 1992, 1993) and, despite the level of botanical and horticultural interest in the group, the taxonomic status of a number of West Indian succulents remains poorly known. The non-endemic succulent species native to the West Indies are listed in Table 2 of Annex 14, whereas the endemics are shown in Table 3 of Annex 14 with their geographic distribution, regional or restricted, and an evaluation of their conservation status.

Stebbins (1952) pointed out that a dry environment stimulates speciation. The ecological and chorological study of most of West Indian endemics provides evidence for this phenomenon. In general the largest number and highest density of endemics may be observed in the arid zones (coastal areas, semi-deserts) and in the physiologically dry habitats (serpentines, limestone karsts, siliceous sands). Endemic succulent taxa are most commonly found within coastal plant communities. Cactus scrub, evergreen bushland and dry evergreen thicket occupy well drained, usually rocky, substrates. Relatively extensive semi-desert vegetation — unique flora of endemic cacti, other succulents, and spiny shrubs — exist along the leeward coasts of the larger islands. The vegetation types where most of the cacti and succulents listed in Tables 1 and 3 of Annex 14 occur are described here.

I. Coastal formations

1) ***Sandy beaches*** — Herbaceous and shrubby vegetation of the tropical sandy sea shores, commonly distinguished by two main associations: a) an open pioneering community formed of creeping lianes and stoloniferous grasses *(Cakile lanceolata* and *Blutaparon vermiculare* are often associates), and b) a less open community, the next successional stage, with *Sesuvium portulacastrum, Chamaesyce mesembrianthemij'olia* and *Argusia gnaphallodes.* On low sandy shores, seaside prairies, and sandy meadows *Borrichia arborescens* and *Scaevola plumieri* might be abundant. *Suriana maritima* is more often found in littoral thickets in the transition of the meadows toward strand vegetation.

Sandy beach communities are common, though of limited extent on the West Indian islands, when compared with the rocky or coralline coastal associations.

* In this account including the Florida cays (only their endemic species, not found in the mainland of Florida) but excluding Aruba, Bonaire, Curaçao, Trinidad, Tobago, Margarita, and other small islands adjacent to Venezuela, which are phytogeographically part of northern South America.

Undisturbed beach areas are increasingly difficult to find; most of the sandy shore areas have been heavily damaged or destroyed. Fortunately, most of the genera and species involved are of wide geographic distribution.

2) Strand ***littoral*** scrub and ***low forest*** — Inland from the coastal beach, dunes may be built up consisting solely of sand or of sand deposited on a rocky substratum. The sea-grape *Coccoloba uvifera* is the classic component of such strand areas. Although the monodominancy of sea-grape stands is an essential characteristic found all over the West Indian islands, there are also differences with respect to the floristic composition of these associations in different locations. The community of sea-grape and *Opuntia dillenii* is relatively common on dry coastal areas, where the sand dunes are situated on shallow coral reefs or low banks. In the larger cays of northern Cuba *Opuntia millspaughii* may also be present. *Selenicereus* spp. are common climbers on the sea-grape. Other associated succulent species found occasionally are *Scaevola plumieri, Suriana maritima,* and *Argugia gnaphallodes.* The strand littoral scrub and low forest are still common on the sandv shores and on the first seaward dunes of the low limestone rocky shores of the Antilles, Bahamas, and Florida.

3) ***Saline flats*** — The vegetation of the salines is comprised of leaf-succulent dwarf shrubs, annual or perennial succulents, and grasses of high osmotic tension. This belt of salt vegetation is developed on the inland side of the mangrove-zone, in the areas flooded only twice a year by the high equinoctial tides, where the salt tends to concentrate by evaporation, and allows the development of herbaceous flats with *Batis maritima, Salicornia* spp., and *Suaeda* spp. Other succulents occurring in the saline prairie vegetation, mostly at the edge of the supratidal belt, are *Heliotropium curassavicum and Blutaparon vermiculare.* They are all of wide geographic distribution, and no endemic taxa occur in these communities. Due to its environmental requirements this saltwort vegetation is not extensive, nor very abundant in the Caribbean islands. However patches and belts up to one kilometer wide may be locally common in Cuba.

4) ***Rock pavement vegetation*** — This orophilous halophytic vegetation of the supratidal rocky shores, is conditioned by the influence of salt spray, the unprotected exposure and extremely poor soil conditions. The rock-pavement substratum for this type of vegetation occurs on uplifted coral reefs as benches. It dominates entire cays of such origin or occurs in outcrops between sandy or low muddy beaches. There is a well-recognised pioneer association of creeping or prostrate leafsucculent plants such as *Sesuvium* spp., *Trianthema portulacastrum* and *Lithophila muscoides,* and another association with *Borrichia arborescens, Chamaesyce mesembrianthemifolia* and *Opuntia dillenii.* This community that grows on the inland side is characterised by more dense growth. In Puerto Rico and the Virgin Islands *Opuntia repens may be* also present, and on Mona Island (Puerto Rico) there is a spectacular dominance of *Mammillaria nivosa* within this type of vegetation. In contrast to sandy and saline vegetations, which are primarily of pan-tropical character, the vegetation of coastal rock pavements is mainly of Antillean and Caribbean distribution.

II. Coastal-lowland formations

1) ***Dry limestone shrubwoods*** — This dense vegetation corn posed of thorny, sclerophyllous, small-leaved trees and shrubs occurs on bare rocks of dry limestone terraces usually on the inland side of the coastal rock pavement vegetation, and on the lowland karstic 'dogtooth' formations. The 2-3 m high shrubs and the emergent individuals or groups of 5-6 m 'rod-like' associated trees are best developed under climatic conditions consisting of two dry seasons per year which together amount to about seven or eight dry months. Columnar or tree-shaped cacti may occur under a loose canopy layer or intermingled with shrubs in denser communities. They are often seen at the edges of cliffs and exposed rock surfaces together with globular cacti.

The dry limestone shrubwood, also known as thorn scrub, is considered to be the most common and characteristic lowland formation of the West Indies. Sometimes restricted to the coast, it may also extend far

A. Areces-Mallea

Opuntia macracantha, Guantánamo, Cuba. Vulnerable.

inland in many of the Caribbean islands. Spectacular coastal benches with dry shrubwoods occur at the eastern end of Cuba arround Punta Maisi, and a series of uplifted coastal benches are found on the southern coast of Hispaniola extending inland to considerable altitude. In Maisi it is common to see *Melocactus acunai* in thinly coppiced rock flats between microphyllous shrubs strongly modified into grotesque windswept aberrant forms. Extensive unbroken stands of this vegetation type are found in the southern terraced Cuban coast between Maisi and Cabo Cruz, with the endemic cactus species *Pilosocereus brooksianus, Leptocereus maxonii, L. sylvestris,* and *Opuntia macracantha,* and in north-eastern Cuba, where *Leptocereus santamarinae* and other species occur. Smaller stands of this vegetation type are found in the northern coastal zone of west Cuba, and in south-central Cuba. In Hispaniola there is also an extensive stand in areas below sea level in the Enriquillo Valley Cul-de-sac area, giving way to succulent sea coast vegetation with *Melocactus lemairei, Leptocereus weingartianus,* and *Mammillaria prolifera,* at the shores of the lake. Smaller floras of endemic cacti, other succulents, and spiny shrubs exist along the leeward coast of Jamaica and Puerto Rico, and also in the Bahamas, the Virgin Islands, and Lesser Antilles.

2) ***Semi-desert cactus scrub*** — This type of open vegetation is characterised by small trees and shrubs with many succulents, mainly cacti, which are co-dominant or even dominant in both shrub and canopy layers. The most conspicuous elements of this vegetation type are the large columnar and treeshaped cacti, which are represented by local vicariant endemics in each island of the Greater Antilles and the southern Bahamas. The semi-desert vegetation in the coastal and subcoastal belts in the Caribbean islands is conditioned by an arid climate with nine to eleven dry months and 30-60 cm of annual precipitation.

In eastern Cuba the open cactus scrubs form an unbroken stretch along the coast from Guantanamo Bay to Imias. From Imias to Maisi smaller fragments occur, especially on the sand deposits of the coastal areas. Several geographically separated associations occur depending on whether the soil is rocky or sandy and on the duration of dry periods. On sandy soils *Stenocereus hystrix, Opuntia dillenii, 0. hystrix, 0. militaris,* and *Pereskia zinniiflora* are dominant, while on rocky habitats *Dendrocereus nudiflorus, Pilosocereus brooksianus, Harrisia taylori, Melocactus acunae,* and *Agave albescens* are more frequent. In the Dominican Republic and Haiti, in the Enriquillo Valley and Cul-de-sac area, there is an impressive cactus scrub with the arboreal *Leptocereus paniculatus* and *Opuntia moniliformis.* It also occurs on alternating salt rock and gypsum outcrops on the slopes of the abutting mountain ranges, and in the Azuá and Bayahibe areas. In Haiti, in the north-western peninsula, there is another stand with the local endemics *Opuntia*

A. Areces-Mallea

Opuntia moniliformis in coastal scrubwoods, north-west Haiti.

falcata, 0. ekmanii, and 0. *acaulis.* A spot of this vegetation type occurs in Mona Island, Puerto Rico. Dominant cactus species in Mona are *Pilosocereus royenii, Stenocereus hystrix,* and *Harrisia portoricensis.*

3) Dry serpentine shrubwoods — The vegetation is dominated by a dense, 2-4 m high, closed shrub layer, small emergent palms, dwarf palms and 4-6 m high microphyllous evergreen trees. These dense stands usually alternate with small grassy clearings which are often transformed into dwarfgrass savannas by human interference and grazing. This vegetation type, which is well developed in Cuba along the central portion of the main island on ophiolitic rock outcrops, is rare or non-existant elsewhere in the Caribbean Islands. Unlike the dry shrubwoods on limestone in Cuba, the serpentine communities are physiognomically quite uniform despite the great differences in climate and floristic composition among the outcrops. They are also relatively devoid of cacti, with the exception of five rare *Melocactus* species and a unique species of endemic *Escobaria,* all of which are highly endangered.

Melocactus actinacanthus, M. matanzanus, and *M. guitartii* occur in the scrubs of western-central Cuba, while *M. holguinensis, M. radoczii,* and *Escobaria cubensis* are only found in eastern Cuba.

III. Montane formations

1) *Tropical karstic forests* — These are limestone-based forests composed of primarily deciduous species with seasonal flowering. They are only found on the 'mogotes' or haystack mountains of Cuba and Puerto Rico, the Cockpit Country and the John Crow Mountains in Jamaica, and on the Samana Peninsula of Hispaniola. Of these areas, only the Cuban mogotes have proven to support a noteworthy succulent flora. The mogote karstic forests have two evolutionary centres in Cuba with different floras, the oldest and richest (40 per cent endemic) in the western part of the island, and the youngest in central and eastern Cuba.

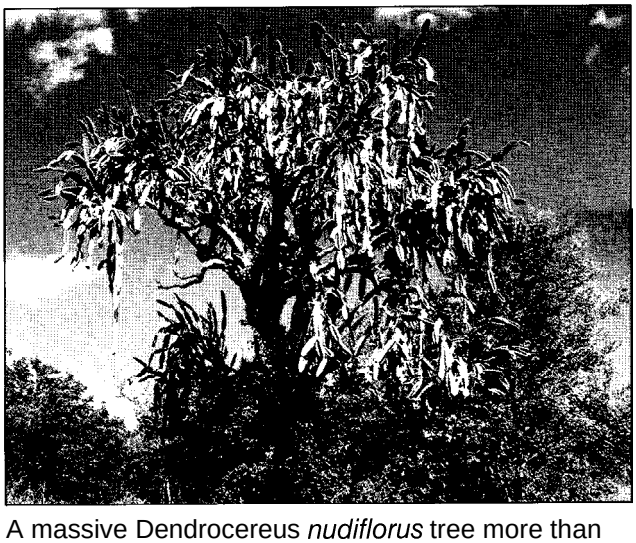
The western mogote forests occur on bare rocks of deeply eroded mountains and solitary cliffs consisting mainly of hard crystalline limestone. There is a single 4-9 m open canopy layer underneath which many smaller plants thrive thanks to the favourable light conditions. *Bombacopsis cubensis,* a Cuban endemic tree with barrel-like trunk capable of water-storage, is present along with various species of *Leptocereus* with very restricted distribution patterns, including *L. assurgens, L. ekmanii, L. leonii,* and *L. prostratus.* Other cactus genera occurring in this habitat are: *Harrisia, Selenicereus, Opuntia,* and *Rhipsalis. Agave tubulata* is only found on the cliffs of the western mogotes. In the central and eastern karstic forests there is only one local species of *Leptocereus, L. carinatus.*

The most important areas where cacti and succulents occur in the West Indies are listed below in the section Priority Sites for Conservation.

Threats

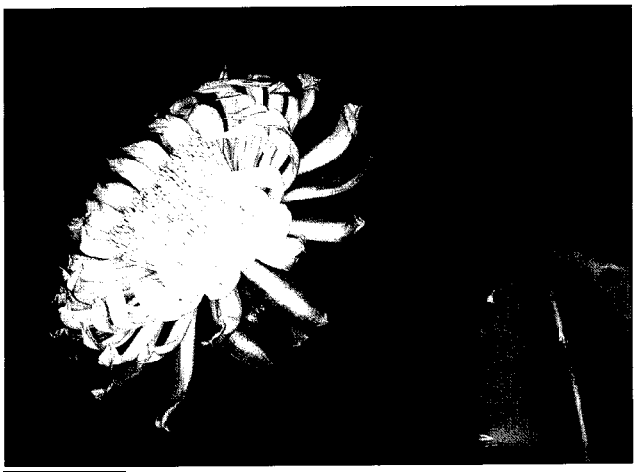
Island floras are usually composed of ecologically restricted populations not capable of adapting to major environmental changes. The ability of the island communities to recuperate from external pressures is, in general, reduced. This characteristic makes them particularly vulnerable to degradation. There is a genetic reason for the vulnerability of island communities: the reduced gene pool from which the populations that colonised the new biotopes are selected. This gene pool does not have the opportunity to improve over a long period of time.

The 'island' effect in the West Indian Archipelago is increased due to the fact that most of the larger island floras consist of groups of ancient, isolated floras (Borhidi 1991). As a consequence of isolation, the ecological tolerance and the genetic flexibility of populations decrease so that the competitiveness of species becomes low. Therefore, they cannot react satisfactorily to new environmental onslaughts, cannot take advantage of succession, and cannot resist, or force back, new competitors. The vulnerability of the succulent endemic flora of the West Indies, in particular, is very pronounced because many taxa have adapted to the extreme ecological conditions of oligotrophic or bare substrates. Thus, the level of metabolism becomes low in these plants, and their competitiveness and degree of sociability diminish even more. On the other hand, it is quite likely that since Pleistocene times the formerly widespread xerophilous elements of the larger Caribbean Islands retreated to relict habitats: dry coastal or subcoastal areas, serpentines, and the slope and cliffs of conical karsts. This was probably due to changes to a more humid climate.



A. Arece-Mallea

A massive Dendrocereus *nudiflorus* tree more than 300 years old (diameter of trunk at base: 1.30 m), Guantánamo, Cuba. Vulnerable.



A. Arece-Mallea

Bat-pollinated flower of Dendrocereus *nudiflorus.*

The relict character of the succulent native flora of the West Indies — another condition that increases vulnerability — is indicated by the presence of relatively primitive, isolated taxa (e.g. the dioecious Antillean group of *Pereskia, Dendrocereus);* the abundance of disjunct geographical distribution types, for example *Dendrocereus nudiflorus, Bombacopsis cubensis, Furcraea hexapetala, Opuntia nashii,* and 0. *millspaughii;* and the large number of local endemics represented by small populations, such as *Opuntia hystrix, 0. militaris, 0. sanguinea, 0. borinquensis,* and *Leptocereus* spp. Consequently, the West Indian succulent flora is one of the most endangered plant communities in the world.

Clearing for agriculture — The human population of the Caribbean Islands in 1991 was estimated to be 35 million (FAO 1990), projected to rise to about 40 million by the year 2000, and to nearly 60 million by 2025. In general, although all-island totals are increasing, the incremental rates and proportions of populations economically active in agriculture have fallen over the past decade. These trends reflect increase in mechanisation and efficiency on farms and in importation of foods replacing local produce, combined with migration to towns and coastal tourist resorts. Higher growth-rates are associated with larger rural populations and relatively smaller movements away from agricultural pursuits, as in Jamaica, Haiti, and

the Dominican Republic. The total number of people comprising agricultural communities actually rose in Jamaica and Haiti (by 7.5 per cent) during the decade, this trend matching several of the poorer Central American republics where, however, numbers of those actually economically active on the land also fell.

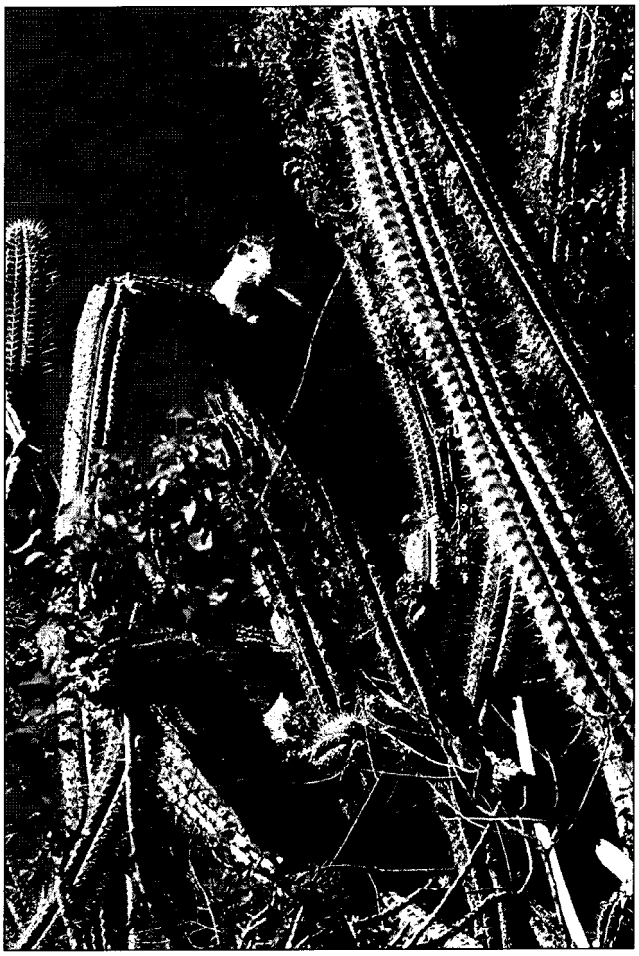
Most agricultural development has been carried out on the seasonal evergreen forest or seasonal rain forest areas, and on lowlands formerly occupied by semi-deciduous forest, which are not succulent-rich communities. Nevertheless, important coastal shrubwood areas in western Cuba with *Dendrocereus nudiflorus* and *Pilosocereus robinii* have been cleared for sisal (*Agave sisalana* and *A. furcroydes)* plantations. Traditional cassava, maize, and other small crop cultivation has also been attempted locally, with limited success, in many West Indian scrub areas.

Grazing — The impact of drought-resistant cattle in the seasonally dry vegetation of the West Indies is well known. In the eastern lowlands of Cuba many stands of semi-deciduous xerophytic forests with *Pereskia zinniiflora* and *Harrisia* sp. were cleared for grazing. Goats are usually grazed in the succulent-rich shrublands of south-eastern Cuba, north-western Haiti, and southern Dominican Republic. *Opuntia caribaea* which is considered a pest in Hispaniola, is one of the few native succulents that seems to benefit in overgrazed areas.

Burning — The natural vegetation of the West Indian islands has not evolved the fire-tolerant life forms that are found throughout much of tropical Africa or continental America, so fire is comparatively more destructive in the Caribbean. Fire is commonly used to clear land for agriculture and settlements, to 'clean' undergrowth in forests and to encourage new growth in savannas and bushland in the dry season for pasturage. Some of the arboreal *Opuntia* (subgenus *Consolea),* with thick-barked trunks, are more fire-tolerant than smaller cacti and can escape damage from fire to some degree, and so can *Escobaria cubensis* which in the dry season is at ground level or even below. But in general, burning is a major threat to the succulent plant flora. Particularly susceptible to fire damage are the thin-stemmed *Harrisia* spp. and most *Melocactus* spp. *Harrisia portoricensis* became extinct in the main island of Puerto Rico mainly because of fire; now the species is confined to Mona and Monito Islands. *Opuntia borinquensis,* which has not been seen in the wild for many years, is probably gone forever due to severe burning of the Cabo Rojo area in south-western Puerto Rico, some years ago. This place was considered an important regeneration area for *Melocactus intortus* in Puerto Rico; today very few individuals of this species can be seen there.

Urbanisation and tourism — There are 16 urban centres in the Caribbean with over 100,000 inhabitants. These are Cuba: Havana, Camaguey, Santiago de Cuba, Guantanamo; Dominican Republic: Santo Domingo, Santiago de los Caballeros; Haiti: Port-au-Prince; Puerto Rico: San Juan; Jamaica: Kingston, Montego Bay; Bahamas: Gran Bahama, Nassau; Guadeloupe: Pointe-a-Pitre; Martinique: Fort-de-France; Barbados: Bridgetown; Trinidad: Port-of-Spain. Most of these centres are located in coastal areas.

Many restricted endemics have suffered the location of an urban centre within their sites of occurrence. *Escobaria cubensis* is facing the growth of the city of Holguin in eastern Cuba, and is dangerously retreating. *Borrichia cubana* and *Leptocereus wrightii,* former occupants of the rocky coastal areas of Havana harbor and its environs, are nearly extinct now. *Agave legrelliana* and *Pilosocereus robinii* are significantly reduced in occurrence by the urbanisation of north Havana province. But these are not the only victims of the relatively populous capital of Cuba; *Cnidoscolus quinquelobatus* and *C. fragrans,* both endemic to the Havana city area, seem to have disappeared forever. They have not been seen in the wild for more than half a century.



A. Areces-Mallea

Wildlife supported by succulents: endemic arboreal rodent (*Capromys pilorides*) on columnar cactus *Stenocereus hystrix,* Guantánamo, Cuba.

The growth of tourism in many of the islands over the past 50 years has resulted in hotel development along coastlines that have attractive sandy beaches. This has often meant a complete change to the landscape locally, involving the removal of natural vegetation and the planting of ornamental trees, shrubs, and grass for lawns and golf courses. Varadero Beach in Cuba and La Romana touristic complex in the Dominican Republic are clear examples of this landscaping policy. The giant *Dendrocereus nudiflorus* in Varadero's famous beach and resort area has been progressively replaced by Royal Poncianas *(Delonix regia)* and other foreign flowering trees. The dioecious *Pereskia quisqueyana,* endemic to the Bayahibe beach and coastal lowlands in south-eastern Dominican Republic, is practically extinct by now; very few male individuals were left on the strand and as yet nobody has ever seen a female plant.

Mosquito control and marina developments have eliminated mangroves and littoral thickets in many places. New roads have often been constructed to give access to coastal areas, and to connect cays with the mainland.

In some Caribbean islands the movement of people from rural areas to towns and resorts with the lure of employment opportunities in servicing the new tourism has coincided with the decline of export-based plantation agriculture. Increased demand for fresh fruit and vegetables has often resulted in unacceptable levels of cultivation on unsuitable land.

Mining and quarrying — Threats to the landscape in the West Indies arise mostly from mining activities. Whatever type of mining is carried out, vegetation is cleared and there is always some surface disturbance either from stripping operations or dumping of tailings. The exploitation of bauxite in south-western Dominican Republic has had a significant impact on the dry shrubwoods of the Pedernales area. Quarrying for limestone in the haystack karstic mountains of north-eastern Puerto Rico and western Cuba has produced significant changes in local landscapes and strain on various species, notably *Leptocereus leonii* and *L. scopulophilus.*

Riversides and beaches are often exploited destructively for building sand and gravel and these removals may have secondary effects in the form of erosion, flooding, pollution, and loss of visual aesthetic.

Collecting for horticulture — Some of the cacti and succulents of the Caribbean region are of considerable horticultural interest and some have been exploited to the detriment of wild populations. Undoubtedly, the most demanded genus is *Melocactus. M. intortus* has been heavily collected in Puerto Rico, for example (Martin and Farmer 1975), where hundreds of plants were formerly removed from the wild. It has also been exported in quantity from St. Eustatius and Grenada (Howard 1977). Fortunately, *M. intortus* is the most widespread and abundant species of this genus in the West Indies.

Melocactus lemairei of Hispaniola, *M. harlowii* of eastern Cuba, and especially the ophiolitic dwellers *M. matanzanus, M. actinacanthus,* and *M. guitartii* were heavily collected in the 1970s, according to local fashions in their respective countries of origin. Many people wanted rock gardens at that time. In Cuba the demand for *M. actinacanthus* led to the wholesale removal of nearly all the wild population; only a few dozen individuals can be seen nowadays in their original location, in very steep, nearly inaccessible cliffs.

The main Caribbean country involved in the export of cacti and other succulents for horticulture is the Dominican Republic. The bulk of the plants exported are non-indigenous, commonly cultivated Mexican cacti, *Aloe* and *Euphorbia* spp. Small quantities of indigenous cacti have, however, been exported including *Opun tia an tillana, Harrisia divaricata,* and *Melocactus lemairei* (Oldfield 1991). One large commercial outlet in the country exports mainly to the US.

Introduced species — The introduction of the extremely aggressive shrub *Dichrostachys cinerea* from the savannas of Africa into Cuba and Marie Galante has been an ecological disaster. The plant regenerates vigorously from the smallest root fragments. In south-central Cuba this invader has had a notable detrimental impact on *Leptocereus arboreus* and the xerophytic indigenous vegetation with which this species is associated.

On the small island of Guana in British Virgin Islands invasive succulent plants, originally introduced for horticultural purposes, include *Sansevieria trifasciata, Kalanchoe* spp., and *Aloe vera.* These pose a significant threat to the native flora and are now being controlled (Krauss 1991).

Local use — The fruits of various species of *Opuntia, Harrisia, Pilosocereus, Melocactus, Hylocereus, Selenicereus, Pereskia aculea ta,* and *Stenocereus hystrix* are used sporadically as sources of food in most West Indian islands, though none of them is commercialised. In north-eastern Cuba a traditional red wine is made out of the ripe fruits of *Opuntia dillenii.* The sticky mucilage from the stems of this species, mixed with slaked lime, is still in use in Cuba to make a coarse paint. *Stenocereus hystrix* is also used in Hispaniola, Cuba, and Jamaica as live fencing.

Agave sobolifera and other species are used for craft materials in Jamaica and other Caribbean islands. The saponin-rich juice extracted from the leaves of *Agave albescens* and *A. underwoodii serves* locally as a laundry detergent in times of needs. It is not yet well known to what extent these uses have a detrimental impact on wild populations.

Natural environmental factors — Hurricanes, volcanic eruptions, severe droughts, floods, and landslides are intrinsically associated with the West Indian environments, and may have profound effects on the

A. Arecas-Mallea

Leptocereus paniculatus, Dominican Repu blic.

floras. On April 13, 1979, for example, the rare *Selenicereus innesii* seems to have been completely wiped out of the wild, when the area it inhabited in St. Vincent was devastated by the violent eruption of La Soufriere.

Conservation status

In general, it remains difficult to estimate population size and area of dispersal for rare plant species of the Caribbean Islands. Gaps in the flora coverage and the limited number of people with specialised knowledge have restricted the availability of data on the conservation status of West Indian plants. Very preliminary and incomplete assessments of the cacti and other succulents have been made. Taxonomic uncertainties add to the difficulties of applying conservation categories. WCMC has records of over 100 Caribbean cacti in its Plants Database. Of these, about 40 are threatened on a world scale.

It has not been until now that a more realistic evaluation of the conservation status of the West Indian cacti has been attempted, and it provides the basis of a preparation of a systematic treatment of the Cactaceae for the New York Botanical Garden's Flora of the Greater Antilles project. Based primarily on my field knowledge of the West Indian islands I have prepared the list of 243 succulent plant species in 16 families endemic to the West Indies (Table 3 of Annex 14). As noted above Aruba, Bonaire, Curaçao, Trinidad, Tobago, Margarita, and other small islands adjacent to Venezuela were excluded from the survey due to the fact that these territories are phytogeographically part of northern South America, and their flora predominantly continental. An appreciation of the current conservation status of each taxon is given by classifying them within four categories.

For some Haitian rare succulent species with very limited distribution data and doubtful assessment information on which to base current conservation status, it is necesary to carry out field surveys for more accurate field-based assessments of their conservation condition.

Priority sites for conservation

The West Indian endemic succulent flora occurs throughout the many islands of this dispersed archipelago. Nearly every island, or group of islands, has its own local taxa. Rather than a few large protected areas, the coverage of such a disperse flora, in terms of conservation needs, requires a number of small-sized sites:

Cuba:

1) ***Coast and lowlands from Guantánamo Bay to Punta Maisi:*** an important part of the south-eastern dry shrubwoods and semi-desert cactus communities with *Agave* spp., *Plumeria* spp., *Cissus* spp., and 18 species of Cactaceae distributed in 11 genera. This area can be identified as particularly outstanding for succulent conservation in the Caribbean.

A. Arecas-Mallea

Coastal limestone habitat with *Stenocereus hystrix*, Guantánamo Bay, Cuba.

2) ***Coast and lowlands of Baconao, sections El Indio-El Morrillo (Reserva de Santiago):*** another part of the south-eastern dry scrubwoods and semi-desert cactus scrubs including the type locality of the rare *Leptocereus maxonii.*

3) ***Coastal section between Pilón and Cabo Cruz:*** also in south-eastern Cuba. With some of the succulent species of the above mentioned areas, it also includes the entire site of occurrence of *Leptocereus sylvestris.*

4) ***Coastal terrace between Gibara and Puerto Padre bay:*** an important area of the north-eastern xerophytic plant communities. An undescribed subspecies of *Opuntia nashii* grows in this site, together with the giant *Dendrocereus nudiflorus.*

5) ***Coco, Paredon Grande, Romano and Sabinal cays:*** important *Leptocereus santamarinae* populations occur in some of the largest islets of the Camaguey Archipelago in northern Cuba. The cays are also inhabited by *Opuntia millspaughii, Pilosocereus millspaughii* (at the southern end of its distribution) and the rare *Selenicereus brevispinus,* a very restricted local endemic.

6) ***Santa Cruz del Sur lowlands:*** the savannas north to Santa Cruz, in southern Cuba (Camaguey province), have the largest populations of *Pereskia zinniiflora* of both sexes, male and female. This Cuban endemic is threatened by habitat destruction at its other locations.

7) ***Coast and lowlands from Playa Girón to Cienfuegos Bay, and from Cienfuegos to Trinidad:*** important for the local endemics *Agave acicularis, A. grisea,* and *Leptocereus arboreus.* The site also has *Pilosocereus, Harrisia, Dendrocereus, Pereskia, Selenicereus, Hylocereus,* and *Opuntia* species.

8) ***Eastern tip of Hicacos Peninsula, from Rincon Frances to the east end:*** the most outstanding area of north-western xerophytic communities in Cuba. Important for populations of *Pilosocereus robinii, Agave legrelliana,* and *Omphalea trichotoma.* The site also has *Dendrocereus.*

9) ***Guanacahabibes Peninsula:*** part of the western dry shrubwoods with the rare *Harrisia taetra.*

10) ***Western haystack mountain complex of Sierra de los Organos:*** the whole karstic mountain range, in Pinar del Rio province, should be an international conservation priority. It has mostly primary vegetation with *Bombacopsis cubensis, Omphalea hypoleuca, Cnidoscolus* spp., *Cissus* spp., *Agave tubulata,* and 11 species of cacti, two of which are yet undescribed.

11) ***Sierra de Anafe:*** an isolated limestone mountain range in Havana province, with *Leptocereus leonii.*

12) ***Sierra de Somorrostro and neighboring hills:*** this other site in Havana province is important for the highly endangered *Leptocereus scopulophilus.*

13) ***Sierra de Najasa:*** an interesting site in Camaguey province with *Hildegardia cubensis* and *Leptocereus carinatus.*

14) ***Jibacoa limestone-mountain area in Guamuhaya:*** steep cliffs inhabited with the local endemic *Melocactus perezassoi.*

15) ***Dry serpentine shrubwood sites on rocky outcrops of the ophiolitic complex:*** there are four geographically unrelated sites each of which has its own endemic taxa, mostly occurring in small, restricted populations. These are:
   a) Tres Ceibas (Havana prov.) with *Melocactus matanzanus,*
   b) Agabama (Villa Clara prov.) with *M. actinacanthus,*
   c) Jatibonico (S. Spiritus prov.) with *M. guitartii,*
   d) Holguin (Holguin prov.) with *M. holguinensis* and *Escobaria cubensis.*

Hispaniola:

1) ***Lake Enriquillo Valley, encircled by Jimani-La Descubierta and Neiba-Duvergé*** (Dominican Republic): a very important part of the south-western semi-desert cactus communities dominated by *Leptocereus paniculatus, Stenocereus hystrix,* and *Opuntia moniliformis.* Because of its cactus richness and diversity (9 genera, **14 species)** this area is of particular interest for succulent plant conservation in the Caribbean. Isla Cabritos National Park, a small island within Lake Enriquillo, gives insufficient protected coverage to this unique xerophilous flora.

2) ***Dry shrublands between Baní and Azuá*** (Dominican Republic): another part of the cactus scrub of southern Hispaniola, with six different species of *Opuntia.*

3) ***Coast and lowlands between Mole St. Nicolas and Port-de-Paix*** (Haiti, Dept. du Nord' Ouest): an important area of the north-western xerophytic communities with the local endemics *Opuntia falcata, 0. ekmanii, 0. acaulis,* and a probable undescribed species of *Leptocereus.* Knowledge of the status in the wild of these taxa is essential to determine their precise conservation needs.

4) ***Coast and lowlands of Barahona and Pedernales provinces*** (Dominican Republic): scarcely disturbed dry shrubwoods and semi-desert cactus scrubs with *Dendrocereus undulosus.* Other important cactus genera present are *Opuntia, Leptocereus, Harrisia, Mammillaria, Pilosocereus, Stenocereus,* and *Melocactus.*

5) ***Coast and lowlands between La Romana and Cabo Engano, including Saona island*** (Eastern Dominican Republic): an interesting part of the southern dry communities with an undescribed taxon of *Opuntia.*

6) ***Dry lowlands south of Montecristi:*** the most important area of the north-western dry shrubwoods and semi-desert cactus communities of the Dominican Republic.

7) ***Coast and lowlands of Bayahibe*** (Dominican Republic): with the rare *Pereskia quisqueyana.*

*8) **Cerro de San Francisco, Banica*** (Elías Piña province, Dominican Republic): important for *Pereskia marcanoi.*

Puerto Rico:

1) ***Coast and lowlands from Bahia de Guayanilla to Boqueron:*** the most important part of the dry shrubwoods and semi-deserts of the main island, with 12 species of Cactaceae, half of which are *Opuntia.*
2) ***Mona and Monito Islands:*** a sanctuary for the Puerto Rican xerophytic communities, with the rare *Harrisia portoricensis* and a yet undescribed taxon of *Opuntia.*
3) ***South-eastern Culebra Island:*** the only site of occurrence of *Leptocereus grantianus.*
4) ***Tetas de Cayey mountain ridge:*** an interesting rocky outcrop with an undescribed *Melocactus* taxon.

Jamaica:

1) ***Hellshire Hills coastal and lowland area:*** an important part, south to Spanish Town, of the southern dry shrubwoods and semi-desert cactus communities with the endemics *Opuntia spinosissima, 0. jamaicensis, Pilosocereus swartzii,* and *Melocactus caroli-linnaei.*
2) ***Coast and lowlands from Treasure Beach to Little Pedro Point area:*** another part of the southern dry shrubwoods with *Acanthocereus* sp., in St. Elizabeth parish.
3) ***Cockpit Country:*** interesting karstic forests in Trelawny parish, with a rare *Mammillaria* species on vertical limestone cliffs.

The Bahama Archipelago:

1) ***Coastal areas and rocky plains of the Turks and Caicos Islands:*** dry shrubwoods with *Opuntia millspaughii, 0. bahamana, 0. lucayana,* and *Limonium hahamense.*
2) ***Eleuthera Island rocky plains:*** important for *Agave braceana, A. cacozela,* and *Pilosocereus bahamensis.*
3) ***Great Inagua open sandy flats and rocky coastal coppices:*** with *Agave inaguensis, A. nashii,* and *Pilosocereus millspaughii.*
4) ***Long Island dry shrublands:*** important for *Agave indaga torum* and *Harrisia brookii.*

The Lesser Antilles:

1) ***Northern Grand Terre of Guadeloupe:*** dry shrubwoods with *Agave dussiana, Acanthocereus pentagonus, Opuntia rubescens,* and 0. *triacantha.*
2) ***Barbuda lowlands:*** with *Agave karatto, Manzmillaria nivosa, Melocactus intortus,* and 0. *rubescens.*
3) ***South-eastern peninsula of St. Kitts:*** important for *Agave van-grolae, Melocactus intortus,* and *Opuntia* spp.
4) ***La Soufrière volcanic cone, St. Vincent:*** the only known site of occurrence of *Selenicereus innesii.* This rare species could have become extinct after the 1979 eruption.
5) ***Additional sites:*** Antigua, south-western area; Anegada, eastern lowlands and eastern central area; Virgin Gorda, central coast area; Martinique, south-western area.

The Cayman Islands:

1) ***The Bluff area of Cayman Brac:*** with an undescribed variety of *Epiphyllum phyllan thus, Opun tia millspaughii,* and new taxa of *Harrisia* and *Pilosocereus.*
2) ***East End area of Little Cayman:*** part of the cactus scrub of the Caymans, with *Opuntia, Harrisia,* and *Pilosocereus.*

Table 3.17 Caribbean protected areas: number and area covered (in hectares) by IUCN category Category definitions are given in Box 2.4.

Country	Cat. I	Cat. II	Cat. III	Cat. IV	Cat. V	TOTAL
Antigua & Barbuda		1/4,128				1/4,128
Bahamas		4/1 21,516		1/1,813		5/1 23,389
Belize		1/4,144		6/1 13,846		7/1 17,990
Bermuda				1/12,000		1/12,000
Caymans	1/1,731			1/3,310		215,041
Cuba	8132,405	8199,518		21/1 70,487	36/1,038,996	73/1,341,406
Dominica		116,872				116,872
Dominican Republic		1 O/488,069		7/476,090		17/964,159
Guadeloupe		1 /17,300		1/3,700		2/21,000
Haiti		217,500			112,200	3/9, 700
Jamaica		2/37,953				2137,953
Martinique					1/ 70,150	1/ 70,150
Dutch Antilles		217,760				2/7,760
Puerto Rico				14128,548		14128,548
St Lucia				1/1,494		1/1,494
St Vincent &Grenadines				218,284		218,284
Trinidad &Tobago				7115,528		7115,528
Turks & Caicos		10186,745	1/1259	1/4,497	4/5,301	14/97,532
BVI				3/673		3/673
US VI		1114,079				1114,079

Existing conservation measures

Unfortunately, until very recently the conservation of the Caribbean biodiversity was not recognised as being of importance by international conservation agencies. There has been remarkably little attention paid to the conservation needs of the cactus and succulent flora in general. Undoubtedly, the historical preoccupation with tree forest, and especially our present-day concern for tropical rain forests, have diverted attention from other vegetations of equally deserving botanical merit in the Caribbean (Adams 1997). Plant formations in need of protection include special floras of serpentine soils in Cuba and Jamaica, and siliceous sand savannas which have a restricted range outside Cuba. Recently attention has been concentrated on the establishment of marine protected areas. These may incidentally protect the succulent flora of coastal areas (e.g. Buck Island, in St. Croix, US Virgin Islands) but do not necessarily protect the habitats of endemic and/or threatened succulent species.

Sometimes areas of cactus scrub vegetation are protected within various sites set aside for conservation throughout the Caribbean. In the British Virgin Islands, for example, the Fallen Jerusalem and West Dog Island Forestry Parks support this type of vegetation. Some priority sites for the protection of specifically representative areas of cactus scrub in the West Indies are Cabo Corrientes and Baconao reserves (Cuba); lsla Cabritos National Park (Dominican Republic); Guanica State Forest and Mona Island reserve (Puerto Rico), and Parc National (proposed in Guadeloupe).

Protected areas

Protected areas currently cover not more than 6.6 percent of the Caribbean Islands' land area, and West Indian biodiversity is not fully represented. Besides, many of the protected areas which do exist are not adequately protected on the ground. According to an AS0 study (Inventory of Caribbean Marine and Coastal Protected Areas, 1988) only 33 percent of the protected area coverage is under a suitable regime of protection and management; 43 percent is partially protected, while the remaining 24 percent is practically unprotected. A review of the protected areas system and conservation legislation in the Caribbean is given in IUCN (1992). A summary of protected areas in the West Indies is presented in Table 3.17, and specific areas important for succulent conservation are presented in Box 3.6.

Notwithstanding that the most common of the West Indian lowland formations is the thorn scrub, most of the area coverage listed in Table 3.17 is of montane and submontane rain forests, seasonal evergreen forests, semi-deciduous, and coniferous forests.

Box 3.6 Protected areas important for succulent conservation in selected Caribbean islands

	Area (km*)	Category
Cuba		
1) Gran Parque Sierra Maestra Integrated Management Area comprising:	5,270	VIII
a) National Park of Desembarco del Granma	258	II
b) National Park of Turquino	175	II
c) Biosphere Reserve of Baconao	846	IX
2) Escambray Integrated Management Area	1,870	VIII
3) Mil Cumbres Integrated Management Area	166	VIII
4) Vinales National Park	134	II
5) Peninsula de Guanacahabibes Biosphere Reserve	1,015	IX
6) Cabo Corrientes Natural Reserve	16	I
7) Subarchipielago Sabana-Camaguey Integrated Management Area	179	V
8) Punta Frances-Punta Pedrales Natural Park	174	II
Hispaniola		
1) Isla Cabritos National Park	24	II
2) Del Este National Park including Saona island	420	II
3) Monte Cristi National Park	1,309	II
4) Sierra de Bahoruco National Park	800	II
5) Jaragua National Park including Beata island and the submerged platform between the island and the mainland)	1,374	II
Puerto Rico		
1) Guanica State Forest		
2) Mona Island Natural Reserve	55	IV
3) Culebra National Wildlife Refuge	6	IV
Jamaica		
1) Hellshire Hills (proposed) reserve		
2) Cockpit Country		

Conservation agencies and botanical institutions

Cuba

1) Viceministerio Forestal, Ministerio de Agricultura (MINAGRI): This government institution has responsibility for forest management and protected areas. MINAGRI is also the CITES Management Authority.
2) Comisión para la Proteccion de la Flora, la Fauna y el uso racional de los Recursos Naturales (COMARNA): This government entity, which works closely with MINAGRI, investigates the development of management plans for protected areas.
3) Instituto de Ecología y Sistematica (IES): Research institute under the Ministerio de las Ciencias y la Tecnologia (former Academia de Ciencias), with a core of botanical and zoological staff supported by a strong reference library and the largest herbarium of the country. It includes the Centro Nacional de Biodiversidad which is developing a database on West Indian biodiversity.
4) Jardín Botánico Nacional (JBN): Large garden under the Universidad de La Habana (Facultad de Biologia); it maintains important collections of Cuban plants. There is also a core of botanical staff and an important library.
5) Museo Nacional de Historia Natural (MNHN): Also under the Ministerio de las Ciencias y la Tecnologia, with a group of well trained and experienced curators, one of which is a Scientific Advisor of RARE Centre for Tropical Conservation.
6) Centro Oriental de Biodiversidad y Ecosistemas (COBE): The same as IES in the eastern provinces.
7) Instituto Superior Pedagogic0 (ISP): Important group of institutes (one in each province) under the Ministerio de Educación, with a Department of Botany and staff specialised in local (provincial) floras.
8) Sociedad pro-Naturaleza (SPN): Recently established NGO for the protection of the environment through local initiatives.

Dominican Republic*

1) Dirección Nacional de Parques (DNP): This government body, under the Secretaria de Estado de Agricultura (SEA), Subsecretaria de Recursos Naturales, is responsible for forest management and protected areas. DNP is also the CITES Management Authority.
2) Jardín Botánico Nacional "Rafael M. Moscoso" (JBN-RMM): Maintains collections of Hispaniolan plants. At the herbarium there is a small but experienced number of curators.
3) Departamento de Biologia, Universidad Autonoma de Santo Domingo (UASD): with a Biological staff, and herbarium.
4) Parque Jaragua (PJ): An NGO for the study and protection of wildlife in Parque Nacional Jaragua. It also investigates the development of management plans for this protected area.
5) Natura (N): Another NGO which serves to check environmental health. Provides control activities developed through local initiatives.

Puerto Rico

1) Departamento de Recursos Naturales (DRN): This government Department has responsibility for forest management and protected areas. DRN is also the CITES Management Authority.
2) Jardín Botánico de la Universidad de Puerto Rico, Recinto de Rio Piedras (JB-UPR): Maintains living collections of Puerto Rican plants and a herbarium.
3) Centro de Información Ambiental del Caribe (CIAC): Recently established centre under the Universidad Metropolitana, to develop a database on Caribbean environment concerns.
4) Centro de Educación Ambiental (CEA): Also established under the Universidad Metropolitana, to popularise environmental information with educational purposes.
5) Fundación Puertoriquena para la Conservación (FPC): An NGO for the conservation of the island's flora and fauna.
6) Fideicomiso para la Conservación (FC): Another NGO for the rescue and protection of Puerto Rico's natural and cultural heritage.

Jamaica

1) Natural Resources Conservation Department (NRCD): Government Department responsible for forest management and protected areas. It is also the CITES Management Authority.
2) Institute of Jamaica (IJ): Renowned Jamaican institution with the most valuable herbarium collections of the Caribbean.
3) Department of Botany, University of West Indies (UWI): With an experienced staff, and herbarium.
4) Entity: Encourages economic progress coupled with natural resource protection through education and hosting a tree bank.
5) Natural History Society of Jamaica (NHS): Disseminates information and provides education on conservation and preservation of the environment.
6) Jamaican Society of Scientists and Technologies: Supports scientists and resource development.

National and regional legislation

Some Caribbean islands have national legislation protecting the environment (e.g. Law no. 33 of 12 July 1981, in Cuba). Although rare and threatened plant species are considered in some of these legislations, in general legal protection for succulents has not been fully elaborated. The SPAW Protocol, outlined in International legislation in Chapter 2, if effectively implemented may provide the impetus to update or develop new legislation.

Ex situ conservation and reintroduction

For a number of highly threatened succulent species there is no other alternative, at this moment, than to conserve and propagate them *ex* situ. Studies need to be carried out to find similar habitats for replanting, following the IUCN Guidelines *for Re-Introductions* (IUCN 1995). Examples of small-scale reintroduction projects for cacti have taken place in Cuba, Puerto Rico, and Guana, British Virgin Islands.

South America

Nigel Taylor, Roberto Kiesling, and Robert Kraus

The South American Continent (i.e. Panama southwards, including the Caribbean islands of the Dutch Antilles, Trinidad and Tobago, and those belonging to Venezuela, and the archipelagos of the Galapagos and Fernando de Noronha) has a complete spectrum of environments and an extremely large and varied flora numbering in the region of 90,000 species of higher plants. Of these, succulents probably represent about 1.5 per cent (i.e. < 1400 spp.), the great majority being endemic and found in regions with less than 1000 mm of annual precipitation (cactus epiphytes excepted). The principal succulent plant families represented (cf. Eggli 1994), in order of importance, are Cactaceae (c. 850 spp. in many genera), Portulacaceae (c. 200-250 often weedy spp. of *Anacampseros, Grahamia, Portulaca, Cistanthe, Montiopsis, Silvaea, Talinum, Xenia),* Bromeliaceae (c. 170 spp. of *Dyckia, Cottendorfia, Encholirium, Deuterocohnia, Abromitiella,* etc.), Crassulaceae (c. 30 spp. of *Echeveria, Villadia, Sedum* etc.), Piperaceae (c. 20 spp. of succulent *Peperomia),* and less than 10 species in each of Agavaceae *(Agave, Furcraea),* Aizoaceae (mostly introduced weeds), Asclepiadaceae *(Marsdenia sessilifolia, M. megalantha,* Brazil), Bombacaceae *(Cavanillesia, Ceiba),* Caricaceae *(Jacaratia corumbensis, Carica chilensis),* Compositae *(Duseniella pa tagonica,* Argentina), Cucurbitaceae *(Apodanthera,* some Brazilian spp. only), Dioscoreaceae *(Dioscorea basiclavicaulis,* Brazil), Euphorbiaceae *(Euphorbia* spp., *Jatropha* spp.), Nolanaceae (*Nolana* spp.), Oxalidaceae (*Oxalis* spp., Chile), and Phytolaccaceae *(Phytolacca dioica).* There are also various species of Basellaceae *(Boussingaultia* spp.), Begoniaceae (e.g. *Begonia venosa),* Bromeliaceae (e.g. *Puya, Tillandsia,* etc.), Commelinaceae (*Callisia, Tripogandra),* Compositae *(Senecio),* Ericaceae *(Sphyrospermum* spp.), Euphorbiaceae *(Euphorbia lutzenbergeriana* and allies, *Manihot* spp.), Gesneriaceae *(Nematanthus gregarius, Sinningia leucotricha),* Melastomataceae, and hydrophilic Crassulaceae *(Tillaea),* etc., which are borderline succulents, caudiciforms, or waterplants not counted here.

The taxonomic status of species in certain genera of Cactaceae, Portulacaceae, and Bromeliaceae remains doubtful, many being poorly or rather narrowly defined. Succulent plants in the floras of Peru and Bolivia are inadequately understood, even though a modern checklist is available for Peru. There is no overall Flora covering South America, and some of its larger countries, such as Brazil, have no modern Flora of any kind and even lack completed Floras at state level. However, floristic knowledge in Argentina, Ecuador, Venezuela, and Paraguay is better, there being either comprehensive state Floras already published or regional/national accounts in preparation, or with parts including succulents published or in finalised manuscript. The largest family involved, the Cactaceae, is relatively well-understood in Venezuela, Chile, Argentina, Paraguay, and eastern Brazil, but presents considerable problems elsewhere.

Takhtajan (1986) divides South America into six floristic regions, which are employed in slightly modified form below: (1) the Caribbean Region, comprising its southernmost islands (Curaçao to Trinidad, etc.), Panama and the coastal areas of northern Venezuela, Colombia, and north-western Ecuador; (2) the Andean Region ranging from the vicinity of Caracas (Venezuela) and Santa Marta (Colombia) southwards to north-western Argentina and northern Chile (including east and west margins of the Atacama Desert), taking in the Pacific coast from southern Ecuador southwards; (3) the Amazon Region including the lowlands of the Rio Orinoco drainage; (4) the Region of the Guyana Highlands of Venezuela, northernmost Brazil, and the Guianas; (5) the Brazilian Region of extra-amazonian Brazil, Paraguay, eastern Bolivia, and northern Argentina (Chaco vegetation); and, lastly, (6) the Chile-Patagonian Region including Uruguay and the remaining parts of Argentina and Chile.

A few widespread and common species of Cactaceae are probably not at risk and need not be mentioned below under individual regions. These include *Pereskia aculeata, Rhipsalis baccifera, Disocactus amazonicus, Epiphyllum phyllanthus, Pseudorhipsalis ramulosa,* and *Selenicereus setaceus.* The very humid Regions (3) and (4) are of limited importance for succulent plants (including epiphytes), these being represented by a few species of Cactaceae *(Melocactus, Cereus, Hylocereus, Pilosocereus, Selenicereus),* Bromeliaceae (especially >20 spp., Guiana Highlands), and *Portulaca,* which are either believed to have extensive distributions or whose habitats are not particularly threatened by anthropogenic change (e.g. tepuis, inselbergs, riverine rocks, flooded forest). They arc not considered further here.

The Caribbean Region

The South American part of this region has two basic kinds of environment in which succulents are found: tropical rain forest and dry seasonal forest including open scrub. The former is the habitat of a few widespread cactus epiphytes, that are probably not threatened as species. There is also the remarkable woody, terrestrial cactus, *Pereskia bleo,* from Panama and Colombia

(Leuenberger 1986) which again is not threatened (Leuenberger, in *litt* 1993). In Panama its range appears to include various protected forest areas (WCMC 1992). Table 3.18 lists succulents under threat in Panama. The dry seasonal forest/scrub, which includes the extensive, Falcon-Lara Depression of Venezuela, south Caribbean islands and the Galapagos Archipelago, is home to about 30 mainly treelike or shrubby cactus species, three or four Agavaceae, and one or more *Echeveria* spp., the majority being widespread and common. However, on the mainland endemics of more restricted distribution are represented by *Agave cocui, Echeveria* sp. nov. (Lara state), *Cereus fricii (C. russellianus), C. mortensenii, C. horrispinus,* and *Pseudoacanthocereus (Acanthocereus) sicariguensis,* all from northern Venezuela, the latter two ranging into Colombia, where a local endemic, *Armatocereus humilis* (Rio Dagua valley, western Colombia), is found. One or more of these could become threatened if widespread conversion of its habitat should take place, and it is unclear whether any occur within the protected areas listed for this region (cf. WCMC 1992).

Table 3.18 Succulent species considered to be under threat in Panama
(Source: Villa-Lobos, in press)

Species	Status
Acanthocereus tetragonus	V
Agave angustifolia	R
Hylocereus costaricensis	V
Hylocereus monacanthus	V
Hylocereus polyrhizus	V
Hylocereus tenopterus	V
Pereskia aculeata	V
Pereskia bleo	V
Pereskia guamacho	V
Weberocereus panamensis	V
Werckleocereus tonduzii	V

The islands of the southern Caribbean are home to two species of *Melocactus* with restricted distributions: *M. macracanthos* (Dutch Antilles, probably not at risk) and *M. broadwayi* (Tobago, Grenada, and St Vincent, status unknown).

The Galapagos islands, which have protected status as an Ecuadorian National Park, are home to *Talinum galapagosum* and about seven rare, endemic cactus species, comprising two endemic monotypic genera *(Brachycereus, Jasminocereus)* and the remarkable, giant tree opuntias. Recent fires on Isabella Island have been cause for concern and pressure from tourism is increasing, though to what extent these are affecting xeric habitats is not clear. Fortunately, attention from conservationists is currently being focused on the archipelago (Jervis 1994).

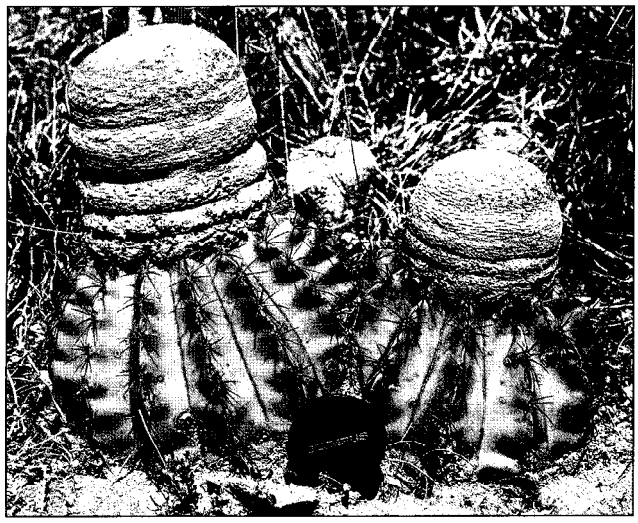
The Andean Region

This is the most important area for succulent plant genera and species in South America, most of the species and many of the genera being endemic. Habitats including succulents are very diverse, ranging from coastal fog desert, where rainfall is almost non-existent, to humid forest, seasonal dry forest and dry alpine vegetation, such as the paramos of the northern Andes and the Puna of Argentina, where some succulents occur at elevations in excess of 4000 m. Unfortunately there are insufficient data concerning some of the areas of greatest diversity in this region (especially Peru), but it seems probable that taxa occurring in regions above 2500 m are generally in less danger than those from lower elevations, where human influence is strongest. However, in parts of the central Andes at high elevations continually expanding primitive agriculture and over-grazing are substantially modifying some ecosystems and almost certainly leading to the endangerment of endemic species.

The Andean Region and those which follow are treated mainly on a country-by-country basis:

Columbia and Venezuela

The part of the northern Andes which falls within the territories of Colombia and Venezuela is not very rich in succulent plant taxa, but there are 2 endemic *Melocactus* spp. (Taylor 1991b), about 7 endemic *Echeveria (c. 4* spp. are awaiting formal description, Taylor and Eggli, ined.), and at least 2 *Agave* spp. Of these endemic taxa, only 2 *(Echeveria recurvata s. l., E. venezuelensis)* are known to be widespread, but most of the remainder, although they may be rare and lacking any kind of habitat protection, are not known to be under particular threat in the dry, precipitous environments they mostly inhabit. An exception is *Melocactus schatzlii,* which occurs at relatively low elevations in habitats near to roads and villages in the Rio Chama valley, south-west of Merida (Venezuela), and to the south of Bucaramanga (Colombia).



N. P. Taylor

Melocactus schatzlii, Rare endemic of two valleys, one in north-west Venezuela, the other in northern Colombia.

Table 3.19 Distributional information for succulents at species level, by region of Peru
(Source: Brako and Zarucchi **1993)**

Region of Peru	Altitudinal range (m)	Species	Per cent total	Endemics
Amazonian	**O-500**	**21**	**6.9**	**9**
Andean I	500-1 **500**	**85**	**28.0**	**54**
Andean II	**1500-3500**	**180**	**59.2**	**133**
Andean III	> **3500**	**44**	**14.5**	**26**
Coastal	o-1 000	49	16.1	**35**

Ecuador

The relatively small succulent flora of the part of Ecuador considered here includes some 25 species of Cactaceae (Madsen 1989), about 4 poorly understood species of *Echeveria* (currently being studied for the Flora of Ecuador project) and the endemic *Peperomia graveolens.* Of the Cactaceae, 8 species are endemic and of these *Armatocereus brevispinus, Cleistocactus leonensis,* and *Espostoa frutescens* are rare and restricted to the Rio Catamayo valley (together with some other, non-endemic succulents), and *Weberocereus rosei,* known from only 2 natural sites in Chimborazo and Cañar Provinces, is regarded as endangered (Hunt 1992) and is not included in any protected area. Likewise, there appear to be no reserves that would afford any protection to the species restricted to the aforementioned Catamayo valley. The non-endemic *Melocactus peruvianus* has apparently become extinct in south-western Ecuador, but is widespread and thought to be abundant in neighbouring Peru.

Peru

The part of Peru included here has the largest but least understood succulent plant flora in South America and, in the Americas, in terms of succulent plant diversity Peru is second only to Mexico. The following discussion utilises the annotated checklist of the flowering plants of Peru (Brako and Zarucchi 1993), which accepts 247 taxa* of Cactaceae (accepted and provisionally accepted species mainly according to Hunt 1992), 75 per cent said to be endemic; 26 species of Portulacaceae, 35 per cent endemic (especially *Cistanthe); 20* species of Crassulaceae (*Tillaea* and introductions excluded), 50 per cent endemic; and one non-endemic succulent Bromeliaceae, *Deuterocohnia longipetala.* In addition, of the many species of *Peperomia* known from Peru, at least 10 are succulent (3 endemic), and there are various endemic *Nolana* spp., but it is uncertain which of these qualify as succulents. There appear to be no endemic Aizoaceae or Agavaceae.

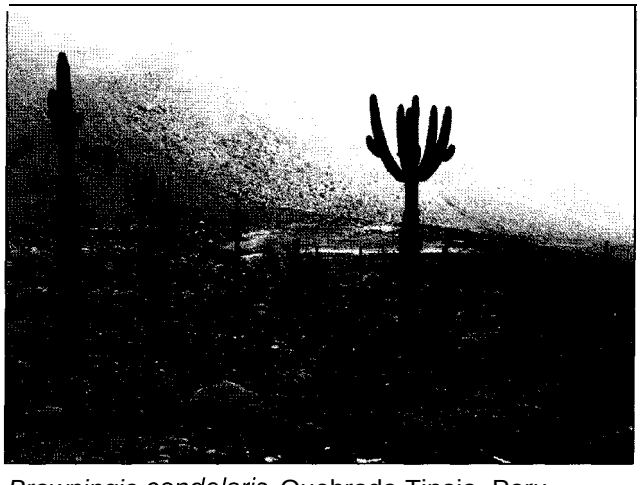
It is unclear whether any of Peru's endemic succulents are included within the few protected areas indicated in WCMC (1992).

* At least 13 taxa of Cactaceae are almost certainly synonyms and 3 spp. have been recorded in error (see *Neoporteria),* while a further 16 represent interspecific or intergeneric hybrids.

At generic level the following are endemic and emphasise the importance of the Andean Region (especially subdiv. I-II): *Calymmanthium* (l-2 spp., Andean I); *Lasiocereus (2* spp., genus of uncertain taxonomic status, Andean I-II); *Matucana (22* spp., various only provisionally accepted, Amazonian and Andean I-III); *Mila* (l-3 spp., Andean I-II and Coastal, probably not threatened); *Oroya* (l-3 spp., Andean II-III); *Rauhocereus* (1 sp., Coastal).

As the Table 3.19 indicates, the Amazonian Region of Peru appears to be the least important in terms of succulents, and the majority of the species it holds and its endemics are found in close proximity to the adjacent Andean I subdivision and do not relate to the vast Amazonian Region in the sense of Takhtajan (see above). There is no information available on the conservation status of succulent plants from this region.

Subdivisions I and II of the Andean Region of Peru (500-3500 m altitude) are extremely rich in succulent plant species, and on average two thirds of these are endemic. These subdivisions include dry vegetation with conspicuous, large-shrubby or treelike cacti from the genera *Armatocereus, Browningia, Cleistocactus, Corryocactus, Echinopsis, Espostoa, Haageocereus,* and *Opuntia,* all of which are credited with numerous species (Hunt 1992; Brako and Zarruchi 1993). The lower-growing, endemic genus *Matucana* also has the majority of its species in subdivisions I and II. The number of recognisable species in these genera will possibly be reduced by 50 per cent or more once proper taxonomic studies are accomplished, but the level of endemism is



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Browningia candelaris, Quebrada Tinaja, Peru.

likely to remain high. As in the case of the previous Peruvian region, very little is known of the conservation status of succulents in these subdivisions, but shifting agriculture and especially overgrazing by livestock, which are inhibiting regeneration of species such as the tree forming cactus *Browningia candelaris* (Anderson and Kattermann, pers. comm.1994), may be placing some species in danger.

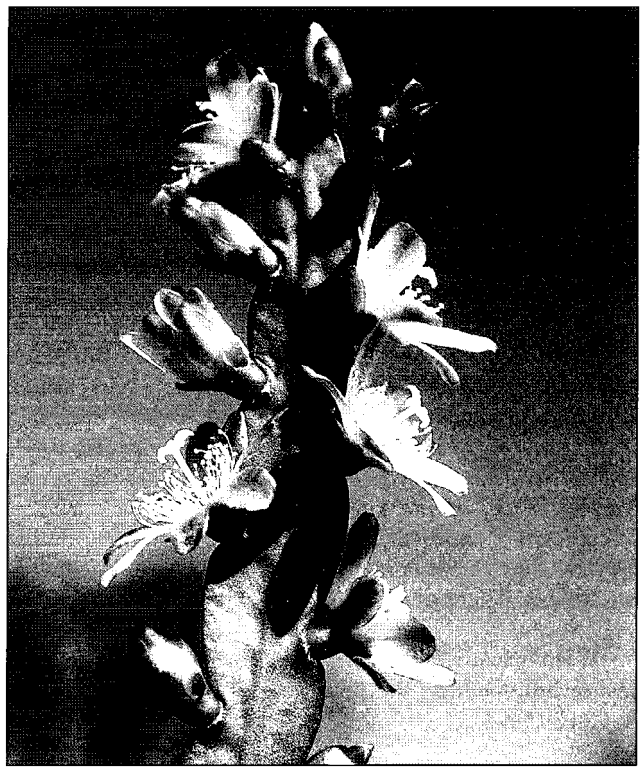
Andean subdivision III, i.e. land above 3500 m altitude, is less rich in succulent species than that at lower Andean elevations and, as might be expected, the taxa it includes are markedly different. Highly specialised, alpine species from the cactus genera *Echinopsis (Lobivia), Matucana, Oreocereus, Oroya, Neowerdermannia,* and *Opuntia* are complemented by various endemic *Echeveria* and *Cistanthe* species, most of whose ranges commence in the Andean II subdivision. Endemism is slightly lower, at about 59 per cent, but there may be taxa at risk, at least in the drier parts of south-eastern Peru, where agricultural practices similar to those described for the high Andes of Bolivia are assumed to occur (see below, especially with reference to *Neowerdermannia).*

In terms of numbers, with 49 species the Coastal Region of Peru is the third most important of the five subdivisions recognised here, but has the second highest ratio of endemics (71.4 per cent). However, it is the part where most of Peru's human population is located. The Region is divisible into two basic zones, the southern, fog-influenced 'lomas' (which represent a continuation of the Chilean Coastal Fog Desert, see below), and the northern Sechura Desert, which is contiguous with the dry south-western corner of Ecuador. According to recent observations, habitat alteration, through urban expansion and overgrazing, is a serious problem in areas where water availability permits the establishment of human settlements. The seasonal 'garua' or coastal fog supports annual grasses and other temporary vegetation. Livestock are transported to coastal areas to graze upon these ephemeral plants and nurse plants and juvenile cacti are severely impacted in some areas (Anderson, pers. comm. 1994).

Bolivia

The Andean part of Bolivia can be subdivided into three zones, the high Andes to the west and the lower inter-andean valleys to the east (which descend until the Chaco is reached) and, partly between these and expanding to the north, the very humid Yungas forest.

High Andes. A large part of Bolivia is situated in the region where the high Andes divide and expand into two major mountain chains with the altiplano between (the 'nudo andino' or Andean knot). The altiplano is a large plateau surrounded and cut through by volcanic, metamorphic, or in many cases sedimentary mountains, the latter having habitats most seriously affected from the conservation standpoint. The rainfall is greater towards the northern end of this area and permits dense human settlements to exist despite the high elevations of the region (3000-5000 m). The main activity is traditional subsistence agriculture, most produce being consumed locally, and heavy machinery is used only in a few places where there are wider plains of clayey soil. Most cultivation takes place on steep slopes, which are sometimes terraced. The farmers collect the many stones from the small fields (average minimum of 100 m^2), piling them up at the field edges, having first removed all the natural vegetation of scattered shrubs, grasses, other herbs and cacti. Then the men take the ox-plough to the field and are followed by the rest of the family who plant crops such as potatoes, broad beans, corn, and *Chenopodium quinoa.* Each field is used for one year then left fallow for 3-7 years, or less if the locality is highly populated. The summer rains expose the clay surface which is then eroded by the wind during the dry winter season. A good example of this agricultural system is the sedimentary plateau at 5000 m elevation near the airport at La Paz. In this region, which presumably continues into the dry Andes of adjacent Peru, all the vegetation is strongly affected by human activity. The traditional agricultural techniques continue to expand into new areas. The perennial vegetation disappears leaving only shortlived herbs and shrub seedlings. The cacti, which are virtually the only succulents of the region, almost disappear. If one estimates the density of cacti per square metre, in a hectare plot about 10,000 plants are destroyed



W. Barthlott

Lepismium bolivianurn, known only from the Yungas forests of Depto. La Paz, Bolivia.

during clearance. If there is an increase of 1000 plots each year, then an annual destruction of 10 million cacti can be imagined. The genera with species most affected by this are *Echinopsis (Lobivia, Mediolobivia), Opuntia (Maihueniopsis* and the *Airampo* Group), *Corryocactus, Parodia, Rebutia,* and *Weingartia.* Many of their Bolivian species are endemics.

Another disturbing development in the high Andes of Bolivia is the planting of *Eucalyptus* to provide wood which is locally in shortage. On the stony slopes where it is not possible to grow other crops the trees are planted only two metres apart over large areas of land, such as can be seen near Sucre. The shade cast by these plantations kills all the low-growing native vegetation including cacti such as *Echinopsis (Lobivia)* spp. and endemic *Rebutia (Sulcorebutia)* spp. Also of special concern is the status of *Neowerdermannia vorwerkii,* a widespread species at high altitudes in northern Argentina, Bolivia, and probably Peru *(N. peruviana),* whose swollen underground stem is harvested at certain times of year as a substitute for potatoes. It can even be found for sale in local markets. Despite its wide distribution and relative abundance it may soon become endangered unless its cultivation can be encouraged, as recently proposed during a course on Cactaceae at the University of La Paz (by W. Hoffmann *et al.*). The same university is currently in the early stages of establishing a botanic garden, which should help in the *ex situ* conservation of some of the cacti threatened in this region. At present (1994) it does not have facilities for the cultivation of the smaller globular cacti, but has planted some of the larger-growing species (Metzing, *in litt.*).

Not all human activities in this region result in a negative influence on the cactus flora. Disturbance or clearance of the natural vegetation sometimes increases the abundance of particular species by reducing competition, e.g. *Opuntia* spp., the larger *Echinopsis* spp. etc., and, in degraded *Prosopis* woodland, columnar cacti including *Oreocereus* may become more abundant.

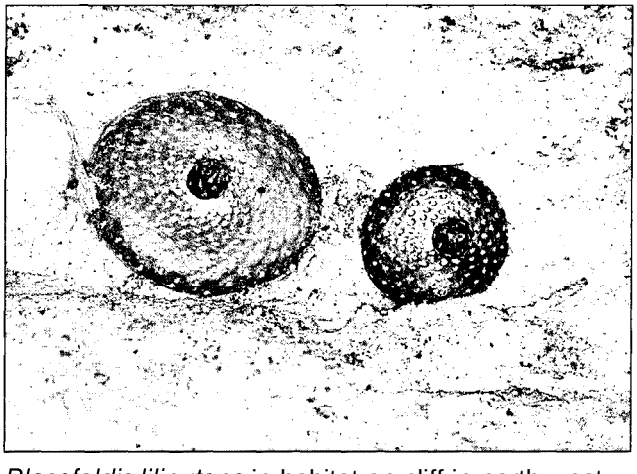
Yungas. This narrow band of rain forest extends along the eastern slopes from the central Bolivian Andes northwards into Peru and is notable mainly for endemic representatives of the primarily epiphyic Cactaceae tribe Rhipsalideae, namely *Lepismium crenatum, L. lorentzianum, L. micranthum, L. miyagawae, L. monacanthum, L. paranganiense, L. incachacanum, L. bolivianum, Rhipsalis cuneata,* and *R. goebeliana.* The conservation status of these cannot be determined at present, but most are known from only one or very few localities. Some have been seen recently (e.g. *R. cuneata),* while others await recollection (e.g. *L. miyagawae).*

Dry Inter-andean valleys. East of the altiplano at altitudes of 1000-2500 m there is a dry vegetation which shares some characteristics with the Chaco. Columnar cactus forests, known as cardonales, are found in the drier parts of this zone, which has a much lower density of human population than the higher region to the west. Habitat modification is limited to river valleys and includes primitive cattle ranching (with consequent soil erosion through trampling) and forestry plantations. In addition, some of the natural forest on the drier slopes is being cleared for charcoal production, all these pressures being of concern to conservationists studying locally endemic macaw species (M.B. Christiansen, pers. comm.). Treelike and shrubby, endemic cacti commonly represen ted in this forest include *Cleistocactus parviflorus,* C. *samaipatanus, Corryocactus pulquinensis, Harrisia tetracantha, Neoraimondia herzogiana, Opun tia cochabambensis, Pereskia diaz-romeroana,* and *P. weberiana.* These and other, non-endemic species (e.g. the epiphytic *Lepismium ianthothele)* may not be under serious threat at present, but the status of more restricted endemics, such as *Samaipaticererrs corroan us, Yungasocereus inquisivensis, Echinopsis (Lobivia) caineana, Gymnocalycium riograndense, Parodia mairanana (P. compressa),* and *Espostoa (Vatricania) guentheri* (Rio Grande drainage system), needs to be monitored. The first two are monotypic genera, while the last-named follows river valleys where cultivation is more prevalent.

NW Argentina

The Andes of north-western Argentina comprise the western Cordillera del Limite and the southern extension of the Cordillera Real of Bolivia, which, as in the latter country, surround the altiplano plateau or Puna. Altitudes range from 500 to 5000(-6950) m, but succulents are absent from the higher parts, where cold is too intense, their altitudinal limit reaching 5000 m in Jujuy in the north, but down to c. 2500 m in San Juan, and less than 1000 m at the southernmost part, to the south of Mendoza, where the climate becomes increasingly wet.

Although succulent species are numerous and many are endemic, relatively few seem to be of conservation concern on present knowledge. On stony slopes in the



W. Barthlott

Blossfeldia liliputana in habitat on cliff in north-west Argentina.

N. P. Taylor

Eriosyce aurata after commercial collection in habitat, northern Chile.

Puna, the attractive, white-woolly, non-endemic *Oreocereus trollii* was formally collected for sale elsewhere in the country as a decorative garden plant, but this has largely stopped with the realisation that most plants soon die. Specimens growing near to roads are still collected by inexperienced tourists, but it remains abundant in less accessible areas. Other succulents from this habitat, such as *Anacampseros kurtzii* and *Parodia maassii,* are either very common or too insignificant to attract attention from collectors.

The dry valleys of the lower Prepuna botanical province have an abundance of succulents from the families Bromeliaceae *(Abromitiella, Deuterocohnia, Dyckia),* Cactaceae (including the endemic *Eriosyce* subsect. *Pyrrhocactus* with 5 spp.), Crassulaceae, Piperaceae *(Peperomia)* and Portulacaceae, and there are vegetation types dominated by succulents including treelike forms (e.g. *Echinopsis pasacana).* A remarkable, highly specialised, dwarf cactus is *Blossfeldia liliputana*, but this, like most species, is not significantly threatened by human influences, and even more local taxa, such as *Sedum jujuyense* (endemic) and *Xenia vulcanensis* (also known from southern Bolivia), are safe, inhabiting very steep slopes. Other local endemics include *Parodia chrysacanthion, P. penicillata,* and *P. nivosa,* the last-named requiring regular monitoring since a road passes through the only locality known.

There is a special conservation problem in the mountains of Tucuman and northern Catamarca, where broad plains have been cleared for the production of seed potatoes, the region being free of potato virus. This has caused the destruction of numerous populations of the endemic *Echinopsis (Lobivia/Soehrensia) bruchii, E. schreiteri (L. stilowiana),* and *Gymnocalycium baldianum.* Fortunately each of these is also found on adjacent stony slopes that are unsuitable for potato culture, but our knowledge is incomplete and it cannot be ruled out that there are other, more threatened species restricted to the plains favoured for this kind of agriculture. Species that are abundant on stony ground unsuitable for cultivation and which can definitely be stated to be out of danger include: *Denmoza rhodacantha, Echinopsis (Trichocereus) angelesiae, E. (T.) candicans, E. (T.) thelegonoides,* and *E. leucantha.*

N Chile

(Region de Coquimbo northwards). This part of Chile comprises two types of habitat, the Coastal Fog Desert with irregular winter rainfall and the montane desert far inland with summer rainfall, the two being separated by the essentially lifeless Atacama Desert.

Coastal Fog ***Desert.*** This is very important in terms of endemic taxa, with more than 65 species, and it was the subject of a conservation field survey sponsored by WWF-US (Anderson *et al.* 1990). Amongst the Cactaceae (ibid.: 18-19; Hunt 1992) the remarkable genus *Copiapoa,* with about 25 species, is endemic, and the treelike genus *Eulychnia (6* spp.) is almost endemic (1 sp. in S Peru). Other cactus taxa with endemic species are *Eriosycc (Neoporteria),* with 18 spp. restricted to the region (Kattermann 1994), *Echinopsis (Trichocereus) (6* spp.), and *Haageocereus* (1 sp.), and there is also the taxonomically isolated *Opuntia miquelii.* Representatives of other families are *Montiopsis* and *Cistanthe (Calandrinia* pro parte, Portulacaceae) with 10 or more

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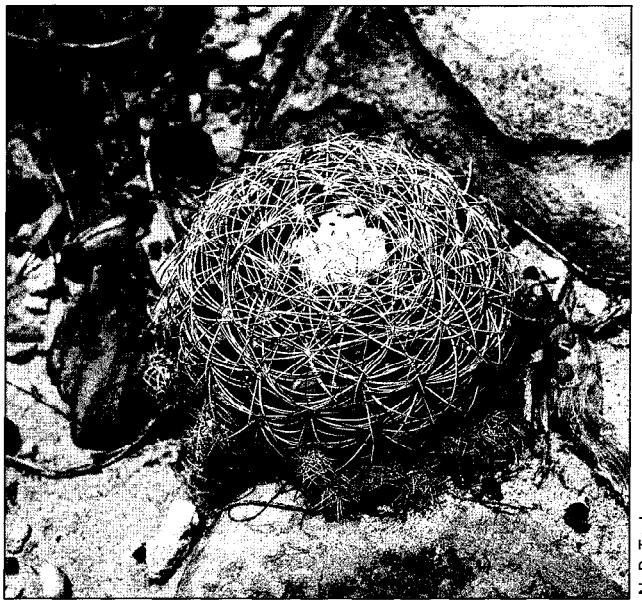
Copiapoa desertorum plants uprooted, Chile.



N. P. Taylor

Discocactus zehntneri ssp. *boomianus,* CITES Appendix I cactus known from only three populations.

mostly endemic spp., *Deuterocohnia chrysantha* (Bromeliaceae, endemic), *Euphorbia lactiflua, Oxalis carnosa, 0. gigantea,* and 0. *succulenta,* and various highly succulent *Nolana* spp. Vegetation in this region is very patchy and is represented by small green islands interspersed with extensive barren areas, their distribution depending on how much moisture deposition from the fog (locally termed 'Camanchaca') takes place, which in turn depends on local land relief, height and steepness of coastal bluffs, and direction of the deep dry valleys ('quebradas'). Almost every one of these 'quebradas' has a distinct and characteristic vegetation, with some endemic species probably restricted to one 'quebrada' only. The most up to date, comprehensive study about phytogeography, climatology, and ecology of this region was published by Rundel *et al.* (1991). However, the flora of the Coastal Fog Desert, known to be extremely rich in endemic species, remains poorly studied.

Hoffmann and Flores (1989) and Hunt (1992) assign IUCN conservation status categories to the above Cactaceae and Bromeliaceae, but these were reinterpreted by Anderson *et al.* (1990) and in general the taxa, though many are Rare, are not considered to be seriously under threat in view of the remoteness of the area and generally limited human influence. However, there are important exceptions to this, notably as a consequence of mining and associated ore treatment activities, goat grazing, rubbish dumping, local harvesting as timber, and commercial and amateur collection for the succulent plant hobby. The species affected, all of them cacti and regarded as Vulnerable or Rare, are as follows: *Copiapoa laui* (Rare, one of the smallest of all cacti and therefore intensively searched for by collectors near Esmeralda); C. *megarhiza* (Rare and insufficiently known, but certainly Endangered in the locality surveyed in 1990 at Paipote, near Copiap6, due to very heavy pollution from ore processing); C. *rupestris (*Rare, and apparently now extinguished at its northernmost site, north of Taltal, by collecting for the horticultural trade); *Eriosyce laui* (Vulnerable, from mining subsidence destroying its montane habitat south of Tocopilla); *E.(Neoporteria) napina* (Vulnerable, from rubbish dumping and urban spread in the vicinity of Huasco); *E. occulta* (Vulnerable and now apparently extinct through over-collection at the type locality near Taltal, the more southern of its two known sites); *E. heinrichiana ('N. jussieui')* and *E. senilis* ssp. e*lquiensis ('N. nidus')* (Rare/Vulnerable through overgrazing by goats in the region of La Serena); *Eulychnia iquiquensis* (Vulnerable - all populations known in northern Chile are dying and there is no regeneration perhaps due to climatic changes leading to greater aridity); *Eulychnia* sp. indet. (Vulnerable, Paposo/Taltal region, where affected by acid fumes from ore processing and local extraction for timber). *Eriosyce aurata (E. sandillon)*, a widespread Chilean endemic ranging into Central Chile, is sometimes collected for planting in local gardens and may be vulnerable where it occurs near large towns, e.g. in the La Serena area. *Echinopsis glauca, Eulychnia aricensis,* and *Haageocereus australis* are possibly Rare/Vulnerable but insufficiently known taxa,

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Uebelmannia pectinifera ssp. *flavispina,* Minas Gerais, Brazil. CITES Appendix I.

which may not be regenerating due to the same climatic changes as are affecting *Eulychnia iquiquensis.*

This part of Chile includes the established Pan de Azúcar and Fray Jorge National Parks (WCMC 1992) and another of considerable size under consideration since 1985 in the region of Paposo (north of Taltal). These areas could protect a considerable number of the succulents found in the region, and the more so if recommendations of the Anderson et al. (1990) report for the modest enlargement of the more northern parks are carried out. This would give protection to additional species currently just outside park limits (amongst these the Rare *Copiapoa rupestris* and C. *desertorum* from south of Taltal, a second population of the rare C. *laui,* and two *Copiapoa* sp. nov. from Quebrada Botija, 70 km north of Paposo). However, one problem to be resolved in the Pan de Azucar National Park is the increasing population of Guanacos (from 17 to >300 in the period 1983-1990), which graze upon the tuberous rootstocks of the geophytic cacti.

Montane Desert. Phytogeographically the Montane Desert is almost completely separated from the Coastal Fog Desert. The cacti there (no other succulents are known for this region) have affinities to those from the adjoining Andean countries. At lower elevations (between c. 2000-3000 m) there seems to be no regeneration of any cactus population at present, which may be due to climatic changes. The conservation status of the cacti from the region has been assessed by Hoffmann and Flores (1989). The vulnerable taxa they identify are: *Browningia candelaris, Oreocereus (Arequipa) australis* (endemic), 0. *(A.) hempeliana, Haageocereus fascicularis* (endemic), *Neowerdermannia chilensis, Echinopsis atacamensis* (endemic, but perhaps conspecific with *E. pasacana* from Argentina), *E. uebelmannianai* (endemic), and *Opuntia conoidea* (endemic). The taxonomic and therefore conservation status of all *Opuntia* taxa from the region remains unclear. All cactus populations from the higher elevations (>3000 m) seem to be out of danger. *Corryocactus brevistylus* and *Neowerdermannia chilensis,* assessed by Hoffmann and Flores as Vulnerable, are widespread and there is no evidence that N. *chilensis* is collected for human consumption as occurs with N. *vorwerkii* in Bolivia. In this part of Chile the Lauca National Park and some other Reserves have been established (WCMC 1992), but these include none of the threatened species.

The Brazilian Region

This vast region is further divisible on a country/vegetational basis as follows:

Extra-Amazonian Brazil and Easternmost Bolivia

Four major vegetational areas are recognised here, in order of their importance for succulent plants. The largest succulent genera, each with 15 or more endemic species,

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Melocactus pachyacanthus ssp. *viridis,* known only from two sites surrounded by agricultural fields, northern Bahia, Brazil. Endangered.

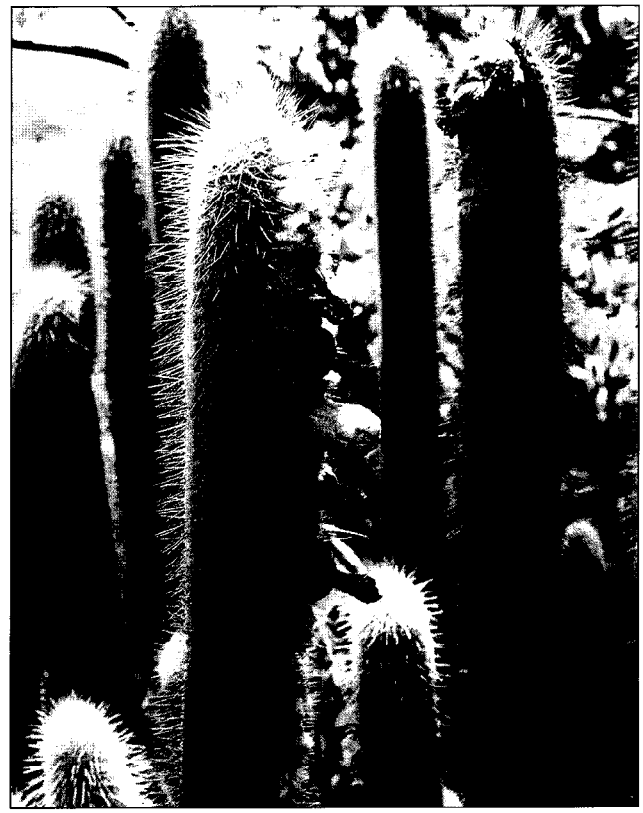
are *Dyckia, Encholirium, Pilosocereus, Rhipsalis,* and *Melocactus* (Smith and Downs 1974; Zappi 1994; Barthlott and Taylor 1995; Taylor 1991b). Only recently has the importance and plight of Brazilian succulents been specifically addressed by that country's authorities, with the proposal to place various endangered cacti on Appendix I of CITES. However, the most serious problem at present is the almost complete lack of reserves to protect the many rare and endemic terrestrial (rather than epiphytic) succulents from the dry parts of north-east and south-east Brazil, and from the rocky East Brazilian Highlands, which rise out of the dry zone.

Eastern Brazil. This area includes the seasonally dry, deciduous thorn forests ('caatinga' and 'agreste') and associated highlands ('campos rupestres') of north-eastern Brazil, plus rock outcrops in the savannas ('cerrados') of the central/eastern parts of the adjoining states of Tocantins and Goiás, and, going south into south-eastern Brazil, dry areas and campos rupestres in the states of Minas Gerais (excluding the extreme west and south-west) and Espirito Santo (inland valleys and inselbergs only). This area is home to about 100 broadly defined Cactaceae species (90 per cent endemic, including 10 endemic genera, Taylor and Zappi, ined.), c. 80 more narrowly defined, ± succulent species of Bromeliaceae, represented by *Encholirium* (endemic, c. 20 spp.) and numerous species of *Dyckia (c. 90* per cent endemic), and many, mostly weedy and inadequately understood *Portulaca* and *Talinum* taxa, besides a few succulents from other families.

Of special conservation concern are endemic species of the cactus genera *Discocactus (6* spp., 5 endemic), *Uebelmannia* (endemic, 3 spp.), and *Melocactus (M. conoideus, M. deinacanthus, M. glaucescens, M. paucispinus),* which are Critically Endangered, Endangered, or Vulnerable and have been placed on Appendix I of CITES to afford them protection from the export trade. Most of these endemics are known from only one or very few localities, where the populations number between less than ten to at most 500 individuals. *Discocactus horstii, D. placentiformis, D. pseudoinsignis, D. zehntneri* ssp. *boomianus, Melocactus glaucescens, M. paucispinus* (both known from only two or three small sites each), and all *Uebelmannia* spp. (U. *buiningii* Critically Endangered, cf. Braun and Esteves Pereira 1988) are threatened primarily by trade, including regular collection of plants for seed production, or of seeds in habitat for wholesale export in large quantities. *Discocactus bahiensis* and *Melocactus deinacanthus* (the latter with only two populations known) are more seriously threatened by agricultural development, and both the former and *D. zehntneri* ssp. *zehntneri* had their ranges and numbers significantly reduced by inundation from the Represa de Sobradinho, a huge dam lake created in the 1970s on the São Francisco River (Bahia/Pernambuco). Repeated commercial collecting was only partly responsible for the decline of *Melocactus conoideus,* a species Critically Endangered due to the extraction of the quartz gravel in which it grows, and threatened with extinction at its type and only known locality above the expanding city of Vitória da Conquista, southern Bahia (Taylor 1992). Some documented plants still exist in cultivation and could be used to effect its reintroduction to the wild, should attempts to find new populations near its original habitat fail. The tall columnar species, *Micranthocereus dolichospermaticus* (from karstic Bambui limestone outcrops of difficult access in south-west Bahia), has attractive young seedlings appreciated by the horticultural trade and may be in danger from the practice of felling mature individuals to facilitate the collection of seed for wholesale export. Export of seed is not controlled for CITES Appendix II species such as this, which deserves further investigation in habitat to determine if it should be proposed for Appendix I listing.

Threats

The driest zone of eastern Brazil, namely the 'caatinga' and its ecotones with Atlantic Forest to the east (known as 'agreste'), dry forests to the south (in Minas Gerais and Espirito Santo) and savannas ('cerrados') to its west (Maranhao to Goiás), represents a severely disturbed ecosystem (Andrade-Lima 1981), which has been subject to forest clearance for agriculture over more than two centuries. However, in general many succulents have probably suffered less than most other plants as a consequence of their frequent occurrence on rock



N. P. Taylor

Espostoopsis dybowskii, Bahia, Maracás, Brazil.

outcrops unsuitable for cultivation or livestock grazing. Thus, many species of succulent Bromeliaceae *(Dyckia, Encholirium), Coleocephalocereus,* various *Pilosocereus,* and some *Melocactus (e.g. M. ernestii, M. oreas)* have significant populations in places dominated by gneiss/granite inselbergs, which are probably at less risk from habitat modification unless situated near expanding towns. Of those cacti that are not mainly restricted to rock outcrops, the least threatened are those which seem able to regenerate when their forest habitat is cut over. These include *Cereus jamacaru, Pereskia grandifolia, P. bahiensis,* and *P. stenantha,* and all are also conserved by their use in the form of impenetrable livestock fences or as hedges surrounding homesteads, both within and sometimes outside their natural ranges. A few very widely distributed endemic cacti which inhabit little-utilised or sufficiently diverse habitats are probably not at risk, even though their numbers may have dropped significantly, e.g. *Facheiroa squamosa, Harrisia adscendens, Opuntia inamoena, Pilosocereus gounellei* ssp. *gounellei* and *P. pachycladus* s.l. However, other, mostly wide-ranging succulents that are mainly found growing in the soil of the caatinga-agreste, or on exposed rocks more or less level with the floor of the surrounding thorn forest, have suffered considerable reductions in their distributions and abundance through forest clearance. Endemic cactus species affected in this way, whose ranges now appear to be strongly fragmented, include *Arrojadoa penicillata, A. rhodantha, Brasilicereus phaeacanthus, Cereus albicarrlis,*

Coleocephalocereus goebelianus, Melocactus salvadorensis, M. zehntneri, Opuntia palmadora, Pereskia aureiflora, Pseudoacan thocereus brasiliensis, Pilosocereus ca tingicola s.l., *P. floccosus* ssp. *quadricostatus, P. flavipulvinatus, P. glaucochrous, P. pentaedrophorus* s.l., *Stephanocereus leucostele, Tacinga braunii, and T. funalis.* Although most of these are unlikely to become seriously threatened in the immediate future, regular monitoring is essential if some are not to become endangered in the longer term. The same applies to some locally abundant and spectacular caatinga bottle-trees or 'barrigudas' from the Bombacaceae *(Cavanillesia arborea, Ceiba insignis* s.l., C. *jasminodora* and *Ceiba* sp. indet. [SW Bahia]), whose habitats have decreased sharply, especially in southern Bahia, adjacent Minas Gerais and drier parts of western Espirito Santo.

Of more urgent concern are *Melocactus azureus* ssp. *azureus* and *M. pachyacanthus,* which have smaller ranges and are restricted to local low-lying outcrops of limestone, whose vegetation gets destroyed when the surrounding caatinga forest is cleared for cultivation. These taxa should be classified as Endangered on the basis of their known populations (see Taylor 1991b: 40-41), but further field studies are needed in the remoter parts of northern Bahia state, where additional and less disturbed habitats could exist.

Other succulents from the caatinga, whose native populations may be threatened, include the complex of species allied with *Euphorbia phosphorea,* certain members of the Cucurbitaceous genus *Apodanthera (e.g. A. succulenta, A. congestiflora), Dioscorea basiclavicaulis,* and *Marsdenia sessilifolia,* but, unfortunately, little is known about their conservation status, although some appear to be Rare or of restricted distribution (Rizzini 1989, Jeffrey 1992, Rizzini and Mattos-Filho 1992). Even if succulents found on raised rock outcrops within the caatinga are generally at less risk from agricultural development etc., some, and particularly those close to roads or human settlements, are at risk from the quarrying of stone for building materials. Those found only on limestone outcrops are probably most at risk (viz. *Encholirium* [3 spp. indet. cited by Andrade-Lima 1977: 191], *Facheiroa cephaliomelana* s.l., *Melocactus azureus* ssp. *ferreophilus, M. levitestatus, Micranthocereus dolichospermaticus, M. estevesii, Pilosocereus albisummus, P. densiareola tus, P. diersianus, P. flexibilispinus, P. floccosus, P. gounellei* ssp. *zehntneri, Opuntia saxatilis, 0. estevesii),* but gneiss, granite, and other crystalline rocks are also quarried and, if this should take place at the site(s) of one of the very local taxa, extinction could be sudden (e.g. *Marsdenia megalantha* [Mun. Iramaia, BA], *Encholirium* sp. nov. [Mun. Tanhaçu, BA], *Coleocephalocereus purpureus, Espostoopsis dybowskii, Melocactus deinacanthus, Opuntia werneri). 0. werneri* is already threatened at one of its localities through granite quarrying (Rui Barbosa, BA) and the other species are each known from only one or two localities.

The few and mostly relatively small protected areas within the vast caatinga zone are as follows:

- Parques Nacionais Serra de Capivara (includes *Pilosocereus piauhyensis)* and Sete Cidades (both in Piaui state),
- Estação Ecologica de Seridó (Rio Grande do Norte),
- Reserva Ecologica Raso da Catarina (NE Bahia),
- Reserva Biologica Federal da Serra Negra (Pernambuco),
- Areas de proteção ambiental da Serra de Baturite (Ceara) and Gruta dos Brejues / Vereda do Romão Gramacho (Bahia, includes *Melocactus azureus),*
- Estação Ecologica Federal de Aiuaba (Ceara).

These can offer protection to only few and mostly the widespread species noted above, since, unfortunately, there are currently no significant protected areas in the southern part of the caatingas zone (central-S Bahia to N Minas Gerais), where higher species diversity and endemism is matched by a most disturbing level of habitat destruction (mainly for agriculture and charcoal production). One of the most important areas needing protection amongst the southern caatinga-agrestes is the middle section of the Rio Jequitinhonha valley (i.e. Araçuaí to Jacinto) in north-eastern Minas Gerais, where a remarkably rich assortment of succulent plants exists (Rizzini and Mattos-Filho 1992), including many endemic and potentially threatened cactus species (Taylor and Zappi 1992). Another promising site for protection, with a comprehensive range of southern caatinga cacti, including the rare *Espostoopsis dybowskii,* is situated to the east of the village of Porto Alegre, on the north bank of the Rio de Contas, Mun. Maracas, Bahia. Other sites need to be identified for the conservation of succulent taxa characteristic of the deep soils and Bambui limestone outcrops in the valley of the São Francisco River (especially for Bombacaceae and columnar Cactaceae). One such would be the massive raised outcrop south of the town of Iuia on the east bank of the river (Bahia), which, besides some spectacular bottle-trees of *Cavanillesia* and *Ceiba* growing around its base, has two very local endemics *(Facheiroa estevesii, Opuntia estevesii)* restricted to the rock itself. Other sites should be found on the west side of the river, where further endemics, such as the aforementioned *Micran thocereus dolichospermaticus* and *Facheiroa cephaliomelana,* are located.

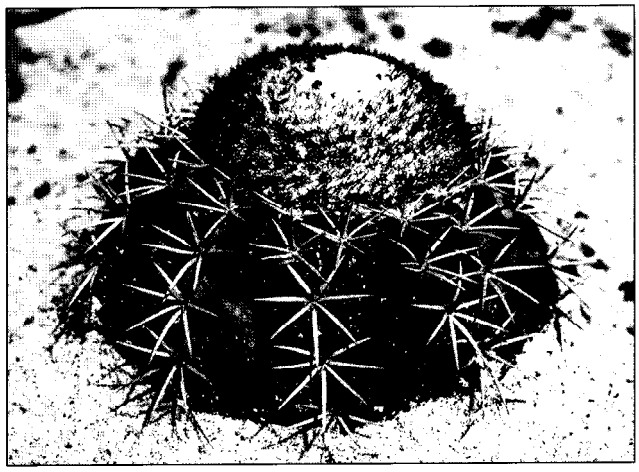
The East Brazilian Highlands, with their mosaic of 'campo rupestre' and 'cerrado' vegetation (Giulietti and Pirani 1988; Zappi and Taylor 1994: 77), represent the least modified of the environments considered under the present heading of eastern Brazil. However, they have as many if not more endemic succulent species than the caatingas-agrestes just discussed, and many are of extremely local occurrence and therefore potentially at risk. Widespread and mostly common, non-threatened

exceptions include *Cottendorfia florida, Cipocereus minensis* ssp. *minensis, Leocereus bahiensis, Melocactus bahiensis, M. concinnus, Pilosocereus aurisetus* ssp. *aurisetus, Micranthocereus purpureus,* and *Stephanocereus luetzelburgii,* the latter two endemic to the extensive uplands of the Chapada Diamantina, Bahia, and also found within its national park (Mucugê-Lencóis).

Utilisation of the campos rupestres is limited to cattle grazing, with associated burning to induce regrowth, and local extraction of some plants, e.g. Eriocaulaceae (dried flower export trade — a serious conservation issue), orchids, and *Vellozia* spp., and there is also limited disturbance caused by small scale mining for gold and precious stones. Some parts where cerrado vegetation is more abundant are being cut over for the production of charcoal and later converted into *Eucalyptus* plantations, especially in Minas Gerais state, where this activity is one of the factors threatening *Uebelmannia* spp. and *Cipocereus crassisepalus.* The burning for cattle grazing does affect some native populations of succulents, but the regular collection of plants, and nowadays more especially of seed? of certain rare cacti may be cause for greater concern.

In addition to some of the CITES Appendix I taxa noted above, the following campo rupestre / cerrado cacti are known from only one or two small populations, or at best have a very localised range which does not include any kind of designated protected area (cf. Taylor and Zappi, ined.): *Arrojadoa dinae* (especially the rare variant known as *A. eriocaulis), Arthrocereus rondonianus, Brasilicereus markgrafii, Cipocereus bradei, C. crassisepalus, C. laniflorus* (sp. nov. ined.), C. *pusilliflorus, Melocactus violaceus* ssp. *ritteri, Micranthocereus albicephalus, M. auriazureus, M. polyanthus, M. streckeri, M. violaciflorus, Pilosocereus vilaboensis, P. aurisetus* ssp. *aurilanatus,* and *P. fulvilanatus* ssp. *fulvilanatus* and *rosae.*

Similarly restricted taxa located within protected areas are rather few: *Arrojadoa bahiensis* (Parque Nacional Chapada Diamantina, Bahia), *Cipocereus minensis* ssp. *pleurocarpus* (Parque Nacional da Serra do Cipó, Minas Gerais), *Arthrocereus melanurus* ssp. nov. (Parque Estadual de Ibitipoca, MG) and *Pilosocereus rupicola* (Estação Ecologica da Serra de Itabaiana, Sergipe). If extended slightly to its west, the first-listed would include a second population of the remarkable *A. bahiensis.* The last-named *Pilosocereus* is possibly endangered or even extinct, but has not been investigated in habitat in recent times. The Serra da Piedade (Mun. Caeté, MG) is not a designated protected area, but a site of religious significance, which has a population of *Arthrocereus glaziovii,* a specialised species restricted to rocks very rich in iron ('canga'), many of its former habitats having disappeared through ore extraction. It is also the type and only known locality for *Dyckia simulans.* Numerous, other, little-known species of *Dyckia* and some *Encholirium* are recorded from various serras in central and eastern Goiãs and especially from the regions of Diamantina, the Serra do Cipó and serras further south in Minas Gerais state.



N. P. Taylor

Melocactus violaceus, on the coast of Bahia, Brazil, threatened by tourist developments.

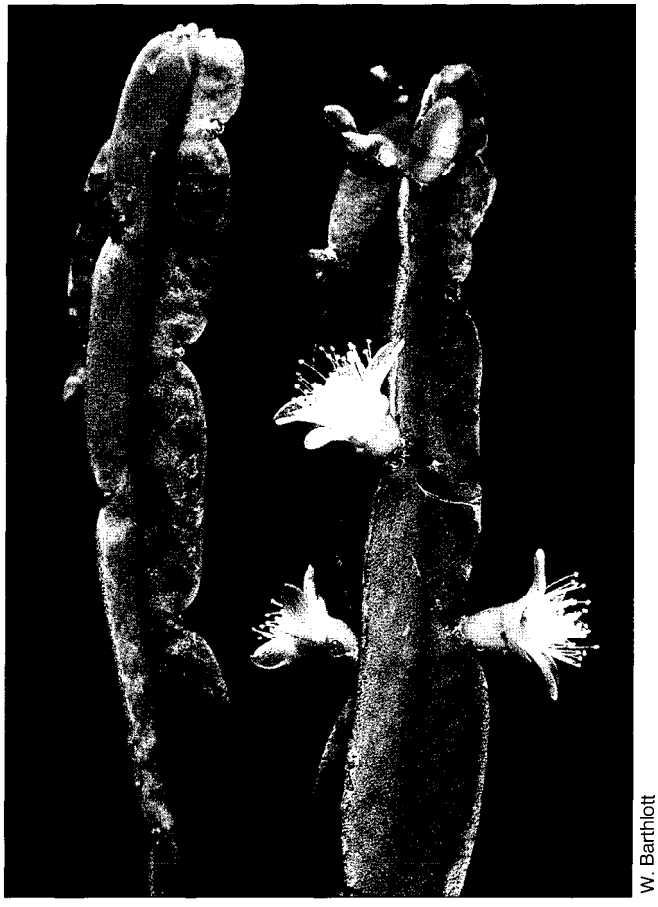
These deserve further study in the field to determine their taxonomic and conservation status. A peculiar and specialised cactus, found in the sandy cerrados bordering on the caatinga and campo rupestre zones, from western Bahia to central-eastern Minas Gerais, is *Cereus mirabella.* It is widespread but of erratic occurrence and much of its habitat is being destroyed by charcoal producers, so its status needs to be monitored carefully.

Locations where new protected areas are needed to assist the conservation of the above listed rarities, including the earlier discussed CITES Appendix I cactus taxa, are as follows and are listed in the Action Proposals.

Atlantic Forest. This comprises the coastal rain forest ('Mata Atlantica' in its strictest sense) and sandy littoral dunes ('restingas') of north-eastern Brazil and their extensions southwards, where the former broadens and merges with the planalto forests of south-eastern and southern Brazil, reaching the northern part of Rio Grande do Sul state. The area, which is very humid, has a high diversity of epiphytic cacti from the tribe Rhipsalideae, but, as is now well known, only a small fraction of the original forest remains. Endemic Rhipsalideae include the horticulturally and economically important genera *Schlumbergera (6* spp.) and *Hatiora (5* spp.). A few very widespread or regionally common taxa, such as the epiphytic *Hatiora salicornioides* f. *salicornioides, Lepismium cruciforme, L. houlletianum, L. warmingianum, Rhipsalis floccosa, R. lindbergiana, R. teres, R. elliptica,* and *R. cereuscula,* and the non-epiphytes *Brasiliopuntia brasiliensis, Opuntia monacantha, Cereus fernambucensis, Pilosocereus arrabidae,* and *P. brasiliensis* are probably to be regarded as at low risk, but the remaining Brazilian endemic species are of conservation concern to varying degrees. For example, the wide-ranging but erratically occurring restinga taxa, *Melocactus violaceus* ssp. *violaceus* and *margaritaceus,* are threatened at various points in their ranges by touristic developments and other forms of urban expansion. Particular species diversity 'hot spots' are found in southern Espirito Santo

state (between Domingos Martins and the Serra do Caparao) and around and between the great cities of Rio de Janeiro and São Paulo, various taxa being endemic to very small areas. The flora of southern Espirito Santo is poorly understood, but includes a recently described species of Christmas Cactus, *Schlumbergera kautskyi* (known from only two or three small sites), and the remarkable, red flowered *Rhipsalis hoelleri.* Other species are represented by disjunct populations, often at their northern limits, such as *Hatiora salicornioides* f. *cylindrica, Rhipsalis cereoides, R. pilocarpa, R. campos-portoana,* and *Schlumbergera microsphaerica* (the latter two within the boundaries of the Parque Nacional do Caparao).

Further south the diversity of epiphytic and epilithic Rhipsalideae increases markedly along the coast and in the Serra do Mar westwards from Cabo Frio (RJ), where also an isolated member of tribe Cereeae, *Pilosocereus ulei,* is narrowly endemic on coastal rocks. *Rhipsalis pentaptera,* a species relatively common in cultivation, is presumed to be extinct in the wild, since its only recorded native site is within what is now the city of Rio de Janeiro (at Praia da Gávea). Other rare and probably vulnerable (but inadequately studied) species of Rhipsalideae from the region of Rio de Janeiro include *Rhipsalis pacheco-leonis, R. cereoides, R. mesembryanthemoides,* and *Schlumbergera orssichiana. Rhipsalis burchellii* is known for certain only from the metropolitan region of São Paulo, and a substantial part of its presumed former habitat appears to have been either destroyed completely or severely affected by industrial pollution. *Hatiora herminiae* and *H. epiphylloides* are each known from only two relatively small areas of montane cloud forest between Rio and São Paulo and should be classified as endangered due to forest clearance, even though they are at least partly found within protected areas (the former in the Parque Estadual Campos do Jordao, SP, the latter in the Parques Nacionais do Itatiaia, RJ/MG, and Serra da Bocaina, RJ/SP). Other species of Rhipsalideae from this part of the Atlantic Forest and montane forest zones appear to have greater ranges, but are infrequent, disjunct or seldom observed. These include *Hatiora salicornioides* f. *cylindrica, Rhipsalis neves-armondii, R. grandiflora, R. pilocarpa, R. clavata, R. pulchra, Schlumbergera truncata, S. russelliana,* and S. *opuntioides.* Protected areas that include or probably include one or other of these species are the Parques Nacionais da Floresta da Tijuca and da Serra dos Orgãos (RJ), the Parques Estaduais de Ilha Grande (RJ), de Ibitipoca (MG), de Campos do Jordao and de Picinguaba (SP), and the Reservas Biologicas de Poço das Antas, de Paranapiacaba, da Jureia, Ilhabela and that proposed for the Serra do Japi (SP).



W. Barthlott

Rhipsalis pentaptera, almost extinct in the wild at the only known site within the city of Rio de Janeiro.

Destruction of the Atlantic Forest has been greatest in north-eastern Brazil, where only 5-10 per cent remains and, therefore, our knowledge of the flora is correspondingly fragmentary. It is quite possible that epiphytic Cactaceae from here have become extinct before discovery and description. In Paraiba and Pernambuco remnants of this forest include the 'brejos' on higher land away from the coast, where the watersheds are important for the human populations living below them. Such forests are currently being studied and catalogued as part of an Anglo-Brazilian initiative (Plantas do Nordeste), with great emphasis being placed on the need to preserve these floristic refuges which, *inter alia*, include disjunct populations of cactus epiphytes, such as *Lepismium cruciforme* and *Rhipsalis crispatu.*

Further south, in coastal Bahia (up to 100 km inland), between the capital Salvador and Belmonte to the south, where annual rainfall is generally in excess of 1750 mm, there are occasional records of various species of Rhipsalideae, indicating a once rich centre of diversity including *Hatiora salicornioides* f. *cylindricu, Rhipsulis paradoxa* ssp. *septentrionalis, R. baccifera* ssp. *hileiabaiana., R. russellii,* and *R. oblonga.* With so little forest remaining it seems reasonable to assume that here all of these are threatened to a greater or lesser extent, even if some may benefit from protection in local reserves, such as the Reserva Biologica Federal de Una (south of Ilheus).

Also part of the Brazilian north-east, is the Archipelago of Fernando de Noronha, a Federal Environment Protection area. These Atlantic islands are

home to at least one endemic cactus, *Cereus insularis* (a relative of the Brazilian coastal C. *fernambucensis),* which seems adequately protected at present. A second species, or perhaps a form of the first, is C. *ridleii,* which has not been seen since its original collection in the 1950s and may now be extinct. It is no longer in cultivation, so far as is known.

Some of the best-preserved Atlantic Forest and coastal habitats are those found in southern Brazil, in the states of Parana, Santa Catarina, and northern Rio Grande do Sul, between sea level and almost 2000 m. Here a wide variety of Rhipsalideae could be protected if deforestation can be controlled. These include the horticulturally important Easter Cacti, *Hatiora gaertneri* and *H. rosea* (its range includes Parque Nacional de São Joaquim, SC), which are characteristic of *Araucaria* forest, the peculiar *Rhipsalis dissimilis* (a widespread but infrequent SE Brazilian lithophyte protected in the Parque Estadual Vila Velha, Parana), and the forest epiphytes *Rhipsalis trigona, R. paradoxa, R. pulvinigera, R. puniceodiscus, R. pachyptera,* and *R. campos-portoana.* There are also at least 11 endemic and 5 non-endemic *Dyckia* spp., all of unknown conservation status. In the western part of southern Brazil, in the drainage of the Rio Parana, the situation is rather different, much of the humid and savanna forest having been cleared for agriculture. Fortunately, there are no endemic succulents known from this vegetation, which extends westwards into eastern Paraguay, where it is better preserved.

Besides those mentioned already, protected areas in the species-rich Atlantic slopes of southern Brazil include the Parque Nacional de Superagui and the Federal Environmental Protection Area and Ecological Station of Guaraqueçaba (Parana), which probably include at least some epiphytic taxa. Non-endemic succulents found in the forested and coastal parts of southern Brazil that are probably out of danger include *Cereus hildmannianus* and *Lepismium lumbricoides.*

The third and fourth areas of extra-amazonian Brazil comprise the plant communities mainly composed of grasses etc. ('campos') of southernmost Brazil (Rio Grande do Sul state) and the savannas or 'cerrados' of Central-western Brazil. The relatively smaller succulent floras of these two areas and the perceived threats have much in common with those of eastern Paraguay, eastern Bolivia, and Uruguay, as discussed below.

Campos. The 'campos' of Rio Grande do Sul are important for the high number of endemic and non-endemic but probably threatened taxa belonging to the Cactaceae-Notocacteae, i.e. the genera *Parodia (Notocactus)* and *Frailea,* and tribe Trichocereeae *(Gymnocalycium).* There are also two endemic species of *Dyckia* (Bromeliaceae), their conservation status Unknown. Other succulents are representatives of widespread elements characteristic of the floras of Argentina and Paraguay and probably not at serious risk as species, e.g. *Cereus aethiops, Echinopsis* spp., *Pereskia nemorosa,* and *Lepismium lumbricoides* (an epiphyte). As explained below, under Uruguay, the habitats of many of the endemic and threatened Notocacteae arc rocky outcrops amongst agricultural land, much of the terrain being cultivated for arable crops or grazing pasture. Exceptions include the Parque Nacional Aparados da Serra, situated at the northern border of the state with part inside adjacent Santa Catarina, and including the habitats of the endemic *Parodia haselbergii* and *P. graessneri,* which are presumed to be adequately protected. The conservation status of most of the remaining 40 or so *Parodia (Notocactus)* taxa (many of doubtful taxonomic standing), c. 15 *Frailea* and 4 *Gymnocalycium* spp. (2 endemic), which are concentrated in the southern part of Rio Grande do Sul, needs to be determined. However, some populations are known to be very small and illegal collection to satisfy the demand for novelties by hobbyists in Europe and elsewhere is certainly taking place. There appear to be no other officially designated, protected areas including Notocacteae/ Trichocereeae in Rio Grande do Sul.

Western cerrados. The 'cerrado' in the states of Mato Grosso, Mato Grosso do Sul, Goiás, the western parts of south-eastern Brazil and easternmost Bolivia (Santa Cruz) comprise open savanna woodlands on oligotrophic (strongly weathered and leached) soils and included rocky outcrops, inselbergs and uplands, such as the Chapada dos Guimaraes (Mato Grosso). The altitude varies between 300-1500 m and rainfall is in excess of 1000 mm per annum with high average temperatures for most of the year. This area has very few endemic succulents, including 8 poorly known species of *Dyckia* and only 5 botanically distinct species of cacti: *Arthrocereus spinosissimus, Cereus adelmarii, C. saddianus, Echinopsis hammerschmidii,* and *Frailea chiquitana* (the latter two are Bolivian endemics found on inselbergs in the ecotonal region between the 'cerrado' and Amazonian forests), all of whose conservation status is inadequately known (the *Arthrocereus* may benefit from any protection afforded by its location inside the Parque Nacional da Chapada dos Guimaraes). Widespread cactus taxa include the highly variable *Discocactus heptacanthus* s.l. and *Pilosocereus machrisii* s.l. (both fragmented into numerous ill-defined microspecies by some authors), besides a treelike species of *Cereus* found on calcareous outcrops, whose identity is uncertain at present (C. *calcirupicola ?), C. bicolor* (botanical affinity uncertain) and the shrubby C. *euchlorus* (= *Praecereus* sp.). One or more *Opuntia* spp., *Cleistocactus horstii* (? = *C. baumannii*), *Frailea cataphracta* s.l. (including *F. matoana,* EW according to Hunt 1992), *Cereus (Mon villea) kroenleinii, Gymnocalycium anisitsii, G. marsoneri (G. matoense), Harrisia guelichii (Cereus balansae), Pereskia sacharosa, Jacaratia corumbensis, Dyckia ferox, D. microcalyx,* and *Deutercohnia meziana* also occur, but have the major parts

of their ranges in adjacent Paraguay. Although the fireswept 'cerrados' are not noted for succulent plants, there may be reason for concern about the status of even the widespread taxa in this large geographical area, and especially taxa restricted to calcareous soils and rocks, which are at greater risk from habitat conversion. Large scale farming operations, for both arable (especially soybean) and livestock, are modifying the environment and local assessments of the likely effects on succulent plant populations are needed. In easternmost Bolivia this environment has been used for cattle grazing for more than 200 years and is now being cultivated in some areas. The seasonally inundated region of the Pantanal (Brazil), which includes raised rocky areas where succulents are found, is currently benefitting from ecotourism and may thus be less at risk from agricultural development.

E Paraguay and NE Argentina

This subdivision includes two of the three vegetational areas of Paraguay (Esser 1982; Metzing 1994), namely the valley of the Rio Paraguay and the part of Paraguay to its east, and the north-eastern Provinces of Misiones and Corrientes from Argentina. The succulents of this area are almost exclusively Cactaceae and Bromeliaceae *(Dyckia* spp.) and many of these are also found in the adjacent parts of central-western and southern Brazil (see above). According to Metzing (see also references to Esser 1984a, b cited therein) some of the cacti of eastern Paraguay are seriously affected by agricultural practices, including the destruction of protective nurse-plant shrubs by fire, and the same threats apply in north-eastern Argentina, where forest clearance is more accentuated. Genera with one or more species affected in this way include Cereus, *Opuntia, Pereskia, Gymnocalycium,* and *Harrisia,* some of which include endemics whose conservation status needs further investigation (e.g. G. *mesopotamicum, H. hahniana,* the first-named known from a single, flat, rock outcrop where grazing occurs). More specific problems are noted below.

Between 30 and 35 species of Cactaceae are known from this region, of which the following are endemic to Paraguay and have been assigned regional conservation status categories by Metzing (1994), who believes they deserve to be included on Appendix I of CITES: *Frailea knippeliana* (Rare, only 2 localities), *Gymnocalycium paraguayense* (Endangered, only 2 small populations, which could be quickly eliminated by collecting and are currently affected by livestock grazing); 'G. *fleischerianum'* (Endangered, ± 5 localities known, affected by tourism, house construction etc.) and *Parodia (Notocactus) nigrispina* (Endangered, only 3 populations, affected by land clearance, grazing and collected for sale at the roadside). The last two are restricted to the crystalline 'Cordilleras', where the peculiar endemic, *Cereus lanosus* (probably not threatened), is also found. Non-endemic species discussed by Metzing (1994) include: *Frailea cataphracta* (ranging to adjacent CW Brazil and Bolivia, vulnerable), *Parodia (Notocactus) ottonis* (Vulnerable/ Endangered in Paraguay through land clearance and grazing, but still common in neighbouring countries), *P. (N.) schumanniana* (NE Argentina and S Brazil, Rare) and *Pilosocereus machrisii (P. juaruensis)* (Vulnerable in Paraguay, but widespread and not threatened in adjacent Brazil). The non-endemic *Discocactus heptacanthus* ssp. *magnimammus (D. hartmannii),* from the campos cerrados of north-eastern Paraguay, is potentially threatened from conversion of its habitat for agriculture.

Besides cacti, there are 5 endemic species of *Dyckia* described from eastern Paraguay *(D. exserta, D. velloziifolia, D. affinis, D. tobatiensis, D. tomentella)* and 3 from Misiones Province, Argentina *(D. niederleinii, D. subinermis, D. mitis),* all known only from the type or very few collections (Smith and Downs 1974).

Of the protected areas listed in WCMC (1992), the Biological Reserve of Itabó includes the habitat of various non-endemic epiphytic cacti (D.C. Zappi, pers. comm.), while the Cerro Corá National Park may give some protection to *Brasiliopuntia brasiliensis, Pilosocereus machrisii,* and the endemic *Dyckia exserta* (Bromeliaceae). It is not known whether the forest reserve of Capivary (13,500 ha) includes and protects populations of the non-endemic *Discocactus heptacanthus* ssp. *magnimammus (D. hartmannii),* whose genus is on Appendix I of CITES.

SE Bolivia, W Paraguay and N Argentina

This is the arid vegetation type known as the Chaco, which is often compared with the Caatinga of north-eastern Brazil, but has, in fact, very few floristic similarities and a quite different succulent flora. Widespread and conspicuous cactus species include *Quiabentia verticilla ta, Cereus (Praecereus) saxicola (Monvillea cavendishii* misapplied), C. *spegazzinii, Browningia (Castellanosia) caineana, Cleistocactus baumannii, Gymnocalycium marsoneri, G. mihanovichii, G. pflanzii, Harrisia pomanensis, Opun tia quimilo, 0. retrorsa, Pereskia sacharosa,* and *Stetsonia coryne,* none of which is believed to be particularly threatened at present, though up-to-date knowledge is poor and environmental change in the form of clearance for agriculture is accelerating. Another widespread succulent is *Ceiba (Chorisia) speciosa* (Bombacaceae).

SE Bolivia. The extensive low forest, spiny scrub and dry savanna loosely referred to as Chaco in south-eastern Bolivia is characterised by a hot climate with precipitation of 500-1000 mm/yr concentrated in the four warmest months. Little knowledge of the succulents found here is currently available, but habitat alteration appears to be limited. However, this could change rapidly if modern machinery is employed on a large scale, as is beginning to occur in Paraguay.

W Paraguay. Here Chaco vegetation is said to cover 60 per cent of the territory of Paraguay, yet this area counts less than 100,000 in human population. However, it has a greater number of endemic species than in the adjacent Chaco countries, e.g. Cereus *lamprospermus, C. pachyrhizus, C. phatnospermus,* and *Gymnocalycium eurypleurum,* and G. *paediophilum* (both rare and known only from or near Cerro Leon). According to a Land Utilisation Survey published in 1991 and based on satellite images, only 4.22 per cent of the total area is under cultivation. However, a somewhat different impression is gained from observations on the ground, where large cultivated fields can be seen along the Trans-Chaco highway (and especially in the vicinity of Filadelfia). There is also selective extraction of timber and cattle ranching in some places, but much of the Chaco is insufficiently explored to give an accurate assessment. According to Metzing (1994) Cerro Leon deserves to be designated a National Park. The vegetation in its vicinity is relatively undisturbed at present.

Further west the soils become more sandy and dunes sometimes occur. Here the vegetation is more open, grasses and other herbs predominating, the shrubs in scattered groups ('espartillares'). The land is potentially suitable for cultivation and pasture, which might lead to the endangerment of the non-endemic *Gymnocalycium megatae.* A distinct species said to come from Paraguay and perhaps from the Chaco region, but of unknown wild status today, is *Cereus haageanus.*

N Argentina. The Chaco environment of Argentina has been modified on a much greater scale than that in Paraguay. For many years timber of the dominant-emergent quebracho trees *(Schinopsis* spp., Anacardiaceae) has been extracted as raw material for tanning, manufacture of railway sleepers, and for firewood. The remaining stumps produce sucker sprouts, which are eaten by cattle, preventing regeneration, and the remainder of the vegetation is often exploited for charcoal. Thereafter, the land becomes pasture or is left abandoned, but does not seem able to return to the original climax vegetation. *Gymnocalycium* spp. suffer immediately after the forest cover is removed, but other succulents, such as *Quiabentia verticillata* and *Frailea* spp., seem to withstand habitat modification and may even increase in abundance in some areas.

The Chile-Patagonian Region

The cactus genera *Austrocactus (6* spp.) and *Maihuenia (2* spp.) are endemic to this region. Another important cactus genus, almost endemic to the region, is *Pterocactus,* an isolated taxon of Opuntioideae with 5 species endemic to Argentinian Patagonia. *P. australis* is said by Kiesling (1990) to be the most southerly occurring species of Cactaceae.

Uraguay

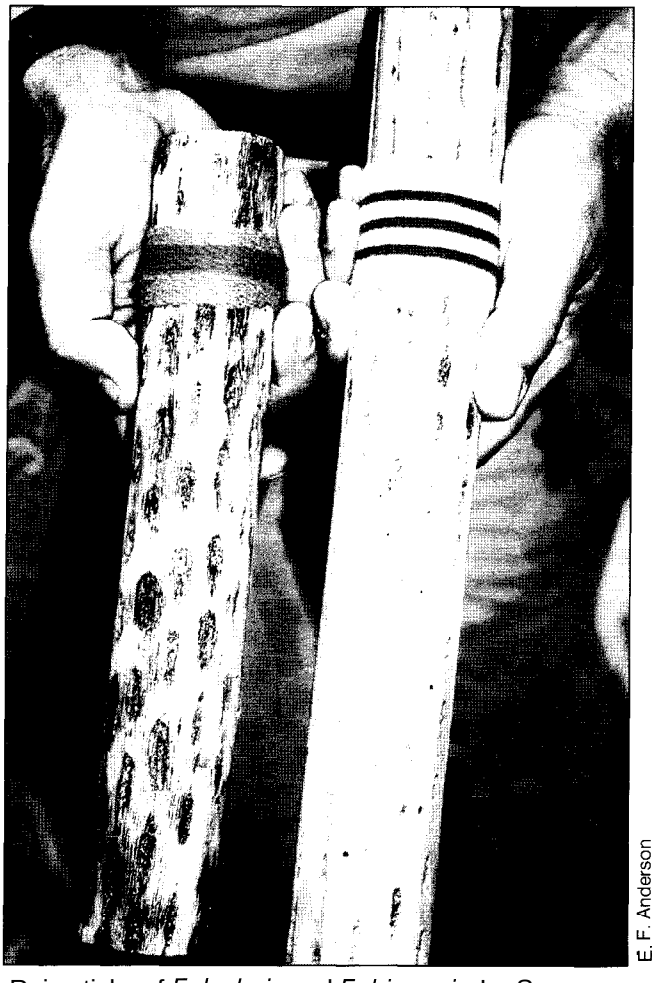
Discounting a few, mostly weedy species of *Portulaca* and the non-endemic and wide-ranging *Dyckia remotiflora* (status unknown), the native succulent plants of Uruguay are all Cactaceae, the most important belonging to the taxonomically complex, dwarf, globular genera *Parodia* (incl. *Notocactus), Gymnocalycium,* and *Frailea.* These three comprise more than 50 species in total, the majority of which, though only provisionally accepted (Hunt 1992), are said to be endemic. Even if many of these taxa are "less-than-species", their conservation status is cause for serious concern, since some 75 per cent of the land surface of Uruguay is said to have been modified with positive or negative effects by agriculture etc. (mainly cattle grazing) and there are scarcely any protected areas (WCMC 1992). Populations of such cacti are often very small, being restricted to isolated rock outcrops surrounded by pasture. Various of the non-endemic globular taxa are otherwise known only from the neighbouring Brazilian state of Rio Grande do Sul (see above), where similar threats apply. Other cacti, such as species of *Cereus, Cleistocactus, Harrisia, Opuntia, Pereskia,* and epiphytic genera, i.e. about 20 species in all, have probably been severely reduced in abundance. Most of these are widely distributed in the adjacent countries of Argentina, Brazil, and eastern Paraguay, where similar problems exist, though to a lesser degree. While reliable information is lacking it is impossible to make suggestions for action other than to instigate field surveys by botanists taxonomically competent in the species-rich globular genera noted above. There are also logistical difficulties in accomplishing such work, since much of the habitat is privately owned land and good contacts with local farmers would therefore seem a prerequisite to any kind of field study.

Argentina

Three geographical/vegetational subdivisions can be recognised here: the Monte, the Pampas, and Patagonia proper.

Monte. This is the western desert of Argentina, to the east of the high Andes, and characterised by a spiny scrub in which *Larrea* (Zygophyllaceae), the creosote bush, dominates. Agricultural activity occurs only in small patches near rivers, due to the irregular and limited rainfall (50-300 mm/yr), but farming of goats and sheep is sometimes intense, especially near villages or isolated houses, where disturbance of the natural vegetation is greatest.

Three genera of Cactaceae are represented by numerous species here: the endemic *Tephrocactus* Group (s. str.) of *Opuntia, Gymnocalycium,* and *Echinopsis (Trichocereus).* Some of the *Tephrocactus* species have a partly clonal mode of reproduction, and others are known from single populations or very limited areas (e.g. 0. *halophila, 0. molinensis),* but none seems to be seriously



E. F. Anderson

Rain sticks of *Eulychnia* and *Echinopsis,* La Serena, Chile.

threatened. The same applies to the numerous *Gymnocalycium* spp., although G. *schickendantzii* plants can be damaged by the trampling of livestock. *Echinopsis strigosa, E. candicans,* and *E. angelesiae* are frequent plants. Other succulents are represented by *Portulaca* (> *3* ephemeral but often abundant spp.) and *Talinum (3* tuberous spp.), which do not appear to be severely affected by grazing.

Pampas. A huge part of the territory of Argentina was naturally covered in herbaceous prairies (the Pampas), where rainfall is regular, the climate warm temperate and the soil fertile. This area originally comprised the province of Buenos Aires and S Santa Fe (humid pampa), and Province La Pampa and S Cordoba (dry pampa), but it has long been occupied by agriculture, which has artificially extended its limits northwards into much of Santa Fe and Cordoba (where spiny forest or 'Espinal' formally occurred). Besides agriculture, the giant conurbation of Buenos Aires (13 million pop.), occupies the central-eastern part of the area.

Cacti and other succulents were never abundant here, although the substantial modification of the environment makes assessment of their original status difficult and depends on what can be observed growing on abandoned farms and beside railway tracks, and sometimes used in hedges or gardens. Such species include *Opuntia bonaerensis (= 0. paraguayensis), 0. monacantha* (not threatened), *Cereus uruguayanus ('C. peruvianus'* hort.), *Gymnocalycium schroederianum* (with a disjunct distribution on low rock outcrops), and G. *platense.*

Patagonia. The succulents of this huge area south of the Rio Negro are chiefly cacti (Kiesling 1990) and the endemic succulent Composite, *Duseniella patagonica,* none of which is considered to be particularly threatened. The cold, dry climate has limited land use to sheep farming, which has altered the floristic composition, possibly favouring the less edible cacti and their spiny shrub nurse-plants. Cacti such as *Maihuenia patagonica, Opuntia (Maihueniopsis) darwinii, Austrocactus* spp., and perhaps even *Pterocactus* spp. may now be more abundant than prior to habitat modification. Other cacti are mostly widespread species that are also out of danger.

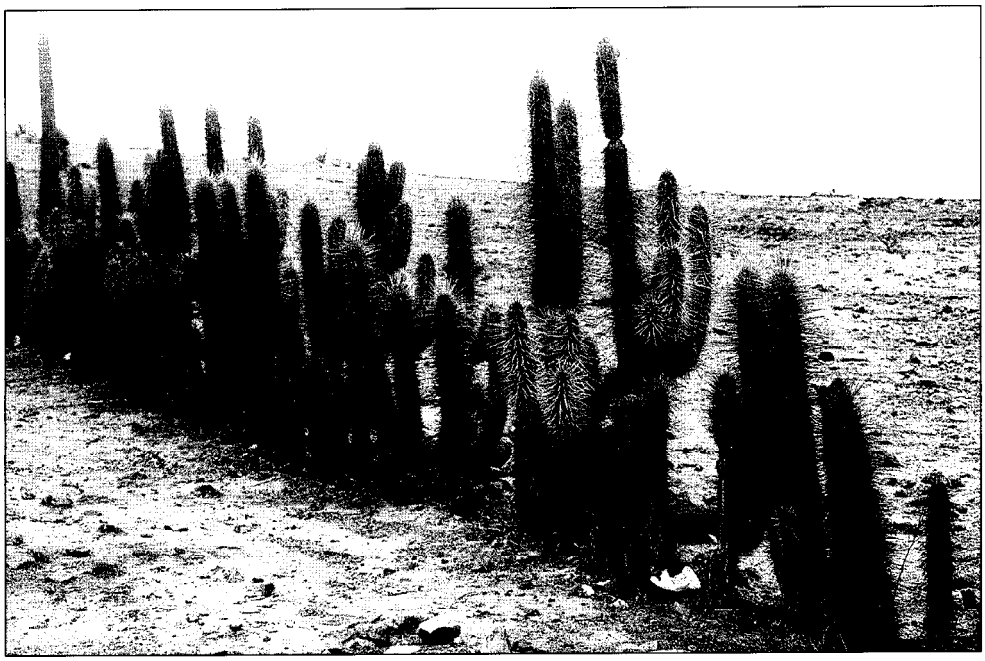
Chile

(Region de Valparaiso southwards). Central and southern Chile is home to approximately 16 species of Cactaceae (9 endemic), some of which are known to be under considerable threat, and one may be extinct. The following information is based mainly on Hoffmann and Flores (1989) and Kattermann (1994).

Straddling the border between the regions of Coquimbo and Valparaiso (but counted amongst the latter's endemics here) are the Vulnerable *Echinopsis litoralis* and endangered *Eriosyce chilensis,* the latter known from only an 11 km stretch of coastal rocks between Pichidangui and Punta Molles and severely threatened by housing construction. Generally, tourism on the Chilean coast is increasing rapidly hand in hand with building projects for the leisure industry, especially between San Antonio and Coquimbo, an area with various endemic *Eriosyce* species. According to Kattermann (1994), *Eriosyce aspillagae* is probably extinct at its only known locality at Hacienda Tanumé (Colchagua) due to habitat modification for pulpwood production and collecting activities for horticulture (another population from Cabo Carranza, Talca Province, may possibly represent this species, but is currently of uncertain identity - Kattermann, l.c. 73). However, the species is still extant as habitat-documented material in a few specialist hobbyist and botanical living collections outside of Chile and in the National Botanical Garden at Viña, which could be utilised to propagate stock for potential reintroduction to the wild. Populations of the endemic *E. cuwispina* var. *tuberisulcata,* from the vicinity of Valparaiso, are now reduced to only a few plants surrounded by apartment complexes, and numbers of the wide-ranging *E. subgibbosa* have been severely reduced in the vicinity of Concepción by collection for the local

markets at Christmas time, when they are in flower. *E. engleri* is known from a single locality in mountains between Santiago and Valparaiso. *Austrocactus spiniflorus* is a rare and perhaps vulnerable species known only from 1500-2500 m altitude in the Andes immediately to the east of the capital, Santiago. *A. hibernus,* from further south, at 2000 m in the Cordillera del Maule, is variously regarded as either Rare, Vulnerable or Endangered (cf. Hoffmann 1989; Hoffmann and Flores 1989; Hunt 1992). A third Chilean species *A. philippii,* is insufficiently known. The only known locality for *A. patagonicus* in Chile, near Chile Chico, has been destroyed by the eruption of the volcano Hudson in 1991, but the species still exists in neighbouring Argentina. The endemic, but common and widespread *Echinopsis chiloensis* and *Eulychnia acida* are regarded as being out of danger. Wood of the *Eulychnia* is used to make percussion instruments ('palos de água') and currently commands a considerable price, the finished articles entering the export trade. At present only dead wood is used (L. Faundez, Univ. de Chile, pers. comm. to R. Kraus) and this presumably does not represent a conservation concern. The almost endemic *Maihuenia poeppigii* is regarded as out of danger at its relatively inaccessible, unpopulated sites in the Andes of southern Chile. However, its localities in the Central Valley to the north are threatened by overgrazing and expanding forestry plantations of *Pinus radiata.* The only coastal habitat of this species near Escuadron will soon be destroyed by urban expansion (0. Matthei, Univ. Concepción, pers. comm. to R. Kraus).

The following individuals reviewed this section and offered valuable criticisms and additional data which have been duly incorporated: D.C. Zappi& R.M. Harley (Kew), M.B. Christiansen (Copenhagen) and D. Metzing (Bremen). D.C. Zappi kindly translated R. Kiesling's contributions from Spanish.



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Eulychnia fence, Rio Limari, Chile.

Chapter 4

Action Proposals

The actions required to conserve the world's diversity of succulent plants are many and varied. The review undertaken by the IUCN/SSC Cactus and Succulent Specialist Group in order to prepare this document indicates some of the main activities which should be undertaken immediately. These can be divided into various broad categories. Some are straightforward and relatively inexpensive: for example, provision of information to conservation decision makers. Others are more complex, involving, for example, long-term development of protected area systems. As far as possible organisations have been identified for the action proposals listed below. The Specialist Group will work with these organisations to develop detailed funding proposals for essential conservation action. The SSC Group will also work with IOS to bring to the attention of national governments the need for effective conservation legislation, the development of effective scientific and management authorities to enforce national and CITES legislation, the need for protected areas, and other conservation initiatives to protect the world's diversity of succulent plants. It is our hope that researchers and students, funding agencies, conservation organisations, specialist groups, societies, collectors and growers will all find this document, and especially the Action Proposals, helpful while playing their part in plant conservation.

General

1) Provision of information. This Action Plan brings together certain data for the first time. Information compiled for this report on the conservation status of species has been incorporated into the Plants Database maintained at WCMC. Provision needs to be made for the regular updating of species data by the IUCN/SSC Cactus and Succulent Specialist Group in association with WCMC. It is also a priority to assign the new IUCN categories of threat to those species of conservation concern indicated in this Action Plan.

It is particularly important that information on the conservation status of species coupled with data on priority habitats for succulent species conservation should be maintained and made available to national protected area agencies for use in designing protected area systems.

2) Development of proposals to amend the Appendices of CITES. Recent information, including the results of various field projects and nursery surveys, indicates that the following changes should be made to the CITES Appendices. The SSC group will help the relevant national CITES management authorities to develop proposals accordingly.

a) Addition of *Beaucarnea* to Appendix II of CITES. All nine species in the genus are threatened, mainly due to collection by the horticultural trade. Over-collection of seed and seedlings is also damaging wild populations. A proposal should be developed to add the genus to Appendix II of CITES.

Contact: UAT and Dr. Luis S. Hernández

b) Addition of other taxa to Appendix II: *Adenia* (Madagascan species), *Adenium, Brachystelma, Cyphostemma, Commiphora* (Madagascan species.), *Fockea, Ha worthia, Kedrostris, Nolina, Odosicyos, Operculicarya, Raphionacme, Trochomeropsis, Xerosicyos, Zygosicyos.*

c) Transfer from Appendix II to Appendix I: *Ceropegia* spp. — Madagascan spp. only; *Micranthocereus* (Brazilian endemic genus) plants in trade are likely to be field-collected. *M. auriazureus*, the most heavily traded species recorded in CITES statistics, is very rare in the wild. *M. dolichospermaticus* is another species adversely impacted by trade.

3) Review of CITES listings for Succulents. A review of the appropriateness of current CITES listings for succulent plants is required using the CITES appendices amendment criteria approved in 1994. This should take into account information on conservation status in the wild, availability in trade, and extent of commercial propagation of both those plants currently listed on the Appendices and others threatened by international trade. The views of conservation organisations, commercial growers, and botanic gardens should be solicited.

Contact: IUCN/SSC Cactus and Succulent Specialist Group

E. F. Anderson

Astrophytum cactus nursery, Kurashiki, Japan.

E. F. Anderson

Pile of collected cacti, Terlingua, Texas.

4) Implementation of nursery registration. All countries with succulent plant nurseries should be encouraged to implement the resolution adopted at the Ninth Meeting of the Conference of the Parties, Ft. Lauderdale, Florida, 1995, to CITES: Guidelines *for* the *registration of nurseries exporting artificially propagated specimens of Appendix I species.*

Contact: Appropriate CITES management authority

5) Regular review of CITES trade data for succulents. As part of the ongoing Significant Plant trade process, regular analysis of the national reported trade in cacti and other succulents should be undertaken by the IUCN/SSC Cactus and Succulent Specialist Group in association with WCMC and TRAFFIC International. Studies should determine the impact of trade on succulents and their suitability for CITES listing.

Contact: IUCN/SSC Cactus and Succulent Specialist Group

6) Report on illegal trade in cacti and succulents. An annual report on international illegal trade in cacti and other succulents should be compiled and distributed to national authorities and relevant interest groups. This will provide information on seizures and prosecutions and results of investigations into availability of recently described and illegally obtained rare cacti.

Contact: TRAFFIC International

7) Training for CITES staff. It is important that CITES Scientific and Management Authorities and customs agencies, in countries which have significant trade in cacti and succulents, should be trained to implement the trade controls and to recognise appropriate illegal material and to deal with this trade. In-country training should be carried out in association with CITES field projects. Transfer training should also be encouraged, with personnel from exporting countries seconded to CITES Authorities of importing countries.

Contact: CITES Secretariat

Ex situ conservation

8) The following are priorities and strategies for future actions needing implementation with regard to *ex situ* conservation of succulents:

a) Analyse existing *ex* situ collections and develop and enhance databases to track them. This can involve more institutions and people than are presently served in botanic garden databases, such as private collections and commercial nurseries. Development of such databases on a national or regional level should be considered a high priority as well as the improvement of software documentation systems for collections and protocols for the exchange data between them.

b) Develop a strategy for the use of *ex* situ collections of cacti and succulents for conservation; that is, to highlight priority species, then overlay these with *ex situ* collections enabling a clear identification of particular conservation needs.

c) Develop means of exchanging data on cultivation techniques and requirements to help promote *ex situ* survival and propagation of rare and threatened species.

d) Develop educational programs at gardens for the general public highlighting the need to conserve cacti and succulents.

e) Conduct a study to determine how flooding the market with artificially propagated plant material would affect the pressures on the wild populations.

f) Develop a marketing strategy to sell artificially propagated rare succulents.

g) Educate collectors about the conservation of wild populations and urge them to buy only artificially propagated plants.

h) Develop more Species Recovery Programmes involving material available ex *situ* to act as models for other conservation action, e.g. species reintroduction programmes.

E. F. Anderson

Tour group, Desert Botanical Garden, Arizona.

i) **Increase awareness of CITES** and its provisions for the holders of cacti and succulent collections and promote such collections as resources for the implementation of this Convention. A CITES Handbook for Botanic Gardens has been published by BGCI (Akeroyd *et al.* 1994) and should be distributed widely.

j) **Initiate research programmes to study the genetic variability** of *ex situ* collections of particularly rare and endangered taxa. Liaise with research institutions, universities, and NGOs.

Taxon specific

Agavaceae

The following are preliminary ideas. Further development of the proposals in co-operation with suggested implementing agencies is needed.

9) Herbaria surveys of Agavaceae, *sensu lato.* Survey of herbaria holdings of all genera (with priority given to *Agave*), to determine the extent of documentation of the taxa. Specimens have been added to various herbaria since the collections and herbaria searches of Gentry from the 1950s to the late 1970s. Surveys would reveal those taxa which are rare or are rare in the records, reveal distributional information and gaps in knowledge of a taxon's distribution, and would help to clarify nomenclatural problems. A review of herbaria holdings may shed light on the status of missing significant specimens, especially type specimens.

Contact: DES, HNT and MEXU with Jardín Botánico de Instituto de Biologia, Mexico City

10) Compile and provide a database of scientists and herbaria actively researching groups within Agavaceae. The initial steps in preparing this list (which could be linked with the review of herbaria holdings) would involve reviewing *Index Herbariorum* (Holmgren *et al.* 1990), consulting with the most recent edition of the *International Register of Specialists and Current Research in Plant Systematics* (Hunt Institute for Botanical Documentation), and consultation of recent editions of the *IOS Repertorium,* Bibliography Section. This database will assist in the development of field survey and documentation projects and subsequent management or recovery plans for rare taxa.

11) Field survey and careful documentation of the Agavaceae, with *Agave, Manfreda, Polianthes,* and *Furcraea* as priorities. This is critical to the assessment of the conservation status of any taxon. Following a review of herbaria holdings, it will become more clear as to which taxa and what areas need to be searched. Documentation of all Agavaceae, in particular *Agave, Furcraea,* and *Yucca* should be carefully undertaken and include photos, concise and descriptive notes (including inflorescence size and shape), and floral measurements. Specimens should be processed in such a way as to minimise loss of character. Many specimens, with the exception of those prepared by Gentry and a few other botanists, are poorly prepared and provide little information, thereby contributing little towards one's understanding of the taxonomic group. In addition, since many collections of Agave occurred from the 1930s to the early 1970s, more recent collections, including areas where specimens were previously collected, should be made. For example, *Manfreda potosina* is known from three collections, all of which were made between 1908 and 1936. Its current status is unknown. Significant land utilisation activities or over-collection during the last SO or 60 years have probably impacted Agavaceae populations, and an assessment of their current status is required. Priorities for field survey are: Bahamas, Guatemala, certain states of Mexico - **see** regional priorities below.

D.J. McDonald

Aloe *ferox* leaves which have been removed for extraction of aloe sap for commercial use in the pharmaceutical and cosmetic industries.

Contact: Research institutions such as universities and botanic gardens

12) Identification of areas of highest diversity in Agavaceae, including protected areas, and documentation of the rare Agavaceae taxa found within these areas. Action plans, which include appropriate management and conservation strategies for the rare taxa and their habitats should be developed within these identified areas.

Contact: IUCN/SSC Cactus and Succulent Specialist Group

13) Review and conduct research on reproductive processes and isolating mechanisms in *Agave* which will lead towards better understanding of the speciation process in this group. A more flexible approach towards applying the general definition of a

species rather than the more strict biological species approach is required for such groups as *Agave* where vegetative reproduction, hybridisation, and polyploidy play very important roles in the speciation process. Such an understanding may prevent problematic groups of taxonomic and systematic interest (other than Fl hybrids) from "falling through the cracks" and thus not receiving recognition or protection. Cultivation, selection and migration of so-called species since remote antiquity need to be addressed in evaluating the integrity of species as some important fibre and pulque "species" may be remnants of selected and cultivated plants dating from pre-Conquest.

14) Development of an *ex situ* conservation program for Agavaceae. Botanic gardens provide an especially effective setting for the study and conservation of the Agavaceae. Important *ex* situ collections of the family include those maintained by the Botanic Garden at UNAM, Mexico and the Desert Botanical Garden, Phoenix. A review of existing botanical garden holdings is of critical importance as recommended in Action 8a. Such a review should determine the number of specimens held for a given taxon, whether they are from different populations, and whether they are documented. In addition, a review of propagation schemes is essential. The *ex* situ conservation programme should emphasise the importance of botanic garden collections for taxonomic and genetic research and the protection of crop genetic resources. Funding should be sought for ex situ conservation activities in botanical gardens in a given region where rare Agavaceae occur, as part of a regionally integrated programme. For example, in Puebla, two botanic gardens exist and can be involved in the *ex* situ conservation of *Agave peacockii, A. trianeularis, A. stricta, Beaucarnea gracilis, B. stricta,* and *Beschorneria calcicola.*

Contact: Asociación Mexicana de Jardines Botánicos

Aloaceae

15) Development of a strategic conservation plan. In drawing up a conservation plan for the group, first priority should be given to the centres of diversity of Aloaceae, especially those in the southern and eastern Cape of Africa where many species are under threat. A prerequisite for this project would be an analysis of the distribution of aloaceous species in relation to the current southern African protected areas. Education on the need for habitat conservation and restrictions on collecting should be an important component.

Contact: IUCN/SSC Cactus and Succulent Specialist Group

16) **Medical research on Aloaceae.** Surveys of the ethnobotanical uses of alooid species should be conducted.

17) Fencing Aloe *bowiea.* This species is one of the most threatened of all the southern African *Aloe* spp. Immediate conservation action, such as fencing off the remaining populations, is required. Alternatively, five specimens should be re-located to *in situ* and/or *ex situ* safe sites.

Contact: Appropriate protected area managers

Crassulaceae

18) Botanical exploration for this family in the following regions: Central and South America, the Near East, southern Central Asia (Himalayas), East Africa, and Madagascar. Revisions of Madagascan species of *Kalanchoe* and *Bryophyllum* are urgently needed.

Contact: Research institutions

Regional action proposals

Canary Islands

19) Modification of species legislation. The following species should be added to Annex 1 of 'Ordren sobre protección de especies de la flora vascular silvestre de la Comunidad Autonoma de Canarias': *Aeonium saundersii, Aichryson pachycaulon, Caralluma burchardii, Euphorbia bourgeauana,* and *E. mellifera.*

20) Development of the proposed National Park on Gran Canaria. The development of the proposed National Park on Gran Canaria is urgently needed to protect *Euphorbia* communities and eroded volcanic landscapes which are threatened by land speculation and urbanisation.

Mediterranean region

21) Review conservation status of theatened plants in this region and evaluate all species with the new categories of threat, in cooperation with the IUCN/SSC Mediterranean Island Plant (see Delanoë *et al.* 1996) and European Plant Specialist Groups.

22) Protect succulent habitat on the Atlantic coastal area of Morocco near Agadir and to the south. Species include *Euphorbia officinanrm, E. echinus, Caralluma burchardii, C. europaea,* and *Kleinia anteuphorbium.* Work must be done to alleviate threats to these plants which include industrial and tourism development, agriculture, and overgrazing.

Somalia

23) Development of protected areas. It is important that when Somalia is in a position to develop a protected area system, sites rich in succulent plant species arc incorporated. These species are uniquely adapted to the climatic and soil conditions and may be important in habitat restoration. Although further botanical survey is a priority for parts of the country, including the Cal Madow

hills of the north-east, there is sufficient information available from earlier surveys on which to base site selection. Ideally a Biosphere Reserve with strictly protected botanical sites within it should be created within the north-east mountain region. Technical assistance will be required and the generation of local support for conservation initiatives.

24) Taxonomic work in Asclepiadaceae.

Southern Africa

(C. Hilton-Taylor)

25) Checklist of southern African succulents. A definitive checklist of southern African succulents needs to be compiled. This list should clearly define what is meant by succulent and should include information on synonymy, distribution, type of succulent (leaf, stem, caudiciform, etc.), plant use, conservation status, and key literature. Arnold and De Wet (1993) provide a starting point for such a list, but much of the information in that volume is inaccurate and out-of-date. An important step which would greatly assist this and many of the other projects listed below, is the computerisation of all specimen labels in southern Africa herbaria.

Contact: National Botanical Institute (NBI) and other herbaria in South Africa; National Herbaria in Botswana, Namibia, Swaziland, and Zimbabwe; systematists/taxonomists working on succulent groups; the Succulent Society of South Africa; and the *Aloe,* Cactus and Succulent Society of Zimbabwe

26) Production of a Red Data Book. A detailed Red Data Book on southern African succulents needs to be compiled which has accurate information on population numbers and sizes and good documentation of the threats to the species including quantitative estimates of population declines. An inventory of all taxa considered to be threatened in southern Africa was recently published (Hilton-Taylor 1996b). Any new or corrected information should be sent to C. Hilton-Taylor at the address given in Annex 17.

Contact: NBI, provincial and national conservation agencies, professional and amateur botanists

27) **Review of in *situ* succulent plant protection.** There is a need to determine which species and the number of their populations are effectively protected in the existing protected area network. Distribution data for all the succulent taxa should be analysed using iterative procedures as described by Rebelo (1994) to obtain the optimal reserve configuration for preserving the maximum diversity of southern African succulents. This configuration needs to be compared to the existing protected area network and gaps in the network identified. All the high priority areas, particularly major sites of succulent diversity, need to be declared conservation areas. A number of gaps in the protected area network have already been identified (see chapters in Huntley 1989 and 1994). Hilton-Taylor and Le Roux (1989) have indicated a number of areas in the Succulent Karoo which need to be set aside for the protection of succulents, however, few of these recommendations have been acted on.

Contact: Conservation agencies, NGOs, herbaria

28) *In situ* succulent plant conservation in Zimbabwe. Kimberley (1991) has outlined an ambitious plan to select thirty habitats in Zimbabwe for botanical reserve purposes. The findings of Timberlake and Müller (1994) should be incorporated into this plan. Kimberley (1991) estimated that the plan would cost approximately five million Zimbabwean dollars (equivalent at that time to one million U.S. dollars) extended over a ten year period. This plan would also have the added economic benefits of creating employment for at least sixty, if not more, people. The proposed plan for Zimbabwe should be emulated in other southern African countries.

Contact: The NBI and other southern African botanical institutions are in the best position to carry out the analysis, but the purchase and setting aside of land is the responsibility of national governments and government conservation agencies with the aid and support of NGOs such as the Succulent Society, Wildlife Society, and World Wide Fund for Nature.

29) Participation in protected area planning. In South Africa during the proposed redistribution of land to those people with historical claims on certain areas it will be important to demonstrate the tangible benefits of conservation to the community concerned through education, workshops, etc., especially aspects such as economic benefits and job opportunities, so as to ensure full public participation. Archer (1993) for example, describes the participation process followed in negotiations between pastoralists and conservationists in the recently established Richtersveld National Park, home to many endemic species of succulent plants.

30) Conservation on private land. Alternatives to publicly owned or legally designated conservation areas are urgently required in situations where formal protected area status is inappropriate. Farmers should be made aware of the importance of conservation and they should be encouraged to leave parcels of natural land for the protection of as wide as possible a variety of genetic diversity. In South Africa, landowners may on a voluntary basis register part of their land as a Natural Heritage Site with the Department of Environment Affairs, so as to protect important natural sites (Fuggle and Rabie 1992). The landowner may receive some management advice for the site, but retains full rights over the property, and as the registration has no legal status, it falls away when the

landowner dies or when the property is sold. Another alternative is for a landowner to join a conservancy where the owners of several properties have combined resources for the improved conservation of the natural areas remaining on their land (Fuggle and Rabie 1992). These conservancies also do not have any legal status. Both of these schemes, however, offer no financial benefits to the landowners concerned and a system of financial assistance or tax incentives for conservation efforts should possibly be introduced. There are many examples of such 'stewardship' schemes world-wide.

Contact: Government departments, conservation agencies, NGOs, landowners, and public participation

31) Survey of *ex situ* succulent plant conservation. Which species, how many, and the sources of all the material, are in cultivation in botanical gardens in southern Africa and elsewhere in the world needs to be documented. In addition to botanical gardens, the species in large privately owned collections particularly of certain succulent genera, also need to be recorded. All botanical gardens and individuals with important collections should be encouraged to register as holders of an IOS Generic Reserve Collection.

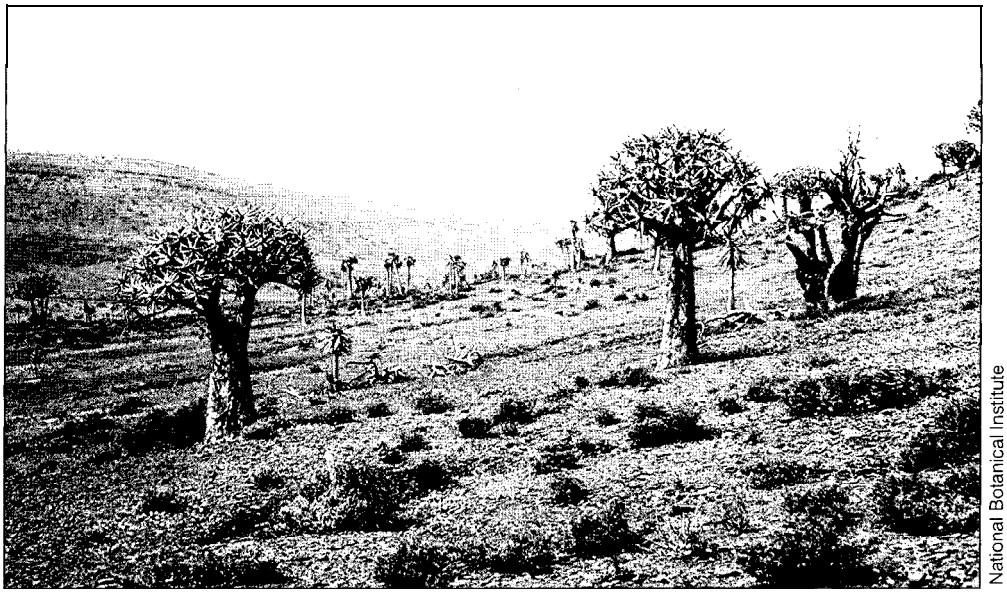
Contact: Botanic Gardens Conservation International (BGCI), NBI, all botanical gardens in southern Africa, Succulent Society of South Africa, National Cactus and Succulent Society of Zimbabwe, IOS

32) **Improving CITES implementation.** In terms of regulating international trade in succulent species from southern Africa, it may be necessary to propose the listing of additional taxa on the CITES Appendices. This will be determined from the results of trade surveys conducted by TRAFFIC. Such surveys will have to be conducted at fairly regular intervals to monitor trends. A number of additional aspects concerning CITES also need to be attended to: (a) non-member states within southern Africa should be encouraged to join; (b) CITES regulations need to be correctly and efficiently enforced by each state and especially by the different provinces within South Africa; (c) inspectors need to be given adequate training and literature to help them in the identification of CITES listed material; (d) there should be separate Management and Scientific CITES Authorities for each country; and (e) the fate of confiscated material should be clearly defined in a policy document.

Contact: CITES Secretariat, TRAFFIC, government conservation agencies, botanical research institutes

33) Development of national legislation. The deficiencies in national and provincial conservation legislation as outlined in the Southern African Regional Account need to be addressed as a matter of top priority. For example, (a) Botswana urgently needs legislation to protect its flora; (b) government funding for the PPC in Lesotho is totally inadequate and staffing is insufficient; (c) the list of protected plants in Namibia is in need of revision (M. Strobach, pers. comm.); (d) now that South Africa is divided into nine provinces, each will have to draw up its own conservation legislation, providing a good opportunity to update and tighten up the ordinances and to ensure even standards and treatment across the country; and (e) penalties imposed for offences are in most cases far too low to act as a deterrent and should be substantially increased to match those for offences relating to animals.

Contact: National governments, conservation agencies, botanical research institutes, environmental lawyers



National Botanical Institute

A koker boom **(Aloe *dichotoma)*** forest which could easily become a major tourist attraction.

34) Law enforcement. The provision of appropriate conservation legislation must also ensure adequate law enforcement. South African legislation for the protection of plants in general and succulent plant species in particular is generally satisfactory, but in many cases the enforcement falls far short of what is desirable. This is not a reflection of the actual abilities of the law enforcers, but on their small numbers and the vast areas they have to police (Cowling and Olivier 1992). The main reason for this, according to Kimberley (1991), is the lack of personnel, and especially the absence of any active and full-time inspectorate, which is largely attributed to the shortage of sufficient financial support.

Contact: National governments, conservation agencies, honorary conservation officers

35) National Biodiversity Action Plans. Government funding for flora conservation in every southern African country is inadequate. This issue should be addressed by countries when compiling national plans in accordance with the Convention on Biological Diversity. Namibia is probably the first southern African country to have started this process (G. Maggs, pers. comm.).

Contact: National governments, conservation agencies, botanical research institutes

36) Education and public awareness. As most land in southern Africa is privately or communally owned an extensive and intensive environmental education and awareness campaign using all the media is required to educate the general public about our floral wealth and especially those species at risk (see Smith 1994). The campaign needs to instil in the population of each country, particularly people in the rural areas and developers, a corporate responsibility to protect and safeguard its floral heritage for future generations. The Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) in Zimbabwe could serve as a role model for such an education campaign. The CAMPFIRE project was started by the Zimbabwean conservation authorities in 1982 as a result of the increasing conflict between people and wildlife and the realisation that much of the land was better used for conservation than for conventional economically and ecologically unsound agricultural purposes (Holt-Biddle 1994). Similar pilot schemes have been started in Botswana and Namibia, but they have not had the same measure of success as CAMPFIRE (Holt-Biddle 1994).

Contact: National governments, conservation agencies, education authorities, traditional leaders, universities and other educational institutions, NGOs

Awareness of the floral wealth also needs to be extended to those people in authority, especially those directly responsible for the conservation of the flora. Ever since the concept of conservation gained popularity and momentum in southern Africa, the emphasis has largely been on the fauna (Huntley 1978; Kimberley 1991). The lack of care and expertise about the flora has been such that those in authority often do not know one protected, specially protected, or endangered plant species from another.

Contact: National governments conservation agencies, the NBI and other botanical institutes, educational institutions, NGOs like the succulent societies, the media

37) Promotion of the financial value of succulents. There is a growing realisation in southern Africa that sustainable and imaginative use of natural resources can be used to generate considerable income, especially through the concept of ecotourism (Cowling 1993). Unique areas of succulent diversity could be used to generate income, especially if promoted as tourist attractions. Millions of visitors to Arizona in the USA for example, pay to see the representative succulent plant communities (organ pipe cactus, giant Saguaro cactus, and Joshua trees) which are protected in the Sonoran Desert. The kokerboom (*Aloe dichotoma*) forests of the Northern Cape and Namibia, *Euphorbia* thickets of the Eastern Cape, *Sesamothamnus lugardii* populations in Botswana, and *Lithops* colonies in Namibia are prime examples of such resources which could easily be promoted.

Contact: Conservation agencies, NGOs, local authorities, and tourism organisations such as SATOUR

38) Development of succulent plant nurseries. To help prevent the removal of succulent plants from the wild, attempts are required to establish sufficient nurseries to meet the demand for plants. Such nurseries would not only supply plants and seeds for the horticultural trade but also plants used for traditional medicinal purposes. Such nurseries should operate according to the guidelines set out in the IOS Code of Conduct (Oldfield 1990). Rural communities in particular, should be helped and encouraged to set up such nurseries, e.g. in the Richtersveld or in Lesotho for *Aloe polyphylla (see* Talukdar 1983). These nurseries would not only benefit the local community financially but would hopefully educate people about the value of the plants thereby engendering a conservation ethic.

Contact: Conservation agencies, NGOs, traditional leaders and their rural communities, commercial nurseries, traditional healers, TRAFFIC, the NBI and other botanical institutes

39) *In situ* monitoring of threatened species. Long-term monitoring studies *in situ* of selected threatened succulent species and their habitats are required to gain further insights into the conservation requirements of

endangered species. Such studies could be modelled along the lines of those conducted on cacti in Mexico by Can Te, A.C. in collaboration with CITES. *Haworthia* and *Euphorbia* are two prime genera which have many suitable candidates for such a monitoring programme.

Contact: CITES, conservation agencies, Succulent Society of South Africa, National Cactus and Succulent Society of Zimbabwe, the NBI, university botany departments

40) **Rescue operations for threatened succulents.** As part of the *ex situ* conservation measures, a co-ordinated approach is required across southern Africa for the rescue of succulent plants, especially threatened species, from areas intended for development. These rescued plants should be grown in cultivation with the view to reintroduction to another suitable and safe site or moved immediately. The Botanical Society of South Africa has a 'Search and Rescue' group run under the auspices of their Flora Conservation Committee. This group, however, is purely Western Cape based and deals mainly with *in situ* problems of habitat conservation, although some plants have been removed from the wild and taken to Kirstenbosch National Botanical Garden for cultivation. 'Operation Wildflower' is another such group, which in recent years has only operated in the Transvaal. This group focuses mainly on indigenous succulents (aloes) and bulbs, which are removed from areas slated for development and cultivated in private gardens. While these local efforts are praiseworthy, national or possibly regional, well co-ordinated approaches to the problem are required, especially if effective reintroduction programmes are to be started. The Centers of Plant Conservation in the USA could possibly serve as a role model for such a programme (Falk 1992).

Contact: Conservation agencies, botanical gardens (especially the NBI), Botanical Society of South Africa, Succulent Society of South Africa, Cactus and Succulent Society of Zimbabwe, other NGOs

Madagascar

41) Incorporation of succulent plant expertise in the IUCN/SSC Specialist Group for **Madagascan** plants. There is an urgent need for conservation activities relating to the plants of Madagascar to be more effectively co-ordinated through the creation of a specialist group of experts from Madagascar and elsewhere, which includes expertise on the succulent flora.

Contact: SSC Plants Programme

42) Analysis of the distribution of succulent species in relation to the current and proposed protected areas. GIS mapping of the known distribution of succulent species by genera should be completed, based on the botanical literature and the results of the CITES field project, to highlight the centres of diversity for each succulent genus. Compare centres of diversity for each genus and the protected area network. Recommend for expansion the protected area coverage of the main centres of diversity for succulent plant species. A GIS project based on orchid, palm and legume data is already underway under the auspices of the Royal Botanic Gardens, Kew. A technician has been employed in Paris to enter locality data for this project. Support should be provided for similar data to be accessed for the succulent flora.

Contact: The Royal Botanic Gardens, Kew

43) Detailed assessment of the conservation needs of the xerophytic vegetation of south-west Madagascar. A comprehensive survey should be conducted of the spiny thicket vegetation of south-west Madagascar to determine the best remaining sites for conservation purposes. Site selection can be based on representative examples of the vegetation structurally defined, succulent species richness, and presence of rare and/or threatened endemics.

Contact: WWF-Madagascar/ ZSS

44) **Cap Sainte Marie Special Reserve.** This reserve is important for the protection of the endemic and threatened *Euphorbia cap-saintemariensis* and for other succulents such as *Aloe millotii, Alluaudia comosa,* and *Alluaudiopsis fiherensis.* While some information on the species present is available, a full botanical inventory should be carried out. The reserve is also scenically attractive and, although no visitor resources exist at present, it is potentially an important site for ecotourism. Reassessment of the boundaries, exclusion of seriously degraded and botanically less important areas and fencing to exclude livestock from the core area is necessary. The development of ecotourism and area management plans should be encouraged.

45) Development of a 'Tulear botanical garden'. Development of a botanic garden with natural vegetation protected as a reserve in the vicinity of Tulear.

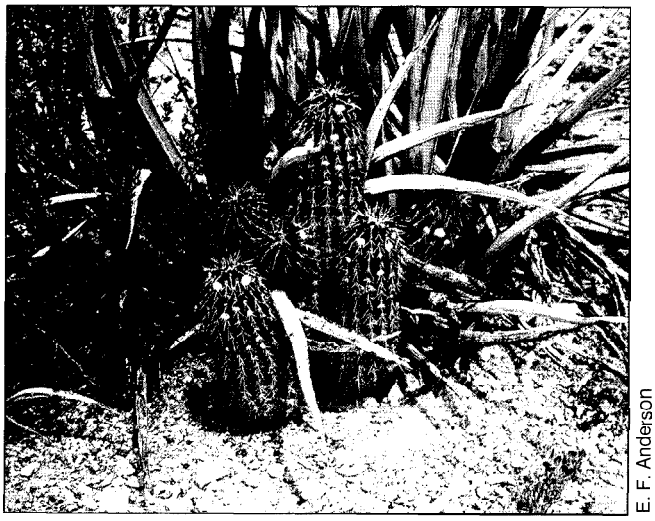
Contact: University of Tulear

46) Assessment of Strict Nature Reserves. Assessment of the condition and realistic prospects for medium- to long-term protection of succulent plants at Reserve naturelle integrale de Tsimanampetsotsa and Reserve naturelle integrale d'Andohahela (parcel 2).

Contact: Missouri Botanic Garden

47) **Detailed survey of the western escarpment of the Central Plateau.** The area between the Mangoky and Manambaho Rivers is in need of a detailed survey to assess the conservation status and conservation needs of the succulent flora.

Contact: WWF-Madagascar/ZSS



E. F. Anderson

Echinocereus chisoensis, Big Bend National Park, Texas. Vulnerable.

48) **Creation of new protected areas.** Protection of the priority sites for succulent plant conservation identified above is urgently required. A feasibility study should be carried out to determine the best form of protection, site boundaries, management requirements, willingness of local people to support protected areas and the costings involved. Funding proposals should be developed for the creation of reserves where the agreement in principle of all interested parties has been reached.

49) **Development of plant conservation legislation.**

Contact: Government offices, lobbying groups

50) **Improvements in nursery monitoring.** It is important to have closer monitoring of plant collection and production for export in the commercial nurseries. There are currently around six such establishments. Details of stock plants and their origin, levels of production, and trade by species should be maintained. Procedures for the monitoring of nurseries by regular inspection and review of documentation should be established. Training for a member of staff with responsibility for control of plant exports should be arranged.

Contact: Department des Eaux et Forêts (DEF)

51) **Development of a CITES Scientific Authority for plants in Madagascar.**

52) **Popular guide to the succulent plant species of Madagascar for local use.** This will promote local interest in conservation in plants and can be used in school education.

53) ***Ex situ* conservation at Parc botanique et zoologique de Tsimbazaza.** The park is now equipped with nursery facilities suitable for propagation on a large scale. The garden needs to produce a strategy for the *ex situ* conservation of succulent plants. Cultivation of rare species should concentrate on high altitude plants from central Madagascar and garden staff should be encouraged to look at the natural localities of the plants in cultivation to ensure that horticultural practices are appropriate. There has been a renovation programme focused on the rockery which displays the succulent flora of Madagascar. Construction is almost complete; planting will require further work for several more years. There is an urgent need for explanatory signs and leaflets on the genera, their natural habitats, and cultivation notes; and training in the ecological requirements of native species, practical conservation, and display of succulents.

54) **Construction of a database of the existing succulent collection at Toliara.** An important collection of natural source succulents is maintained at the privately owned Arboretum d'Antsoky. The scientific value of this collection should be evaluated and, if appropriate, funding provided for a technician to develop a database on site. This could be linked to Action 8a.

India

55) **Survey of endangered species.** Survey and inventory of endangered succulent species as a basis for selection of reserves. Tea companies, owners of vast tracts of land rich in succulents, could also be involved as they are in a position to set aside small areas as reserves.

Contact: President of the Cactus and Succulent Society of India

56) **Sustainable use management plan.** Many species are collected for local and commercial use and are threatened by over-collection. Attention should be given to educating users about sustainable collection methods.

United States of America

57) **Implementation of published recovery plans.** The US Fish and Wildlife Service (USFWS) oversees and publishes status reports of recovery plans. See Chapter 2 - National Legislation for details. Although the onus is on the USFWS, outside individuals and institutions can help with implementation.

E. F. Anderson

Inserting an electronic chip in *Ariocarpus bravoanus.*

E. F. Anderson

Reading an electronic chip.

58) **Peyote salvage operations in southern Texas.** Peyote populations in south Texas are of considerable importance to members of the Native American Church, who obtain plants to use as their sacrament. Most of the land is privately owned, so often neither Native Americans or Peyoteros (those who have permits to collect peyote) are allowed onto the land where the plants grow. Consequently available populations are being badly overcollected. Another serious threat to the peyote in south Texas is the root plough which is used by land owners to remove the natural plants before sowing exotic plants for grazing. If land owners could be persuaded to permit peyoteros to collect the peyote plants prior to ploughing, these cacti could be transplanted to another site to be grown for traditional use. The development of nursery seed grown peyote stock for local use should also be investigated.

Budget: Funding would provide for the lease of land for growing the cacti and to hire peyoteros to collect them. A pilot project should be carried out and funded for $5000 - 10,000.

59) **Long-term monitoring of *Echinocereus chisoensis*.** This taxon is considered threatened in the USA. It grows only in Big Bend National Park, Texas, but there may be additional populations outside the park boundaries in Texas and similar plants are known in Mexico. Survey is needed to determine the range of this species. Permanent monitoring sites should also be established to study the long-term dynamics of the known populations, especially those protected within the Park.

Budget: Annual cost would be $2000 - 3000.

60) **Establishment of permanent monitoring sites for species of *Sclerocactus* and *Pediocactus* in the USA.** These genera contain some of the rarest cacti in the USA. Permanent monitoring sites should be established to study the population dynamics of these plants, as well as to determine the effects of activities such as collecting, mining and construction. Some of this work should be done in co-operation with Native Americans, for several species are located on Indian reservations.

Budget: The estimated cost of such work is $3000 - 5000 per year.

61) **Search for *Astrophytum asterias* populations.** This species is known from a single locality in Texas, but almost certainly it was once widespread throughout the shrubland of south Texas and into north-eastern Mexico. It is known to occur east of the Sierra Madre Oriental and south of Ciudad Victoria, Tamaulipas in Mexico and is likely to occur elsewhere. Much of the land where it grows, or has grown, is being developed for agriculture. A survey of distribution and conservation status is required.

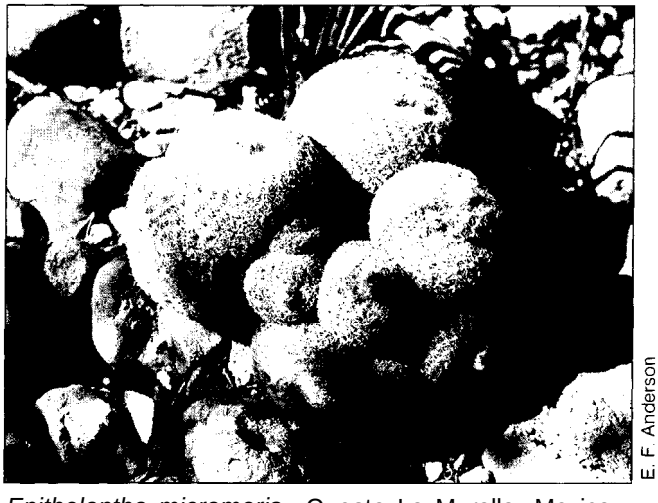
Budget: The estimated annual cost would be $4000.

62) **Support for succulent conservation work by institutions working with the Center for Plant Conservation (CPC).** Various cacti and other succulents are currently being propagated and studied by member institutions of CPC; however, their funding is limited, and financial support for their important field work, as well as conservation of germplasm, is much needed. More publicity is needed about CPC's program and how botanic gardens and specialists can participate in this.

63) Assistance in the development of conservation education. The public must be informed of the present threats to many plant species in the wild. Some US institutions have plans to develop extensive programmes. For example, the Desert Botanical Garden has developed plans for a Conservation Trail by which the public will be informed of the purpose of conservation and how it mav be accomplished. Outside funding to encourage such programmes is required.

***64)* Survey of Agavaceae.** This work is needed in Arizona and Texas.

Contact: Desert Botanical Garden



E. F. Anderson

Epithelantha micromeris, Cuesta La Muralla, Mexico.

Mexico and United States of America

65) Cooperative Mexican-American conservation studies along the US-Mexico border. Much of the area south of the Rio Grande, especially that area to the south of west Texas is poorly known. Several rare cacti may occur in this area but extensive field work is necessary to determine ranges of some of these plants, such as peyote *(Lophophora williamsii), Ariocarpus fissuratus, Echinocereus chisoensis,* and *Sclerocactus (Neolloydia) mariposensis.*

66) A survey of the genus *Ferocactus* in trade. A study should be conducted to compile data from the range states in Mexico and the USA and the major importing countries of Europe and Japan. A sizeable trade exists in seed-grown *Ferocactus* and the study must distinguish between wild and nursery-grown plants.

67) *Epithelantha micromeris.* A population survey of this species is needed to determine the status of this species in the wild in Texas and Mexico. It can be grown easily and seedraised plants are generally seen in European nurseries. Wild-collected plants are, however, also available in trade and the impact of international trade on wild populations needs to be assessed.

68) Permanent marking of rare plants. Illegal collecting continues to be a significant threat to some species of cacti in Mexico and the USA. It would be helpful to mark individual plants in some of these seriously threatened populations, not only to enable authorities to determine the origin of confiscated plants, but also to assist researchers in locating the plants in the field. Some of the most popular plants are small and nearly invisible, and permanent markers would greatly facilitate continuing studies of these populations. Electronic chips could be inserted into the body of the cactus without injury to the plant.

Budget: Equipment and supplies would cost $5000 - 6000.

Mexico

69) Education. Long term conservation can be served best through education at the grass-roots level. Mexico needs books about cacti and other succulents, suitable for use in basic education. A series of children's books on appreciation of arid habitats and the native flora is now in preparation by Can Te, A.C. Other planned publications include a pictorial encyclopedia of Mexican succulents, introductory and primarily pictorial works on succulent-rich regions, and field identification guides to potentially threatened taxa. Continued support is needed in this very important area. While it will remain difficult to control the collection of succulent plants by individuals for decorative or medicinal purposes, educational efforts should help.

70) Preparation of clear guidelines on conservation legislation and collecting regulations relating to Mexican succulents. A major problem in Mexico is a lack of communication about conservation activities and lack of understanding about the federal laws that affect native plants, especially important among the farmers and villagers who live in the arid regions of Mexico. Local people need to be informed of conservation activities, especially when they involve populations of plants occurring near their farms or villages, especially if the succulents are found on their *ejidos* (communal land tenure system). The success of local conservation efforts is possible only with the knowledge and support of local residents.

71) Enforcement of conservation legislation. Mexico has called on importing countries to help with problems of illegal plant exports. Recently, Mexican authorities have been studying where collectors go within the country and concentrating enforcement efforts in those areas. Complementary stricter controls by importing countries are required.

72) Indigenous plant propagation. The Mexican Government is encouraging those botanical gardens and nurseries that are beginning to propagate succulents for both domestic and international markets. In this way a source of income is generated, and the pressures on wild populations of succulents are reduced. If inexpensive plants of high quality can be marketed by responsible Mexican nurseries, this should lead to less demand on field-collected (and illegal) cacti and succulents. Propagation activities and market research clearly merit continued encouragement and support from both the Mexican authorities and international conservation organisations. Assistance with mass-propagation techniques and marketing skills is required. International expertise in the development of the horticultural industry should be offered.

73) **Development of protected area system.** Priority sites for succulent plant conservation have been identified in the Regional Account for Mexico. These sites will be brought to the attention of the relevant authorities in Mexico and investigations carried out to identify the most appropriate means to protect the sites.

74) **Population studies.** Ecological and population studies are the foundation of future conservation activities. All recommendations for conservation action depend, at the least, upon reliable population data in order to best allocate limited funding. The following proposed population studies have been proposed for the Action Plan by Can Te, A.C. Only plants that are felt to warrant study as candidates for Critically Endangered, Endangered, or Vulnerable status (new IUCN threat categories) are included in the examples. Each study would provide a population estimate of sufficient accuracy for the plants listed to allow threat classification

by SEMARNAP. Each study corresponds to a one week undertaking for three investigators. The cost for each study (US $740) covers per diem expenses and transportation costs.

Las Tablas - Cuidad Maiz - Los Cerritos, State of San Luis Potosi

Coryphantha maiz-tablasensis
Mammillaria aureilanata (1 of several sites)
M. microthele
M. dumetorum (1 of several sites)
Turbinicarpus gielsdorfianus
T. knuthianus
T. laui
T. lophophoroides

Zaragoa, State of Nuevo León

Echeveria shaviana
Echeveria sp. nov.
Echinocereus knippelianus var. *reyesii*
Mammillaria rubrograndis
M. glassii var. nova
Thelocactus conothele (yellow-flowered form)
Turbinicarpus subterraneus var. *zaragosae*

Aramberri, State of Nuevo León

Ariocarpus kotschoubeyanus (white-flowered form)
Mammillaria albicoma (1 of several sites)
Pelecyphora strobiliformis
Thelocactus conothele var. *aurantiacus*
Turbinicarpus hoferi
T. pseudopectinatus (red-flowered form)
T. subterraneus var. *subterraneus*
T. schmiedickeanus var. *dickisoniae*
T. schmiedickeanus var. *gracilis*

Galeana, State of Nuevo León

Aztekium hintonii
Geohintonia mexicana
Mammillaria glassii (1 of several sites)
M. weingartiana (1 of several sites)
Turbinicarpus pseudopectinatus (red-flowered form)
T. booleanus (aff. *T. subterraneus)*

Ascension, State of Nuevo León

Escobaria roseana var. *galeanensis* (1 of several sites)
E. asperispina (2 of several sites)
Echinocereus knippelianus var. *krugeri*
E. pulchellus var. *sharpii*
Mammillaria glassii var. *ascensionis*
M. weingartiana (1 of several sites)
Thelocactus conothele var. *argenteus*
Turbinicarpus sp. nov. (aff. T. *gautii)*

Rayones, State of Nuevo León

Escobaria roseana var. *galeanensis* (1 of several sites)
Agave victoriae-reginae (1 of several sites)
***A** riocarpus scaphiros tris*
Aztekium ritteri
Echeveria lilacina
Echinocereus knippelianus (new form)
E. pulchellus (new form)
Turbinicarpus swobodae

These examples cover abbreviated field investigations. feasible as a consequence of prior experiences of theCan Te, A.C. staff. Similarly abbreviated field investigations should be possible as a consequence of prior experience of the UNAM staff in the Tehuacán area and the Universidad Autónoma de Tamulipas staff in the Juamave area. Additional proposals can be solicited from other institutions in Mexico, either directly or through Can Te, A.C., in order to take advantage of both work in process and proximity to the sites.

With the participation of all relevant institutions in carrying out population estimates of Critically Endangered, Endangered, or Vulnerable succulents, it appears that the task can be completed within two years. Plant populations are dynamic, and continuing observations will be necessary to evaluate new potentially threatening situations.

75) Surveys of Agavaceae. The following arc priority survey projects for Agavaceae. Organisations serving as possible primary contacts are suggested, these indicated by their herbarium acronyms and appropriate botanical gardens. These suggestions do not constitute a commitment by that institution at this time.

a) Field surveys and documentations of *Agave* in Baja California (including islands)

Contact: DES and Desert Botanical Garden with BCMEX and El Charco del Ingenio, San Miguel de Allende, Guanajuato
Budget: $15,000 for 5-year period

b) Field surveys and documentation of rare Agavaceae in Sonora

Contact: DES and Desert Botanical Garden with El Charco del Ingenio and Centro Ecología de Sonora.

c) Field surveys and documentation of rare Agavaceae in Coahuila

Contact: DES and Desert Botanical Garden, with El Charco del Ingenio

d) Field surveys and documentation of *Agave* and rare Agavaceae in Oaxaca

Contact: MEXU and Jardín Botánico de Instituto de Biologia with OAX, and El Charco del Ingenio

e) Field surveys and documentation of rare Agavaceae in San Luis Potosi

Contact: SLPM and El Charco del Ingenio

f) Field surveys and documentation of rare Agavaceae in Jalisco

Contact: MEXU and Jardín Botánico de Instituto de Biologia with IBUG, and El Charco del Ingenio

Other states of lower priority, but nonetheless requiring field surveys and documentation for rare Agavaceae, are listed below with suggested contact organisations along with MEXU and Jardín Botánico de Instituto de Biologia and El Charco del Ingenio:

a) Durango, with CIIDIR and DES and Desert Botanical Garden
b) Nayarit
c) Hidalgo
d) Vera Cruz
e) Mexico
f) Puebla
g) Guerrer
h) Chiapas, CHIP

Central America

76) Field surveys of Agavaceae in Guatemala.

Contact: AGUAT and UAT *(Beaucarnea)*

Caribbean

77) Survey of the conservation status of the genera *Agave* and *Furcraea* in the Bahamas. The conservation status of the endemic species of *Agave* in the Bahamas is currently unknown. Review of the status of wild populations and current threats is required in order to effectively implement the SPAW Protocol of the Cartagena Convention.

A. Areces-Mallea

Flower of *Leptocereus wrightii*, a species practically extinct in the wild.

A. Areces-Mallea

Cactus scrub habitat near Azuá, Dominican Republic.

78) **Creation of an SSC Specialist Group for the Flora of the Caribbean islands.** There is an urgent need for conservation activities relating to the plants of the Caribbean Archipelago; not only are species of cactus and other succulents facing extinction, but also many taxa within the Arecaceae, Myrtaceae, Rubiaceae, Melastomataceae, Magnoliaceae, Eriocaulaceae, Xyridaceae, and other families. In a multinational region such as the West Indies, the best way to make conservation activities effective is by co-ordinating them through the creation of an international Specialist Group.

79) Detailed assessment of the conservation status of cacti and succulent species that remain insufficiently known, based on field survey. Priorities are:

a) *Agave brevipetala*
b) *A. brevispina*
c) Neobuchia paulinae
d) *Opuntia ekmanii*
e) 0. falcata
f) *Dorstenia caimitensis*
g) D. cordifolia
h) *D. crenulata*
i) *D. erythrandra*
j) D. flagellifera
k) *D. hotteana*
1) *D. marginata*
m) *D. multisquamea*
n) *D. tuberosa*
o) Cissus haitiensia

Contact: NYBG, DNP, JBN-RMM

80) **Detailed search for the 'extinct' or nearly extinct cactus and succulent species.** A detailed search for the most endangered taxa in the wild is necessary to determine whether they are gone or are yet capable of surviving. Mapping of the last remaining sites of these taxa, if existing, and assessment of their conservation needs is urgently needed. Taxa to be considered:

a) *Escobaria cubensis*
b) *Hylocereus cubensis*
c) *Leptocereus scopulophilus*
d) *L. wrigh tii*
e) *Melocactus actinacanthus*
f) *M. matanzanus*
g) *Opuntia borinquensis*
h) *0. corallicola*
i) *Pereskia quisqueyana*
j) *Selenicereus innesii*
k) *Borrichia cubana*
l) *Cnidoscolus fragrans*
m) *C. quinqueloba tus*

Contact: NYBG, IES, MNHN, JBN, DNP, DRN

81) Analysis of the distribution of succulent species in relation to the current and proposed protected areas. Mapping of the known distribution of cacti and succulent species based on botanical literature and field work will highlight the centres of diversity. A comparison between these centres of diversity and the protected area network is to be made. Also, recommendations should be made for the expansion of protected area coverage to include all the centres of diversity for cacti and succulent plant species, and most, if not all, of the taxa involved.

Contact: NYBG

82) Detailed assessment of the conservation needs of important dry shrubwoods and semi-desert cactus communities not covered by national protection systems. A comprehensive survey of important unprotected dry shrubwoods and semi-desert cactus communities is needed to determine the best remaining sites for conservation purposes. Site selection for the expansion of protected area coverage should be based on representative examples of the vegetation defined by structure, succulent species richness, and the presence of rare and/or threatened endemics. Priorities are:

a) Coast and lowlands from Guantanamo to Maisi, Cuba
b) Coastal terrace between Gibara and Puerto Padre, Cuba
c) Holguin serpentine outcrops, Cuba
d) Lake Enriquillo Valley, Domincan Republic, Cul-de-Sac Plain, Haiti
e) Shrublands between Bani and Azuá, Dominican Republic
f) Coast and lowlands from Mule St. Nicolas to Port-de-Paix, Haïti
g) Coast and lowlands between Treasure Beach and Little Pedro Point, Jamaica
h) Hellshire Hills coastal and lowland area, Jamaica
i) Dry coastal plains in the Turks and Caicos Islands, Bahama Archipelago
j) Eleuthera Island rocky plains, Bahama Archipelago
k) Great Inagua sandy and rocky flats, Bahama Archipelago
l) Long Island shrublands, Bahama Archipelago

Contact: NYBG, COMARNA, IES, DNP, NRCD

83) Creation of new protected areas. Protection of all the priority sites for cactus and other succulent plants identified in the Action Plan is urgently required. A feasibility study should be carried out to determine the best form of protection, site boundaries, management requirements, requirements of local people and the costs involved. Most of the sites proposed are small in terms of area coverage (for example, Cerro de San Francisco, in the Dominican Republic, is only a hill). Thus, their selection follows the general strategy conceived under "Priority sites for conservation". Funding proposals should be developed for the creation of reserves where the agreement in principle of all interested parties has been reached. Proposed sites are:

a) Santa Cruz del Sur lowlands, Cuba
b) Sierra de Anafe, Cuba
c) Sierra de Somorrostro and neighbouring hills, Cuba
d) Sierra de Najasa, Cuba
e) Tres Ceibas serpentine outcrop, Cuba
f) Jatibonico ophiolitic outcrop, Cuba
g) Bayahibe coast and lowlands, Dominican Republic
h) Cerro de San Francisco, Banica, Dominican Republic
i) Tetas de Cayey mountain ridge, Puerto Rico
j) Northern Grand Terre of Guadeloupe, Lesser Antilles
k) Barbuda lowlands, Lesser Antilles
l) South-eastern peninsula of St. Kitts, Lesser Antilles
m) La Soufriere, St. Vincent, Lesser Antilles
n) The Bluff, Cayman Brac, Cayman Islands
o) East End, Little Cayman, Cayman Islands

Contact: NYBG, MINAGRI, COMARNA, DNP, DRN, NRCD, NTCI

84) **Assessment of strict nature reserves.** Many protected areas are not adequately protected on the ground. Assessment of the condition and realistic prospects for long-term protection of cacti and other succulent plants in the existing protected areas of the Caribbean Islands is to be done. Recommendations to secure the protected status of the plants involved should be given.

Contact: NYBG

85) Detailed survey of the Department du Nord'Ouest, Haiti. In all the Caribbean the dry shrublands and coastal areas of north-west Haïti are the

poorest known sites with respect to their native succulent flora. Judging from old collections of this area, there seems to be an undescribed new genus of Cactaceae. The region is in great need of a detailed survey to inventory the succulent taxa, and to assess the conservation status and conservation needs of its succulent flora.

Contact: NYBG, Fundation botanique d'Haïti

86) **Development of plant conservation legislation.** Each Caribbean country should develop plant conservation legislation to give special protection to its rare and threatened species.

87) Development of CITES Scientific Authorities for plants with a mechanism for regional coordination.

88) Completion and amendments to the succulent taxa of the Caribbean's SPAW Protocol Annexes.

89) Improvements in nursery monitoring. Closer monitoring of plant collections and production for export in the commercial West Indian nurseries is important. Details of stock plants and their origin, and levels of production and trade by species should be maintained. Procedures for the monitoring of nurseries by regular inspection and review of documentation should be established. Training within the CITES Management Authority for a member of staff with responsibility for control of plant exports should be arranged.

90) *Ex situ* conservation. Creation of a complete *ex* situ Caribbean succulent plant conservation collection is urgently required. Due to the potential for adverse natural environmental factors in the West Indies, such as hurricanes, it is desirable to have more than one regional collection. The St. George Village Botanical Garden on St. Croix (US Virgin Islands) has, at present, the most important *ex* situ collection of endangered Caribbean cacti. Also the Jardín Botánico Nacional at Havana, and the Cayman National Botanic Park in Grand Cayman have started, on their own initiative, *ex* situ succulent plant conservation collections.

The idea of creating a sanctuary for endangered Caribbean succulents at the Tetas de Cayey mountain ridge (Puerto Rico) by its private owner is worthy of backing and support. The development of such a sanctuary in a place with natural vegetation protected as a reserve (the rocky slopes are inhabited by a yet undescribed variety of *Melocactus* and several local endemics), is a very exciting idea. There is an ongoing project for the rockery displays. This place is soon going to be equipped with nursery facilities suitable for propagation on a regular scale.

91) Educational programs. There is a need to develop educational programmes for the Caribbean islanders to make them acquainted with the richness and value of their dry shrublands. Preparation of a popular guide for regional use to the succulent plant species of the West Indies would be useful. These programmes should aim to dispel the general misconception that the West Indian thorn scrubs are useless, and to move people to the forefront of the battle to conserve the rare and unique plants that are only found in this type of vegetation; people should believe in developing different sustainable approaches to the dry shrubland use, but only if this is accomplished by evaluating the interaction between man-made and natural environments, and the ways in which this sets limits for social and economic aspects of life.

Contact: NYBG, MNHN, CIAC, CEA, NTCI

South America

92) *Ex situ* conservation. Organisation and help to regional botanic gardens as well as germplasm centrcs is needed for future action.

93) Taxonomic research. Provide data and facilities to those who are currently revising the taxonomy of succulent plants. Encourage those to include information on the conservation status of the species treated.

94) Study of the South American cactus trade. Investigation of the collection and propagation of South American cacti for international trade, including trade in wild-collected seed, focusing on nurseries and commercial dealers within the region. Investigation of trade patterns within South America concentrating on Peru, Chile and Brazil.

Contact: TRAFFIC South America

95) Field surveys of the taxonomic and conservation status of *Parodia (Notocactus), Frailea,* and *Gymnocalycium.* The conservation status of most of the *Parodia (Notocactus)* taxa (many of doubtful taxonomic standing), c. 15 *Frailea* and 6 *Gymnocalycium* spp. (2 endemic), in the southern part of Rio Grande do Sul, Brazil and Uruguay needs to be determined. Some populations are known to be very small and illegal collection to satisfy the demand for novelties by hobbyists in Europe and elsewhere is certainly taking place. Field surveys are needed to assess the taxonomic and conservation status of these taxa and to investigate the possibilities for *in situ* conservation.

Colombia/Venezuela

96) Assessment of conservation status. Field surveys are needed to assess the conservation status of local species with restricted distributions in northern Venezuela and Colombia: *Agave cocui, Echeveria* sp. nov. (Lara state), *Cereus fricii (C. russellianus), C. mortensenii, C. horrispinus* all from northern Venezuela; *Pseudoacanthocereus (Acanthocereus) sicariguensis*, northern Venezuela and Colombia; *Armatocereus humilis*, Rio Dagua valley, western Colombia.

Venezuela

97) Creation of a reserve. Consideration should be given to setting aside a site within the Venezuelan range of *Melocactus schatzlii, e.g.* south of Ejido, which could also protect a currently undescribed endemic *Echeveria* species.

Ecuador

98) Survey of Catamayo valley. Determine status of all succulent species in Catamayo valley: *Armatocereus brevispinus, Cleistocactus leonensis,* and *Espostoa frutescens* are rare and restricted to the valley as are some other, non-endemic succulents and *Weberocereus rosei,* known from only two natural sites in Chimborazo and Caóar Provinces.

Peru

99) Assessment of the *in situ* conservation requirements of succulents. Assessment of the extent to which the protected area system of Peru protects the habitats of endemic succulents. The Andean Region of Peru is extremely rich in succulent plant species, with high levels of endemism. Survey work is needed throughout the drier areas. In the Coastal Region, surveys are needed to determine the degree of threat to populations of particular succulent species in the more mesic areas.

100) Peru/Bolivian Andes. Field study is needed to resolve questions of taxonomic and conservation status considering the high endemicity in this region.

Bolivia

101) *Ex situ* conservation. Support is needed to encourage the *ex situ* conservation of threatened cacti in the newly formed botanic garden at the University of La Paz.

Chile

102) *In situ* protection. The following recommendations for protected areas result from field work carried out by the SSC Cactus and Succulent Group (Anderson *et al.* 1990):

a) Emphasise the establishment of Paposo National Park.
b) Expand the boundaries of Pan de Azucar National Park. It is important to include the complete ranges of the very restricted taxa *Copiapoa laui, C. longistaminea,* and C. *serpentisulcata* within the Park's protection. If possible the Park should extend north to Taltal and south to Chanaral, the northern extension including the entire ranges of the rare *Copiapoa rupestris* and C. *desertorum.*
c) Establish a national park or protected area between Totoral and Huasco. Such a legally protected zone would specifically preserve the spectacular and remarkable populations of *Copiapoa malletiana.*
d) Set aside Quedrada El Leon as a nature reserve. This canyon, located near the town of Caldera, contains an important mixture of the northern and southern cactus and other floristic elements.
e) Expand the boundary of the proposed wetlands nature reserve to include Punta de Teatinos, which is north of La Serena.

103) Survey of Coastal Fog Desert. Further study of the endemic flora and ecology of the Coastal Fog Desert and field surveys to determine range and conservation status of taxa affected by mining and ore processing in the vicinity of Tocopilla and Copiapo.

104) Evaluation of the conservation status of the Chilean Cactaceae. A comprehensive proposal to study the taxonomy, distribution, ecology, and conservation status of all Chilean cacti was presented at the Sixth meeting of the CITES Plants Committee. This would form the basis for implementation and improvement of conservation legislation and regulation of the uses of cacti resources.

Contact: Departamento de Proteccion de los Recursos Naturales Renovables (Ricardo Scheu)
Budget: US$ 334,903

Brazil

105) Creation of reserves in eastern Brazil. The most serious conservation problem in Brazil at present is the almost complete lack of federally-run reserves to protect the rare and endemic terrestrial succulents from the dry parts of north-east and south-east Brazil, and from the rocky east Brazilian Highlands, which rise out of the dry zone.

a) Rio Jequitinhonha valley, middle section (i.e. Araçuaí to Jacinto), north-eastern Minas Gcrais. One of the most important areas needing protection amongst the southern caatinga-agrcstc vegetation zone where a remarkably rich assortment of endemic and potentially threatened cactus species exists.
b) Rio de Contas, Mun. Maracas, Bahia, just cast of Porto Alegre on the north bank. Here lies a comprehensive range of southern caatinga cacti, including the rare *Espostoopsis dybowskyi.*
c) São Francisco River valley with its deep soils and Bambui limestone outcrops in the (especially for Bombacaceae and columnar Cactaceae) hosts two potential sites:
   i) massive raised outcrop south of the town of Iuiú on the east bank of the river (Bahia) hosting some spectacular bottle-trees of *Cavanillesia* and *Ceiba* as well as two very local

endemics *(Facheiroa estevesii, Opuntia estevesii)* restricted to the rock itself,

ii) west side of the river where further endemics, such as the *Micranthocereus dolichospermaticus* and *Facheiroa cephaliomelana,* are located.

Locations where new protected areas are needed to assist the conservation of the rare cacti of eastern Brazil, including the CITES Appendix I cactus taxa, are as follows:

a) Serra Dourada (Goiás),
b) arenitic outcrops 20-25 km west of Morro do Chapéu (Bahia),
c) southern end of the Serra Chapada and associated cerrado (27-28 km W of Seabra, BA),
d) quartzitic outcrops at Brejinho das Ametistas (S BA),
e) Serra Geral c. 12-15 km east of Monte Azul (Minas Gerais),
f) Serra Geral with white sand cerrado 12 km east of Mato Verde (MG),
g) Serra Bocaina (N of Grão Mogol, MG),
h) cerrado and mountains around Grão Mogol itself,
i) Serra do Cabral (MG),
j) western slopes of the Serra de Minas east of Santa Barbara (Mun. Augusto de Lima, MG),
k) one or more sites in the vicinity of Diamantina (MG),
l) Serra Negra between Itamarandiba and Rio Vermelho (MG),
m) Serra do Caraça (Mun. Santa Barbara, MG)

Extension of the Parque Nacional Chapada Diamantina, Bahia slightly to its west, to include a second population of the remarkable *Arrojada bahiensis.*

Field survey to investigate the feasibility of recommending protected areas for rare and probably vulnerable (but inadequately studied) species of Rhipsalideae from the region of Rio de Janeiro such as *Rhipsalis cereoides, R. mesembryanthemoides,* and *Schlumbergera orssichiana.*

106) **Monitoring of epiphytic cacti in the Atlantic Coastal Forest.** Monitoring by local scientists of the status and level of protection afforded to epiphytic cacti at the following sites:

a) Parques Nacionais da Floresta da Tijuca and da Serra dos Orgãos (RJ),
b) Parques Estaduais de Ilha Grande (RJ), de Ibitipoca (MG), de Campos do Jordão and de Picinguaba (SP),
c) Reservas Biologicas de Poço das Antas, de Paranapiacaba, da Jureia, Ilhabela, and that proposed for the Serra do Japi (SP).

Paraguay

107) Designation of Cerro León as a national park.

108) Field surveys in the Cordillera de los Altos to determine status of smaller-growing species.

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Annex 1

Members of the Agavaceae with restricted distribution'

Prepared by Wendy Hodgson and Abisai Garcia Mendoza.

	Conservation status			
	CITES	IUCN[3]	FWS[4]	SEMARNAP[5]
Agave acicularis Trel.		E		
A. acklinicola Trel.		I		
A. aktites Gentry				
A. angustifolia Haw. var. ***nivea*** (Trel.) Gentry		R		
A. arizonica Gentry & J.Weber	I	E	E	
A. asperrima Jacobi ssp. ***maderensis*** (Gentry) Ullrich				
A. asperrima ssp. ***potosiensis*** (Gentry) Ullrich				
A. asperrima ssp. *zarcensis* (Gentry) Ullrich				
A. atrovirens Karw. var. ***mirabilis*** (Trel.) Gentry				
A. attenuata Salm-Dyck				
A. avellanidens Trel.				
A. bahamana Trel.				
A. braceana Trel.				
A. bracteosa S.Watson ex Engelm.				A
A. cacozela Trel.				
A. capensis Gentry				
A. celsii Hook.f. var. ***albicans*** (Jacobi) Gentry				
A. chiapensis Jacobi				R
A. *chrysoglossa* I.M.Johnston				
A. colimana Gentry				
A. *congesta* Gentry		R		R
A. cupreata Trel. & Berger				
A. dasylirioides Jacobi & Bouché		V		A
A. deamiana Trel.				
A. *eggersiana* Trel.				
A. *felgeri* Gentry				
A. *filifera* Salm-Dyck				
A. *fortiflora* Gentry				
A. *funkiana* Koch & Bouche				
A. *geminiflora* (Tagl.) Ker Gawler				
A. gigantensis Gentry				
A. *glomeruliflora* (Engelm.) Berger		I	c2	
A. grisea Trel.		E		
A. guiengola Gentry		V		A
A. gypsophila Gentry				R
A. *hiemiflora* Gentry				
A. hookeri Jacobi				
A. *horrida* Lem. ex Jacobi				
A. *hurteri* Trel.		nt		
A. *impressa* Gentry		V		***A***
A. inaguensis Trel.				
A. inaequidens Koch ssp. ***barrancensis*** Gentry				
A. indagatoncm Trel.				
A. *intermixta* Trel.				
A. isthmensis Garcia-Mend. & Palma				
A. jaibolie Gentry				
A. kellermaniana Trel.				
A. kewensis Jacobi		R		R
A. lagunae Trel.		R		
A. longipes Trel.		R		
A. *lurida* Aiton		E		P
A. *margaritae* Brandegee				
A. mckelveyana Gentry			C3	
A. *millspaughii* Trel.		I		
A. minarum Trel.				
A. moranii Gentry				
A. murpheyi Gibson		R	c2	
A. nashii Trel.				
A. nayaritensis Gentry				
A. *neglecta* Small				
A. nizandensis Cutak		E		
A. *obscura* Schiede				
A. ocahui Gentry var. ***ocahui***				
A. ocahui var. ***longifolia*** Gentry				
A. ornithobroma Gentry				
A. oroensis Gentry				
A. panamana Trel.				
A. papyrocarpa Trel.		E		
A. parrasana Berger		R		R
A. *parviflora* ssp. *flexiflora* Gentry	I	V		A
A. *parviflora* Torr. ssp. *parviflora*	I	R	C2	R
A. peacockii Croucher		R		R
A. pelona Gentry				
A. pendula Schnittsp.				
A. polian *thiflora*				A
A. potrerana Trel.				
A. promontori Trel.				
A. pumila De Smet ex Baker				
A. rhodacantha Trel.				
A. scaposa Gentry				
A. schottii Engelm. var. ***treleasei*** (Tourney) Kearney & Peebles		E	C2	
A. sebastiana Greene				
A. shrevei Gentry ssp. ***matapensis*** Gentry				
A. sobria Brandegee ssp. *frailensis* Gentry				

	Conservation status			
	CITES	FWS[4]	IUCN[3]	SEMARNAP[5]
A. sobria ssp. *roseana* (Trel.) Gentry				
A. stringens Trel.				
A. subsimplex Trel.				
A. tecta Trel.			R	R
A. thomasae Trel.			R	R
A. titanota Gentry			R	R
A. triangularis Jacobi				
A. utahensis Engelm. var. *eborispina* (Hes.) Breitung			nt	*c3*
A. victoriae-reginae Moore	II		E	P
A. vizcainoensis Gentry			R	R
A. warelliana Baker				
A. weberi Cels ex Poiss.				
A. wendtii Basañez, sp. nov. in ed.				
A. wercklei Weber ex Berger			E	
A. zebra Gentry				
Agave sp. (central Arizona)				*c2*
Beaucarnea *congesta* Hernandez, sp. nov. in ed.				
B. goldmanii Rose				A
B. gracilis Lemaire				A
B. guatemalensis Rose				
B. hiriartiae Hernandez				A
B. pliabilis (Baker) Rose				A
B. purpusii Lemaire				A
B. recurvata Lemaire (incl. *B. inermis* [S.Watson] Rose)				A
B. stricta Lemaire				A
Beschorneria *albiflora* Matuda			R	
B. calcicola Garcia-Mend.			R	R
B. tubiflora (Kunth & Bouche) Kunth				R
B. wrightii Hook.			R	R
Calibanus *hookeri* (Lem.) Trel.			I	
Dasylirion *longissimum*				A
D. longistylum Macbride				
D. palaciosii Rzed.				R
Furcraea *bedinghausii* Koch			**V**	A
F. cabuya Trel.				
F. cahum Trel.				
F. guatemalensis Trel.				
F. guerrerensis Matuda				
F. hexapetala (Jacq.) Urban				
F. macdougalii Matuda			I	P
F. macrophylla Baker				
F. melanodonta Trel.				
F. stratiotes Boye-Pedersen			R	
F. tuberosa (Willd.) W.T.Aiton				
Hesperaloe *chiangii* Starr, sp. nov. in ed.				
H. funifera (Koch) Trel.			R	
H. nocturna Gentry				
H. parviflora (Torr.) Coulter				
Manfredae *brunnea*				A
Manfreda chamelensis Lott & Verhoek				
M. elongata Rose				
M. fusca Ravenna				
M. guerrerensis Matuda			R	R
M. hauniensis (Boyc-Petersen) Verhoek				

	Conservation status			
	CITES	FWS[4]	IUCN[3]	SEMARNAP[5]
M. involuta McVaugh				
M. longibracteata Verhoek				
M. longiflora (Rose) Verhoek				A
M. maculata (Mart.) Rose				
M. nanchititlensis Matuda				A
M. planifolia (S.Watson) Rose				
M. potosina (Robinson & Greenm.) Rose				
M. pubescens (Regel & Ortega) Verhoek ex I.L.Piña				
M. revoluta (Klotsch) Rose				
M. rubescens Rose				
M. sileri Verhoek				
Nolina *arenicola* Correll				
N. atopocarpa Bartlett				
N. beldingii Brandegee var. *deserticola* Trel.				
N. brittoniana Nash				E
N. cespitifera Trel.				
N. elegans Rose				
N. humilis S.Watson				
N. inter-rata Gentry	I		E	
N. lindheimeriana (K.Schum.) S.Watson				
N. nelsoni Rose				
N. palmeri S.Watson var. *palmeri*				
N. palmeri var. *brandegeei* Trel.				
N. pumila Rose				
N. parryi S.Watson var. *wolfii* Munz				
Pleomele *angustifolia* N.E.Br.				
P. aurea (Mann.) N.E.Br.			nt	
P. auwahiensis St.John			nt	
P. elliptica (Thunb.) O.Deg.				
P. femaldii St.John			nt	
P. flexuosa (Regel) O.Deg.				
P. forbesii O.Deg.			nt	
P. halapepe St.John			nt	
P. hawaiiensis O.Deg. & I.Deg.				
Pleomele sp. (Hawaii)				
Polianthes *densiflora* (Robinson & Fernald) Shinner			R	
P. elongata Rose				
P. geminiflora (Lex.) Rose var. *clivicola* McVaugh				
P. gracilis Link & Otto				
P. howardii Verhoek			R	R
P. longiflora Rose			R	R
P. montana Rose				
P. nelsoni Rose				
P. palustris Rose			R	R
P. platyphylla Rose			R	R
P. sessiliflora (Hemsl.) Rose				
Yucca *angustissima* Engelm. & Trel. var. *avia* Reveal				
Y. angustissima var. *toftiae* (Welsh) Reveal			E	
Y. arizonica McKelvey			nt	
Y. campestris McKelvey				
Y. coahuilensis Matuda & I.L.Piña				
Y. elata Engelm. var. *verdiensis* (McKelvey) Reveal				
Y. endlichiana Trel.				

	Conservation status		
	CITES	FWS[4]	
		IUCN[3]	SEMARNAP[5]
Y. grandiflora Gentry		R	R
Y. jaliscensis Trel.		V	
Y. lacandonica Gómez Pompa & Valdez		V	A
Y. madrensis Gentry		nt	
Y. queretaroensis			*R*
Y. necopina Shinner		E	
Y. potosina Rzed.			
Y. queretaroensis I.L Piña			
Y. whipplei Torr. var. *eremica* Epling & Haines			

[1] Taxa considered to be micro-aerial (narrow) endemics inhabiting zones of less than 100km in length and width.

[2] CITES:

Appendix 1 No international tradc allowed

Appendix II International trade only by permit

[3] IUCN Categories at the global level (old categories of threat are used here): see Annex 16

[4] US Fish and Wildlife Service (USFWS) listing:

E = Endangered: any species in danger of extinction throughout all or a significant portion of its range.

T = Threatened: any species likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Cl = Category 1 status: taxa for which the FWS has sufficient (but not necessarily complete) information on vulnerability and threats to support a proposal to list them as threatened or endangered.

C2= Category 2 status: taxa for which the FWS has insufficient information to support a proposed rule to add the species to the threatened or endangered species list; further biological research and field study will usually be needed to change the status of taxa in category 2.

C3= Category 3 status: taxa that are no longer being considered for listing as endangered or threatened (and included in one of the three subcategories).

[5] SEMARNAP Categories for Mexico

A = threatened (amenazada)

R = rare (rara)

P = in danger of extinction (en peligro de extinción)

Annex 2

Asclepiadaceae of conservation concern

Prepared by Focke Albers and Ulrich Meve.

Brachystelma S i m s

R *B. alpinum* R.A.Dyer
R *B. arenarium* S.Moore
R *B. attenuatum* (Wight) Hook.
R *B. australe* R.A.Dyer
R *B. blepharanthera* Huber
I *B. bourneae* Gamble
R *B. brevipedicellatum* Turrill
I *B. brevitubulatum* (Bedd.) Gamble
R *B. buchananii* N.E.Br.
R *B. caffrum* (Schltr.) N.E.Br.
R *B. campanulatum* N.E.Br.
E *B. canum* R.A.Dyer
E *B. cathcartense* R.A.Dyer
R *B. caudatum* (Thunb.) N.E.Br.
R *B. chlorozonum* E.A.Bruce
K *B. ciliatum* Arekal & Ramakrishna
I *B. comptum* N.E.Br.
R *B. constrictum* J .Hall
R *B. decipiens* N.E.Br.
E *B. delicatum* R.A.Dyer
I *B. dimorphum* R.A.Dyer ssp. *dimorphum*
I *B. dimorphum* R.A.Dyer *ssp. gratum* R.A.Dyer
R *B. discoidcum* R.A.Dyer
R *B. duplicatum* R.A. Dyer
R *B. edulis* Coll. & Hemsl.
R *B. elegantulum* S.Moore
R *B. elenanduensis* M.Char
R *B. elongatum* (Schltr.) N.E.Br.
E *B. exile* Bull.
R *B. festucifolium* E.A.Bruce
E *B. furcatum* Boele
E *B. gemmeum* R.A.Dycr
R *B. gerrardii* Harv.
R *B. glabriflorum* (F.Muell.) Schltr.
E *B. glabrum* Hook.f.
Ex *B. glenense* R. A. Dycr
E *B. gracillimum* R.A.Dyer
R *B. huttonii* (Ha-v.) N.E.Br.
E *B. incanum* R.A.Dycr
R *B. keniense* Schweinf.
R *B. kerrii* Craib
K *B. kolarensis*
R *B. laevigatum* (Wight) Hook.f.
R *B. lancasteri* Bocle
R *B. lankana* Dassan. & Jayag.
E *B. letestui* Peller.
R*(?*Ex*)* *B. longifolium* (Schltr.) N.E.Br.
R *B. macropetalum* (Schltr.) N.E.Br.
I *B. maculatum* Hook.f.
R *B. medusanthemum* J.-P.Lebrun & Stork
R *B. merrillii* Schltr.
R *B. meyerianum* Schltr.
R *B. micranthum* E.Mey.
R *B. minimum* R.A.Dyer
R *B. minor* E.A.Bruce
R *B. modestum* R.A.Dyer
E *B. montanum* R.A.Dyer
R *B. mortonii* Walker
E*(?*Ex*)* *B. natalense* (Schltr.) N.E.Br.
E *B. ngomense* R.A.Dycr
I*(?*Ex*)* *B. occidentale* Schltr.
R *B. omissum* Bull.
I *B. pachypodium* R.A.Dyer
R *B. papuanum* Schltr.
R *B. parviflorum* (Wight) Hook.f.
I *B. parvulum* R.A.Dyer
K *B. pauciflorum* Duthie
R *B. perditum* R.A.Dyer
R *B. petraeum* R.A.Dyer
R *B. pilosum* R.A.Dyer
E *B. praelongum* S.Moore
R *B. prostratum* E.A.Bruce
R *B. ramosissimum* (Schltr.) N.E.Br.
R *B. rangacharii* Gamble
R *B. sandersonii* (Oliv.) N.E.Br.
E *B. schinzii (*K.Schum.*)* N.E.Br.
E *B. schizoglossoides* (Schltr.) N.E.Br.
I*(?*Ex*)* *B. schoenlandianum* Schltr.
R *B. simplex* Schltr.
R *B. subaphyllum* K.Schum.
R *B. swazicum* R.A.Dycr
E *B. tabularium* R.A.Dyer
R *B. tavalla* K.Schum.
E *B. tenellum* R.A.Dyer
Ex *B. tenue* R.A.Dyer
R *B. thunbergii* N.E.Br.
R *B. tuberosum* R.Br.
R *B. vahrmeijeri* R.A.Dyer
R *B. villosum* (Schltr.) N.E.Br.
R *B. volubile* Hook.f.

Caralluma **R.Br.**

K *C. adscendens* (Roxb.) R.Br. var. *adscendens*
K *C. arabica* N.E.Br.
R *C. baradii* Lavranos
R *C. beviloba* (P.R.O.Bally) M.G.Gilbert
R *C. bhupinderana* Sarkaria
R C. *circes* M.G.Gilbert
R *C. congestiflora* P.R.O.Bally
R *C. crenulata* Wall.
R *C. dicapuae* (Chiov.) Chiov. ssp. *dicapuae*
V *C. diffusa* (Wight) N.E.Br.
E *C. dodsoniana* Lavranos
K *C. dolichocarpa* Schwartz
R *C. edwardsae* (M.G.Gilbert) M.G.Gilbert
K *C. foetida* Bruce
E *c. furta* P.R.O.Bally
E *C. joannis* Maire
R *C. lavrani* Rauh & Wertel
R *C. laticorona* (M.G.Gilbert) M.G.Gilbert
R *C. longiflora* M.G.Gilbert
R *C. mireillae* Lavranos
R *C. moniliformis* P.R.O.Bally
R *C. munbyana* (Decne) N.E.Br. var. *munbyana*
R *C. nilagiriana* Kumani & Rao
R *C. peckii* P.R.O.Bally

R *C. munbyana* (Decne) N.E.Br. var. *munbyana*
R *C. nilagiriana* Kumani & Rao
R *C. peckii* P.R.O.Bally
R *C. peschii* Nel
R *C. priogonium* K.Schum.
K *C. procumbens* Grav. & May.
K *C. rauhii* Lavranos
R *C. sarkariae* Lavranos & Frandsen
R *C. socrotrana* (Balf.f.) N.E.Br.
R *C. solenophora* Lavranos
K *C. somalica* N.E.Br.
R *C. staintonii* Hara
K *C. truncatocoronata* (Sedgw.) Grav. & May.
R *C. umbellata* Haw.
R *C. vaduliae* Lavranos

***Ceropegia* L.**

R *C. affinis* Vatke
R *C. albisepta* Jum. & H.Perrier
E *C. ampliata* var. *madagascariensis* Lavranos & Morat
Ex *C. antennifera* Schltr.
E *C. arenaria* R.A.Dyer
R *C. aridicola* W.W.Sm.
E *C. armandii* Rauh
K *C. arnottiana* Wight
R *C. attenuata*
I *C. barbata* R.A.Dyer
E *C. bamesii* Bruce & Chatterjee
R *C. beddomei* Hook.f.
I *C. bhutanica* Hara
E *C. bosseri* Rauh & Buchloh
R C. *botrys* K.Schum.
K *C. bowkeri Harv. ssp. bowkeri*
R *C. bowkeri* ssp. s.o. *sororia* (Harv. ex Hook.f.) R.A.Dyer
R *C. brevirostris* P.R.O.Bally & Field
K *C. campanulata* Don var. *campanulata*
R *C. cancellata* Rchb.
K *C. candelabrum L.* ssp. s.o. *candelabrum*
K *C. ca taphyllaris* Bull.
V *C. cera tophora* Sven t .
R *C. chipiaensis* Stopp.
K *C. chortophylla* Werderm.
K *C. christenseniana* Hand.-Mazz.
E *C. chrysantha*
V *C. cimiciodora* Oberm.
R *C. conrathii* Schltr.
K *C. convoluloides* A.Rich.
E *C. cycniflora* R.A.Dyer
K *C. damannii* Stopp.
R *C. decidua* Bruce ssp. *decidua*
R *C. decidua* ssp. *pretoriensis*
R *C. deightonii Hutch. & Dalzell* ssp. *deightonii*
R *C. dimorpha* Humbert
E *C. dinteri* Schltr.
R *C. distincta* ssp. *vermcolosa*
R C. *dorjei* C.E.C.Fisch.
E *C. evansii* McCann
E *C. fantastica* Sedgw.
R *C. filiformis* (Burch.) Schltr.
R *C. fimbriata* E.Mey. ssp. *fimbriata*
R *C. fimbriata* ssp. *connivens* (R.A.Dyer) Bruyns
R *C. fimbriata* ssp. *geniculata* (R.A.Dyer) Bruyns
R *C. fimbrifera* Beddome
R *C. floribunda* N.E.Br.
K *C. furcata* Werderm.
K *C. gemmifera* K.Schum.
K *C. gilgiana* Werderm.
K *C. hirsuta* Wight & Arn.
E *C. hofstaetteri* Rauh
E *C. huberi* Ansari
R *C. humbertii* Huber
K *C. illegitima* Huber
K *C. inflata* Hochst. ex Chiov.
E *C. insignis* R.A.Dyer
R *C. jainii* Ansari & B.G.P. Kulk.
R *C. kachinensis* Prain
V *C. krainzii* Svent.
R *C. kundelunguensis* Malaisse
R *C. langkawiensis* Rintz
E *C. lawii* Hook.f
K *C. ledermanii* Schltr.
E *C. leroyi* Rauh & Marn.- Lap.
R *C. lindenii* Lavranos
K *C. loranthiflora* K.Schum.
K *C. ludlowii* Huber
R *C. maccannii* Ansari
R *C. madagascariensis* Decne.
K *C. madens* Werderm.
R *C. mafekingensis* (N.E.Br.) R.A.Dyer
E *C. mahabalei* Hem. & Ansari
K *C. mairei* (Lev.) Huber var. *mairei*
R *C. maiuscula* Huber
E *C. mayottae* Huber
R *C. media* (Huber) Ansari
K *C. mendesii* Stopp
K *C. mirabilis* Huber
K *C. monticola* W.W.Sm.
K *C. muliensis* W.W.Sm.
R *C. muzhingana* Malaisse
K *C. nana* Coll. & Hemsl.
R *C. noorjahanae* Ansari
R *C. ngoyana* Malaisse
R *C. nuda* Hutch. & Bruce
V *C. occidentalis* R.A.Dyer
E *C. occulta* R.A.Dyer
E *C. odorata* Nimmo ex Hook.f.
E *C. omissa* Huber
E *C. panchganiensis* Blatt. & McCann
K *C. paohsingensos* Tsiang & Li
R *C. paricyma* N.E.Br.
I *C. parviflora* Trimen
K *C. peteri* Werderm.
E *C. petignatii* Rauh
K *C. porphyrotricha* W.W.Sm.
R *C. pusilla* Wight & Arn.
R *C. radicans* Schltr. ssp. *radicans*
E *C. razafindratsirana* (Rauh & Buchloh) Rauh
K *C. renzii* Stopp
K *C. ringens* A.Rich
R *C. rollae* Hemadri
V *C. rudatisii* Schltr.
E *C. sahyadrica* Ansari & Kulk.
K *C. salicifolia* Huber
R *C. santapaui* Wadhwa & Ansari
R *C. saxatilis* Jum. & Perr.
R *C. scabra* Jum. & Perr.
R *C. scabyriflora* N.E.Br.
K *C. schliebenii* Markgr.
K *C. senegalensis* Huber
E *C. simoneae* Rauh
K *C. sootepensis* Huber
K *C. speciosa* Huber

R *C. spiralis* Wight
E *C. stentiae* Bruce
R *C. swaziorum* D.V.Field
R *C. taprobanica* Huber
K *C. teniana* Hand.-Mazz.
K *C. thwaitesii* Hook
R *C. tihamana* Chaudhary & Lavranos
R *C. tomentosa* Schltr.
R *C. turricula* Bruce
R C. *ugeni* C.E.C.Fisch.
K *C. vanderystii* De Wild.
K *C. vignaldiana* A.Rich.
E *C. vincaefolia* Hook
R *C. viridis* Choux
K *C. wallichii* Wight

***Cynanchum* L.**

K *C. aequilongum* Choux
K *C. ambositrense* Choux
K *C. ampanihense* Jum. & H.Perrier
K *C. andringitrense* Choux
K *C. angkavokeliense* Choux
K *C. antandroy* Desc.
K *C. appendicula turn* Choux
K *C. arenarium* Jum. & H.Perrier
K *C. bekinolense* Choux
K *C. bisinuatum* Jum. & H.Perrier
K *C. bojerianum* Decne.
R *C. compactum* Choux
K *C. cucullatum* N.E.Br.
K *C. danguyanum* Choux
K *C. decaisneanum* Desc.
R *C. descii* Rauh
K *C. fibriatum* Choux
K *C. gerrerdii* (Harvey) Liede
K *C. implicatum* (Jum. & H.Perrier) Jum. & H.Perrier
K *C. juliani-marnieri* Desc.
K *C. Jumi* Choux
K *C. junciforme* (Decne.)Liede
K *C. lecontei* Choux
K *C. lineare* N.E.Br.
K *C. luteifluens* (Jum. & H.Perrier) Desc.
K *C. macranthum* Jum. & H.Perrier
R *C. macrolobum* Jum. & H.Perrier
K *C. madagascariense* K.Schum.
K *C. madecassum* Desc.
K *C. mahafalense* Jum. & H.Perrier
K *C. menarandrense* Jum. & H.Perrier
K *C. messeri* (Buchenau) Jum. & H.Perrier
R *C. marnieranum* Rauh
K *C. moramangense* Choux
K *C. napiferum* Choux
K *C. napiforme* Choux
K *C. nodosum* (Jum. & H.Perrier) Desc.
R *C. pachylobum* Choux
K *C. papillatum* Choux
K *C. radiatum* Jum. & H.Perrier
E *C. rossii* Rauh
K *C. sessiliflorum* (Decne.)Liede
K *C. subtilis* Liede
K *C. surprisum* Liede

***Duvalia* N.E.Br.**

E *D. anemoniflora* (Deflers) R.A.Dyer & Lavranos
E *D. galgallensis* Lavranos
R *D. parviflora* N.E.Br.
K *D. pillansii* N.E.Br.
R *D. somalensis* Lavranos

***Duvaliandra* M.G.Gilbert**

E *D. dioscoriodes* (Lavranos) M.G.Gilber

***Echidnopsis* Hook.f.**

R/E *E. angustiloba* Bruce & P.R.O.Bally
R *E. archeri* P.R.O.Bally
E *E. ballyi* (Marnier-Lap.) P.R.O.Bally
E *E. bihendulensis* P.R.O.Bally
E *E. ciliata* P.R.O.Bally
E *E. ericiflora* Lavranos
E *E. insularis* Lavranos
E *E. leachii* Lavranos
R *E. malum* (Lavranos) Bruyns
R *E. mijerteina* Lavranos var. *mijerteina*
R *E. milleri* Lavranos
R *E. montana* (R.A.Dyer & Bruce) P.R.O.Bally
R *E. repens* R.A.Dyer & I.Verd.
E *E. seibanica* Lavranos
R *E. socotrana* Lavranos
R *E. squamulata* (Decne.) P.R.O.Bally
R *E. urceolata* P.R.O.Bally
R *E. virchowii* K.Schum.

Folotsia

K *F. aculeatum* Jum. & H.Perrier
K *F. floribundum* Desc.
K *F. grandiflorum* Jum. & H.Perrier
K *F. madagascariense* (Jum. & H.Perrier) Desc.
K *F. sarcostemmoides* cost. & Bois

***Frerea* Dalzell**

E *F. indica* Dalzell

Hoodia Sweet.

R *H. dregei* N.E.Br.
R *H. juttae* Dinter
I *H. mossamedensis* (Leach) Plowes
R *H. officinalis* ssp. *delaetiana* (Dinter) Bryuns
R *H. pilifera* (L.f.) Plowes ssp. *annulata* (N.E.Br.) Bryuns
R *H. pilifera* ssp. *pilifera* (L.f.) Plowes
V *H. pilifera* ssp. *pillansii* (N.E.Br.) Bryuns
I *H. ruschii* Dinter
R *H. triebneri* (Nel) Bruyns

Huernia R.Br.

R *H. andreaeana* (Rauh) Leach
R *H. arabica* N.E.Br.
E *H. archeri* Leach
E *H. baveri* Leach
E *H. boleana* M.G.Gilbert
R *H. coninna* N.E.Br.
I *H. erectiloba* Leach & Lavranos
R *H. erinacea* P.R.O.Bally
E *H. hadhramautica* Lavranos
R *H. hallii* E. & B.M. Lamb
R *H. humilis* (Masson) Haw.
V *H. hystrix* (Hook.f.)N.E.Br. var. *parvula* L.C.Leach
V *H. kennedyana* Lavranos
R *H. leachii* Lavranos
R *H. lodarensis* Lavranos
R *H. longii* Pillans
R *H. marnieriana* Lavranos
R *H. nigeriana* Lavranos

V *H. nouhuysii* I.Verd.
I *H. pendula* E.A.Bruce
R *H. piersii* N.E.Br.
R *H. plowesii* Leach
R *H. praestans* N.E.Br.
R *H. procumbens* (R.A.Dyer) Leach
R *H. quinta* (Phillips) A.C. White & B. Sloane
R *H. recondita* M.G.Gilbert
I *H. schneideriana* Berger
I *H. similis* N.E.Br.
R *H. tanganyikensis* Bruce & P.R.O.Bally
Ex *H. thudichumii* Leach
R *H. urceolata* Leach
R *H. whitesloaneana* Nel
Ex *H. witzenbergensis* C.A. Liickh.

***Huerniopsis* N.E.Br.**
R *H. atrosanguinea* (N.E.Br.) A.C. Wight & B.Sloane

Karimbolea
E *Karimbloea verrucosa* Desc.

***Lavrania* Plowes**
R *L. haagnerae* Plowes

***Notechidnopsis* Lavranos & Bleck**
R *N. columnaris* (Nel) Lavranos & Bleck

***Orbea* (L.) Haw.**
R *0. ciliata* (Thunb.) Leach
R *0. halipedicola* Leach ssp. *halipedicola*
I *0. macloughlinii* (I.Verd.) Leach
V *0. paradoxa* (I.Verd.) Leach
I *0. prognatha* (P.R.O.Bally) Leach
R *0. rangeana* (Dinter & Berger) Leach
V *0. speciosa* Leach
R *0. woodii* (N.E.Br.) Leach

***Orbeanthus* Leach**
V *0. conjunctus* (A.C. White & B. Sloane) Leach
V *0. hardyi* (R.A.Dyer) Leach

***Orbeopsis* Leach**
R *0. albocastanea* (Marloth) Leach
R *0. gerstneri* (Letty) Leach ssp. *elongata* (R.A.Dyer) Leach
V *0. gerstneri* ssp. *gerstneri*
R *0. gossweileri* (S.Moore) Leach
R *0. huillensis* (Hiern) Leach
K *0. knobelii* (Phillips) Leach
R *0. tsumebensis* (Oberm.) Leach

***Pachycymbium* Leach**
R *P. abayense* (M.G.Gilbert) M.G.Gilbert
R *P. araysianum* (Lavranos & Bilaidi) M.G.Gilbert
K *P. chrysostephanum* (Deflers) M.G.Gilbert
R *P. denboefii* (Lavranos) M.G.Gilbert
R *P. distinctum* (E.A.Bruce) M.G.Gilbert
R *P. eremastrum* (Schwartz) M.G.Gilbert
R *P. gemugofanum* (M.G.Gilbert) M.G.Gilbert
R *P. huernioides* (P.R.O.Bally) M.G.Gilbert
R *P. kochii* (Lavranos) M.G.Gilbert
R *P. laikipiense* M.G.Gilbert
R *P. lancasteri* Lavranos
R *P. meintjesianum* (Lavranos) M.G.Gilbert
R *P. rogersii* (L.Bolus) M.G.Gilbert
R *P. sacculatum* (N.E.Br.) M.G.Gilbert
E *P. sprengeri* ssp. *ogadense* (M.G.Gilbert) M.G.Gilbert
R *P. tubiforme* (Bruce & P.R.O.Bally) M.G.Gilbert
V *P. umbomboense* (I.Verd.) M.G.Gilbert
E *P. wilsonii* (P.R.O.Bally) M.G.Gilbert

***Pectinaria* Haw**
R *P. articulata* (Aiton) Haw. ssp. *articulata*
R *P. articulata* ssp. *borealis* Bruyns
R *P. longipes* (N.E.Br.) Bruyns

***Piaranthus* R.Br.**
R *P. barrydalensis* Meve
R *P. framesii* Pillans

***Pseudolithos* P.R.0 Bally**
I *P. caput-viperae* Lavranos
I *P. cubiformis* (P.R.O.Bally) P.R.O.Bally
I *P. horwoodii* P.R.O.Bally & Lavranos
I *P. migiurtinus* (Chiov.) P.R.O.Bally

***Quaqua* N.E.Br.**
R *Q. armata* (N.E.Br.) Bruyns ssp. *arenicola* (N.E.Br.) Bruyns
R *Q. armata* ssp. *maritima* Bruyns
R *Q. framesii* (Pillans) Bruyns
R *Q. inversa* (N.E.Br.) Bruyns var. *cincta* (C.A. Lückh.) Bruyns
R *Q. inversa* (N.E.Br.) Bruyns ssp. *inversa*
R *Q. linearis* (N.E.Br.) Bruyns
R *Q. multiflora* (R.A.Dyer) Bruyns
R *Q. parviflora* ssp. *bayeriana* Bruyns
R *Q. pruinosa* (Masson) Bruyns

***Rhytidocaulon* P.R.O.Bally**
E *R. fulleri* Lavranos & Mort.
E *R. paradoxum* P.R.O.Bally
R *R. sheilae* Field
E *R. subscandens* P.R.O.Bally
E *R. tortum* (N.R.Br.) M.G.Gilbert
E *R. richardianum* Lavranos

***Riocreuxia* Decne**
R *R. aberrans* R.A.Dyer
E *R. alexandrina* R.A.Dyer
E *R. bolusii* N.E.Br.
R *R. chrysochroma* (Huber) A.C. Smith
K *R. nepalensis* A.C.Smith
K *R. splendida* K.Schum.
Ex *R. woodii* N.E.Br.

***Sarcostemma* R.Br.**
K *S. decorsei* Cost. & Gall.
K *S. insignis* N.E.Br.
K *S. madagascariensis* Desc.
K *S. viminale* R.Br.

***Stapelia* L.**
R *S. baylissii* Leach
E *S. cedrimontana* Frandsen
V *S. clavicorona* I.Verd.
V *S. divaricata* Masson
R *S. erectiflora* N.E.Br. var. *prostratiflora* L.C. Leach
I *S. glabricaulis* N.E.Br.
V *S. immelmaniae* Pillans
R *S. kouga bergensis* Leach
R *S. montana* Leach var. *montana*
I *S. obducta* Leach
R *S. paniculata* Willd.
E *S. parvula* Kers.
R *S. pearsonii* N.E.Br.
R *S. peglerae* N.E.Br.

R	*S. pillansii* N.E.Br. var. *pillansii*
R	*S. praetermissa* Leach var. *praetermissa* Leach
R/V	*S. remota* R.A.Dyer
R/V	*S. rubiginosa* Nel
E/V	*S. scitula* Leach
R	*S. tsomoensis* N.E.Br.
E	*S. unicornis* C.A. Lückh.
	***Stapelianthus* Choux**
R	*S. arenarius* Bosser & Morat
K	*S. calcarophilus* Morat
R	*S. decaryi* Choux
R	*S. hardyi* Lavranos
R	*S. insignis* Desc. var. *insignis*
R	*S. insignis* var. *tangoboryensis* Rauh
R	*S. keraudreniae* Bosser & Morat
R	*S. montagnacii* (Boiteau) Boiteau & Bertrand
R	*S. pilosus* (Choux) Lavranos & Hardy
	***Stapeliopsis* Pillans**
V	*S. breviloba (*R.A.Dyer*)* Bruyns
R	*S. exasperata* (Bruyns) Bruyns
E	*S. neronis* Pillans
R	*S. pillansii* (N.E.Br.) Bruyns
V	*S. saxatilis* N.E.Br. ssp. *stayneri* (M.B.Bayer) Bruyns
R	*S. urniflora* Lavranos
	***Tavaresia* Welw.**
R	*T. angolensis* Welw.
	Tenaris E. Mey
R	*T. schultzei* (Schltr.) Phillips
	***Tridentea* Haw.**
R	*T. baylisii* (Leach) var. *baylisii*
R	*T. baylisii* (Leach) var. *ciliata*
R	*T. choanantha* (Lavranos & Hall) Leach
K	*T. dwequensis* (C.A.Lückh.) Leach
R/V	T. *herrei* (Nel) Leach
R	*T. longii* (C.A.Lückh.) Leach
R	*T. marientalensis* ssp. *albipilosa* (Giess) Leach
R/V	*T. pachyrrhiza* (Dinter) Leach
R	*T. parvipuncta* var. *truncata* (C.A. Liickh.) Leach
R	*T. peculiaris* (C.A.Lückh.) Leach
R	*T. ruschiana* (Dinter) Leach
	***Tromotriche* Haw.**
R	*T. engleriana* (Schltr.) Leach
E	*T. revoluta* (Masson) Haw.
R	*T. thudichumii* (Pillans) Leach
	***White-slonea* Chiov.**
E	*W. crassa* (N.E.Br.) Chiov.

[1] Old TUCN Red List categories are used. See Annex 16 for definitions.

Annex 3

Succulents regulated by CITES

Source: CITES/WCMC 1996.

	CITES listing'
AGAVACEAE	
Agave *arizonica*	I
A. parviflora	I
A. victoriae-reginae	II
Nolina *interra ta*	I
APOCYNACEAE	
Pachypodium entire genus	II
P. am bongense	I
P. baronii	I
P. decaryi	I
Rauvolfia *serpentina*	II
ASCLEPIADACEAE	
Ceropegia *en tire genus*	II
Frerea *indica*	II
CACTACEAE	
Entire familv	II
Ariocarpus entire genus	I
Astrophytum *asterias*	I
Aztekium *ritteri*	I
Coryphantha *werderrnannii*	I
Discocactus entire genus	I
Disocactus macdougallii (Nopalxochia macdougallii)	I
Echinocereus *ferreirianus* var. *lindsayi*	I
E. schmollii	I
Escobaria *minima (E. nellieae, Coryphantha minima)*	I
E. sneedii var. *leei*	I
- var. *sneedii*	I
Mammillaria *pectinifera*	I
M. solisioides	I
Melocactus *conoideus*	I
M. deinacanthus	I
M. *glaucescens*	I
M. paucispinus	I
Obregonia *denegrii*	I
Pachycereus *militaris*	I
Pediocactus *bradyi*	I
P. despainii	I
P. kno wltonii	I
P. paradinei	I
P. peeblesianus	I
P. sileri	I
P. winkleri	I
Pelecyphora entire genus	I
Sclerocactus *brevihama tus*	I
S. erectocentrus (Echinomastus erectocen trus)	I
S. glaucus	I
S. mariposensis (E. mariposensis)	I
S. mesae-verdae	I
S. papyracanthus	I
S. pubispinus	I
S. wrigh tiae	I
Strombocactus *disciformis*	
Turbinicarpus entire genus	
Uebelmannia entire genus	
DIDIEREACEAE	
Entire family	II
EUPHORBIACEAE	
Euphorbia entire genus	II
E. ambovombensis	
E. cremersii	
E. cylindrifolia	
E. decaryi	
E. francoisii	
E. moratii	
E. parvicya thophora	
E. quartziticola	
E. tulearensis	
FOUQUIERIACEAE	
Fouquieria *columnaris*	II
F. fascicula ta	
F. purpusii	
LILIACEAE	
Aloe entire genus (except *A. vera*)	II
A. albida	
A. albiflora	
A. alfredii	
A. bakeri	
A. bella tula	
A. calcairophila	
A. compressa	
A. delphinensis	
A. descoingsii	
A. fragilis	
A. ha worthioides	
A. helenae	
A. laeta	
A. parallelifolia	
A. parvula	
A. pillansii	
A. polyphylla	
A. rauhii	
A. suzannae	
A. thorncroftii	
A. versicolor	
A. vossii	
PORTULACACEAE	
Anacampseros entire genus	II
Cistanthe *tweedyi (Lewisia tweedyi)*	II
Lewisia *cotyledon*	II
L. maguirei	II
L. serrata	II

'Appendix I lists endangered species; international trade of wild specimens is banned under the terms of the CITES Convention. **Appendix II** lists species which may be threatened by excessive levels of trade and for which trade is permitted but controlled and monitored through a licensing system.

Annex 4

Succulents of Kenya of highest conservation concern

Compiled by Len Newton, 1995.

AIZOACEAE

Delosperma *abyssinicum* (Regel) Schwantes

ALOACEAE

Aloe *archeri* Lavranos
A. ballyi Reynolds
A. juvenna Brandham & S.Carter
A. massawana Reynolds
A. microdonta Chiovenda
A. parvidens M.G.Gilbert & Sebsebe
A. tugenensis L.E.Netwon & Lavranos
A. wrefordii Reynolds

ASCLEPIADACEAE

Brachystelma *lineare* A.Richard
Caralluma *distincta* Bruce
C. tubiformis Bruce & Bally
C. vibratilis Bruce & Bally
Ceropegia *albisepta* Jum. & Perr. var. *robynsiana* H.Huber
C. ampliata E.Meyer var. *oxyloba* H.Huber
C. ballyana Bullock
C. crassifolia Schlechter var. *copleyae* (Bruce & Bally) H.Huber
C. galeata H.Huber
C. somalensis Chiovenda
C. stenoloba Hochst. ex Chiovenda var. *moyalensis* H.Huber
C. variegata Decaisne
Echidnopsis *angustiloba* Bruce & Bally
E. ericiflora Lavranos
E. mariae Lavranos
E. radians Bleck
E. urceolata Bally
Huernia *andreaeana* (Rauh) Leach
H. archeri Leach
H. keniensis R.E.Fries var. *molonyae* White & Sloane
Orbea *semota* (N.E.Br.) Leach
Rhytidocaulon *paradoxum* Bally

CRASSULACEAE

Kalanchoe abyssinica ssp. hildebrandtii
K. aubrevillei Cufodontis
K. bipartita Chiovenda
K. boranae Raadts
K. fadeniorum Raadts
K. obtusa Engler

CURCURBITACEAE

Cephalopentandra *ecirrhosa* (Cogn.) Jeffrey

EUPHORBIACEAE

Euphorbia *ballyana* Rauh
E. borenensis Gilbert
E. brevitorta Bally
E. brunellii Chiovenda
E. classenii Bally & S.Carter
E. cussonioides Bally
E. pseudoburuana Bally & S.Carter
E. robecchii Pax
E. tanaensis Bally
E. taruensis S.Carter
E. turkanensis S.Carter
E. wakefieldii N.E.Br.
Jatropha *hildebrandtii* Pax var. *hildebrandtii*
Monadenium *rhizophorum* Bally
M. rubellum (Bally) S.Carter
M. stapelioides Pax var. *congestum* (Bally) S.Carter
M. trinerve Bally
M. yattanum Bally

ICACINACEAE

Pyrenacantha *malvifolia* Engler

MORACEAE

Dorstenia *bamimiana* Schweinfurth var. *tropaeolifolia*
D. zanzibarica Oliver

PASSIFLORACEAE

Adenia *globosa* Engler *ssp. globosa*

PERIPLOCACEAE

Raphionacme madiensis S.Moore

PORTULACACEAE

Portulaca *ciferrii*
P. grandis
P. oblonga
P. pilosa

VITACEAE

Cissus *quadrangularis* L. var. *aculeatangula* Verdcourt
C. rotundifolia (Forsskal) Vahl var. *ferruginea*

Annex 5

Provisional list of succulent species of the Mediterranean Region

Based on text compiled by Silvio Fici and Mauricio Sajeva. Table compiled by M. Sajeva and Henk t'Hart.

The Mediterranean phytogeographic region is generally considered to include the coastal fringe of the Mediterranean area with the exception of parts of the Libyan, Egyptian, and Tunisian coasts, but with the inclusion of the Atlantic coasts of Portugal, Spain, and Morocco. Macaronesia (Canaries, Madeira, and the Azores) and parts of the Black Sea coasts have a Mediterranean climate and are often included in this phytogeographic region.

Within the region there is considerable geological and climatic diversity which is reflected in the vegetation and flora. In large areas of the region, however, thousands of years of human influence, involving deforestation, overgrazing, fire, and urbanisation, has caused complete modification of the landscape and vegetation dynamics.

Succulent plants are relatively scarce in the Mediterranean flora; those that do occur are usually small in stature. They occur in various different habitat types, predominantly in montane regions. In contrast to the widely dispersed Macaronisian succulent flora, these plants are relatively dominant in only a few areas in the Mediterranean basin, most notably on the Atlantic coast of Morocco. Some succulents, such as *Caralluma* and *Kalanchoe,* belong to tropical or subtropical genera that reach their northern limits in this region. Most succulents, however, belong to genera of the Crassulaceae which are widespread in boreal regions, principally *Sedum, Jovibarba, Sempervivum,* and *Rosularia.* The succulent flora of Morocco has some genera in common with the Canary Islands, notably *Aeonium, Aichryson, Caralluma, Euphorbia,* and *Kleinia,* and a few species are common to both.

The Atlantic coastal area of Morocco near Agadir and to the south where there are many succulents is a priority area for protection. Species include *Euphorbia officinarum, E. echinus, Caralluma burchardii, C. europaea,* and *Kleinia anteuphorbium.* Threats to these plants include industrial and tourism development, agriculture, and overgrazing.

The main threat for the survival of cacti and succulents in this region is habitat modification and destruction, mainly from industrial and tourism development of coastal and mountain grassland areas.

M. Sajeva

Caralluma europaea on Lampedusa Island.

Refuse disposal from construction also poses a threat to some habitats, for example that of *Caralluma europaea* on Lampedusa Island, Italy. Other threats to mountainous habitats are dams and mining activities. Grazing, especially by goats, is a major factor in the loss of biodiversity in the Mediterranean region. Although not serious, collection by individuals poses a threat to some small populations of rare mountain succulents within the region. Fire destroys large areas of drier vegetation where these plants are often found. Invasive species, such as *Opuntia ficus-indica* are a problem for native species in parts of Spain and Greece primarily threatening *Aeonium arboreum* and *Dracaena draco,* both native in north-west Africa.

Existing conservation measures

Europe is generally well endowed with protected areas, but the Mediterranean region is probably that with the least coverage. For the Mediterranean region the Bern Convention only lists nine succulent species of the Canary Islands. There are a few succulents from the region listed on CITES, but a significant trade in cacti and other CITES succulents continues in the Mediterranean. Botanical gardens in the region which have important succulent collections include Blanes (Spain); The Almeda, Gibraltar Botanic Gardens; Monte Carlo (Monaco); and Palermo (Sicily).

Status[1]	Taxon[2]	Distribution[3]
	AIZOACEAE	
	Aizoon *canariense*	(southern Mediterranean)
	A. hispanicum	(widely distributed)
	Mesembryanthemum *crystallinum*	(non perennial, widely distributed)
E	*M. gaussenii*	Ag (E)
	M. nodifolium	(widely distributed)
	ASCLEPIADACEAE	
	Caralluma *aaronis*	Eg, IJ
V	*C. burchardii*	Ma
	C. commutata ssp. hesperidium	Ma
	C. europaea ssp. europaea	Si, Eg, Li, Tn, Ag
	C. europaea ssp. maroccana	Hs
I	*C. joannis*	Ma (I)
	C. munbyana	Hs (R), Ag, Ma
nt	*C. negevensis*	IJ, Sn
R	*C. sinaica*	IJ, SN, Eg (E)
	C. tombuctuensis	Ag
V	*C. venenosa*	Ag (V)
	COMPOSITAE	
nt	***Kleinia*** *anteuphorbium*	Ma
	CRASSULACEAE	
V	***Aeonium*** *korneliuslemsii*	Ma
	Hylotelephium *anacampseros*	Hs, Ga, It
	H. telephium	Lu, Hs, Ga, Co, Sa, It, Ju, Al, Bu, RK, Gr, Tu, An
K	***Kalanchoe*** *laciniata*	Ma
	Pistorinia *breviflora*	Ag, Ma, Tn
	P. hispanica	Hs, Ma
	Rhodiola *rosea*	Bu (R), Hs, Ga, It
I	***Rosularia*** *aizoon*	An (I)
K	*R. blepharophylla*	An (only known from 2 localities)
nt	*R. chrysantha*	An
R	*R. davisii*	An (R) (only known from 2 collections)
	R. elyymaitica	An
nt	*R. globulariifolia*	AE, An (nt), Cy, LS
R	*R. haussknectii*	An *(R)*
	R. hirsuta	Ga, Hs, It, Lu, North Africa
R	*R. jaccardiana*	Ma
V/R	*R. kesrouanensis*	LS
	R. lineata	LS, Jl, Sn
R	*R. pallidiflora*	An, Cy
	R. parvifolia	LS
	R. radiciflora ssp. *glabra*	An, LS
	R. radiciflora ssp. kurduca	An
	R. radiciflora ssp. *radiciflora*	An
	R. sempewivum ssp. *sempervivum*	An
	R. sempervivum ssp. *amanensis*	An, LS
	R. sempervivum ssp. *glaucophylla*	An
	R. sempervivum ssp. *kurdica*	An, LS
	R. sempervivum ssp. *libanotica*	An, IJ, LS, Sn (R)
	R. sempervivum ssp. *persica:*	An, LS
	R. sempervivum ssp. *pestalozzae*	An, LS
	R. serpentinica ssp. *serpentinica*	An
	R. serpentinica ssp. *gigantea*	An
	R. serrata	Gr, Cr, AE, An
	Sedum *aetnense*	Hs (V), Si (E), Ju, Al, Bu (R), RK, An; this species is a minute, ephemeral, undcrcollcctcd annual; extremely local and rare throughout Europe, but quite common in Anatolia
	S. acre	Lu, Hs, Ga, Si, It, Ju, Al, Bu, RK, Cr, AE, An, Li, Tn, Ag, Ma
	S. album	Lu, Hs, Bl, Ga, Co, Sa, Sl, It, Ju, Al, Bu, RK, Gr, Cr, Tu, An, LS, Li, Tn, Ag, Ma
	S. alpestre	It, Ju, Gr, An
	S. alsinefolium	Co, It; quite local and rare in Liguria and Piemonte
	S. amplexicaule ssp. amplexicaule	Lu, Hs, Ga, ?Ma

	S. amplexicaule ssp. *tenuifolium*	AE, Al, An, Bu, Cr, Gr, It, Ju, Si, Tu
	S. andegavense	Lu, Hs, Ga, Co, Sa, It
	S. *anglicum*	Lu, Hs, Ga
	S. *annuum*	Al, An, Bu, Co, Ga, Gr, Hs, It, Ju, Tu
	S. apoleipon	Gr
	S. atratum	Hs, Ga, It, Ju, AL, Bu, Gr, An
	S. arenarium	Lu, Hs; quite common and widely spread in large part of Central Spain and Portugal
V	***S. assyriacum***	An, LS; extremely local and rare, only in temporarily wet places
R	***S. bractea turn***	Li (R)
	S. brevifolium	Lu, Hs, Ga, Co, Sa, Ma
	S. caeruleum	Co, Sa, Me, Si, Li, Tn, Ag, Ma
	S. caricum	AE, An; confined to Rhodos and adjacent Anatolia; probably a ssp. of S. rubens
	S. cepaea	Hs, Ga, Co, Sa, Si, It, Ju, Al, Bu, Gr, AE, An, LS, Li, Tn, Ag
	S. coespitosum	all but AL, Sn, Eg
	S. *confertiflorum*	AE (R), An
V	***S. creticum*** var. ***creticum***	Cr; restricted to east Crete
R	***S. creticum*** var. ***monocarpicum***	Cr
R	***S. cyprium***	Cy (R)
R	***S. cyrenaicum***	Li (R)
	S. dasyphyllum	all but RK, AE, Tu, Cy, LS, IJ, EG, Li; rare in Anatolia
	S. euxinum	An
	S. forsterianum	Ga, Hs, Ma, Lu
	S. *fragrans*	Ga, It
R	***S. ga ttefossei***	Ma (R)
	S. *gracile*	An
	S. grisebachii	Ju, Al, Bu, Gr; comprises two ecotypes, of which the lowland form (up to c. I 500 m) has two cytotypes (2n=16, 32)
	S. gypsicolum	Hs, Ma
	S. hispanicum	Si, It, Ju, Al, Bu, RK, Gr, Cr, AE, Tu, An, LS, IJ
K	***S. inconspicuum***	An
nt	***S. jahandiezii***	Ma (nt)
	S. laconicum ssp. laconicum	Gr, AE, An, LS, LJ
	S. laconicum ssp. pentapolitanum	Li
	S. laconicum ssp. pallidum	IJ, LS, ?An
R	***S. lampusae***	Cy
	S. litoreum	Co, Sa, Me (R), Si, It, Gr, Cr, AE, An, Cy, LS, IJ, Li, Ga (E)
R	***S. lydium***	An; only known from a few mountain peaks in west Anatolia
	S. magellense	It, Lu, Al, Gr, Cr, An, Br
R	***S. maw-urn***	Ma (R)
R	***S.*** *melanantherum*	Hs, Ma
R	***S. microstachyum***	Cy (R)
nt	***S. modestum***	Ma
	S. monregalense	Ga, Co, It
	S. montanum	Ga, It, Ju, (Hs?)
	S. mucizonia	Ag, Hs, Lu, Ma, Tn
R	***S. multiceps***	Ag (R), Co (probably introduced)
V	***S. nanum***	An
	S. ochroleucum	Al, Bu, Ga, Gr, It, Ju, Si, Tu
K	***S. palestinum***	LS, IJ
	S. pallidum	An, Bu, RK, Tu.
R	***S. pedicellatum ssp. lusitanicum***	Lu, Hs
R	***S. pedicella turn ssp. pedicella turn***	Hs
	S. pilosum	An
Ex	***S. polystriatum***	An (Ex); probably identical with Rosularia sempervivum but type not yet traced
nt	***S. porphyreum***	Cy (nt)
R	***S. pruina turn***	Hs, Lu (R); species is confined to a specific biotope in north Portugal and a very small region in adjacent Spain
	S. *pubescens*	Th, Ag, Ma
	S. *obtusifolium*	An
	S. *rubens*	all but Sn, Eg; extremely polymorphic species (cytologically as well as morphologically, especially at the tetraploid level in the east Mediterranean region)
	S. rupestre	Hs, Ga, Co, Sa, Si, It, Ju
	S. samium ssp. samium	AE, An
	S. schizolepsis	An, IJ, LS; probably could be included in S. hispanicum, but taxonomic status not fully understood; most likely related or conspecific with S. longibracteatum
	S. sediforme	all but Bu, RK, Sn, Eg

	S. sempervivoides	An
	S. sexangulare	Bu, Gr, Ga, It, Ju, Al
	S. spurium	An
	S. steudelii	An, LS
	S. stefco	Bu (R), Gr
	S. stellaturn	Bl, Ga, Co, Sa, Me, Si, It, Ju, Al, Gr, An (V), Ae (R)
	S. stoloniferum	An
	S. subulatum	An
R	*S. surculosum*	Ma
	S. tenellum	An
	S. tristria turn	Gr (R), Cr
	S. tuberiferum	Bu, Gr
R	*S. tu berosum*	Tn, Ag
R	*S. tymphaeum*	Gr; confined to three mountain peaks in the Northern Pindos
	3'.ursi	An
	S. urvillei	Ju, Al, Bu, RK, Gr, An, LS, IJ
R	*S. versicolor*	Ma
	S. villosum	Hs, Ga, Co, Sa, It, Ju, Ag, Ma
R	*S. wilczekianum*	Ma (R)
R	***Jovibarba*** *allionii*	Ga (R); It(R)
	J. arenaria	It
	J. heuffellii	Ju, Al, Bu, Gr
	J. hirta	It
	Sempervivum *arachnoideum*	Hs, Ga, Co, It,
	S. armenum	An
	S. artvinense	An
R	*S. ballsi*	Gr (R)
nt	*S. brevipilum*	An
R	*S. ciliosum*	Ju (R), Bu (R), Gr (R)
	S. davisii	An
R	*S. dolomiticum*	Hs, Bl, Ga, It (R)
nt	*S. erythraeum*	Al
R	*S. furseorum*	An (R)
R	*S. gillianii*	An (R)
R	*S. gla brifolium*	An (R)
	S. grandiflorum	It
R	*S. ispartae*	An (R)
	S. italicum	It
	S. ja kucsii	Al
R	*S. kindingeri*	Ju (R), Gr (R)
R	*S. kosaninii*	Ju (R)
nt	*S. leucanthum*	Bu
R	*S. macedonicum*	Ju (R)
	S. marmoreum	Ju, Al, Bu, Gr
R	*S. minus*	An (R)
	S. montanum	Hs, Bl, Ga, It
R	*S. octopodes*	Ju (R)
R	*S. pisidicum*	An (R)
	S. ruthenicum	Ju, Bu, RK, Gr
R	*S. staintonii*	An (R)
	S. tectorum	Hs, Bl, Ga, It, Ju
R	*S. thompsonianum*	Ju (R)
	S. transcaucasicum	An
	S. vicentei ssp. cantabricum	Hs
	S. vicentei ssp. paui	Hs
	S. vicentei ssp. vicentei	Hs
	S. wulfenii	It
	Umbilicus albido-opacus	AE
	U. chloranthis	Ju, Gr, AE
	U. erectus	It, Ju, Al, Bu, Gr, Cr, Tu, An, LS

U. heylandianus	Hs, Bl, Ma
U. horizantulis	all but Lu, Ga, Co, Gr, Tu, IJ, Sn
U. gaditanus	Hs
U. in termedius	An, LS, IJ, Sn
U. mirus	Li
U. neglectus	Lu, Hs, Bl
U. parviflorus	Gr, Cr, AE, AN
U. rupestris	all but RK, IJ, Eg
U. tropaelifolius	An, LS

EUPHORBIACEAE

nt	*Euphorbiu ohtusijoliu*	Ma
nt	*E. officinarum* ssp. *officinarum*	Ma
nt	*E. officinarum* ssp. *echinus*	
Ma (nt)		

[1] IUCN Red Data categories of global threa t arc given as recorded in the Plants Database maintained by WCMC as of July 1996. Additional categories are given by Focke Albers and Henk t'Hart. Country categories are given in brackets following the country code.

[2] In compiling this list, all the succulents recorded by Greuter, Burdet and Long (1984) in Med-Checklist were included, extended to the administrative limits of the countries boarding the Mediterranean Sea, plus Portugal, Crimea, Bulgaria, and Jordan. The definition of succulent followed is that given by Willert *et* al. (1992). The listing for Crassulaceae has been updated by Henk t' Hart, and following Eggli (1988).

[3] The two-letter distribution symbols are as used by Grcutcr, Burdet, and Long (1984):

AE East Aegean Islands, **Ag** Algeria, **Al** Albania, **An** Asiatic Turkey, **Bl** Balearic Islands, **Bu** Bulgaria, Co Corsica, **Cr** Crete and Karpathos, Cy Cyprus, **Eg** Egypt, **Ga** France, **Gr** Greece, **Hs** Spain, **IJ** Israel and Jordan, **It** Italy, **Ju** former Jugoslavia, **Li** Libya, **LS** Lebanon and Syria, **Lu** Portugal, **Ma** Morocco, **Me** Malta, **RK** Crimea, **Sa** Sardinia, **Si** Sicily, **Sn** Sinai, **Tn** Tunisia, **Tu** Turkey-in-Europe

M. Sajeva

Lampedusa Island, Italy.

Annex 6

Succulents of the Canary Islands

Prepared by David Bramwell.

Status	Taxon	Distribution
	CRASSULACEAE	
nt	*Aeonium canariense*	Common on the north coast of Tenerife though declining.
nt	*A. castello-paivae*	Very frequent on the northern slopes of La Gomera.
nt	*A. cilia turn*	Common in the Anaga region of Tenerife where hybridization with *A. urbicum* is the main threat. Its main habitats in the forest regions (where it remains pure) are within the network of protcctcd areas.
nt	*A. cuneatum*	Locally abundant in the laurel forests of Tenerife most of which arc now protected areas.
nt	*A. davidbram wellii*	This is the most common *Aeonium* on La Palma and is extremely abundant especially in the south of the island.
nt	*A. decorum*	Locally common on La Gomera, polymorphic.
E	*A. gomerense*	Extremely rare and endangered species, the main locality is threatened by a road-building project financed by the EEC. It is endemic to a small area in the north-east of La Gomcra.
V	*A. goochiae*	Included here because of the recent fires which may have destroyed much of its natural habitat.
nt	*A. ha worthii*	Frequent in some areas of the north-west of Tenerife, many localities within the network of protected areas, for example, Masca and Teno.
nt	*A. hierrense*	Common on El Hierro.
nt	*A. holochrysum*	Common throughout the lower zone of Tenerife, La Palma, El Hierro and parts of La Gomcra.
nt	*A. luncerottense*	A species in expansion, for example, on recent lava flows. Most habitats protected and included in the MAB reserve.
nt	*A. lindleyi*	Common in the lower zones of the Anaga region of Tenerife and also occurring on the west side of La Palma.
nt	*A. manriqueorum*	Very common all over Gran Canaria.
E	*A. mascaense*	Known from two populations in the Masca valley on Tenerife and threatened by over-collecting. Probably the rarest of all the Aeoniums but it is in cultivation and its habitat is included in a proposal for a protected area.
V	*A. nobile*	Several populations exist, some of them quite large with over 500 individuals but this species is threatened by overcollecting and by road improvement projects.
nt	*A. palmense*	Common on La Palma but affected by recent forest fires, its status needs revising. The local form of this species on El Hierro is common.
nt	*A. percarneum*	Locally very common throughout Gran Canaria.
V	*A. rubrolinea turn*	Rare with restricted distribution on La Gomera, threats include changes in agricultural methods and overcollecting, some populations are protected by the National Park but the main ones arc outside the limits and should be considered for reserve status especially Lomo de Carretón and Benchijigua.
E	*A. saundersii*	A locally very restricted species, abundant in a couple of small areas such as the Barranco dc la Laja where it should be strictly protected.
nt	*A. sedifolium*	Abundant on the west side of Tenerife and parts of La Palma. Though of restricted distribution the species is not threatened and most populations are in protected areas.
nt	*A. simsii*	Common in the mountains of Gran Canaria.
R	*A. smithii*	A local species of the southern parts of Tenerife from 500 to 2000 m. Not common but most habitats are included within protected areas.
nt	*A. sputhulatum*	Found on all the western and central islands but common only on Tcnerife. Confined to a few localities on La Gomera and Gran Canaria but all within the network of protected areas.
nt	*A. subplanum*	Locally very common in the forest zones of La Gomera and widespread in the Garajonay National Park.
nt	*A. ta buliforme*	Still frequent on the north coast of Tencrife but declining due to urbanization and general degradation of the natural habitat, not currently threatened.
nt	*A. undula turn*	Locally abundant in the mountain regions of Gran Canaria and not threatened even though it is, in some areas, susceptible to hybridization with *A. simsii*.
nt	*A. urbicum*	Common on the north and western slopes of Tenerife where its main threat is hybridization with *A. ciliatum* in the north east, in other areas very abundant. The populations (rare) on La Gomcra may be referable to a distinct taxon and need further study.
nt	*A. valverdense*	Locally common on El Hierro.
V	*A. vestitum*	A species requiring revision and which may be only a local form of *A. holochrysum* but if a good species it is rare, occurring only in the north east of La Palma where its main habitats may have been damaged bv recent forest fires.
nt	*A. virgineum*	Locally frequent in the forest remnants of the island of Gran Canaria and extending to the lower zone on the west side, many of its main localities fall within protected areas.

nt	*A. viscatum*	Locally frequent on the northern side of La Gomera.
nt	***Aichryson bethencourtianum***	Restricted distribution on Fuerteventura but locally common.
V	*A. bollei*	Occurs on La Palma where recent forest fires have almost certainly affected all the main populations of this species.
V	*A. brevipetalum*	As previous species, this local La Palma endemic is seriously threatened by the effects of forest fires which recently destroyed almost 50% of the forests of the island.
nt	*A. laxum*	Occurs on Tenerife, Gran Canaria, La Palma, La Gomera and El Hierro, very common.
E / V	*A. pachycaulon*	A rare species with individual endemic island subspecies which form part of the diversity of the species and should be protected. The species is probably not monophyletic, each subspecies probably being of independent origin and so it is an important taxon from an evolutionary point of view.
R	*A. palmensis*	Common on La Palma but declining along with its forest habitats.
nt	*A. parlatorei*	Occurs on Tenerife, Gran Canaria, La Palma, La Gomera and El Hierro, common and colonising walls.
R	*A. porphyrogennetos*	Sometimes confused with the previous species, seems to be in an expansion phase in the north of Gran Canaria.
nt	*A. punctatum*	Occurs on Tenerife, Gran Canaria, La Palma, La Gomera and El Hierro, very common but polymorphic and its genetic diversity should be taken into account for conservation.
nt	*A. tortuosum*	Common cliff plant of Lanzarote and Fuerteventura.
	Monanthes	About 17 species but in need of a good revision; recent attempts have only added to the problems and the basis provided by Praeger in the 1930s is still valid.
V	*Monanthes adenoscepes*	A few scattered populations in the south of Tenerife, over-collected.
nt	*M. amydros*	Common on the north side of La Gomera.
nt	*M. anagensis*	Still locally quite common but confined to the Anaga hills at the eastern end of Tenerife.
nt	*M. brachycaulon*	Occurs on Tenerife and Gran Canaria, common but polymorphic and conservation measures should take the possible genetic diversity into consideration.
nt	*M. dasyphylla*	Tenerife, restricted distribution but locally very abundant.
nt	*M. laxiflora*	Occurs on all the islands; any conservation plan for this species should, however, take into account its extreme polymorphism.
K	*M. minima*	May be the same as *M. adenoscepes* but needs revising.
nt	*M. muralis*	Occurs on Tenerife, La Palma and La Gomera, locally common.
V	*M. niphophila*	High mountain species, over-collected but now in Teide National Park and protected.
nt	*M. pallens*	Occurs on Tenerife, locally common.
nt	*M. polyphylla*	Occurs on Tenerife, very common.
V	*M. praegeri*	Single locality on the north coast of Tenerife.
K	*M. purpurascens*	Occurs on Gran Canaria; this is probably one of the many local forms of *M. brachycaulon.*
nt	*M. subcrassicaulis*	Occurs on Tenerife and La Gomera; needs taxonomic revision, appears to be common but confused with *M. muralis.*
V	*M. wildpretii*	Tenerife, single locality, recently described species.
K	***Sedum*** *lancerottense*	Locally abundant on the Famara cliffs of Lanzarote and not threatened. Main habitat is in a protected area.
	Greenovia	This genus of four species has no threatened taxa even though two species are restricted in distribution, *G. dodrentalis* (its western Tenerife localities are in protected areas) and G. *aizoon,* protected in the Guimar natural park.
	EUPHORBIACEAE	
nt	***Euphorbia*** *aphylla*	Tenerife, La Gomera, Gran Canaria, protected at Teno, Tenerife and the largest populations on Gran Canaria will come within the proposed Roque Nublo National Park.
nt	*E. atropurpurea*	Abundant in the west and south of Tenerife where many populations are within the protected areas network.
nt	*E. balsamifera*	Widespread colonizing species abundant on all the islands in coastal regions.
nt	*E. berthelotii*	Endemic to La Gomera but locally common especially in the east and southeast.
E	*E. bourgaeana*	Remains, this species should be brought into cultivation and restocking used to augment the natural population.
V	*E. bravoana*	Two main localities, Riscos de Agulo with few plants but in a protected area and Majona which is a Natural Park with a relatively large population. A recovery plan should be included in the Park management programme.
nt	*E. broussonetii*	Tenerife, La Palma, La Gomera, El Hierro, the comment under the previous species also applies here.
nt	*E. canariensis*	Common on most islands but rather rarer on La Gomera and with only a few localities on Lanzarotc (Malpais de la Corona) and Fuerteventura (mainly Jandia).
V	*E. handiensis*	Declining species threatened by tourist development and over-collecting, its main remaining populations arc protected in theory but are still declining especially due to the removal of young plants. The species should be strictly protected in its natural habitat.
V	*E. lambii*	A local segregate of the previous species Gomera where three main populations occur; two of these arc within the National Park and if correctly managed this species should survive without too many problems.
E	*E. mellifera*	Extremely rare species of Tenerife, La Palma and La Gomera. It is almost extinct in all its known localities where populations are reduced to single figures with 1-5 individuals only. All localities should be protected and reintroduction considered.

nt	***E.*** *regis-jubae*	Occurs on Gran Canaria, Lanzarote, Fuerteventura; locally common but variable and a system of population protection for a wide sample of its diversity should be devised.
	ASCLEPIADACEAE	
V	***Caralluma*** *burchardii*	Confined to Lanzarote and Fuerteventura, most populations are in decline especially where rcgcncrating vegetation causes excessive shading. Its main localities should be protected and the species positively managed.
V	***Ceropegia*** *cera tophora*	Endemic to La Gomera and confined to a few localities though further exploration of the southwest may reveal new populations. Threatened by overcollection. Habitat should be protected and a management plan developed.
E	*C. chrysantha*	Confined to a single locality in the south of Tenerife and was thought to be extinct. The remaining population should be strictly protected and a recovery plan developed including ex situ conservation and restocking.
nt	*C. dichotoma*	Tenerife, locally common especially on the north side, many populations in protected areas.
nt	*C. fusca*	Abundant in the south of Tenerife and on Gran Canaria but over-collected and sometimes taken from the wild for use in gardens, for example of hotels.
nt	*C. hians*	A local segregate of the above from La Palma where it is locally common and El Hierro where it is confined to the cliffs of El Golfo.
V	*C. kra inzii*	North east part of La Gomera, habitats should be protected and a management plan developed.
	COMPOSITAE	
nt	***Kleinia*** *nerifolia (Senecio kleinia)*	A very common species on all the islands, it has a wide range of variability and a plan for the conservation of its ample genetic diversity should be prepared.

Annex 7

Succulents of Madagascar

Compiled by Diedrich Supthut and Reto Nyffeler, October 1994.

An asterisk (*) indicates taxa found in trade. When a province is not indicated for infraspecific taxa, assume the same distribution as the species.
Province abbreviations: **Ant** Antananarivo, **Ants** Antsiranana, **Fia** Fianarantsoa, **Mah** Mahajanga, **Toa** Toamasina, **Tol** Toliara, **un** unknown.

Status	Taxon	Distribution
	ALOACEAE	
nt *	*Aloe acutissima* H.Perrier var. *acutissima*	Fia/Tol
R *	- var. *antanimorensis* Reynolds	Tol
E *	*A. albiflora* Guillaumin	Tol
R	*A. alfredii* Rauh	Ant
R	*A. andringitrensis* H.Perrier	Fia
nt *	*A. antandroi* (Decary) H.Perrier	Tol
R *	*A. bakeri* Scott-Elliot	Tol
E *	*A. bellatula* Reynolds	Fia
R	*A. betsiliensis* H.Perrier	Tol
K *	*A. boiteaui* Guillaumin	Tol
R *	*A. buchlohii* Rauh	Tol
nt *	*A. bulbillifera* H.Perrier var. *bulbillifera*	Mah
K	- var. *pauliana* Reynolds	Mah
E *	*A. calcairophila* Reynolds	Fia
nt *	*A. capitata* Baker var. *capitata*	Ant
R *	- var. *cipolinicola* H.Perrier	Fia
nt *	- var. *gneissicola* H.Perrier	Mah/Ant
nt *	- var. *quartziticola* H.Perrier	Fia
R	- var. *silvicola* H.Perrier	Mah
E *	*A. compressa* H.Perrier var. *compressa*	Ant
E *	- var. *rugosquamosa* H.Perrier	Ant
E *	- var. *schistophila* H.Perrier	Ant
R *	*A. conifera* H.Perrier	Fia
E *	*A. cremersii* Lavranos	Fia
R *	*A. cryptoflora* Reynolds	Fia
K *	*A. decaryi* Guillaumin	Tol
K	*A. decorsei* H. Perrier	Fia
R	*A. delphinensis* Rauh	Tol
K *	*A. deltoideodonta* Baker var. *deltoideodonta*	Fia
nt *	- var. *breviflora* H.Perrier	Tol
nt *	- var. *candicans* H.Perrier	Fia
E *	*A. descoingsii* Reynolds	Tol
nt *	*A. divaricata* A.Berger var. *divaricata*	Fia/Tol/Mah
K	- var. *rosea* (Decary) Reynolds	Tol
K	*A. ericetorum* Bosser	Mah
R *	*A. erythrophylla* Bosser	Fia
R	*A. fievetii* Reynolds	Fia
E *	*A. fragilis* Lavranos & Röösli	Ants
K	*A. guillaumetii* Cremers	Ants
R *	*A. haworthioides* Baker var. *haworthioides*	Fia
R *	- var. *aurantiaca* H.Perrier	Fia
E	*A. helenae* Danguy	Tol
K	*A. humbertii* H.Perrier	Tol
R	*A. ibitiensis* H.Perrier	Ant
0	*A. imalotensis* Reynolds	Fia
nt *	*A. isaloensis* H.Perrier	Fia/Tol
R	*A. itremensis* Reynolds	Fia
R *	*A. laeta* A.Berger var. *laeta*	Ant
R	- var. *maniaensis* H.Perrier	Fia
K	*A. leandrii* Bosser	Toa
K *	*A. macroclada* Baker	Ant/Fia
K	*A. madecassa* H.Perrier var. *madecassa*	Ant
K	- var. *lutea* Guillaumin	un
K	*A. mayottensis* A.Berger	Comores
R *	*A. millotii* Reynolds	Tol
E *	*A. parallelifolia* H.Perrier	Ant
E *	*A. parvula* A.Berger	Fia
R	*A. perrieri* Reynolds	Fia
K	*A. peyrierasii* Cremers	Ants
R *	*A. rauhii* Reynolds	Tol
K *	*A. schomeri* Rauh	Tol
K	*A. silicicola* H.Perrier	Ant
nt *	*A. suarezensis* H.Perrier	Ants
nt	*A. subacutissima* G.D.Rowley	Tol/Fia
E	*A. suzannae* Decary	Tol
R *	*A. trachyticola* (H.Perrier) Reynolds	Ant/Fia
nt *	*A. vaombe* Decorse & Poiss. var. *vaombe*	Tol
K	- var. *poissonii* Decary	Tol
nt	*A. vaotsanda* Decary	Tol
R *	*A.versicolor* Guillaumin	Tol
R *	*A. viguieri* H.Perrier	Tol
R	***Lomatophyllum** antsingyense* Leandri	Mah
R	*L. belavenokense* Rauh & R. Gerold	Tol
K	*L. citreum* Guillaumin	un
R	*L. occidentale* H.Perrier	Mah
K	*L. oligophyllum* (Baker) H.Perrier	un
R	*L. orientale* H.Perrier	Fia
R	*L. prostratum* H.Perrier	Mah
R	*L. viviparum* H.Perrier	Ants
R	*L. roseum* H.Perrier	Mah
R	*L. sociale* H.Perrier	Mah

All *Lomatophyllum* species grow at localities half-shaded by trees and shrubs. They are semi-succulents, have beautiful flowers, but are not well known by succulent enthusiasts.

	APOCYNACEAE	
E *	***Pachypodium** ambongense* Poiss.	Mah
R *	*P. baronii* Constantin & Bois var. *baronii*	Mah
E *	- var. *windsori* (Poiss.) Pichon	Ants
nt *	*P. brevicaule* Baker	Ant/Fia
E *	*P. decaryi* Poiss.	Mah
nt *	*P. densiflorum* Baker var. *densiflorum*	Ant/Fia
R *	- var. *brevicalyx* H.Perrier	Ant
nt *	*P. geayi* Constantin & Bois	Tol
E*	*P. inopinutum* Lavranos	Mah
nt *	*P. lamerei* Drake var. *lamerei*	Fia/Tol
R *	- var. *ramosum* (Constantin & Bois) Pichon	Tol
R *	*P. rosulatum* Baker var. *rosulatum*	Mah
nt *	- var. *delphinensis* *(=stenanthum)* Constantin & Bois	Tol

Status	Taxon	Distribution
nt *	- var. *drukei* (Constantin & Bois) Pichon	Mah
nt *	- var. *gracilius* H.Perrier	Fia/Tol
nt *	- var. *horombense* (Poiss.) G.D.Rowley	Fia/Tol
nt *	P. *rutenbergianum* Vatke var. *rutenbergianum*	Mah/Ants
nt *	- var. *meridionale* (Pichon)H.Perrier	Tol
nt *	***P.*** *sofiense* (Poiss.)H.Perrier	Mah
	ASCLEPIADACEAE	
E *	***Ceropegia*** *armandii* Rauh	Tol
E *	*C. petignatii* Rauh	Tol
E *	*C. hofstaetteri* Rauh	Mah
E *	*C. simoneae* Rauh	Tol
E *	*C. bosseri* Rauh & Buchloh	Fia
E *	*C. razafindratsirana* (Rauh & Buchloh) Rauh	Fia
E	*C. ampliatu* var. *madagascariensis* Lavranos & Morat	Fia
R	*C. albisepta* Jum. & H.Perrier	Tol
R	*C. viridis* Choux	Tol
R *	*C. dimorpha* Rauh	Fia
E *	*C. leroyi* Rauh & Marn.-Lap.	Fia
R	*C. humbertii* H.Huber	Ants
R	*C. scabra* Jum. & H.Perrier	Tol
R	*C. saxatilis* Jum. & H.Perrier	Mah
R	*C. madagascariensis* Decne.	Mah
R*	***Stapelianthus*** *arenarius* Bosser & Morat	Tol
K	*S. calcarophilus* Morat	?
R *	*S. decaryi* Choux	Tol
R *	*S. hardyi* Lavranos	Tol
R *	*S. insignis* Desc. var. *insignis*	Tol
R *	- var. *tangoboryensis* Rauh	Tol
R *	*S. keraudreniae* Bosser & Morat	Tol
R *	*S. mudagascariensis* (Choux) Choux	Tol
R *	*S. montagnacii* (Boiteau) Boiteau & Bertrand	Tol
R *	*S. pilosus* Lavranos & Hardy	Tol

Most *Stapelianthus* species grow in the Euphorbia-Didieraceen-forest in the south-west of Madagascar, which is threatened by clearing and fire. *Stapelianthus* species are not easy to grow, all are succulent.

	Succulent species (following S. Liede 1992): low-growing and leafless	
R	***Cynanchum*** *descoingsii* Rau h	Tol
E *	*C. rossii* Rauh	Tol
K	*C. antandroy* Desc.	Tol
R*	*C. compactum* Choux	Fia
K	*C. juliani-murnieri* Desc.	Tol
R*	*C. macrolobum* Jum. & H.Perrier	Tol
R *	*C. marnieranum* Rauh	Tol
K *	*C. perrieri* Choux	Fia
R	*C. rauhianum* Desc.	Fia
K	***Folotsia*** *sarcostemmoides* Cost. & Bois	Tol
E	***Karimbolea*** *verrucosa* Desc.	Tol
K	***Sarcostemma*** *insignis* N.E.Br.	Ant
	Succulent species: leafless vines	
K	***Cynanchum*** *aequilongum* Choux	Tol/Toa
K	*C. ambositrense* Choux	Fia
K	*C. ampanihense* Jum. & H.Perrier	Tol
K	*C. arenarium* Jum. & H.Perrier	Mah
K	*C. bekinolense* Choux	Fia
K	*C. bisinuatum* Jum. & H.Perrier	Tol
K	*C. decaisneanum* Desc.	Fia/Tol/Mah
K	*C. gerrerdii* (Harvey)Liede	Tol
K	*C. implicatum* (Jum. & H.Perrier) Jum. & H.Perrier	Ants
K	*C. lecontei* Choux	Tol
K	*C. luteifluens* (Jum. & H.Perrier) Desc.	Tol
K	*C. macranthum* Jum. & H.Perrier	Tol
K	*C. madecassum* Desc.	Tol
K	*C. mahafalense* Jum. & H.Perrier	Tol/Fia
K	*C. menarandrense* Jum. & H.Perrier	Tol
K	*C. messeri* (Buchenau) Jum. & H.Perrier	Ants/Tol
K	C. *nodosum* (Jum. & H.Perrier) Desc.	Tol
K	*C. radiatum* Jum. & H.Perrier	Tol
K	***Folotsia*** *aculeatum* Jum. & H.Perrier	Tol
K	*F. floribundum* Desc.	Fia
K	*F. grandiflorum* Jum. & H.Perrier	Mah
K	*F. madagascariense* (Jum. & H.Perrier)Desc.	Fia/Tol
K	**Sarcostemma** *decorsei* Cost. & Gall.	Tol
K	*S. madagascariensis* Desc.	Tol
K	*S. viminale* R.Br.	Tol
	Herbaceous scramblers with tuberous roots	
K	***Cynanchum*** *subtilis* Liede	Tol
K	*C. andringitrense* Choux	Ant
K	*C. danguyanum* Choux	Fia/Tol
K	*C. madagascariense* K.Schum.	Ant/Fia
K	*C. angkavokeliense* Choux	Ant
K	*C. bojerianum* Decne.	Ant/Ants
K	*C. cucullatum* N.E.Br.	Ant
K	*C. jumellei* Choux	Ant
K	*C. lineare* N.E.Br.	Ant
K	*C. moramangense* Choux	Ant
K	*C. papilla turn C* houx	Ant/Fia
K	*C. surprisum* Liede	Tol
K	*C. napiforme* Choux	un
	Erect herbs with tuberous roots	
K	***Cynanchum*** *appendiculatum* Choux	Fia
K	*C. fibriatum* Choux	Ant
K	*C. napiferum* Choux	**Ant**
K	*C. junciforme* (Decne.)Liede	Ant/Fia/Tol
K	*C. sessiliflorum* (Decne.)Liede	Ant/Mah
	Broad leaved vines	
R	*C. pachylobum* Choux	TO I
	BALSAMINACEAE	
R *	***Impatiens*** *tuberosa* H.Perrier	Ants
	COMPOSITAE (Asteraceae) (Group XVI ex Fl. dc Madagascar')	
K *	***Senecio*** *antandroi* Scott-Elliot	Tol
K	*S. antitensis* Baker	Fia
K	*S. barorum* Humbcrt	Fia/Tol
K	*S. boiteaui* Humbert	Tol
R *	*S. canaliculatus* DC.	Ant/Fia
K	*S. capuronii* Humbert	Fia
R *	*S. cedrorum* Raynal	Tol
K *	*S. crassissimus* Humbert	Fia/Tol
K	S. *decuryi* Humbert	Fia
K	*S. hirto-crassus* Humbert	Ant/Fia
K	*S. hildebrandtii* Baker	Ant/Fia
K *	*S. longiflorus* (DC.) Schultz-Bip. - var. *madugascariensis* (Humbert) G.D.Rowley	Tol
K	*S. marnieri* Humbert	Ant
K	*S. melastomaefolius* Baker ssp. *melastomaefolius*	Ant/Fia
K	- ssp. *longibracteatus* Humbert	Ants
K	*S. mesembryanthemoides* Bojer ex DC.	Ant/Fia
R *	*S. meuselii* Rauh	Fia
K	*S. navicularis* Humbert	Tol
K	*S.quartziticolus* Humbcrt	Ant/Fia
K	*S. saboureaui* Humbert	Ants
K	*S. sakamaliensis* (Humbert)Humbert	Tol

Status	Taxon	Distribution
K	*S. sakalavorum* Humbert	Mah
K *	***Kleinia*** *descoingii* (Humbert)Jeffrey	Fia/Tol
K *	*K. madagascariensis* (Humbert) P.Halliday	Mah/Tol
K	***Notonia*** *hehdingii* Rauh & Buchloh	Tol
	CRASSULACEAE	
R	***Crassula*** *cordifolia* Baker	Ant
K	*C. fragilis* Baker	un
R *	*C. humbertii* Desc.	Tol
K	*C. micans* Vahl ex Baillon	un
K	*C. nummulariifolia* Baker	Ant
K	***Kalanchoe*** *adelae* Raym.-Hamet	Comores
K	*K. adolphi-engleri* Raym.-Hamet	Fia/Tol
	K. aliciae Raym.-Hamet see *K. pubescens* Baker	
K	*K. ambolensis* Humbert	Tol
	K. amplexicaulis (Baker) Baillon see *K. campanulata* (Baker) Baillon	
K	*K. antanosiana* Drake	Tol
K *	*K. arborescens* Humbert	Tol
K	*K. aromatica* H.Perrier	Ant
K *	*K. beauverdii* Raym.-Hamet var. *beauverdii*	Ant/Fia
K	- var. *guignardii* Raym.-Hamet	Mahajanga
K	- var. *parviflora* Manning & Boit.	Tol
nt *	*K. beharensis* Drake var. beharensis	Tol/Fia
K *	- var. *aureo-aeneus* H.Jacobsen	Tol
K *	- var. *subnuda* H.Jacobsen	Tol
K	*K. bergeri* Raym.-Hamet var. *bergeri*	Ant/Toa/Tol/Fia
K	- var. *glabra* Manning & Boit.	
nt *	*K. bitteri* Raym.-Hamet	Ant/Fia
K *	*K. blossfeldiana* Poelln.	Ants
K	*K. boissii* Raym.-Hamet & H.Perrier	Mah/Tol
K	*K. bouvetii* Raym.-Hamet & H.Perrier	Mah/Toa
K	*K. bracteata* Scott-Elliott	Tol
K	*K. campanulata* (Baker) Baillon	Ant/Fia
	- var. *campanulata*	
K	- var. *orthosyla* Manning & Boit.	Ant
K	*K. chapototi* Raym.-Hamet & H.Perrier	Mah
	K. constantinii Raym.-Hamet see *K. beauverdii* Raym.-Hamet	
nt *	*K. daigremontiana* Raym.-Hamet & H.Perrier	Tol
K	*K. ebracteata* Scott Elliott	Tol
R*	*K. eriophylla* Hils. & Bojer	Fia/Ant
*	*K. fedtschenkoi* Raym.-Hamet & H.Perrier	
K *	- var. *fedtschenkoi*	Fia/Ant/Tol
K	- var. *isalensis* Manning & Boit.	
K*	*K. gastonis-bonnieri* Raym.-Hamet & H.Perrier	
K	*K. gentyi* Raym.-Hamet & H.Perrier	Ant/Fia
K	*K. globulifera* H.Perrier	Ants/Mah
K*	*K. gracilipes* (Baker)Baillon	Tol/Fia/Ant
K *	*K. grandidieri* Baillon	Tol
K	*K. heckelii* Raym.-Hamet & H.Perrier	Ant
nt *	*K. hildebrandtii* Baillon	Tol
K	*K. humberti* H.Perrier	Tol
R *	*K. integrifolia* Baker	Fia/Ant
*	*K. jongmansii* Raym.-Hamet & H.Perrier	
K *	- var. *jongmansii*	Fia
K	- var. *ivohibensis* Humbert	
	K. julea Raym.-Hamet & H.Perrier see *K. beauverdii* Raym.-Hamet	
K *	*K. laxiflora* Baker var. *laxiflora*	Ant/Fia
K	- var. *stipitata* Manning & Boit.	
K	- var. *subpeltata* Manning & Boit	
K	- var. *violacea* Manning & Boit.	
R *	*K. linearifolia* Drake	Tol
K	*K. macrochlamys* H.Perrier	Ants
K *	*K. manginii* Raym.-Hamet & H.Perrier	Ant/Fia
K *	*K. marnierana* H.Jacobsen	?
K	*K. millotii* Raym.-Hamet & H.Perrier	Tol
K *	*K. miniata* Hils. & Bojer var. *miniata*	Ant/Fia/Tol
K	- var. *andringitrensis* H.Perrier	
K	- var. *anjirensis* H.Perrier	
K	- var. *comfertifolia* H.Perrier	
K	- var. *peltata* Baker	
K	- var. *sicaformis* Manning & Boit.	
K	- var. *subsessilis* H.Perrier	Ant
K	*K. mortagei* Raym.-Hamet & H.Perrier	Ants
K *	*K. nadyae* Raym.-Hamet	Tol
K *	*K. orgyalis* Baker	Tol/Fia
	K. panduriformis (Baker) Baillon see *K. companulata* (Baker) Baillon	
K *	*K. peltata* (Baker)Baillon var. *peltata*	Ant/Fia/Mah
K	- var. *mandrakensi* H.Perrier	Ant/Mah
K	- var. *stapfii* (H.Perrier) Raym.-Hamet & H.Perrier	Ants
K	*K. poincarei* Raym.-Hamet	Fia/Tol
K	*K. porphyrocalyx* (Baker) Baillon var. *porphyrocalyx*	Ant/Toa
K	- var. *sambiramensis* Humbert	Ants
K	- var. *sulphurea* Baker	Tol
K	*K. prolifera* (Bowie)Raym.-Hamet	Toa
K	*K. pseudocampanulata* Manning & Boit.	Fia
K	*K. pubescens* Baker var. *pubescens*	Ant/Tol/Fia/Ants
K	- var. *alexiana* Manning & Boit.	Fia
K	- var. *brevicalyx* Manning & Boit.	
K	- var. *decolorata* Manning & Boit.	
K	- var. *grandiflora* Manning & Boit.	
K	- var. *subglabrata* Manning & Boit.	Tol
K	- var. *subsessilis* Manning & Boit.	
K *	*K. pumila* Baker	Ant/Fia
K *	*K. rhombopilosa* Manning & Boit.	Tol
K	*K. rolandi-bonapartei* Raym.-Hamet & H.Perrier	Ants
K *	*K. rosei* Raym.-Hamet & H.Perrier var. *rosei*	Tol
K	- var. *seyrigii* Manning & Boit.	Tol
K	- var. *varifolia* Guill. & Humbert	Tol
K	*K. rubella* (Baker)Raym.-Hamet	un
	K. scandens H.Perrier see *K. beauverdii* Raym.-Hamet	
K *	*K. schizophylla* (Baker) Baillon	Ant/Fia
K	*K. serrata* Manning & Boit.	Fia
K	*K. streptantha* Baker	Ants/Mah
K	*K. suarezensis* H.Perrier	Ants
nt *	*K. synsepala* Baker	Fia/Ant/Tol
R *	*K. tetraphylla* H.Perrier	Fia/Ant
K	*K. tieghemi* Raym.-Hamet	un
nt *	*K. tomentosa* Baker	Fia/Ant/Tol/Ants
K	*K. trichantha* Baker	un
	K. tsaratananensis H.Perrier see *K. rolandi-bonapartei* Raym.-Hamet & H.Perrier	
K	*K. tuberosa* H.Perrier	Ant
nt *	*K. tubiflora* (Harvey)Raym.-Hamet	Tol/Fia
K *	*K. uniflora* (Stapf)Raym.-Hamet var. *uniflora*	Ants
K	- var. *brachycalyx* Manning & Boit.	
K	*K. verticillata* Scott-Elliot	Tol
R	*K. viguieri* Raym.-Hamet & H.Perrier	Tol/Mah
K	*K. waldheimii* Raym.-Hamet & H.Perrier	Fia/Tol

Status	Taxon	Distribution
K	*Sedum madagascariense* H.Perrier	Fia
	CUCURBITACEAE	
K	***Seyrigia*** *bosseri* Keraudren	Tol
K	*S. gracilis* Keraudren	Tol
K	*S. humbertii* Keraudren	Tol
K	*S. multiflora* Keraudren	Tol
	The clearing of the dry thorn-forest is a possible reason for the threatening of the species of *Seyrigia*. They are not often found in trade.	
nt *	***Trochomeriopsis*** *diversifolia*	Ants/Mah/Tol
nt	***Xerosicyos*** *danguyi* Humbert	Tol
nt	*X. perrieri* Humbert	Mah/Tol
nt	*X. decaryi* Guill. & Keraudren	Mah/Tol
R *	*X. pubescens* Keraudren (caudiciform, traded in large quantities)	Tol
K *	***Zygosicyos*** *tripartitus* Humbert	Tol
K	*Z. hirtellus* Humbert	Tol
	Trochomeriopsis and *Zygosicyos* are in trade from time to time.	
	DIDIEREACEAE	
E*	*Alluaudia ascendens* (Drake) Drake	Tol
nt*	*A. comosa* Drake	Tol
nt	*A. dumosa* Drake	Tol
nt	*A. humbertii* Choux	Tol/Fia
R*	*A. montagnacii* Rauh	Tol
nt*	*A. procera* Drake	Tol
R	*Alluaudiopsisfiherensis* Humbert & Choux	Tol
nt	*A. marnierana* Rauh	Tol
nt*	*Decaryia madagascariensis* Choux	Tol
nt*	*Didierea madagascariensis* Baillon	Tol
nt*	*D. trollii* Capuron & Rauh	Tol
	DRACAENACEAE	
R	***Sansevieria*** *canaliculata* Carrière	Ants
R	*S. sambiranensis* H.Perrier	Ants
	Sansevieria species are semi succulent.	
	EUPHORBIACEAE	
K	***Euphorbia*** *alcicornis* Baker	un
R*	*E. alfredii* Rauh	Ants
nt*	*E. alluaudii* Drake ssp. *alluaudii*	Tol
R	- ssp. *oncoclada* (Drake) Friedm. & Cremers	Tol
	E. ambatofinandranae Leandri *see E. stenoclada* Baillon ssp. *ambatofinandranae* (Leandri) Cremers	
E*	*E. ambovombensis* Rauh & Razaf.	Tol
K	*E. anahaka* Humbert & Leandri	un
K	*E. analalavensis* Leandri	Ants
R	*E. annamarieae* Rauh	Tol
nt*	*E. ankarensis* Boit.	Ants
K	*E. arahaka* Humbert & Leandri	Tol
K*	*E. beharensis* Leandri	Tol
K	*E. benoisti* Leandri	un
K	*E. betacea* Humbert	un
K	*E. biaculeata* Denis	Tol
K	*E. boinensis* Humbert & Leandri	Mah
K	*E. boissieri* Baillon	un
K	*E. boiteaui* Leandri	Tol
K	*E. boivinsis* Humbert & Leandri	un
R*	*E. bongola vensis* Rau h	Tol
K*	*E. bosseri* Leandri	Tol
K	*E. brachyphylla* Denis	Tol
R *	*E. bulbispina* Rauh & Razaf.	Ants
	E. capsaintemariensis Rauh *see E. decaryi* Guillaumin var. *capsaintemariensis* (Rauh) Cremers	
nt *	*E. capuronii* Ursch & Leandri	Tol
K	*E. caputaureum* Denis	un
K	*E. commersonii* Denis	un
E *	*E. cremersii* Rauh & Razaf.	Mah
E	-fa. *viridifolia* Rauh	Mah
nt*	*E. croizatii* Leandri	Tol
E *	*E. cylindrifolia* Marn.-Lap. & Rauh	Tol
	- ssp. *cylindrifolia*	
E*	- ssp. *tuberifera* Rauh	Tol
E*	*E. decaryi* Guillaumin var. *decaryi*	Tol
E*	- var. *ampanihensis* Cremers	Tol
E*	- var. *capsaintemariensis* (Rauh) Cremers	Tol
E	- var. *robinsonii* Cremers	Tol
E*	- var. *spirosticha* Rauh & Buchloh	Tol
K *	*E. delphinensis* Ursch & Leandri	Tol
K	*E. denisiana* Guillaumin	Un
nt	*E. denisii* Oudejans	Tol
I*	*E. didiereoides* Leandri	Fia
nt *	*E. duranii* Ursch & Leandri var. *duranii*	Fia
K	- var. *ankaratrae* Ursch & Leandri	Ant
nt *	*E. enterophora* Drake ssp. *enterophora*	Tol
nt*	- ssp. *crassa* Cremers	Fia
K	*E. eumyrodes* Baron	un
nt	*E. famatamboay* Friedm. & Cremers	
	- ssp. *famatamboay*	Tol
nt	- ssp. *itampolensis* Friedm. & Cremers	Tol
K	*E. fauroti* Franch.	un
nt *	*E. jianarantsoae* Ursch & Leandri	Fia
nt*	*E. fiherenensis* Poiss.	Tol
E *	*E. francoisii* Lcandri var. *francoisii*	Tol
K	*E. francoisii* var. *rakotozafyi* Cremers	un
K	*E. geayi* Const. & Gall.	un
K	*E. genistoides* Berg.	un
nt*	*E. genoudiana* Ursch & Leandri	Tol
R*	*E. gottlebei* Rauh	Tol
R*	*E. guillauminiana* Boit.	Mah
K	*E. guillemetii* Ursch & Leandri	Tol
nt*	*E. hedyotoides* N.E.Br.	Tol
R*	*E. herman-sch wartzii* Rauh	Ants
R*	*E. hofstaetteri* Rauh	Tol
nt *	*E. horombensis* Ursch & Lcandri	Fia/Tol
K	*E. imerina* Cremers	TO l
nt	*E. intisy* Drake var. *intisy*	Tol
	- var. *maintyi* (Decorse) Poiss. *see E. maintyi* Leandri	
K*	*E. isaloensis* Drake	Fia/Tol
R*	*E. kondoi* Rauh & Razaf.	Tol
K	*E. laro* Drake	un
K	*E. leandriana* Boit.	?
K	*E. leptomyura* Poiss.	un
	E. leucodendron Drake *see E. alluaudii* Drake ssp. *alluaudii*	
K*	*E. leuconeura* Boiss.	un
K	*E. lohahensis* Grand.	un
K *	*E. lophogona* Lam. var. *lophogona*	TO l
nt	- var. *tenuicaulis* Rauh	Tol
K	*E. macroglypha* Lemaire	un
K	*E. mahafalensis* Leandri var. *mahafalensis*	Tol
K	- var. *xanthadenia* (Denis)Leandri	Tol
nt	*E. maintyi* Leandri	Tol
K	*E. mandrariensis* Drake	Tol

Status	Taxon	Distribution
K	*E. mandravioky* Leandri	un
K	*E. mangokyensis* Denis	Tol
K	*E. melanacantha Drake*	un
K *	*E. milii* Des Moul. var. *milii*	Madagascar
K	- var. *betsiliana* Leandri	
K	- var. *bevilaniensis* (Croizat) Ursch & Leandri	
K	- var. *bosseri* Rauh syn. *see E. neobosseri* Rauh	
K *	- var. *breonii* (Nois.) Ursch & Leandri	
K	- var. *hislopii* (N.E.Br.)	
K *	- var. *imperatae* (Leandri) Ursch & Leandri	
K	- var. *longifolia* Rauh	
K	- var. *roseana* Marn.-Lap.	
K *	- var. *splendens* (Hooker) Ursch-Leandri	
K *	- var. *tananarivae* Leandri	
R *	- var. *tenuispina* Rauh & Razaf.	Fia
R *	- var. *tulearensis* Ursch & Leandri	Tol
K *	- var. *vulcanii* Leandri	R *
	E. millotii Ursch & Leandri	Ants
E *	*E. moratti* Rauh var. *moratti*	Mah
E	- var. *antsingiensis* Cremers	Mah
E	- var. *bemarahensis* Cremers	Mah
E	- var. *multiflora* Rauh	Mah
R*	*E. neobosseri* Rauh	Tol
nt *	*E. neohumbertii* Boit. var. *neohumbertii*	Ants
R*	- var. *aureo-viridiflora* Rauh	Ants
	E. obcordata Denis (later homonym) *see E. denisii* Oudejans	
	E. oncoclada Drake see *E. alluaudii* Drake ssp. *oncoclada* (Drake) Friedm. & Cremers	
K*	*E. orthoclada* Baker ssp. *orthoclada*	Fia/Ant
K	- ssp. *vepretorum* (Drake) Leandri	Tol
R*	*E. pachypodioides* Boi t.	Ants
E*	*E. parvicya tophora* Rau h	Tol
nt *	*E. pauliana* Ursch & Leandri	Mah
nt*	*E. pedilanthoides* Denis	Mah
R*	*E. perrieri* Drake var. *perrieri*	Mah
R*	- var. *elongata* Denis	Ants
nt *	*E. plagiantha* Drake	Tol
R *	*E. platyclada* Rauh var. *platyclada*	Tol
R*	- var. *hardyi* Rauh	Tol
O*	*E. primulifolia* Baker var. *primulifolia*	Ant/Fia
O	- var. *begardii* Cremers	Fia
K	*E. prostrata* Poiss	un
K	*E. pyrifolia* Lamk.	Ants
E *	*E. quartziticola* Leandri	Fia
K	*E. radula* Poiss.	un
K	*E. razafinjohanii* Ursch & Leandri	Fia
R*	*E. rossii* Rauh & Buchloh	Tol
K	*E. rubrostriata* Drake var. *rubrostriata*	un
K	- var. *dulioti* Drake	un
R*	*E. sakarahaensis* Rauh	Tol
K	*E. sapiifolia* Poiss.	un
K	*E. solota* Leandri	un
nt *	*E. stenoclada* Baillon ssp. *stenoclada*	Fia
R *	- ssp. *ambatofinandranae* (Leandri) Cremers	Fia
K	*E. suareziana* Croizat	Ants
K	*E. tardieuana* Leandri	Toa
K	*E. tetraptera* Poiss.	un
K	*E. thymifolia* Poiss.	un
nt*	*E. tirucalli* L.	Tol
K	*E. tsimbazatae* Leandri	un
E*	*E. tulearensis* (Rau h) Rau h	Tol
nt*	*E. viguieri* Denis var. *viguieri*	Ants/Mah
R*	- var. *ankarafantsiensis* Ursch & Leandri	Mah
nt*	- var. *capuroniana* Ursch & Leandri	Ants
K	- var. *tsimbazazae* Ursch & Leandri	un
R *	- var. *vilanandrensis* Ursch & Leandri	Mah
	E. xylophylloides Lemaire *see E. enterophora* Drake var. *crassa* Cremers	
K	*E. zakamenae* Leandri	Toa

PASSIFLORACEAE

K	***Adenia*** *ambongensis* Claverie	Mah/Tol
K	*A. antongilliana* Schinz	Ants/Toa
K*	*A. epigea* H.Perrier	Mah
K	*A. elegans* H.Perrier	Tol
K	*A. densiflora* Harms	Ant/Fia
K*	*A. firingalavensis* (Drake)Harms	Antsilanana/Mah/Tol
K	*A. monadelpha* H.Perrier	Tol
K*	*A. olaboensis* Claverie	Ants/Mah/Tol
K*	*A. peltata* Schinz	Tol/Fia
K*	*A. perrieri* Claverie	Mah
K	*A. refracta* Schinz	Mah
K	*A. subsessilifolia* H.Perrier	Tol
K	*A. sphaerocarpa* Claverie	Mah/Tol
K	- ssp. *mandrarensis* H.Perrier	Tol
K	- ssp. *isaloensis* H.Perrier	Fia/Tol

All *Adenia* species are caudiciform succulents, which are in trade as big and adult specimens.

PEDALIACEAE

nt *	***Uncarina*** *abbreviata* (Baillon) Ihlenf. & Straka	Tol/Mah
nt*	*U. decaryii* Humbert	Tol
nt*	*U. grandidieri* (Baillon) Stapf	Tol
nt	*U. leandrii* Humbert	Fia/Tol
nt	*U. leptoccarpa* (Decne.) Ihlenf. & Straka	Mah/Tol
nt *	*U. peltata* (Baker) Stapf	Ant/Mah
nt	*U. perrieri* Humbert	Ant/Mah
E*	*U. roeoesliana* Rauh	
nt	*U. sakalava* Humbert	Mah
nt *	*U. stellulifera* Humbert	Tol

VITACEAE

R	***Cyphostemma*** *pachypus* Desc.	Ants
K	*C. ankirihitrense* Desc.	Mah
K	*C. amplexicaule* Desc.	Ant
K	*C. comigerum* Desc.	Mah
K	*C. cristigerum* Desc.	Fia
K	*C. delphinense* Desc.	Tol
K	*C. echinocarpum* Desc.	Tol
R*	*C. elephantopus* Desc.	Tol
K	*C. glandulosopilosum* Desc.	Ants/Toa
K	*C. greveanum* Desc.	Ants/Mah/Fia
K	*C. horombense* Desc.	Fia
nt*	*C. laza* Desc. var. laza	Tol
nt*	- var. *parvifolia* Desc.	Tol
K	*C. leucorufescens* Desc.	Ant
K	*C. macrocarpum* Desc.	Ants
K	*C. manambovense* Desc.	Tol
nt	*C. microdipterum* Desc.	Tol/Ant/Fia
K*	*C. montagnacii* Desc.	Tol
K	*C. pumilum* Desc.	Tol
K	*C. roseiglandulosa* Desc.	Mah
K	*C. sakalavense* Desc.	Tol
K	*C. tsaratananense* Desc.	Ants
K	*C. vezense* Desc.	Tol

Annex 8

Threatened succulents recorded for the Flora of southern Africa (FSA) region

Compiled by Craig Hilton-Taylor.

The data presented here were extracted from the threatened plants database 'SARARES' maintained at the Ecology and Conservation research division of the National Botanical Institute in Kirstenbosch, South Africa. All species are endemic unless noted by an asterisk (*).

AIZOACEAE

R ***Aloinopsis*** *acuta* L.Bolus
R *A. jamesii* L.Bolus
R *A. loganii* L.Bolus
R A. *setifera* (L.Bolus) L.Bolus
R *A. villetii* (L.Bolus) L.Bolus
K ***Argyroderma*** *framesii* L.Bolus ssp. *framesii*
K A. *ringens* L.Bolus
K *A. subalbum* (N.E.Br.) N.E.Br.
K *A. testicular-e* (Aiton) N.E.Br.
R ***Astridia*** *citrina* (L.Bolus) L.Bolus
K *A. herrei* L.Bolus
I *A. speciosa* L.Bolus
K *A. vanheerdei* L.Bolus
K ***Bergeranthus*** *addoensis* L.Bolus
K *B. katbergensis* L.Bolus
I ***Bijlia*** *tugwelliae* (L.Bolus) L.Bolus
R ***Braunsia*** *stayneri* (L.Bolus) L.Bolus
R *B. vanrensburgii* (L.Bolus) L.Bolus
R ***Caryotophora*** *skiatophytoides* Leistner
R ***Cephalophyllum*** *confusum* (Dinter) Dinter & Schwantes
V *C. fulleri* L.Bolus
Ex *C. parvulum* (Schltr.) H.E.K.Hartmann
R *C. pulchellum* L.Bolus
R/V *C. pulchrum* L.Bolus
K *C. rostellum* (L.Bolus) H.E.K.Hartmann
R *C. staminodiosum* L.Bolus
V *C. tetrastichum* H.E.K.Hartmann
K ***Chasmatophyllum*** *braunsii* Schwantes
K *C. maninum* L.Bolus
K *C. willowmorense* L.Bolus
I ***Cheiridopsis*** *alata* L.Bolus
R *C. delphinoides* S.A.Hammer
V *C. pearsonii* N.E.Br.
V *C. peculiaris* N.E.Br.
I C. *rudis* L.Bolus
V *C. umdausensis* L.Bolus
I C. *velox* S.A.Hammer
Ex ***Circandra*** *serrata* (L.) N.E.Br.
R ***Cleretum*** *lyratifolium* Ihlenf. & Struck
R ***Conophytum*** *achabense* S.A.Hammer
V *C. acutum* L.Bolus
R *C. armianum* S.A.Hammer
R *C. auriflorum* Tischer ssp. *auriflorum*
R *C. bicarinatum* L.Bolus
R *C. blandum* L.Bolus
V *C. burgeri* L.Bolus
R *C. carpianum* L.Bolus
R *C. concavum* L.Bolus
R *C. ernstii* S.A.Hammer ssp. *ernstii*
R C. *frutescens* Schwantes
R *C. halenbergense* (Dinter & Schwantes) N.E.Br.
E *C. herreanthus* S.A.Hammer ssp. *herreanthus*
R *C. khamiesbergense* (L.Bolus) Schwantes
R *C. klinghardtense* Rawe ssp. *baradii* (Rawe) S.A.Hammer
K *C. lithopsoides* L.Bolus ssp. *lithopsoides*
R *C. loeschianum* Tischer
R *C. phoeniceum* S.A.Hammer
K *C. praesectum* N.E. Br.
R *C. regale* Lavis
R *C. ricardianum* Loesch & Tischer ssp. *ricardianum*
Ex *C. ricardianum* Loesch & Tischer ssp. *rubriflorum* Tischer
R C. *rugosum* S.A.Hammer ssp. *rugosum*
R C. *rugosum* S.A.Hammer ssp. *sanguineum* S.A.Hammer
R *C. schlechteri* Schwantes
Ex *C. semivestitum* L.Bolus
E *C. smorenskaduense* de Boer ssp. *hermarium* S.A.Hammer
R *C. smorenskaduense* de Boer ssp. *smorenskaduense*
R *C. swanepoelianum* Rawe ssp. *swanepoelianum*
R *C. taylorianum* (Dinter & Schwantes) N.E.Br. ssp. *taylorianum*
V C. *uviforme* (Haw.) N.E.Br. ssp. *subincanum* (Tischer) S.A.Hammer
R *C. vanheerdei* Tischer
R *C. velutinum* Schwantes ssp. *velutinum*
I C. *verrucosum* (Lavis) G.D. Rowley
K ***Delosperma*** *clavipes* Lavis
V *D. guthriei* Lavis
R *D. hallii* L.Bolus
K *D. inaequale* L.Bolus
K *D. leendertziae* N.E.Br.
K *D. macrostigma* L.Bolus
K *D. mariae* L.Bolus
I *D. pondoense* L.Bolus
I *D. subpetiolatum* L.Bolus
I *D. suttoniae* Lavis
I *D. velutinum* L.Bolus
V ***Didymaotus*** *lapidiformis* (Marloth) N.E.Br.
R ***Dinteranthus*** *microspermus* (Dinter & Derenb.) Schwantcs ssp. *microspermus*
I *D. pole-evansii* (N.E.Br.) Schwantcs
V *D. vanzylii* (L.Bolus) Schwantes
R *D. wilmotianus* L.Bolus ssp. *impunctatus* N.Sauer
R *Diplosoma luckhoffii* (L.Bolus) Schwantes cx Ihlcnf.
E *D. retroversum* (Kensit) Schwantes
K ***Dorotheanthus*** *apetalus* (L.f.) N.E.Br.
E ***Drosanthemum*** *austricolum* L.Bolus
R *D. bellum* L.Bolus
R *D. hallii* L.Bolus
R *D. micans* (L.) Schwantes
K *D. nordenstamii* L.Bolus
R *D. thudichumii* L.Bolus var. *gracilis* L.Bolus
K *Ebracteola montis-moltkei* (Dinter) Dinter & Schwantcs
I ***Ectotropis*** *alpina* N.E.Br.
E ***Erepsia*** *brevipetala* L.Bolus
R *E. dubia* Liede
I *E. hallii* L.Bolus
R *E. insignis* (Schltr.) Schwantcs
R *E. patula* (Haw.) Schwantes
V *E. pentagona* (L.Bolus) L.Bolus

I *E. pillansii* (Kensit) Liede
E *E. polita* (L.Bolus) L.Bolus
R *E. polypetala* (A.Berger & Schltr.) L.Bolus
Ex *E. promontorii* L.Bolus
I *E. steytlerae* L.Bolus
V *E. villiersii* L.Bolus
V *Faucaria tigrina* (Haw.) Schwantes
R ***Fenestraria*** *rhopalophylla* (Schltr. & Diels) N.E.Br. ssp. *aurantiaca* (N.E.Br.) H.E.K.Hartmann
R *Frithia pulchra* N.E.Br. var. *pulchra*
K ***Gibbaeum*** *angulipes* (L.Bolus) N.E.Br.
K *G. dispar* N.E.Br.
Ex *G. esterhuyseniae* L.Bolus
K *G. nebrownii* Tischer
K *G. pachypodium* (Kensit) L.Bolus
R/V *G. schwantesii* Tischer
K ***Imitaria*** *rnuirii* N.E.Br.
R ***Jacobsenia*** *hallii* L.Bolus
R ***Jensenobotrya*** *lossowiana* Herre
R ***Jordaaniella*** *clavifolia* (L.Bolus) H.E.K.Hartmann
R/V *J. uniflora* (L.Bolus) H.E.K.Hartmann
R ***Lampranthus*** *algoensis* L.Bolus
I *L. dunensis* (Sond.) L.Bolus
R *L. fugitans* L.Bolus
R *L. rustii* (A.Berger) N.E.Br.
V *L. scaber* (L.) N.E.Br.
R *L. stenus* (Haw.) N.E.Br.
K *Lithops aucampiae* L.Bolus ssp. *aucampiae* var. *koelmanii* (de Boer) D.T.Cole
R *L. aucampiae* L.Bolus ssp. *euniciae* (de Boer) D.T.Cole var. *euniciae*
R *L. aucampiae* L.Bolus ssp. *euniciae* (de Boer) D.T.Cole var. *fluminalis* D.T.Cole
I *L. bromfieldii* L.Bolus var. *glaudinae* (de Boer) D.T.Cole
V *L. coleorum* S.A.Hammer & R.Uijs
E *L. comptonii* L.Bolus var. *comptonii*
R *L. comptonii* L.Bolus var. *weberi* (L.Bolus) B.Fearn
K *L. dinteri* Schwantes ssp. *dinteri* var. *brevis* (L.Bolus) B.Fearn
K *L. dinteri* Schwantes ssp. *dinteri* var. *dinteri*
K *L. dinteri* Schwantes *ssp.frederici* (D.T.Cole) D.T.Cole
K *L. dinteri* Schwantes *ssp.multipunctata* (de Boer) D.T.Cole
I *L. divergens* L.Bolus var. *amethystina* de Boer
V *L. divergens* L.Bolus var. *divergens*
V *L. dorotheae* Nel
R *L. franciscii* (Dinter & Schwantes) N.E.Br.
R *L. fulviceps* (N.E.Br.) N.E.Br. var. *lactinea* D.T.Cole
I *L. gesineae* de Boer var. *annae* (de Boer) D.T.Cole
E *L. gesineae* de Boer var. *gesineae*
R *L. geyeri* Nel
R *L. gracidelineata* Dinter ssp. *brandbergensis* (de Boer) D.T.Cole
K *L. gracilidelineata* Dinter ssp. *gracilidelineata* var. *waldroniae* de Boer
R *L. helmutii* L.Bolus
K *L. hookeri* (A.Berger) Schwantes var. *dabneri* L.Bolus
K *L. hookeri* (A.Berger) Schwantes var. *marginata* (Nel) D.T.Cole
K *L. hookeri* (A.Berger) Schwantes var. *subfenestrata* (de Boer) D.T.Cole
R *L. hookeri* (A.Berger) Schwantes var. *susannae* (D.T.Cole) D.T.Cole
K *L. karasmontana* (Dinter & Schwantes) N.E.Br. ssp. *karasmontana* var. *aiaisensis* (de Boer) D.T.Cole
K *L. karasmontana* (Dinter & Schwantes) N.E.Br. ssp. *karasmontana* var. *tischeri* D.T.Cole
R *L. lesliei* (N.E.Br.) N.E.Br. ssp. *burchellii* D.T.Cole
K ***L.*** *lesliei* (N.E.Br.) N.E.Br. ssp. *lesliei* var. *hornii* de Boer
K *L. lesliei* (N.E.Br.) N.E.Br. ssp. *lesliei* var. *mariae* D.T.Cole
R *L. meyeri* L.Bolus
R *L. naureeniae* D.T.Cole
R *L. olivacea* L.Bolus var. *nebrownii* D.T.Cole
R *L. otzeniana* Nel
R *L. pseudotruncatella* (A.Berger) N.E.Br. ssp. *pseudotruncatella* var. *elisabethae* (Dinter) de Boer & Boom
R *L. pseudotruncatella* (A.Berger) N.E.Br. ssp. *pseudotruncatella* var. *riehmerae* D.T.Cole
R *L. pseudotruncatella* (A.Berger) N.E. Br. ssp. *volkii* (Schwantes ex de Boer & Boom) D.T. Cole
V *L. salicola* N.E.Br.
R *L. schwantesii* Dinter ssp. *schwantesii* var. *rugosa* (Dinter) de Boer & Boom
R *L. viridis* C.A.Lückh.
R *L. werneri* Schwantes & H. Jacobsen
K ***Mestoklema*** *albanicum* N.E.Br. ex Glen
R ***Mitrophyllum*** *abbreviatum* L.Bolus
R/V *M. roseum* L.Bolus
R ***Mossia*** *intervallaris* (L.Bolus) N.E.Br.
E ***Muiria*** *hortenseae* N.E.Br.
K ***Nananthus*** *pole-evansii* N.E.Br.
K *N. vittatus* (N.E.Br.) Schwantes
I ***Nelia*** *pillansii* (N.E.Br.) Schwantes
R *N. schlechteri* Schwantes
V ***Neohenricia*** *sibbettii* (L.Bolus) L.Bolus
R *N. spiculata* S.A.Hammer
I ***Odontophorus*** *marlothii* N.E.Br.
K ***Ophthalmophyllum*** *longitubum* L.Bolus
R ***0. villetii*** L.Bolus
E ***Orthopterum*** *coegana* L.Bolus
R ***Pleiospilos*** *compactus* (Aiton) Schwantes ssp. *minor* (L.Bolus) H.E.K.Hartman & Liede
R/V *P. nelii* Schwantes
E *P. simulans* (Marloth) N.E.Br.
I ***Rabiea*** *jamesii* (L.Bolus) L.Bolus
I ***Rhinephyllum*** *inaequale* L.Bolus var. *inaequale*
I *R. inaequale* L.Bolus var. *latipetalum* L.Bolus
R ***Ruschia*** *amicorum* (L.Bolus) Schwantes
I *R. filamentosa* (L.) L.Bolus
R *R. firma* L.Bolus
K *R. lawsonii* (L.Bolus) L.Bolus
E *R. leipoldtii* L.Bolus
E *R. promontorii* L.Bolus
I *R. rubricaulis* (Haw.) L.Bolus
E ***Saphesia*** *flaccida* (Jacq.) N.E.Br.
R/V ***Schwantesia*** *acutipetala* L.Bolus
V *S. borcherdsii* L.Bolus
I *S. triebneri* L.Bolus
R ***Scopologena*** *veruculata* (L.) L.Bolus
K ***Stayneria*** *neilii* (L.Bolus) L.Bolus
I ***Stomatium*** *geoffreyi* L.Bolus
I *S. ronaldii* L.Bolus
R ***Tanquana*** *archeri* (L.Bolus) H.E.K.Hartmann & Liede
R *T. hilmarii* (L.Bolus) H.E.K.Hartmann & Liede
R ***Trianthema*** *hereroensis* Schinz
I ***Trichodiadema*** *aureum* L.Bolus
R *T. burgeri* L.Bolus
R *T. hallii* L.Bolus
I *T. obliquum* L.Bolus
I *T. peersii* L.Bolus
R *T. pygmaeum* L.Bolus
I *T. rogersiae* L.Bolus
I *T. rupicolum* L.Bolus
R ***Vlokia*** *ater* S.A.Hammer
Ex ***Zeuktophyllum*** *suppositum* (L.Bolus) N.E.Br.

ALOACEAE

V *Aloe alhida* (Stapf) Reynolds
V *A. arenicola* Reynolds
E *A. bowiea* Schult. & Schult.f.
R *A. buhrii* Lavranos
E *A. chlorantha* Lavranos
R *A. comosa* Marloth & A.Berger
K *A. cooperi* Baker ssp. *pulchra* Glen & D.S.Hardy
R *A. corallina* I.Verd.
R *A. dabenorisana* Van Jaarsv.
R *A. dewinteri* Giess
R *A. dinteri* A.Berger
R *A. distans* Haw.
R *A. erinacea* D.S.Hardy
V *A. falcata* Baker
K *A. fouriei* D.S.Hardy & Glen
R *A. gerstneri* Reynolds
R *A. gracilis* Haw. var. *decumbens* Reynolds
R *A. haemanthifolia* A.Berger & Marloth
K *A. hardyi* Glen
R *A. inconspicua* Plowes
R *A. keithii* Reynolds
K *A. khamiesensis* Pillans
V *A. krapohliana* Marloth
V *A. longistyla* Baker
R *A. meyeri* Van Jaarsv.
R *A. microcantha* Haw.
K *A. modesta* Reynolds
R *A. monotropa* I.Vcrd.
R *A. namibensis* Giess
V *A. pearsonii* Schonland
R *A. peglerae* Schonland
R *A. petrophila* Pillans
R *A. pictifolia* D.S.Hardy
E *A. pillansii* L.Guthrie
E *A. polyphylla* Schonland ex Pillans
K *A. pratensis* Baker
R *A. prinslooi* I.Verd. & D.S.Hardy
R *A. pruinosa* Reynolds
V *A. ramosissima* Pillans
I *A. reitzii* Reynolds var. *reitzii*
R *A. reitzii* Reynolds var. *vernalis* D.S.Hardy
V *A. reynoldsii* Let ty
V *A. saundersiae* (Reynolds) Reynolds
V *A. simii* Pole-Evans
R *A. sladeniana* Pole-Evans
R *A. soutpansbergensis* I.Verd.
R *A. striata* Haw. ssp. *komaggasensis* (Kritzinger & Van Jaarsv.) Glen & D.S.Hardy
I *A. thompsoniae* Groenew.
V *A. thomcroftii* Pole-Evans
R *A. vandermerwei* Reynolds
R *A. viridiflora* Reynolds
R *A. vogtsii* Reynolds
R *A. vossii* Reynolds
R *A. vryheidensis* Groenew.
R ***Astroloba*** *herrei* Uitewaal
K ***Gasteria*** *batesiana* G.D.Rowley
E *G. baylissiana* Rauh
R *G. bicolor* Haw. var. *liliputana* (Poelln.) Van Jaarsv.
V *G. croucheri* (Hook.f.) Baker
R *G. ellaphieae* Van Jaarsv.
R *G. glomerata* Van Jaarsv.
K *G. nitida* (Salm-Dyck) Haw. var. *armstrongii* (Schonland) Van Jaarsv.
R *G. rawlinsonii* Oberm.
R *G. vlokii* Van Jaarsv.
V ***Haworthia*** *archeri* W.F.Barker ex M.B.Bayer var. *archeri*
E *H. archeri* W.F.Barker ex M.B.Bayer var. *dimorpha* M.B.Bayer
R *H. blackburniae* W.F.Barker
V *H. bruynsii* M.B.Bayer
E *H. comptoniana* G.G.Sm.
V *H. emelyae* Poelln. var. *emelyae*
E *H. emelyae* Poelln. var. *multifolia* M.B.Bayer
R *H. fasciata* (Willd.) Haw.
V *H. floribunda* Poelln.
R *H. graminifolia* G.G.Sm.
V *H. heidelbergensis* G.G.Sm.
V *H. kingiana* Poelln.
V *H. koelmaniorum* Oberm. & D.S.Hardy
V *H. limifolia* Marloth var. *gigantea* M.B.Bayer
V *H. limifolia* Marloth var. *limifolia**
I *H. limifolia* Marloth var. *ubomboensis* (I.Verd.) G.G.Sm.
V *H. lockwoodii* Archibald
E *H. magnifica* Poelln. var. *atrofusca* G.G.Sm.
E *H. magnifica* Poelln. var. *major* (G.G.Sm.) M.B.Bayer
E *H. magnifica* Poelln. var. *paradoxa* (Poelln.) M.B.Bayer
E *H. marginata* (Lam.) Stearn
V *H. maughanii* Poelln.
I *H. mcmurtryi* C.L.Scott
E *H. mirabilis* (Haw.) Haw. ssp. *badia* (Poclln.) M.B.Bayer
E *H. mirabilis* (Haw.) Haw. ssp. *mundula* (G.G.Sm.) M.B.Bayer
V *H. mutica* Haw.
V *H. nortieri* G.G.Sm. var. *globosiflora* (G.G.Sm.) M.B.Bayer
E *H. parksiana* Poelln.
E *H. pehlemanniae* C.L.Scott
E *H. poellnitziana* Uitewaal
V *H. pubescens* M.B.Bayer
E *H. pygmaea* Poelln.
E *H. retusa* (L.) Duval var. *dekanahii* (G.G.Sm.) M.B.Bayer
E *H. serrata* M.B.Bayer
V *H. sordida* Haw.
V *H. springbokvlakensis* C.L.Scott
E *H. starkiana* Poelln. var. *lateganiae* (Poclln.) M.B.Bayer
V *H. truncata* Schonland
R *H. wittebergensis* W.F.Barker
V *H. woolleyi* Poelln.
R ***Poellnitzia*** *rubriflora* (L.Bolus) Uitewaal

APOCYNACEAE

I ***Adenium*** *swazicum* Stapf *
V ***Pachypodium*** *namaquanum* (Wyley ex Harv.) Wclw.

ASCLEPIADACEAE

I ***Ceropegia*** *barbata* R.A.Dyer
R *C. cancellata* Rchb.
V *C. cimiciodora* Oberm.
R *C. decidua* E.A.Bruce ssp. *pretoriensis* R.A.Dyer
V *C. occidentalis* R.A.Dyer
R *C. radicans* Schltr. ssp. *radicans*
R *C. verruculosa* (R.A.Dyer) D.V.Field
R *Cynanchum meyeri* (Decne.) Schltr.
R ***Duvalia*** *parviflora* N.E.Br.
K *D. pillansii* N.E.Br. var. *albanica* N.E.Br.
K *D. pillansii* N.E.Br. var. *pillansii*
R ***Hoodia*** *dregei* N.E.Br.
R *H. juttae* Dinter
R *H. officinalis* (N.E.Br.) Plowes ssp. *delaetiana* (Dintcr) Bruyns
R *H. pilifera* (L.f.) Plowes ssp. *annulata* (N.E.Br.) Bruyns
R *H. pilifera* (L.f.) Plowes ssp. *pilifera*
V *H. pilifera* (L.f.) Plowes ssp. *pillansii* (N.E.Br.)
I *H. ruschii* Dinter

R *H. triebneri* (Nel) Bruyns
I ***Huernia*** *echidnopsioides* (L.C.Leach) L.C.Leach
R *H. hallii* E. & B.M.Lamb
R *H. humilis* (Masson) Haw.
V *H. hystrix* (Hook-f.) N.E.Br. var. *parvula* L.C.Leach
V *H. kennedyana* Lavranos
R *H. longii* Pillans
E *H. nouhuysii* I.Verd.
I *H. pendula* E.A.Bruce
R *H. plowesii* L.C.Leach
R *H. praestans* N.E.Br.
Ex *H. thudichumii* L.C.Leach
Ex *H. witzenbergensis* C.A.Liickh.
R ***Lavrania*** *haagnerae* Plowes
R ***Notechidnopsis*** *columnaris* (Nel) Lavranos & Bleck
K ***Orbea*** *irrorata* (Masson) L.C.Leach
K *0. lepida* (Jacq.) Haw.
I *0. macloughlinii* (I.Verd.) L.C.Leach
R *0. maculata* (N.E.Br.) L.C.Leach
V *0. paradoxa* (I.Verd.) L.C.Leach
I *0. pulchella* (Masson) L.C.Leach
R *0. rangeana* (Dinter & A.Berger) L.C. Leach
V *0. speciosa* L.C.Leach
R *0. woodii* (N.E.Br.) L.C.Leach
V ***Orbeanthus*** *conjunctus* (A.C.White & B.Sloane) L.C.Leach
V *0. hardyi* (R.A.Dyer) L.C.Leach
K ***Orbeopsis*** *albocastanea* (Marloth) L.C.Leach
R *0. gerstneri* (Letty) L.C.Leach ssp. *elongata* (R.A.Dyer) L.C.Leach
V *0. gerstneri* (Letty) L.C.Leach ssp. *gerstneri*
K *0. knohelii* (E.Phillips) L.C.Leach
K *0. tsumebensis* (Oberm.) L.C.Leach
R ***Pachycymbium*** *lancasteri* Lavranos
V *P. ubomboense* (I.Verd.) M.G.Gilbert *
R ***Pectinaria*** *articulata* (Aiton) Haw. ssp. *articulata*
R *P. articulata* (Aiton) Haw. ssp. *borealis* Bruyns
R *P. longipes* (N.E.Br.) Bruyns
R ***Piaranthus*** *barrydalensis* Meve
R ***Quaqua*** *armata* (N.E.Br.) Bruyns ssp. *arenicola* (N.E.Br.) Bruyns
R *Q. armata* (N.E.Br.) Bruyns ssp. *maritima* Bruyns
R *Q. framesii* (Pillans) Bruyns
R *Q. inversa* (N.E.Br.) Bruyns var. *cincta* (C.A.Lückh.) Bruyns
R *Q. inversa* (N.E.Br.) Bruyns var. *inversa*
R *Q. linearis* (N.E.Br.) Bruyns
R *Q. multiflora* (R.A.Dyer) Bruyns
R *Q. parviflora* (Masson) Bruyns ssp. *bayeriana* Bruyns
R *Q. pruinosa* (Masson) Bruyns
R ***Stapelia*** *baylissii* L.C.Leach
V *S. clavicorona* I.Verd.
V *S. divaricata* Masson
R *S. erectiflora* N.E.Br. var. *prostratiflora* L.C.Leach
I *S. glabricaulis* N.E.Br.
V *S. immelmaniae* Pillans
K *S. macowanii* N.E.Br. var. *macowanii*
I *S. obducta* L.C.Leach
R *S. paniculata* Willd.
R *S. pearsonii* N.E.Br.
R *S. peglerae* N.E.Br.
R *S. praetermissa* L.C.Leach var. *luteola* L.C.Leach
R *S. praetermissa* L.C.Leach var. *praetermissa* L.C.Leach
K *S. remota* R.A.Dyer
R/V *S. rubiginosa* Nel
V/E *S. scitula* L.C.Leach
R *S. tsomoensis* N.E.Br.
V ***Stapeliopsis*** *breviloba* (R.A.Dyer) Bruyns
R *S. exasperata* (Bruyns) Bruyns
E *S. neronis* Pillans
R *S. pillansii* (N.E.Br.) Bruyns
V S. saxatilis (N.E.Br.) Bruyns ssp. *stayneri* (M.B.Bayer) Bruyns
R *S. urniflora* Lavranos
R/V ***Tridentea*** *pachyrrhiza* (Dinter) L.C.Leach
R *7'. virescens* (N.E.Br.) L.C.Leach
R/V ***Tromotriche*** *herrei* (Nel) L.C.Leach
R *T. longii* (C.A.Lückh.) L.C.Leach
R *T. ruschiana* (Dinter) L.C.Leach
R *T. thudichumii* (Pillans) L.C.Leach

ASPHODELACEAE
R ***Bulbine*** *brunsvigiifolia* Baker
R *B. diphylla* Schltr. ex Poelln.
R *B. fallax* Poelln.
R *B. francescae* G.Will. & Baijnath ined.
V *B. haworthioides* B.Nord.
R *B. louwii* L.I.Hall
E *B. margarethae* L.I.Hall
K *B. monophylla* Poelln.
R *B. orchioides* Drége ex Poelln.
R *B. striata* Baijnath & Van Jaarsv.
V *B. wiesei* L.I.Hall

ASTERACEAE
K ***Othonna*** *abrotanifolia* (Harv.) Druce
R *0. armiana* Van Jaarsv.
K *0. cacalioides* L.f.
R *0. hallii* B.Nord.
K *0. lepidocaulis* Schltr.
R/V *0. rechingeri* B.Nord.
K ***Senecio*** *scaposus* DC. var. *addoensis* (Compton) G.D.Rowley
K *S. haworthii* (Sweet) Sch.Bip.
K *S. medley-woodii* Hutch.
K *S. muirii* L.Bolus

BRASSICACEAE
R *Heliophila eximia* Marais

CRASSULACEAE
K ***Adromischus*** *bicolor* Hutchison
K *A. cooperi* (Baker) A.Berger
K *A. cristatus* (Haw.) Lem. var. *zeyheri* (Harv.) Toelken
I *A. diabolicus* Toelken
I *A. fallax* Toelken
K *A. humilis* (Marloth) Poelln.
R *A. liebenbergii* Hutchison
R *A. mammillaris* (L.f.) Lem.
K *A. marianiae* (Marloth) A.Berger var. *marianiae*
R *A. nanus* (N.E.Br.) Poelln.
K *A. phillipsiae* (Marloth) Poelln.
R *A. schuldtianus* (Poelln.) Poelln. ssp. *juttae* (Poelln.) Toelken
R *A. subviridis* Toelken
R ***Cotyledon*** *orbiculata* L. var. *flanaganii* (Schönland & Baker f.) Toelken
R *C. tomentosa* Harv. ssp. *ladismithiensis* (Poelln.) Toelkcn
Ex ***Crassula*** *alcicornis* Schonland
K *C. alpestris* Thunb. ssp. *massonii* (Britten & Baker f.) Toelken
R *C. arborescens* (Mill.) Willd. ssp. *undulatifolia* Toelkcn
R *C. aurusbergensis* G.Will.
R *C. ausensis* Hutchison ssp. *giessii* (Friedrich) Toelken
K *C. brachystachya* Toelken
R/V *C. brevifolia* Harv. ssp. *psammophilu* Toelken
R *C. decidua* Schonland
R *C. elsieae* Toelken

R *C. exilis* Harv. ssp. *exilis*
R *C. garibina* Marloth & Schonland ssp. *glabra* Toelken
K *C. latibracteata* Toelken
R *C. luederitzii* Schonland
R *C. multiceps* Harv.
K *C. multiflora* Schonland & Baker f. ssp. *leucantha* (Schonland & Baker f.) Toelken
R *C. namaquensis* Schonland & Baker f. ssp. *comptonii* (Hutch. & Pillans) Toelken
V *C. planifolia* Schonland
R/V *C. plegmatoides* Friedrich
R *C. qoatlhambensis* Hargr.
K *C. rupestris* Thunb. ssp. *commutata* (Friedrich) Toelken
R *C. rupestris* Thunb. ssp. *marnierana* (H.E.Huber & Jacobsen) Toelken
R *C. sericea* Schonland var. *velutina* (Friedr.) Toelken
R *C. sladenii* Schonland
R *C. socialis* Schonland
R *C. streyi* Toelken
R *C. subacaulis* Schonland & Baker f. ssp. *subacaulis*
Ex *C. subulata* L. var. *hispida* Toelken
I *C. susannae* Rauh & Friedrich
R *C. thunbergiana* Schult. ssp. *minutiflora* (Schonland & Baker f.) Toelkcn
R *C. tuberella* Toelken
K ***Crassula*** *vaginata* Eckl. & Zeyh. ssp. *minuta* Toelken
R *C. vestita* Thunb.
R ***Tylecodon*** *albiflorus* Bruyns
R *T. atropurpureus* Bruyns
R *T. bayeri* Van Jaarsv.
R *T. boddleyae* Van Jaarsv.
R *T. decipiens* Toelken
R *T. ellaphieae* Van Jaarsv.
V *T. fragilis* (R.A.Dyer) Toelken
R *T. hirtifolius* (W.F.Barker) Toelken
R *T. kritzingeri* Van Jaarsv.
K *T. occultans* (Toelken) Toelken
E *T. singularis* (R.A.Dyer) Toelken
R *T. suffultus* Bruyns ex Toelken
R *T. sulphureus* (Toclken) Toelken
R *T. tenuis* (Toclken) Bruyns
R *T. torulosus* Toelken

EUPHORBIACEAE
R/V ***Euphorbia*** *albertensis* N.E.Br.
V *E. albipollinifera* L.C.Leach
K *E. artifolia* N.E.Br.
R *E. baliola* N.E.Br.
V *E. barnardii* A.C.White, R.A.Dyer & B.Sloane
V *E. bayeri* L.C.Leach
R *E. berotica* N.E.Br.
R *E. brakdamensis* N.E.Br.
Ex *E. brevirama* N.E.Br.
R E. *bruynsii* L.C.Leach
R *E. cibdela* N.E.Br.
V *E. clavigera* N.E.Br.
V *E. clivicola* R.A.Dyer
K *E. corymbosa* N.E.Br.
Ex *E. crassipes* Marloth
V *E. cylindrica* A.C.White, R.A.Dyer & B.Sloane
R/V *E. decepta* N.E.Br.
V *E. fasciculata* Thunb.
I *E. friedrichiae* Dinter
R *E. globosa* (Haw.) Sims
R *E. grandialata* R.A.Dyer
E *E. groenewaldii* R.A.Dyer
R *E. hallii* R.A.Dyer
V/E *E. hopetownensis* Nel
R *E. hottentota* Marloth
K *E. inomata* N.E.Br.
K *E. insarmentosa* P.G.Mey.
E *E. jansenvillensis* Ncl
R *E. kaokoensis* (A.C.White, R.A.Dyer & B.Sloane) L.C.Leach
K *E. keithii* R.A.Dyer
R *E. knobelii* Letty
R *E. lavrani* L.C.Leach
R *E. ledienii* A.Berger var. *dregei* N.E.Br.
K *E. louwii* L.C.Lcach
R *E. lumbricalis* L.C.Leach
R *E. malevola* L.C.Leach ssp. *bechuanica* L.C.Leach
V *E. marlothiana* N.E.Br.
V/E *E. meloformis* Aiton
K *E. monteiroi* Hook.f. ssp. *brandbergensis* B.Nord.
R *E. namuskluftensis* L.C.Leach
R *E. nesemannii* R.A.Dyer
E *E. obesa* Hook.f.
K *E. ornithopus* J acy.
R *E. otjipembana* L.C.Leach
V/E *E. oxystegia* Boiss.
I *E. pedemontana* L.C.Leach
K *E. pentops* A.C.White, R.A.Dyer & B.Sloane
E *E. perangusta* R.A.Dyer
K *E. planiceps* A.C.White, R.A.Dyer & B.Sloane
V/E *E. polycephala* Marloth
K *E. pseudoglobosa* Marloth
R *E. quadrata* Nel
R *E. restituta* N.E.Br.
R *E. restricta* R.A.Dyer
R *E. rowlandii* R.A.Dyer *
K *E. rudolfii* N.E.Br.
V *E. schoenlandii* Pax
R *E. sekukuniensis* R.A.Dyer
V *E. symmetrica* A.C.White, R.A.Dyer & B.Sloane
V *E. tortirama* R.A.Dyer
R *E. umfoloziensis* Pcckover
R *E. vaalputsiana* L.C.Leach
V *E. valida* N.E.Br.
K *E. venenata* Marloth
R *E. versicolores* G.Will.
V *E. waterbergensis* R.A.Dyer
R *E. woodii* N.E.Br.
R *E. zoutpansbergensis* R.A.Dycr

GERANIACEAE
I ***Pelargonium*** *crassipes* Harv.
R *P. desertorum* Vorster
R *P. hystrix* Harv.
R *P. torulosum* E.M.Marais
K ***Sarcocaulon*** *herrei* L.Bolus
K *S. inerme* Rehm
R *S. peniculinum* Moffctt

PASSIFLORACEAE
R ***Adenia*** *fruticosa* Burtt Davy ssp. *simplicifolia* W.J.de Wilde *
Ex *A. natalensis* W.J.de Wilde
R *A. pechuelii* (Engl.) Harms

PORTULACACEAE
R ***Anacampseros*** *bayeriana* S.A.Hammer
R *A. comptonii* Pillans
R *A. dinteri* Schinz
R/V *A. filamentosa* (Haw.) Sims ssp. *filamentosa*

R *A. filamentosa* (Haw.) Sims ssp. *tomentosa* (A.Berger) Gerbaulet
R *A. herreana* Poelln.
R *A. karasmontana* Dinter
R *A. lanceolata* (Haw.) Sweet ssp. *lanceolata*
R *A. lanceolata* (Haw.) Sweet ssp. *nebrownii* (Poelln.) Gerbaulet
R *A. papyracea* E.Mey. *ex* Fenzl ssp. *papyracea*
I *A. yuinaria* E.Mey. cx Fenzl
R *A. recurvata* Schonland ssp. *buderiana* (Poelln.) Gerbaulet
R *A. recurvata* Schonland ssp. *minuta* Gerbaulet
R *A. recurvata* Schonland ssp. *recurvata*
R *A. rhodesica* N.E.Br. *
K *A. rufescens* (Haw.) Sweet
R *A. ruschii* Dinter ex Poelln.
R *A. scopata* G.Will.
R *A. subnuda* Poelln. ssp. *lubbersii* (Bleck) Gerbaulet
R ***Avonia*** *mallei* G.Will.
V ***Portulaca*** *trianthemoides* Bremek.

VITACEAE
R ***Cyphostemma*** *bainesii* (Hook.f.) Desc.
K *C. hardyi* Retief
R *C. juttae* (Dinter & Gilg) Desc.
R *C. uter* (Exe11 & Mendonça) Desc.*

ZYGOPHYLLACEAE
R ***Zygophyllum*** *teretifolium* Schltr.

Annex 9

Threatened succulents of Zimbabwe

Compiled by Craig Hilton-Taylor.

The data presented here were extracted from Kimberley (1991) and the World Conservation Monitoring Centre (WCMC 1993), with corrections based on information from the 'SARARES' database and unpublished notes of M.J. Kimberley. All species are endemic unless noted by an asterisk (*).

Status[1] Local	Global	Taxon[2]
		AIZOACEAE
I		***Delosperma*** *steytlerae* L.Bolus
		ALOACEAE
R		***Aloe*** *ballii* Reynolds
V		*A. cameronii* Hemsl. var. *bondana* Reynolds
R	nt	*A. chabaudii* Schönland var. *verekeri* Christian *
V	V	*A. hazeliana* Reynolds *
V		*A. howmanii* Reynolds
V		*A. inyangensis* Christian
R	nt	*A. lutescens* Groenew. *
V	V	*A. munchii* Christian *
R		*A. musapana* Reynolds
E		*A. ortholopha* Christian & Milne-Redh.
V	V	*A. plowesii* Reynolds *
I	nt	*A. pretoriensis* Pole-Evans *
V/E	I	*A. rhodesiana* Rendle *
R	nt	*A. sessiliflora* Pole-Evans *
V	nt	*A. suffulta* Reynolds *
V/E		*A. tauri* L.C.Leach
V/E		*A. wildii* (Reynolds) Reynolds
		APOCYNACEAE
V/E	nt	***Adenium*** *multiflorum* Klotzsch *
R	nt	***Pachypodium*** *saundersii* N.E.Br. *
		ASCLEPIADACEAE
E	nt	***Hoodia*** *currorii* (Hook.) Decne. ssp. *lugardii* (N.E.Br.) Bruyns *
R		***Huernia*** *longituba* N.E.Br. ssp. *cashelensis* L.C.Leach & Plowes
R		*H. occulta* L.C.Leach & Plowes
R		*Orbea umbracula* (M.D.Hend.) L.C.Leach
E	nt	***Tavaresia*** *barklyi* (Dyer) N.E.Br. *
		CRASSULACEAE
R		***Kalanchoe*** *velutina* Welw. ex Britten ssp. *chimanimanensis* (R.Fern.) R.Fern.
R		*K. lobata* R.Fern.
R		*K. wildii* Raym.-Hamet ex R.Fern.
		EUPHORBIACEAE
R	nt	***Euphorbia*** *confinalis* R.A.Dyer ssp. *confinalis* *
V		*E. confinalis* R.A.Dyer ssp. *rhodesica* L.C.Leach
V	nt	*E. cooperi* N.E.Br. ex A.Berger var. *calidicola* L.C.Leach *
R	nt	*E. davyi* N.E.Br. *
V/E	nt	*E. decidua* P.R.O.Bally & L.C.Leach *
R		*E. dissitispina* L.C.Leach
E	I	*E. fortissima* L.C.Leach *
R	nt	*E. gossypina* Pax var. *gossypina* *
R	nt	*E. guerichiana* Pax *
E	nt	*E. halipedicola* L.C.Leach *
E	?	*E. lividiflora* L.C. Leach *
V		*E. memoralis* R.A.Dyer
R	R	*E. rowlandii* R.A.Dyer *
R		*E. rugosiflora* L.C.Leach
V/E	nt	*E. trichadenia* Pax *
V		*E. wildii* L.C.Leach
E	nt	***Monadenium*** *lugardae* N.E.Br. *
		PASSIFLORACEAE
R	R	***Adenia*** *fruticosa* Burtt Davy ssp. *simplicifolia* W.J.de Wilde *
V		*A. karibaensis* W.J.de Wilde
V	nt	*A. spinosa* Burtt Davy *

[1] Column one indicates the conservation status of each taxon within Zimbabwe; the global status is indicated in column two, except for endemics where the global status is the same as that for the country. The global status was obtained from the WCMC (1993) and updated based on information from the 'SARARES' database.

[2] The taxon name given generally follows the nomenclature used in Arnold and De Wet (1993). however, there are differences whet-o WC have followed taxonomic treatments published subsequent to those referred to in Arnold and Dc Wet (1993) or taxonomic treatments not followed by the National Herbarium in Pretoria, South Africa (PKE). The abbreviations of author names are according to Brummitt and Powell (1992). The taxa are arranged in alphabetical order by family then genus. The family names used are those most commonly used. Families which are often given alternative names are (name used here/alternative): Aloaceae/Asphodelaceae, Aizoaceae/Mesembryanthemaceae. and Asteraceae/Compositae.

Annex10

Threatened succulents of India

Information provided by C. R. Babu and Meena Singh, reviewed by S. Karthikeyan.

India has an estimated 15,000 vascular plant species including pteridophytes and about 5000 endemic flowering plants. The geographical position of India and its varied climatic conditions are factors which contribute to the diversity of its flora. Many species are of economic or medicinal value and local societies traditionally have managed plant resources sustainably; however dramatic population growth in the current century has placed an enormous strain on these natural resources.

Destruction of forests for local fuel use, for timber by outside agencies, over-grazing by cattle and goats, quarrying and mining, development activity and reclamation of "unproductive" land have all lead to a decline in the country's floristic diversity. Forests have undergone varying degrees of transformation, ranging from degenerative changes brought about by accelerated rates of soil erosion to complete replacement by monoculture. The effects of over-exploitation are manifested in increasing desertification of our lands and changing global climate patterns. Much conservation work is called for in India, but regeneration of endemic flora in regions characterised by economic under-development and rural poverty will only succeed as long as it yields diverse and tangible benefits to inhabitants of the region.

Here we present a conservation assessment and status report for India's most threatened cacti and succulents. Basic survey and population monitoring, as well as conservation status reports, remain to be carried out for many taxa.

ASCLEPIADACEAE

The economic importance of the family includes the use of some species of *Caralluma* such as C. *edulis*, as green vegetables and the tubers of *Ceropegia* species as food.

Ceropegia

The Indian subcontinent is one of the primary centres of genetic diversity for *Ceropegia;* here are about 45 indigenous species including both succulents with tuberous rootstocks and non-succulent herbaceous plants. The genus ranges from humid tropical regions to the temperate zone of the Himalayas with the chief centre of distribution in the Western Ghat mountains, from Maharashtra to Kerala. Most of the species are endemic to India and 27 species are endemic to peninsular India. Deforestation and overexploitation are among the many threats to these taxa causing some species, such as *C. longifolia, C. wallichii,* and *C. macrantha* in the sub-Himalayan tracts and Arvallis, to be on the verge of extinction. C. *bulbosa* is almost extinct from Delhi and the adjoining areas, and species reported from sub-Himalayan tracts have not been re-located in spite of repeated field trips to known localities. Immediate inventory, monitoring, and *in situ* conservation measures for these taxa are required along with *ex situ* conservation in botanic gardens (Babu 1994).

R	***Ceropegia a ttenua ta***	Endemic to Maharashtra and Karnataka. Tubers are harvested for food.
E	*C. bamesii*	Endemic to Tamil Nadu and Karnataka. Endangered due to habitat loss.
nt	*C. ciliata*	Endemic to Kerala and Tamil Nadu.
nt	*C. ensifolia*	Endemic to Kerala and Tamil Nadu.
E	*C. evansii*	Endemic to Maharashtra. Tubers are edible. Endangered due to harvests from the wild.
E	*C. fantastica*	Endemic to Goa and Karnataka.
R	*C. fimbriifera*	Endemic to Karnataka and Tamil Nadu.
E	*C. huberi*	Endemic to Maharashtra. Endangered due to landslides.
nt	*C. in termedia*	Endemic to Kerala and Tamil Nadu.
R	*C. jainii*	Endemic to Maharashtra.
nt	*C. juncea*	Endemic to Andhra Pradesh, Tamil Nadu, and Karnataka. The extract of the plant is used as a tranquilizer.
E	*C. lawii*	Endemic to Maharashtra. Endangered due to habitat destruction.
R	*C. maccanii*	Endemic to Maharashtra.
E	*C. mahabalei*	Endemic to Maharashtra.
R	*C. media*	Endemic to Maharashtra.
R	*C. noorjahanae*	Endemic to Maharashtra.
R	*C. oculata*	Endemic to Maharashtra and Kerala.
E	*C. odorata*	Endemic to Gujarat and Maharashtra. It is protected in the Amravati Tiger Reserve.
E	*C. omissa*	Endemic to Kcrala and Tamil Nadu.

E	*C. panchganiensis*	Endemic to Maharashtra. It appears to be on the verge of extinction due to harvest of edible tubers from the wild.
R	*C. pusilla*	Restricted to Karnataka, Kerala, and Tamil Nadu.
R	*C. rollae*	Endemic to Maharashtra.
E	*C. sa hayadrica*	Endemic to Maharashtra. Endangered due to overcollection of its edible tubers.
R	*C. santapaui*	Endemic to Maharashtra.
R	*C. spira lis*	Restricted to Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu.
E	*C. vincaefolia*	Endemic to Maharashtra. Endangered due to overcollection of its edible tubers.

Caralluma

In India there are 13 species of ***Caralluma*** most of which are confined to Peninsular India; 6 are endemic to Peninsular India and are found in most of the states located in the phytogeographical zone (Ahmedullah 1993). Populations are declining in size and distribution range due to overexploitation, mining, and deforestation. The habitats of this genus, particularly in the Western and Eastern Ghats and Vindhyan ranges, are fast disappearing due to mining activities. Inventory of the genus is urgently needed. Habitat protection will hopefully ensure the conservation of this unique group of plants.

R	***Caralluma*** *edulis*	Restricted to a small area in Rajasthan.
nt/R	*C. indica*	Not threatened according to Babu (1994); Rare according to Singh (1994a); edible and enjoyed by shepherd boys.
I	*C. lasiantha*	
R	*C. nilagiriana*	Described from a single clone and has not been found again in the wild.
nt	*C. pauciflora*	
R	*C. procumbens*	Found only on a few remote hills of Tamil Nadu.
nt	*C. stalagmifera*	Not threatened according to Babu (1994); threatened by proposed housing development according to Singh (1994a).
K	*C. trunca to-corona ta*	Endemic to Karnataka.
R	*C. tu bercula ta*	An edible species found on the lower tracts of the northern Himalayas grazed by sheep and goats.
	C. umbellata	Threatened by habitat clearance.

Brachystelma

Peninsular India is the second centre of origin of the genus ***Brachystelma.*** Species are distributed in the hill ranges of Madhya Pradesh, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Goa, Maharashtra, Gujarat, and Karnataka. Of the ten species found in India, nine are endemic to Peninsular India; the only species occurring outside this region is ***B.*** *parviflorus* in the north-west (Ahmedullah 1993). The main threat to the species is quarrying and mining (Babu 1994).

I	***Brachystelma*** *bourneae*	Endemic to Tamil Nadu.
I	*B. brevitubula tum*	Endemic to Tamil Nadu.
K	*B. cilia tum*	Endemic to Karnataka.
E	*B. glabrum*	Endemic to Andhra Pradesh.
K	*B. kolarensis*	Endemic to Karnataka.
I	*B. maculatum*	Endemic to Karnataka and Tamil Nadu.
I	*B. rangacharii*	Endemic to Coimbatore.
R	*B. volubile*	Endemic to Andhra Pradesh.

Dischidia

Three species are found in the Andaman Islands. ***Dischidia*** *bengalensis* and ***D.*** *nimularia* can be found extensively while ***D.*** *raffelsian*a var. ***major*** is Rare.

Hoya

The genus *Hoya* is widely distributed in the temperate regions of the Himalayas where species are under threat due to deforestation. Since forty percent of the forest cover in the Himalayas has been lost, substantial numbers of populations of Himalayan *Hoya* species have also been lost. The remainder of these species requires immediate conservation measures. *H.* ***wightii*** is an endemic species of Peninsular India but is likely to become extinct when its habitat is submerged upon completion of the Idukki Hydroelectric dam.

CRASSULACEAE

The Himalayas constitute one of the centres of diversity for the genus ***Sedum.*** The genus requires inventory and monitoring and critical taxonomic assessment before its conservation status is assessed. *Kalanchoe cherukondensis*, an endemic of Eastern Ghats (Visakhapatnam Hills), is also endangered due to habitat destruction.

CUCURBITACEAE

A few Indian species with tuberous roots can be considered semi-succulent. Of these the genera *Corallocarpus*, *Kedrostis*, and *Momordica* are widely distributed in Peninsular India. *Corallocarpus epigaeus* tubers are of medicinal value and the species is threatened by over-exploitation. The fruits of *Momordica dioica* are edible and attempts are being made to commercialise this species.

EUPHORBIACEAE

Within the genus *Euphorbia*, *19* Indian species show succulence. Of these 16 are dendroid and three are geophytic. All Indian *Jatropha* species are semi-succulent.

The cactoid euphorbias are the major elements of dry slopes and cliffs in all the hill ranges and the Himalayas up to 4000 m. In the dry hill tracts of Peninsular India they comprise the climax formation. These cactoid euphorbias include tree euphorbias with fleshy stems with or without leaves as well as pencil euphorbias. The taxonomy of these species is not yet fully worked out and needs further attention. Inventory and reclassification is also needed for the three geophytic *Euphorbia* spp.

Some of the tree euphorbias have been utilised as renewable sources of energy and also in making toys. This has led to depletion of populations in the Himalaya and other hill ecosystems.

	***Euphorbia** antiquorum*	This species mostly grows in mixed populations with *E. tortilis* (see below). It is threatened by collection for fuel and land reclamation.
	E. atoto	A semi-succulent species of coastal regions; apparently rare.
	E. harnhartii	Very rare. This species has disappeared in the wild on the Indian mainland. Small populations still exist in the Andaman Islands but are under threat as habitat is cleared for cultivation by settlers.
	E. ca ttimandoo	Very rare. Found only in a small area in Andhra Pradesh; habitats have been cleared for cultivation.
	E. cauducifolia	Common in dry rocky areas of Rajasthan, Gujarat, and Andhra Pradesh.
nt	*E. corrigioloides*	Endemic to Peninsular India. It has a tuberous rootstock and is herbaceous.
	E. epiphylloides	Very rare. Although the habitat of this species is in a reserved forest the population is declining for unknown reasons. Serious conservation attention is required for this species.
	E. fusiformis	Restricted to north-western sub-Himalayan tracts; it is endangered due to overexploitation of its medicinally important tuberous rootstock (Babu, *in litt*, 1994). Four or five sites have been located within a 300 km radius (Singh, *in litt.* 1994b).
E	*E. khandallensis*	Endemic to Maharashtra where it is restricted to a small area in Khandala and Lonavala. A herbaceous species with tuberous rootstock; its habitat is very stony and poor for cultivation, but land is being reclaimed for farming and holiday retreats.
	E. mayurnathanii	Described from a group of three isolated trees and now extinct.
	E. neriifolia	This species does not seem to be threatened as populations in restricted areas are doing well. This species is commonly seen as a hedge plant in Maharashtra.
	E. nivulia	Few wild populations of this species remain.
R	*E. panchaganiensis*	Endemic to a small area in the Panchgani Hills, Maharashtra. A herbaceous species with cylindric underground rootstock. Threatened by the conversion of its habitat into a large fairground.
	E. royleana	A species of the sub-Himalayan tracts. Habitat has shrunk due to land clearing but is still common in various locations.
R	*E. santapauii*	Endemic to Tamil Nadu. A shrub or tree with fleshy leaves. This species is endemic to Mount Agasthaya onthe border between Kerala and Tamil Nadu, recently declared a Biosphere Reserve.
E	*E. senguptae*	Endemic to Kurnool. An erect herb.
	E. susan-holmesiae	Very rare; a recently described species which is threatened by periodic river flooding washing away the seeds so that the species cannot regenerate. Relocation of plants needs to be considered.
	E. tortilis	This species is commonly seen as a hedge plant, but has been reduced in its natural habitats by felling for fuel and by land reclamation.
	E. vajravelui	Rare; a recently described species, found on the lower slopes of the Western Ghats. Threatened as habitats arc being cleared to make way for tea plantations.

Annex 11

Threatened succulents of Mexico

Categories of threat are given by SEMARNAP: P = in danger of extinction (en Peligro de Extinción), A = threatened (amenazada), R = rare (rara). The corresponding IUCN categories are as follows: P = Endangered, A = Vulnerable, R = Rare. An asterisk (*) indicates an endemic taxa.

AGAVACEAE	
Agave *bracteosa*	A
A. chiapensis	R*
A. congests	R
A. dasylirioides	A*
A. guiengola	A”
A. gypsophila	R
A. impressa	A*
A. kewensis	R*
A. lurida	P*
A. nizandensis	P*
A. ornithobroma	R
A. parrasana	R*
A. parviflora	A
A. peacockii	R*
A. polianthiflora	A
A. titanota	R*
A. Victoria-reginae	P*
A. vizcainoensis	R*
Beaucarnea *gracilis*	A*
B. goldmanii	A*
B. hiriartiae	A*
B. plia bilis	A”
B. purpusii	A*
B. recurva ta	A
B. stricta	A*
Beschorneria *albiflora*	*R*
B. calcicola	R*
B. tu biflora	R
B. wrigh tii	R*
Dasylirion *palaciosii*	R*
D. longissimum	A
Furcraea bendinghausii	A*
F. macdougallii	P*
Manfreda *brunnea*	A
M. guerrerensis	R*
M. longiflora	A
M. nanchititlensis	A*
M. planifolia	R*
M. potosina	R*
Polianthes *densiflora*	R*
P. howardii	R*
P. longiflora	R*
P. palustris	R*
P. platyphylla	R*
Yucca *endlichiana*	R
Y. grandiflora	R*
Y. lacandonica	A
Y. queretaroensis	R
ASCLEPIADACEAE	
Asclepias *macvaughii*	R
CACTACEAE	
Aporocactus *leptophis*	P*
A. flagelliformis	R*
Ariocarpus *agavoides*	P*
A. bravoanus	R*
A. fissura tus	A*
A. kotschoubeyanus	A”
A. scapharostrus	P*
A. trigonus	A”
Astrophytum *asterias*	P*
A. capricorne	A”
A. ornatum	A*
A. myrios tigma	A*
A. hintonii	R*
A. ritteri	A*
Backebergia *militaris*	R*
Cephalocereus *nizandensis*	R*
C. senilis	A”
Coryphantha *delica ta*	R*
C. durangensis	R*
C. elephan tidens	A
C. glanduligera	A*
C. gra cilis	P*
C. grata	R*
C. green woodii	R*
C. odorata	R*
C. poselgeriana	A”
C. pseudoechinus	R*
C. pulleiniana	A*
C. ramillosa	A
C. retusa var. melleospina	R*
C. sch warziana	R*
C. sulcata var. nickelsiae	A
C. werdermannii	P*
Cryptocereus *anthonyanus*	A
Echinocactus *grusonii*	P*
E. parryi	A”
E. platyacanthus	Pr*
Echinocereus adustus	A*
E. bristolii	R
E. delaetii	A”
E. freuden bergerii	A*
E. knippelianus	A”
E. laui	A”
E. leucanthus	R*
E. lindsayi	P*
E. longisetus	R*
E. nivosus	R*
E. palmeri	P
E. poselgeri	P
E. pulchellus	A*
E. reichenbachii var. *fitchii*	A*
E. schmollii	P*
E. sciurus	R*
E. stoloniferus	R*
E. subinermis	R*
E. wein bergii	R*
Echinomastus *erectocentra* var. *acunensis*	P
E. in tertextus	A”
E. mariposensi	A”
E. unguispinus var. *durangensis*	A
E. unguispinus var. *laui*	A*
E. unguispinus var. *unguispinus*	R*
E. warnockii	R
Epiphyllum *chrysocardium*	A*
Epithelantha *bokci*	A
E. micromeris	R
Escobaria *aguirreana*	R*
E. asperispina	A*
E. chaffeyi	A*
E. laredoi	R*
E. roseana	R*
Ferocactus *chrysacanthus*	A*
F. cylindraceus	R
F. haematacanthus	R*
F. johnstonianus	R*
F. pilosus	A*
F. reppenhagenni	R*
F. townsendianus var. *townsendianus*	A
F. viridescens	A*
Geohintonia *mexicana*	R*
Hamatocactus *crassihamatus*	A*
H. uncinatus	A*
Leuchtenbergia *principis*	A*
Lophocereus *schottii* var. *mieckleyanus*	R*
Lophophora *diffusa*	A*
L. williamsii	P1
Mammillaria *albicans*	R*
M. albicoma	A*
M. angelensis	R*
M. anniana	R*
M. aureiceps	A*
M. aureilanata	A*
M. aurihamata	R*
M. backebergiana	R*
M. baumii	R*
M. beiselii	R*
M. blossfeldiana	R*
M. bocasana	A*
M. bombycina	R*
M. boolii	R*
M. candida	A*
M. capensis	R*
M. carmenae	P*
M. carretii	R*
M. cerralboa	R*
M. coahuilensis	A*
M. crucigera	R*
M. dehcrdtiana var. *deherdtiana*	R*
M. dcherdtiana var. *dodsonii*	A*
M. dixanthocentron	R*
M. duoformis	R*
M. erectacantha	A*
M. evermanniana	R*
M. fittkaui	R*

*M. **gaumeri***	R*
***M.** glareosa*	R*
M. goodridgii	R*
M. grusonii	R*
M. guelzowiana	A*
M. guerreronis	R*
M. hahniana	**A"**
M. halei	R*
M. heidiae	R*
M. hernandezii	R*
M. herrerae	P*
M. hertrichiana	R*
M. huitzilopochtli	R*
M. humboldtii	A*
M. insularis	R*
M. johnstonii	R*
M. klissingiana	A*
M. knippeliana	R*
M. kraehenbuehlii	R*
M. laui var. laui	P*
- var. *dasyacantha*	P*
- var. *discata*	P*
M. lenta	**A"**
M. lindsayi	R*
M. longiflora	A*
M. longimamma	**A""**
M. magnifica	R*
M. maritima	R*
M. marksiana	R*
M. mathildae	A*
M. matudae	R*
M. melaleuca	A*
M. mercadensis	R*
M. meyrunii	R*
M. microhelia	R*
M. miegiuna	R*
M. moelleriana	R*
M. multidigita ta	R*
M. nana	R*
M. napina	A*
M. neopalmeri	R*
M. oteroi	A*
M. painteri	R*
M. parkinsonii	R*
M. pectinifera	**A"**
M. peninsularis	R*
M. pennispinosa	R*
M. perezdelarosae	R*
M. pilcuyensis	R*
M. pilispina	R*
M. plumosa	A*
M. pondii	R*
M. pringlei	R*
M. pubispina	R*
M. repenhagenii	R*
M. rettigiana	R*
M. roseoalba	R*
M. rubrograndis	R*
M. saboae	A*
M. san-angelensis	P*
M. sanchezmejoradae	P*
M. schiedeana	A*
M. sch warzii	R*
M. senilis	A*
M. setispina	R*
M. slevinii	R*
M. solisioides	A*
M. stella-de-tacubaya	R*
M. surculosa	R*
M. tayloriorum	R*
M. tepexicensis	R*
M. theresae	A*
M. tonalensis	A*
M. varieaculeata	R*
M. weingartiana	A*
M. wiesingeri	R*
M. xaltianguensis	R*
M. yaquensis	R*
M. vucu tensis	R*
M. zeilmanniana	R*
M. zephyran thoides	A*
Melocactus dawsonii	**A"**
M. delessertianus	P*
M. ruestii	**A**
***Mitrocereus** fulviceps*	R*
***Morangaya** pensilis*	R*
***Nopalxochia** macdougallii*	*R*
N. phyllanthoides	**A"**
***Obregonia** denegrii*	**A"**
***Opuntia** an teojoensis*	R*
0. arenaria	**R**
0. bravoana	R*
0. excelsa	R*
0. rosarica	R*
0. santamaria	R*
***Ortegocactus ma**cdougallii*	A*
***Pachycereus** gaumeri*	P*
***Pelecyphora** aselliformis*	**A"**
P. strobiliformis	P*
***Peniocereus** cuixmalensis*	R*
P. fosterianus	R*
P. greggii	**R**
P. lazaro-cardenasii	R*
P. maculatus	R*
P. marianus	R*
P. tepalcatepecanus	R*
P. zopilotensis	R*
***Pilosocereus** cometes*	R*
***Pterocereus** gaumeri*	R*
***Selenicereus** anthonyanus*	A*
S. a tropilosus	R*
***Stenocactus** coptonogonus*	R*
S. sulphureus	*R**
***Stenocereus** chacalapensis*	R*
S. eruca	A*
S. martinezii	R*
***Strombocactus** disciformis*	A*
***Thelocactus** bicolor* var. *bolansis*	A*
T. hastifer	R*
T. heterochromus	A*
T. leucanthus var. ehrenbergii	R*
T. macdowelii	A*
***T.** rinconensis* var. *nidulans*	A*
T. sch warzii	R*
T. tulensis	A*
***Turbinicarpus** gautii*	A*
T. gielsdorfianus	A*
T. hoferi	A*
T. laui	A*
T. lophophoroides	A'-
T. mandragora	A*
T. pseudomacrochele	I'*
T. pseoudopectinatus	R*
T. saueri	A*
T. schmiedickeanus	A*
T. schmiedickeanus var. *gracilis*	P*
T. subterraneus	A*
T. swobodac	A*
T. valdezianus	A*
T. viereckii	A".
*T. **ysa**belae*	A*
CRASSULACEAE	
***Echeveria** amphoralis*	R*
E. elegans	I'*
E. laui	P*
E. longissima var. aztatlensis	A*
E. longissima var. *longissima*	A*
E. moranii	R*
E. purpusorum	I'*
E. setosa var. *ciliata*	P*
E. setosa var. *deminuata*	P*
E. setosa var. *minor*	P*
E. setosa var. otero	I'*
E. setosa var. setos	I'*
***Graptopetalum** grande*	R
G. macdougallii	P*
***Sedum** frutescens*	P*
S. platyphyllum	R*
S. suaveolens	P*
s. torulosum	R*
FOUQUIERIACEAE	
***Fouquieria** fasciculata*	A*
F. leonilae	R*
F. ochoterenae	P*
F. purpusii	I'*
F. shrevei	R*

Annex 12

Mexican succulent nurseries

I.T.E.S.M.-Campus Queretaro
Henry Ford 10, Parques Industriales,
Queretaro 76130 Qro.
Tel: 91 (42) 17 38 28
Fax: 91 (42) 17 38 23

Quinta Las Camelinas
Carr. Cordoba-Fortin de las Flores, Km 133
Fortin de las Flores, Ver.
Tel: 91 (271) 308 08

Rancho La Joya, S.P.R. De R.I.
Domicilio conocido,
Col. Juan Ubera,
Atlixco, Pue.
Tel: 91 (244) 532 99
Fax: 91 (244) 534 91

Orquideario De Baja
Carr. Transpeninsular, Km 16 y Calle No. 5
Ejido "El Centenario",
Baja California Sur, B.C.S.

Quinta Fernando Schmoll Vivero De
Quinta s/n.
Cadereyta de Montes, Qro.

Vivero De Cactus Y Suculentas De Coahuila
Lote no 5, Ex-Hacienda Los Carritos
Km 5 de la Carretera a Mexico
Saltillo, Coah.

Can Te, A.C.
Mesones 71
Col. Centro,
San Miguel de Allende
37700 Gto.
Tel: 91 (465) 229 90
Fax: 91 (465) 240 15

Jose Raul Gomez Perez
Miguel Rebolledo 4
Coatepec
91500 Ver.

Follaje Y Ornato
Barrio de San Martinito s/n
Tlaxcalancingo Cholula, Pue.
Tel: 91(22) 49 72 64

La Flor De Catemaco
S.P.R. de R.L.de C.V.
Carr. Catemaco-Coyame, Km 9.5
70607 Catemaco, Ver.
Tel: 91 (294) 303 25
Fax: 91 (294) 305 68

Orquideas Jardin Rio Verde
Calle de Arista 201
51200, Valle de Bravo, Edo. de Mexico,
Apartado Postal 69
Tel: 91 (726) 202 89
Fax: 91 (726) 209 11

Plantas y Excursiones de California Sur
Calle 12 y Ave. 10 s/n
Col. Lindavista
Fortin de la Flores, Ver.

Mic-Cacti
Plantas, Cactaceas y Suculentas
Ave. San Jose, Lte. 8 Mza Vll
Col Granjas Residenciales de Tequisquiapan
Tequisquiapan, Qro.

Monte Obscuro
Ejido El Palmar
Congregación Monte Obscuro
Mpo. Emiliano Zapata, Ver.
Tel: 91 (271) 464 99

Centro De Reproduccion De Cactaceas "El Copal"
Ejido Banco Nacional Agrario
Mapimi, Dgo.

Vivero De Arboles, S.A. De C.V.
Lope de Vega 791
Jardines del Bosque
44520 Guadalajara, Jal.

Annex 13

Mexican botanic gardens

Aguascalientes
Jardín Botánico del Parque "Heroes Mexicanos"
Domicilio Conocido
Aguascalientes, Ags

Campeche
Jardín Natural Forestal C.E.F
"Ing. Eduardo Sangri Serrano"
Carr. Fed. NO. 186 Villahermosa
Escarcega Km. 292
Escarcega, Campeche 24350

Jardín Botánico "Xmuch-Haltun"
Calle 8-49
Campeche, Campeche

Coahuila
Jardín Botánico "Gustavo Aguirre Benavides"
Universidad Autonoma Agraria
"Antonio Narro"
Apdo. Postal 554
Saltillo, Coahuila 25000

Jardín Botánico "Jerzy Rzedowski"
Univ. Aut. Agraria "Antonio Narro"
Unidad Laguna
Carr. A Santa Fe y Periferico
Apartado Postal 94 Carro 2
Torreón, Coahuila

C hiapas
Jardín Botánico "Dr. Faustino Miranda"
Inst. de Historia Natural de Chiapas
Departamento de Botnica
5a. Norte Oriente Apdo. Postal 6
Tuxtla-Gutierrez, Chiapas 29000

Orquidiariodel Consejo Protector de La Naturaleza
5a. Norte Oriente
A. P. 391 Tuxtla-Gutierrez
Chiapas 29000

Jardín Botanico "San Cristobal"
Centro de Investigaciones Ecologicas del Sureste
Carretera Panamericana y Periferico Sur
San Cristobal de Las Casas, Chiapas 29290

Chihuahua
Jardín Botánico de Zonas Aridas "Alberto Carballo A."
Escuela Superior de Agricultura
"Hermanos Escobar"
Km. 12.5 Carr. Panamericana
Cd. Juarez, Chihuahua

Distrito Federal
Jardín Botánico de La Escuela Nacional De Maestros
Avenida Mexico-Tacuba y Avenida del Maestro Rural
Mexico, D.F. 02801

Jardín Botánico del Instituto de Biologia
Universidad Nacional Autonoma de Mexico
Ciudad Universitaria Delegación Coyoacan
Mexico, D.F. 04510

Jardín Botánico "de La Cruz Badiano"
Campus Ii. Enep Zaragoza
Apdo. Postal 9-020
Mexico, D.F. 15000

Durango
Jardín Botánico y Vivero de Cactaceas
De Gomez Palacio
Boulevard Gonzalez de La Vega y Calzada Lázaro Cárdenas
Cd. de Gomez Palacio, Durango

Estado De México
Jardín Didáctico de Cactaceas
Adyacente a La Zona Arqueologica de Teotihuacan
Teotihuacán, Edo. de Mexico 55831

Jardín Botánico de La Enep-Iztacala
Av. de Los Barrios S/N
Sn. Juan de Los Reyes Iztacala
Tlalnepantla, Edo. de Mexico 54090

Jardín Botánico "Maximino Martinez"
Universidad Autonoma de Chapingo
Km. 38.5 Carr. Mexico-Texcoco
Chapingo, Edo. de Mexico 56230

Pinetum Maximino Martinez
Centro de Genética Forestal
Lomas de San Juan Chapingo
Apartado Postal 104
Chapingo, Estado de Mexico 56230

Guanajuato
Jardín Botanico
El Charco del Ingenio
Can Te, AC.
Mesones 7 1
San Miguel de Allende, Gto. 37700

Guerrero
Jardín Botánico de La Universidad Autonoma de Guerrero
Ciudad Universitaria
Chilpancingo, Guerrero

Jalisco
Jardín Botanico "Jorge Victor Eller T."
de La Univ. Autonoma de Guadalajara
Avenida Patria No. 120 1
Fraccionamiento Lomas del Valle
Zapopan, Jalisco 45 129

Michoacán
Orquidario del Centro
Convenciones de Morelia
Av. Ventura Puente S/N
Morelia, Michoacan

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Annex 14

Succulents of the West Indies

Compiled by Alberto Areces-Mallea.

Table 1 Native genera

Genera marked with an asterisk (*) contain non-succulent species in the West Indies.

	Total no. of species	No. of endemic species
AGAVACEAE		
Agave	33	33
Furcraea	4	3
AIZOACEAE		
Cypselea	2	
Sesu vium	3	
Trianthema	1	0
AMARANTHACEAE		
Blu taparon		0
Litophila	1	0
APOCYNACEAE		
Plumeria	12	10
Rhabdadenia	1	0
ASCLEPIADACEAE		
Cynanchum *	3	1
Sarcostemma		0
BASELLACEAE		
Anredera		0
BATACEAE		
Ba tis		0
BOMBACACEAE		
Bomhacopsis	2	2
Ceiba		0
Neobuchia		
Ochroma		0
Quararibea		0
BORAGINACEAE		
Argusia	1	0
Heliotropium *	1	0
CACTACEAE		
Acanthocereus		0
Cereus		0
Dendrocereus	2	2
Disocactus	2	
Epiphyllum		0
Escobaria		1
Harrisia	9	9
Hylocereus	4	3
Leptocereus	15	15
Mammillaria	3	2
Melocactus	12	11
Opun tia	28	22
Pereskia	5	4
Pilosocereus	8	8
Rhipsalis	1	0
Selenicereus	5	4
Stenocereus	1	1
CARICACEAE		
Carica		
CHENOPODIACEAE		
Heterostachys		
Salicornia	3	0
Suaeda	5	0
COMPOSITAE		
Borrichia	3	
Iva	2	
CRUCIFERAE		
Ca kile		0
Chamaesyce *	12	8
Cnidoscolus	5	
Cubanthus	3	
Euphorbia *	15	14
Grimmeodendron	2	2
Ja tropha *	6	6
Omphalea	6	5
Pedilan thus	2	
Victorinia	2	2
GOODENIACEAE		
Scaevola	10	0
MORACEAE		
Dorstenia	24	23
ORCHIDACEAE		
Vanilla	12	6
PLUMBAGINACEAE		
Limonium		
PORTULACACEAE		
Portulaca	11	4
Talinum	3	
SCROPHULARIACEAE		
Agalinis *		0
Bacopa *		0
Cissus	27	21
Hildegardia		
Pterocissus		
Suriana	1	0

Table 2 Non-endemic native species

AGAVACEAE
- Furcraea *foetida*

AIZOACEAE
- ***Cypselea*** *humifusa*
- ***Sesuvium*** *maritimum*
- *S. portul'acastrum*
- ***Trianthema*** *portulacastrum*

AMARANTHACEAE
- ***Blutaparon*** *vermiculare*
- ***Litophila*** *muscoides*

APOCYNACEAE
- ***Plumeria*** *alba*
- *P. obtusa*
- ***Rhabdadenia*** *biflora*

ASCLEPIADACEAE
- ***Cynanchum*** *angusti-folium*
- *C. scoparium*
- ***Sarcostemma*** *clausum*

BASELLACEAE
- ***Anredera*** *leptostachys*

BATACEAE
- ***Batis*** *maritima*

BOMBACACEAE
- ***Ceiba*** *pentandra*
- ***Ochroma*** *pyramidale*
- ***Quararibea*** *turbina ta*

BORAGINACEAE
- ***Argusia*** *gnaphalodes*
- ***Heliotropium*** *curassavicum*

CACTACEAE
- ***Acanthocereus*** *pen tagonus*
- ***Cereus*** *margaritensis*
- ***Disocactus*** *ramulosus*
- ***Epiphyllum*** *phyllanthus*
- ***Hylocereus*** *unda tus*
- ***Mammillaria*** *mammillaris*
- ***Melocactus*** *broadwayi*
- ***Opuntia*** *caribaea*
- *0. curassavica*
- *0. dillenii*
- *0. elatior*
- *0. stricta*
- *0. wen tiana*
- ***Pereskia*** *aculea ta*
- ***Rhipsalis*** *baccifera*
- ***Selenicereus*** *boeckmannii*

CHENOPODIACEAE
- ***Salicornia*** *bigelovii*
- *S. perennis*
- *S. virginica*
- ***Suaeda*** *conferta*
- *S. fruticosa*
- *S. linearis*
- *S. tampicensis*
- *S. torreyana*

COMPOSITAE
- ***Borrichia*** *arborescens*
- *B. fru tescens*
- ***Iva*** *im brica ta*

CRUCIFERAE
- ***Cakile*** *lanceolata*

EUPHORBIACEAE
- ***Chamaesyce*** *blodgetti*
- *C. lasiocarpa*
- *C. mesembrian themifolia*
- *C. thymifolia*
- ***Euphorbia*** *trichotoma*
- ***Omphalea*** *diandra*
- ***Pedilanthus*** *tithymaloides*

GOODENIACEAE
- ***Scaevola*** *plum ieri*

MORACEAE
- ***Dorstenia*** *con trajerva*

ORCHIDACEAE
- ***Vanilla*** *barbella ta*
- *V. dilloniana*
- *V. hartii*
- *V. mexicana*
- *V. phaean tha*
- *V. wrightii*

PORTULACACEAE
- ***Portulaca*** *ela tior*
- *P. halimoides*
- *P. pilosa*
- *P. quadrijida*
- *P. rubricaulis*
- *P. teretifolia*
- *P. um bra ticola*
- ***Talinum*** *fru ticosum*
- *T. paniculatum*

SCROPHULARIACEAE
- ***Agalinis*** *maritima*
- ***Bacopa*** *monnieri*

SURIANACEAE
- ***Suriana*** *maritima*

VITACEAE
- ***Cissus*** *erosa*
- *C. formosa*
- *C. microcarpa*
- *C. rhom bifolia*
- *C. trifolia ta*
- *C. verticilla ta*

Table 3 Endemic species

	Distribution1	Status2
AGAVACEAE		
Agave *acicularis*	Central Cuba*	PE
A. acklinicola	Acklin I (B)*	PE
A. albescens	East Cuba*	NE
A. anomala	B, C	NE
A. antillarum	Hispaniola*	NE
A. bahamana	B	NE
A. barbadensis	Barbados*	PE
A. braceana	B	NE
A. brevipetala	Haiti*	ST?
A. brevispina	Haiti"	ST?
A. cacozela	B	PE
A. cajalbanensis	West Cuba*	PE
A. caribaeicola	LA	NE
A. dussiana	LA	NE
A. grisea	Cuba*	ST
A. harrisii	Jamaica*	ST
A. inaguensis	B	NE
A. indaga torum	B	NE
A. in termixta	Hispaniola*	NE
A. kara tto	LA	NE
A. legrelliana	West Cuba*	ST
A. longipes	Jamaica*	PE
A. millspaughii	B	PE
A. missionum	PR, VI	NE
A. nashii	B	PE
A. papyrocarpa	Central Cuba*	NE
A. penden ta ta	East Cuba"	PE
A. shaferi	East Cuba*	PE
A. sheuermaniana	LA	ST
A. sobolifera	CI, J	NE
A. tubulata	West Cuba*	NE
A. underwoodii	East Cuba*	NE
A. van-grolae	LA	NE
Furcraea *hexapetala*	C, H, J	NE
F. macrophylla	B, C	NE
F. tu berosa	LA, PR	
AIZOACEAE		
Cypselea *rubriflora*	West Cuba*	ST
Sesuvium *microphyllum*	B, CI, C, LA	NE
APOCYNACEAE		
Plumeria *clusioides*	Cuba*	NE
P. filifolia	E. Cuba*	ST
P. krugii	W. Puerto Rico*	ST
P. lanata	E. Cuba*	NE
P. montana	E. Cuba*	NE
P. stenopetala	Hispaniola*	NE
P. stenophylla	E. Cuba'"	NE
P. subsessilis	Hispaniola*	NE
P. trinitensis	Central Cuba*	NE
P. tu bercula ta	C, H	NE
ASCLEPADACEAE		
Cynanchum *eggersii*	B, C, I-I	NE
BOMBACACEAE		
Bombacopsis *cubensis*	W. Cuba*	NE
B. emarginata	Hispaniola*	NE
Neobuchia *paulinae*	Haiti*	NE'?
CACTACEAE		
Dendrocereus *nudiflorus*	Cuba"'	NE
D. undulosus	Hispanioloa*	NE
Disocactus *ala tus*	Jamaica*	PE
Escobaria *cubensis*	E. Cuba*	HE
Harrisia *brookii*	Long I (B)*	PE
H. divarica ta	Hispaniola"	NE
H. earlei	W. Cuba"'	NE
H. eriophora	Cuba*	NE
H. gracilis	Jamaica*	NE
H. nashii	Hispaniola*	NE
H. portoricensis	Puerto Rico*	PE
H. taetra	W. Cuba*	PE
H. taylori	E. Cuba*	NE
Hylocereus *cu bensis*	W. Cuba"	HE
H. triangularis	Jamaica"'	NE
H. trigonus	H, LA, PR	NE
Leptocereus *arboreus*	Central Cuba*	ST
L. assurgens	W. Cuba"	NE
L. carina tus	E. Cuba*	PE
L. ekmanii	W. Cuba"'	PE
L. grantianus	Culebra I, PR*	ST
L. leonii	W. Cuba"	ST
L. maxonii	E. Cuba*	NE
L. panicula tus	Hispaniola"	NE
L. prostra tus	W. Cuba*	NE
L. quadricosta tus	Puerto Rico"	NE
L. santamarinae	E. Cuba*	NE
L. scopulophilus	W. Cuba*	HE
L. sylvestris	East Cuba"'	PE
L. weingartianus	Hispaniola"	NE
L. wrigh tii	West Cuba"	HE
Mammillaria *nivosa*	B, LA, PR	NE
M. prolifera	C, H	NE
Melocactus *actinacanthus*	Central Cuba":	HE
M. acunai	East Cuba*	NE
M. communis	Jamaica*	NE
M. guitarti	Central Cuba*	NE
M. harlowii	East Cuba'	NE
M. holguinensis	East Cuba"	ST
M. in tortus	B, LA, PR	NE
M. lemairei	Hispanola*	NE
M. matanzanus	West Cuba *	HE
M. perezassoi	Central Cuba*	PE
M. radoczii	East Cuba"	PE
Opuntia *acaulis*	Haiti*	PE?
0. an tillana	H, LA, PR	NE
0. bahamana	B	NE
0. borinquensis	W. PR*	HE
0. corallicola	Florida cays*	HE
0. ekmanii	Haiti*	PE?
0. falcata	Haiti*	PE?
0. hystrix	East Cuba"	NE
0. jamaicensis	Jamaica"	NE
0. lucayana	Bahamas"	PE
0. macracantha	East Cuba"	NE
0. militaris	East Cuba"	NE
0. millspaughii	B, CI, C	NE
0. monilifonnis	C, H, PR	NE
0. nashii	B, C	NE
0. repens	PR, VI	NE
0. ru bescens	LA, PR	NE
0. sanguinea	Jamaica*	PE
0. spinosissima	Jamaica"	NE
0. taylori	Hispaniola*	NE
0. triacan tha	LA, PR	NE
0. tuna	Jamaica*	NE
Pereskia *marcanoi*	Hispaniola"	PE
P. portulacifolia	Hispaniola*	NE

	Distribution[1]	Status[2]
P. quisqueyana	Hispaniola*	HE
P. zinniiflora	Cuba*	ST
Pilosocereus *bahamensis*	B	NE
P. brooksianus	East Cuba*	NE
P. millspaughii	B, C	NE
P. nobilis	LA (Windward I.)	NE
P. polygonus	C, H	NE
P. robinii	WC, F cays	ST
P. royenii	LA, PR	NE
P. swartzii	CI, J	NE
Selenicereus *brevispinus*	Cuba*	PE
S. grandiflorus	CI, C, J	NE
S. innesii	St. Vincent'"	HE
S. urbanianus	C, H	NE
Stenocereus *hystrix*	C, J, PR	NE
CARICACEAE		
Carica *jamaicensis*	Jamaica*	NE
CHENOPODIACEAE		
Heterostachys *ritteriana*	Hispaniola*	NE
COMPOSITAE		
Borrichia *cubana*	West Cuba"	HE
Iva *cheiranthifolia*	B, CI, C	NE
EUPHORBIACEAE		
Chamaesyce *abbrevia ta*	B	NE
C. brittonii	Bahamas*	NE
C. cayensis	B	NE
C. cowellii	H, PR	NE
C. hepatica	H, Navassa	NE
C. lecheoides	B	NE
C. vaginula ta	B	NE
C. wilsonii	*B*	*NE*
Cnidoscolus *bella tor*	West Cuba*	NE
C. fragrans	West Cuba*	HE
C. matosii	East Cuba"	PE
C. quinquelobatus	West Cuba*	HE
C. range1	West Cuba*	NE
Cubanthus *brittonii*	Central Cuba*	NE
C. linearifolius	Cuba*	NE
C. umbelliformis	C, H	NE
Euphorbia *ala ta*	Jamaica*	PE
E. cassythoides	B, CI, C, H	NE
E. cubensis	West Cuba*	NE
E. defolia ta	Hispaniola*	ST
E. dussii	Mart., St. Lucia"	PE
E. eggersii	Hispaniola*	NE
E. gymnonota	B	NE
E. helenae	East Cuba	NE
E. longinsulicola	Long I. (B)*	PE
E. marchii	East Cuba*	NE
E. munizii	East Cuba"	NE
E. petiolaris	B, GA, LA	NE
E. podocarpifolia	East Cuba*	NE
E. punicea	Jamaica*	NE
Grimmeodendron *eglandul sum*	B, C, H	NE
G. jamaicense	Jamaica*	PE
Jatropha *angustifolia*	Cuba*	NE
J. divarica ta	Jamaica*	NE
J. hernandiifolia	H, J?, PR	NE
J. in tegerrima	Cuba*	NE
J. minor	East Cuba*	NE
J. tupifolia	Cuba*	NE
Omphalea *commutata*	Hispaniola*	NE
0. ekmanii	Hispaniola*	NE
0. hypoleuca	West Cuba*	NE
0. triandra	Jamaica*	NE
0. trichotoma	West Cuba*	NE

	Distribution1	status
Pedilanthus *bahamensis*	B	NE
Victorinia *acrandra*	Hispaniola'"	PE
V. regina	East Cuba*	PE
MORACEAE		
Dorstenia *caimitensis*	Hispaniola:"	ST?
D. cordifolia	Hispaniola*	ST?
D. crassipes	East Cuba *	PE
D. crenula ta	East Cuba"	ST?
D. domingensis	Hispaniola*	NE
D. ekmanii	Central Cuba	PE
D. erythrandra	East Cuba*	PE?
D. fa wcettii	Jamaica"'	NE
D. flagellifera	Hispaniola *	ST?
D. hotteana	Hispaniola*	ST?
D. howardii	East Cuba *	NE
D. jamaicensis	Jamaica"'	NE
D. lanei	Central Cuba	ST
D. marginata	Hispaniola*	ST?
D. multisquamea	Hispaniola*	ST?
D. nipensis	East Cuba":	NE
D. nummularia	Central Cuba	PE
D. peltata	Hispaniola*	ST
D. petraea	East Cuba *	NE
D. rocana	Central Cuba	NE
D. roigii	west Cuba*	NE
D. tricolor	East Cuba*	NE
D. tuberosa	East Cuba*	ST?
ORCHIDACEAE		
Vanilla *claviculata*	CI, GA	NE
V. correllii	Bahamas"'	NE?
V. pleei	Mart. (LA)'"	PE
V. poitaei	H, PR	NE
V. rubra	Haiti"'	PE?
V. savanarum	East Cuba*	NE
PLUMBAGINACEAE		
Limonium *bahamense*	Bahamas*	PE
PORTULACACEAE		
Portulaca *brevijolia*	C, Haiti	NE
P. caulerpoides	W PR*	NE
P. minuta	B	NE
P. tu bercula ta	CI, E, C	PE
Talinum *domingense*	Hispaniola*	PE
STERCULIACEAE		
Hildegardia *cubensis*	East Cuba"'	ST
VITACEAE		
Cissus *carnifolia*	Haiti*	PE
C. corullicola	East Cuba*	ST
C. dichroa	west Cuba":	NE
C. dissecta	Hispaniola*	NE
C. fuertessii	Hispaniola*	NE
C. gonavensis	Hispaniola*	PE
C. grisebachii	C, H	NE
C. haitiensis	Haiti*	HE?
C. hotteana	Hispaniola*	NE
C. in termedia	B, GA	NE
C. micran tha	Hispaniola*	NE
C. morn icola	Hispaniola*	PE
C. n ipensis	East Cuba*	NE
C. obovata	GA, LA	NE
C. parciflora	Hispaniola*	PE
C. picardae	Hispaniola*	NE
C. ru brinerviu	Hispaniola*	NE
C. rupicola	west Cuba":	NE
C. subavenia	East Cuba *	NE
C. torreana	Cuba*	NE
C. tuberculata	B, GA	NE
Pterocissus *m ira bilis*	Hispaniola*	NE

‘An asterisk (*) indicates restricted distribution; abbreviated location indicates regional or widespread distribution. **B** Bahamas, C Cuba, **CI** Cayman Islands, **E.** East, **F** Florida, GA Greater Antilles, **H** Hispaniola, **J** Jamaica, **LA** Lesser Antilles, **Mart.** Martinique, N. North, **PR** Puerto Rico, S. South, **St.** Saint, VI Virgin Islands, **W.** West

“Conservation categories:
NE ‘Not endangered’ stands for those taxa commonly represented by a relatively large number of individuals often distributed in geographically widespread populations, which are not facing any inminent threat at present. There are 155 endemics in this category.

PE ‘Potentially endangered’ is mostly assigned to those highly vulnerable species represented by one or few populations, and few individuals therein, that are not threatened at present but with very little degrading effort can be wiped out of the wild. Forty-six endemic species are listed as such.

ST ‘Somewhat threatened’ applies to those taxa whose strained wild populations have had a more or less significant detrimental impact, that if maintained could lead to the extinction of the species. The plants under this category are expected to recover relatively easily if the strain ceases and adequate sound management plans for protection are applied. There are 28 species given this status.

HE ‘Highly endangered to nearly extinct’ is the hottest category; most of the species listed here are unsalvagable unless very urgent actions are taken immediately to preserve them for posterity. Unfortunately, for *Opuntia borinquensis, Cnidoscolus fragrans,* and *C. quinquelobatus* it seems that nothing can possibly be done at this moment. Fourteen species in total fall into this conservation category.

Annex15

Brazilian cacti

Compiled by Nigel P. Taylor.

The new IUCN categories of threat (see Annex 16 for definitions) are given below for the Cactaceae of eastern Brazil and the Brazilian Atlantic Forest, geographically defined as in the regional account of South America. The order of taxa is systematic. Endemics are indicated by an asterisk (*). Introduced, naturalised, and most hybrid taxa are omitted.

Taxon	Conservation information
PERESKIOIDEAE	
Pereskia *aculeata*	Low Risk.
P. grandifolia ssp. *grandifolia**	Data Deficient, but perhaps Low Risk, since it has been taken into cultivation (as a hedge plant) in the region where it is native.
ssp. *violacea**	Data Deficient, ibid.
*P. bahiensis**	Low Risk; it has been taken into cultivation (as a hedge plant) in the region where it is native.
*P. stenantha**	Low Risk; it has been taken into cultivation (as a hedge plant) in the region where it is native.
*P. aureiflora**	Vulnerable; this plant is rare except in north-eastern Minas Gerais (Rio Jequitinhonha valley).
OPUNTIOIDEAE	
Quiabentia *zehntneri**	Low Risk and perhaps locally increasing by vegetative propagation when its habitat is disturbed.
Tacinga *braunii**	Vulnerable.
*T. funalis**	Low Risk at present, but habitat destruction continuing.
Opuntia *werneri**	Vulnerable; its habitat at Rui Barbosa (BA) is being destroyed by mining operations.
*0. palmadora**	Low Risk.
0. saxatilis ssp. *saxatilis**	Low risk at present, but found only on limestone and therefore potentially at risk from quarrying activities in the long term.
ssp. *estevesii**	Data Deficient, but probably vulnerable, since it is presently known only from one location and could be affected by quarrying in the future.
*0. inamoena**	Low Risk.
*0. x quipa**	Low Risk.
0. monacantha	Low Risk.
Brasiliopuntia *brasiliensis*	Data Deficient; much of its habitat has been destroyed in Brazil, but it does occur in some Parques Nacionais and has a wide distribution in the southern Neotropics.
CACTOIDEAE	
Pseudoacathocereus *brasiliensis**	Vulnerable.
Harrisia *adscendens**	Low Risk.
Selenicereus *setaceus*	Low Risk.
Epiphyllum *phyllanthus*	Low Risk.
Lepismium *cruciforme*	Low Risk.
*L. houlletianum**	Low Risk.
L. warmingianum	Low Risk.
L. lumbricoides	Low Risk.
Rhipsalis *pulchra**	Data Deficient; possibly Conservation Dependent, since it is found within various protected areas.
*R. puniceodiscus**	Low Risk.
*R. hoelleri**	Data Deficient, but to date collected only once.
*R. neves-armondii**	Low Risk, but needs to be monitored.
*R. dissimilis**	Data deficient; included within at least one protected area in the southern part of its range.
*R. trigona**	Low Risk, but needs to be monitored.
R. floccosa ssp. *floccosa*	Low Risk.
ssp. *pulvinigera**	Low Risk.
R. paradoxa	
ssp. *septentrionalis**	Data deficient, but potentially endangered in view of continuing habitat destruction.
ssp. *paradoxa**	Low Risk.
R. pacheco-leonis ssp. *catenulata**	Data deficient, but known from only two localities.
ssp. *pacheco-leonis**	Vulnerable; known only from the region of Cabo Frio (RJ), where considerable development for tourism is taking place.
*R. pentaptera**	Extinct in the Wild.
*R. sulcata**	Data Deficient, but currently known from only a single collection.

R. russellii *	Low Risk; however, its habitat has contracted markedly especially in southern Bahia, where the most recent collection was made in 1971. Elsewhere, it is found within some reasonably secure protected areas.
R. elliptica *	Low Risk taking its total range into account.
R. pachyptera *	Low Risk.
*R. oblonga**	Low Risk taking its total range into account.
*R. crispata**	Data Deficient. Apparently wide-ranging but rarely observed and potentially vulnerable despite its range.
R. cereoides *	Vulnerable; known from only two localities, the southern one close to the city of Rio de Janeiro and potentially affected by coastal tourism.
R. densiareola ta *	Data Deficient.
R. baccifera ssp. *baccifera*	Low Risk.
ssp. *hileiabaiana* *	Vulnerable.
R. lindbergiana *	Not threatened.
*R. teres**	Low Risk.
*R. grandiflora**	Low Risk, but needs to be monitored.
R. mesembryanthemoides *	Vulnerable; situated close to the city of Rio de Janeiro.
R. juengeri *	Data Deficient.
R. cereuscula	Low Risk.
R. pilocarpa *	Vulnerable or Conservation Dependent; found only in virgin forest, very little of which remains (some of it possibly in National Parks or other reserves).
R. burchellii *	Vulnerable; its type locality (one of only five known for the species) is now within the city of São Paulo and has been heavily polluted in recent times.
R. ewaldiana *	Data Deficient.
R. campos-portoana *	Low Risk.
R. clavata *	Low Risk or possibly Conservation Dependent, since included in various protected areas.
***Hatiora** salicornioides* *	Low Risk.
H. herminiae *	Vulnerable and probably dependent on the maintenance of its habitat in the Parque Estadual Campos do Jordão to avoid it becoming endangered or critical.
H. epiphylloides ssp. *epiphylloides* *	Endangered; known only from the type locality, now situated inside a National Park, but not known to have been seen or collected in recent times.
ssp. *bradei* *	Vulnerable; known only from a single habitat, only part of which is included inside a protected area.
H. gaertneri *	Data Deficient.
*H. rosea**	Data Deficient, but relatively wide-ranging and possibly Low Risk.
***Schlumbergera** kau tskyi**	Data deficient, but potentially vulnerable or endangered.
S. russelliana *	Conservation Dependent?
*S. truncata**	Conservation Dependent?
S. orssichiana *	Data Deficient; possibly included within a protected area, but range poorly understood.
S. microsphaerica *	Data deficient; included within some protected areas.
*S. opuntioides**	Data deficient; included within some protected areas.
***Brasilicereus** phaeacanthus* *	Low Risk.
*B. markgrafii**	Vulnerable.
***Cereus** euchlorus*	Low Risk.
C. mirabella *	Vulnerable.
C. albicaulis *	Low Risk, but habitat is declining.
C. fernambucensis ssp. *fernambucensis**	Low Risk.
ssp. *sericifer**	Low Risk.
*C. insular-is**	Low Risk.
C. jamacaru ssp. *jamacaru* *	Low Risk.
ssp. *calcirupicola*	Low Risk, but habitat is declining in some places due to quarrying of limestone.
C. hildmannianus	Low Risk.
***Cipocereus** laniflorus** (sp. nov. ined.)	Data Deficient. Presently known from only a single, small population (< 50 mature individuals), but further field investigations are needed to determine range and abundance.
C. crassisepalus *	Vulnerable, from habitat destruction by charcoal producers.
*C. bradei**	Vulnerable; of very limited range and not included within any protected area.
C. minensis ssp. *minensis**	Low risk.
ssp. *pleurocarpus**	Vulnerable from excessive burning of its habitat, which is partly within the Parque Nacional da Serra do Cipó.
*C. pusilliflorus**	Critically Endangered on present knowledge and urgently in need of further field studies to determine if its range is more extensive.
***Stephanocereus** leucostele* *	Low Risk at present, but its habitat is continuing to decline and its status needs to be monitored.
S. luetzelburgii *	Low Risk.
***Arrojadoa** bahiensis* *	Vulnerable: known from only four populations (one within the Parque Nacional da Chapada Diamantina) and at risk from collection of plants and seeds. However, many individuals are protected by the plant's preference for steep slopes and cliffs inaccessible to the collector.

*A. dinae ssp. dinae**	Vulnerable from habitat destruction by charcoal producers.
*ssp. eriocaulis**	Vulnerable from habitat destruction by charcoal producers. Needs regular monitoring if it is not to become endangered.
A. penicilla ta *	Low Risk, but its habitat continues to decline.
A. rhodantha *	Low Risk, but its habitat continues to decline.
***Pilosocereus** tuberculatus* *	Low Risk, but its habitat continues to decline.
P. gounellei ssp. gounellei *	Low Risk.
ssp. zehntneri *	Low Risk, but since many populations are found on limestone it may decline due to quarrying activities.
P. ca tingicola ssp. ca tingicola *	Low Risk, but its habitat continues to decline and its status needs to be monitor-cd.
ssp. salvadorensis *	Low Risk, ibid.
P. sp. nov. ined. [Pedra Azul, MG]*	Data Deficient, but possibly Vulnerable, since known populations inhabit forest vegetation which could be cleared for agriculture or charcoal production.
*P. arra bidae**	Low Risk.
P. brasiliensis ssp. *brasiliensis**	Data Deficient, but has apparently declined markedly in the southern part of its range (Rio de Janeiro).
ssp. *ruschianus**	Low Risk.
*P. flavipulvina tus**	Data Deficient, but has probably declined in the southern part of its range due to forest clearance (Piaui).
P. pentaedrophorus ssp. *pentaedrophorus**	Low Risk, but its habitat continues to decline.
ssp. *robustus**	Low Risk, but its habitat continues to decline.
P. glaucochrous *	Low Risk, but its habitat continues to decline.
P. floccosus ssp. *floccosus**	Low Risk, but its habitat on limestone outcrops is at risk from quarrying operations.
ssp. *quadricostatus* *	Vulnerable from clearance of its caatinga habitat.
P. albisummus *	Data Deficient, but known from only a single site.
*P. flexibilispinus**	Data Deficient, ibid.
*P. ulei**	Vulnerable; known only from a very limited area which continues to be developed for tourism (Cabo Frio, RJ).
P. fulvilanatus ssp. fulvilanatus *	Vulnerable from habitat disturbance and destruction for charcoal production.
ssp. *rosae**	Data Deficient, but possibly vulnerable from habitat disturbance caused by local industry.
P. pachycladus ssp. *pachycladus* *	Low Risk, but caatinga habitat continues to decline (campo rupestre habitats less threatened).
ssp. *pemambucoensis* *	Low Risk, but habitat continues to decline.
*P. magnificus**	Low Risk, but range limited.
P. machrisii	Low Risk.
P. aurisetus ssp. *aurisetus**	Low Risk.
ssp. *aurilanatus* *	Vulnerable; known only from a small region without protected areas, the surrounding habitats at risk from charcoal production activities.
P. aureispinus *	Data Deficient. Range may be much greater than presently known.
*P. vila boensis**	Data Deficient; known from only two sites.
P. multicosta tus *	Low Risk, but needs to be monitored in view of its restricted distribution.
P. piauhyensis *	Data Deficient.
P. chrysostele *	Data Deficient.
P. diersianus *	Data Deficient, but known from only a single site.
P. densiareola tus *	Low Risk, but habitat liable to decline through limestone quarrying.
***Micranthocereus** violaciflorus**	Vulnerable and liable to become Endangered if charcoal producers move into the restricted area where it occurs. It needs regular monitoring.
M. albicephalus *	Vulnerable.
M. purpureus *	Low Risk.
M. auriazureus *	Vulnerable, due to its restricted distribution.
M. streckeri *	Data Deficient, but possibly Endangered or Vulnerable, due to its very restricted distribution.
*M. polyanthus**	Vulnerable, due to its restricted distribution.
*M. flaviflorus**	Low Risk.
M. dolichospermaticus *	Data Deficient, but probably vulnerable from destructive collection of seeds and from potential quarrying of limestone.
M. estevesii *	Data Deficient, ibid.
***Coleocephalocereus** buxbaumianus* *	Low Risk in the eastern sector of its range, but Endangered to the west, where mining operations have destroyed its habitat.
*C. fluminensis ssp. decumbens**	Data Deficient, but vulnerable at its type locality from urban expansion.
ssp. *fluminensis**	Low Risk.
C. pluricosta tus *	Low Risk, since its habitats are mostly inaccessible, steep slopes.
C. goebelianus *	Low Risk at present, but its habitat continues to be lost.
*C. aureus**	Low Risk.
C. purpureus *	Data Deficient, but perhaps vulnerable, since the known habitat is close to a road and may be visited by collectors for plants and seed.
***Melocactus** oreas* ssp. *oreas**	Low Risk at present, but further modification of its habitats is likely and it requires monitoring.
ssp. *cremnophilus* *	Low Risk.
M. emestii ssp. *ernestii**	Low Risk.
ssp. *longicarpus**	Low Risk at present, but habitats are being disturbed in certain parts of its range; needs to be monitored.

M. ba hiensis * *ssp. bahiensis* *	Low Risk.
ssp. amethystinus *	Low Risk.
M. conoideus *	Critically Endangered. Regrettably, survival of *M. conoideus* in the wild is severely threatened by extraction of the quartz gravel in which it grows, and through commercial collection for the European horticultural market. Since June 1992 it has been listed on Appendix I of CITES
M. deinacanthus *	Vulnerable or Endangered, depending on its status at the locality in Municipio Born Jesus da Lapa, which has not been visited. In view of its rarity and vulnerability to commercial exploitation it has been placed on Appendix I of CITES since June 1992.
M. levites ta tus *	Low Risk at present, but in need of monitoring in view of the potential threat from limestone quarrying.
M. azureus ssp. *azureus**	Endangered by actual or potential habitat destruction at its few known localities.
*ssp. ferreophilus**	Vulnerable from limestone quarrying.
M. pachyacanthus ssp. pachyacanthus *	Endangered by actual or potential habitat destruction at its few known localities.
ssp. *viridis* *	Critically Endangered by habitat destruction at its known localities.
M. salvadorensis *	Low Risk at present, but its habitat continues to disappear.
M. zehntneri *	Low Risk.
*M. lanssensianus**	Data Deficient.
*M. glaucescens**	Endangered. In view of its rarity and the threats from commercial collection *M. glaucescens* has been placed on Appendix I of CITES since 1992.
M. concinnus *	Low Risk, but some populations affected by vegetation burning (campos rupestres).
M. paucispinus *	Endangered. In view of its restricted distribution, rarity and desirability to collectors this species has been listed in Appendix I of CITES since 1992.
M. violaceus ssp. *violaceus**	Vulnerable from habitat modification by the tourist industry.
ssp. *ritteri* *	Vulnerable. Known from only two locations, both near to towns.
ssp. *margaritaceus**	Vulnerable from habitat modification by the expanding tourist industry.
Leocereus *bahiensis* *	Low Risk.
Facheiroa *ulei* *	Data Deficient.
F. cephaliomelana ssp. *cephaliomelana* *	Data Deficient, but restricted to limestone which may be quarried in future.
ssp. *estevesii* *	Vulnerable, with the potential for future limestone quarrying at its only known site.
F. squamosa *	Low Risk.
Espostoopsis *dybowskii* *	Vulnerable; both populations of limited extent, the northern one affected by clearance of the caatinga in some places.
Arthrocereus *melanurus* ssp. *melanurus* *	Vulnerable.
ssp. *magnus* [ssp. nov. ined.]*	Vulnerable due to its very limited range, but located within a protected area.
ssp. *odor-us* *	Vulnerable.
A. rondonianus *	Vulnerable.
A. glaziovii *	Vulnerable; many of its former habitats have been eliminated through the mining of iron ore.
Discocactus *zehntneri* ssp. *zehntneri* *	Vulnerable; part of its former habitat has been submerged beneath the Represa de Sobradinho.
ssp. *boomianus* *	Vulnerable; subject to collection, at least one of its habitats being accessible from a main road.
D. ba hiensis *	Data Deficient, but part of its range was eliminated by inundation from the Represa de Sobradinho and some of its few sites are accessible by road and may be visited by collectors.
D. heptacanthus	Low Risk, but in need of monitoring, since the cerrado habitats are undergoing much change.
*D. placentiformis**	Vulnerable, since most populations are small.
D. pseudoinsignis *	Vulnerable; range restricted.
D. horstii *	Endangered; range very restricted and heavily impacted by collectors in the recent past.
Uebelmannia *buiningii* *	Critically Endangered. According to Braun & Esteves Pereira this species is on the verge of extinction and is scarcely if at all in cultivation, where it has proved very difficult. Affected by collection of plants and seed.
U. gummifera *	Endangered. Range very limited and habitat affected by charcoal production and collection of plants and seed.
U. pectinifera ssp. *pectinifera* *	Vulnerable, from collection of plants and seed.
ssp. *flavispina**	Vulnerable, from collection of plants and seed.
ssp. *horrida**	Vulnerable; known from only a single locality.

Annex 16

The IUCN Red List Categories

Pre-1994 categories (IUCN 1980)

Extinct (Ex). Taxa which are no longer known to exist in the wild after repeated searches of their type localities and other known or likely places.

Endangered (E). Taxa in danger of extinction and whose survival is unlikely if the causal factors continue operating. Included are taxa whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed in immediate danger of extinction.

Vulnerable (V). Taxa believed likely to move into the Endangered category in the near future if the causal factors continue operating. Included are taxa of which most or all the populations are decreasing because of over-exploitation, extensive destruction of habitat or other environmental disturbance; taxa with populations that have been seriously depleted and whose ultimate security is not yet assured; and taxa with populations that are still abundant but are under threat from serious adverse factors throughout their range.

Rare (R). Taxa with small world populations that are not at present Endangered or Vulnerable, but are at risk. These taxa are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range.

Indeterminate (I). Taxa known to be Extinct, Endangered, Vulnerable or Rare, but where there is not enough information to say which of the four categories is appropriate.

Insufficiently Known (K). Taxa that are suspected but not definitely known to belong to any of the above categories because of a lack of information.

Not threatened (nt). Taxa that are not in any of the above categories.

No Information or Unknown (?). Taxa for which there is no information.

Note: In addition to the categories above, occasionally "hybrid" categories are used, such as Ex/E (probably Extinct) or E/V (near Endangered).

The IUCN Red List Categories

Prepared by the IUCN Species Survival Commission
As approved by the 40th Meeting of the IUCN Council, Gland, Switzerland, 30 November 1994

The categories

Extinct (EX)
A taxon is Extinct when there is no reasonable doubt that the last individual has died.

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 it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) below.

Endangered (EN)
A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria (A to E) below.

Vulnerable (VU)
A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to D) below.

Lower Risk (LR)
A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:

Conservation Dependent (cd). Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.

Near Threatened (nt). Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.

Least Concern (lc). Taxa which do not qualify for Conservation Dependent or Near Threatened.

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 is lacking. Data Deficient is therefore not a category of threat or Lower Risk. 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 threatened status. If the range of a taxon is suspected to be relatively circumscribed, if 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 assessed against the criteria.

The Criteria for Critically Endangered, Endangered and Vulnerable

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the following criteria (A to E):

A) Population reduction in the form of either of the following:

1) An observed, estimated, inferred or suspected reduction of at least 80% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
   a) direct observation
   b) an index of abundance appropriate for 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) A reduction of at least 80%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

B) Extent of occurrence estimated to be less than 100 km^2 or area of occupancy estimated to be less than 10 km^2, and estimates indicating any two of the following:

1) Severely fragmented or known to exist at only a single location.

2) Continuing decline, observed, inferred or projected, in any of the following:
   a) extent of occurrence
   b) area of occupancy
   c) area, extent and/or quality of habitat
   d) number of locations or subpopulations
   e) number of mature individuals.

3) Extreme fluctuations in any of the following:
   a) extent of occurrence
   b) area of occupancy
   c) number of locations or subpopulations
   d) number of mature individuals.

C) Population estimated to number less than 250 mature individuals and either:

1) An estimated continuing decline of at least 25% within three years or one generation, whichever is longer or

2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:
   a) severely fragmented (i.e. no subpopulation estimated to contain more than 50 mature individuals)
   b) all individuals are in a single subpopulation.

D) Population estimated to number less 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.

ENDANGERED (EN)

A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the following criteria (A to E):

A) Population reduction in the form of either of the following:

1) An observed, estimated, inferred or suspected reduction of at least 50% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
   a) direct observation
   b) an index of abundance appropriate for 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) A reduction of at least 50%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d), or (e) above.

B) Extent of occurrence estimated to be less than 5000 km^2 or area of occupancy estimated to be less than 500 km2, and estimates indicating any two of the following:

1) Severely fragmented or known to exist at no more than five locations.

2) Continuing decline, inferred, observed or projected, in any of the following:
   a) extent of occurrence
   b) area of occupancy
   c) area, extent and/or quality of habitat
   d) number of locations or subpopulations
   e) number of mature individuals.

3) Extreme fluctuations in any of the following:
   a) extent of occurrence
   b) area of occupancy
   c) number of locations or subpopulations
   d) number of mature individuals.

C) Population estimated to number less than 2500 mature individuals and either:

1) An estimated continuing decline of at least 20% within five years or two generations, whichever is longer, or

2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:
   a) severely fragmented (i.e. no subpopulation estimated to contain more than 250 mature individuals)
   b) all individuals are in a single subpopulation.

D) Population estimated to number less 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.

VULNERABLE (VU)

A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the following criteria (A to E):

A) Population reduction in the form of either of the following:

1) An observed, estimated, inferred or suspected reduction of at least 20% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:
   a) direct observation
   b) an index of abundance appropriate for 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) A reduction of at least 20%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

B) Extent of occurrence estimated to be less than 20,000 km^2 or area of occupancy estimated to be less than 2000 km^2, and estimates indicating any two of the following:
   1) Severely fragmented or known to exist at no more than ten locations.

2) Continuing decline, inferred, observed or projected, in any of the following:
   a) extent of occurrence
   b) area of occupancy
   c) area, extent and/or quality of habitat
   d) number of locations or subpopulations
   e) number of mature individuals

3) Extreme fluctuations in any of the following:
   a) extent of occurrence
   b) area of occupancy
   c) number of locations or subpopulations
   d) number of mature individuals

C) Population estimated to number less 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, or

2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:
   a) severely fragmented (i.e. no subpopulation estimated to contain more than 1000 mature individuals)
   b) all individuals are in a single subpopulation

D) Population very small or restricted in the form of either of the following:

1) Population estimated to number less than 1000 mature individuals.

2) Population is characterised by an acute restriction in its area of occupancy (typically less than 100 km^2) or in the number of locations (typically less than five). Such a taxon would thus be prone to the effects of human activities (or stochastic events whose impact is increased by human activities) within a very short period of time in an unforeseeable future, and is thus capable of becoming Critically Endangered or even Extinct in a very short period.

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

Annex 17

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The IUCN/SSC Action Plan series assesses the conservation status of species and their habitats, and specifies conservation priorities. The series is one of the world's most authoritative sources of species conservation information available to nature resource managers, conservationists and government officials around the world.

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