Identification of Key Species for Conservation and Socio-Economic Development

PROCEEDINGS OF A WORKSHOP

EDITED BY PROMILA KAPOOR-VIJAY & MICHAEL B USHER

Identification of Key Species for Conservation and Socio-Economic Development:

PROCEEDINGS OF A WORKSHOP ORGANISED

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1. INTRODUCTION

The worldwide conservation effort has often been focused on a few "flagship" species. These species tend to be the large carnivores, such as lions and tigers, the primates, such as the mountain gorilla, and other mammals, for example the giant panda, or birds. There seems to have been no real scientific reason for selecting these species. Indeed, it is possible to criticise the selection as being driven by emotions, with the emotions controlled by apparently cuddly animals that are either furry or feathery. What we need to do is to find a much more scientifically rigorous and objective approach to the conservation of the world's biota. Why is it that such large sums of money need to be spent on single mammal or single bird species when we know that tens of thousands of plants, invertebrates, or microorganisms are being lost year by year from the face of this planet? It is true that amongst the plants some have found favour, such as the orchids. Amongst the invertebrates, one or two groups, such as the butterflies and more recently the dragonflies, have found favour. And even amongst the microorganisms, some groups of fungi, such as the truffles, have aroused attention. However, all of these cases only highlight the difficulty of planning for conservation. Should our conservation efforts be focused on one or two popular species, or should they be focused on less popular species that may be more important in the whole functioning of the planet Earth?

The important aspect of the Trinidad meeting was that the focus was moved from the "flagship" species to those species which have a core function either ecologically or socio-economically. One realises that much less research is available on these species. They might not necessarily be those that arouse the public attention, but yet we, as scientists, believe that they are the most important species for the long term survival of *Homo sapiens* on this planet. Conservation must move from the emotionally-based activities of the past to the more scientifically-based activities of the future. All of this was recognised in the meeting held in the Republic of Trinidad & Tobago in March 1989. Very soon after the seminar a report was duplicated and circulated. This report has been slightly modified in forming Chapter 2 of the current report. It sets out the background to the Trinidad meeting, sets out 16 points which are required for action, but more importantly sets out a 12-point action plan for the future.

This action plan could be criticised as containing only pious words, a wishlist of the participants in Trinidad. However, there must be a greater sense of urgency and realism about the effects of human communities upon the natural biota of this planet. The first 5 of the 12 points are directed towards national governments and the agencies that those governments support. Governments are not only charged with a responsibility for conserving the species richness within their territorial areas, but they are also charged with a responsibility for using those biotic resources for the well-being, on a sustainable basis, of their indigenous populations. The mechanisms for doing this are multitudinous, ranging from the designation of sites for conservation and landscape purposes to the *ex situ* conservation of germplasm of the species which are currently, or are likely to be, of economic importance. And, above all, the interrelationships between the human societies and the biota throughout the territory administered by government or its agencies are important ingredients for sustainable development.

The Trinidad meeting did not just lead to another conservation report, but was a real move towards investigating how conservation and development are linked and integrated. In the words of the Brundtland Report, this would be "sustainability". How does one conserve our natural heritage, whilst at the same time supporting the development aspirations of the human societies? For too long, development has been seen to ruin the natural environment, to pollute it, to lead to the loss of biodiversity both of species and genetic material, and indeed to stimulate the general degradation of this planet. If development leads to degradation, what will be the end point of those developments? Above all, the Trinidad meeting was concerned with sustainable development, how one finds a way of investing in the future in both economic and ecological terms, whilst sustaining the biota on which development depends.

But the recommendations are not just addressed to governments, since there are many partners in the new approach to conservation. There are international agencies, as well as the voluntary or non-governmental organisations. There is a community that is working on research, at the forefront of technology or ecological ideas, as well as the analysis of the sociology and economics of rural communities. The thoughts and results of this research community need to be harnessed, via policy initiatives, to help the governmental, multi-national and non-governmental institutions. In other words, the first paper dealing with the report from the Trinidad meeting highlights the need for a partnership approach, for a view of land use in a sustainable way.

There are then four papers that explore aspects of key species and their place in development. These four papers were invited to be written and presented at the Trinidad meeting. Professor John Harper analyses some biological aspects of key species. He views the subject in terms of the use made of these species by human communities. The greatest use is clearly that of food, be it of the seeds, the leaves, the roots or the reproductive parts of the species concerned. In a lengthy discussion, Harper analyses the difficulties of secondary compounds that make many plants toxic. How does one get around these problems, destroying the toxins and leaving the cell contents of the plant suitable for human food? But plants are not used as foods, because they also have a role in pharmaceuticals, for fuel, or in clothing and construction. One group of natural resources, should not, therefore, be forgotten in relation to the other natural resources of the planet.

It is these interrelationships between the species that form the focus of Professor John Lawton's paper. He approaches a potentially difficult question in asking "what constitutes a key species". Initial thoughts may focus on some of the more prominent or dominant species of communities, though Lawton reminds us that these may not be the key species that hold together the communities in which they occur. The example of a starfish which maintains species diversity on rocky intertidal seashores is important in demonstrating the role of a predator in preventing the competitive exclusion of some species from a community. His example of the desert snails, rasping away at the surface of a rock, is important in indicating how many other species can be dependent upon this one species of phytophagous invertebrate. But above all, his paper warns us to beware of prejudging any situation. The most unlikely of species may turn out to be key species in the longer term, when sufficient research on the functioning of its ecosystem has been carried out.

Professor Tony Bradshaw focuses on just one group of potentially key species, those small microorganisms in the environment that fix atmospheric nitrogen. Many biologists were brought up to know something about the genus *Rhizobium*, forming root nodules with many leguminous species. Sure enough, these are included within Bradshaw's paper. Perhaps rather fewer people know about the genus *Frankia*, less well known but yet in some ecosystems particularly important again for fixing nitrogen. All of these microorganisms, associated with legumes or other higher plant species, are building up soil fertility, adding to the productivity of the biosphere. It is as well to remember that such insignificant species as these microbes may be tremendously important for the maintenance of many plant and animal communities.

However, it is Professor Ramakrishnan who reminds us of the social and economic contexts of many conservation activities. The agricultural cycle in many parts of the world is tremendously important, with land being left fallow for a while and then recultivated. What are the factors that lead to sustainable agriculture of this nature, requiring low inputs of fertilizer and insecticides, but in the long term continuing to be productive for the crops on which local populations of people depend? Ramakrishnan reminds us that conservation is not just for the scientists, not just for the élite who enjoy going and seeing a variety of species, maybe keeping their "life lists" of all species that they have seen. Conservation is much more integrated with the well-being of rural communities. Conservation is concerned with sustainable development, whilst at the same time preserving the biological diversity of communities, species and genetic material.

Many Commonwealth nations are thinking about the concepts that stemmed from this Trinidad meeting. Can one identify the key species in defined geographical areas? Five appendices are included in Part II; these are the first attempts to identify the key species in five Commonwealth nations. It must be remembered that these are first attempts, that in time other species may be added to these lists, or species included in the lists may be deleted because they are found not to be so important as was once thought.

But above all, the concept of key species, developed in this seminar held in Trinidad, is tremendously important in the evolution of conservation thinking. Conservation, and the related problems of sustainable development, needs to get away from the few "flagship" species and move towards a scientifically sound basis for its activities. If that sound basis identifies the key species, either ecologically for the functioning of the ecosystem or socio-economically for the well-being of a local community, then the Trinidad meeting will have achieved its objectives. And also, importantly, one must think in terms not of just species and the ecosystems but of the landscapes within which both the species and the ecosystems operate. Landscapes involve a mixture of different ecosystems, interacting with each other. It is not just the cultivated field, but also the hedge or stone wall or grassland baulk that surrounds that field. It includes the small woodlands within the agricultural environment, as well as the wetlands and freshwater courses. How do all of these interact with each other? How do the species, the wild species, of the hedgerow or stone wall affect the potential pest populations that are damaging the crops? There is so much that we are glimpsing in the environment at the present time, and so many questions that remain to be answered. The Trinidad meeting, which is reported here, has focused our attention on identifying priorities, rather than just identifying those species which happen to capture the public's imagination.

Promila Kapoor-Vijay
Michael B. Usher

PART I

2. THE TRINIDAD REPORT: IDENTIFICATION OF KEY SPECIES FOR CONSERVATION AND SOCIO-ECONOMIC DEVELOPMENT

2.1 Introduction

As emphasised in the World Conservation Strategy (Anon. 1980), the preservation of biological diversity is of paramount importance to the future welfare of mankind. As such, it requires urgent and co-ordinated action from both developing and developed countries. In the face of spreading environmental degradation and increasing species loss, one urgent priority is for us to identify, for immediate protection, monitoring, and potential application, those species (hereafter called 'key species') that are most critical

a) as keystone species to maintain the ecological integrity of ecosystems, and
b) as life-support species to ensure human survival under environmental stress (e.g. drought, water pollution, soil pollution, etc.).

In spite of their far-reaching potential, key species as a whole have never been systematically studied. Three key areas of study are:

a) identification and monitoring;
b) preparation of inventories; and
c) application in native environment and the potential for introduction to new environments to promote national socio-economic goals.

To prepare the necessary groundwork, a workshop was organised jointly by IUCN and CSC in which 20 leading international experts on the subject were invited from the respective networks of both organisations (Species Survival Commission for IUCN; Network on Biodiversity and Genetic Resources for CSC).

The workshop objective was to examine and develop guidelines and methodologies, so as

a) to develop systematic analysis of key species which play a controlling influence on biotic communities (including human) especially in terms of stability, resistance and resilience through their important linkages;
b) to identify and develop priority action on those species which present life-support value to rural people (especially in tropical environments);
c) to develop the application of information for use in the identification mechanisms and processes underlying occurrence, maintenance and survival of these key species by initiating co-ordinating research on (1) theoretical/predictive approaches, (2) experimental approaches and (3) socio-economic relevance/interface approaches; and

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d) to develop specific research programmes for terrestrial (forests, agro-ecosystems, etc.) and aquatic environments with emphasis on problems of (1) drought, (2) emergency, (3) flooding, (4) toxicity of soil, (5) water and soil pollution, etc.

2.2 Background

2.2.1 *Keystone species*

In most ecosystems, certain species exert a controlling influence out of proportion to their density or biomass over the overall diversity and long-term stability of their ecological communities. Identifying those critical species is one major objective of the IUCN Conservation Science Programme for the next triennium.

Unfortunately, keystone species are difficult to identify: they are not usually the most abundant, the most striking or the most glamorous members of the community. Further, they do not belong to a particular ecological type: in a given ecosystem, the keystone species might include top carnivores, decomposers, herbivores, pollinators, some of the plants or even microbes. Up to now, except for a few celebrated experiments, keystone species have been discovered accidentally, following their removal – via harvesting or replacement by an introduced species – from the habitat.

The workshop was organised to examine how to undertake a systematic analysis of all such cases, to decipher the underlying mechanisms at play so that it would allow us to predict, within reliable limits, the potential keystone species in the major biomes and habitats. A likely spin-off of this effort is the development of a co-ordinated research programme, based on controlled experimental perturbation, to verify such predictions in an integrated programme worldwide.

2.2.2 *Life-support species*

Many plant species display distinct adaptations to environmental extremes, as they are able to grow and reproduce under such conditions as drought and desertification, flood, water pollution, soil toxicity and high salinity. Among such species a number can provide sources of food, materials and energy to humans, livestock and other animals, and so are of considerable potential benefit to people. Those species are referred to as life-support species. As such, they naturally include keystone species since these hold the key to the integrity of landscapes which include both the diversity of living biota and the human communities.

The potential value of life-support species is only now beginning to be appreciated, and has still to receive proper recognition by agroforesters, aquaculturalists, and more generally from ecological and environmental scientists. For example, of a global total of some 80 000 edible terrestrial plants, only about 150 species have ever been cultivated on a large scale, and over 90% of the world's food is produced from less than 20 species.

As highlighted in a regional workshop of the Commonwealth Science Council (New Delhi, April 1987), there are no integrated inventories and studies available worldwide to allow for the use of life-support species. There is therefore a need to develop a strategy for action to collect information, and focus research priorities, on key species.

2.3 Sixteen critical points for the preparation of an action plan

1 Along with the degradation of ecosystems worldwide, thousands of species and even more genetic variants, are being lost. The main causes of this destruction are rapid growth in human population, unsustainable levels of resource consumption by the relatively affluent, and the impact of the increasing numbers of people struggling to survive.

2 Some of the species (or species groups) under threat possess special economic or cultural significance, and are essential for the survival of the ecosystems and landscapes in which they occur. They are therefore regarded as 'key' species.

3 Conservation and integrated development strategies are needed to halt the biological impoverishment of the planet. Unless human numbers are stabilised and consumption levels are brought into balance with environmental capacities any conservation strategies will be ineffective.

4 Conservation efforts to save species and maintain ecosystems have expanded in recent years. Historically these efforts have tended to focus on rare and beautiful species. Today, there is increasing concern for species having particular ecological, economic and cultural significance. Although conservation priorities are recognised for species of obvious economic importance, such as rice, eucalyptus, cows or catfish, many other species of key ecological and socio-economic importance will be lost unless action is taken urgently, within the next decade.

5 The objectives of the workshop were considered in the following three ways:

a) to begin to identify such species;
b) to define the most urgent research priorities; and
c) to identify priorities for conservation/development action.

6 A small, but unknown, fraction of the world's plant species has a disproportionately important role in the ecological processes that maintain the totality of life on this planet. It is important to relate human life and biological diversity to the sustainable ecological and social systems of the Earth. The species that do this are called 'ecological key species' (or 'amplifier species').

7 Similarly, another unknown fraction of the world's species, used by people for food or for their culture, makes a disproportionate contribution to people's social and economic well-being. Such species are called 'socio-economic key species' (or 'service species').

8 Both ecological and socio-economic key species can be 'Life-Support Species'. Conservation of these key species will result in the conservation of many other species and assists in the long-term survival of human communities.

9 Ecological key species and species groups are key with respect to certain major natural processes, particularly:

a) organic production,
b) nutrient accumulation,
c) habitat structuring,
d) colonisation,
e) herbivory,
f) pollination,
g) seed dispersal,
h) decomposition,
i) predation, and
k) defence against parasites and predators.

10 Socio-economic key species and species groups are key with respect to certain categories of use, particularly

a) commodities (important economic products such as foods, animal feed, fibre and medicines),
b) genetic resources (source of new domesticates and of improvements to established domesticates, and of potential value in biotechnology),
c) cultural value (significant contribution to the spiritual, emotional, and/or psychological lives of people), and
d) environmental management (use by people to modify, stabilise or rehabilitate environments).

11 Certain species and species groups are key both ecologically and socio-economically (and some ecological and socio-economic key species are important in more than one of the categories listed in (9) and (10) above).

12 Key species and species groups are usually specific to particular ecological, cultural and economic circumstances. In other words there are few, if any, universally key species. Likewise, one cannot anticipate which species, or which genetic variants, might become significant in the future. In other words, species not considered important today may become key tomorrow.

13 Although we know of a large number of socio-economic species, knowledge of key species among them is highly fragmented and often limited to their immediate users. We know much less about ecological key species and can identify only a few. Improving our knowledge of key species is essential; the starting point is in their recognition.

As a preliminary step examples of key species that are thought to have ecological and socio-economic importance are given in Appendix 2.1. In Part II, Appendices A-E focus on some of the key species of five countries around the world.

14 Because of the rapid loss of species and reduction of genetic variability, direct conservation action is needed now, not next year or sometime in the future. At the same time international research co-ordination to identify key species is called for. The sooner the results of research can guide action, the better it will be for the sustainability of human life on this planet.

15 A strategy for conservation and sustainable use of key species and species groups should include the following six points

a) Management and protection of those areas where key species and species groups, occur should ensure their long-term survival, at the same time recognising the needs and rights of the local human population.
b) Conservation plans to identify and maintain migratory key species should be developed.
c) In human-modified ecosystems the contribution of agriculture, silviculture and aquaculture to the maintenance and genetic improvement of socio-economic key species should be encouraged.
d) In degraded lands restoration through the use of key species and species groups, particularly nutrient accumulators and ecosystem engineers, should be promoted.
e) The most efficient and best adapted species (and genetic variants of such species and other species) should be identified.
f) Native species and genetic variants of native species should be investigated and tested before using exotic species.

16 Particular attention should be paid to three groups of key species, namely

a) species that serve as both ecological and socio-economic key species,
b) threatened ecological and socio-economic key species, and
c) key species with known, yet unfulfilled, socio-economic potential.

2.4 The twelve recommended actions

2.4.1 *For Governments and Government Agencies*

1 Governments should promote the identification of both ecological and socio-economic key species, and assess their ecological and socio-economic contribution, within their own countries.

2 Governments should support those local socio-economic systems that are actually, or potentially, compatible with the maintenance of key species, and explore with the local people involved ways of supporting such systems sustainably.

3 Governments should determine which key species are adequately maintained in the protected area system of their country, and should as a matter priority make adequate provision for the conservation of those species that are not adequately protected.

4 Governments should ensure that the germplasm of key species is properly collected, conserved and made available including, where appropriate, through captive breeding programmes.

5 Regardless of their socio-economic importance, species should not be translocated to new bio-geographic provinces (whether marine or continental) without stringent evaluation of the likely ecological consequences.

2.4.2 *For International Agencies*

6 The relevant agencies should promote the international co-ordination of research programmes and information systems concerning key species.

2.4.3 *For Non-Governmental Organisations (NGOs)*

7 National and international NGOs should consider and advocate the most effective way to promote the conservation of key species.

8 NGOs should promote the information gathering process on, and the conservation of, key species at the local community level with particular emphasis on the perceptions and practices of indigenous peoples, recognising especially the contribution that women make in this process.

2.4.4 *For the research and technology sector*

9 A major research effort is required to identify ecological key species in natural and semi-natural ecosystems. A much better understanding is needed of how key species influence the diversity and the structure of major ecosystems.

10 Research should be carried out on ways of using native key species, exploiting their fullest genetic variability, for socio-economic development activities such as in silviculture, cyclical agriculture, aquaculture and land rehabilitation.

11 The range of genetic diversity in key species be assessed for its potential use and should be conserved in perpetuity, incorporating modern developments in biotechnology as appropriate.

12 Research on the ecological implications of global change must be closely integrated with research on key species and their conservation in a changing environment.

2.5 Motion of Thanks

The participants in the workshop (listed in Appendix 2.2) express their profound gratitude to the Government of Trinidad & Tobago for its generous hospitality, and in particular the Minister of Agriculture, Dr Brinsley Samaroo; and to NIHERST, especially its President (Mr Frank Rampersad), Chairman (Professor Courtney Bartholomew) and staff (Christiane Francois, Lisa McShine, Clayt La Motte, Denyse Singh and Lauren Chang) for their assistance in making the meeting such a success.

2.6 Reference

Anon. (1980). *World Conservation Strategy: Living Resources Conservation for Sustainable Development.* International Union for the Conservation of Nature and Natural Resources (IUCN), United Nations Environment Programme (UNEP) and World Wildlife Fund (WWF).

APPENDIX 2.1

Illustrative examples of key species having both ecological and socio-economic importance (N.B. This list is by no means exhaustive)

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
TROPICAL										
TREES										
Azadirachta indica (Neem)	S.E. Asia	X	X	X		X		X		Outstanding multi-purpose tree
Bertholletia excelsa (Brazil nut)	Brazil	X		X		X		X		Nuts harvested from wild only, now threatened
Dalbergia species (Rosewoods)	Worldwide	X	X	X		X				Grossly overexploited high value timber
Mora excelsa	N.S. America	X	X	X	X	X			X	High value timber, vigorous, very localised distribution
Parkia roxburgii	S.E. Asia	X	X			X			X	Edible seed harvested from wild
Shorea species (Meranti)	S.E. Asia	X	X	X		X		X	X	High value timber, some species have edible nuts
Butyrospermum paradoxum (Butter nut)	Africa	X		X		X		X		Provides important source of income for women
PALMS										
Bactris species	Latin America	X		X	X	X		X		Important for fruit and construction
Borassus species (Palmyrahs)	Africa, Asia	X	X	X	X	X		X	X	Many different uses (alleged > 700)

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
TROPICAL										
PALMS cont.										
Calamus species (Cane palm)	S.E. Asia	X			X	X		X		Very important for handicraft industries
Jessenia	S. America	X		X		X		X		Source of food, oil, beverages and fibre
Mauritia flexuosa	S. America	X		X	X	X		X		Source of oil and starch
Raphia species (Raffia)	Africa	X				X		X		Major source of fibre
BAMBOOS										
Bambusa vulgaris (Common bamboo)	Worldwide	X	X	X	X	X		X		Major source of construction material
Dendrocalamus giganteus (Giant bamboo)	S. Asia	X	X	X	X	X		X		Very fast growing, major source of construction material
HERBACEOUS LEGUMES										
Lespedeza species	S. America/ E. Asia	X	X		X	X	X	X	X	Important as tropical pasture legumes and in land restoration
Psophocarpus tetragonolobus (Winged bean)	S.E. Asia, New Guinea	X	X			X				Edible tubers, pods and seeds (high protein content)

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
GRASSES										
Cymbopogon species (Lemon grass, etc.)	Old world tropics	X	X		X	X			X	Wild species good coloniser, cultivated species source of essential oil
Saccharum spontaneum (Wild cane)	S.E. Asia	X	X	X	X	X	X		X	Important for soil stability
Vetiveria zizanioides (Khus-khus)	Asia	X	X	X		X		X	X	Essential oil, roots for insecticide, handicrafts, good soil stabiliser
MEDITERRANEAN										
TREES & SHRUBS										
Ceratonia siliqua (Carob)	Mediterranean	X	X	X	X	X		X	X	Multi-purpose
Erica arborea (Tree heath)	Mediterranean	X		X	X	X			X	Ecologically important in Mediterranean subseral communities
Juniperus phoenicea (Juniper)	Mediterranean			X	X	X		X		Widespread resistant shrub
Olea europaea (Olive)	Mediterranean	X		X		X	X	X		Major oil producer of social and cultural importance
Pinus halepensis (Aleppo pine)	Mediterranean	X		X	X	X	X		X	Widespread coloniser
Quercus ilex (Holm oak)	Mediterranean	X		X	X	X		X		Used for wood, fuel and fodder

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
ARID										
SHRUBS										
Acacia senegal (Senegal gum)	Africa	X	X	X	X	X		X	X	Produces gum arabic
Caesalpinia sappan	Asia	X	X	X	X	X			X	Source of tannin, dye and fuel wood
Capparis decidua (Caper)	India	X		X	X	X		X		Major source of fodder in arid areas; fruit edible
Prosopis cineraria, *P. nigra*, *P. tamarugo*	Latin America	X	X	X	X	X		X	X	Important source of fodder, fuel and food in very arid areas
TEMPERATE										
TREES										
Alnus nepalensis (Nepalese alder)	Himalaya	X	X	X	X	X		X	X	Coloniser and stabiliser of disturbed hill slopes, N-fixing non-legume
Betula utilis (Himalayan birch)	Himalaya	X		X	X	X		X	X	Major coloniser in cold areas, timber and bark valuable
Nothofagus species (Southern beech)	S. Hemisphere	X		X	X	X				Important trees in montane tropics and in lowland Australasia and S. America
Populus species (Poplar)	H. Hemisphere	X	X	X	X	X			X	Fast-growing timber species and wind break in agricultural land
Pinus radiata (Monterey pine)	W.N. America	X		X	X	X			X	Vigorous soft wood, grows very well outside original habitat
Salix species (Willows)	N. temperate	X	X	X	X	X	X	X	X	Extraordinary complex of valuable species

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
SHRUBS										
Calluna vulgaris (Heather)	N. Europe	X		X	X	X		X	X	Widespread dominant of poor land; habitat for diverse wildlife
Caragona pygmaea	C. Asia	X	X	X	X	X				Coloniser of moraines and hill slopes, primary source of fuel wood
Hippophae rhamnoides (Buckthorn)	C. Asia	X	X	X	X	X	X		X	Vigorous, N-fixing non-legume
MOSSES										
Sphagnum species (Bog moss)	Worldwide			X	X	X			X	Major habitat determinant in wet areas
HERBS										
Chenopodium quinoa (Quinoa)	Andes	X			X	X	X	X		Important subsistence grain crop in tribal areas
Typha angustifolia (Cat-tail)	Europe, America	X	X	X	X	X			X	Coloniser of shallow water and concentrates nutrients and toxic metals
Brassica species (eg. mustard, cabbage, rape, turnips)	Eurasia	X			X	X	X	X		Important food materials

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
COASTAL AND SUBTIDAL										
SHRUBS										
Halimione portulacoides	Europe		X	X	X				X	Important coloniser and dominant of salt marsh
Casuarina equisetifolia	Australia	X	X	X	X	X			X	Vigorous stabiliser of sandy soils, important source of fuel wood
HERBS										
Salicornia species (Glassworts)	Worldwide	X		X	X	X				Early coloniser and stabiliser of mud flats
Spinifex littoreus	Pan tropical	X	X	X	X				X	Major coloniser and stabiliser of coastal sand in tropics
MANGROVE										
Avicennia species (White mangrove)	Worldwide	X		X	X	X		X	X	Important in coastal protection, fisheries and wildlife
Rhizophora species (Red mangrove)	Worldwide	X		X	X	X		X	X	As above

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS: Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	SOCIO-ECONOMIC FUNCTIONS: Commodity	Genetic Resource	Cultural	Environmental Management	Reasons for inclusion
ALGAE										
Laminaria species (Leaf kelp)	N. temperate	X		X	X	X	X	X	X	Forms large coastal beds, source of algin
Macrocystis pyrifera (Giant kelp)	Temperate	X		X	X	X			X	Determines habitat structure, main source of algin, acts as a major breakwater
Porphyra species (Nori)	Worldwide	X			X	X	X	X		Edible; basis for largescale aquaculture in the orient
Rhodymenia palmata (Dulse)	N. temperate	X			X	X		X		Widely used as food for 12 centuries (for humans, cattle and sheep)
Sargassum species (Sargasso weed)	Tropical Pacifica and Atlantic	X	X	X	X	X			X	Forms extensive intertidal beds, supporting many species
SEA GRASSES										
Posidonia species (Sea grass)	Mediterranean	X	X	X	X				X	Stabilises shallow sea bottoms, concentrates heavy metals
Zostera species (Eel grass)	Temperate	X		X	X				X	Stabilises mud flats, source of food for wild fowl
Thalassia species (Turtle grass)	Tropical	X	X	X	X				X	Colonises shallow lagoon bottoms, food sources for many fish

Animal Taxa (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS						SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Herbivory	Predation	Pollination	Dispersal	Decomposition	Secondary Production	Commodity	Genetic Resource	Cultural	Environmental Management	
TERRESTRIAL												
Loxodonta africana (African elephant)	Africa	X			X			X		X	X	Major habitat modifier, threatened by poaching and habitat restriction
Bubalus mindorensis (Tamaraw)	Philippines	X							X	X		Local example of a genetic resource with high potential; highly endangered
Trinervitermes (Termites)	African savanna	X				X	X					Important for soil fertility in arid areas
Milsonias (Earthworms)	Africa				X	X	X					Major fertilizing role for African soils
Apis mellifera (Common honey bee)	Worldwide		X	X				X		X	X	Very important for pollination, as well as honey
Euglossini (Orchid bees)	Neo tropical			X								Essential for the survival of many orchid species
AQUATIC												
Trichechus (Manatee)	Major river basins and adjacent coastal waters, E. America & W. Africa	X									X	Controls water hyacinth and other water weeds
Enhydra lutris (Sea otter)	N.E. Pacific		X							X	X	Maintains diversity in kelp beds, cultural value to Indian populations

Animal Taxa (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS					SOCIO-ECONOMIC FUNCTIONS					Reasons for inclusion
		Herbivory	Predation	Pollination	Dispersal	Decomposition	Secondary Production	Commodity	Genetic Resource	Cultural	Environmental Management	
AQUATIC cont.												
Salmo salar (Salmon)	Atlantic		X				X	X	X	X		Major fishery species, wild populations depleted
Homarus americanus; Panulirus argus (Lobsters)	N. Atlantic, Caribbean		X			X	X	X	X	X		As above and major retainers of diversity
Strombus gigas (Queen conch)	Caribbean		X			X	X	X	X	X	X	As above
Crassostrea gigas (Oyster)	Estuaries, lagoons, Far East origin						X	X	X	X	X	Excellent coloniser, substituted for European oyster
Euphausia superba (Krill)	Antarctic	X					X	X				Critical food for other animals, exploited by man
Lobodon carcinophagus (Crabeater seal)	Southern oceans		X				X	X				Major food web determinant
Eubalaenidae (Rorquals)	All oceans		X				X	X		X		Major ecosystem determinant, immense cultural importance
Scleractinia (True corals)	All warm seas	X	X				X	X			X	Essential in reef construction, supports nearshore fisheries

APPENDIX 2.2

LIST OF PARTICIPANTS

IUCN/CSC Workshop on Key Species

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3. THE IDENTIFICATION OF KEY SPECIES FOR CONSERVATION

by JOHN L. HARPER

3.1 Introduction

There is a diversity of arguments made to support conservation practice which ranges from an extremely nostalgic position (that any gain to or loss from the natural environment is a change in our heritage, and therefore to be resisted), to a purely economic argument that conservation retains species (and genes) that might in the future be found to be useful to man. There are further arguments that, in some way, the diversity of nature, or the persistence of natural communities, contributes to the stability of the earth as a long term habitat for humans. The arguments are very often intertwined. It is not the aim of this paper to enter into the discussion of when and how much conservation should be practised but rather to examine the types of species that it might be most important to conserve ('key species').

It is convenient first to consider the principles that might guide the choice of species that should be conserved because, although they are scarcely used, or not used at all by humans at present, might at some time prove useful and should not be lost. Although this paper is concerned with species that might warrant conservation it is important not to lose sight of the fact that it may sometimes be some of their genes rather than whole genomes that might become useful – even if transferred transgenically to other species.

3.2 Plant species that might become useful to man as food

Overwhelmingly the present provision of staple foods for man depends on plant species that concentrate carbohydrates, fats or proteins in large storage organs. This paper does not consider the very wide range of potential food crops that are not staple but may contribute important minerals and vitamins to diet (e.g. potential salad vegetables).

3.2.1 *Seeds*

It is annual plants with large seeds (almost entirely grasses and legumes) that provide the major staple seed food crops of the world. Among higher plant species the weight of individual seeds varies over 11 orders of magnitude (from 10^{-6} g in the orchids to more than 10^{5} g in the double coconut). Yet the range size of the seeds that are used as staple foods by most of mankind is only a narrow band, ca 3-4 orders of magnitude from this range. The limits on seed size for agronomically useful plants are placed by the difficulty of harvesting large crops of very small seeds and the

Identification of Key Species for Conservation and Socio-Economic Development
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apparently very limited habitat range of species with very large seeds. Rare exceptions occur when many small seeds are held in non-shattering capsules which are therefore harvestable e.g. the oil-seed poppy.

It is overwhelmingly annual plants that provide the world's bulk seed foods. This is presumably because annual plants allocate a very high proportion of their annual growth to seeds. The major grain crops (rice, maize, wheat, oats, barley, sorghum and rye) allocate 25-40% in this way. This contrasts with herbaceous perennials, and especially trees, in which the allocation appears always to be much lower (Harper 1977).

It seems likely that plants that might contribute significant staple foods in the future will continue to be annuals with large seeds, or (perhaps very important) that have the potential for the breeder to increase seed size or for the engineer to devise methods to harvest them efficiently. It is often argued that species that might become most useful as staple foods for man must be those capable of providing a bulk energy resource, i.e. species that store concentrated carbohydrate or oils. It may well be, however, that plants that store abundant reserve proteins may become increasingly important. In many diets a major protein component is provided by animals (meat and milk products) which convert carbohydrate (energy rich) plant material into a protein rich component of diet. Such animal protein is likely to remain an article of diet where the grazing animal is the only efficient harvester of land areas, but elsewhere it is on plant products that expanding populations are likely to depend for dietary protein. It is arguable that, in most parts of the world, protein famine will occur before energy famine. Key species are then likely to be those with efficient protein storage rather than those with efficient carbon fixation and storage. In the longer term, as fossil energy reserves are exploited and become more expensive, plants that store oils (in seeds or in latex) may become important sources of fuels for heating and cooking.

In summary, if we were to recognise key species for conservation that might become useful because they are potential sources of seed food crops, we would place special emphasis on annuals with large seeds and that store carbohydrates; proteins, fats and oils may become equally valuable.

The plant communities from which annual crops have been derived and from which new annual crops might be developed are of course primarily those of early successional stages and of semi-arid regions. These are likely to remain the source of 'key species' that may provide staple diets. Most staple food crops have come from the two families, Gramineae and Fabaceae. This may be because in species of these families the main defence against seed predators in nature is the physical hardness of their seed coats or pericarps or leachable secondary chemical compounds – this makes them easily accessible as a diet to man after milling and cooking. It may be that a much wider range of species could be potential food crops if they were bred to remove unpleasant flavours and toxins.

3.2.2 *Vegetative storage organs*

A wide variety of perennial plants store reserves in bulbs, corms or tubers. A few of these have become major contributors to diets (e.g. potato, yam, cassava, carrots) but, as with seed crops, the species that are used in significant quantities by humans are a tiny minority of those that might conceivably be used. There are three major problems with those sort of crops; (a) the product is usually bulky because of its high water content compared with seeds, (b) because the storage structures are almost always underground there are harvesting problems, and (c) the storage organs almost always contain defence compounds of one sort or another – e.g. alkaloids in Solanaceae, glucosinolates in Cruciferae, terpenes in Umbelliferae, raphides of oxalic acid in the bulbs of many Liliaceae. Such chemical defences appears to be very much rarer in potential crops for food from seed where the reserves are usually protected from predators and pathogens by physical defences (e.g. thick seed coats).

Chemical defences often make the vegetative storage organs of plants unpalatable or even toxic to man and restrict their use as food. However, they may be so desirable as contributors to diet that special cooking regimes have been developed to remove or inactivate the toxins. Pate & Dixon (1982) surveyed the bulb, tuber and corm flora of Western Australia and collected evidence of the use of the various species by aboriginals (see also Cribb & Cribb 1975). Of the ca. 7 000 species of flowering plant in the flora 304 bear fleshy underground storage organs and 36 of these species are eaten. Only 14 species are eaten raw, the majority are cooked, sometimes after prolonged soaking to remove toxins. For example, the storage organs of *Macrozamia riedlei* are soaked for a long period before cooking to remove cyanide and alleged carcinogens.

The choice here of the Australian example is made partly to illustrate how anthropological information may help in identifying possible 'key species' – it is not suggested that Western Australia is the likely source of the world's new food crops! However, among the Australian plants with vegetative storage organs there are 'potentials' of the sort that one might look for in a search for 'key species'. Pate & Dixon list four species in which the storage organs contain 16-18% storage protein, almost the equivalent of grain legumes (e.g. *Isoetes muelleri, Philydrella pygmaea* and *Stylidium petiolare* and seven species in which the storage organs contain 11-14% protein. Australasia has contributed no staple food crops to world agriculture and it would be foolish to imagine that there are, lurking in Pate & Dixon's list, new foods for the immediate future. What is more important for the conservationist argument is that there are clearly interesting qualities in some of the species that might, sometime in the future, be useful (though they might need to be transferred into other species).

In making any judgement of which native species in a flora might be worth conserving as potential future food crops it would be shortsighted to think only of those that already possess the qualities of a potential crop. Deliberate breeding programmes, e.g. to remove toxic principles, might easily release species from constraints that make them unacceptable at present. Recent advances in genetic technology – especially the possibilities of transgenic manipulation – may mean that genes, in species that are now unexploited, might usefully be transferred into other species – even if they are not exploitable in their present home. Virtually the whole effort in plant genetic engineering is at present concentrated on species that are already important crops. When genetic engineers widen their vision they will need to call on a much wider range of genetic resources.

This very brief consideration of conservation of species that might become 'key species' as potential food crops has concentrated on staple foods. Of course minor crops are not unimportant – especially as economies develop to provide rare and unusual plant delicacies for the ever more esoteric tastes of the wealthier nations. The ready acceptance of kiwi fruit, mangoes and star fruit in British markets implies that dietary tastes are not after all so very conservative and new industries may develop in the tropics and sub-tropics if they can offer novel delicacies for export. In this category of possible 'key species', plants bearing nuts or fleshy fruits are particularly interesting as the basis of possible new luxury export crops. There may be many such species that, freed of toxic or unpleasant tasting compounds and improved in size and keeping quality by the genetic engineer, might become important items in local economies.

The communities from which we might expect to recruit perennial 'key species' are of course quite different from those that might contain useful annuals. Lianas from forest communities commonly bear large fleshy storage organs (even the highly toxic *Tamus communis* of temperate communities forms a massive underground food reserve) and, as in the Western Australian species already mentioned, semi-arid regions also contain interesting plants with below ground food storage. Bulbous, cormous and rhizomatous plants extend into almost every community type in which there is a sharp alternation between seasonal conditions so that rapid regrowth from a large food reserve confers clear advantages. One would be hard put to define a plant community from which a potential food plant of this sort could not possibly be derived.

The communities from which potential new fruit and nut crops might be developed are more limited. Perhaps it is in tropical rain forest that such species are most likely to be found and developed – but needing to be freed of distasteful compounds or toxins. It is unrealistic wholly to write off fruit and nut crops as potential staple foods because we know that, even in Europe, *Castanea sativa* formed the staple diet over centuries in SW France and the walnut and olive were not unimportant! The reason why they appear less likely candidates for new staple diets is (as with fruits) the low yield per unit area of edible product; but such species may yet have a role in regions that are difficult of cultivation, too arid for traditional annual staple crops or if they produce a luxury food for export.

3.3 Plants potentially useful as pharmaceuticals, flavourings, etc

An immense variety of secondary chemical products are produced by higher plants – enough to make organic chemists deeply jealous. Almost all of these seem likely to have arisen as defence compounds in environments where protection from grazing or other forms of herbivory have been important. Among these, the species that are used by man for their volatile compounds (especially terpenes) seem most often to have come from grazed and over grazed communities – many from Mediterranean climates (e.g. thyme, sage, marjoram, eucalyptus, carrot, parsnip) though there are plenty of others from the tropics that have formed the basis of important spice trades (flower buds in cloves, nuts of nutmeg, bark of cinnamon, rhizomes of ginger, seed pods of vanilla, fruits of pepper and cardamom, etc.) It is not easy to predict what tastes might appeal to a new public and form the basis of export trades. Certainly tastes change as evidenced by the popularity of the tansy (*Tanacetum vulgare*) and even rue (*Ruta graveolens*) as flavourings in Elizabethan cuisine and their present distastefulness and the growing popularity of bergamot as the flavouring in Earl Grey tea.

Possibly more important is the range of potential pharmaceuticals that may lurk hidden in species yet unexplored and unexploited. There are hints of where we might expect to find the greatest diversity of plant chemical products and therefore 'key species' remaining to be exploited. Just as speciation itself (and outbreeding with its consequential accumulation of genetic variations) may have been strongly driven by selective pressures from pathogens and predators, so the evolution of chemical diversity may be expected to have been most intense where these same pressures were greatest – in tropical forests. We might expect to find the most interesting new pharmaceuticals in species that have evolved highly species-specific repellents and attractants and that form parts of specialised linear food chains. It can be argued that defences against generalist predators are less likely to have uniquely interesting properties. One might predict that interesting new chemicals (and so the 'key species' that produce them) are most likely to be discovered by looking for specialist herbivores and then tracing what plant it is that they eat. This would be an intelligent route to discovering new cardiac glycosides for example. It is likely that the most interesting specialist pharmaceuticals will be discovered by looking for plants that are eaten, but by only one predator, rather than by looking for plants that appear to escape predation altogether.

3.4 Plants to serve as fuel for cooking or as food without cooking

It has been estimated that by the end of the century 3 000 million people will face a shortage of fuel wood. Already 120 million people in the Sahelian and Himalayan regions face such shortage. Indeed it may well be that the retreat of forest margins as a result of the pressure from communities seeking fuel may be as or more important a cause of world deforestation that the commercial felling of tropical forests. The problem arises because man evolved as a species almost entirely dependent on plants that can be made acceptable as food only after being cooked (or processed by an animal into meat and milk products). Any definition of 'key species' ought therefore to consider both those that might be used to provide rapidly growing fuel and species that might form elements in staple diets but do not need to be cooked. If, in the course of their evolution, plants have been selected to be unacceptable to some predator or pathogen it is not surprising that most plants are unacceptable to humans until they have received some sort of treatment. Even the presence of cellulose cell walls makes plant cell contents difficult to digest by any large animal that lacks a rumen and has not learnt how to cook. An exciting discovery among 'key species' would be one that released its cell contents easily – perhaps after fermentation instead of cooking.

3.5 Key species for environmental protection

Key species could be those that can be used in protecting the environment because they are effective in special roles such as reducing soil erosion, colonising soils subject to creeping saline blight after irrigation, and the revegetation of industrial wastelands. Such species will usually have to be perennials with rhizomatous habit with or without specific tolerances of special soil conditions (heavy metals, salt, etc). They may therefore be found in rather unusual habitats (sand dunes, serpentine soils, metal quarry wastes, salt marshes). Many of these habitats are not those usually placed high on the list of those worthy of conservation but may become the source of useful species or of useful genes.

3.6 Key species for environmental conservation

Clearly a major argument for conserving the diversity of nature is that some of its species might become useful sometime. However, there are other forms to the argument for conservation e.g. that the variety of natural species transforms human values by the range of experience that natural diversity provides. There are arguments that it is the diversity (rather than just the biomass) of natural communities that in some way stabilises life on earth for man. If we are to identify which particular species are 'key species', because they play a special role in maintaining the diversity of nature, there seem to be only a few generalisations that might form useful guides. It can be argued that perennials and particularly trees contribute more to the earth's biota than short lived species because they provide a wider variety of resources for others (a tree is a more complex resource than an annual). Trees, especially in forests, create a wider variety of micro-habitats than short lived species and therefore control and permit greater potential diversity in their associated fauna. It can be argued that species (or other taxa) with a long evolutionary history in an area are more likely to have evolved a rich dependent fauna (contrast the rich insect fauna of the oak which has long been part of the British flora compared with the poor fauna of the sycamore which is a recent arrival). We might expect that species without specialised defences will support a greater variety of predators than those that possess such defences, because the latter may be parts of narrow relatively unbranched food chains which could disappear as a whole without drastic effect on the diversity of the whole community. But perhaps the relatively undefended species of plant will in general support large numbers of a few dominant consumers rather than a wide diversity of consumers.

Almost without question species that fix atmospheric nitrogen will be 'key species' in most communities. This is not only because nitrogen is so commonly a limiting resource, but because the activity of nitrogen fixers (the hosts of *Rhizobium*, *Frankia* and perhaps others) is to produce a patchy distribution of nitrogen in the soil and patchiness favours diversity. It may even be the case that plants that fix nitrogen are in a sense locally suicidal, making their nitrogen enriched environment suitable for others that will then replace them. Species that have life cycles or physiologies that initiate local patchworks of micro-successions may make an important contribution to natural diversity. Species that are efficient foragers of soil phosphorus may also act in this way (Bunting 1960).

3.7 General conclusions

There are very few clear generalisations that emerge from trying to define what species should be regarded as 'key species' – a species only becomes a 'key species' when some future role for it has been identified. The identification of 'key species' requires as much the art of the soothsayer and prophet as that of the professional biologist. I have argued that staple foods are most likely to be found among annual plants with large seeds that can be freed of toxins (and ideally do not require cooking). Species appropriate for staple diets at present may become quite unsuitable for a large part of mankind, if fuel for cooking becomes limiting as quickly as is forecast. The species that become 'key species' may then be those that can serve as quick growing fuel or can be eaten without being cooked. I have argued that plants that might produce new pharmaceuticals are most likely to be found in perennials – especially among tropical trees. But it could well be that new pharmaceuticals will be synthesised mainly by genetically engineered microorganisms, and that what will make a higher plant into a 'key species' is that it can be used as a source of bulk chemical feed stocks from which other compounds can be microbially synthesised in the laboratory or factory.

It could be that the definition of the sorts of species that are especially worth conserving will be completely altered by climatic changes (greenhouse effect or depletion of the ozone layer). The overwhelming need might then be for 'key species' (perhaps species of forest tree that could be planted extensively) that have especially great powers of fixing atmospheric carbon dioxide or special tolerance of high levels of incident ultraviolet radiation (the effect of ozone depletion). The latter might sensibly be looked for in the genomes of 'key species' from high alpine habitats. It might even be that the biggest influence on the stability of the terrestrial environment will come from the activities of 'key species' of microalgae in the ocean because of the overwhelming role that they are believed to play in regulating the concentration of atmospheric carbon dioxide so influencing the productivity of terrestrial life.

The main problem in trying to recognise what are 'key species' is that the world and its problems keep changing. When a new problem or opportunity arises the risk is that we did not foresee it; we might then have lost a species or gene because we had not foreseen the lock to which it was the key.

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4. WHAT CONSTITUTES A KEY SPECIES?

By JOHN H. LAWTON

4.1 Introduction

This background document has as its brief the general question of what constitutes "a key species for its role in conservation and socio-economic development", from the perspective of an experimental ecologist. I was asked to address two particular points.

a) To what extent should the consideration of ecological stability guide selection of key species (a) in what direction, and (b) by what criteria?
b) Should particular types of ecosystems, and/or particular taxa, be systematically favoured? If so, using what criteria, e.g. rarity, threat of extinction, utility, etc.?

The first section of this paper explains what ecologists mean by 'key species', and what we know about their role in plant and animal communities. I then extend the concept of a key species by developing a new theoretical argument, and present ways in which the importance of a key species might be measured and assessed. These are purely scientific arguments, couched in ecological terms, and stressing the role of individual species in creating and maintaining habitats for others. The second part of the paper considers ways in which ecological ideas about key species and the diversity and stability of ecosystems might be used to select 'target' species for conservation. I am not hopeful that theoretical and experimental ecology have much to contribute to the selection of key species for conservation; the scale of ecosystem destruction and species extinction is now so great, and accelerating so quickly, that we cannot hope to identify more than a trivial proportion of key species in the world's major ecosystems, before they are lost forever. Most species conservation is, and will continue to be, pragmatic and dominated by 'aesthetic' and 'moral' considerations, bolstered occasionally by economic arguments. We have neither the time, the money, nor the resources to fiddle with key species whilst Rome burns; or, more aptly, while the ark sinks.

The science of ecology can contribute to species conservation by specifying minimum viable population sizes, helping to formulate management policies for reserves and parks, and so on. However, there is no set of magic scientific criteria for identifying key species that must be saved.

An alternative, and probably the only practical approach if our goal is to conserve as many species as possible, is to use key groups of species to pinpoint, albeit crudely, major centres of global diversity, and then to make great efforts to protect those areas.

4.2 The ecological definition of a key species

The American ecologist R. T. Paine seems to have been the first to use the term 'keystone species' to describe species that play a critical role in determining

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community structure (Paine 1969). Reviewing the concept, Krebs (1978) gives as examples Paine's own work on the starfish *Pisaster ochraceus*, that maintains species diversity on rocky intertidal sea shores by preying on mussels; lobsters that play a similar role as predators in subtidal communities off the east coast of Canada; and African elephants that promote the establishment and maintenance of grassiness by feeding on woody shrubs and trees. In current technical usage, 'keystone' and 'key' species seem to have identical meanings.

In his brief review, Krebs expresses the opinion: "Keystone species may be relatively rare in natural communities, or they may be common but not recognised. At present few terrestrial communities are believed to be organised by keystone species, but in aquatic communities keystone species may be common." Ecological thinking about key species has advanced very little in the subsequent ten or more years. The third edition of Krebs (1985) simply adds one more example of a key species (the sea otter, *Enhydra lutris*), but leaves his conclusions intact. One of the most up to date, and arguably the best recent major ecology text (Begon *et al.* 1986) does not even have the concept in the index, and has nothing explicit to say about the problem! In other words, the study of key species is hardly in the mainstream of contemporary theoretical and experimental ecology.

In its present form the idea is basically trophic: key species exert their effect primarily by feeding on other plants or animals. By reducing the abundance of victims lower in the food chain, key species create space and resources for other organisms, and thereby promote the existence of these other species in the community. The impact of key species is most easily gauged by a deliberate or accidental removal experiment. Only if the effects of removing a species are dramatic and easy to see does it qualify for the term 'key species'. Interestingly, a number of recent studies have identified what are essentially key species in particular ecosystems, without using the term, and without reference to the earlier literature. Carpenter *et al.* (1987) is a good example. They describe a 'trophic cascade' in which manipulation of fish populations in freshwater lakes has major effects on phytoplankton and lake primary productivity, via intermediate links in the food web. Predatory fish in these systems are clearly key species, and the trophic cascade is simply a good way of describing the extent of their impact.

There are at least two things wrong with the notion of a key species in its present form. First, by focusing primarily upon trophic interactions it misses a huge range of ecological effects and species that may be vital to the maintenance of ecological diversity in most ecosystems. And second, it provides no objective criteria for measuring the impact of a species, and deciding whether it is, or is not, 'key'.

4.3 Towards a broader and more rigorous measure of key species: the concept of organisms as ecosystem engineers

With Clive Jones at the Institute of Ecosystem Studies in New York, I have been attempting to broaden the idea of a key species to embrace processes other than trophic interactions, whilst at the same time sharpening our own perception of the problem. Our ideas are at a very preliminary stage, but I hope they may at least serve as a stimulus for debate in the present context.

Ecological processes, by definition, are driven by interaction between organisms and their environment. Pick up any ecology textbook and it will tell you what these important interactions are: interspecific competition; predation; parasitism; mutualisms of various kinds and; if you are lucky, something on diseases. There will also usually be chapters describing ecosystem processes, energy flow, nutrient cycling and so on.

On the one hand, we try to understand and model these processes by taking the community or ecosystem within which organisms occur as given; we study interspecific competition between voles in a meadow, and predation by sharks on a coral reef. On the other hand we describe processes such as energy flow in a pond, or nitrogen flux in a pine forest, and treat the organisms as black boxes. Missing from virtually all ecological textbooks (and, I suspect, from the day-to-day thinking of most ecologists, though many would deny it!) is any consideration of the major role played by organisms in the maintenance and creation of entire habitats and ecosystems. We do not even have a particular word, or words, to describe the process. The concept of a key species comes closest, but it is too restrictive because of its emphasis on trophic interactions. For want of anything better, Jones and I have coined the term 'organisms as ecosystem engineers'.

Some of the processes that fall within the scope of the term ecosystem engineering are simple, familiar, even trite. The growth of trees, for example, creates a complex habitat for thousands of other species; coral reefs play a similar role in the sea. But there are many other ways for one or a small group of species to influence hundreds if not thousands of other species by creating habitats, sometimes by trophic interactions (as in the classical concept of a key species) but often in many other ways. Take these habitat engineers away, and the ecosystem or community changes, perhaps drastically. Surprisingly, ecologists have no formal language to describe and measure the impact of species as ecosystem engineers, and no formal theory to organise our understanding. Examples range from beaver dams to gopher, ant and termite mounds, and from nitrogen fixing plants that shape succession to rock-eating snails that regulate nitrogen cycling. Honey fungus, chestnut blight and Dutch elm disease create worlds for hundreds of species reliant on dead or dying trees. Earthworms and termites create soils, *Sphagnum* makes blanket bogs, and so on. All these organisms create and maintain, that is they engineer, habitats for a host of other species, and hence have major impacts on energy flow, nutrient cycling, and other ecological processes. The systems we study and may wish to conserve are there, to a greater or lesser extent, because key organisms, the ecosystem engineers, contribute to their creation and maintenance.

Important questions, for which ecology currently has no generally agreed answers, include the following.

a) Do all major ecosystems have key organisms that engineer their structure? What functions do they fulfil and why? What would happen if we took them away?

b) Within the fossil record, can we identify major evolutionary breakthroughs that gave organisms new tools to engineer novel ecosystems? When did these events take place? What effects did they have on the subsequent evolution of species and the development of the world's ecosystems?
c) How can we model the impact of these natural engineers on other species? What currency should we use? Are there any useful, general ways of doing it, or is each case special?

One way to think of the role of natural engineers, and to measure their impact, is as a 'gate' or 'control point'. One measure of importance is then to estimate how many other species would disappear entirely from the area, habitat or ecosystem in question if the gates were closed. For example, alligator-wallows in the everglades are vital reservoirs during dry weather for large numbers of species of fishes, birds and probably invertebrates. Remove the alligators, allow the wallows to silt up, and there will be a cascading loss of species throughout the entire ecosystem that is measurable, at least in principle. Sea otters are key species because their demise leads to the collapse of offshore kelp beds, brought about by a ten-fold increase in grazing sea urchins, an important food for the otters (Estes *et al.* 1978). The effects of removing the kelp reverberate throughout offshore and coastal environments. But we can now see that the classical effects of these key species, driven by trophic interactions, are only one way in which species may engineer and create habitats for other organisms.

A simpler measure of the importance of any species as a habitat engineer, by whatever means, is the number of other species that would be lost from the area, community or ecosystem in question if the 'target' species were removed, or greatly reduced in abundance. In practice, such a measure may be difficult to achieve, but in principle it provides an objective measure of the importance of any particular species for the continuing existence of others. A broader and more useful definition of a key species is therefore one whose presence controls community diversity, by creating and maintaining, that is engineering, habitats for other organisms. (Usually key species will greatly amplify diversity, but we must also keep in mind the possibility that some key species reduce diversity, for example by favouring a small number of dominant taxa).

4.4 Application to conservation

In theory, it clearly makes sense to conserve key species of plants and animals, thus ensuring the continuing existence of the habitats and conditions necessary to sustain large numbers of other organisms.

In practice, conservation already relies heavily on the implicit notion of organisms as habitat engineers in selecting and managing parks and reserves. We know that we cannot conserve particular species without conserving their habitat. At its most simple, we therefore set aside particular kinds of forests to conserve particular kinds of birds or butterflies, dependent upon the forest for habitat. (We have already noted that treating plants as habitat engineers is trite; but that does not mean that it is a false argument, just a very simple one.) Things get more complex when man himself has to engineer the habitat to maintain particular species, or communities; by lighting fires, by controlling grazing regimes, by culling herbivores or by manipulating water levels. Many reserve and park managers are acutely aware that particular species of plants or animals play a vital role in maintaining habitats within their domain, and go to great lengths to ensure their correct management; sometimes with considerable controversy over what constitutes the pristine state, and how it should be maintained! There is therefore nothing new about recognising that key species (now defined in the broader context as species whose presence controls and maintains local diversity) must be conserved if we wish to conserve many other ecologically less important taxa, and entire communities. But in the main, the concept is implicit in what we do, not explicit.

Would more explicit use of the key species concept be useful in framing future conservation strategies? I wish the answer was 'yes', but believe that it will usually be 'no'. As an ecologist I would like to know whether there are rules and general principles in the game of ecological engineering. I would like the idea of trying to measure 'species amplification' across a variety of taxa and communities. It is obvious that if we only knew a great deal more than we now know about key species, conservation would benefit greatly, but I see no prospect of getting this information fast enough to help conservation organisations significantly over the next decade and beyond.

Given the rapid and accelerating pace at which we are currently exterminating species and destroying entire ecosystems (e.g. Roberts 1988), there is really only one way in which application of an ecologically sound keys species concept might aid selection of species for conservation. This is if there already existed some easily identifiable criteria for recognising key species and what they do. But as we have seen, this is not the case; ecologists have hardly studied key species in a formal sense, and there are no useful generalisations about where key species occur, or about what they do, or how they can be recognised. Hence we are reduced to studying each case individually, guided by natural history observations, insight and inspired guesses. In principle it is not difficult to do experiments to discuss whether this fish, that snail, or the other snake is, or is not an important amplifier and maintainer of local diversity. But such experiments take time, and time is not on our side. Where the role of key species can be deduced by simple observation and common sense by all means use the idea to promote conservation. But I see no prospect of ever gathering sufficient hard, experimental information about most threatened communities and ecosystems to use the key species concept as a practical tool for conservation. We have neither the time, the money nor the resources for this.

One example will suffice. I have twice referred to snails as key species. They seem an unlikely choice, but the example is deliberate. Several years of careful research in the Negev desert by Clive Jones and Moshe Shachak have revealed a remarkable food chain. Endolithic lichens (lichens growing under the surface of rocks) are consumed by two closely related species of desert snails, *Euchondrus albulus* and *Euchondrus desertorum*, both able to rasp away the surface of the limestone. The snails are so abundant that their faeces (ground up rock) are a major contribution to soil formation in the desert (Shachak *et al.* 1987), and also liberate significant quantities of nitrogen 'locked up' in the lichens, with major effects on ecosystem productivity (C. G. Jones & M. Shachak, unpublished MS). Extinction or marked reduction in the abundance of the snails would probably have a cascading effect throughout the Negev ecosystem, with loss of many dependent species, and considerable reduction in productivity (I say 'probably', because the experiment has not been tried, and might in any case take many years before the full effects were noticed).

Clearly, *Euchondrus* snails are key species, acting as significant, if unexpected, habitat engineers. Now we know this, conservation of the Negev must ensure that snail populations are maintained; it is difficult to envisage many significant threats, but introduction of an alien predatory snail would be one possibility. Having said all this, it is inconceivable that the establishment of existing or planned reserves or conservation areas in the Negev might have been influenced by earlier recognition of the role of *Euchondrus*. Snails inspire neither the public, nor politicians: desert gazelles and leopards do. We may now know that we need snails to conserve gazelles and leopards, but my money is on the mammals, not the molluscs, in trying to win over public opinion in the battle to conserve more than tattered remnants from the ark. It would also be manifest stupidity to suggest that before we identify any habitat or species for conservation, we must know on the one hand what the key species are, or on the other hand whether that particular bird, mammal, or what have you is, or is not, a key species. In other words, I do not see how a drive to identifying key species will help practical conservation significantly.

4.5 The problem of ecological stability

Although the direct application of the concept of a key species seems to offer little immediate help in the race to conserve biological diversity, to what extent should the consideration of ecological stability guide selection? To answer this part of the brief, we again need to clarify what ecologists mean by stability, before deciding whether the idea is practically useful.

Stability has several distinct meanings (Pimm 1984) in the ecological literature. These ideas are not interchangeable; a population or community may be unstable under one definition, but stable in the sense of another. Hence vague reference to 'stability' is meaningless. There are three principal usages.

a) Stable populations vary, or fluctuate, less than unstable ones. It is not easy to see how this idea could be used to select species for conservation. However, minimum viable population sizes will be larger for species with widely fluctuating populations than for species with more constant population sizes, other things being equal (Soulé 1987).
b) Stable populations return to equilibrium after a disturbance; unstable populations do not. Populations stable to 'small' perturbations are said to be locally stable; populations that will recover from any perturbation short of complete extinction are said to be globally stable. We know rather little about global stability in either theory or practice in ecology and the idea has little to contribute to the

present debate. Local stability analysis, in contrast, is the basis of a great deal of mathematical modelling in theoretical ecology (e.g. May 1974; Pimm 1982). One of the central assumptions of these endeavours is that most of the persistent populations, food webs and communities of plants and animals that we observe in the real world are, by definition, locally stable (otherwise they would not long persist in the face of repeated environmental shocks). If this central assumption is true, all species have stable populations, and the concept provides no basis for selecting species for conservation.

However, it is not actually this simple. A growing body of theoretical and experimental work suggests that a number of major types of communities may exist very far from mathematical equilibrium. Instead, they are formally unstable, and diversity is maintained, not damaged, by repeated disturbances. For example, a good case can be made that both the diversity of tropical rain forest trees and the diversity of corals on tropical reefs are both maintained by repeated disturbance, with neither kind of system being either close to equilibrium, or formally locally stable (Connell 1978). Clearly, if this hypothesis is correct, it has profound implications for the size of reserves necessary to maintain diversity, and for reserve management. But I do not see how it would help us to identify key species.

c) The third, and potentially most pertinent definition is termed species-deletion stability, which measures the capacity of a system to withstand the selective removal of particular species (Pimm 1982, 1984). Theoretically, it can be shown that certain types of food webs, or certain types of communities, are robust to species deletion, and others are not; and that removing certain types of species (top predators for example) is likely to have much greater impact on the remaining species in the system than removing, say, one of several alternative host-plant species for herbivores. A moment's thought, however, shows that if a system is drastically changed by deleting a component population (the system is not stable to species deletion), then the deleted species is, by definition, a key species. In other words, stability (or lack of it) to species deletion and key species are different facets of the same problem, and we are back where we started.

Drawing these arguments together, we must conclude that consideration of ecological stability in its various (and very different) usages is extremely unlikely to help in the selection of species for conservation.

4.6 Other considerations

Should particular types of ecosystems, and/or particular taxa, be systematically favoured? If so, using what criteria? This part of my brief is at one and the same time the easiest to deal with, and the most difficult. It is the easiest because from the point of view of experimental (or for that matter theoretical) science, there is rather little to say. The question, what criteria should we use to select species for conservation (for example rarity, threat of extinction, potential medicinal use, potential as a food resource, multiple use species, or beautiful species) is not a scientific question, and it is not one to which science can provide an answer, except in marginal cases. One such marginal case may be in identifying populations that are so reduced that they are no longer viable in the wild (Soulé 1987). But even this limited application of ecological science presupposes that we have already identified the species worthy of conservation; and that major, initial choice has little or nothing to do with science.

We select species for conservation for all kinds of mixed, often confused, and certainly rarely expressed reasons. Let me make my own position clear, as a citizen, not as a scientist. I care passionately about conservation, and am horrified by the current scale of species' extinction, and the prospects of much, much worse to come during the rest of my lifetime. I care because wild plants and animals, and the places where they live give me, and the people about whom I care most dearly, enormous pleasure. They enrich my life, just as medieval cathedrals, Mozart and Monet enrich my life, and the lives of others. It has been a powerful notice for conservation ever since it began to dawn on thinking people that wholesale destruction of nature impoverishes mankind (Leopold 1949). In other words, one great notice for conservation is 'moral' or 'aesthetic'. That is why we plan to conserve gazelles and leopards, and accidentally conserve snails at the same time. Gazelles are beautiful and leopards are exciting; it takes time to love snails. Put bluntly, we select species for conservation on emotional grounds; science has little or nothing to do with it.

Interestingly, what I have just outlined is a new type of 'key species', but not in the scientific sense defined earlier. They are political, or emotional key species, for which a conservation case is relatively easily constructed because they are spectacular, exciting, intelligent, beautiful, cute or pretty, – grizzly bears, lions, chimpanzees, pandas or butterflies to select a handful of examples. By coincidence some of these organisms may also be key species in the ecological sense of the word, but this is a bonus. The two definitions of key species may coincide most often in dominant large predators, big cats, wolves, eagles, sharks, and so on. So that if I had to target money and resources on any ecological group, it is here that I would put greatest effort, in full realisation that it is at best a crude, first approximation. The reasonable hope is that by conserving viable populations of these kinds of organisms in the wild, thousands of other more humble creatures get a ride into the twenty-first century.

Unfortunately, as pressures mount, and nature shrinks, these arguments frequently fail in the face of pressing and very real human needs, and other arguments come to the fore, or are used to bolster the aesthetic and moral case for conservation. It is clearly desirable that nations conserve species with the potential to pay their way in the world, be it via tourism, or sources of potential medicines, or food, or some other trade.

But these are matters of common sense, politics, economics and luck. (Luck because we have no idea, for example, how many plant species offer the potential for new drugs, or new pest resistant genes for our crops, and currently no simple and quick ways of recognising them; it will therefore be a matter of luck how many such species survive to be useful.) So as a scientist, I have little or nothing to contribute to the selection of 'key species' because they are, or may be, in some way useful. It is not a scientific problem.

It is not to say that ecological principles cannot be applied to pressing human and environmental problems in both the developed and developing world. Obviously they can, they are, and must increasingly be. Application may involve promotion of new plant species for shelter, firewood or food, or different way of using semi-natural ecosystems, or what have you. Each such project may involve 'key' species, vital to its success. But I see no general set of theoretical ideas linking these numerous efforts. Once pressing problems have been identified, we can use science to help solve them. But it is not easy to see how science (ecological or any other) can ever identify particular types of ecosystems and/or particular taxa that must be conserved.

A major exception to these generalisations may lie in discovering, as quickly as possible, where the world's exceptionally rich ecosystems are located. We already know some of them; they include the Cape Floral Region, and parts of the western Amazon basin. Then, if our aim is to conserve as much as possible of global diversity, we must ensure maximum protection for taxonomic 'hot spots'. Identification of such areas must rely on surveying a limited range of organisms; there is not time to do otherwise. Butterflies, freshwater fishes, woody plants, birds and other vertebrates have been suggested as suitable representative taxa (Roberts 1988). The hope is that these groups of species can serve as the nominated representatives of a silent and largely unknown majority.

Last but not least, it is obviously a valid scientific question to ask whether the planet as we know it will continue to function, that is continue to support and sustain our people, our cultures and our civilisations, in the face of massive species' extinction. Since we do not know the answer, I personally believe it would be prudent not to do the experiment! Unfortunately, this is a powerful, but somewhat two-edged scientific reason for conservation of species. It is two-edged because I cannot say with any confidence that the world would not be a perfectly acceptable, albeit rather dull place to live, even without 95% of current species; and indeed there are those who believe that a simplified planet would still "work". To put it bluntly, even at this level, the case for conservation lacks hard scientific support, provides those who do not care about gazelles and leopards, still less about snakes and snails, with a powerful argument to do nothing to prevent their demise.

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5. NITROGEN FIXING SPECIES

By A. D. BRADSHAW

5.1 Introduction

A major feature of the present-day is the ever increasing degradation of the surface of the earth and the ecosystems upon it. This is no new process. Civilizations throughout time have been destroyed by loss of the soils of the croplands which allowed those civilizations to prosper as well by loss of the original vegetation on lands surrounding them. But the situation today is exacerbated by a combination of pressure of increased populations, the use of machinery and the particular demands of industry for more and more resources taken from the ground.

The first pressure leads initially only to removal of cover vegetation by grazing animals and by cropping. Carried out carefully, there need be no soil loss. But as population pressure builds up, good husbandry cannot be sustained, and inevitably soils are over-exploited, eroded and lost. Mechanisation only adds to this by allowing greater disturbance. The demands of industry lead to even more savage destruction of land as surface layers are removed to get at resources beneath.

We can see this as a progressive process. Firstly only the original vegetation may be destroyed, a loss which can easily be remedied if appropriate steps are taken. Nevertheless, all the nutrient capital held in that vegetation will be lost and will have to be replaced. Secondly, soon, because of the disappearance of its protective cover, the surface layers of the soil begin to be eroded. These contain all the capital of available plant nutrients, particularly nitrogen because this is held in organic matter. As the damage proceeds, so the whole of the soil disappears. Now, not only is the physical framework of the soil lost, but also the store of more tightly held nutrients contained within the matrix of soil particles. Only hard rock may remain. Where there has been industrial activity, the original soil is usually completely lost and replaced by some subsoil material which may even be toxic.

This scenario is familiar to everyone. It can be seen all over the world wherever human populations are concentrated. There is a critical need at the present time, not only to prevent the damage developing further, but also to restore those areas which have been destroyed. Obviously there are many steps which must be taken, involving proper management of plants, soils and animals. The techniques required are detailed in many textbooks and handbooks. But underlying the whole restoration and management process is one important principle which must be explored, because it has important implications for key species.

5.2 Nitrogen as a critical element in ecosystems

In all the tissues of living organisms, after carbon, oxygen and hydrogen, the commonest element is nitrogen. In plants it constitutes about 2% of the total dry

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matter. In ecosystems it is also one of the most critical elements. There is widespread evidence that it is the element most commonly holding the growth of terrestrial ecosystems in check.

Of course it occupies a special position in ecosystems, because although originally derived from air and not, like other elements, from soil minerals, it is stored mainly within the soil in organic form. Successful ecosystem functioning depends on there being not only the nitrogen in the vegetation itself, without which plants could not exist, but also a much larger capital within the soil, a small fraction of which is released annually by the decomposition of organic matter. The actual amounts vary from one ecosystem to another, but on average there is at least 100kg N ha^{-1}, representing 2.5% of the total soil capital.

The need for this soil capital can be verified not only by calculations based on known rates of organic matter decomposition in soil, but also on the growth of plant communities on degraded land. It can be shown that in temperate climates a soil capital of 1 000kg N ha^{-1} is the minimum necessary for proper ecosystem functioning. In tropical climates, where rates of organic matter breakdown are higher, the minimum capital will be less, but it will still be an appreciable amount.

5.3 Restoration of nitrogen capital in soils

The crucial point then is that, in all situations where land degradation is to be reversed, the over-riding need is to find a way in which the lost nitrogen capital can be replaced. Without its replacement, land and ecosystem restoration is impossible. The practical demonstration of this is in studies on the reclamation of land made derelict by industrial activity (Bradshaw & Chadwick 1980). Similarly, if land degradation is to be prevented in situations where exploitation is heavy, then an adequate nitrogen input, at least equal to the total of all losses, must be ensured.

In modern agriculture, nitrogen levels are now usually maintained by fertilizer inputs. This is perfectly possible in a high output system, where high inputs, in particular the high cost of a nitrogen input, can be paid for by the profits of the high output. But it is quite impossible to contemplate this for degraded land, since, because of the degradation, returns will inevitably be low. It will also be impossible in most cases where land is in the process of being degraded because the factors leading to a situation where degradation is occurring are likely to make fertilizer use impossible.

Wise use and recycling of organic materials, by minimising nitrogen losses, can go a long way to minimise degradation in progress. But it can do little to restore nitrogen capital that has been lost, except where special supplies can be brought in from other areas where they are in surplus. We are therefore left with the need to find a major source of nitrogen, which is readily available, easy to organise, and entails little or not extras in order to get it to operate.

The use of nitrogen-fixing species is the one obvious method which meets all these requirements. The species are mostly members of the family Leguminosae with their associated root-nodule organism, *Rhizobium*. But there are some notable species, such as *Casuarina equisetifolia*, which belong to other families and whose N-fixation is due to other micro-organisms. The levels of N-fixation that these species can achieve is remarkable. Even in the rather restricting conditions of totally skeletal materials produced by mining, in a cool temperate climate, annual nitrogen accumulation rates of 100-150kg N ha^{-1} can be produced by normal agricultural cultivars (Dancer *et al.* 1977). Wild established plants of *Lupinus arboreus* under the same conditions can achieve 185kg N ha^{-1}.

There is plenty is similar evidence. However, not all species can achieve these rates, and many have ecological requirements that either preclude them from certain soil where they would be valuable or require that the soil be ameliorated in some way, for instance by the addition of phosphorus. Other species, however, have surprising tolerance to special soil conditions, such as the aluminium and manganese toxicity found in acid soils.

A great deal of work has been done to find species with appropriate adaptations and effectiveness. The work of the Division of Tropical Pastures of CSIRO at Brisbane in Australia is outstanding, but it has been concerned with species suitable for pastures (Moore 1975). There is a good review of valuable tropical legumes (National Academy of Science 1979), but little about legumes for degraded land. A great deal of general knowledge has accumulated, from practical experience, about species suitable for the restoration of degraded land (Table 5.1) (Bradshaw & Chadwick 1980), but the information is really very limited.

In my experience of degraded land restoration in many different parts of the world, the usual position is that, firstly the importance of N-fixing plants is often only poorly understood, secondly where it is understood reliance is placed on one or two species only which have been found to be good elsewhere (such as *Leucaena leucocephala*), and thirdly little or no attempt has been made to find, or even assess the value of, other species. Yet the Leguminosae is an enormous family, and there are other groups of N-fixing species also. At the species level there is, therefore, room for a great deal more work. The experience of the CSIRO group shows that suitable species may come from anywhere in the world.

But there is also the need to work within species, at the level of ecological race and even population. The enormous diversity that can be found within species, much of it critical for ecological adaptation, is well documented. This diversity can certainly be found within members of the Leguminosae, for instance *Trifolium repens* (Snaydon & Bradshaw 1962).

5.4 Conclusions

All this argues that N-fixing species, particularly members of the Leguminosae, should be considered as one very important group of key species. There is considerable appreciation of their value as crop species already. Their importance as pasture plants is well understood. Recently their value in agroforestry has been realised. But their crucial importance in the restoration of all forms of degraded land is not fully appreciated, and certainly sufficient work to find and assess the most suitable species has not been carried out.

Degraded land provides a series of ecological and social constraints which species, to be used in restoration, must meet if they are to be successful. Some species are already known, and are being used successfully. But the problem of degraded land is so great and diverse, and the species and populations which might be useful so diverse and relatively unknown, that a great deal of work needs to be done.

It is the type of work which is best done as an international cooperative programme. The problem is shared by all countries. The suitable material may occur in any country. The expertise and experience of scientists from all parts of the world, especially those with good field knowledge of the species in their particular country, needs to be combined, if the best material is to be discovered and harnessed for the future of mankind.

Table 5.1 Perennial legumes suitable for the improvement of degraded land (from Bradshaw & Chadwick 1980)

Species	Soil preference*	Climate preference*
Amorpha fruticosa (indigo bush)	NC	W
Centrosema pubescens (centro)	AN	W
Coronilla varia (crown vetch)	AN	W
Desmodium uncinatum (silverleaf)	AN	W
Lathyrus sylvestris (mat peavine)	NC	W
Lespedeza bicolor (lespedeza)	AN	W
Lespedeza japonica (japan lespedeza)	AN	W
Lotus corniculatus (birdsfoot trefoil)	NC	CW
Lupinus arboreus (tree lupin)	ANC	CW
Macroptilium atropurpureum (siratro)	ANC	W
Medicago sativa (alfalfa)	NC	CW
Melilotus alba (white sweet clover)	ANC	CW
Melilotus officinalis (yellow sweet clover)	ANC	W
Stylosanthes humilis (townsville stylo)	AN	W
Trifolium hybridum (alsike clover)	ANC	C
Trifolium pratense (red clover)	NC	C
Trifolium repens (white clover)	NC	CW
Ulex europaeus (gorse)	ANC	C

* *For soil preference, A = acidic, C = calcareous and N = neutral.*
For climate preference, C = cool and W = warm.

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6. CONSERVATION STRATEGIES: AN AGRO-ECOLOGIST'S VIEWPOINT

by P.S. RAMARKRISHNAN

6.1 Introduction

The estimate of the number of species on earth varies from 5 to 30 million; in any case, no one doubts that the numbers are far higher than was thought until recently (World Resources Institute 1988). With an estimated 15 to 33% loss out of the total wildlife by 2 000 AD, the extinction rate is becoming critical (Lovejoy 1986). It is in this context that conservation biology assumes considerable significance. Apart from a number of biological problems such a community equilibrium and fragility of ecosystems, there are many social challenges that impinge upon people's perception of environment and development. It is, therefore, only in recent times that efforts are directed to build up the obvious contacts between social and natural sciences. What is it that we wish to conserve? Is it possible or even necessary to conserve all the species that are likely to be lost and about which we may or may not even be aware of? How do we ensure that our conservation strategies are effective? What is sustainable development in the context of biological conservation? This paper considers some of these issues and attempts to answer them using experiences in linking conservation with development.

6.2 Agro-ecosystem concept and conservation

6.2.1 *Lesser-known plants of food value*

Of all the 3 000 plant species used as food at some time during human civilization, less than 20 provide over 90% of the food needs (N.R.C. 1982). In fact, just about 3 species (wheat, rice and maize) meet over half of the human energy needs (Wilkes 1981). Reliance on such a small number of plants carries great risks, for monocultures are extremely vulnerable to catastrophic failures brought about by diseases or climatic stresses.

Over large areas of the humid tropics, genetic uniformity of a few varieties is displacing many local varieties traditionally cultivated by the farmers (Wilkes 1977). As the produce of technology displaces the source upon which the technology itself is based, namely the genetic diversity, short-term solutions often become long-term irreversible liabilities. In fact, 75% of the world's lesser-known crops are grown and consumed in tropical countries (N.R.C. 1975). With depletion of genetic diversity of crop plants (Sasson 1987) there is considerable interest in lesser-known plants of food value for meeting the needs of the increasing population, particularly in the developing world (N.R.C. 1975; Raven 1981). There is a need not only to conserve

Identification of Key Species for Conservation and Socio-Economic Development
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them but also to improve upon the economic yield of the more promising ones. Such a diversification of the agro-ecosystem base would go a long way to meet the nutritional needs of people and for the stability of agro-ecosystems.

Some important under exploited food plants are the grain chenopods (N.R.C. 1975; Risi & Galwey 1984; Partap & Kapoor 1985), with a high protein value. These plants are presently cultivated in the Andes or in the Himalayas. Greater emphasis on cultivation, improvement and consumption by the local communities would contribute to enhancement of the quality of life of the people concerned. With considerable similarity in the preparations made out of many chenopods by the Himalayan communities and their counterparts (Risi & Galwey 1984; Partap & Kapoor 1985) possibilities exist for preparation of marketable products. Needless to say that there is much scope for improvement of the grain chenopods.

The people in the humid tropics, such as in the north-eastern hill region of India endowed with rich natural resources and from a variety of socio-economic and socio-cultural conditions, depend upon under exploited food plants. In a recent study in north-eastern India (Gangwar & Ramakrishnan 1989a) over 70 such plant species and 12 animal species were identified for four tribes, namely, the Nishis, the Hill Miris, the Sulungs and the Apatanis. The plant species often come in handy during the lean season of the year when traditional food items are in short supply. With over 200 tribes in a small geographic area, each being highly insulated due to language barriers and socio-cultural differences, north-eastern India is a veritable ethnobiological treasure.

The Khasi tribe of Meghalaya in north-eastern India, practising slash and burn agriculture (jhum) (Ramakrishnan 1985) and having sedentary agriculture under short fallow systems (FAO/SIDA 1974; Ganwar & Ramakrishnan 1989b) cultivate a variety of lesser-known plants for food, such as *Digitaria cruciata* var. *esculenta, Perilla ocimoides* and *Flemingia vestita.* Many tribes in Arunachal Pradesh also cultivate *Dioscorea* species for tubers, *Amaranthus viridis* for leaves, *Chenopodium ambrosioides, Panicum miliaceum, Setaria italica* and *Coix lacryma-jobi* for seeds, apart from others (Gangwar & Ramakrishnan 1989a). Though the contribution of energy and protein through lesser-known plants was only a small fraction of the total food consumed by the Khasis (Table 6.1), the seasonal pattern of consumption varied so that more was consumed during the monsoon season (Figure 6.1). Apparently the lesser-known crops play a more important role when traditional food items are in short supply.

Flemingia vestita, in particular, has a dual role in the agro-ecosystem. Apart from the value of the tuber as a protein source, this legume considerably improves the nitrogen status of the soil through nodular fixation (Table 6.2). While in the developed countries nitrogen level in the soil is maintained through intense use of nitrogen fertilizers, attempts to transfer this technology to the humid tropics have been unsuccessful (Greenland 1977). Nitrogen is a highly mobile element in the soil of the humid tropics. Through our earlier studies on nitrogen budgeting under jhum, we have shown that the loss during one cropping season may be as much as 600kg ha^{-1} $year^{-1}$ (Mishra and Ramakrishnan 1984; Swamy & Ramakrishnan 1987b). Under shorter jhum cycles of 5 years, not more than half of what is lost is put back into the system (Table 6.3). Therefore, the role of nitrogen-fixing legume species such as *Flemingia vestita* offers possibilities of improving yield under sedentary agriculture, through appropriately managed crop rotation.

Table 6.1 Per capita annual consumption of lesser-known crops in relation to other food item of the Khasis of Meghalaya in north-eastern India (after Gangwar & Ramakrishnan 1989b).

Food items	Quantity (kg)	Energy (MJ)	Protein (kg)
Traditional crops	216.8	3187.2	17.3
Lesser-known crops	17.7	217.9	1.3
Animal products	15.7	325.9	12.5
Total	250.2	3731.0	31.1
Standard requirements		3665.3	20.1

Table 6.2 Nitrogen economy (kg ha^{-1} yr^{-1}) under *Flemingia vestit* cultivated in pure or mixed stands by the Khasis at higher elevations in north-eastern India (after Gangwar & Ramakrishnan 1989).

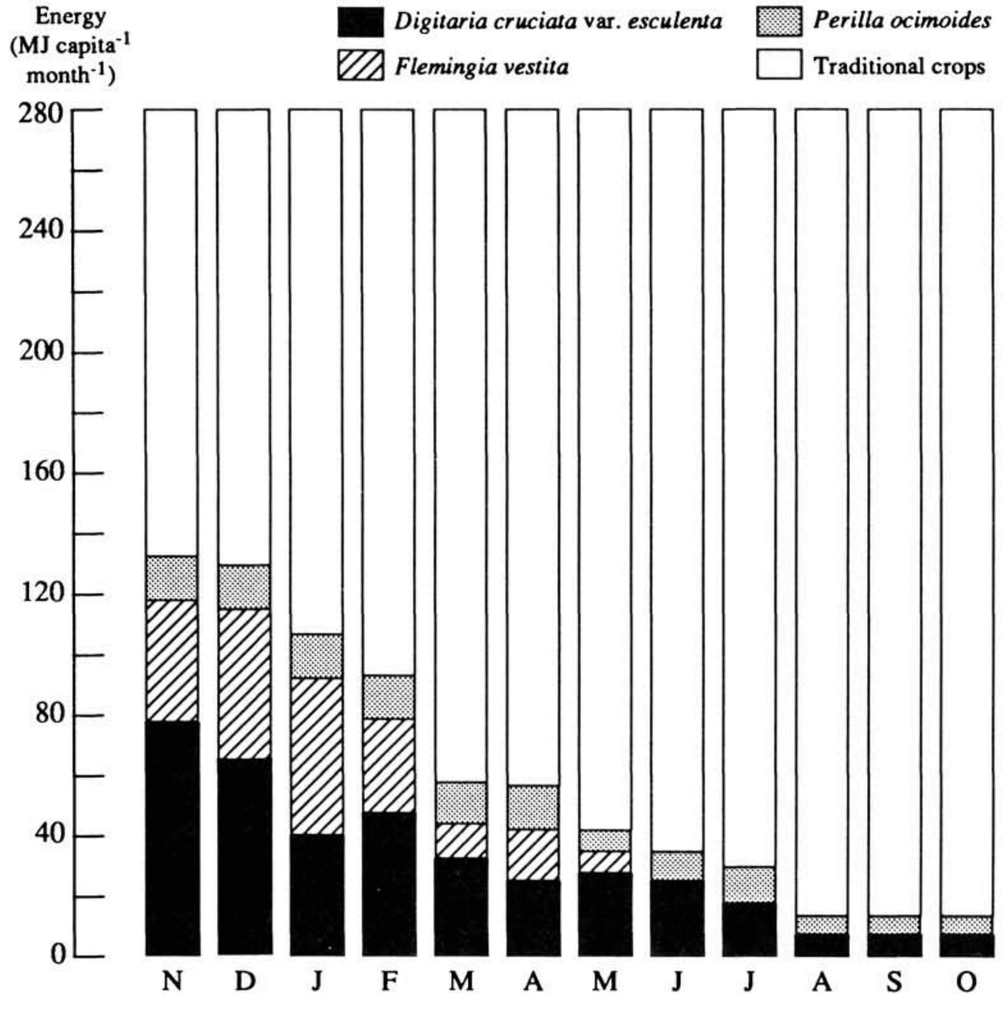
	Pure	Mixed with cabbage	
Accumulation in the crop biomass			
Shoot	19± 0.7	16± 0.6	(3± 0.1)[1]
Root	10± 0.5	10± 0.3	(2± 0.1)
Economic yield removed	31± 0.5	23± 1.0	(10± 0.1)
Crop biomass recycled	29± 1.7	26± 1.5	
Weed biomass recycled	9± 0.6	13± 0.9	
Nitrogen fixation	207± 7.2	154± 5.5	
Net gain in soil	245±18.3	193±15.6	

[1] *Values for cabbage are in parenthesis.*

Table 6.3 Net change of nitrogen (103kg ha^{-1} yr^{-1}) (after Mishra & Ramakrishnan 1984).

	Fallow cycle (yr)			
	15	10	5	
			I yr crop	II yr crop
Soil pool before burning	7.68	7.74	6.40	5.98
Soil pool at the end of cropping	7.04	7.15	5.98	5.60
Net difference	0.64	0.59	0.42	0.18

Figure 6.1 Consumption patterns of lesser-known and traditional crops by the Khasis of Meghalaya in north-eastern India (after Gangwar & Ramakrishnan 1989b).



6.2.2 *Shifting agriculture in north-eastern India – a case study*

Shifting agricultural farmers throughout the humid tropics cultivate a variety of traditional crops. The stability and sustainability of this and other traditional agro-ecosystems are based on crop diversity (Altierri 1983; Ramakrishnan 1984). The important consideration in their multiple cropping systems is related to optimal use of nutrient resources from the soil by appropriate changes in crop mixtures and/or through manipulation of their placement, depending upon soil fertility. Thus in north-eastern India, the shifting agriculture farmers often shift to tuber and perennial crops when soil fertility is low under a short agricultural cycle (Toky & Ramakrishnan 1981a).

Under shifting agriculture in north-eastern India, the cropping system involves a number of local varieties of traditional and non-traditional species. The number in the mixture may vary from 4 or 5 to over 35 (Ramakrishnan 1985). The species mixture consisting of pulses, cucurbits, vegetables, legumes, cereals, tuber and fruit crops, both annuals and perennials, are planted and often harvested sequentially. The crop mixture and the varieties used are location-specific, differing depending upon ecological conditions and socio-economic and socio-cultural factors of the people who are involved in the activities.

The shift in crop mixtures is often linked with soil fertility characteristics and related optimisation of production. Thus, in a recent study (Gangwar & Ramakrishnan 1987), 17 different cropping patterns were identified over a small area within 20km radius around Shillong. These cropping patterns gave economic returns ranging from about INR 15 000 to as high an over INR 35 000 ha^{-1} yr^{-1}.

In many areas on the humid tropics where shifting agriculture is the chief land use system, attempts have been made to develop alternate land use strategies. This has been necessitated because of drastic shortening of the shifting agricultural cycle from a reasonably long 10-20 years to a rather short 5 years or less. Among the different strategies suggested, sedentary terrace agriculture on hill slopes has been one of them. These sedentary systems are often energy intensive and ecologically inefficient. This apart, such alternatives are conceived more as intensive production systems, with emphasis on monoculture of a high yielding crop variety.

These are often rejected by the traditional farmers. The tendency of the farmers to hold on to traditional land use practices has to some extent contributed towards conservation of traditional varieties. Even sedentary agriculture, for example in valley land with wet cultivation of rice, traditional varieties are often not totally dispensed with. Thus rice farmers in Thailand combine traditional varieties of rice during the dry season optimising production and at the same time maintaining stability of the system (Grigg 1974). Some potato cultivation has a mixture of both native and modern bred varieties perhaps because of the risk and expense involved in sustaining production under the modern system.

The renewed interest of recent times in traditional agro-ecosystems has contributed towards their adaption to the modern age wherever possible. The concept of 'home garden', which is well developed in the humid tropics, offers possibilities of maximising the production per unit area through tight vertical packing of species, as is done by many tribes in north-eastern India (Maikhuri 1987). An extreme example of this is the te'lom plots of about 6 ha maintained by Huastec Indian farmers of north-eastern Mexico. With over 300 species in a te'lom plot, the Huastec system is not only an alternative to land management in the humid tropics but provides protection for wild genetic conservation and contributes towards a combination of commercial and subsistence agriculture (Alcorn 1984).

In north-eastern India, the shifting agriculture shown to be a system based on sound scientific principles (Ramakrishnan 1984), has been distorted due to rapid shortening of the jhum cycle. The overall conclusion is that the low production costs and high energy efficiency make the shifting agriculture system more viable than terrace cropping (Ramakrishnan 1984). Mixed cropping with sequential harvesting of crops (Table 6.4) is efficient in light capture for photosynthesis, meets the varied needs of the community and ensures self sufficiency of the village (Mishra & Ramakrishnan 1982; Ganwar & Ramakrishnan 1987). During the rainy season, it provides closed plant cover and checks rapid nutrient loses (Toky & Ramakrishnan 1981b) and enables weeds to be kept under control (Saxena & Ramakrishnan 1984). The entire shifting agriculture operations involves efficient recycling of resources for optimising yield through the use of crop and weed residue as organic manure (Swamy & Ramakrishnan 1988) and as feed in swine husbandry (Mishra & Ramakrishnan 1982).

However, the studies of Ramakrishnan and his co-workers (Ramakrishnan 1988; Mishra & Ramakrishnan 1981, 1984) has led to a number of practical guidelines for redeveloping shifting agriculture in north-eastern India under very short agricultural cycles. The ten guidelines noted below would also contribute to effective resource management and conservation in north-eastern India.

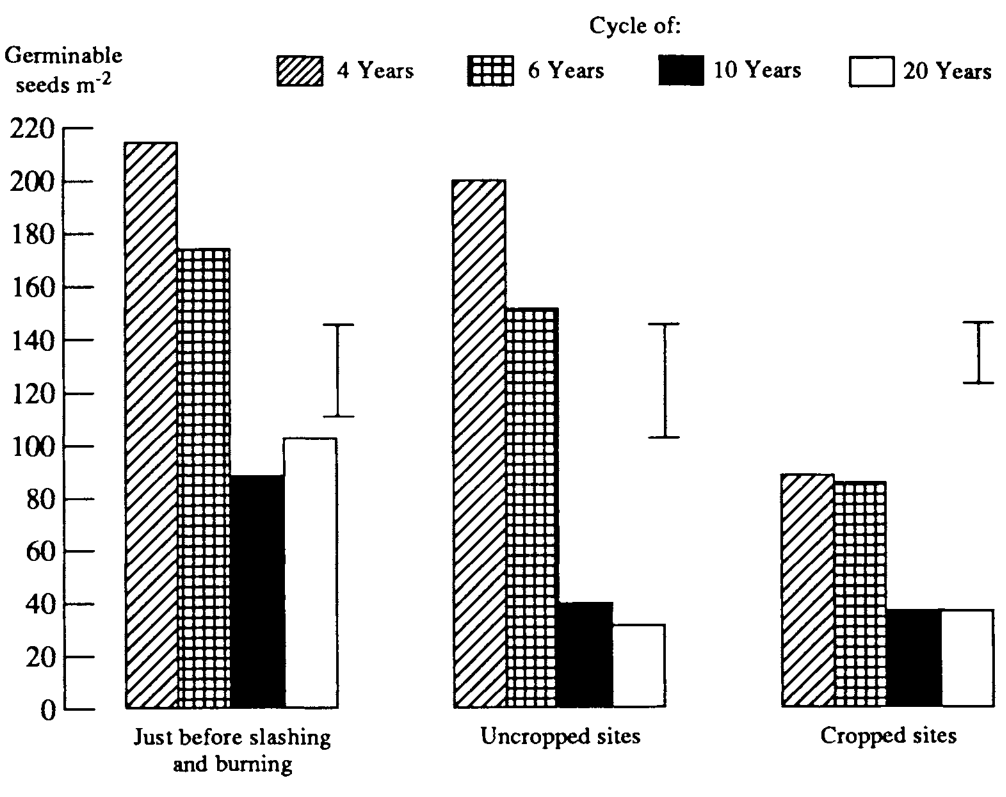
Table 6.4 Sequential harvesting of crops on jhum plots under 30 year cycle at lower elevation of Meghalaya (after Ramakrishnan *et al.* 1981a). All the seeds were sown in April.

Species	Harvesting time
Setaria italica	Mid-July
Zea mays	Mid July
Oryza sativa	Early September
Lagenaria species	Early September
Cucumis sativa	Early September
Zingiber officinalis	Early October
Sesamum indicum	Early October
Vigna mungo	Early October
Cucurbita species	Early November
Manihot esculenta	Early November
Colocasia esculenta	Early November
Hibiscus sabdariffa	Early December
Ricinus communis	(Perennial crop)

a) Condense the time span of vegetation succession and reconstitution, through manipulation of species mixture in time and space (Figure 6.2).
b) Accelerate fallow regeneration through introduction of fast growing native shrubs and trees.
c) Redesign agroforestry systems incorporating ecological insights on tree architecture (e.g. the canopy form of tree species should be compatible with crop species at the ground level, by permitting sufficient light penetration and through fast recycling of nutrients).

d) Vary species composition in the crop mixture at different altitudes (e.g. emphasis on potato at higher elevations compared to rice at lower elevations has resulted in a manifold increase in economic yield, in spite of low fertility of the more acidic soils at higher elevations.
e) Improve nitrogen economy through introducing nitrogen fixing legumes and non-legumes such as Nepalese alder (*Alnus nepalensis*).
f) Use bamboo and other fast growing trees as windbreaks, to check wind blown losses of ash and nutrient losses in water.
g) Incorporate cash crops such as black pepper and cardamom into the agroforestry system.
h) Introduce improved breeds of swine and poultry.
i) Introduce improved low level technology into the village units to relieve drudgery and increase energy efficiency (agricultural implements, cooking stoves, micro-hydroelectric projects, biogas systems).
j) Encourage artisan skills and products based on leather, bamboo and other woods and blacksmith work.

Figure 6.2 Germinable soil seed population of herbaceous species under different jhum cycles. Vertical lines represent least significant difference (P=0.01) (after Saxena & Ramakrishnan 1983).



6.3 Rainforest – a critical ecosystem

In recent times, ecologists, evolutionary biologists, and conservationists have focused increasing attention on tropical rain forests. Though they cover only about 7% of the earth's land area, they harbour more than half the species of the world's biota. With rapid conversion of these forests, they will mostly disappear by the turn of the century, resulting in extinction of a large number of species, many of them not even catalogued and understood by the tropical biologists. Besides, the tropical rainforests are among the most fragile of all habitats. Often conversion results in wet deserts (Ramakrishnan 1987; Ramakrishnan & Ram 1988) because of the highly leached infertile soil subjected to wash-out by heavy rains. Most of the soils under rainforests are red and yellow earths which are acidic and nutrient deficient. With high concentration of iron and aluminium, phosphorous availability is restricted because of the formation of insoluble compounds. Potassium is highly mobile (Table 6.5) and therefore is leached quickly (Toky & Ramakrishnan 1981b; Ram & Ramakrishnan 1988). With a weak soil base, a dense forest cover is supported because of a thick fine root mat located on the top of the mineral soil which helps in tight recycling of nutrients released by the quickly decomposing leaf litter, even before the element could seep into the mineral soil (Ramakrishnan 1984). This fine root biomass may be up to about 15 tonne ha^{-1} (Khiewtam 1986). Any large-scale disturbance in this system would make it unstable and make recovery difficult.

In north-eastern India, large scale disturbance to rainforest has resulted in varied levels of degradation, ranging from unproductive grasslands to arrested weedy communities, consisting largely of exotica (Swamy & Ramakrishnan 1987a; Ramakrishnan & Ram 1988). This has resulted in considerable erosion of species diversity.

The concept of succession offers the basis for a meaningful restoration programme for conserving biological diversity. Plant strategies starting with herbaceous weeds of early successional communities and that of bamboos, shrubs and trees of mid and late-successional environment offer the basis for designing strategies for restoration. The dry matter allocation strategy studies on herbaceous weeds (Saxena & Ramakrishnan 1983, 1984) suggest that organisms in more open habitats are selected for greater reproductive capacity (r-strategists), while those in closed habitats are selected for greater ability to compete for resources, though at the cost of lower reproductive potential (K-strategists). Thus species such as *Eupatorium odoratum* which is a r-strategist, is not able to survive in a more competitive environment of a 6-yr old fallow regenerated after shifting agriculture (Saxena & Ramakrishnan 1984). Further, some arterial species such as *E. odoratum* emphasises sexual reproduction and others such as *Imperata cylindrica* reproduce largely through rhizomes. In early successional stages following shifting agriculture in the hill tops of north-eastern India the soil is highly heterogeneous. Availability of nitrogen is uncertain, since that is a highly mobile element. The micro-distribution of C_3 and C_4 plants in early herbaceous communities is designed to exploit nutrients from such a heterogeneous soil. The C_4 species with a high nutrient use efficiency occur in nutrient

Table 6.5 Nutrient losses (kg ha^{-1} yr^{-1}) through run-off and percolation water under 10 yr jhum cycle agro-ecosystem and a 5 yr fallow (after Toky & Ramakrishnan 1981; Mishra & Ramakrishnan 1983).

	10 year cycle jhum plot		5 year fallow	
	Run-off	Percolation	Run-off	Percolation
Low elevation jhum				
Nitrate nitrogen	4.2	10.7	0.8	1.1
Available phosphate	1.3	0.1	0.1	0.02
Potassium	91.2	21.2	0.9	0.5
High elevation jhum				
Nitrate nitrogen	1.7	0.5	1.0	0.9
Available phosphate	0.9	0.1	ND	ND
Potassium	80.1	25.8	19.6	ND

ND – Not detectable

rich micro-sites (Saxena & Ramakrishnan 1984). These and other attributes of early successional communities could form the basis for early restoration of desertified landscapes as in north-eastern India. Population dynamics and growth strategies of bamboos (Rao & Ramakrishnan 1987, 1988) could form the basis for management of bamboo forests that come up subsequently.

Realising that light availability in the environment would change during forest succession and that light to a large extent determines the architecture of a tree and consequently allows appropriate leaf display for optimal photosynthesis (Ramakrishnan 1987) under varied light regimes, early successional trees were compared and contrasted with late successional trees. Early successional tree species are characterised by rapid extension growth, more allocation of biomass to the shoot system than to the root system, greater allocation of biomass to the first order branches than to other higher order branches, excurrent (narrow) crown form, larger leaf population and faster leaf turnover rates. This contrasts with the late successional species (Ramakrishnan 1986).

The differential features of early versus late successional tree species could be utilised for restoration of human-impacted ecosystems through mixed plantation programmes. Species characterised for social forestry and agroforestry systems could form the basis for rural development, which in turn would take the human pressure off the land.

Social forestry programmes in a developing country should aim at identification of fast growing, multi-purpose native species for meeting the fodder, fuelwood and timber needs of the rural population. Use of early successional species for social forestry is appropriate because they have a fast growth rate and relatively faster accumulation of biomass. The leaf population of early successionals having a shorter life-span would help in faster turnover of nutrients between the plant and the soil, ensuring their success in nutrient deficient wastelands, so that more fertile land is available for agricultural and other land uses.

With greater realisation that agriculture and forestry could form compatible systems on the same site, identification of trees that could optimise production in a viable agroforestry system is important. The early succession trees have a crown architecture that permits maximum light penetration to the ground layer so that the growth and productivity of crop species would not be limited by light. Besides, a fast turnover of nutrients would ensure a constant and steady supply of nutrients in the surface layers of the soil to be used by crop species. If the root architecture of the tree species used is such that the roots are more uniformly distributed at different depths, rather than being chiefly restricted to surface soil layers, it would make the species mixture in the agroforestry system more compatible. Though early succession trees have superficially placed root systems, some of the mid-successional trees are better suited in this respect. Identification of suitable root architecture from the successional continuum should not be difficult.

Mixed plantation programmes, having distinct ecological advantages over monoculture forestry, could also be economically as productive or even better than the latter, if compatible species are used. Fast growing, light demanding, early successional species could form compatible mixtures with shade tolerant mid or late successional species for exploiting light availability at different canopy levels and thus optimise production per unit area. Such a mixture would also allow optimum use of nutrients from the soil profile, the early successional species exploiting deeper soil layers. It should even be possible to have a "condensed succession" for revegetation of damaged sites by appropriate mixture of different categories of trees that are mutually compatible (Figure 6.3). The applications of tree architecture and growth strategy analysis for forestry management are immense. More work in this emerging area would indeed be rewarding to resolve basic issues and concepts and for designing better forest management strategies and ultimately for better conservation.

6.4 The human factor and the biosphere concept

When the Man and Biosphere (MAB) programme was launched in 1971 by UNESCO, it was also decided to have biosphere reserves as representative ecological areas, as part of an international network. The chief objective was to demonstrate the value of conservation and its relationship both with eco-development and with local participation. The last two components are perhaps the most important, as this would set apart the concept of biosphere reserve from all other conservation strategies.

At the outset, it would be realised that biosphere reserve management, because it demands peoples' participation, cannot be governed by a standardised set of strategies. With differing ecological conditions one may consider only a few generalities related to management; the specifics have to be tailored to the needs of a given situation. The management strategies have to be focused around the human population both within and outside the reserve, taking into account the socio-economic and socio-cultural background of the people concerned, as has been shown for the tribes of north-eastern India (Ramakrishnan 1983). If developmental strategies are based on a value system that the people concerned cherish and with which they can identify, then their participation in development and conservation of resources would be ensured

(Ramakrishnan 1987).

It is well recognised that for the management of a biosphere reserve, two distinct zones, the core zone and buffer zone, have to be considered separately. The basis for such a differential approach is based on the fact that each of these two zones are managed with divergent objectives in view.

In a developing country like India, one needs to consider another zone, outside the buffer zone, that I prefer to call an "interaction zone". This zone would be a zone of gradual transition into the typical rural environment. With a high population pressure, the core zone itself could be subject to human pressure. The buffer zone and the interaction zone would indeed be under intense biotic stresses. In these two zones, eco-development should be aimed at adequately meeting the food, fodder and fuelwood needs of the people. It should then be possible to diversify the economic activities in a phased manner.

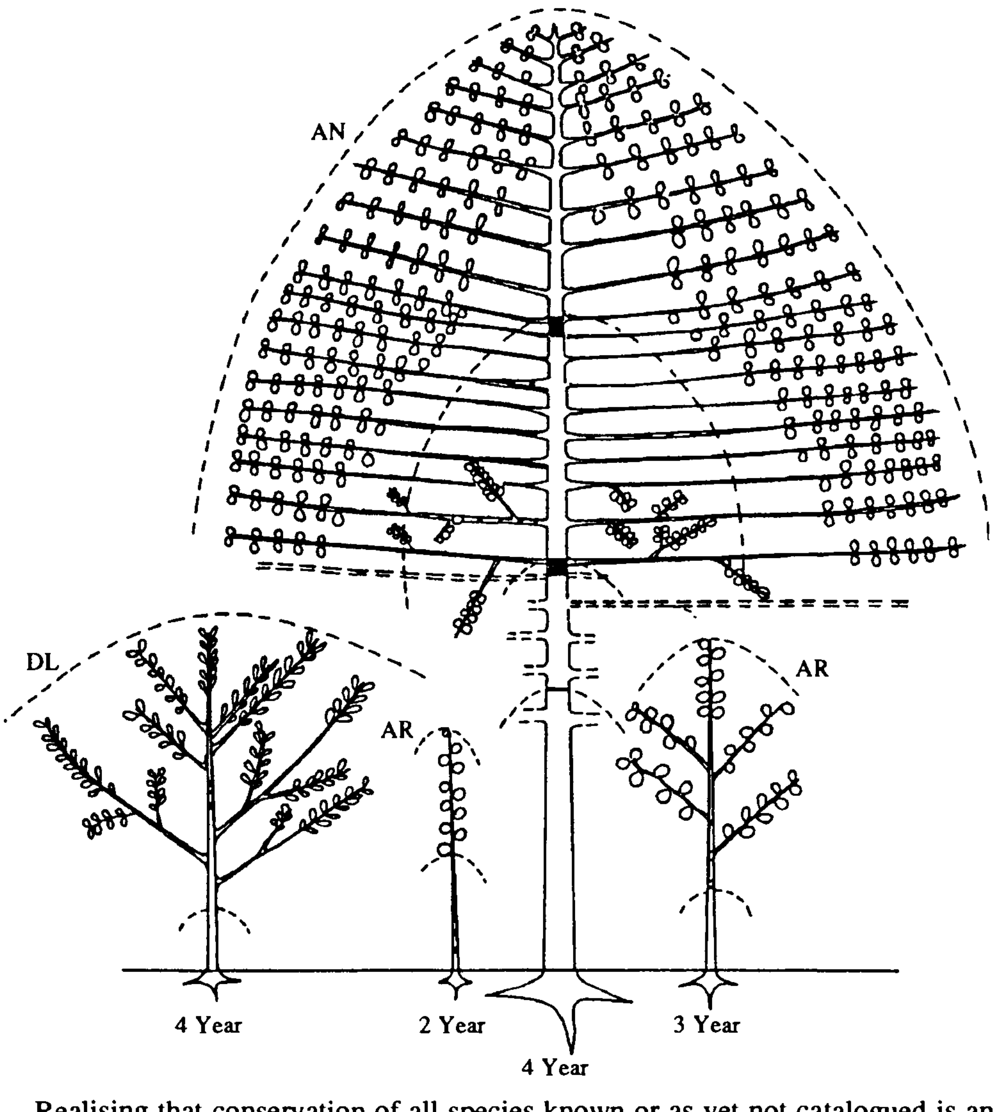
Introduction of technology of a high level but of low magnitude such as small-scale processing units for primary produce of various kinds, solar energy, wind power, energy efficient stoves, etc., are some of the possibilities. Peoples' participation in these activities is important. This is possible only through building on the traditional knowledge and wisdom of the people. Developmental strategies should include health and hygiene of the population and educational facilities through vocation-oriented programmes. What is required is a holistic approach to the development of the rural ecosystem. This alone would lead to effective *in situ* conservation.

6.5 Conclusion

The concept of biological conservation is closely linked to sustainable development. The launching of the World Conservation Strategy in 1980 was a significant turning point involving an integration of nature conservation with sustainable development of both human and natural resources. This implies that ecological integrity is to be maintained not only to meet human needs but also to achieve equity with social justice and provision for maintenance of cultural diversity (Jacobs *et al.* 1986). Local peoples' participation in conservation is crucial and this could only be achieved by ensuring access to the natural resources developed on a sustainable basis.

Sustaining cultural diversity is an important mechanism to promote conservation. The case study of north-eastern India, inhabited by a large number of tribal societies, is an example to illustrate this point. Shifting agriculture, which is the chief land use system, differs significantly depending upon social and cultural difference of the people. Consequently, the variety of non-conventional crop plants conserved by them is remarkable indeed (Gangwar & Ramakrishnan 1989a). Religion and culture form important factors for promoting conservation in traditional societies. Many tribes of north-eastern India maintain sacred groves protected for cultural reasons. They believe that the spirits of their ancestors and their Gods live in these forests (Boojh & Ramakrishnan 1983; Khiewtam 1986). The fact that these sacred groves once formed part of each village is suggestive of the value attached to conservation by traditional societies. With the advent of modernity, it is unfortunate that these values have been rapidly eroded. There is a need for a revival of these traditions.

Figure 6.3 Model of mixed tree plantation involving early successional *Anthocephalus cadamba* (AN) and late successional *Dillenia pentagyna* (DL) and *Artocarpus chaplasha* (AR) (after Ramakrishnan 1986).



Realising that conservation of all species known or as yet not catalogued is an impossible task, priorities have to be determined. The criticality from a conservation point of view may be defined both in terms of ecosystem fragility and biological diversity. In such a definition, diversity sustained through human activities, such as agriculture, is also significant. The concept of the biosphere reserve where the local human population is integrated with conservation strategies through their sustainable development, offers a unique approach for biological conservation.

What is to be conserved would also depend upon the variety of ways in which the species could be used by the society. Thus a species such as *Flemingia vestita*, cultivated by tribes in north-eastern India (Gangwar & Ramakrishnan 1989b), is not only a lesser-known plant of food value for the use of the village community during the lean season when traditional food items are in short supply, but is also an important component of the shifting agriculture and the fallow systems of agriculture, for building up the nitrogen status of the soil. The germplasm of such multipurpose species needs to be conserved, as they serve a variety of purposes.

Fragility of an ecosystem should be an important criterion for conservation. We have seen how in a tropical rainforest extreme deficiency in soil nutrients leads to the development of an extensive surface root mat system leading to tight cycling of nutrients and therefore contributes to its fragility (Ramakrishnan 1984b). This fragility may lead to total site desertification (Ramakrishnan & Ram 1988) or may lead to biological invasion by exotic weeds (Ramakrishnan & Vitousek 1988). In the western Himalayas, climax oak forests are often irretrievable, or retrievable only at a great cost, from seral pine forests, because of a drastic alteration in site characteristics by the latter (Singh *et al.* 1984). These and many other causative factors contribute towards ecosystem fragility. Obviously, such ecosystem types should receive priority for conservation.

An agro-ecologist's viewpoint is not necessarily confined to agricultural systems alone. Agriculture as a land use system is closely linked with forestry and other land use practices. Therefore, a holistic approach towards a conservation strategy has a distinct advantage over *ex situ* management, in that it not only ensures conservation at the specific level but also enables conservation of natural populations at the subspecific level (Ramakrishnan 1981). This is particularly important because ecotype populations often would be as different amongst themselves as two distinct species of contrasting ecological characteristics. The ultimate objective should be to integrate *ex situ* conservation strategies with the existing or altered life styles of the human population.

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PART II

APPENDIX A

A. KEY SPECIES OF GRENADA

By GUIDO MARCELLE AND JAMES DE VERE PITT

A.1 Grenada's Vital Statistics

Grenada, located at the southern end of the Lesser Antillean Island chain (approximately 90 miles north of Trinidad), is the largest of the three main islands which make up the nation of Grenada; the other two being Carriacou and Petit Martinique in the Grenada Grenadines. There are also a number of small islands, islets and rocks which lie offshore from the main islands.

Location

Latitude:	11 degrees 58 minutes/12 degrees 13 minutes North
Longitude:	61 degrees 20 minutes/61 degrees 35 minutes West

Area

Grenada:	21 miles long, 12 miles wide; 120sq miles or 78 000 acres (312km^2 or 3 400ha)
Carriacou:	(15 miles N of Grenada) 13sq miles or 8 500 acres (34km^2 or 3 400ha)
Petit Martinique:	(2.4 miles E of Carriacou) 0.9 sq miles or 575 acres (2.3km^2 or 230 ha)

Total land area

133sq miles or 86 500 acres (346km^2 or 34 600ha)

Population

100 000, largely concentrated in the southwestern part of the main island near the capital of St George's. Largest villages: Grenville, Gouyave, Sauteurs, Victoria and Hillsborough (Carriacou).

Economic activities

Grenada:	Agriculture, tourism, small manufacturing sector
Satellite islands:	Inter-island trade, fishing, livestock raising, subsistence agriculture, boat building

Identification of Key Species for Conservation and Socio-Economic Development
Edited by P. Kapoor-Vijay and M.B. Usher.

Primary crops

Cocoa, nutmeg, banana

Secondary crops

Coconut, sugar cane, citrus

Physical features

Grenada:	Apart from limestone in the north, the island is volcanic. It is mountainous and thickly wooded, with numerous streams and rivers. The central mountain mass consists of a number of ridges, some of which contain crater basins. Mount St Catherine (2 749ft/ 840m) is the highest peak. There are several beaches.
Carriacou/ Petit Martinique:	Both islands are volcanic mountain peaks with shallow and highly eroded soils.

A.2 Introduction

The island of Grenada, located 12 degrees north and 61.5 degrees west, is one of the Caribbean chain of islands. Being a tropical island, it has a resplendent verdant cover of many plant species. A complete inventory has not been made of all the plant species, but a number of publications have dealt with different aspects of local plant flora (Beard 1949; Howard 1974, 1977, 1979 and Groome 1970).

The state of Grenada includes two other islands, Carriacou and Petit Martinique.

Grenada, being an agricultural society, depends heavily on some major crops. The authors, having listed these for their economic importance, will venture to select other species which, because of their biological importance and other significance, may be listed as key plant species.

Even for a small island state like Grenada, the key plant species, (economically, culturally and ecologically important species), must be listed, known and conserved.

It may well be that for the agriculturally important crop species, the need for their conservation is more readily significant so that they may survive. However, for other species, where their biological significance does not immediately manifest itself, conscious efforts or systems will have to be enforced to guarantee their survival 4.

Conservation of key species of life support species is key in the conservation and survival of many other species. It must be noted also that all key species are primary producers, utilising energy from the sun for initial entrapment of energy to start the food chain.

The primary crops may be listed as nutmeg, cocoa and banana and the secondary crops as coconut, sugar cane and citrus.

Invariably, all varieties of these crops are key genetic resources for Grenada.

A.3 List of key ecological and economic species for Grenada

Plant Species (Common name in parentheses)	ECOLOGICAL FUNCTIONS					SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
	Primary Production	Nutrient Accumulation	Organic Matter Production	Habitat Structuring	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
TREES										
Acacia farnesiana (Briars)	X	X		X	X	X		X	X	Coloniser Stabiliser of mud flats and N-fixing
Acacia macracantha (Briars)	X	X		X	X	X		X	X	As above
Acacia species (Briars)	X	X		X	X	X		X	X	As above
Artocarpus altilis (Breadfruit)	X					X	X	X		Important food source
Bursera simaruba (Lowland gommier, Naked Indian)	X		X	X	X	X			X	Important soil stabiliser, provider of organic matter and habitat structuring
Cecropia peltata (Bois canot)	X		X		X	X		X		Coloniser and provider of organic matter
Ceiba pentandra (Silk cotton)	X		X	X				X	X	Stabiliser of hill slopes and provider of organic matter
Citharexylum fruticosum (Cutlette)	X		X	X	X			X	X	Coloniser and soil stabiliser
Citrus species (Citrus)	X					X	X			Important genetic resource
Cola acuminata (Kola nut)	X					X		X		Culturally valued species
Cordia alliodora (Cyp, cype)	X			X	X	X		X	X	Important soil stabiliser and wildlife food
Cordia collococca (Clammy cherry)	X			X	X				X	Important coloniser of muddy swamps

Plant Species (Common name in parentheses)	ECOLOGICAL FUNCTIONS					SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
	Primary Production	Nutrient Accumulation	Organic Matter Production	Habitat Structuring	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
TREES continued										
Crescentia cujete (Calabash)	X					X		X		Highly culturally valued species
Dacryodes excelsa (Mountain gommier)	X			X	X	X	X		X	Dominant tree species in moist forest
Erythrina corallodendrum (Immortelle)	X	X	X	X		X		X	X	Fast growing soil stabiliser, provider of organic matter, water and N-fixing
E. glauca (Immortelle)	X	X	X	X		X		X	X	As above
E. micropteryx (Immortelle)	X	X	X	X		X		X	X	As above
Erythrina species (Immortelle)	X	X	X	X		X		X	X	As above
Gliricidia sepium (Glorisita gloriseda)	X	X	X	X	X	X	X	X	X	Fast growing multipurpose species
Haematoxylum campechianum (Campeche)	X	X		X	X	X			X	Coloniser, soil stabiliser and N-fixing
Hibiscus elatus (Blue mahoe)	X			X		X		X	X	Soil stabiliser, high value timber and watershed maintenance
Leucaena leucocephala (Wild tambran, leucaena)	X	X		X	X	X	X		X	Very fast growing, source of fodder, coloniser, soil stabiliser and N-fixing
Licania ternatensis (Bois gris)	X			X	X	X			X	Valuable forest tree, a dominant species

Plant Species (Common name in parentheses)	ECOLOGICAL FUNCTIONS					SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
	Primary Production	Nutrient Accumulation	Organic Matter Production	Habitat Structuring	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
TREES continued										
Mangifera indica (Mango)	X					X	X	X		Important genetic resource and fruit
Melicoccus bijugus (Skin up, genip)	X		X			X		X		Important for honey bees and organic matter production
Micropholis chrysophylloides (Bois)	X					X				Dominant forest tree in montane thicket watershed areas
Pachira insignis (Wild breadnut, Chataigne marron, marron)	X						X	X		Insect control in cocoa
Pithecellobium unguiscati (Briar)	X	X		X	X	X			X	Coloniser, soil stabiliser and N-fixing
Spondias mombin (Hog plum)	X		X	X		X		X	X	Soil stabiliser and provider of organic matter
Swietenia macrophylla (Mahogany)	X		X	X		X		X	X	Most valued timber tree and good soil stabiliser and organic matter producer
S. mahogani	X		X	X		X		X	X	As above
Tabebuina pentaphyla (White cedar, pink poui)	X		X	X	X	X	X		X	Important lowhill forest species, soil stabiliser, organic matter provider, and timber for boat building
Tamarindus indica (Tambran, tamarind)	X	X	X	X		X			X	Important soil stabiliser and fruit

Plant Species (Common name in parentheses)	ECOLOGICAL FUNCTIONS					SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
	Primary Production	Nutrient Accumulation	Organic Matter Production	Habitat Structuring	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
SHRUBS										
Cajanus cajan (Pigeon peas)	X	X				X	X	X		Important protein food source and valuable genetic resource
Clerodendrum aculeatum (Bitter fence)	X								X	Underutilised in environmental management
Cordia curassavica (Black sage)	X			X	X			X	X	Coloniser and vigorous stabiliser of dry lands
Croton species (Bois buc)	X			X	X	X		X	X	As above
Hibiscus sabdariffa (Sorrel)	X					X	X			Important commodity and genetic resource
Leucaena leucocephala (Wild tambran, leuceana)	X	X		X	X	X	X		X	Very fast growing, source of fodder, coloniser, soil stabiliser and N-fixing
Moghania strobilifera (Moghania)	X	X		X	X				X	Important coloniser and soil stabiliser, N-fixing
Pandanus species (Wild pine, screw pine)	X			X	X	X	X	X	X	Provides important source of income for women. Soil stabiliser
Piper species (Shining bush, Malestomache, candle bush)	X			X	X					Important animal fodder (goats and rabbits)

Plant Species (Common name in parentheses)	ECOLOGICAL FUNCTIONS					SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
	Primary Production	Nutrient Accumulation	Organic Matter Production	Habitat Structuring	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
HERBS										
Abrus precatorius (Jumbie bead, Gwen le glase)	X	X				X		X		Important in folklore and traditional medicine
Aloe vera (Aloes)	X					X		X		Very important in traditional medicine
Amaranthus dubius (Bhagee, Bhaji, Zephena)	X				X	X				An underutilised food
Antigonon leptopus (Coralita)	X		X		X	X				Important coloniser and nectar producing species
Bidens pilosa (Spanish needle)	X				X					Early coloniser on agricultural lands
Commelina elegans (Water grass)	X				X		X			Coloniser and important herbivore feed
Desmodium species (Sweetheart, Coeur de velot)	X	X			X			X		Early coloniser and nutrient accumulation on cultivated land
Dioscorea species (Bush yam)	X									Important food source in times of crisis
Heliconia species (Balizier)	X			X	X	X	X	X	X	Important coloniser, soil stabiliser and genetic resource
Merremia species (Rabbit vine, goat vine)	X				X		X			Important coloniser and herbivore feed
Mimosa pudica (Sensitive plant, maria hunt)	X	X			X			X		Important coloniser of agricultural lands and in nutrient accumulation

Plant Species (Common name in parentheses)	ECOLOGICAL FUNCTIONS					SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
	Primary Production	Nutrient Accumulation	Organic Matter Production	Habitat Structuring	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
HERBS continued										
Momordica charantia (Coolie pawpaw, corillie)	X				X			X		Important medicinal herb and coloniser
Xanthosoma sagittifolium (Tania)	X					X	X			Source of food
PALMS										
Euterpe dominicana syn. *E. hagleyi* (Cabbage palm, mountain cabbage, Hagley's palm)	X			X					X	Coloniser in moist forest areas
GRASSES										
Cymbopogon citratus (Lemongrass)	X			X		X		X	X	Soil stabiliser, valuable herbal tea commodity
Cynodon dactylon (Devil grass, fine grass)	X			X					X	Coloniser, soil stabiliser and fodder for herbivores
Eleusine indica (Pye poule)	X			X					X	As above
Gynerium sagittatum (Roseau)	X			X	X	X	X		X	Soil stabiliser and house decorating commodity
Paspalum species	X				X				X	Coloniser, soil stabiliser and fodder for herbivores
Vetiveria zizanioides (Khus-Khus, sweet root)	X			X		X		X	X	Soil stabiliser, essential for environmental management in agricultural lands, a valuable craft commodity
Zea mays (Corn)	X					X	X	X		Important food and genetic resource

Plant Species (Common name in parentheses)	ECOLOGICAL FUNCTIONS					SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
	Primary Production	Nutrient Accumulation	Organic Matter Production	Habitat Structuring	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
BAMBOO										
Bambusa vulgaris (Bamboo)	X			X		X		X	X	Important in soil stabilisation, construction and craft
SEDGES										
Cyperus rotundus (Welcome grass, Nut grass)	X			X				X		Important early coloniser of agricultural lands
Cyperus surinamensis	X				X				X	Early coloniser
Mariscus fuligineus	X			X	X				X	Stabilises soil
Mariscus meyenianus	X			X	X				X	As above
FERNS										
Cyathea species (Tree fern)	X			X	X					Important in soil stabilising and habitat structuring
Dicranopteris pectinata (Grand Etang fern)	X		X	X	X				X	Important soil stabiliser in disturbed hillslopes
MOSSES	X									Important in soil formation, soil stabilisation and water retention
FUNGI		X								Important decomposers

Plant Species (Common name in parentheses)	ECOLOGICAL FUNCTIONS					SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
	Primary Production	Nutrient Accumulation	Organic Matter Production	Habitat Structuring	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
COASTAL SPECIES										
MANGROVES										
Avicennia nitida (Black mangrove)	X	X	X	X	X	X		X	X	Important in coastal protection, island fringing
Conocarpus erectus (Button mangrove)	X	X	X	X	X	X		X	X	Fisheries and wildlife habitat
Laguncularia racemosa (White mangrove)	X	X	X	X	X	X		X	X	Fisheries and wildlife habitat
Rhizophora mangle (Red mangrove)	X	X	X	X	X	X		X	X	As above
TREES										
Chrysobalanus icaco (Fat pork)	X			X		X			X	Important stabiliser of sandy soils on coastal fronts
Coccoloba uvifera (Sea-side grape)	X			X		X			X	As above
Hippomane mancinella (Manchineel)	X		X	X					X	As above
Terminalia catappa (Sea-side almond)	X		X	X		X			X	As above
Thespesia populnea (Sea-side mahoe)	X		X						X	As above

Plant Species (Common name in parentheses)	ECOLOGICAL FUNCTIONS					SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
	Primary Production	Nutrient Accumulation	Organic Matter Production	Habitat Structuring	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
HERBS										
Ipomoea pes-caprae (Sea-side potato, creeping vine)	X			X	X				X	Important coloniser and stabiliser of sandy soils on coastal fronts
GRASSES										
Sporobolus species (Crab grass)	X			X	X				X	Important coloniser and stabiliser of sandy soils on coastal fronts
ALGAE (Marine)										
Gracillaria crassissima (Sea moss)	X					X		X		Widely used as food, potential source of agar
Gracillaria debilis (Sea moss)	X					X		X		As above
Gracillaria domingensis (Sea moss)	X					X		X		As above
Gracillaria species (Sea moss)	X					X		X		As above

A.4 Brief Species Details

Trees

Acacia species (plus others)

Briars

In some lowland areas of Grenada, especially the southern, south-eastern, east and north-eastern, on flat lands that tend to be flooded in the rainy season and parched in the dry season, a number of prickly-stemmed, fine-leaved leguminous shrubs and trees abound. Also found bordering mangrove swamps in Carriacou. These are collectively called briars or briar pickers. About seven regular species appear to make up these patches. There are five acacias, three unidentified and the other two being *Acacia farnesiana* and *A. macracantha*. The other two species are *Pithecellobium unguiscati* and logwood or campeche, *Haematoxylum campechianum*.

These species are particularly adapted for this habitat which they help to structure. They possess hard, woody stems, very pliant branches bearing numerous fine leaves broken up in many leaflets, an aid to low transpiration, especially in the dry season. The stems and branches are prickly and thus are usually avoided by herbivorous predators. The roots are deep, extensive and tolerant of brackish water.

In dry season, along with mangrove and other coastline species, the briars represent the only patches of significant greenery in the dry lowland areas. These significant species colonise and help to reclaim swamp lands. Being leguminous, they bind nitrogen in the soil. Bees are attracted to the flowers for nectar and pollen. The briars are the nesting grounds for many species of birds.

Their hard-wooded nature makes them very attractive for coal burning and thus these species are under pressure from human exploitation.

However, these species must not be overlooked since they are key in habitat formation in the dry areas, key for effecting nutrient movements and key for certain wildlife.

These species also spread into the low hills but there they are widely mixed with a number of different trees. They prevent erosion.

Artocarpus altilis (plus others)

Some crucial food crops and fruits

Locally, there are certain plant species that are crucial as foods or nutrients in a normal Grenadian diet. In the case of a crisis in imported food supplies, these may become key survival species. In any event, it should not be necessary to wait for a crisis to appreciate the importance of these species. The species mentioned here occur in many varieties and it is this genetic diversity that qualifies them as genetic resources.

Species in this list are:

Tannia (*Xanthosoma sagittifolium*, an edible aroid; bush yams (*Dioscorea* species)): a large variety of underground tubers found growing on hills and mountain sides. Apart from improving yam yields and disease resistance in the yam varieties, there may be potential for new products, eg steroids.

Breadfruit (*Artocarpus altilis*): a starch food with the potential for many different agro-products. This species is underutilised.

Pigeon peas (*Cajanus cajan*): a high protein legume. The major legume utilised locally. The many varieties constitute an important genetic resource.

Corn (*Zea mays*): its importance as a locally grown staple is declining even in Carriacou where it was the major staple. It is the major grain that can be grown here so all genetic varieties should be preserved.

Sorrel (*Hibiscus sabdariffa*): The mature calyces are used to prepare a popular local drink. The diverse varieties that grow locally should be conserved.

Bursera simaruba

Lowland gommier, Naked Indian

In the low hills of the drier regions, one of the dominant tree species is the smooth, reddish bark tree, *Bursera simaruba*. These trees, though dominant on the hillside, are never seen to form close clusters. Instead, they occur almost regularly distanced from each other with mixed species in between. They are very deep rooted and deciduous, losing all their leaves in the dry season and thus are providers of organic matter of the forest floor. In structuring this low hill habitat, the gommier functions in soil conservation by lessening erosion. The green leaves are used as goat feed. Particularly in the Mount Hartman area, this species helps to structure the habitat where one of Grenada's declining endemic species, the Grenada Dove, (*Leptotilia wellsi*) is found. The prolific clusters of flowers are visited by honey bees for pollen and nectar.

Cecropia peltata

Bois Canot

The species *Cecropia peltata* occurs in a wide range of habitats, from dry forests to wet mountain sides. It is a prolific coloniser, and an early species to arrive on cleared grounds. This soft-stemmed, deciduous species, sheds its leaves regularly. The leaves are said to be rich in potash and local farmers have incorporated these with white lime in treating acid soils. The hollow, soft wood is used as floats by fishermen. The tea from the dried leaves is a popular local remedy for hypertension.

It is said locally that bad weather is heralded by the green leaves turning over, thus exposing their lower silvery surface.

Ceiba pentandra

Silk cotton

The gigantic, thorn-stemmed *Ceiba pentandra* is a deciduous tree which grows on steep slopes. In these locations, the large and extensive buttress roots as well as the extensive underground root system function to prevent erosion and major slides of the steep slopes. The seeds are readily dispersed by wind and in the dry months the tree sheds all its leaves providing good ground cover with organic matter. The flowers are visited by honey bees.

Culturally, it features in local folklore as the tree the devil visits at midnight.

Citharexylum fruticosum

Cutlette

Citharexylum fruticosum is a popular interspersing tree species in the low hills and dry land forest. It is an early coloniser, being dispersed by birds. It functions in soil stabilisation. The shed leaves provide organic matter and the herbal tea from the leaves is used as an expectorant for colds. Further, the flowers are popularly visited by honey bees.

Citrus species

Citrus

The species of concern here are not the regular and common citrus species, but varieties like sour orange or gospo. There may be valuable local genetic resource for resistance to pests, etc. here. These species form stocks to which scions of other desirable citrus species are grafted. Such stock are very resistant to fungal attack.

Cola acuminata

Jumbie bead and Kola nut

The red and black seeds, jumbie beads, of the legume *Abrus precatorius* and the brown seeds of the kola nut, *Cola acuminata* are used in the folkloric rituals of Shango. Both species therefore continue to be culturally significant.

Further, both species are used in herbal preparation for folk medicine. The leaves of *A. precatorius* are drunk as a herbal tea for colds, whereas the ground seeds of *C. acuminata* are boiled and the herbal extract used a tonic.

Cordia alliodora

Cyp, cype

At its climax *Cordia alliodora* is a medium height, soft-wooded tree, with layers of horizontal branches separated by a straight stem. It establishes itself quite readily in the drier end of swampy coastland close to mangroves, and extends in distribution up to the dry forest. Its extensive root system is known to lead to accumulation of moisture as well as helping to loosen the soil. Some trees of this species are usually left growing on agricultural lands.

The red, sweet, ripe berries produced are the popular food of the national bird, the ramier. The affinity of these birds to this food make them easy prey for human hunters who stalk the birds in the vicinity of the cyp trees. Birds also afford ready disposal of fruit seeds. The young shoots are fed on by goats. As a commodity, the timber is used in furniture manufacture and the peculiar trimeric branching system of young shoots make it a popular choice for swizzle stick manufacture. No attempts have been made to utilise this species in any structured environmental management system.

Cordia collococca

Clammy cherry

In some swampy areas, especially around Levera Lake in the northeast, the species *Cordia collococca* abound as small patches of short tree forest. Though this species occurs in other habitats, it flourishes in the brackish swampy areas, where it actually leads to habitat structuring and swamp reclamation. These forest patches are homes for many species of birds, and the ripe fruits are fed on by wildlife. This is an important species bordering the seashore mangrove species.

Crescentia cujete

Calabash

Short, sturdy trees of *C. cujete* are found growing isolated in small patches all over the islands, except in the upper mountain area. This species is key for its cultural value. The slender growing branches are very pliant and strong and are used as fishing rods.

The roundish or oblong hard exterior fruit finds many uses. They are used as vessels for carrying, storing and dipping water; also as utensils for eating or drinking, storing and carrying planting seeds, for lanterns, crafts and as musical instruments. Culturally, in our folklore, the calabash is key to the Shango ritual. It holds the food for the spirits, water for sprinklings and is fashioned into shaking musical instruments. The calabash fruit is also used in making many craft items. It is very important therefore, that the numerous varieties of this species be conserved since mode of utilisation depends on the size and shape of the fruit.

Dacryodes excelsa

Mountain gommier

The mountain gommier *Dacryodes excelsa* is the principal dominant tree in the lowland tropical evergreen moist forest and other mountain forest in Grenada. It is estimated to comprise 40% of the trees present. It is therefore one of the key mountain species for maintaining forest cover and a water enhanced watershed.

Historically, it was the tree used for making dugout canoes by the Amerindians. The gum exudate was used for kindling fires and also burned as incense. Economically, the wood of *D. excelsa* could be used for charcoal, furniture, boat-building, produce crates, house construction, farm construction and handicraft. However, its value to the natural forest of Grenada is far more important than the benefits from any economic exploitation. Since the species is well-established and flourishes in that habitat, it should be conserved.

Erythrina species

Immortelle

A number of immortelle species grow in Grenada, but the three most popular species are *Erythrina corallodendrum, E. glauca* and *E. micropteryx.* These fast growing, deep-rooted soft wood trees, provide shade for essential crops as well as the function of humidity modifiers. They draw water from deep down and thus help replenish the upper soil layers. Being legumes, they accumulate nitrogen in the soil and they shed copious quantities of leaves, a valuable source of organic matter. They conserve river banks and since they are fast-growing, or better still, pieces of stem always grow when planted, they are useful species in environmental management. When in bloom, they cover the valleys and hillside with resplendent shades of yellow, gold, orange and red, and these flowers are a valuable source of nectar and pollen for honey bees.

Euterpe dominicana

Mountain cabbage, cabbage palm or Hagley's palm

E. dominicana syn. *E. hagleyi,* is a tall palm found abundantly in the lower montane moist forest. It is an important coloniser of mountain sides with landslide areas, sometimes forming a palm brake. In some areas they outgrow the stunted forest trees.

Gliricidia sepium

Glorisita, Gliriseda

This is a fast growing leguminaceous tree which binds nitrogen in the soil. It also produces copious organic matter in the dry season from the dried, fallen leaves. Numerous herbivores feed on the green leaves, and the flowers are known to produce the choicest nectar and pollen which provide the best flavoured honey. This species also grows readily in low rainfall areas. Being very fast growing, it is utilised in environmental management.

Hibiscus elatus

Blue Mahoe

After the severe Hurricane Janet in 1955, the species *Hibiscus elatus* was introduced to help with the reafforestation programme. This species has become well established and is now a key species in the protection of some watersheds. It is also a key forest commodity, the wood being used for fencing, telegraph poles, furniture, boat building, produce crates, house construction, farm construction and handicraft.

Though a key commodity species, it must be realised that its benefits to the forest should be carefully considered, so that exploitation can be avoided.

Leucaena leucocepha syn. *L. glauca*

Wild tambran, Leucaena

This is a far-ranging species, extending from swamp or coastline fringes to low hill tops. In habit it may be shrubby or a small tree. The seeds of this fast-growing legume are easily dispersed by wind and birds, and this species is an early coloniser of cleared lands. Being a legume, it leads to nutrient accumulation by binding nitrogen in the soil. The leaves are fed on by many herbivores, especially sheep and goats.

This species and other similar species have been given consideration for forest cultivation for wood and fodder because they are fast-growing.

Licania ternatensis

Bois gris

This hardwood tree represents the second most abundant tree species in the rain forest or lower montane rain forest of Grenada. In this habitat, it is a key forest species. It is not used popularly for timber because the wood is very hard and difficult to work. The dominance of this species decreases down the mountain side. This species never extends to be dominant forming the canopy.

Mangifera indica (and other honey producers)

Coralita and skin up

The herbaceous vine *Antigonon leptopus* (Coralita) covers exposed ground forming a thick mat of green and dried leaves. It occludes other herbaceous species growing in the vicinity. The white or pink flowers are popularly visited by honey bees for nectar. It is thus a key species for honey production.

Two other species that are heavily visited by bees during other flowering periods are the fruit trees, skin up (*Melicoccus bijugus*) and mango (*Mangifera indica*). There are a number of varieties of mangoes locally. This constitutes a valuable genetic resource. All varieties must therefore be considered for conservation. Mango trees are widely used as windbreaks for field crops. Some varieties have also assisted in thrips control in cocoa plants. *Melicoccus bijugus* produces an edible fruit and generates copious organic matter from shed leaves.

Micropholis chrysophylloides

Bois

This is a dominant species in the main watershed areas or montane thicket area, and it is said to make up just over 40% of forest trees. In this habitat, this species is established as a very big tree, averaging 6 feet in girth.

Pachira insignis

Wild breadnut, Chataigne marron

Split branches from this tree are used as a natural attractant for the cocoa beetle (*Steirastoma breve*), a serious pest of the cocoa plant.

Spondias mombin

Hog plum

Scattered on the lower hills of Grenada is a rough-barked deciduous tree *Spondias mombin*. The trees have become established on some of the slopes and their extensive root systems help to control soil erosion. The shed leaves provide a fair quantity of organic matter to the dry forest floor. The cluster of flowers are visited by honey bees. The fruit, though not popularly eaten locally, is made into jams, wines and preserves. Culturally, the leaves are used as a herbal tea for sore throat.

Swietenia macrophylla

Mahogany

Trees of the species *Swietenia macrophylla* and *S. mahogani* have declined drastically in number. This species must be conserved and the planting of new trees is absolutely essential. The sturdy rough-barked, hardwood mahogany tree is very deep rooted, deciduous and grows well on flat lands or inclines. It is a provider of organic matter since it sheds copious leaves, flower petals, fruits and seeds. It is an excellent stabiliser of soil on sloping ground. Culturally, it is the most valuable timber tree processed locally and the wood is used in construction, furniture, crafts, boats and vehicles, and burial caskets. This wood is not easily attacked by termites, etc. Conservation of this species and replanting in carefully selected areas can enhance the timber industry as well as afford environmental management.

Tabebuina pentaphyla

White cedar, Pink poui

This is a prolific hardwood, deciduous tree found growing on low hills and hill ranges in the southeastern, east-central and north-eastern areas of Grenada and the hillsides of Carriacou. On both islands, the extensiveness of this forest has rapidly declined, but this species continues to be a great producer of organic matter since it sheds all its leaves and flower petals to the forest floor in the dry season. It is very deep-rooted and readily establishes itself as the dominant species in the low hill habitat. Dispersal is by winged seeds and thus it establishes early colonies on cleared patches of ground.

As a commodity, this is the most significant and best used species in boat building for the three islands, a feature which has contributed to its decline. Construction works on low hills have also led to this species' decline. It needs to be recognised as a key species and steps should be taken for its reintroduction and cultivation. The forest species provided soil stabilisation and retention of water in the low hill areas it populated. In many locations the white cedar stands have become interspersed with lowland hardy dry forest trees.

Tamarindus indica

Tambran, tamarind

This sturdy, hardwood tree is best known for the highly acidic fruit which is used for making jams, jellies, preserves and sauces. The tree can grow in a variety of habitats but it does very well in the drier areas of Grenada and Carriacou.

There is potential for a tree that could be cultivated in the drier areas. The extensive deep root system firmly binds the tree in the soil and some trees actually prosper in precipitous areas. Advantage could be taken of this characteristic and species may be planted to control precipitous areas. This qualifies tamarind as a key leguminous fruit species with environmental management potential. It is also a provider of organic matter from leaves shedding.

Shrubs

Clerodendrum aculeatum

Bitter fence

This fast-growing, thorny shrub is underutilised. It is potentially a very useful species for soil stabilisation in environmental management. It grows readily from cuttings, forming a strong shrub. If planted closely, then a sturdy, almost impenetrable fence develops. This is a key species that could be utilised for roadsides, where soil conservation is needed, as well as for protection in precipitous areas. It is one of the most popular fencing plant used. Its fast growth permits it to be trimmed and trained. The leaves of the plant are used as bitter herbal tea.

Cordia curassavica

Black sage

This is a persistent hardy shrub found growing mainly in the drier areas of Grenada, Carriacou and Petit Martinique. Its distribution is island-wide with decreasing numbers at higher, wetter elevations. Its extensive root system, shrubby nature, roughened leaves, as well as the fact that it is not eaten by herbivores, have provided adaptations for its survival in the dry areas. This species functions as a natural soil stabiliser. It grows quite readily from cuttings, but currently is not used in environmental management. It must be noted that the authors are of the opinion that this species should be utilised in selected areas to control landslides or soil movement, etc. The yellow leaves of this plant are popularly used as herbal teas for fever and stomach aches. Chewing bits of stem cleans the teeth.

Croton species

Bois buc

In the dry lowland areas of Grenada, these species abound as hardy, deep-rooted, variegated shrubs, essential as natural soil management agents. They also occur on neighbouring islands. The most popular species are utilised locally for yard brooms. It is well adapted for survival in the drier areas and is not fed on by herbivores.

Moghania strobilifera

Moghania

This legume is usually found growing profusely on abandoned fields and riversides. It helps to colonise cleared ground, binds nitrogen in the soil and prevents soil erosion. A wild growing species which may be utilised in soil conservation or environmental management by planting in desired areas.

Merremia species

Rabbit vine, goat vine, shining bush

Feed for livestock is crucial in any country's survival. For Grenada, the smaller livestock (goats, sheep and rabbits), are important sources of meat, and this importance may well grow in the future. Two natural species that are important as animal feed are the vines *Merremia* species and the shrubby *Piper* species. Among most of the other feed plants, these two are key for the extensiveness with which they are used.

Pandanus species

Wild pine, Screw pine

These species constitute the plants that contribute most to the economic and social life of the villagers of the eastern seaboard villages of Soubise and Marquis. This is particularly so for the women-folk who are involved in the harvesting, processing and preparation of craft products and craft items. These include plaited straw, straw hats, bags, slippers, table mats, etc. The plants are not cultivated but have colonised and structured a habitat in the low lying semi-swamp lands of the surrounding river basins. Thus this species has functioned in swamp reclamation. This constitutes a species whose genetic material is a valuable resource.

Herbs

Aloe vera

Aloes

This is an outstanding multipurpose herbaceous plant. Although not cultivated in Grenada or Carriacou as such, it grows in areas with not too high rainfall. Where the plants grow, they afford soil conservation. This species is esteemed for its cultural value and is a popularly used medicinal herb, the juice being used on burns and bruises or ingested for certain stomach ailments. A plant growing in the yard is supposed to bring good luck to the family within. Its use as a cosmetic is recognised and the juice is used as a shampoo and cleansing body wash locally. This plant holds good economic potential for cultivation, processing and exportation of gel.

Amaranthus dubius

Bhagee, Bhaji

This amaranth is a fast-growing, easily dispersed, herbaceous plant, found growing as a weed in most pasture lands. This species is fed to animals, especially hogs. It is sometimes used as a spinach. This wild species and other close varieties may well be considered for cultivation for use as a vegetable rich in fibre and iron. They are very fast-growing and easy to grow. Close species may also be cultivated for their food seeds.

Commelina elegans

Water grass

Though called water grass, this species is in fact a herbaceous, monocotyledanous, flowering plant of the family Commelinaceae. This species grows prodigiously where there is water and decaying organic matter. In fact some farmers use its growth to tell that the soil is rich in organic matter. This luxuriant soft stemmed herb is used as feed for sheep, pigs, cattle, rabbits, and fowls. It may be the genetic resource for an edible vegetable herb for humans – an area that needs investigation.

Desmodium species

Sweetheart, Coeur de velot

Locally, there are many species of *Desmodium*, a short vine-like herb with sticky pea-like fruits. These plants occur in many different habitats, but especially so as a wild species on cultivated soils. Their sticky fruits adhere to most surfaces and are readily dispersed. They are one of the early herbaceous colonisers of freshly cut or newly cultivated lands. As early and rapid colonisers they cover exposed land, thus reducing erosion. Further, being legumes, they lead to nutrient accumulation by binding nitrogen in the soil. Also used as a medicinal herb for dysentery.

Heliconia species

Balizier

There are as many as seven *Heliconia* species found growing naturally in the lower montane moist forest of Grenada. This diversity constitutes a very important genetic resource. Herein may be the resource for successful cultivation and, thus supported, agricultural diversification which may include cut flowers. In their natural habitat, the balizier is a significant coloniser of mountain slopes that have become exposed due to falling or cut trees, and land slides. It grows and spreads very rapidly, thus controlling erosion, returning plant cover for water capture, and reinstatement of forest trees. A key species in habitat structuring in the moist forest. Leaves useful as disposable plates.

Mimosa pudica

Sensitive plant, Spanish needle

The sensitive plant (maria hunt) *Mimosa pudica* and Spanish needle, *Bidens pilosa* are key early herbaceous colonisers on tilled agricultural lands, helping to lessen soil erosion. *Mimosa*, being leguminous, binds nitrogen in the soil. *Mimosa* extends on the soil surface by producing runners. Both species produce numerous seeded fruits which are easily dispersed. The herbaceous *Mimosa* is used in herbal medicines.

Momordica charantia

Coolie pawpaw

The herbaceous vine is the most popularly used species in local herbal medicine. A bitter tea made from the herbs is drunk for diabetes, hypertension and fevers. Extracts from the herbs are used in patches for certain skin ailments. The large-fruited variety of this species is cooked as a vegetable. This prolific growing vine, found on the three islands, constitutes a culturally significant species. The herbaceous vine is an early coloniser of pasture land, dry areas and most lowland and hills.

Grasses

It is very difficult to select the key species of grasses for the three island State. More work needs to be done on the grasses for a more comprehensive appreciation of their functioning in the various ecosystems and their habitats. Their importance in soil cover is undeniable, especially so in the drier areas or areas devoid of many trees or shrubs, where grasses are the major ground cover species.

For the farmers, some grasses may constitute serious weeds. Because they are easily dispersed, as well as having persistent seeds, they are early colonisers, a feature that leads to quick plant cover of exposed grounds. Grasses are therefore good natural soil stabilisers and could be managed to this end. Some species that are early colonisers are *Eleusine indica, Cynodon dactylon* and *Paspalum* species.

Grenada does not have a thriving livestock industry as such. The few cattle around are reared by small farmers. Such cattle will feed on a mixture of wild grasses, cane tops and other herbs, etc. There are few species of grasses that are specifically cultivated for livestock feed, but these include elephant grass, para grass and pangola.

Gynerium sagittatum

Roseau

The tall hard-stemmed grass, *Gynerium sagittatum*, grows in river beds, on river banks and on swamp fringes, especially around river mouths. The extensive fibrous roots bind the soil, thus controlling erosion as well as helping in swamp reclamation. The slender bamboo-like stems are used in farm construction and mainly in decoration in homes or bars. The large plumous flower is used in interior decoration. Currently, this species grows wild. Controlled cultivation may yield better use of its environmental management potential coupled with commodity use.

Elephant grass

This tough, solid-stemmed grass is a useful cattle feed especially in the dry season when most grasses have dried back. Very important also is its use in soil stabilisation. This species is grown on the steep hillsides to prevent slides and in areas where bush fires have removed vegetation covering. A key species in environmental management.

Cymbopogon citratus

Lemon grass

This is a tufted grass. It is not cultivated in large acreage, but a stool or two may be found in most rural yards. It is culturally important as a herbal tea, just a pleasant hot tea, or for fevers. It is also used to control soil erosion. Small quantities are now exported as herbal tea preparations. This species can assist in soil conservation as well as being economically important.

Vetiveria zizanioides

Khus-Khus, Sweet root

This is utilised in environmental management as a soil stabiliser to lessen or control erosion. The same fibrous binding roots are the source of essential oils valued for cosmetics and an insect repellent. The leaves provide a valuable commodity for craft.

As Grenada diversifies and intensifies its agriculture, this will be a necessary species for hillside conservation. Also on the islands of Carriacou and Petit Martinique.

Bamboo

The thickly clustered, fibrous-rooted *Bambusa vulgaris* is one of the most popular species found growing along river banks or watercourses where it functions to prevent landslips, slides and soil erosion. It may be found growing naturally or directly introduced for soil management. The bamboo is very important in preventing sedimentation of streams and rivers. Consideration should be given to cultivation of this or allied species. As a commodity, the hard stems find utilisation as building materials, construction aids, craft items, furniture, sports, fishing rods, stakes for bananas and farm or livestock house construction.

Sedges

The sedges are members of the family of Cyperaceae. A number of species are crucial in Grenada. One of the fastest colonisers on newly cut ground is the pernicious welcome grass or nut grass, *Cyperus rotundus*. Once established, it is a very difficult species to get rid of.

The corms are used in herbal medicine as a tea for colds. An accompanying colonising sedge is *Cyperus surinamensis*.

Sedges are found growing abundantly in river beds and on river banks. On the banks they help to control or reduce soil erosion. Two popular species in this regard are *Mariscus fuligineus* and *M. meyenianus*.

Ferns

Of the many species of fern in Grenada, growing in many different habitats, two species stand out as being key. These are the Grand Etang fern, *Dicranopteris pectinata* and the tree fern *Cyathea* species. In the mountain areas where deforestation has taken place, either through natural action or the interference of man, *D. pectinata* has successfully recolonised these areas and now extends as a thick mat covering and protecting the soil from further erosion, increasing the soil's organic matter as well as the water retention properties; and thus allowing for the reestablishment of forest trees. The fern does not harbour any critical pest and is not fed on by herbivores. A highly valuable species in habitat structuring and natural environment management. The tree fern occurs in a similar habitat and also functions in habitat structuring.

Mosses

On some of the mountain peaks of Grenada, in the region classified by Beard (1949) as the cloud cover forest or elfin woodland, mosses abound on the rock and soil surface. Here they function in top soil formation and stabilisation. Lower down the mountain sides, mosses now occur on the tree barks. The species of mosses have not been identified. Similar unidentified species occurring in this habitat are algae and lichen.

Fungi

On the forest floor and in rotting trees, myriads of fungi exist as decomposing agents. Here, too, species have not been identified.

COASTAL SPECIES

Trees

Avicennia nitida (plus others)

Mangroves

In the mangrove stands remaining around Grenada and Carriacou, the four species usually coexist showing a progression from the sea to dry land in the order of species, *Rhizophora mangle* (red mangrove), *Avicennia nitida* (black mangrove), *Laguncularia racemosa* (white mangrove) and *Conocarpus erectus* (button mangrove). The major remaining mangrove stands are small patches of shoreland around Prickly Bay, Mt Hartman Bay, Clarkes Court Bay, Petit Caliviny Harbour, Caliviny Harbour, Westerhall Bay, Petit Bacaye Bay, Conference Bay, Antoine Bay and Levera Bay. Mangrove locations are dotted from southeast to the northeast along the coast. Total acreage of remaining mangrove is about 470 acres. In Carriacou, the two major mangrove stands are at Tyrrel Bay and at L'Esterre Bay.

Mangrove are important in coastal protection, fisheries and wildlife. On the coastline they function in organic production, habitat structuring and colonisation and stabilisation of the zone between dry land and sea. They therefore provide natural environmental management. It is important to realise that mangrove forest are zones of significant nutrient accumulation since there is no direct leaching into the sea and direct washing of land by the sea. They also buffer sea-wave and wind energy. The fact that mangrove is a useful commodity for coals, wood and tannin materials, should be de-emphasised locally. This will then lead to the longer survival of key contributing species. The long term benefits from these species far outweigh any immediate economic gain.

In the mangrove ecosystem, fishes and other wildlife abound and the mangroves of Tyrrel Bay in Carriacou are well known for their oyster beds in the roots. A significant observation is that most of the beautiful sandy beaches of Grenada and Carriacou are juxtaposed to a thriving mangrove patch or a swampy area.

Coccoloba uvifera

Sea-side grape

This deep and extensive rooted, multi-branched, thick-leaved tree is naturally adapted to withstand salty sea spray and salty underground water. It is a significant species in beach-front habitat formation, sand binding, as well as guarding the less well adapted inland plants from salty sea spray and wind energy. Additionally, the fruit is edible. Because of its ecological importance, the use of the hardwood as a commodity for fuel should be discontinued.

Dry Evergreen Forest Species (Coastal)

The following tree species will be best treated as a group since they all occur in the dry evergreen forest or salt spray zone. They all tend to have a deep or extensive root system which is tolerant of salty underground water, and they are resistant to salt spray and high winds. It may be worthwhile to predict that they serve as a frontal barrier against physical, chemical and also biological agents. Leaf modifications protect these species from excessive direct sun rays as well as dry atmosphere.

These key species are important in habitat structuring, protecting and conserving the coastline and protecting the close inland plant species, be they natural or planted crops. The species include sea-side grape (*Coccoloba uvifera*), sea-side mahoe (*Thespesia populnea, Hibiscus tilaceus*), Machineel (*Hippomane mancinella*), sea-side almond (*Terminalia catappa*), fat pork (*Chrysobalanus icaco*) and coconut (*Cocos nucifera*). The indiscriminate clearing of all or some of these species in certain eastern coastline areas has already led to serious coastline erosion as well as disastrous effects on what used to be protected inland crops.

The seaside almond produces a utilisable fruit and an edible seed, and both the fruit and seed (when parched) of the fat pork are edible. The economic importance of the coconut in the tropics is well known and this species is not restricted to a coastline habitat. The other species are also found inland and the almond is popular along some river courses.

The machineel must be noted for its intense dermal toxicity to humans. One should not get into contact with the milky latex of the leaf, stem or fruit. However, it is an excellent provider of organic matter from falling leaves.

Herbs

Ipomoea pes-caprae

Seaside potato, Creeping vine

The succulent creeping herbaceous stem of *Ipomea pes-caprae* forms a mat lying close to the ground. Its highly branched roots hold fast to the sand, thus preventing shifting of sand. The thick leaves are well insulated from salt spray, halophytically adapted. This species is an ample coloniser of upper beach sand, just above the high tide mark and it functions to prevent shifting of sand. A key species for controlling erosion of upper beach sand in the pioneer zone.

Grasses

Sporobolus species

Crab grass

This rhizomatous grass is an early coloniser of the pioneer zone usually growing close to or intermixed with *I. pes-caprae* in similar habitats. It is a key species for binding sand in the zone just above the high tide mark.

Algae

Edible seaweeds/sea moss

There are four species of agar-producing seaweeds that are utilised in Grenada, Carriacou and Petit Martinique as a food item. These are *Gracillaria crassissima, G. debilis, G. domingensis* and a *Gracillaria* species. These are all marine algae found growing in the waters of these islands and are commonly referred to as sea moss.

In some habitats, two or more species may co-exist, whilst in others, one dominant species occurs. The species *G. crassissima* is found growing flat on rocks from the intertidal zone to depths as much as 25m (80 ft). *G. debilis* establishes itself on rough waters on rocky shores. The more delicate *G. domingensis* survives best in sheltered areas such as protected bays near river outflows, a similar habitat for the unknown *Gracillaria* species. This species, however, shows a little more extended range to rougher or muddier waters.

Gracillaria represents key natural sea weed species with the potential for cultivation and expanded utilisation as a food commodity.

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B. KEY SPECIES FOR CONSERVATION AND ECONOMIC DEVELOPMENT IN NEW ZEALAND

By T. R. PARTRIDGE

B.1 Summary

A list of plant species considered to be either 'key' for ecological reasons or for socio-economic reasons is presented in this report. An introductory section outlines the application of these concepts to the New Zealand situation, with special emphasis on problems.

B.2 'Key' ecological and socio-economic species in New Zealand

B.2.1 *Framework and overview*

New Zealand ecologists are unaccustomed to the concept of 'key ecological species', that is, those that contribute a disproportionate role to the maintenance of the quality of life on this island group. There are a number of clear reasons for this, that apply to both 'ecological key species' and 'socio-economic key species'.

The flora and fauna of New Zealand are made up of plants and animals of two very distinct origins. There are firstly the native species that existed in New Zealand before human settlement some 800 years ago. The Polynesian inhabitants modified large areas of New Zealand, but introduced few species of plants and animals. In contrast, 150-200 years of European settlement has seen the introduction of a vast number of new species that have had a massive impact upon the landscape. In New Zealand's agriculturally based economy this has meant the replacement of native species of little economic value with the agricultural species that have become the source of food for New Zealanders. Conservation priorities are therefore concentrated on the native species that are threatened by those that are introduced. As some habitats are more threatened than others, ecologists tend to associate with 'key habitats' that have been especially depleted or threatened. These include, for instance, wetlands, lowland forest, sand dunes, and hard tussock grassland. Preservation of habitat is therefore the priority, irrespective of whether or not they contain 'key' species.

The indigenous Maori people are now no longer reliant on traditional foods. These foods are used, and have great spiritual value, but for regular nourishment, they consume the same foods as eaten by Europeans. Therefore, 'key socio-economic'

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species are more based on spiritual value or use as fibre rather than value as food.

We are, however, able to categorise a number of species as being perceived as 'key'. It is unlikely, however, that by doing so conservation priorities need to be changed. These species will be protected as we protect key habitats or in situations where they are, for instance, valuable for land stabilisation. The indigenous people are well aware of the need to conserve resources of their culturally important species.

During compilation of the list it became apparent that species of certain kinds of habitats were more likely to be 'key' ecologically. Dominant species were especially obvious, more so when the vegetation was species poor as well. Monocultures are the obvious extreme of this situation. These habitats are often stressed, including estuaries, dunes, dry forest, wetlands, etc. New Zealand does, however, have an extensive alpine flora where, apart from in snow-tussock grassland, there tends to be less dominance despite the obvious stress.

The report presented emphasises plants. For a list of 'key' animals, other agencies should be contacted. It is important to note that (a) apart from bats, there are no native mammals, and (b) the insect fauna is very poorly understood, especially from an ecological viewpoint. As a result of their differing origins, native and introduced species are presented as separate lists. Otherwise the habitat system of presentation is followed.

The species are listed as 'key' for perceived positive values. New Zealand has a large number of introduced (and a few native) weeds that have considerable impact upon other species to such an extent that they are considered noxious. Some species are of 'key' status in certain situations, but a threat to other 'key' species in others. For instance, the introduced grass marram (*Ammophila arenaria)* is of immense value in stabilising wandering dunes, yet threatens the native pingao (*Desmoschoenus spiralis*) on coastal dune systems where that species is found and used for fibre. Likewise, certain ecological 'key' species are frequent agricultural problems, for instance manuka (*Leptospermum scoparium*) which is an important coloniser after fire, but at the same time is a hindrance to the conversion of land for agriculture.

Within the montane to alpine scrublands and grasslands of New Zealand, there are groups of large numbers of closely related plant species occupying similar habitats and ecological niches in different regions. These groups are considered to have speciated relatively recently, sometimes to such an extent that some species are confined to individual mountain ranges. Characteristic genera include *Dracophyllum, Hebe, Coprosma, Celmisia, Chionochloa, Aciphylla, Raoulia, Olearia* and *Senecio*. If this speciation had not taken place, some related groups of species (eg shrubby *Dracophyllum*) would have qualified as a single 'key' species. This contrasts with the widespread shrub *Cassinia leptophylla*, which has not undergone such speciation, and which although not considered a 'key ecological' species, is certainly very close. Nor is it possible to group these situations as single entries as the number of species is large and there are many that are excluded. Because this situation is such a feature of these habitats, there are few entries of 'key' species for them. A similar situation exists within the lowland drought-tolerant grass species of *Rytidosperma*. The difficulty here though is mainly of identification, which is difficult, so the actual species contributing to the core 'key' group are essentially unknown.

The list of adventive plant species is comparatively short. Many do, however, play a critical role in agricultural and pastoral production. Pasture grasses such as *Lolium perenne* and pasture legumes such as *Trifolium repens* are the mainstay of New Zealand's meat and wool production, but they are not strictly 'key' ecological or socio-economic species as defined in the CSC report. Similarly, the large number of agricultural crops are excluded. Also important are the many trees that are the mainstay of New Zealand's increasing timber industry. One adventive tree *(Pinus radiata)* does, however, stand out as also being of particular value in stabilisation, especially of sand and has been included in the list. Of difficult status are the many adventive tree species used for land stabilisation. Many of these are species of *Salix* and *Populus* that have been planted on slumps, roadside cuttings, screes, etc, and play locally important roles.

B.3 List of key ecological and socio-economic plant species in New Zealand

B.3.A *Indigenous species*

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
COASTAL SPECIES										
TREES										
Metrosideros excelsa (Pohutukawa)	New Zealand			X				X		Trees of great cultural significance. Food supply for birds. Threatened by opossums
Corynocarpus laevigatus (Karaka)	New Zealand					X		X		Important spiritual tree. Nuts of great nutritive value (but potentially poisonous). Also inland
Myoporum laetum (Ngaio)	New Zealand			X					X	Important tree for coastal shelter
SHRUBS										
Avicennia resinifera (Mangrove)	New Zealand	X		X	X				X	Crucial species in estuarine food chain, sediment and coastal protection. Threatened by reclamation
Olearia traversii	New Zealand (Chatham Island)								X	Coastal protection on Chatham Island. Threatened by exploitation for firewood
HERBS										
Zostera novae-zelandiae (Eel grass)	New Zealand	X	X	X	X				X	Important in estuarine food chain and sediment holder in estuaries

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
HERBS continued										
Ruppia megacarpa	New Zealand	X	X	X					X	Major food supply for animals using brackish lagoonal waters
Sarcocomia quinquefolia (Glasswort)	New Zealand	X		X	X				X	Primary coloniser on estuarine muds. Important in estuarine food chain
Juncus maritimus (Sea rush)	New Zealand	X		X	X				X	Important salt marsh species for stability
Spinifex sericeus (Spinifex)	New Zealand			X	X	X		X	X	Significant coastal sand binder on dunes
Desmoschoenus spiralis (Pingao)	New Zealand			X	X	X		X	X	Sand binder on dunes. Leaves used for fibre in traditional weaving. Threatened by spread of marram
Lepidium oleraceum (Scurvey grass)	New Zealand					X	X			Source of vitamin C. Species is now rare and endangered and virtually confined to offshore islands
Poa species (Tall subantarctic tussocks)	New Zealand – Subantarctic			X					X	Source of shelter for significant subantarctic birds (eg. albatross)
WETLAND SPECIES										
TREES										
Dacrycarpus dacrydioides (Kahikatea)	New Zealand	X	X	X		X			X	Tall tree of swamp forest. Exploited for use as quality wood. Also on drier soils. Food for birds
Laurelia novae-zelandiae (Laurel)	New Zealand	X	X	X					X	Important sub-tropical forest tree with buttress roots. Threatened by land clearance

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
HERBS										
Typha orientalis (Raupo)	New Zealand	X	X	X	X				X	Important stabiliser and nutrient accumulator
Carex secta (Tussock sedge)	New Zealand	X	X	X					X	Significant wetland species in a range of situations. Threatened by drainage
Chionochola rubra (Red tussock)	New Zealand	X	X	X					X	Important species maintaining water quality in lowland and montane wetlands. Threatened by drainage
Phormium tenax (Flax)	New Zealand	X	X	X		X	X	X	X	Important wetland species. Significant source of weaving fibre. Nectar used by birds. Great source of genetic variability
Empodisma minus (Wire rush)	New Zealand	X	X	X	X				X	Coloniser of nutrient poor wetlands, especially after fire. Important in soil conservation
Schoenus pauciflorus	New Zealand	X	X	X					X	Significant in maintaining water quality and flows and wetlands
FOREST SPECIES										
LARGE TREES										
Agathis australis (Kauri)	New Zealand	X		X		X		X		A vast tree of great value for its wood and gum. Of great cultural significance. Overexploited
Dacrydium cupressinum (Rimu)	New Zealand	X		X		X			X	Significant lowland forest tree. Quality wood has resulted in overexploitation

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
LARGE TREES continued										
Nothofagus solandri (Mountain beech)	New Zealand	X		X	X	X			X	Dominant tree of dry hillslopes. Critical in land stability. Quick coloniser. Honeydew feeds forest fauna, but is threatened by introduced wasp
Nothofagus menziesii, *N. fusca* (Silver beech, red beech)	New Zealand	X		X	X	X			X	Important stabilisers of steep slopes. Good colonisers. Quality wood
Sophora tetraptera, *S. microphylla* (Kowhai)	New Zealand			X				X		Significant food source for native birds. Trees of cultural significance. Regeneration threatened by grazing, spraying
Podocarpus totara, *P. halli* (Totara)	New Zealand	X		X		X		X		Important for wood. Of cultural significance. Depleted by opossums
Vitex lucens (Puriri)	New Zealand							X		Cultural significance as the tree is used for wood for spears
Metrosideros robusta, *M. umbellata* (Rata)	New Zealand	X		X		X		X	X	Significant ecological and spiritual tree. Under threat from introduced opossums. Honey
Rhopalostylis sapida (Nikau)	New Zealand			X		X		X		Edible parts. A palm of significant cultural value
Fuchsia exorticata (Tree fuchsia)	New Zealand	X		X	X	X			X	Coloniser following disturbance. Under threat from opossums in some areas
SMALL TREES										
Melicytus ramiflorus (Mahoe)	New Zealand	X		X	X				X	Ubiquitous tree that is a good coloniser following disturbance

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
SMALL TREES continued										
Weinmannia racemosa, W. silvicola (Kamahi)	New Zealand	X		X	X	X			X	Ubiquitous subcanopy tree of forests. Threatened by opossums. Source of honey
Solanum aviculare, S. laciniatum (Poroporo)	New Zealand				X	X	X	X		Pharmaceutical properties. Good colonisers of open areas
Beilschmiedia tawa, B. tarairi (Tawa, tarairi)	New Zealand	X		X		X			X	Significant canopy trees in North Island. Quality wood. Threatened by land clearance
Cyathea species, *Dicksonia* species (Tree ferns)	New Zealand	X		X	X	X		X	X	Remnant species following forest burning. Some have edible parts
Leptospermum scoparium (Manuka)	New Zealand	X		X	X	X	X		X	Coloniser following fire. Excellent firewood. Also in wetlands and dry areas. A scale insect that has severely depleted this once abundant tree. Honey
Kunzea ericioides (Kanuka)	New Zealand	X		X	X	X			X	Coloniser following disturbance. Good quality firewood
CLIMBERS										
Freycinetia baueriana (Kiekie)	New Zealand					X		X		Edible parts and used in weaving
Clematis paniculata	New Zealand							X		Culturally significant and showy climber
GRASSLAND AND SCRUB SPECIES										
TREES										
Cordyline australis, C. indivisa (Cabbage tree)	New Zealand					X		X		Leaves used for fibre. Shoots and roots as food (high sugar content). Affected by disease in north

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
SHRUBS										
Discaria toumatou (Matagouri)	New Zealand	X	X		X			X		Nitrogen fixer (non-legume). Coloniser of open, stony areas. Also regarded as weed
HERBS										
Raoulia australis (Scabweed)	New Zealand			X	X			X		Coloniser following severe grassland grazing depletion. Critical in soil conservation
Chionochloa rigida, *C. flavescens*, *C. macra* (Snow tussock)	New Zealand	X		X					X	Major dominants of alpine grasslands. Maintain water quality and flow. Important in soil conservation
Celmisia spectabilis (Mountain daisy)	New Zealand			X	X				X	Survivor of overgrazed and overburnt alpine grassland. Significant in soil conservation
Festuca novea-zelandiae (Hard tussock)	New Zealand	X		X	X				X	Dominant on poor quality montane grasslands. Threatened by *Hieracium*, grazing
Poa cita (Silver tussock)	New Zealand	X		X	X				X	Important lowland grass of many situations
Rytidosperma species	New Zealand	X		X	X					Some of these are significant holders of soil in low nutrient grassland
Pteridium aquilinum (Bracken fern)	New Zealand	X			X			X	X	Significant species of burned areas, but can dominate to become a weed. Soil conservation values. Rhizomes a traditional food
Poa colensoi (Blue tussock)	New Zealand	X		X	X				X	Important alpine grass with a role in water quality and soil conservation. Survives fire

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
MARINE ALGAE										
Durvillea antarctica, *D. willana* (Bull kelp)	New Zealand	X	X	X		X		X	X	Large seaweed dominant on many coasts. Wave energy absorption delays erosion Culturally used for bags. Has potential for food and alginate production
Porphyra species	New Zealand	X				X		X		Important cultural source of food – potential for further use
Macrocystis pyrifera	New Zealand	X		X					X	Source of food chain for fish – shelter
Ecklonia radiata	New Zealand								X	Source of food chain for fish
Gracillaria sordida	New Zealand					X			X	Food for fish. Alginate production
B.3.B *Adventive species*										
Ammophila arenaria (Marram grass)	New Zealand				X				X	Significant introduced sand binder on wandering dunes
Lupinus arboreus (Tree lupin)	New Zealand	X	X		X				X	Significant sand stabiliser. Nitrogen fixer
Agrostis tenuis (Browntop)	New Zealand	X			X				X	Major grass of nutrient poor areas with soil conservation role
Ipomoea batatas (Kumera)	New Zealand					X	X	X		Main crop of Maori people before Europeans, but has been replaced by cultivars derived from elsewhere. Indigenous cultivars are of greater spiritual value than actually cultivated
Pinus radiata (Monterey pine)	New Zealand	X			X	X	X		X	Principal timber tree that also has value in land stabilisation, especially wandering dunes

B.4 Acknowledgments

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C. SOME KEY SPECIES OF THE NIGERIAN FLORA

By M. O. SOLADOYE AND O. ONI

C.1 Introduction

The alarming rate of destruction of the natural forests of Nigeria has been a subject of grave concern in recent times. Aladejana (1985) reported that the forest estate of Nigeria is approximately 9.6 million hectares or 9.8% of the total land area of the country, covering approximately 92.4 million hectares. Of this, only 2% is said to be within the unit regarded as commercial forests, most of which lies in the high forests of the southern states. Soladoye & Ola-Adams (1990) pointed out that Nigeria loses about 300 000 hectares of her forests annually while reforesting (Aladejana 1985) is between 15-17 000 hectares per annum as opposed to the projected rate of 60 000 hectares per annum.

Ola-Adams (1981) identified the factors responsible for the loss of the natural forest and its gene pool in Nigeria as uncontrolled timber exploitation, agriculture, urbanisation and increased socio-economic development. From the fore-going, it is apparent that there is a need for conservation of the genetic resources of the species as well as the ecosystems. Extensive discussions of the need for conservation have been made by Charter (1968), Roche (1973), Okali (1975), Ola-Adams & Iyamabo (1977) and Soladoye & Ola-Adams (1990). A list of the threatened and endangered or rare species of Nigerian plants which require urgent conservation has been prepared by Gbile *et al.* (1978).

The savanna zones of Nigeria have also been plagued with several socio-economic development projects as well as over-grazing, over-exploitation for firewood and uncontrolled use of fire for agriculture and hunting purposes. As a result of this, the savanna vegetation has been grossly abused and most of the useful species have either become endangered or extinct. It was reported that *Balanites* was almost extinct in Nigeria until recently (IUCN 1988). The situation has been further aggravated by the rapid encroachment of the desert. This has resulted in the declaration of some states in the northern part of Nigeria as ecological disaster zones.

In order to forestall the complete decimation of the ecosystem, various ameliorative measures are being embarked upon but these may not be able to replace the lost genes, neither will they be able to check the erosion of the gene-pool of these native economic species.

Based on the need for conservation and improvement, a list of some socio-economic/ecological key species requiring urgent attention is hereby presented (Table 1) along with short morphological descriptions, their habitat, distribution and

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uses. In arriving at this list cognizance was taken of the commodities such as food, fibre and medicines produced by these plants, their cultural value and their role in environmental management. It must be emphasised that the list is by no means exhaustive, the limitation of space has been a major constraint. Abbreviations used in the text are IUCN (International Union for the Conservation of Nature), FHI (Forest Herbarium, Ibadan), EFH (Enugu Forest Herbarium) and ABU (Ahmadu Bello University Herbarium).

Table 1 Some key species of Nigerian flora requiring urgent conservation and improvement.

Number	Species	Family
1	*Acacia senegal*	Leguminosae – Mimosoideae
2	*Adansonia digitata*	Bombacaceae
3	*Balanites aegyptiaca*	Balanitaceae
4	*Bombax buonopozense*	Bombacaceae
5	*Chrysophyllum albidum*	Sapotaceae
6	*Dennettia tripetala*	Annonaceae
7	*Faidherbia albida*	Leguminosae – Mimosoideae
8	*Garcinia kola*	Guttiferae
9	*Irvingia gabonensis*	Irvingiaceae
10	*Khaya ivorensis*	Meliaceae
11	*Massularia acuminata*	Rubiaceae
12	*Milicia excelsa*	Moraceae
13	*Parkia biglobosa*	Leguminosae – Mimosoideae
14	*Prosopis africana*	Leguminosae
15	*Pterocarpus mildbraedii*	Leguminosae – Papilionoideae
16	*Raphia hookeri*	Palmae
17	*Tetrapleura tetraptera*	Leguminosae – Mimosoideae
18	*Triplochiton scleroxylon*	Sterculiaceae
19	*Vitellaria paradoxa*	Sapotaceae
20	*Vitex doniana*	Verbenaceae
21	*Xylopia aethiopica*	Annonaceae
22	*Zanthoxylum zanthoxyloides*	Rutaceae

C.2 List of socio-economic/ecological key species

Botanical name: *Acacia senegal* (Linn.) Willd.
Synonyms: *Mimosa senegal* Linn., *Acacia verek* Guill. & Perr
Family: Leguminosae
Sub-family: Mimosoideae
English name: Gum arabic tree
Local names: Hausa: dakwara; Fulani: dibehi; Kanuri: kolkol.

Small tree up to 8m high armed with triple spines. Bark greyish and fissured, flaking off in papery patches. Easily recognised by the spines which are short, sharp and broad at the base. Leaves are bipinnate with slender common stalks 2-4cm long. There are 3-6 pairs of pinnae and about 15 pairs of leaflets. Flowering in Nigeria is between April and August. The flowers are cream coloured, fragrant, densely crowded in spikes 2.5-8cm long and about 1cm thick including the stamens. Fruits, which are pods, could be observed as from September of every year. The fruits are usually flat and papery pods, about 4-8cm long by 1.5cm broad with straight edges or sometimes constricted between the seeds. The fruits are fawn to pale olive-green in colour with the surface covered with minute hairs. The pod often contains between 1-6 olive-brown seeds (Keay, 1989).

Distribution/Habitat: Distributional range covers the area from Senegal to north-eastern Africa and south of Mozambique. This distribution is associated with the coarse sandy stabilised dunes of the Sahel zone and usually sporadic in occurrence due to intensive use by man (Kio & Ladipo 1987).

The micro-habitats of *A. senegal* are the Sudan and Sahel zones where it is often found in scattered patches. The macro-habitat of the species is the Savanna. Herbarium records (FHI, ABU) show that the species could be found in Sokoto, Bam-Ngelzarma Forest Reserve, Borno State, Nguru, Yola, Maiduguri, Kano, Katsina, Wumiri Forest Reserve, Fuchu Forest Reserve, Zaria, Sokoto, Funtua, Gusau, Bauchi and Gombe.

Uses: The stems are used for bows and as fibres for the manufacture of very strong ropes. The species is also useful as live fences in villages. *A. senegal* produces gum arabic for commerce. Gum arabic has featured in Nigeria's export trade for over 45 years (Soladoye 1977). The gum is also useful in making ink, sweet meats, poultry pigments and for dressing fabrics as well as in pharmacy, water colour, wax polish and liquid gum. The gum is also used locally for the cure of nodular leprosy.

Botanical Name:	*Adansonia digitata* Linn.
Synonym:	*A. sphaerocarpa* A. Chev.
Family:	Bombacaceae
English name:	Baobab
Local names:	Hausa: kuka; Yoruba: ose; Edo: usi.

Baobab is a very large tree and one of the longest lived in Africa. The trunk is usually irregular and conspicuously tapered with very broad base and very narrow top. This feature is easily noticeable in the saplings. Tree is up to 24m high and 12m in girth. It is easily recognised by its large pendulous fruits and compound leaves with digitate leaflets. The leaves are often 5-7 foliate, long petiolate with obovate leaflets. Flowering occurs between May and June. The flowers are solitary in the leaf axis and pendulous on stalks about 24cm long appearing just before the leaves. The pendant white flowers are visited by fruit bats. Fruiting occurs between November and March. The fruits are ellipsoid, ovoid or spherical, 10-28cm long and 5-12cm in diameter with a woody shell covered on the outside with yellowish-brown felted hairs. The large pod often contains numerous seeds embedded in a dry acid pulp.

Distribution/Habitat: The baobab is widely distributed in the drier region of Africa. In Nigeria, its distribution extends from the savanna to the forest regions near villages and residential areas. Herbarium records (FHI, ABU) show that the species could be found in Eruwa, Ijaye Forest Reserve, Borgu, Zaria, Birnin Gwara, Ibadan, Kaduna and Maiduguri.

Uses: The wood of *A. digitata* is currently being used for light construction works and packaging materials. It is used in construction of kiosks, and supports for laying of concrete and decking of houses and bridges. The pulp of the fruit is edible. The young leaves are used as a soup vegetable. The fibre from the inner bark is very strong and often used in manufacturing durable ropes and production of some local musical instruments.

Medically, *A. digitata*'s pulp is used as a remedy or palliative and diaphoretic for fever. The leaves are used for the cure of kidney and bladder diseases, asthma, general fatigue, tonic, blood-cleanser, prophylactic and febrifuge, diarrhoea inflammations, insect bites, expulsion of guinea worm, control of internal pains and other infections. The leaves are also fed to horses. Burkill (1985) has a long list of uses to which different parts of this plant are put outside Nigeria.

Botanical name:	*Balanites aegyptiaca* (Linn.) Del.
Synonyms:	*Ximenia aegyptiaca* Linn., *Agialida senegalensis* Van Tiegh., *A. barteri* Van Tiegh., *A. tombouctensis* Van Tiegh., *Balanites zizyphoides* Mildbr. & Schlechter.
Family:	Balanitaceae
Local Names:	Hausa: aduwa; Fulani: tanni; Kanuri: kingo.

A savanna tree of about 8-10m high, evergreen and often with fluted bole. It is characterised by long straight green spines up to 8cm long, spirally arranged along the branches, with each spine having a two-leaflet compound leaf below it. Leaves are arranged alternately on the branches. The leaf petiole is about 1cm long, pubescent and often glabrescent, leaflets subsessile, obovate to orbicular-rhomboid. Flowering occurs in the species between March and June. The flowers are yellowish green and about 1.3cm diameter borne in supra axillary clusters. Fruiting occurs in March to October. The fruits are broadly ellipsoid, green at first and later yellowish at maturity and about 3-4cm long. The fruits are usually smooth or wrinkled with a yellow brown sticky edible flesh.

Distribution/Habitat: It is widespread in the Sudan and Sahel zone savanna of Africa where it is usually preserved as a fruit tree. Kio & Ladipo (1987) reported that *B. aegyptiaca* could be found in Sokoto, Katsina, Kano, Borno, and Niger states of Nigeria. Herbarium records (FHI, ABU) show that the species could be found in Jos, Wunti Forest Reserve in Borno, Jimeta, Ago-Are, Zamfara, Zaria and Kaduna .

Uses: The timber is used for agricultural implements, local furniture, joinery, window sills, walking sticks, and bent wood chairs. It provides good firewood and charcoal. The fruits are edible and the inner core of the seed is usually crushed to provide oil for cooking. The fruits and oil are used for medicinal purposes. The kernels are used for soap making and could be used to bake bread. The leaves are also used as a vegetable. The plant is reported to contain sapogenins (dicsgenin and yamogenin) used in the synthesis of steroid drugs. The plant is also important in pest control as the fruit and bark extract are toxic to the fresh water snails that are vectors for schistosomiasis (bilharzia) and it also kills the water flea that harbours guinea worm. Spiny branches are used as fencing materials for cattle pens. Other uses in areas outside Nigeria are copiously enumerated by Burkill (1985).

Botanical Name:	*Bombax buonopozense* P. Beauv.
Synonyms:	*Gossampinus buonopozensis* (P. Beauv.) Bakh., *B. flammeum* Ulbr., *G. flammea* (Ulbr.) Bakh., *B. buesgenii* Ulbr., *G. buesgenii* (Ulbr.) Bakh., *B. angulicarpum* Ulbr., *G. angulicarpa* (Ulbr.) Bakh.
Family:	Bombacaeae
English Names:	Bombax, red-flowered silk-cotton tree, red cotton tree, West African Bombax.
Local Names:	Yoruba: ponpola; Edo: obokha; Ijaw: ido undu; Igbo: akpu.

This is the red-flowered Kapok tree of the forest regions, usually up to 40m high and 4m in girth. It is a deciduous tree with cylindrical bole and small rounded buttresses. The bark is grey, rough with small warty excrescences. Old trees are usually fissured with corky scales often armed with tent-shaped prickles composed of concentric layers which are roughly conical. Leaves are compound and digitate, glabrous with 5-8 leaflets. The leaflets are abruptly acuminate at the apex and narrowly tapered to the base (Keay 1989). Flowering usually occurs between December and February and extends to May when the tree is leafless. The deep pink or red flowers are solitary and erect on the branches. Fruiting in the species occurs between February and May. The fruits are cylindrical in shape and dark brown in colour, about 8-15cm long and about 3-5cm broad. In cross-section, the fruit is pentagonal with flat sides which break apart to expose the copious white or greyish kapok in which the numerous seeds are embedded (Keay 1989).

Distribution/Habitat: Distributed widely in Africa from Sierra Leone – Uganda, Zaire, Angola. In Nigeria, it occurs in the lowland rainforest zone especially in secondary forest and also in forest outliers. Herbarium records (FHI) show that the species could be found in Ibadan, Gambari Forest Reserve, Forest Hill, Ibadan, Shasha Forest Reserve, Ikom, Aponmu Forest Reserve, Olokemeji Forest Reserve and Akure Forest Reserve.

Uses: The bark, leaves and flowers are used chiefly for their emollient properties. A decoction of the young leaves forms a warm bath for febrile patients, especially children. The pounded bark is taken by women to increase lactation. An extract of the bark is drunk or rubbed on the head against dizziness, or rice cooked in the liquid extract is taken as a remedy. A decoction of the bark is regarded as emmenagogue among the Yorubas of Nigeria. The young leaves when dried and pulverised are sometimes used as a pot herb and the fresh leaves could be used as fodder for goats. The bark along with the spine attached is sold in the market for the preparation of ointment for treating skin diseases, such as craw-craw. Sheets of the bark are often used for roofing small huts or temporary shelters.

Botanical Name:	*Chrysophyllum albidum* G. Don
Synonym:	*Gambeya albida* (G. Don) Aubrév. & Pellegr.
Family:	Sapotaceae
Local Names:	Yoruba: osan agbalumo; Igbo: udala.

This is a fruit tree of the high forest zone of Nigeria. It attains a height of 50m but usually smaller. The bole is usually long and straight but often branched close to the ground. It is deeply fluted, sometimes with small buttresses at the base. The bark is pale greyish-brown usually exuding copious white latex when cut. The simple alternate leaves could be up to 24cm long and 7cm broad, oblanceolate, tapering rather rapidly to the acuminate apex and wedge-shaped base with whitish or yellowish fine tomentose beneath. Flowering occurs between April and June with the flowers in clusters in the axis of the leaves and covered with minute yellowish hairs. Fruiting occurs in the species between January and March. The fruits, which are edible, are a pale orange colour usually ovoid to subglobose and pointed at the apex.

Distribution/Habitat: The tree occurs in the lowland rain forest and also frequently planted in villages. It also occurs in Sierra Leone up to East Africa. Herbarium records (FHI & EFH) indicate the availability of the species in Onitsha, Ibadan, Mambilla, Adamawa, Aponmu Forest Reserve, Olokemeji Forest Reserve, Kafanchan, Ikom, Ado-Ekiti, Awka, Enugu, Owerri, Asaba, Nnewi.

Uses: The fruit is edible and according to Okafor (1991) jam, jellies and fruit juice can be produced from the fruit. The bark of the tree is used medically whilst the latex from the bark is used as bird-lime (trap).

Botanical Name:	*Dennettia tripetala* Bak. f.
Family:	Annonaceae
Local Names:	Yoruba: ata igberi; Edo: ako; Igbo: nmimi; Ibibio: nkarika.

A medium sized tree of up to 17m high and 70cm in girth with a dense compact crown. The bole is generally very sharp with strongly scented bark. The branchlets are glabrous. The leaves are simple, alternate and entire, about 6-12cm long by 3-5cm broad, elliptic to ovate, shortly acuminate, broadly cuneate to rounded at the base, glabrous above, sometimes sparsely and finely hairy beneath. The stalk is about 5mm long. Flowering occurs between October and April. The flowers are hermaphrodite on short peduncles on branches or bole, in pairs or singly. Fruiting takes place between April and May. The fruits are edible, with a peppery, spicy taste, green at first, eventually red, with finger-like carpels constricted between the seeds.

Distribution/Habitat: This species extends throughout the rain forests and sometimes occurs in forests in savanna areas. The range extends from Senegal to Cameroon. Very common in Oban group of forests and in Olokemeji Forest Reserve, Owena, Benin, Onitsha, Nnewi, Ukpor and Iko Efanga in Nigeria.

Uses: The young leaves and fruits have a distinctive spicy taste and are a very good source of vitamins.

Botanical Name: *Faidherbia albida* (Del.) A. Chev.
Synonym: *Acacia albida* Del.
Family: Leguminosae
Sub-family: Mimosoideae
English Name: Apple Ring Tree
Local Names: Hausa: gawo; Fulani: kyaski.

This tree is readily recognised by its grey-green foliage. It is a tree with straight bole up to 2.5m in height and 3m in girth. It has a very deep tap root, up to 20m. The bark is brown, thick, and fissured. In old trees the crowns are rounded. Branches are armed with white spines. The leaves are bipinnate with a stout common stalk 3-10cm long and are arranged alternately on the branches. Each bipinnate leaf has 3-7 pairs of pinnae. *Faidherbia albida* is a unique tree in that it has a reversed flush phenology. Quite unlike the related species in the genus *Acacia*, it sheds its leaves in the wet season and produces new leaves in the dry season. Flowering in the species is between October and January while fruiting occurs between January and May. The flowers are often in stout spikes in the axils of the leaves. They are yellowish in colour. The fruits which are elongated pods are usually yellowish-green when dry, about 10-15cm long and irregularly coiled.

Distribution/Habitat: The plant is both a Sudanian and Sahelian tree with its micro-habitat in the arid savanna and macro-habitat in the savanna of tropical Africa. The range also extends southwards in east Africa to Transvaal. Herbaria collections (FHI, ABU, AFG) show that in Nigeria, the species could be found in Kaduna, Kaltungo, Bauchi, Kano, Maiduguri, Jos and Adamawa.

Uses: The wood is used locally for the manufacture of handles for implements and utensils. The tree produces gum. Medicinal values of the species include anti-vomiting (bark) and as liniment for pneumonia. The bark is also useful for the control of coughs and could assist in difficult child birth. Ashes from the wood are often used in making soap and in dehairing and tanning of hides and skins.

The species is very useful in agroforestry in the semi-arid region. It has been reported that millet harvest was increased by 152% for crops adjacent to *Faidherbia* trees in comparison to millet grown away from the plant (Anon 1989). Leaves and ripe pods are good forage for livestock. Branches are used for construction of fences for livestock. Plants are also used in various ways to combat soil degradation.

Botanical Name: *Garcinia kola* Heckel
Synonym: *G. dinklagei* Engl.
Family: Guttiferae
English Name: Bitter kola
Local Names: Yoruba: orogbo; Igbo: adu; Edo: edun.

The tree is usually up to 14m in height and can sometimes reach 32m high with a spreading crown. The bole is usually straight with a brownish, smooth bark. The tree has drooping branches which are whorled. The leaves are simple, opposite, about 7.5-16.5cm long by 3-7.5cm broad, elongated, elliptic to broadly elliptic, acute or shortly acuminate at apex, cunneate at base; leathery with distinct resinous canals. The leaves have a stout stalk, finely hairy in young leaves and about 0.75cm long. Flowering between December and January, the flowers are greenish-white covered with fine reddish hairs. The flowers are usually in umbellate clusters at the end of short shoots. There are two types of flowers, the bisexual flowers are larger than the male flowers. Fruiting occurs between July and October. The fruits are usually reddish yellow about 7.5cm in diameter containing 2-4 brown seeds embedded in an orange coloured pulp.

Distribution/Habitat: The tree is usually found in the forest zone and could be cultivated. The distribution range extends from Sierra Leone to the Congo. Herbarium records (EFH, FHI) indicate the occurrence of the species at Ijebu-Ode, Benin, Omo and Okomu Forest Reserves, Onitsha, Nnewi, Degema, Ogoja.

Uses: Both the pulp and the seeds are edible. Seeds are used in performing traditional rites and offerings in local religious beliefs. Seeds are reputed as a poison antidote and are useful in the treatment of hepatitis (Iwu *et al.* 1987). It is often eaten to treat coughs and generally as traditional snacks. It is said to prevent heart attacks when eaten.

Botanical Name:	*Irvingia gabonensis* (O'Rorke) Baill.
Synonyms:	*Mangifera gabonensis* Aubry-Lecomte ex O'Rorke, *Irvingia barteri* Hook. f., *Irvingia tenuinucleata* Van Tiegh.
Family:	Irvingiaceae
English Names:	Wild Mango or Dika Nut
Local Names:	Hausa: goron biri; Yoruba: oro; Edo: ogwe; Igbo: obono; Efik: oyo.

A tree of about 25m height and 1.86m in girth, occasionally more in height. The tree is readily recognised by its dense dark green shining evergreen foliage and characteristic stipules. The bole is usually fluted and slightly buttressed. The bark is greyish, smooth or slightly scaly. The leaves are 6-12cm long by 3-7cm broad, elliptic to slightly obovate, shortly acuminate at apex, usually cuneate at base, leathery, dark green and shining. The leaves have a very stout stalk about 7cm long. Flowering occurs between November through March to June. The yellowish to greenish flowers are arranged in racemes or panicles among the leaves. Fruiting takes place usually between April and July and can also occur in September. The fruits are yellowish, broadly ellipsoid and about 6-9cm long with a yellowish fibrous pulp surrounding a large seed.

Distribution/Habitat: The species extends from Senegal to the Sudan and south to Angola. It is very common in the forest zone. Herbarium (FHI & EFH) records indicate that the species could be found in Onitsha, Nsukka, Ihiala, Ilaro, Aponmu Forest Reserve, Ikole, Ohe-Eshan, Irrua Forest Reserve, Ibadan and Shasha Forest Reserve.

Uses: It is a fruit tree and the seeds are used as soup condiment. Jams, jellies and fruit juice can be produced from the fruit (Okafor 1973 & 1991, Okafor & Okolo 1974). Useful for timber and construction of ships, canoes, pestles and other household utensils. It is said to be immune to attack by termites.

Botanical Name:	*Khaya ivorensis* A. Chev.
Synonyms:	*K. klainei* Pierre ex Pellegr., *K. caudata* Stapf ex Hutch. & Dalz.
Family:	Meliaceae
English Name:	African or Lagos Mahogany
Local Name:	Yoruba: oganwo; Edo: ogwango; Igbo: ono.

This is a timber species commercially referred to as African or Lagos Mahogany. It grows up to 70m in height and 8m in girth with conspicuous buttresses. The bark is scaly, grey or reddish-brown, sometimes dark brown. The pinnate leaves are always crowded at the ends of the branches. The leaves contain 4-7 pairs of leaflets, 9-16.2cm long by 3-6cm broad, oblong, abruptly long-acuminate at apex. The stalk of the leaflets is about 0.6cm long. Flowering is between September and December. The white flowers are in panicles. Fruiting occurs between February and June. The capsules are very woody and round, breaking when matured into 5 valves. The seeds are about 3cm in diameter and narrowly winged.

Distribution/Habitat: The distribution of *K. ivorensis* extends from Ivory Coast to Gabon and Cabinda. Very common in lowland rain forests. Herbarium (FHI) records indicate the presence of the species in Oluwa, Sapoba and Okomu Forest Reserves. It is also present in Gambari and Ilaro Forest Reserves.

Uses: "Oganwo" or African Mahogany is probably the most widely used of the true mahoganies. Its most important uses are for furniture and interior decoration both in the solid and as a veneer for surface covering. It is also used for good quality joinery, ships' cabins and railway coaches.

Medicinally, a decoction from the bark is used for the cure of lumbago, coughs and in preparation of lotion for rheumatic pains, malaria fever and other diseases.

Botanical Name:	*Massularia acuminata* (G. Don) Bullock ex Hoyle
Synonym:	*Gardenia acuminata* G. Don
Family:	Rubiaceae
Local Names:	Yoruba: pako-ijebu, orin-ijebu (Ijebu chewing stick).

Keay (1989) described the habit as a borderline case between a shrub and a tree. Plant usually up to 9m high. Young branches pubescent with short hairs. The leaves are large simple, opposite entire, oblanceolate, long acuminate and practically stalkless, with a pair of stipules at right angles to each pair of leaves. Flowering occurs in the species between September and December producing greenish white to pink or reddish purple bisexual flowers. Fruiting occurs between June and August. The fruits are glabrous, ovoid, beaked, 5-9cm long and up to 6.5cm in diameter, containing several tiny stony seeds.

Distribution/Habitat: The distribution range of the species covers Sierra-Leone, Guinea, Ivory Coast, Ghana and Southern Nigeria. It grows in the rain forest zone. Herbarium (FHI) records indicate that plants have been collected at Ijebu-Ode, Omo Forest Reserve, Ibuso-gboro, Gambari Forest Reserve, Okomu Forest Reserve, Warri.

Uses: The stem is used as a chewing stick and highly reputed for the curing of toothache and other mouth ailments. The rural dwellers earn considerable income from sales of the stem as a chewing stick. This exploitation is having a deleterious effect on the population of the plant in areas where it grows. Plants are not allowed to mature and fruit before being harvested. If the trend continues, the species will soon become endangered in Nigeria.

Botanical Name:	*Milicia excelsa* (Welw.) C. C. Berg
Synonyms:	*Chlorophora excelsa* (Welw.) Benth., *C. tenuifolia* Engl., *C. alba* Chev., *Morus excelsa* Welw., *Antiaris kerstingii* Chev., *C. regia* A. Chev. (partly)
Family:	Moraceae
Trade Name:	Iroko
Local Names:	Hausa: loko; Yoruba: iroko; Edo: uloko; Nupe: roko; Urhobo: uno; Igbo: oji; Ijaw: olokpata.

This plant is commercially known as "iroko". The tree usually attains a very large size, reaching up to 50m or more in height and up to 3m in diameter. The stem is usually cylindrical and mostly without buttresses. It is a deciduous tree with grey to dark brown or blackish bark, usually flaking off in small scales. The bole exudes a white resinous juice when slashed. The branches are in ascending order with a flat crown. The simple leaves, which are arranged alternately, can be 8-16cm long by 4-8cm broad; broadly elliptic and very shortly acuminate, usually unequally cordate but sometimes rounded at the base. Flowering occurs between December and March with the flowers occurring in single spikes in the axils of the young leaves. Male flowers are white, closely crowded in a slender pendulous catkin up to 16cm long. Female flowers are usually greenish in shorter and much fatter spikes, with styles of each flower projecting so that the inflorescence appears to be hairy (Keay 1989). Fruiting in the species occurs between February and April. The fruits are usually green, about 4-6cm long by about 2cm thick with short stalk, wrinkled and fleshy.

Distribution/Habitat: The tree has a wide natural distribution in tropical Africa, stretching from Sierra Leone to Tanzania and Mozambique, being especially exported from Nigeria and Uganda. It occurs in the rain forest and forest outliers in savanna woodland areas. Herbarium records (FHI, EFH) indicate that the species could be found at Olokemeji, Okomu and Sapoba Forest Reserves. It also occurs in Onitsha, Ibadan Jericho Reservation area, Sapele, Kabba, Benue, Zaria, Onigambari and Ijaiye Forest Reserves.

Uses: Iroko is one of the most useful woods from Africa and it is hard, long, very durable and well figured. The timber seasons very well either in kiln or under natural conditions. Iroko has excellent strength values and has great resistance to fungus and insect attack. Iroko is used for such purposes as high-class joinery, eg window frames, sills, stair treads, fireproof doors, and also for flooring. It is used for draining boards owing to its high resistance to decay and for laboratory benches because of its size. In Nigeria, it is used for building and other heavy construction works, such as railway sleepers, fence posts, etc. Medicinally, the resinous juice is used for the treatment of craw-craw. The ashes from the bark, when mixed with palm oil, are rubbed on swellings on the body. The bark when crushed in water or palm wine is taken for the treatment of heart troubles, lumbago and general fatigue. The fruits and leaves are used as fodder for goats. Igbos of Nigeria regard the plant as very sacred and it is usually preserved.

Botanical Name:	*Parkia biglobosa* (Jacq.) R. Br. ex G. Don
Synonyms:	*P. africana* R. Br., *P. clappertoniana* Keay
Family:	Leguminosae
Sub-family:	Mimosoideae
English Name:	Locust bean tree
Local Names:	Hausa: dorowa; Fulani: narehi; Kanuri: runo; Tiv: nune; Yoruba: igba; Edo: eyiniwan; Igbo: oririli.

This plant is popularly known as the locust bean tree. It is a fruit tree, of up to 27m in height and about 3.5m in girth. It has a short crooked bole with a very wide crown. The bark is grey, very rough and flaky. Bark exudes gum when slashed. Leaf is bipinnate, the stalk is very long, up to 54cm, and swollen at base. There are about 6-11 pairs of pinnae on each leaf arranged alternately, rarely opposite. Each pinna has 14-20 pairs of leaflets. Flowering occurs between December and March. The red flowers are usually hung in large globose heads at the end of long stalks. Individual flowers are almost stalkless. Fruiting occurs between February and July. The fruits are pods of about 18-36cm long by 3cm broad; usually light brown in colour containing numerous black seeds. The seeds are usually embedded in a yellowish, mealy sweet-tasting edible pulp. The seeds are usually covered with black fairly hard testa.

Distribution/Habitat: The species is widely distributed, extending from Senegal to the Sudan. In Nigeria, it is distributed over the lower Sudan savanna, southwards to the derived savanna and the lowland forest zones of the south. The wide ecological spread and the continuous erosion of the gene pool as a result of constant harvesting of the fruits and seeds for human consumption have made the species a candidate species for conservation (Soladoye *et al.* 1989; Ladipo *et al.* 1990). Herbarium records (FHI, ABU) show that the species could be found in Yola, Adamawa, Okenne, Okeho, Kaduna, Kabba, Mokwa, Birnin Gwari, Zaria, Kano, Bauchi, Markudi, Tegina.

Uses: The plant is economically important for its seeds, which are fermented to produce a popular condiment of several Nigerian dishes. It is now industrially produced as 'Dadawa cubes' and exported to neighbouring countries. The pulp of the fruit is sweet-tasting and is made into a refreshing non-alcoholic drink sold in rural markets. Oil extract from the seed is also edible. Extracts and washings (water) from the fermented seeds are very useful in preparing anti-termite chemicals. In some West African countries and the Sudan, the fruit husks, including the bark of the tree, are used in preparing fish poison. The bark is also used for tannin. The ash of the tree is used for soap making and preparation of snuff. Decoction from the bark of the species is used for curing fever while a mixture of the pulped bark and lemon-juice is often used for wound healing and treatment of ulcers, rickets and in preparation of a tonic.

Botanical Name: *Prosopis africana* (Guill. & Perr.) Taub.
Synonym: *Coulteria africana* Guill. & Perr.
Family: Leguminosae
Sub-family: Mimosoideae
Local Names: Hausa: kiriya; Fulani: kohi; Yoruba: ayan; Igbo: ubwa.

A tree of up to 15-20m high and up to 1.8m in girth with branches very low down. Bole clean for about 8-9m in plants growing in forest conditions. Bark very dark, fissured and scaly. Branchlets shortly pubescent or puberulous. Leaves bipinnate, greyish, green and drooping, petiole 2.5-6.6cm long, pubescent or puberulous. Rhachis about 2.7-9.5cm long; pinnae 2-4 pairs, glandular between most of the pairs of leaflets. Leaflets opposite 7-15 pairs, oblong or elliptic-lanceolate, 1.5-3cm long, 0.4-1cm wide narrowed to acute or subacute apex. Flowering occurs between December and February. The flower is creamy white or yellowish, fragrant, densely crowded in fat spikes 3-6cm long and about 1 cm broad. Spikes are solitary in the leaf axils. Individual flowers occur in shallow cup-like calyx. Fruits can be observed in April to May, sausage-shaped and very persistent, about 10-15cm long by 2.5cm thick. Fruit more or less cylindrical in shape, blackish, glossy and thick-walled. Seeds numerous in pod.

Distribution/Habitat: It is usually found in the savanna, especially in the Sudan and Sahel savanna zones. Its distribution range extends from Senegal to the Sudan and Uganda. Herbarium records (FHI, EBU) show that *P. africana* occurs in Sokoto, Nsukka, Lappai, Gurara Falls, New Bussa, Katsina, Zaria, Afaka, Ilorin, Oyo, Enugu, Adamawa, Zaria and Yola.

Uses: The wood is very heavy and hard and usually used for turnery, mortars, bedstead legs, canoes, railway sleepers, firewood and charcoal. Medicinally, the bark is useful in preparing lotion for wound healing. A decoction from the root is used for curing toothache. The leaves, young twigs and fruit pods are a delicacy to livestock. The pod is often appreciated by humans (Kennedy 1936).

Botanical Name: *Pterocarpus mildbraedii* Harms
Family: Leguminosae
Sub-family: Papilionoideae
Local Names: Hausa: madobiyar; Edo: urube; Urhobo: urhuko.

It is a medium-sized tree up to 27m in height and about 2m in girth, with drooping branches. Bark grey, smooth or longitudinally fissured. The bark oozes out bright red juice when slashed. Branchlets glabrescent. Leaves compound-pinnate with a glabrous common stalk 12-24cm long, usually with 5-9 glabrous leaflets which are sometimes opposite with upper leaflets up to 9-18cm long by 4.25-8.25cm broad, with various shapes, abruptly acuminate at apex, and rounded at the base. The lower leaflets are more ovate. Flowering is between January and March with the flowers occuring in axillary racemes, appearing with the new flush of leaves. Flower bract very conspicuous, calyx broadly cup-shaped, glabrous outside except for the margins of the shallow teeth. Fruiting occurs between March and May. Fruits are flat and papery.

Distribution/Habitat: The species could be found from Ivory Coast to Gabon under forest conditions. Herbarium records (FHI, EFH) show that the species had been collected at Onitsha, Ogbomosho, Ibadan, Ehor, Port-Harcourt, Benin, Mamu River and Sapoba Forest Reserves, Zaria, Birnin Gwari, and Kafanchan.

Uses: The wood is used for firewood while the leaves serve as a vegetable (Okafor 1991). The plant is used in fetish-groves and shrines in the Igbo lands of Nigeria. It is also used as a timber in southern Nigeria.

Botanical Name:	*Raphia hookeri* Mann & Wendl.
Synonyms:	*R. angolensis* Rendle, *R. gigantea* Chev., *R. sassandrensis* Chev., *R. longrostris* Becc. *R. maxima* Peschuel-Loesche
Family:	Palmae
English Name:	Raffia palm or wine palm
Local Names:	Yoruba: iko; Urhobo: ovie-ogoro.

A tree with a trunk up to 12m high with the upper part being very conspicuously tangled with a mass of black fibres. Usually single but occasionally with up to 4 suckers. Leaves massive, pinnate with very large midribs. Leaflets up to 60cm long and 6cm broad with a spiny margin. Flowering occurs usually in December. Inflorescence usually terminal with massive branched spadix, pendulous up to 24cm long. The plant is monocarpic. Fruits are top-shaped or ellipsoid, 6-15cm long by 4.5-6cm thick, with stout prominent beak about 1.5cm long.

Distribution/Habitat: The species is widely distributed from Guinea to Cameroon and south to Gabon, usually occurring in the swampy areas in forest regions in colonies and could be cultivated. Herbarium specimens have been collected at Ibadan, Ogoja, Oshogbo, Ikom, Ila, Benin, Warri, Sapele, Lagos, Ijebu Water side, Abeokuta, Okitipupa.

Uses: This is the common wine palm of the forest zone. It is also cultivated for palm wine production. Wine is obtained by tapping the inflorescence. Some varieties yield over 10 gallons of palm wine a day (Otedoh 1974). It is a source of piassava and raffia fibres used for weaving bags and mats. The bamboos are used for house construction and for making beds, stools and chairs. Mesocarp of seed when crushed is used in the killing or stupefaction of fish.

Botanical Name:	*Tetrapleura tetraptera* (Schum. & Thonn.) Taub.
Synonyms:	*Adenanthera tetraptera* Schum. & Thonn., *Tetrapleura thonningii* Benth.
Family:	Leguminosae
Sub-family:	Mimosoideae
Local Names:	Yoruba: aridan; Igbo: oshosho; Edo: ighimiakia; Nupe: ikoho.

A tree up to 28m in height and 3.5m in girth. The bole is usually without buttress, but sometimes with small sharp buttresses. The bark is usually smooth, greyish, very thin with reddish strong-smelling slash. The leaves are bipinnate, glabrous or minutely hairy with a common stalk 16-28cm long, usually with 5-9 pairs of pinnae, opposite but sometimes alternate; 6-12 glabrous leaflets on each side of the pinna-stalk, always alternate. Flowers between January and April and also between June and July with flowers appearing after a new flush of leaves. Infloresecence is a raceme with pink or cream coloured flowers, usually in pairs in the upper leaf-axis. Fruiting occurs mostly in November and March. However, fruits have been collected on some trees in May, June and August. The fruits, which are strongly scented, are usually very persistent, hanging at the ends of the branches on stout stalks and are about 14-28cm long and 4-6cm across with wing-like ribs. The indehiscent fruits are dark purple-brown, glabrous and glossy, usually slightly curved. The seeds are black and flat.

Distribution/Habitat: It is widespread in tropical Africa in secondary forest. Herbarium records (FHI) indicate that the species could be found in Ibadan, Ikom and some Forest Reserves, such as Olokemeji, Okomu, Sapoba, Gambari, Aponmu and Akpaka.

Uses: The soft wings or ridges of the fruit are edible. The fruit is used in preparing soup and food flavours. The bark is usually prepared for use as an enema for constipation. The fruit could also be used in preparing pomade for use in curing rheumatism and also used in improving fertility in females. The bark is needed in preparing enema for coughs. The pod ashes are used as salts and also in soap making. The bark has various medicinal uses such as after illness tonic, beverage and enema against gonorrhoea.

Botanical Name:	*Triplochiton scleroxylon* K. Schum.
Synonyms:	*T. johnsoni* C. H. Wright, *T. nigericum* Sprague, *Samba scleroxylon* (K. Schum.) Roberty.
Family:	Sterculiaceae
English Name:	Obeche
Local Names:	Yoruba: arere; Edo: obeche; Orhobo: ewowo; Itsekiri: egin-fifen; Igbo: okpobo.

A deciduous tree, native to West Africa where it has been identified as a light demander and an early coloniser of secondary forest. It reaches up to 60m in height with a girth of about 6m and producing a light hardwood of 384kg/m^3. It has a straight cylindrical bole with greyish bark. Leaves alternate, compound digitate, palmately lobed with up to 7 lobes but usually 5. Leaf stalk up to 8cm long. Flowering occurs between September and February. The inflorescence is a paniculate cyme. Each inflorescence is about 4-5cm long. Flower buds are covered with three early caducous broadly elliptic bracts about 3-5mm long, 2.5-4mm wide and softly tomentose on the upper surface and pilose on the lower. Fruiting occurs between January and April. The fruit is a samara, and composed of 5 winged carpels. The maricarp may be densely or sparsely pilose either from the point of attachment to the slit at the apex or only on the slit and at the point of attachment.

Distribution/Habitat: The species occupies a narrow band from Sierra Leone in the west to Central Africa in the east. It is most abundant in Nigeria, Ghana and Ivory Coast where it forms 13% of trees over 61cm in girth at breast height and 20% of those with 183cm girth at breast height (Hall & Bada 1979). The tree occurs mostly on ferruginous soils derived from the basement complex and in localities with between 1 000-2 500mm rainfall per annum. Optimal temperatures for the growth of *T. scleroxylon* ranges from 25°C to 35°C (Hall & Bada 1979). Herbarium records (FHI, EFH) indicate that the plants have been collected at Onitsha, Sapoba, Akure, Gambari Forest Reserve, Olokemeji Forest Reserve, Ibadan, Ikirun, Zaria, Benin, Ondo, Ilesha and Owo.

Uses: Obeche is a timber species used for plywood, interior joinery, boat building, corewood for blockboard, match boxes, match splints, panelling, blackboards, food containers, domestic wood-work, artificial limbs, motor bodies, etc. The young shoots and foliage are used as a vegetable while the insect pests of the species are good protein sources in Africa.

Botanical Name:	*Vitellaria paradoxa* Gaertn. f.
Synonyms:	*Butyrospermum paradoxum* (Gaertn. f.) Hepper, *B. parkii* (D. Don) Kotschy
Family:	Sapotaceae
English Name:	Shea butter or shea nut tree
Local Names:	Hausa: kadanya; Fulani: kareje; Tiv: chanimal; Yoruba: emi, emi-emi; Igbo: osisi.

Tree usually up to 15m in height and about 7m in girth. The bark is dark grey, rough, deeply fissured into more or less square pieces. The leaves are clustered at the end of stout twigs, and could be up to 18cm long and 7cm broad; elongated or slightly broadest in the upper half, usually rounded at the apex and densely hairy while young. Older leaves have sparse hairs. The stalk could be between 3-8cm long. Flowering occurs between January and February. The flowers are fragrant long stalked, clustered at the ends of leafless twigs. Fruiting in the species occurs between May and August. The fruits are usually yellow, ellipsoid, about 4cm long and 2cm broad, usually with one seed but occasionally with 2 or 3 seeds. The seeds are ovoid about 3cm long by 2cm broad with a hard bony testa and shield-shaped scar.

Distribution/Habitat: The species occurs from Senegal to the Sudan and Uganda. It is commonly found in savanna woodland, especially on poor soils. It occurs in scattered patches in the Sudan zone of northern Nigeria. Herbarium records (FHI, ABU) indicate that the species could be found in Ibadan, Kabama Forest Reserve, Adamawa, Old Oyo Forest Reserve, Olokemeji Forest Reserve, Awba Hills, Lafiagi, Zaria, Birnin Gwari, Kaduna, Kotangora, Tegina, Mokwa, Kainji and Jebba.

Uses: This is the well known shea butter tree of northern Nigeria. It is a source of edible oil which is extracted from the seeds. The shea butter from the seed is used in the soap and candle industries. It is also used in preparing a local pomade. The shea butter is very useful medicinally, for both humans and horses. The commercial potential of the shea butter is enumerated by Kio & Ladipo (1987), Soladoye *et al.* (1989), Igboanugo & Soladoye (1992) and Ogigirigi (1985). The wood is used for carving and for making wooden bowls as well as very durable mortars and pestles.

Botanical Name:	*Vitex doniana* Sweet
Synonyms:	*V. umbrosa* G. Don, *V. cuneata* Schum. & Thonn., *V. cienkowskii* Kotschy & Peyr.
Family:	Verbenaceae
Local Names:	Hausa: dinya; Fulani: galbihi; Yoruba: cori-nla; Igbo: ucha koro.

A tree up to 18m high and 3m in girth, with a dense rounded crown and dark glossy green foliage. The bark is grey to pale brown, finely fissured longitudinally. The digitately compound leaves have a common long stalk which could be 9-18cm long with 5-7 obovate to very broadly elliptic leaflets, most rounded at the apex and tapering to the cuneate base. Flowering is between January and April. Inflorescence is branched and axillary. Flowers are purplish-white. Fruiting occurs in March. The fruit is a drupe, globose and about 2.5cm in diameter. Black when ripe.

Distribution/Habitat: Very common in the savanna woodland of tropical Africa. Herbarium records (FHI, EFH, ABU) indicate that the species could be found in Iseyin, Obodu, Abeokuta, Sepeteri, Sokoto, Kano, Jos, Bauchi, Enugu, Ikom, Gashaka, Zamfara Forest Reserve, Afaka Forest Reserve, Awun Forest Reserve and Idanre Forest Reserve.

Uses: The fruits of *V. doniana* are edible and the young leaves are consumed as a vegetable. The flowers and fruits usually attract bees and are therefore useful in bee keeping. The young leaves are also used in making ink. The ashes are used for soap making. Medicinally, decoctions from the leaf are drunk to the treatment of dysenteric diarrhoea. The leaves and bark are said to be useful in inducing conception in females.

Botanical Name:	*Xylopia aethiopica* (Dunal) A. Rich.
Synonyms:	*Unona aethiopica* Dunal, *Xylopia eminii* Engl.
Family:	Annonaceae
Local Names:	Hausa: kimba; Fulani: kimbare; Yoruba: erunke; Edo: unien; Efik: atta; Igbo: uda; Ibibio: ata; Nupe: tsunfyanyi

A tree or shrub usually tall, evergreen, up to 45m high and about 20cm diameter.

Bole straight, often buttressed, with grey fairly smooth bark. Crown profusely branched with branches and branchlets containing numerous whitish lenticles. Leaves alternate, simple, petiole 2-9mm long, blade elliptic, ovate or oblanceolate 6-17cm long, 3-6cm wide, apex obtuse to markedly acuminate, margins entire, coriaceous, dark green glabrous above, very pale glaucous green, glabrescent below. Flowering occurs in the species between March and November producing axillary inflorescences with thick pedicles. The flowers are solitary or in 3-5 flower clusters. *X. aethiopica* fruits between June and March. Fruit has about 10-12 fingers (carpels) on a common stalk. Matured fruit is reddish at first, eventually turning black. Each fruit contains about 5-7 seeds.

Distribution/Habitat: Distribution extends from Senegal to Angola, Sudan and Mozambique. It is found in evergreen rainforest, lowland forest, riverine and swamp forest in Nigeria. FHI records show that the species has been collected at Ijehu-Ode, Omo Forest Reserve, Sapoba, Mamu Forest Reserve, Owerri, Calabar, Ikom, Onitsha.

Uses: The folk medicinal uses of *X. aethiopica* are listed in our contribution to the FAO publication of some medicinal forest plants of Africa and Latin America (FAO Forestry Paper 67, 1986). A decoction of the fruit of this plant with other species listed in the above publication is used as remedy for stomach-ache, coughs, ammenorrhoea and for bathing of children as anti-convulsant. The fruit is also useful in the preparation of medicine for dizziness, and it is an important condiment in the Yoruba native decoction (Agbo). Dalziel (1937) reported that a fluid extract or a decoction of the fruit or bark is useful in the treatment of bronchitis, dysenteric conditions and biliousness.

Botanical Name:	*Zanthoxylum zanthoxyloides* (Lam.) Zepernick
Synonym:	*Fagara zanthoxyloides* Lam., *Zanthoxylum senegalense* DC., *Zanthoxylum polygonum* Schum. & Thonn., *Fagara senegalensis* (DC.) A. Chev.
Family:	Rutaceae
English Name:	Candle wood
Local Names:	Hausa: fasakwari; Yoruba: ata; Fulani: fasakorihi; Edo: ughanghan; Urhobo: ujo; Itsekiri: atako; Ijaw: korokumo.

A shrub or tree up to 18m high and 0.5m in diameter. The bole is grey and armed with large woody thorns that usually fall off due to aging, leaving the bark covered with very thick cork. Branches and branchlets are also armed with curved sharp spines. Leaves are alternate, compound with a common stalk up to 10cm long. Leaflets are about 3-5, opposite or nearly opposite pairs often with a terminal leaflet, oblong or oblong-oblanceolate, rarely elliptic or obovate 4-10cm long, 2-3.5cm broad, apex rounded or notched or very abruptly and shortly acuminate, base broadly cuneate, margins entire; coriaceous, smooth, shining, medium green above, dull light green below. It flowers between January and February and also between May and August; producing greenish-white flowers. The inflorescence is axillary or terminal panicles. The flowers are unisexual due to abortion, greenish white to cream white, 2-3mm long. Fruiting occurs between July and September. The fruit is red and ellipsoid with only one blue black seed.

Distribution/Habitat: It is widely distributed in west tropical Africa from Senegal to Cameroo. Herbarium records (FHI, EFH) show that plants have been collected at Minna, Eruwa, Ibadan, Abeokuta, Ikeja, Enugu, Nsukka, Asaba, Benin and Awka.

Uses: A mixture of the powdered bark of the species and fruits of *Piper guineense* and that of *Xylopia aethiopica* taken with pap is said to be good for the treatment of general body weakness. Also good for the treatment of swollen legs or elephantiasis and checking of over-development of the spleen. A root powder of *Z. zanthoxyloides* is useful in the control of toothache, cure of sore throat, and relief from indigestion as well as treatment of gonorrhoea or as a urinary antiseptic. It is also used for the cure of impotence. Research work has been going on for the past two decades on the medicinal use of anti-sickling agents from the roots of *Z. zanthoxyloides* (Sofowora & Isaacs 1971). Tannin extracted from this plant when used in combination with tannin extract from *Rhizophora racemosa* is used to tan skins or leather.

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D. TRINIDAD AND TOBAGO: STATUS REPORT ON KEY ANIMAL SPECIES

By M. ALKINS-KOO AND S. SOOMAI

D.1 Introduction

The Interim Technical Committee on Biological Diversity and Genetic Resources decided at its meeting of 17 July 1990 to initiate one of its objectives by compiling a status report on key species of animals for Trinidad and Tobago. A graduate student was hired for four months to collate the available information and conduct the necessary interviews forming the basis of the report. The format of the report is structured upon a questionnaire from the Commonwealth Science Council which refers to potentially valuable plants. Some difficulty was experienced in translating individual questions into the context of animals and as a result, the general headings for sections of the questionnaire were used as the basis for this report instead of attempting to answer specific questions.

In addition, the original CSC questionnaire refers largely to under-exploited species of potential economic importance. However, it is the authors' opinion that many local animals have a high potential economic importance for sustained exploitation/production, e.g. aquaculture of local fish species or ranching of game mammals, but these same species are at present over-exploited in the wild. This lead to some confusion as to exactly which species should be considered for the lists. In order to make the list as useful as possible in terms of deterring *valuable* animal species, it was decided to consider all local species of potential importance whether under- or over-exploited.

D.2 Survey and documentation of potentially valuable animals

The vertebrate fauna of Trinidad and Tobago is comparatively well known with several accounts of species available. The knowledge of the invertebrates, however, is patchy and dependent upon the economic importance of the group (e.g. veterinary and crop pests) or their aesthetic/collection value (Mollusca, Lepidoptera).

Identification of Key Species for Conservation and Socio-Economic Development
Edited by P. Kapoor-Vijay and M.B. Usher.

Several major libraries and collection of identified reference specimens exist (Table 1). The subject of maintenance and co-ordination of reference collections has been dealt with separately and in more detail by the Subcommittee of the Interim Technical Committee chaired by Dr P. Baker. The role of reference collections in the assessment of local faunas is invaluable and must be given more attention in future. Reference collections for certain groups may exist for which supporting literature (checklists, keys or catalogues) are lacking, thus making them the only source available for assessment of these groups. Conversely, for taxonomically difficult groups, literature may be available but in the absence of a collection, is of limited value for the non-specialist.

Table 1 Institutions housing libraries or reference collections which serve as source material on the fauna of Trinidad and Tobago. Details of the areas covered by each institution are given.

Institution	Library	Reference Collection
Caribbean Epidemiology Centre (CAREC) Port of Spain	Medical/veterinary entomology	Mammals, birds, insect vectors
Central Experimental Station (CES) Centeno	Crop entomology	
Emperor Valley Zoo Port of Spain	General	Living collection
Institute of Marine Affairs (IMA) Chaguaramas	Marine	Marine
International Institute for Biological Control (IIBC) Curepe	Pests, biological agents (access to CAB database)	Pests biocontrol agents
The National Museum Port of Spain		Limited
Pointe-a-Pierre Wildfowl Trust Pointe-a-Pierre	Limited	Peter Percharde mollusc collection
The University of the West Indies St Augustine	General (Main Library Zoology Department)	General (Zoology Dept)
Wildlife Section, Forestry Division St Joseph	Terrestrial wildlife and waterfowl	Limited (mammals, birds)

Source references available for the most important groups of animals are given in Table 2. Attempts to update information contained in the references is continuing at various research institutions. The Department of Zoology, University of the West

Table 2 Sources for the identification of animals of importance for Trinidad and Tobago.

Taxon	References
Mammals	Goodwin & Greenhall (1961, 1964) [keys to bats], Alkins (1979) [annotated list of species], Boos (1986) [checklist]
Birds	Bond (1960) [Caribbean], Herklots (1961) [Trinidad & Tobago], ffrench (1980, 1988) [Trinidad & Tobago]
Reptiles	Underwood (1962) [all reptiles], Emsley (1977) [snakes of Trinidad& Tobago]
Amphibia	Kenny (1969, 1971, 1977) [larval and adult keys]
Fish	Price (1955) [freshwater], Boeseman (1960, 1964 [freshwater, keys], Fischer (1978) [marine fish of fisheries importance], Randall (1968) [Caribbean marine fishes], Hoese & Moore (1977) [Gulf of Mexico marine fishes]
Insects	Many monographs exist for specific groups, Pollard & Francis (1989)
Crustacea	Chace (1972) [marine and estuarine shrimps], Chace & Hobbs (1969) [crabs, prawns], Fischer (1978) [crustacea of fisheries importance], Stonley (1970) [marine, estuarine, freshwater crabs]
Mollusca	Bacon (1975) [mussels], Baboolal & Johnatty (1982) [chitons], Warmke & Abbot (1961) [marine gastropods, bivalves], Humfrey (1975) [marine gastropods, bivalves]
see also	Emsley (1977); ffrench (1980, 1984); Kenny & Bacon (1981), Price (1955), Thelen & Faizool (1980)

Indies, produces an Occasional Paper series which attempts, *inter alia*, to produce faunal accounts, e.g. Cock's (1979) catalogue of the Hesperiidae, Michalski's (1988) catalogue and keys to the Odonata. In addition, publications of individual researchers in local or international journals contribute to expansion of knowledge of local faunas (e.g. Alkins-Koo 1990). The Forestry Division, Wildlife Section have produced questionnaires which are distributed to the public and hunters, e.g. James (1981-82, 1982-83) to collect data on game species. A Bibliography is also being compiled by the Wildlife Section.

Annex D.1 is an inventory of the indigenous species of animals, many of which are either of importance in the traditional economy of Trinidad and Tobago or are considered threatened in status and therefore of value for conservation. Their natural habitats and main areas of distribution as well as traditional uses are given. Bats and native rodents are not included due to inadequate information on their status. It was extremely difficult to isolate the top ten most important species since many more than ten are of economic value or of conservation interest. However, Tables 3 and 4 list the most important species of conservation interest and economic importance respectively for each of the major taxa. No attempt was made to identify ten of the most important species of animals for all taxa.

The value of wild animals is apparent in many different ways (James 1983). The use of these animals for food is of priority importance to social and economic development due to their direct nutritional value in subsistence hunting/gathering and due to income derived from sales of the animals and indirectly from sales of items related to hunting or fishing (Asibey 1984a).

Another very important use of these animals is in recreation or for aesthetics. In recent times the concept of ecotourism has become popular and both local and foreign tourists are attracted to certain natural areas as a result of their component wildlife. Economic benefits are obtained from the sale of equipment or supplies to support photography, birdwatching or art. Income may be derived from accommodation, tours and craft sales and jobs may be created from these and related activities (Ramdial 1980).

The use of animals in the live trade as pets is also important. The prices of some selected song birds on the local market may be exorbitant. As well, there is export of live animals for the international pet trade. Freshwater fish such as the teta and pui pui are exported in the aquarium trade.

Medicinal uses are important in the following ways:

Disease monitoring – howler monkeys are very susceptible to yellow fever and mass deaths of monkeys occur immediately preceding outbreaks in human populations.

Traditional medicine – certain animal products are used, e.g. snake oil for stiff joints; matte fat for rheumatism and arthritis; porcupine quills for toothache. Modern medicine – species of marine invertebrates such as the sponge *Tethya crypta* which occurs in local waters have been found to contain important compounds which may be used against leukaemia, some forms of cancer or viruses. Research is being conducted by the University of the West Indies on the following:

a) The antiviral component in the tunicate, *Eudistoma olivaceum*, found on the prop roots of mangrove trees in the Caroni Swamp.
b) Extraction of antitoxin from game animals to enhance the domestic breeding of wild animals.
c) Extraction of thyroid and other hormones from the reproductive glands of animals which breed easily in captivity, viz. the brocket deer and agouti, to facilitate farming/breeding on a large scale.

Table 3 Key vertebrate species of conservation priority.

Common Name	Scientific Name
Mammals:	
Manatee	*Trichechus manatus*
Red howler monkey	*Alouatta seniculus insularis*
Woolly opossum	*Caluromys philander trinitatis*
Capuchin	*Cebus albifrons*
Porcupine	*Coendu prehensilis longicaudatus*
Silky anteater	*Cyclope didactylus didactylus*
Tayra	*Eira barbara trinitatis*
Ocelot	*Felis pardalis*
Otter	*Lutra enudris*
Crab-eating racoon	*Procyon cancrivorus cancrivorus*
Birds:	
Pawi	*Aburria pipile*
Blue and yellow macaw	*Ara ararauna*
Yellow-headed parrot	*Amazona ochrocephala*
Red-bellied macaw	*Ara manilata*
Scarlet ibis	*Eudocimus ruber*
Tobago picoplat	*Sporophila americana*
Picoplat	*Sporophila intermedia*
Robin	*Sporophila minuta*
Bullfinch	*Oryzoborus angolensis*
Twa twa	*Oryzoborus crassirostris*
Moriche oriole	*Icterus chrysocephalus*
Red siskin	*Spinus cucullatus*
Fulvous whistling duck	*Dendrocygna bicolor*
Black-bellied whistling duck	*Dendrocygna autumnalis*
Great blue heron	*Ardea herodias*
Anhinga	*Anhinga anhinga*
Blue-winged teal	*Anas discors*
Limkin	*Aramus guarauna*
Boat-bellied heron	*Cochlearius cochlearius*
Pinnated bittern	*Botaurus pinnatus*
Osprey	*Pandion haliaetus*
Reptiles:	
Green turtle	*Chelonia mydas*
Hawksbill turtle	*Eretmochelys imbricata*
Leatherback turtle	*Dermochelys coriacea*
Pacific ridley	*Lepidochelys olivacea*
Yellow-footed morocoy	*Geochelone denticulata*
Red-footed morocoy	*Geochelone carbonaria*
Anaconda	*Eunectes murinus*
Mangrove snake	*Liophis cobella*
False coral	*Erythrolamprus aesculapii ocellatus*
Ocellated gecko	*Gonatodes ocellatus*
Amphibians:	
Golden tree frog	*Phyllodytes auratus*
Surinam toad	*Pipa pipa*

Table 4 Key species of animals which are of potential importance for food and other uses by captive breeding and aquaculture.

Common Name	Scientific Name
Mammals::	
Agouti	*Dasyprocta agouti*
Deer	*Mazama americana trinitatis*
Lappe	*Agouti paca*
Wildhog	*Tayassu tayaçu*
Tatoo	*Dasypus novemcinctus novemcinctus*
Manicou	*Didelphis marsupialis insularis*
Birds:	
Cocrico	*Ortalis ruficauda*
Seedeaters	*Sporophila* species
Seed finches	*Oryzoborus* species
Ducks	*Dendrcygna* species
Reptiles:	
Common iguana	*Iguana iguana*
Matte	*Tupinambis nigropunctatus*
Caiman	*Caiman scleops*
Galap	*Rhinoclemys punctularia*
Morocoy	*Geochelone* species
Fish:	
Cascadu	*Hoplosternum littorale*
Pui pui	*Corydoras aeneus*
Teta	*Hypostomus robinii*
Sword-tailed tetra	*Corynopoma riisei*
Blue coscorob	*Aequidens pulcher*
River catfish	*Rhamdia quelen*
Snook	*Centropomus* species
Mountain mullet	*Agonostomus monticola*
Grey mullet	*Mugil* species
Grey snapper	*Lutjanus griseus*
Mollusca:	
Mok	*Mytella* species
Mangrove oyster	*Crassostrea rhizophorae*
Chip chip	*Donax* species
Gaudy asaphis	*Asaphis deflorata*
River conch	*Pomacea urceus*
Black conch	*Melongena melongena*
Sea conch	*Strombus* species
Crustacea:	
Shrimp	*Penaeus* species
Prawn	*Macrobrachium* species

Certain ecological functions are also carried out by wild species of animals:

Biological pest control – control of insects by birds and bats, control of rodents, slugs and snails by snakes or birds of prey, are examples of this function. Further, some species may be of value as biocontrol agents in other countries, e.g. the snail *Marisa cornuarietis* is used as a predator of schistosome snail vectors, and many insect species are used as pest predators or parasites.

Environmental sanitation – scavenging of carcasses and other organic material is carried out by mongoose and corbeaux.

Forest regeneration – seed dispersal in tropical forests may be accomplished by animals such as agouti, bats or birds. In some cases preliminary digestion of the seed coat while in the gut of these animals may be necessary in order for successful germination to take place.

Fruit production – pollination of flowers by bats, birds and insects is essential for fruit production and may be critical in commercial production of fruit, e.g. cocoa.

Soil conditioning – degradation of organic material and mixing of soil is doneby the activities of a host of soil invertebrates such as earthworms, millipedes and insects.

The distribution of species is well documented (Annex D.1). Various research institutions as well as amateur naturalists have contributed to this exercise. Many species exist in areas under control of the State such as forest reserves, wildlife sanctuaries and nature reserves (Thelen & Faizool 1980; CNPPA 1982; Scott & Carbonell 1986). Some private lands are managed as nature reserves/centres (Reddock 1974). Table 5 lists areas which fall under the above categories of protected area. Legislation establishing these areas include the Forest Reserves Act of 1950, the Conservation of Wildlife Ordinance No. 16 of 1958, and the Marine Preservation and Enhancement Act of 1970. In 1980 a much more extensive system of national protected areas was proposed (Thelen & Faizool 1980) but this has not yet been officially established.

The status of national protected areas is variable with some being adequately managed for their original protective objectives, others are not and are even experiencing severe disruption (Bacon & Ffrench 1972; CNPPA 1982). All of the national reserves need adequate patrols by wardens. The present status of each State protected wildlife sanctuary is dealt with below. The private reserves may be the only areas where wildlife species thrive because of the ability to restrict activities more effectively.

Northern Range: El Tucuche is one of only two localities (the other being El Cierro del Aripo) where the golden tree frog, *Phyllodytes auratus*, occurs. Recent sightings of the species have become rare. Threats include poaching of game species and forest fires.

Table 5 Existing protected areas in Trinidad and Tobago.

Status	Name of Area
Wildlife sanctuary	Northern Range Valencia Central Range Trinity Hills Southern Watershed Little Tobago Saut D'Eau Soldado Rock Caroni Swamp Kronstadt Island Morne L'Enfer St Giles Islands Bush Bush
National nature reserve	Mt Harris Tamana Hill Melajo Rochard Douglas Brickfield No 1 Brickfield No 2 Brickfield No 3 Blue Basin Mahagual Morne Diablo Long Stretch
Marine restricted area	Buccoo Reef
Private nature reserves/parks	Asa Wright Nature Centre Pointe-a-Pierre Wildfowl Trust Simla Research Station El Naranjo Tropical Gardens Palmiste Estate Savanna Caledonia Estate Oropouche Caves, Brothers' Estate Non Pareil Estate St Marie Estate Christiandora Development Blue Basin Oropouche Lagoon Grafton Estate Bon Accord Lagoon North Coast Reserve Mt Irvine Bay Hotel Bird Sanctuary Buccoo Swamp L'Anse Fourmi Estate Bird of Paradise Inn Kilgwin Lagoon and Swamp

Valencia: This area is home to 50 species of birds which include doves, antbirds, manakins, flycatchers and tanagers. Game animals are also present. Patrol of the area is difficult due to the numerous gravel pits. The area has suffered great losses from poaching, quarrying, timber harvesting, establishment of pine plantations and forest fires.

Central Range: This area includes most of the game animals, red howler and capuchin monkeys. Birds such as manakins, flycatchers, antbirds, trogons, woodpeckers, toucans and the pawi may be seen there. In recent times there has been reforestation with teak thus negatively altering the wildlife habitat. Threats include poaching and forest exploitation.

Trinity Hills: This area contains a high diversity of fauna with game mammals, wild cat and the reptiles are well represented (including the morocoys). Thirty-one species of birds have been recorded including the most reliable record of the pawi. It is one of the few areas where wildlife is still relatively abundant due to its inaccessibility. Disturbances include oil exploration and poaching.

Southern Watershed: Species present here are similar to those in the Trinity Hills. However, the wildhog population is reported to have been reduced substantially. Squatting on the boundaries and inadequate patrols are some reasons for decline in wildlife numbers. Introduction of teak has also taken place here.

Little Tobago: This island is the habitat of the Bird of Paradise and 58 other species, mainly seabirds. Proper management and protection against poaching of eggs and chicks of seabirds are necessary.

Saut D'Eau Island: This island supports the only breeding colony of the brown pelican *Pelicanus occidentalis*. Other birds can also be seen here. Its inaccessibility prevents much poaching and wardens given ample protection.

Soldado Rock: A variety of seabirds, iguana and other lizards occur on this small island. Due to its inaccessibility it is relatively well protected but some poaching takes place.

Caroni Swamp: This area supports a diversity of shellfish, insects, birds, crabs, finfish, shrimp and other crustaceans and mammals such as the silky anteater. The diverting of drainage systems nearby has altered the hydrology of the swamp causing certain major vegetational changes to occur. Pollution is also a major threat. Most economically important species such as the mangrove oyster have been over-exploited. The status of the most prominent species in the swamp, the scarlet ibis, is uncertain. Changes in the salinity and fauna of parts of the swamp have apparently resulted in the lack of appropriate food for scarlet ibis nestlings and the trend towards birds nesting elsewhere in Trinidad or on the mainland. Patrols have been hindered by the lack of a functional boat engine for some years.

Kronstadt Island: Birds are the main existing species and some efforts have been made for the protection of the habitat. However, extensive quarrying of the island for barytes has significantly affected the wildlife and poaching does occur. The introduction of cats has also affected populations of some species.

Morne L'Enfer: Game animals and birds are most common. Threats include poachers and intensive oil exploitation.

St Giles Islands: This is the only breeding site in the country of the magnificent frigate birds *Fregata magnificens* and the red-footed booby *Sula sula*. Nest raids on the island have reduced their numbers.

Bush Bush: Red howler and capuchin monkeys, reptiles, fish and insects and 171 species of birds have been recorded from this area of Nariva Swamp. Threats include hunting, fishing, forest exploitation and cattle grazing (recently controlled). Efforts have been made to improve the status of this area but it is very accessible and also used for illegal purposes such as the growing of marijuana.

Inventories of the pockets of diversity of important species have been conducted by various research organisations as well as the Forestry Division, Wildlife Section in conjunction with international organisations such as the OAS and the FAO (Thelen & Faizool 1980; Bindernagel 1984; Asibey 1984b). The Wildlife Section also has an ongoing programme where its wildlife officers make continuous surveys of game animals in the field and recently extension of this work has begun to include invertebrates such as insects.

The Wildlife Section of the Forestry Division is the primary unit responsible for surveying and documenting wildlife species. Manpower and transportation are limited and scientific officer are often graduates hired on a temporary and daily paid basis. Financial resources are derived directly from government grants. For the year 1990 this amounted to TT$40,000 for research purposes. Marine, freshwater and other terrestrial organisms are surveyed and documented depending on interest by researchers of the University of the West Indies (UWI), Institute of Marine Affairs (IMA) and other organisations. Funding for these projects is largely from Government.

The Wildlife Section of the Forestry Division gives on-the-job training to all its Wildlife Officers. The basic requirement for such a job is an undergraduate degree in Zoology, Ecology or Agriculture or a Diploma in Forestry and Wildlife Management from the Forestry School of the Eastern Caribbean Institute for Agriculture and Forestry (ECIAF). Sub-professional training can be received at ECIAF. Undergraduate or postgraduate training in wildlife management would be valuable to produce more research officers who can initiate and direct scientific studies. At present, such levels of training can not be had at the UWI or other institutions. Current training available at the UWI is very strong in marine and freshwater sciences; more emphasis needs to be put into terrestrial ecology and wildlife management.

D.3 Evaluation and growth characteristics of target species

Some potentially valuable species of animals have been investigated for their biology and potential for exploitation by various researchers. At present two main groups of animals have high potential for exploitation for food other than from wild stocks, viz. game animals and aquatic crustacea, mollusca and fish. The potential of species for uses other than for food has not been adequately investigated.

Attempts have been made to rear and breed in captivity some game animals locally. The most appropriate species for this are agouti, lappe, deer, wildhog, cocrico and ducks. Limited success has been obtained with tatoo and manicou because of the special care needed for the young. Similarly, morocoy has been farmed but without much success. No commercial farming on a large scale is undertaken; most operations are small scale, in backyard pens or enclosures. Studies on the biology and rearing techniques of these species are listed in Table 6. A review of species amenable to farming and details of farming the most important of these are given by Asibey (1984c) and Wildlife Section, Forestry Division (1989). The Wildlife Section, Forestry Division has a great deal of experience with captive breeding and rearing of game species but details are not published. The Pointe-a-Pierre Wildfowl Trust is a private body involved in captive breeding of several waterfowl species of conservation interest but no publications have been produced.

Aquatic organisms with potential for culture include fish, mollusca and crustacea. Publications which give details of aspects of the biology of potentially valuable species are listed in Table 6. Studies have been conducted by the Zoology Department, UWI, to a large extent. Some studies have been made by the IMA. Further infrastructure and funds are essential in order to continue this type of research. The Fisheries Division's Aquaculture Project at Bamboo Grove has also been involved in aquaculture but its work is largely related to the non-indigenous tilapia and no publications have resulted within recent times.

Infrastructure and financial resources for evaluating the growth characteristics of potentially important species are basically similar to those available for inventorying and surveying these species (see previous section). The level of training necessary for serious scientific research to be conducted on the biology of these species is at least a first degree in the life sciences. Such training is available locally at the UWI but, as mentioned in the previous section, programmes there tend to concentrate at present on aquatic sciences and therefore the biology of aquatic species. Very little research on waterfowl or terrestrial game animals is done at this institution because of the interests of staff.

D.4 Diversity of genetic expression of target species

To our knowledge, no information is available on this subject for any potentially important animal species.

D.5 Training

In Trinidad and Tobago there are several institutions which are capable of training personnel in fields related to taxonomy and conservation biology.

The Forestry School of the Eastern Caribbean Institute of Agriculture and Forestry trains lower level personnel providing a Diploma in Forestry and Wildlife Management. In addition, on-the-job training is given to wildlife officers at the Forestry Division.

The University of the West Indies provides Natural Science degrees in which majors in Zoology or Botany provide good training in taxonomy and conservation biology. A major in Zoology also offers an option in Fisheries and Aquaculture which deals with the biology and technology of culture of various local species.

Training in the taxonomy of specialist groups, such as certain insects, in unavailable locally. In addition, museum development and training of curators would be invaluable in order to maintain the existing specimen collections in the country.

Table 6 Studies on the biology and rearing of indigenous potentially important species.

Species	Reference
Mammals:	
Dasyprocta agouti	Ramdial & Ramdial (undated)
	Smythe (1978) [*D. punctata*]
Agouti paca	Ramdial (undated)
Dasypus novemcinctus	Ramdial & Ramdial (undated)
Mazama americana	Sampath (1984)
Fish:	
Hoplosternum littorale	Singh (1978)
	Ramnarine (1989)
	Ramnarine (1990)
	Ramnarine (PhD in progress)
	Cazabon (1987)
Corydoras aeneus	Alkins (1987)
	Mohammed (1989)
	Mohammed (MPhil in progress)
	Hosein (1985)
	Samlalsingh (1989)
	Kramer & McClure (1980)
Agonostomus monticola	Phillip (1990)
Corynopoma riisei	Durity (1988)
	Nelson (1964, 1965)
Aequidens pulcher	Gandhi (1990)
Crustacea:	
Macrobrachium crenulatum	Batchasingh (1987)
	Batchasingh & Ramnarine (1990)
M. jelskii	Gobin (1990)
Mollusca:	
Mytella guyanensis	Kishore (MPhil in progress)
Donax species	Carrington (1981)
	Buckmire (1989)
Asaphis deflorata	Webb (1987)
	O'Brady (1989)
Pomacea urceus	Lum Kong (1986)
	Lum Kong (1989)
	Lum Kong & Kenny (1989)
	Lum Kong & Ramnarine (1988)
	Bennett (1989)
	Thomas (MPhil in progress)
Melongena melongena	Budge (1973)

D.6 Propagation and farming of animals

The farming techniques used are of course quite diverse and dependent upon the species of animal concerned.

For game animals this involves an extensive form of farming where stock is collected from the wild and allowed to breed in captivity in fenced enclosures or cages. The captive breeding of game animals is not as yet an established enterprise. A body of people involved in the activity has formed the Wildlife Farming Association but it is not very active or high profile.

Farming of game animals is an extensive system (Asibey 1984c; Wildlife Section, Forestry Division 1989). Of all the game animals, the agouti has thus far successfully been farmed. Deer, lappe and wildhog have already been bred in captivity and have the potential for farming. Deer is potentially the most expensive in terms of land, fencing, health and availability of stock. Lappe, a hystricomorph rodent like the agouti, is believed to be as easy to house, feed and manage under captive conditions. Wildhog can be kept in small pens and farmed as domestic pigs. Manicou and morocoy have so far not given any encouraging records. Captive breeding of the tatoo is also difficult because of the nutritional requirements of the young. The cocrico, considered a pest in Tobago, can be reared like the domestic fowl.

Aquaculture techniques are, however, well established. Generally, production systems include the following:

Extensive: This involves the use of natural ponds and the collection of brood stock from the wild. No artificial feeding is given.

Semi-intensive: Involves the use of earthen embankment ponds with a developed drainage system; juveniles may be obtained from a hatchery; three types of ponds are used: nursery, brood and production ponds. Supplementary feeding is given.

Intensive: Juveniles are obtained from a hatchery usually located on the same site with the production operations; all stages included juveniles and brood stock are maintained in tanks. Diets are completely artificial.

Other techniques involved in aquaculture are as follows:

a) Larviculture: includes the techniques in hatchery operations and production of seedstock.
b) Breeding of broodstock in captivity: this may be natural or induced breeding. The latter involves the use of hormones or the manipulation of environmental conditions.

Aquaculture of the following is being performed at present:

Indigenous species

Round-headed cascadu (*Hoplosternum littorale*)

Non-indigenous species

Tilapia: a red hybrid produced from crossing *Oreochromis mossambicus* x *Sarotherodon hornorum* and a silver hybrid from *S. hornorum* x *Oreochromis niloticus*

Freshwater prawn (*Macrobrachium rosenbergii*)

All are culture in a semi-intensive or an extensive system. As the interest in the field increases, intensive forms of commercial culture of species will be developed. Culture of marine species has not yet been successfully performed at the commercial level. An attempt has been made at commercial production of *Penaeus monodon* and *P. vannamai* but failed. More recently larviculture of the mangrove oyster has been successfully attempted and grow-out trials are being conducted. Difficulties in the culture of marine species include the maintenance and cost of a seawater system.

The following persons and institutions are actively culturing species:

1) Caroni (1975) Ltd., Aquaculture Project, Orange Grove Estate, Orange Grove: semi-intensive culture of the non-indigenous *Macrobrachium rosenbergii.*
2) Institute of Marine Affairs (IMA), Hilltop Lane, Chaguaramas: semi-intensive culture of cascadu (*Hoplosternum littorale*), *Macrobrachium rosenbergii* and red hybrid tilapia.
3) Bamboo Grove Fish Farm, Fisheries Division, Ministry of Agriculture, Lands and Fisheries, Valsyn: Production of red hybrid tilapia fingerlings.
4) Ragoonath Fish Farm, Plum Mitan, Nariva: commercial aquaculture of the cascadu (*Hoplosternum littorale*).
5) Montano Shrimp Farm, Orange Valley: attempt at commercial culture of non-indigenous shrimp (*Penaeus monodon* and *P. vannamai*) from imported juveniles (postlarvae).
6) R. Batchasingh, Gran Couva: commercial hatchery production of cascadu (*Hoplosternum littorale*) fingerlings.
7) J. Rampersad & D. Ammons, Bayshore, Carenage: preliminary research and trials on the larviculture and production of the mangrove oyster *Crassostrea rhizophorae.*
8) The Emperor Valley Zoo, Port of Spain: the only established body where game animals are bred in any numbers in captivity for release into the wild or for export to other zoos. Species bred include deer, wildhog, agouti, lappe, manicou, morocoy, iguana, ocelot, capuchin monkey.
9) Pointe-a-Pierre Wildfowl Trust, TRINTOC, Pointe-a-Pierre: this private organisation maintains habitats to encourage waterfowl breeding in the centre of an oil refinery complex as well as conducts artificial breeding in cages of several species of endangered species of indigenous waterfowl and some exotic species. These include muscovy duck, black-bellied whistling ducks, white-faced whistling ducks and scarlet ibis.

The status of aquaculture locally is good in terms of transfer of technology, however, financial resources for infrastructure can be a deterrent. Several other species with potential for culture are still to be investigated for their biology and techniques for culture (e.g. the local prawns *Macrobrachium* species, the catfish *Rhamdia quelen*, aquarium fish such as the pui pui, *Corydoras aeneus* (some research is in progress by a graduate student at UWI) and the teta, *Hypostomus robinii*).

For terrestrial game species, the biology of several species must still be investigated in detail to promote efficient breeding and rearing. The most recent information available is by Sampath (1984) and Vos (1982) on deer farming. Techniques of ranching available in other countries may be able to be adapted to the local situation.

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ANNEX D.1

Indigenous species of economic importance [The proposed protected areas within which they occur are given for some groups. Conservation status: E – endangered; V – vulnerable; R – rare (Thelen & Faizool 1980)].

Species	Habitat	Importance
Mammals		
Didelphidae:		
Black-eared opossum *Didelphis marsupialis insularis*	Forest, secondary growth Widespread	Hunting, food
Greater Trinidadian murine opossum *Marmosa mitis chapmani*	Forested areas Trinity Hills, Arena	Hunting, food, R
Lesser Trinidad murine opossum *Marmosa fuscata carri*	Dry, forested areas Arena, Trinity Hills	Hunting, food, R
Woolly opossum *Caluromys philander trinitatis*	Forest Trinity Hills, Asa Wright	Hunting, food, R Hunting, food, R
Water opossum *Chironectes minimus minimus*	Intermediate forest along river banks	Hunting, food, E
Cebidae:		
Red howler monkey *Alouatta seniculus insularis*	Dense forest Nariva Swamp, Chaguaramus, Trinity Hills	Disease monitoring, hunting, V
Capuchin *Cebus albifrons trinitatis*	Intermediate forest near coasts Nariva Swamp	Pets, hunting, V
Myrmecophagidae:		
Three-toed anteater *Tamandua longicaudata longicauda*	Grasslands and open forest Southern Watershed	Hunting, E
Silky anteater, Two-toed anteater *Cyclopes didactylus didactylus*	Coastal and swamp areas Caroni Swamp	Hunting, E
Dasypodidae:		
Nine-banded armadillo *Dasyphus novemcinctus novemcinctus*	Forest, mixed vegetation Matura, Madamas, Trinity Hills	Hunting, food, V
Sciuridae:		
Trinidadian squirrel *Sciurus granatensis chapmani*	Forested areas Widespread	Pets, hunting

Species	Habitat	Importance
Erethizontidae:		
Prehensile-tailed porcupine *Coendu prehensilis longicaudatus*	Secluded forest Trinity Hills	Traditional medicine, E
Dasyproctidae:		
Agouti *Dasyprocta agouti*	Forest, secondary growth Widespread	Pets, hunting
Lappe *Agouti paca*	Dense moist forest with thick undergrowth and freshwater Matura, Navet, Trinity Hill	Hunting, food, V
Procyonidae:		
Crab-eating raccoon *Procyon cancrivorus cancrivorus*	Swamp and inland waterways Caroni Swamp, Nariva Swamp	Hunting, E
Mustelidae:		
Otter *Lutra enudris*	Swamps and estuaries Caroni Swamp, North Coast	Hunting, E
Tayra *Eira barbara trinitatis*	Montane forest Maracas, Madamas, Matura	Hunting, V
Felidae:		
Ocelot *Felis pardalis*	Montane forest Maracas, Madamas, Matura	Hunting, E
Trichechidae:		
Manatee *Trichechus manatus*	Coastal, brackish and inland waters with aquatic vegetation	Hunting, food, E
Tayassuidae:		
Collared peccary, wildhog *Tayassu tayaçu*	Forested areas Matura, Navet, Trinity Hills	Hunting, food, V
Cervidae:		
Red brocket, deer *Mazama americana trinitatis*	Intermediate forst Matura, Trinity Hills, Arena	Hunting, food, V
Birds		
Phalacrocoracidae:		
Neotropic cormorant, black duck *Phalacrocorax olivaceus*	Inland reservoirs, coasts Caroni Swamp	Hunting
Anhingidae:		
Anhinga *Anhinga anhinga*	Inland waters, swamp	Hunting, food

Species	Habitat	Importance
Ardeidae:		
Great blue heron *Ardea herodias*	Seas coasts, swamps	Hunting
White-necked heron *Ardea cocoi*	Freshwater lakes, swamps	Hunting
Great egret *Egretta alba*	Mangrove swamp Caroni Swamp	Conservation, E
Black-crowned night heron *Nycticorax nycticorax*	Mangrove swamp	Hunting, food, V
Yellow-crowned night heron *Nyctanassa violacea*	Mangrove swamps, reservoirs, coasts	Hunting
Rufescent tiger heron *Tigrisoma lineatum*	Mangrove swamp Nariva Swamp	Conservation, E
Stripe-backed bittern *Ixobrychus involucris*	Mangrove swamp Caroni Swamp	Hunting, food, E
Pinnated bittern *Botaurus pinnatus*	Mangrove swamp Caroni Swamp	Hunting, food, V
Cochleariidae:		
Boat-billed heron *Cochlearius cochlearius*	Mangrove swamp Caroni Swamp	Hunting, food, E
Threskiornithidae:		
Scarlet ibis *Eudocimus ruber*	Mangrove swamp Caroni Swamp	Hunting, food, a national bird, V
Anhimidae:		
Horned screamer *Anhima cornuta*	Herbaceous, freshwater swamp Nariva Swamp	Conservation, E
Anatidae:		
Fulvous tree (whistling) duck *Dendrocygna bicolor*	Mangrove and herbaceous swamps, Caroni, Nariva Swamps	Hunting, food, E
White-faced tree duck *Dendrocygna viduata*	Mangrove, herbaceous swamps Caroni, Nariva Swamps	Hunting, food, E
Black-bellied tree (whistling) duck *Dendrocygna autumnalis*	Swamps, marshy savannas	Hunting, V
Green-winged teal *Anas crecca*	Swamps, Tobago	Hunting
American wigeon *Anas americana*	Swamps	Hunting
White-cheeked pintail *Anas bahamensis*	Swamps	Hunting

Species	Habitat	Importance
Blue-winged teal *Anas discors*	Swamps, freshwater marshes, reservoirs, seas coasts	Hunting, food
Northern shoveler *Anas clypeata*	Swamps	Hunting
Lesser scaup *Aythya affinis*	Swamps, reservoirs	Hunting
Ring-necked duck *Aythya collaris*	Swamps	Hunting
Masked duck *Oxyura dominica*	Mangrove swamp, freshwater marshes Caroni Swamp	Hunting, food, E
Accipitridae:		
White-tailed kite *Elanus leucurus*	Herbaceous swamp Nariva Swamp	Conservation, E
Pearl kite *Gampsonyx swainsonii*	Herbaceous swamp Nariva Swamp	Conservation, E
Swallow-tailed kite *Elanoides forficatus*	Montane forest Maracas, Madamas	Conservation, E
Everglade kite *Rostrhamus sociabilis*	Herbaceous swamp Nariva Swamp	Conservation, E
Zone-tailed hawk *Buteo albonotatus*	Semi-deciduous forest with steep coastal cliffs Chaguaramas	Conservation, E
Broad-winged hawk *Buteo platypterus*	Forest East Tobago	Conservation, E
Black-collared hawk *Busarellus nigricollis*	Herbaceous swamp Nariva Swamp	Hunting, E
Savanna hawk *Heterospizias meridionalis*	Marsh forest/palm marsh/ savanna complex Aripo Savanna	Conservation, E
Long-winged harrier *Circus buffoni*	Mangrove swamp Caroni Swamp	Conservation, E
Pandionidae:		
Osprey *Pandion haliaetus*	Reservoirs, waterways, sea coasts	Conservation
Cracidae:		
Trinidad piping guan, pawi *Aburria pipile*	Montane forest Madamas, Trinity Hills	Hunting, food, E
Aramidae:		
Limkin *Aramus guarauna*	Herbaceous swamp Nariva, Caroni Swamps	Conservation, E

Species	Habitat	Importance
Rallidae:		
Clapper rail *Rallus longirostris*	Mangrove swamps	Hunting
Spotted rail *Rallus maculatus*	Mangrove swamp Caroni Swamp	Hunting, food, V
Grey-necked wood rail *Aramides cajanea*	Mangrove swamp Caroni Swamp	Hunting, food, V
Rufous-necked wood rail *Aramides axillaris*	Remote areas with steep cliffs, crevices, sparse vegetation Chaguaramas, Blue Basin	Hunting, food, E
Sora *Porzana carolina*	Swamps, marshes	Hunting
Ash-throated crake *Porzana albicollis*	Mangrove and herbaceous swamps Caroni Swamp	Hunting, food, E
Yellow-breasted crake *Porzana flaviventer*	Mangrove lagoons, swamps Caroni Swamp	Hunting, food, E
Grey-breasted crake *Laterallus exilis*	Mangrove swamp Caroni Swamp	Hunting, food, V
Common gallinule *Gallinula chloropus*	Sea coast, mangrove swamp Buccoo Reef	Hunting, food, V
Purple gallinule *Porphyrula martinica*	Freshwater swamps, marshes	Hunting
Caribbean coot *Fulica caribaea*	Marshes	Hunting
Charadriidae:		
Southern lapwing *Vanellus chilensis*	Marshy savannas, open areas near water	Hunting
Black-bellied plover *Pluvialis squatarola*	Coastal mudflats	Hunting
American golden plover *Pluvialis dominica*	Savannas, coasts, grassy areas	Hunting
Semi-palmated plover *Charadrius semipalmatus*	Coasts, marshes	Hunting
Collared plover *Charadrius collaris*	Sandy beaches, mudflats, savannas	Hunting
Thick-billed plover *Charadrius wilsonia*	Mudflats, swamps, beaches	Hunting
Scolopacidae:		
Solitary sandpiper *Tringa solitaria*	Freshwater habitats	Hunting

Species	Habitat	Importance
Lesser yellowlegs *Tringa flavipes*	Swamps, coastal mudflats, wed pastures	Hunting
Greater yellowlegs *Tringa melanoleuca*	Swamps, coastal mudflats, fresh waters	Hunting
Spotted sandpiper *Actitis macularia*	Coasts, swamps, forest streams	Hunting
Willet *Catoptrophorus semipalmatus*	Coasts, mudflats, inland swamps	Hunting
Least sandpiper *Calidris minutilla*	Coasts, flooded savannas, marshes, ditches	Hunting
White-rumped sandpiper *Calidris fuscicollis*	Coastal mudflats, marshes, reservoirs	Hunting
Semipalmated sandpiper *Calidris pusilla*	Coasts, inland marshes, reservoirs	Hunting
Western sandpiper *Calidris mauri*	Coastal mudflats, inland marshes	Hunting
Stilt sandpiper *Micropalama himantopus*	Coastal mudflats, lagoons, swamps	Hunting
Whimbrel *Numenius phaeopus*	Mudflats, swamps	Hunting
Common dowitcher *Limnodromus griseus*	Mudflats, freshwater swamps	Hunting
Common snipe *Gallinago gallinago*	Marsh forest/palm marsh/ savanna complex	Hunting, food, E
Columbidae:		
Band-tailed pigeon *Columba fasciata*	Montane forest Maracas, Madamas	Hunting, E
Psittacidae:		
Yellow-headed parrot *Amazona ochrocephala*	Forests of Northern Range, Cedros	Pets, V
Scarlet-shouldered parrotlet *Touit huetii*	Marsh forest/palm marsh/ savanna complex Nariva Swamp	Pets, E
Red-bellied macaw *Ara manilata*	Herbaceous swamp, savanna Nariva Swamp, Aripo Swamp	Pets, V
Blue and yellow macaw *Ara ararauna*	Herbaceous swamp Nariva Swamp	Pets, presumed extinct
Cuculidae:		
Dark-billed cuckoo *Coccyzus melacoryphus*	Mangrove Caroni Swamp	Conservation, E

Species	Habitat	Importance
Strigidae:		
Striped owl *Asio clamator*	Semi-deciduous forest East Tobago	Conservation, E
Caprimulgidae:		
Rufous nightjar *Caprimulgus rufus*	Semi-deciduous forest Chaguaramas	Conservation, E
Trochilidae:		
White-tailed sabrewing *Campylopterus ensipennis*	Forest East Tobago	Conservation, E
White-tailed golden throat *Polytmus guainumbi*	Marsh forest/palm marsh/ savanna complex Aripo Savannas	Conservation, E
Blue-tailed emerald hummingbird *Chlorostilbon mellisugus*	Semi-deciduous forest Chaguaramus	Conservation, E
Dendrocolaptidae:		
Straight-billed woodcreeper *Xiphorhynchus picus*	Mangrove swamp Caroni Swamp	Conservation, E
Formicariidae:		
Plain antvireo *Dysithamnus mentalis*	Forest East Tobago	Conservation, E
Cotingidae:		
White bellbird *Procnias alba*	Montane forest Madamas, Maracas	Conservation, E
Tyrannidae:		
Venezuelan flycatcher *Mriarchus venezuelensis*	Forest Tobago	Conservation, E
Sulphury flycatcher *Tyrannopsis sulphurea*	Herbaceous swamp, marsh forest/palm marsh/ savanna complex	Conservation, E
Lesser elaenia *Elaenia chiriquensis*	Marsh forest/palm marsh/ savanna complex Aripo Savannas	Conservation, E
Crested doradito *Pseudocolopteryx sclateri*	Mangrove Caroni Swamp	Conservation, E
Turdidae:		
Orange-billed nightingale thrush *Catharus aurantiirostris*	Montane forest Maracas, Madamas	Conservation, E

Species	Habitat	Importance
Icteridae:		
Moriche oriole, moriche *Icterus chrysocephalus*	Herbaceous swamp, savanna/ palm forest Nariva Swamp, Aripo Savannas	Pets, E
Coerebidae:		
Red-legged honeycreeper *Cyanerpes cyaneus*	Forest East Tobago	Conservation, E
Tersinidae:		
Swallow tanager *Tersina viridis*	Montane forest Maracas, Madamas	Conservation, E
Thraupidae:		
Blue-capped tanager *Thraupis cyanocephala*	Montane forest Maracas	Conservation, E
Blue-hooded euphonia *Euphonia musica*	Montane forest Maracas, Madamas	Pets, E
Fringillidae:		
Yellow-bellied seedeater, silverbeak *Sporophila nigricollis*	Light woodland, forest edges Charguaramas, East Tobago	Pets, E
Variable seedeater, picoplat (Tobago) *Sporophila americana*	Forest edges, semi-open areas East Tobago	Pets, E
Ruddy-breasted seedeater, robin *Sporophila minuta*	Forest, open areas, marsh edges, cultivated lowlands	Pets, V
Red siskin, colorado *Spinus cucullatus*	Semi-deciduous forest East Tobago	Pets, on verge of worldwide extinction
Red-capped cardinal *Paroaria gularis*	Mangrove swamp Caroni Swamp	Conservation, E
Lesser seed finch, bullfinch, chickichong, twa twa *Oryzoborus angolensis*	Herbaceous swamp, marsh forest/palm marsh/ savanna complex, semi-deciduous forest	Pets, E
Large-billed seed finch, twa twa *Oryzoborus crassirostris*	Herbaceous swamp, light woodland Nariva Swamp	Pets, E
Grey seedeater, picoplat *Sporophila intermedia*	Lowland secondary growth, light forest Nariva Swamp	Pets, E

Species	Habitat	Importance
Reptiles		
Dermochelyidae:		
Leatherback turtles *Dermochelys coriacea*	Nests on open beaches with strong surf Matura, Madamas, Manzanilla, Tobago	Food, E
Cheloniidae:		
Pacific Ridley *Lepidochelys olivacea*	Nests on small North Coast bays	Food, E
Loggerhead turtle *Caretta caretta*	Nests on North Coast bays	Food, E
Hawksbill turtle *Eretmochelys imbricata*	Nests on small bays North Coast, Chaguaramas, East Tobago	Food, craft, E
Green turtle *Chelonia mydas*	Nests on sheltered bays Matura	Food, E
Emydidae:		
Galap *Rhinoclemys punctularia*	Rivers and swamps Widespread	Pets
Chelyidae:		
Mata mata *Chelus fimbriatus*	Freshwater swamps Nariva Swamp	Food, E
Testudinidae:		
Morocoy, yellow-footed *Geochelone denticulata*	Forested areas Trinity Hills	Pets, religious purposes, E
Morocoy, red-footed *Geochelone carbonaria*	As above	Food
Gekkonidae:		
Ocellated gecko *Gonatodes ocellatus*	Tobago	Conservation
Iguanidae:		
Common iguana *Iguana iguana*	Forest areas	Hunting, food
Teiidae:		
Mountain teiid *Proctoporus shrevei*	High mountain forests of the Northern Range	Conservation, R

Species	Habitat	Importance
Matte, Northern tegu or jacuaru *Tupinambis nigropunctatus*	Widespread in a variety of conditions	Hunting, R
Crocodylidae:		
Spectacled caiman *Caiman sclerops*	Rivers and swamps Widespread	Hunting, skin, stuffed as curios
Boidae:		
Anaconda *Eunectes murinus*	Freshwater swamps, lowland rivers Nariva Swamp	Hunting, oils
Colubridae:		
Mangrove snake *Liophis cobella*	Swamp Caroni, Nariva Swamps	Hunting, R
False coral *Erythrolamprus aesculapii ocellatus*	Tobago	Conservation
Amphibians		
Pipidae:		
Surinam toad *Pipa pipa*	Swamp forests Nariva Swamp, Cedros Peninsula	Conservation, R
Leptodactylidae:		
Mountain chicken, edible frog *Leptodactylus bolivianus*	Forest and swamp Mayaro, Cedros	Food, R
Hylidae:		
Golden tree frog *Phyllodytes auratus*	Bromeliads on summit of El Tucuche, El Cierro del Aripo	Conservation, E
Freshwater and Estuarine Fish		
Megalopidae:		
Tarpon, grand ecaille *Megalops atlanticus*	Near coasts, at river mouths	Food, sport fishing
Erythrinidae:		
Guabine, trahira, terarira, tigerfish *Hoplias malabaricus*	Drainages south of the Northern Range, widespread	Food, aquarium trade
Yarrow, jejü, yarau *Hoplerythrinus unitaeniatus*	Drainages south of the Northern Range	Food
Erythrinus erythrinus	Drainages south of the Northern Range, scattered	Food

Species	Habitat	Importance
Gasteropelecidae:		
Common hatchetfish *Gasteropelecus sternicla*	Streams in southwest peninsula	Potential for aquarium trade
Characidae:		
Stout sardine, silverfish *Curimata argentea*	Northern parts of island in muddy streams, waterholes and drains	Aquarium trade, food
The Calypso tetra *Megalamphodus axelrodi*	Stagnant, muddy waters	Potential for aquarium trade
Sardine doree, featherfish tetra *Hemigrammus unilineatus*	Drainages south of the Northern Range, in muddy waters and forest pools	Potential for aquarium trade
Sardine, sardine doree *Odontostilbe pulchre*	Watersheds south of the Northern Range	Potential for aquarium trade
Silver tetra *Gymnocarymhust thaycric*	Streams in Erin	Potential for aquarium trade
Pink-finned sardine *Astyanax bimaculatus*	Drainages south of the Northern Range, widespread	Potential for aquarium trade, food
Hunch-back sardine, glassfish *Roeboides dayi*	Drainages south of the Northern Range	Potential for aquarium trade, food
Mountain stream sardine, band-tailed tetra *Hemibrycon taeniurus*	Restricted to middle and upper courses of south-flowing rivers of the Northern Range	Some potential for aquarium trade, food
Sword-tailed tetra, swallow-tailed sardine *Corynopoma riisei*	Drainages south of the Northern Range, widespread	Export aquarium trade
Gymnotidae:		
Cutlass fish, tiger knifefish *Gymnotus carapo*	Pools and ravines south of the Northern Range	Export aquarium trade
Pimelodidae:		
River catfish *Rhamdia quelen*	Drainages south of the Northern Range, widespread	Food, aquarium trade
Blind catfish *Rhamdia quelen urichi*	Oropouche Caves	Endemic subspecies
Callichthyidae:		
Pui pui, goldfish, armoured catfish *Corydoras aeneus*	Streams and pools south of the Northern Range	Export aquarium trade
Flathead cascadu, chato *Callichthys callichthys*	Muddy and brackish slow-moving waters, swamps	Export aquarium trade, food

Species	Habitat	Importance
Roundhead cascadu *Hoplosternum littorale*	Muddy and brackish slow-moving waters, swamps	Food
Loricariidae:		
Bearded teta *Ancistrus cirrhosus*	Drainage south of the Northern Range	Export aquarium trade, food
Teta *Hypostomus robinii*	As above	Export aquarium trade, food
Cyprinodontidae:		
Jumping guabine *Rivulus hartii*	Abundant throughout the island	Aquarium trade
Poeciliidae:		
Guppy, millions fish *Poecilia reticulata*	Abundant throughout the island	Limited aquarium trade, scientific research
Mugilidae:		
Mountain mullet *Agonostomus monticola*	Rivers and streams draining north of the Northern Range	Food, sport fishing
Centropomidae:		
Brochet, snook *Centropomus pectinatus, C. undecimalis, C. ensiferus, C. parallelus*	Coastal and brackish waters	Food, sport fishing
Polycentridae:		
Black coscorob, schomburaks leaffish *Polycentrus schomburgkii*	Rivers and streams south of the Northern Range	Aquarium trade
Cichlidae:		
Blue acara, small coscorob *Aequidens pulcher*	Streams south of the Northern Range to Couva and Ortoire Rivers	Food, aquarium trade
Large (brown) coscorob, Cichlasoma portalegrensis *Cichlasoma bimaculatum*	Muddy waters south of the Northern Range	Food, aquarium trade
Matawal, watamal *Crenicichla alta*	Streams, ponds south of the Northern Range, widespread	Food, aquarium trade
Tetraodontidae:		
Puffer *Colomesus psittacus*	Coastal waters, ventures upstream	Aquarium trade

Species	Habitat	Importance
Marine Fish		
Carcharhinidae:		
Requiem sharks		
Black-fin shark *Carcharhinus limbatus*	Marine	Commercially exploited
Black-nose shark *C. acronotus*	Marine	Commercially exploited
Silky shark *C. falciformis*	Marine	Commercially exploited
Bull shark *C. leucas*	Marine	Commercially exploited
Tiger shark *Galeocerdo cuvieri*	Marine	Commercially exploited
Lemon shark *Negaprion brevirostris*	Marine	Commercially exploited
Sphyrnidae:		
(Hammerhead sharks)		
Hammerhead shark, scalloped hammerhead *Sphyrna lewini*	Marine	Commercially exploited
Bonnet-head shark *S. tiburo*	Marine	Commercially exploited
Elopidae:		
Banane, ladyfish or tenpounder *Elops saurus*	Marine	Commercially exploited
Clupeidae:		
Sardine, herring, false herring *Harengula clupeola*	Marine	Commercially exploited
Atlantic thread herring *Opisthonema oglinum*	Marine	Commercially exploited
Engraulididae:		
Joshua, zanchois *Anchoa trinitatis,* *Atlantic unchosella,* *Cetengraulis edentulus*	Marine	Commercially exploited
Exocetidae:		
Flying fish *Hirundichithys affinis*	Marine	Commercially exploited

Species	Habitat	Importance
Mugilidae:		
Grey mullet *Mugil curema, M. cephalus*	Marine	Commercially exploited
Grey mullet, Lebranche *M. liza*	Marine	Commercially exploited
Sphyraenidae:		
Barracuda *Sphyraena barracuda*	Marine	Commercially exploited
Bechine, Southern sennet *S. picudilla*	Marine	Commercially exploited
Serranidae:		
Red hind *Epinephelus guttatus*	Marine	Commercially exploited
Nassau grouper *E. striatus*	Marine	Commercially exploited
Grouper, jewfish *E. itajara*	Marine	Commercially exploited
Black grouper *Myctoperca bonaci*	Marine	Commercially exploited
White grouper *M. cidi*	Marine	Commercially exploited
Rachycentridae:		
Codfish cobia, sergeant fish *Rachycentron canadum*	Marine	Commercially exploited
Carangidae:		
Couvalli, crevalle jack *Caranyx hippos*	Marine	Commercially exploited
Big-eye cavali *C. latus*	Marine	Commercially exploited
Pompano, palometa *Trachinotus goodei*	Marine	Commercially exploited
Moonshine *Selene vomer*	Marine	Commercially exploited
Scombridae:		
Carite, serra spanish mackerel *Scomberomorus brasiliensis*	Marine	Commercially exploited
Kingfish, king mackerel *S. cavalla*	Marine	Commercially exploited

Species	Habitat	Importance
Wahoo *Acanthocybium solandri*	Marine	Commercially exploited
Bonito *Sarda sarda, Auxis thazard*	Marine	Commercially exploited
Little tuna *Euthynus allettaratus*	Marine	Commercially exploited
Stromateidae:		
Butterfish *Peprilus paru*	Marine	Commercially exploited
Istiophoridae:		
Sailfish *Istiophorus albicans*	Marine	Commercially exploited
Lutjanidae:		
Walliacke, lane snapper *Lutjanus synagris*	Marine	Commercially exploited
Pargue *L. aya*	Marine	Commercially exploited
Vivanot, silk snapper *L. vivanus*	Marine	Commercially exploited
Sorbe, mutton snapper *L. analis*	Marine	Commercially exploited
Mangrove pargue, grey snapper *L. griseus*	Marine	Commercially exploited
Dent chien, dog snapper *L. jocu*	Marine	Commercially exploited
Pomadasyidae:		
Cro-cro, latin grunt *Haemulon steindachneri*	Marine	Commercially exploited
Red-mouth grunt, white grunt *H. plumieri*	Marine	Commercially exploited
French grunt *H. flavolineatum*	Marine	Commercially exploited
Lippe, black margate *Anisotremus surinamensis*	Marine	Commercially exploited
Pomatomidae:		
Ancho, bluefish *Pomatomus saltatrix*	Marine	Commercially exploited

Species	Habitat	Importance
Sciaenidae:		
Croaker *Micropognias furnieri*	Marine	Commercially exploited
Salmon, croakern *Cynoscion acoupa,* *C. jamaicensis*	Marine	Commercially exploited
Gerreidae:		
Blinch *Gerres cinereus*	Marine	Commercially exploited
Ephippidae:		
Paoua, spadefish *Chaetodipterus faber*	Marine	Commercially exploited
Pleuronectidae:		
Tropical flounder *Paralichthys tropicus*	Marine	Commercially exploited
Crustacea		
Penaeidae:		
Red spotted shrimp *Penaeus brasiliensis*	Gulf of Paria	Food
White shrimp *P. schmitti*	Gulf of Paria	Food
Brown shrimp *P. subtilis*	Gulf of Paria	Food
Pink shrimp *P. notialis*	Gulf of Paria	Food
Sea bob, honey shrimp *Xiphopenaeus kroyeri*	Gulf of Paria	Food
Palaemonidae:		
Crayfish *Atya scabra*	Streams, rivers of the Northern Range	Food
Crayfish *Macrobrachium carcinus*	Northern Range streams	Food
Crayfish *M. crenulatum*	Northern Range to central lowlands	Food
Crayfish *M. jelskii*	Widespread in lowland waters	Food
Crayfish *M. acanthurus*	Nariva Swamp	Food

Species	Habitat	Importance
Palinuridae:		
Lobster *Panulirus argus*	North coast Trinidad, coastal areas of Tobago	Food
Lobster *P. laevicaudus*	As above	Food
Grapsidae:		
Rock crab *Grapsus* species	Rocky shores	Food
Portunidae:		
Cirique, swimming crab *Callinectes bocourti, C. danae, C. arcuatus, C. sapidus, C. ornatus*	Caroni, Oropouche Swamps	Food
Gecarcinidae:		
Blue crab, land crab *Cardisoma guanhumi*	Caroni, Nariva Swamps, brackish coastal lands	Food
Callaloo crab, hairy crab *Ucides cordatus*	Caroni Swamp	Food
Red crab *Goniopsis cruentata*	Mangrove swamps	Food
Pseudothelphusidae:		
Manicou crab *Pseudothelphusa garmani*	North, Central Ranges	Food
Mollusca		
Polyplacophora (chitons):		
Pachro, sea cockroach *Chiton marmoratus, C. tuberculatus, Acanthopleura granulata*	Rocky shores	Food
Bivalvia:		
Rock mussel *Perna perna*	Rocky shores, North Coast	Food
Mok, mussel *Mytella guyanensis, M. falcata*	Caroni, Oropouche Swamps	Food
Clam *Phacoides pectinatus*	As above	Food
Oyster *Crassostrea rhizophorae*	As above	Food

Species	Habitat	Importance
Chip chip *Donax denticulatus, D. striatus*	Sandy shores, east coast	Food
Gastropoda:		
Lambia, queen conch *Strombus gigas, S. costatus*	North coast of Trinidad, Tobago: sandy bottoms, lagoons, turtle grass beds	Food
Sea, black, swamp conch *Melongena melongena*	Muddy bottoms, swamps	Food
Swamp, sea conch *Pugilina morio,* *Thais trinitatensis*	Caroni, Oropouche Swamps	Food
River, black conch *Pomacea urceus*	Nariva Swamp, Caroni Plain	Food

E. LIST OF KEY ECOLOGICAL AND ECONOMIC SPECIES OF ZAMBIA

By W. K. CHISHIMBA

E.1 Introduction

The continent of Africa is richly endowed with great biological diversity and genetic resources. Zambia being one of the countries in sub-saharan Africa is rich in plant and animal taxa. Unfortunately, due to modern farming techniques, population pressure and over-exploitation of these genetic resources, the rich biological diversity that once existed is slowly being lost. Unless urgent measures are taken to rescue some of the already endangered species, the consequences will be disastrous on the globe and to humanity in particular. It is therefore with this view that a compilation or checklist of key ecological and economic species in Zambia will enable target scientists in the field to establish meaningful conservation strategies.

Zambia is blessed with a rich diversity of plant genetic resources which are important both in terms of their ecological and economic functions. Obviously, compiling a list of this magnitude in a country like Zambia, would be too enormous if every plant was included without following a proper criterion. Therefore, in order to come up with a well defined checklist, the authors confined themselves to four groups of plants, trees and shrubs, herbs, grasses and mushrooms, that possess a certain economic value. The latter included utilisation as food, medicine, fodder or as an industrial raw material. The list focused more on underutilised plants, for example, if medicinal they are mainly useful to villagers or poor town dwellers, but are commercially underexploited. In terms of food utilisation, plants that serve as a good source of food when in season but are still wild, or those which people turn to in times of famine and yet they are least emphasised as agricultural crops. Furthermore, any wild plant that has an agricultural crop relative is regarded as important because of its usefulness as a plant genetic resource in future breeding. As for fodder plants, Zambia enjoys a rich endowment of this group of plants. Few of these plants are commercially cultivated, and yet they sustain the livestock industry in Zambia both at commercial and non-commercial levels. Finally, mushrooms add variety to the diet of many people in Zambia and yet none of the local species can be commercially grown due to lack of adequate information. The deliciousness of some of these mushrooms affords local people a good opportunity of raising a cheap source of income.

Identification of Key Species for Conservation and Socio-Economic Development
Edited by P. Kapoor-Vijay and M.B. Usher.

E.2 Key species of Zambia

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
Chrysophyllum magalismontanum	Zambia			X		X		X		Edible fruit, bark possesses traditional value
Diplorhynchus condylocarpon	Zambia			X		X		X		Medicinal value and source of fodder
Ficus capensis (Cape fig)	Zambia			X		X				Varied use for fruit and wood
Ficus ingens	Zambia			X		X				Possesses a medicinal value
Ficus sycomorus	Zambia			X		X				Used as fodder and also has medicinal value
Mimusops zeyheri (Red milkwood)	Zambia			X		X				A tree of riparian woodlands and termite mounds. Popular and high in vitamin C
Rauvolfia caffra (Quinine tree)	Zambia			X				X		Wood used for domestic tools. Has cultural value
Acacia albida (Winter thorn)	Africa	X	X	X	X	X			X	Good animal fodder
Acacia erioloba (Camel thorn)	Southern Africa	X	X	X	X	X			X	As above
Acacia sieberana (White thorn)	Africa	X	X	X	X	X			X	Pods eaten by game and cattle. Flowers attractive to bees
Acacia tortilis (Umbrella thorn)	Africa	X	X	X	X	X			X	Pods eaten by game and cattle
Balanites aegyptiaca (Torchwood, desert date)	Africa			X	X	X		X		Good animal fodder, contains high crude protein

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS: Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	SOCIO-ECONOMIC FUNCTIONS: Commodity	Genetic Resource	Cultural	Environmental Management	Reasons for inclusion
Dalbergia melanoxylon (African blackwood)	Africa			X		X				Wood is excellent for instruments. High demand from abroad
Oncoba spinosa (Wild rose)	Africa			X				X		Has medicinal and cultural value
Acacia nigrescens (Knob thorn)	Zambia	X	X	X	X	X			X	Game fodder. Bark, root and leaves are used for medicine
Acacia polyacantha (Hook thorn)	Africa	X	X	X	X	X			X	Good animal fodder. Produces gum for dying and tanning
Strychnos cocculoides (Bush orange)	Zambia			X	X	X				Produces fruit which is highly consumed
Zanthoxylum chalybeum	Africa			X	X	X				Leaves consumed by cattle and humans
Ziziphus abyssinica	Zambia			X		X				Excellent tree for bees. Used as fodder
Bauhinia petersiana	Zambia				X	X				Elephant fodder. Root used in tanning. Both roots and leaves have medicinal uses
Colophospermum mopane (Mopane, turpentine tree)	Southern Africa			X	X	X				Host for edible caterpillar (mopane worm). Good fodder for cattle and game
Guibourtia coleosperma	Southern Africa			X	X	X				Elephant fodder. Bark useful in dying and tanning
Piliostigma thoningii (Monkey bread)	Africa			X	X	X				Useful fodder tree. Dyes made from bark and roots. Various medicinal uses

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	SOCIO-ECONOMIC FUNCTIONS Commodity	Genetic Resource	Cultural	Environmental Management	Reasons for inclusion
Rhus longipes	Africa			X	X	X				Good bee tree. Leaves browsed by cattle
Adansonia digitata (Baobab)	Africa			X	X	X				Fruit high in vitamin C. Used to make refreshing drink
Azanza garckeana (Tree hibiscus)	Africa			X	X	X				Browsed by game. Fruit and leaves edible
Cussonia arborea	Africa				X	X				Possesses medicinal value. Wood useful in toolmaking
Oldfieldia dactylophylla	Southern Africa			X		X				Has medicinal value
Ricinodendron rautanenii	Southern Africa			X	X	X				Wood is used in handicraft production. Fruit is eaten by cattle and game
Sterculia quinqueloba (Egyptian plant tree)	Southern Africa			X	X	X		X		Makes a good live fence. Bark and leaves have magical and medicinal use
Vitex doniana	Africa			X		X				Fruit is rich in vitamins A and E. Can be processed to make jam
Afzelia quanzensis (Pod mahogany, lucky beam)	Africa				X	X		X		Very durable all-purpose timber. Bark a useful medicine
Baikiaea plurijuga (Zambezi redwood, Zambian teak)	Southern Africa			X	X	X				Excellent durable timber. Bark cures syphilis
Bruchystegia boehmii	Southern Africa			X	X	X				Suitable to hang bark beehives. An infusion of roots treats diarrhoea
Brachystegia floribunda	Southern Africa			X		X				Used for mine timbers. Makes good charcoal

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
Brachystegia longifolia	Southern Africa			X	X	X				Used for mine timbers. Good for bees. Useful in local medicine preparation
Brachystegia microphylla (Mountain acacia)	Zambia			X	X	X				Excellent for mine timbers. Useful for construction industry
Brachystegia spiciformis	Southern Africa			X	X	X				Popular beehive tree. Good mining timber
Brachystegia taxifolia	Zambia			X	X			X		An infusion of roots is believed to wash away bad luck in some places
Cassia abbreviata (Long-pod cassia)	East/ Central Africa			X		X		X		Various medicinal uses, eg. treatment of smallpox, stomach pains and syphilis
Dalbergia nitidula	Zambia			X	X	X		X		Roots have a variety of medicinal uses, including pleurisy and gonorrhoea
Ekebergia benguelensis	Zambia			X		X		X		Leaves used to treat snakebite. Bark useful in treating venereal disease
Ekebergia capensis	Africa			X		X		X		Various medicinal uses for roots, bark and leaves
Entandrophragma caudatum	Southern Africa			X	X	X		X		Sacred tree, used in making chiefs' canoes, masks, etc
Entandrophragma delevoyi	Zambia			X		X		X		Bark has medicinal value. Wood is used in building
Isoberlinia angolensis	Zambia			X	X	X		X		Used as mining timber. Good honey. Host to several edible caterpillars
Julbernardia globiflora	Zambia			X	X	X				It is a good bee tree. Used for mine timbers

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	SOCIO-ECONOMIC FUNCTIONS Commodity	Genetic Resource	Cultural	Environmental Management	Reasons for inclusion
Julbernardia paniculata	Southern Africa			X		X				Very valuable tree for beekeepers because of abundant flowers. Good mining timber. Host to 3 species of edible caterpillar. Cattle browse on leaves
Khaya nyasica	Southern Africa			X		X		X		Bark has a variety of medicinal uses. Wood good for furniture and quality joinery
Kigelia africana (Sausage tree)	Africa			X	X			X		Has numerous magical and medicinal uses
Kirkia acuminata	Southern Africa			X	X	X				Makes a good live fence. Bark reported to have toothache treatment qualities
Lannea discolor	Southern Africa			X	X	X				Suitable for light carpentry and joinery
Lannea stuhlmannii	Africa			X	X	X		X		Tree believed to invoke ancestral spirits
Lonchocarpus capassa (Lilac tree)	Southern Africa			X	X	X				Good tree with copious honey flow
Markhamia obtusifolia	Southern Africa			X	X	X				Tree heavily browsed by cattle. Both roots and fruit have medicinal value
Parkia filicoidea	Africa			X		X				Pods are a good stock food. Has been used for tanning leather in Sudan
Pericopsis angolensis	Zambia			X		X				Useful fence post. Tanning and carving. Leaves browsed by cattle and game

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
Pterocarpus angolensis	Southern Africa			X		X				Excellent for furniture and high class joinery as well as construction
Pterocarpus antunesii	Southern Africa	X		X		X				Browsed by cattle. A favourite tree of the elephant
Sclerocarya caffra (Marula)	Africa			X	X	X				Leaves browsed by cattle and game. Edible fruit rich in vitamin C
Spathodea campanulata	Africa			X		X		X	X	A good ornamental and shade tree. Various parts have medicinal value. It has a cultural value
Steganotaenia araliacea (Carrot tree)	Africa			X		X		X		Both roots and leaves have medicinal uses
Stereospermum kunthianum (Pink jacaranda)	Africa			X				X	X	Of ornamental importance. Leaves, bark, roots and pods are reported to be useful medicinally
Swartzia madagascariensis (Snake bean)	Africa			X	X	X				Has a variety of local medicinal uses
Tamarindus indica (Tamarind)	Africa			X	X	X				Leaves and fruit much liked by elephants. Various medicinal uses are reported
Xeroderris stuhlmannii	Africa			X		X				Leaves are browsed by elephants
Albizia adianthifolia	Africa			X	X	X		X		Foliage browsed by cattle. Gum, roots and bark have a variety of medicinal uses

		ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				
Plant Species (Common name in parentheses)	Region (where important)	Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	Reasons for inclusion
Albizia amara	Southern Africa			X	X	X				Useful for furniture, tanning and general construction. Fruit used as remedy for coughs and malaria
Albizia antunesiana	Southern Africa			X	X	X				Has very good honey flow. Browsed by cattle. The bark roots and leaves have varied medicinal uses
Albizia harveyi	Eastern and Southern Africa			X	X	X				Foliage browsed by cattle and game
Albizia versicolor	Eastern and Southern Africa			X	X	X				Leaves browsed by game. Wood used to make domestic tools
Amblygonocarpus andongensis	Africa			X	X	X				Pods browsed by cattle and game. Wood useful in general construction and building works
Burkea africana (Wild syringa)	Africa			X	X	X				Foliage eaten by game. Host to edible caterpillars
Delonix regia (Flamboyant)	Malagasy			X		X			X	A common street tree in Zambia. The bark has medicinal value
Entada abyssinica	Africa			X	X			X		Plays a part in rain making ceremonies
Erythrophleum africanum	Africa			X	X	X				Good mining timber. Suitable for general building and construction
Peltophorum africanum (African wattle)	Southern Africa			X	X				X	As above. Foliage eaten by rhino

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
Anisophyllea boehmii	Zambia			X		X				The wild fruit is very popular. Roots, bark and leaves are used in medicines. Foliage grazed by cattle
Anisophyllea pomifera	Zambia			X		X				The wild fruit is very popular. Tree browsed by cattle
Baphia bequaertii	Zambia			X		X				Trees browsed by cattle
Baphia massaiensis	Southern Africa		X		X	X			X	Rapid invader of soils depleted by cassava. N-fixer. Has medicinal value
Boscia angustifolia	Africa			X	X	X				Tree good for honey. Game and livestock fodder
Bridelia micrantha	Africa			X	X	X				A variety of medicinal uses. Excellent firewood and charcoal
Diospyros batocana	Southern Africa			X				X		Magico-medical properties. Wide variety of medicinal uses
Diospyros kirkii	Southern Africa			X		X				Edible fruit, not cultivated
Diospyros mespiliformis (African ebony)	Africa			X	X	X				Leaves browsed by game and birds
Dombeya rotundifolia (Wild pear)	Southern Africa			X		X				Has good nectar flow and makes good honey
Faurea saligna	Africa			X		X				Produces abundant nectar, good bee tree
Faurea speciosa	Africa			X	X	X				Used in furniture making. Roots and leaves have medicinal value

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
Hymenocardia acida	Africa			X		X				Has a variety of medicinal and magical uses
Magnistipula butayei	Africa				X	X				Bark and roots useful in preparation of few traditional medicines
Marquesia macroura	Zambia			X		X				A valuable mining timber. Good flooring timber
Parinari curatellifolia	Africa			X		X		X		Edible fruit. Kernel has high oil content
Phyllocosmus lemaireanus	Southern Africa			X		X		X		Reputed to be good for colds, coughs and sore eyes
Pseudolachnostylis maprouneifolia	Africa			X	X	X				It is browsed by game and is a good fuel wood. The tree has both magical and medicinal value
Securidaca longepedunculata (Violet tree)	Africa			X		X				Game animals browse the leaves
Terminalia mollis	Central Africa			X	X	X				Leaves browsed by game and sometimes cattle
Uapaca kirkiana (Wild loquat)	Southern Africa			X		X				Fruit is highly sought after from wild. Very nutritious. Can be processed into refreshing drink or jam. Good bee tree
Uapaca nitida	Central Africa			X		X		X		The fruits make nourishing pig feed. Both magical and medicinal values
Uvariastrum hexaloboides	Zambia			X		X				Elephants like the bark, leaves and fruit

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
Xylopia odoratissima	Southern Africa			X		X		X		Roots used in local medicines. Also some magical value
Berchemia discolor	Africa			X		X				The fruit is edible and very popular
Combretum imberbe (Leadwood)	Southern Africa			X		X				Useful in general construction including railway sleepers
Combretum molle (Bush willow)	Africa			X	X	X				Leaves browsed by giraffe, elephant and cattle
Combretum zeyheri	Africa			X		X				Produces abundant nectar, good honey tree. Roots, leaves and bark have local medicinal value
Garcinia huillensis	Africa			X		X				The bark, roots and leaves used for a wide variety of illnesses, including syphilis
Garcinia livingstonei	Africa			X		X				Foliage browsed by elephants. Barks and roots have limited medicinal value
Mitragyna stipulosa	Africa			X		X		X		It is alleged to have many medicinal uses
Rothmannia whitfeldii	Africa			X		X				Roots, leaves, bark and fruit are useful in preparing local medicines
Strychnos innocua (Wild orange)	Africa			X		X				Leaves are eaten by livestock. The fruit is edible
Syzgium cordatum (Water berry)	Southern Africa			X	X	X				Leaves browsed by elephants. Fruits eaten by birds, bushbabies and bats

		ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				
Plant Species (Common name in parentheses)	Region (where important)	Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	Reasons for inclusion
Syzgium guineense	Eastern and Southern Africa			X	X	X				Fruit edible. Roots, bark and leaves have various medicinal uses
Syzgium owariense (Water berry)	Africa			X	X	X				It is an excellent bee tree
Vangueriopsis lanciflora (Wild medlar)	Southern Africa			X	X			X		Considered sacred in some parts of Zambia
Acacia giraffae Burch. (Camel thorn)	Africa		X	X		X		X	X	Pods are relished by game and cattle, especially giraffe
Ximenia americana L. (Sour plum, wild plum)	Africa			X		X				The plum-like fruits are edible. Almond-flavoured and tasty when fully ripe
Cordyla africana Lour. (Wild mango)	Zambia			X		X				Fruit is favourite food of elephants. Seeds roasted before eaten. Timber useful in construction
Dialium englerianum Henriques	Zambia			X	X	X				Fruit eaten by cattle
PALMS										
Hexalobus monopetalus Engl.	Zambia			X		X				The fruit is edible and makes a delicious jam
Hyphaene ventricosa (Doum palm)	Southern Africa	X		X	X	X				Fruit sap used as palm wine
Phoenix reclinata	Africa	X		X	X	X			X	As above. Also useful ornamental
Raphia farinifera	Zambia	X		X	X	X				Leaflets used for weaving mats, baskets and fish traps

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
GRASSES										
Acrocera macrum	Zambia	X		X		X	X			Very palatable hay and pasture grass
Andropogon amplectens	Zambia			X		X				Suitable as a graze only when young
Andropogon gayanus	Zambia	X				X				Leafy and palatable when young. Suitable graze for livestock
Brachiaria brizantha	Zambia	X		X		X				Softer, more succulent and of better quality for grazing
Brachiaria serrifolia	Africa	X				X	X			A leafy and palatable annual grass which is good for grazing
Chloris gayana (Rhodes grass)	Zambia	X		X		X	X		X	Palatable grass, with good management provides excellent pasture
Chloris virgata	Zambia	X					X			Very palatable for grazing
Cynodon dactylon	Zambia	X		X	X	X			X	Very valuable pasture grass. Useful for soil conservation. Useful as a loan grass
Dactyloctenium aegyptium (Crowsfoot)	Zambia	X			X	X				A leafy and palatable grass, well grazed
Dichantium papillosum	Zambia	X				X				Leafy, thin-stemmed, palatable tussock grass for grazing
Digitaria acuminatissima	Zambia	X		X	X	X				It is palatable and well grazed by livestock
Digitaria milanjiana	Zambia	X		X	X	X				A leafy palatable grass which is very well grazed

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS: Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	SOCIO-ECONOMIC FUNCTIONS: Commodity	Genetic Resource	Cultural	Environmental Management	Reasons for inclusion
Digitaria setivalva	Zambia	X		X		X				Very palatable grass which is well grazed by cattle
Digitaria ternata	Zambia				X	X				Palatable and grazed by stock
Echinochloa colonum	Africa			X		X				A leafy, soft-stemmed, palatable and useful annual grass for stock grazing
Echinochloa holubii	Zambia	X		X		X				Very leafy, palatable and well grazed by stock
Echinochloa pyramidalis	Africa	X		X		X				Very palatable and valuable pasture grass
Echinochloa stagnina	Zambia	X		X		X				Very succulent and valuable fodder
Eleusine corocana (Fingermillet)	Zambia	X		X	X	X	X			Highly consumed in Zambia
Eleusine africana	Zambia	X			X	X				Eaten by types of livestock
Eleusine indica	Zambia	X			X	X			X	Used as livestock pasture and loan grass
Enteropogon macrostachyus	Zambia			X		X				Leafy and palatable when young
Heteropogon contortus (Spear grass)	Zambia			X	X	X			X	Provides reasonable grazing when young. Useful in preventing soil erosion
Hyperrhania filipendula (Thatch grass)	Zambia				X	X				Traditionally important in thatching house roofs
Panicum coloratum	Zambia	X		X		X	X			Very useful pasture grass. Some varieties useful for cultivated pasture

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
Panicum maximum (Guinea grass)	Zambia	X		X	X	X				Very palatable and valuable pasture grass
Panicum merkeri	Zambia	X		X		X				Fairly succulent, leafy and appears to be useful pasture grass
Panicum meyeranum	Zambia	X			X	X				Useful grazing grass, leafy and palatable
Panicum repens	Zambia			X		X				Palatable and useful grazing grass
Panicum sabalbidum	Zambia	X		X		X				Succulent and leafy palatable grass
Panicum swynnertonii	Zambia	X		X	X	X				A leafy pasture grass
Paspalidium platyrrhachis	Zambia				X	X				A palatable and well-grazed grass
Paspalum commersonii	Zambia	X		X	X	X				A palatable and useful grazing grass
Paspalum polystachyum	Zambia	X			X	X				A succulent, leafy grass which seems promising as a pasture species
Pennisetum polystachyon	Zambia			X		X				A leafy palatable grass
Pennisetum purpureum (Elephant grass)	Zambia	X	X		X	X	X		X	Succulent, nutritious and palatable while young. Widely used as a cultivated fodder for grazing and silage mulching and soil conservation
Piptostachya inamoena	Zambia				X	X				Provides reasonable early grazing

		ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				
Plant Species (Common name in parentheses)	Region (where important)	Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	Reasons for inclusion
Setaria anceps	Zambia			X		X				Succulent, leafy and excellent pasture grass
Setaria pallide fusca	Zambia				X	X				Leafy, palatable and generally well grazed by stock
Setaria sphecelata (African foxtail)	Zambia			X		X	X			Excellent, leafy and palatable pasture grass. Some varieties used for cultivated pasture and are gaining in popularity
Setaria verticillata	Zambia	X			X	X				Very leafy and succulent when young. It is well eaten by stock
Sorghum marcrochaeta	Zambia	X			X	X				Leafy and grazed by cattle
Sorghum verticilliflorum	Zambia	X			X	X				Leafy and eaten by stock
Sporobolus marginatus	Zambia				X	X				Well grazed by cattle and game. Indicator species for saline soil conditions
Sporobolus piramidolis	Zambia				X	X				The grass is very good as a traditional broom
Sporobolus spicatus	Zambia				X	X				It is palatable and well grazed by stock and game
Trachypogon spicatus	Zambia			X		X				Provides useful grazing during the early growing season
Tristachya superba	Zambia	X		X	X	X				It is grazed when very young

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
Urochloa bulbodes	Zambia				X	X				A useful grazing grass during early stages of growth
Urochloa pullullans	Zambia	X		X	X	X				A very palatable and excellent grazing grass. Also well grazed when dry
Urochloa trichopus	Zambia			X	X	X				It is a leafy, very palatable grass, well grazed by stock
Vetiveria nigritana	Zambia			X	X	X				Leaves grazed when very young
Vossia cuspidata	Zambia	X		X	X	X				Palatable, well eaten by stock
HERBS										
Amaranthus hybridus (Pigweed)	Zambia	X			X	X	X			Leaves used like spinach. Commercial variety now developed. Medicinal properties
Amaranthus spinosus	Zambia	X			X	X	X			Leaves used like spinach
Amaranthus thunbergii	Zambia	X			X	X	X			As above
Celosia trigyna	Zambia	X			X	X				Leaves and young shoots cooked and eaten
Portulaca oleracea	Zambia				X	X				Leaves cooked and eaten
Cleome gynandra	Zambia				X	X				Widely distributed edible herb
Corchorus tridens	Zambia				X	X				Leaves cooked like spinach
Hibiscus cannabinus	Zambia				X	X	X			Leaves, flowers and pods cooked for food. Fibre useful in producing sacks

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				Reasons for inclusion
		Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	
Hibiscus meeusei	Zambia				X	X				Leaves, flowers and pods cooked for food. Fibre useful in producing sacks
Hibiscus trionum	Zambia				X	X				As above
Solanum nigrum (Black nightshade)	Zambia				X	X				Leaves and ripe fruit are eaten
Bidens pilosa (Black jack)	Zambia				X	X				Young plants and leaves of older plants are cooked like spinach
Achyranthes aspera (Prickly chaff)	Zambia				X	X				Treats boils, skin eruptions, colic and snake bite
Datura stramonium (Thorn apple)	Zambia				X	X				Whole plant is an anaesthetic anodyne and antibelennorrgagic. Seeds are antispasmodic, narcotic and anodyne
Sesamum angolense	Zambia				X	X				An infusion of plant is remedy for diarrhoea and skin disease. Root powder cures ophthalmia. Decoction of roots and leaves is remedy for measles
Gnidia kraussiana	Zambia				X	X				Good remedy for snake bite. Chewed leaves are applied to burns
Solanum incanum (Bitter apple)	Zambia				X	X				Cures chest pain, snakebite, pleurisy and pneumonia, toothache and sore throat

		ECOLOGICAL FUNCTIONS				SOCIO-ECONOMIC FUNCTIONS				
Plant Species (Common name in parentheses)	Region (where important)	Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	Commodity	Genetic Resource	Cultural	Environmental Management	Reasons for inclusion
Leonotis nepetifolia (Pig weed)	Zambia				X	X				Whole plant expels tape worms. Cures abdominal troubles, fevers, headache, elephantiasis and amenorrhoea. Leaves are antiasthmatic
Elephantopus scaber	Zambia				X	X				Possesses medical properties as a cardiac tonic. Treats snake bite. Arrests vomiting
MUSHROOMS										
Termitomyces letestui (Brown cap)	Zambia		X	X		X		X		Edible, very highly prized in season
Termitomyces titanicus (Mushroom giant)	Zambia		X	X		X				Edible, rich source of relish
Termitomyces microcarpus	Zambia		X	X		X				Edible, well used in season
Termitomyces clypeatus	Zambia		X	X		X				Edible, very tasty
Macrolepiota procera (Parasol mushroom)	Zambia		X	X		X				Edible, excellent flavour
Amanita zambiana (Christmas mushroom)	Zambia		X	X		X				Edible, delicious, soft-fleshed

Plant Species (Common name in parentheses)	Region (where important)	ECOLOGICAL FUNCTIONS Primary Production	Nutrient Accumulation	Habitat Structure	Colonisation	SOCIO-ECONOMIC FUNCTIONS Commodity	Genetic Resource	Cultural	Environmental Management	Reasons for inclusion
Amanita flammeola	Zambia		X	X		X				Edible, good alternative relish
Lactarius kabansus	Zambia		X	X		X				Edible, widely consumed, sells quickly when in season
Lactarius gymnocarpus	Zambia		X	X		X				Edible, well consumed
Lactarius piperatus	Zambia		X	X		X				Edible, rich source of relish
Cantharellus miniatessens	Zambia		X	X		X				Edible, delicious. Sells fast
Cantharellus cibarius	Zambia		X	X		X				Edible, as above
Cantharellus densifolius	Zambia		X	X		X				Edible, delicious
Cantharellus longisporus	Zambia		X	X		X				As above
Schizophyllum commune	Central Africa		X	X		X				Edible. Eaten throughout central Africa
Lentinus cladopus	Zambia		X	X		X				Edible, less popular than others

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The worldwide conservation effort has often been focused on a few "flagship" species. It is recognised by experts that large sums of money need not be spent on single mammal or bird species while tens of thousands of plants, invertebrates and microorganisms are being lost year by year from the face of the Earth. Various partners involved in the conservation and sustainable development need to move from the emotionally-based activities to more scientifically sound work. This will require working on key species which have a core function either ecologically or socioeconomically. These species might not necessarily be those that arouse the public's attention, but yet scientists believe that they are the most important species for the long term survival of ***Homo sapiens***. To develop the concept of key species a technical workshop was held in Trinidad and Tobago. The objective was to equate diverse views on what are key species, how to identify and conserve them in the context of current socioeconomic development? The first part of this book gives a complete report of the proceedings of the workshop. The second part contains the results of the first attempts by five member countries of the Commonwealth to identify key species in their respective countries based on the concepts given in the first part.

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