INTERNATIONAL COUNCIL FOR BIRD PRESERVATION

BIOLOGICAL DIVERSITY ASSESSMENT

OF

THE REPUBLIC OF YEMEN

by

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DISCLAIMER

This report was researched and prepared before the reunification of the People's Democratic Republic of Yemen and the Yemen Arab Republic into the Republic of Yemen on 22 May 1990. It therefore only covers what was the Yemen Arab Republic (North Yemen), although much of the information and some major recommendations may be equally appropriate to the whole country.

CONTENTS

ANNEXES

EDITORIAL

ACRONYMS USED IN THIS REPORT

AID	Agency for International Development
APP	Appendices
ARA	Agricultural Research Authority
BDA	Biological Diversity Assessment
BIB	Bibliography
CBP	Conservation of Biological Diversity Project
CDSS	Country Development Strategy Statement
CLCCD	Confederation of Local Councils for Cooperative Development
CPO	Central Planning Organization
DOF	Directorate of Fisheries
EPC	Environmental Protection Council
FAA	Foreign Assistance Act
FAO	Food and Agriculture Organization of the United Nations
FPP	Farming Practices for Productivity Project
FSN	Foreign Service National
GCFD	General Corporation for Fisheries Department
ICBP	International Council for Bird Preservation
ILL	Illustrated
IUCN	International Union for the Conservation of Nature and Natural Resources
LOP	Length of Project
MAF	Ministry of Agriculture and Fisheries
MMH	Ministry of Municipalities and Housing
MOH	Ministry of Health
MOMR	Ministry of Oil and Mineral Wealth
NGO	Non-governmental Organization
PCD	Planned Completion Date
RLIP	Range and Livestock Improvement Project, Dhamar
ROY	Republic of Yemen
ROYG	Republic of Yemen Government
SIP	Social and Institutional Profile
sp.	species
TDA	Tihamah Development Authority
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
USAID	United States Agency for International Development
WWF	Wide World Fund for Nature

EXECUTIVE SUMMARY

The purpose of the Biological Diversity Assessment (BDA) is to describe the state of Yemen's natural flora and fauna, identify the unique and endangered species and habitats, and develop a strategy for conservation of the country's biological resources within its overall development policy. Recommendations are made for the Republic of Yemen Government (ROYG), United States Agency for International Development (USAID) and other concerned donors and international conservation organizations.

The main conclusion of this study is that biological diversity in Yemen is being drastically reduced by the rapid degradation of the environment. This includes the ecological and economic consequences of unchecked cutting of trees and forests for fuelwood, major declines in water tables, and massive erosion of the highland terrace ecosystem. Because of the overall process of destruction to the environment, conservation initiatives for biological resources must be framed within a development policy committed to saving the total environment. It is essential that the conservation of biological resources be undertaken immediately because of the serious degradation of the environment resulting from the current infrastructural development, especially rural roads and coastal construction.

Biological resources of Yemen

Since Yemen is located at the conjunction of African, Asian and Palearctic ecological zones, the diversity of plants and animals is greater than in any other part of the Arabian Peninsula. Indeed, the wide variety of environments within the country has resulted in some of the greatest biological diversity in the Middle East. Due to the range of environmental zones and relative isolation of the country, a number of endemic species are found. The valuable biological resources have an obvious scientific significance, but there are also major economic implications for sustainable productivity in the country. The genetic diversity of indigenous crops, most notably sorghum, and medicinal plants is of critical importance for pest management and the control of viral diseases in the expanding agricultural sector. Similarly, protection of critical habitats is necessary for sustainable fisheries and for reforestation of much of the country.

The flora of Yemen is especially rich, with an estimated 1700 plant species in a wide variety of ecological habitats. About one-third of these belong to the Saharo-Arabian plant geographic region; the remaining two-thirds are of African orientation. There is a high degree of similarity for both plant and animal species with East Africa, although the areas have been isolated for at least 18,000 years. The variations in elevation and rainfall in the western escarpment have led to significant genetic variation. Much of the original forest cover has been denuded, especially in the last two decades, for fuelwood. The rangeland remains an important part of the agricultural ecosystem, although this has deteriorated with the collapse of numerous terrace systems. A wide range of plants have been used in traditional medicine and in local industries in Yemen's history. Some of these species (e.g. certain *Aloe*, *Juniperus*, and *Acacia*) are rare and important. There is a variety of marine plant communities, the most important economically being the mangrove forest on which the shrimp stock depends.

The fauna of Yemen is also quite diverse, in large part because of the range of plant communities and habitats. New species are regularly being described as scientific research on the fauna continues. The long history of human settlement and transformation of the landscape into a terrace cultivation ecosystem have led to major reductions in the larger vertebrates, particularly mammals. The ibex and three species of gazelle were once plentiful here, but are severely threatened today. Indications are that there has been a major decline in the numbers of most species of large mammal during the past three decades because of increased access to remote areas of the countryside and the use of rifles and automatic weapons. From a scientific point of view, certain species are of particular interest because

of the long genetic isolation from African components (e.g. local race of baboon populations). Among the more important ~~threatened and~~ endemic vertebrate species in Yemen are: leopard, caracal, Queen of Sheba gazelle, ibex (possibly extinct), Ruppell's sandfox, striped hyaena, African small-spotted genet, dugong, green and hawksbill turtles, bald ibis, Arabian bustard, Philby's rock partridge, Arabian red-legged partridge, Arabian woodpecker, Arabian accentor, Arabian wheatear, Yemen thrush, Yemen warbler, Arabian golden sparrow, Arabian waxbill, Arabian serin, Yemen serin, golden-winged grosbeak, and Yemen linnet.

Environmental policy and education

Within the ROYG the Environmental Protection Council (EPC) has been newly formed to develop and coordinate environmental policy in the country. This council is located in the Department of Environmental Health of the MMH and it does not currently have the capabilities to deal with the full range of environmental issues in the country. Specific functions related to wildlife conservation, sustainable fisheries and reforestation are located in various departments of the MAF. The MOMR has responsibilities for environmental damage from the pipeline or off-shore oil spills. Faculty at Sana'a University have conducted research on biological resources, but the Faculty of Science lacks funding, materials and support for specific projects.

Environmental education and promotion of conservation have been very limited in the country. Two major examples include a Dutch-sponsored tree-planting campaign in 1988 and a limited publication effort regarding Yemen's endemic birds by ICBP and MAF. The EPC has a committee to deal with environmental education, but it is still in the planning stages. The Yemeni media have shown a willingness to assist in educational programming in coordination with other government institutions, but specific information for environmental programming needs to be developed.

Conservation priorities

One of the main conclusions of this study is that the overall development policy and actual direction of development in the country have ignored the environmental consequences of change. There has been a dominant focus, throughout the development community, on increasing productivity on irrigated land. Yet, at the same time the natural resource base, dominated by the terrace ecosystem of the western escarpment, has deteriorated to an alarming degree. While this is not the most productive land in the agricultural sector, it still supports the majority of small farmers in the country. If the environment continues to deteriorate without efforts to change direction, Yemen will be faced with major economic and social problems as large numbers of rural farmers will be forced off the land.

The conservation priorities for Yemen include:

1. The need for reassessment of a development policy which currently ignores the present day environmental degradation and responds only to short-term problems. It is necessary to stress the costs in economic and human terms of continuing to ignore the collapse of the terrace ecosystem and wadi agricultural regimes. This will require a perspective looking beyond the short-term economic goal of increased productivity exclusively on irrigated land.

2. There is a need for institutional development of a targeted nature for those governmental ministries and councils directly concerned with developing environmental policy, monitoring the environment and promoting conservation. This is primarily for the EPC and various departments of the MAF, as well as MOMR. It is important to focus on the need for private and NGO involvement on environmental issues, since government agencies will not be able to address all the problems while at the same time responding to their regular functions.

3. There is a critical need to raise conservation awareness through dialogue with ROYG and through media presentations to the public. It is important that conservation of biological resources (especially species and habitats) be presented as a practical part of the development program.

4. There are several critical habitats and localities in need of protected status. First it is necessary to define the mechanisms for establishing legislation and implementing protection. It is especially important to involve local communities in self-policing programs to protect trees and the environment from over-development.

5. There are several species in Yemen on the international list of threatened species. There is currently no legislation to protect any of these.

6. The genetic diversity in the country is critical for a sustainable agricultural and rangeland ecosystem. This is especially relevant given the potential for pest and virus problems with the switch to irrigated crops.

7. There is currently no program for the sustainable management of fisheries and coastal development. This poses a grave danger for critical habitats such as mangroves and the maintenance of marine and coastal fisheries.

Recommendations

The recommendations of this study are directed at ROYG and donors in general, and specifically at USAID/Sana'a and AID/Washington. The general recommendations include:

1. High priority for a mission from an international conservation agency to establish affiliation with a Yemeni institution and initiate projects under existing international programs. This would provide an institutional focus for a variety of conservation organizations to work on projects in Yemen.

2. Technical support for the EPC to complement the activities of other donors. The most critical needs are for a natural resource ecologist to deal with the range of environmental problems and for assistance in designing legislation and communication packages.

3. The Department of Wildlife and Zoos in MAF has no capabilities at present for wildlife conservation. The most practical need at this time is for training to staff this function.

4. The Directorate of Fisheries needs assistance in planning coastal management and sustainable fisheries development. It is especially important to examine the potential for private sector fishing rather than the current GCFD.

5. The Faculty of Science at Sana'a University needs support in training and in funding of specific projects, including research on biological species, a national herbarium, and a greenhouse.

6. The MOMR needs technical support for dealing with potential oil spills and environmental damage from the pipeline. This should be modelled on the other oil-producing states in the region.

7. There are a number of specific initiatives for using the media to promote conservation. A Yemeni documentary on wildlife conservation is proposed. It is important that the conservation message be packaged for Yemen rather than simply using existing conservation programs designed for a western audience.

8. Critical areas for conservation and protection are defined in the study. It is necessary to define the nature and level of protection needed before trying to establish a formal park or reserve.

9. Critical species are defined for ~~protection~~ the conservation of their global biodiversity.

~~10. Conservation of genetic diversity.~~

10 ~~11~~. A high visibility initiative is proposed to focus attention on conservation. A proposal is presented for a feasibility study to protect the gazelle in Yemen and possibly reintroduce the ibex.

~~12. At present little rhino horn is entering Yemen and there is little in a practical manner that can be done to stop the trade from this end.~~

The recommendations for USAID relate to the recent Conservation of Biological Diversity Project (CBD) between AID and WWF and to the mission portfolio. Initiatives under the CBD would include: use of PCV for conservation projects at the community level; technical assistance to help faculty at Sana'a University in preparing proposals for research on biological resources and obtaining funding; assistance from The Nature Conservancy in adapting a Conservation Data Center for the EPB or Sana'a University; assistance for a pilot project to create a protected area; assistance for policy dialogue with ROYG on the economic value of protected areas and natural plant species; assistance to Sana'a University for materials to study Yemeni species.

Under the USAID/Sana'a portfolio there are several recommendations. The major recommendation is for a policy study to review ROYG agricultural policy and make recommendations on how to integrate economic concerns with environmental degradation under the existing policy. ~~In the context of Dev. Training III, two scholarships should be made available to the Faculty of Science at Sana'a University~~ to train a future zoologist and botanist at the University, both of whom would have a conservation focus. The Educational Support Project should include a component on science curricula. The ADSP should examine some policy implications of the environmental problems facing the country and assist the DLC with materials on environmental conservation. The FFP should look at environmental issues, as outlined in the report, resulting from the focus on irrigation of horticultural crops. The potential harm from increased use of pesticides should be carefully monitored. The Small Project Assistance Program should work with Peace Corps in implementing a conservation project at the community level. PL450 funds can be used for several environmental initiatives not currently funded in the country.

1. INTRODUCTION

1.1 Project rationale

Development policy within Yemen in its first 25 years has focused on the pressing needs for economic growth, infrastructure development, and meeting basic human needs. While both the Republic of Yemen Government (ROYG) and the donor community have noted a range of environmental problems, particularly the critical decline in water sources, little attention has thus far been directed at the biological resources of the country.

The purpose of this study is to define the state of Yemen's natural flora and fauna, identify unique and threatened communities of these resources, and to devise a strategy and recommend initiatives for the conservation of such resources within the overall development program of Yemen. It is essential that the conservation of biological resources be approached immediately because of the serious degradation of the environment as a result of the developing infrastructure, particularly rural roads and coastal construction.

Biological diversity (or biodiversity) is defined by AID as "the variety and variability among living organisms and the ecological systems in which they occur. Species diversity, genetic diversity, and ecosystem diversity are included under the term biological diversity." (AID, April 1988:8). AID policy in support of biological diversity focuses on:

1. Resource inventories and conservation strategies to identify areas to protect.

2. Establishment and maintenance of wildlife sanctuaries, reserves and parks.

3. Development of buffer zones and promote alternative sources for products in protected areas.

4. Efforts in resource management or land-use which protect and conserve indigenous plants and animals.

5. Training, education, public awareness and institution building to improve host-country capabilities in conservation management.

6. Encouraging and promoting policies and policy dialogue to increase the host-country's national commitment and long-term ability to protect diversity.

1.2 Scope of work

The principle objectives for this BDA were defined in the scope of work as follows:

A. Evaluate the status of existing floral and faunal diversity in Yemen, both terrestrial and marine, as well as current trends in the utilization of biological resources in Yemen.

B. Identify the effects of human population and economic growth rates on the conservation of biological diversity in Yemen.

C. Evaluate existing and proposed environmental policies and laws in Yemen designed to conserve biological diversity.

D. Evaluate the institutional capacity, including educational and training opportunities, to address conservation needs.

E. Determine the major biological diversity issues and prioritize the conservation needs in Yemen.

The primary purpose for conducting the BDA in Yemen is to provide the USAID Mission and AID/Washington with relevant information in preparation of the CDSS and/or Action Plans. This will fulfil the requirements of the Foreign Assistance Act (FAA) in reference to Amendment 118 regarding the conservation of tropical forests and Amendment 119 concerning conservation of biological diversity. The BDA will also address and document issues for future conservation activities within Yemen. Recommendations will also be most pertinent to, and have been written for, the ROYG, USAID and a variety of international support and donor organizations, including the international conservation community.

1.3 Methodology

The BDA was conducted in Yemen from November 16, 1989 through December 10, 1989 by a team from the International Council for Bird Preservation (ICBP), based in Cambridge, England. This contract was awarded by the U.S. Fish and Wildlife Service, which arranged the study for USAID.

The primary members of the team included Dr Daniel Martin Varisco (Team Leader), an anthropologist with extensive experience in development and environmental issues in Yemen; Dr James Perran Ross (Marine Biologist), with previous experience in Oman and Saudi Arabia; and, Anthony Milroy (Agricultural Engineer), with previous experience in the agricultural sector and media of Yemen. In addition a number of local experts, both Yemeni and expatriate, contributed to the documentation of the study (Annex 2). Scientific data regarding Yemen's flora and fauna were checked in England by several specialists that have experience in the country. The project was supervised by Dr Michael Rands, ICBP Programme Director, an experienced, professional conservationist with first hand field experience of ornithology and wildlife conservation in Yemen, who also edited this report.

The team worked in Yemen with officials of the USAID Mission in Sana'a, the Environmental Protection Council (EPC), Ministry of Agriculture and Fisheries (MAF), Confederation of Local Cooperative Councils for Development (CLCCD), Sana'a University, and Yemeni media. Each primary team member conducted a fact-finding field trip to supplement existing data available in reports and from local experts. Varisco took a three-day field trip to Jabal Bura, one of the best preserved examples of indigenous forest in the country. He was accompanied by two officials of the MAF and one from the CLCCD. Ross made a four-day survey of the coastal environment in the Tihama, accompanied by an official of the MAF and FSN from USAID. Milroy made a four-day survey of the upper and lower portions of Wadi Zabid, accompanied by an official from ARA in the MAF. For part of the trip he was joined by a FSN agricultural economist from USAID/Sana'a.

Given the lack of time for extensive field research, the focus of the project was on existing documentation and expertise in Yemen. The main report of the BDA highlights the relevant variables and salient features of Yemen's biological resources within the overall development context of the country. Supporting documentation and important bibliographic sources are included in a series of annexes. The perspective of the report is primarily on the environmental variables, i.e. the biological resources within the various ecosystems within the country. However, these resources cannot be properly understood or evaluated without consideration of the economic and policy issues of development.

1.4 Status of available data

It is commonly assumed that the documentation of Yemen's flora and fauna is limited. In fact a wide variety of information is available, although not always in published form. Much of these data have

been collected piecemeal, so that some regions are fairly well covered and others much less so. The annotated guide to the bibliography in Annex 1 includes the significant and useful sources. Most of the previous studies have been made and written by expatriates or foreign researchers. Recently, however, Yemenis trained in botany, zoology and related fields have begun field research projects, primarily through Sana'a University's Faculty of Science. Applied research from the concerned ministries, particularly the MAF, has largely been done by foreign experts.

A critical problem in the analysis of the data on Yemen's biological resources is the difficulty of access to sources. In many cases relevant articles on a particular species are to be found in obscure or specialist journals not readily found in Yemen. The information is also spread out through several languages, with English and German being dominant. Relatively little attention has thus far been paid to collection of data from Arabic sources, included Yemeni folklore, folk medicine and the written tradition of herbals. These sources, however, are critical for understanding the local perceptions and use of the flora and fauna (Annex 8).

Yemen's flora is better documented than its fauna, although many of the earlier sources are out-of-date and primarily of historical rather than practical significance. The most important development for flora is the completion of a national vegetation map of the country as a result of efforts through the Dutch RLIP in Dhamar. A series of reports and field collections by Kessler, Scholte and Khuleidi represent some of the best studies of Yemen's flora, particularly for the Central Highlands. Ongoing field research by the faculty of Sana'a University, including the creation of an herbarium, will be the focus of future study and analysis of Yemeni flora.

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The primary source of recent information on the marine environment is the IUCN report by ~~Ormond~~ (1987) which gives a comprehensive analysis of biotopes, habitats and species examined in a two-month survey in 1985. This report includes maps of habitats and faunal distribution, species lists and a useful series of recommendations. It is the major source for much of the information on the coastal zone in this report. Additional useful information on commercial fisheries is contained in a series of reports from the FAO Fisheries Development Project 1972-1977 (see Walczak 1977 for review). The report of the Tihama Expedition (Stone 1985) has a useful account of traditional fisheries and faunal distributions. A marine survey of the Ras Isa area commissioned by Hunt Yemen Oil is not yet available for distribution.

The terrestrial fauna of the ROY is adequately described, as noted in the index to the bibliography in Annex 1. Following the Ornithological Society of the Middle East's survey in 1985, the avifauna is particularly well studied and birds do provide a useful indicator of overall biodiversity and species-rich habitats. Nevertheless, new species of fauna continue to be discovered and described, most recently a large monitor lizard in the Tihama foothills, a new gazelle species from southern ROY, and several new snakes and reptiles.

1.5 Background on Yemen's development context

GOVERNMENT: The republic was formed in 1962 after the toppling of the centuries-old religious imamate dominated by the Zaydi sect. The current president, Colonel Ali Abdullah Salah, came to power in 1978 and has fostered elections since that time. The government structure is democratic with a great emphasis on cooperative development. The government is non-aligned and has cordial relations with East and West bloc countries. Tribal politics is still an important factor in much of the country, although a growing nationalism has taken shape. Recent development in the country has been heavily dependent on outside donors, especially nearby states on the Peninsula.

POPULATION: The February 1986 national census recorded a total population of 9,274,173 with a large number of emigrants working abroad. Most of the population is distributed in small, rural communities. The largest city is the capital, Sana'a, with a population of 427,150; only two other cities

have populations over 100,000. The rate of population growth is officially estimated at 3.3 per cent per year, but health statistics are dismal. The infant mortality rate is one of the highest in the world and the average life expectancy at birth is around 50 years. The major cities have hospitals, but rural clinics are only slowly reaching outlying areas. The number of doctors in the country increased from about 600 in 1980 to about 1200 in 1986.

ECONOMY: The backbone of the Yemeni economy has always been agriculture, which employs appropriately 60 per cent of the work force. Although subsistence crops such as sorghum, millet and wheat still predominate, in recent years new crops have been introduced and production figures have been improved. Subsistence crops are still the main source of food for the majority of the population, although imported grains are rapidly replacing these in the diet throughout the country. There is relatively little industry. Oil production began in late 1987, and is now a substantial source of government revenues. In the mid-1970s, almost a third of the Yemeni male labor force was working outside the country, primarily in neighboring oil-producing states. By the end of the decade, the amount of remittances peaked at about $1,000,000,000 per year; remittances have since declined by more than half. Current government revenues are limited, with a total budget in 1989 of about $2.5 billion. The official value of the Yemeni riyal has fallen from 4.5 Yemeni riyals per dollar in the late 1970s to 12 Yemeni riyals per dollar in 1990. Tourism is developing, with an estimated 43,550 tourist visas issued in 1986. Most tourists come from Europe; only about 4200 of the tourist visas issued in 1986 were for all of North and South America.

EDUCATION: In 1986-1987, only about half of Yemen's primary school age population were enroled in the six-year primary school system. Approximately one-fifth of these primary students were female. Participation rates at the intermediate and secondary levels are much lower. The teaching work force remains dominated by foreigners. In 1986-1987, two-thirds (12,000 out of 18,000) of Yemen's primary school teachers were from outside the country. Enrolment at Sana'a University has increased from less than 2000 in 1974-1975 to more than 30,000 today, 90 per cent of whom are male. Several hundred Yemenis also depart each year for higher education in other countries, primarily in eastern Europe, the Soviet Union, the United States, and other Arab nations.

SOCIAL: Yemen is an Islamic country, with most people belonging to the Zaydi or Shafei sects. The country has a long and important history, including the famous incense kingdoms of South Arabia. The country as a whole has never been occupied by a Western power, although the Turks had nominal control of the government for a brief span. In the past, there were marked differences in social class, with an elite of educated and religious people, a range of free citizens (many of whom were tribal), and several low-status service groups. Most of these social differences have disappeared with the new republic, except in remote rural areas. Perhaps, the most important social institution is the daily afternoon *qat* chew. Most Yemenis chew the fresh, young leaves of *qat* (*Catha edulis*) in social gatherings. *Qat* acts as a stimulant, but it is not a narcotic. While in the past only a few could afford to chew, it has become a national passion in the past two decades.

2. BIOLOGICAL RESOURCES OF YEMEN

2.1 Ecosystem variety

Yemen is characterized by a variety of environmental zones, from an arid coastal strip on the Red Sea to a rugged north-south mountain chain with the highest point (Jabal Nabi Shu'ayb) on the Arabian Peninsula. Information on the various environmental zones is available in numerous sources (e.g. Varisco *et al.* 1983; Kopp 1981; Steffen *et al.* 1978). Unfortunately, as noted in the Yemen SIP, no uniform classification of environmental zones or ecosystem types has been uniformly adopted by ROYG and the various donors.

In simple terms, on a west-east transect, the 195,000 square kilometers of Yemen may be divided into the following major zones (*Figure 2.1.1*).

1. Tihama or coastal plain. This covers about 16 per cent of the land area and stretches inland about 65 kilometers to an elevation of 500 meters.

2. Western escarpment. This steep and rugged mountain zone covers about 30 per cent of the land area, extending from 500 meters to over 3,000 meters in elevation. The traditional Yemeni term for this mountain chain is the Sarat. This area receives the highest rainfall and supports the majority of farmers.

3. Central highlands. This series of basins with several variations in elevation, covers about 40 per cent of the country and contains the major cities.

4. Eastern plateau. This is the smallest, least populated and least hospitable part of Yemen. To the east it ranges into the so-called al-Rub al-Khali (Empty Quarter) of the Arabian desert.

For future study, we urge the adoption of the most detailed and relevant breakdown of the environmental zones for the context of discussing biological species. This is the National Vegetation Map compiled by the efforts of Paul Scholte, J. J. Kessler and Abd al-Wali al-Khuleidi (in prep.). The anticipated publication of this map with accompanying details on each unit will be the primary data base for future study of the country's flora and fauna. A preliminary map and legend is presented in *Figure 2.1.2.*

Since this study has not yet been completed, it is important to provide summaries of the major ecological variations over the more general environmental zones. This is divided here according to coastal and marine habitat types, Tihama foothills, western escarpment, central highlands, and eastern plateau.

2.1.1 Coastal and marine habitat types in ROY

The coastal environment in ROY is structured by the dominant climatic, oceanographic and topographical features that determine the distribution of habitat types or biotopes. The distribution of biotopes in turn determines the distribution and abundance of the organisms living in them.

The climate of the coastal region is dominated by the influence of monsoons. In summer the winds are northerly and in winter, after a transitional period, winds are southerly. There is also a daily pattern of heating over the land causing onshore winds to develop during the day. Air temperatures are usually high throughout the year (range 18-41°C, average 30°C) and rain is sparse and variable ranging from 14-120 millimeters/year at the coast. However, humidity is high. There is an additional indirect influence from runoff and wadi flooding from rain on the highlands of the scarp and interior where rainfall is higher (100-400 millimeters/year).

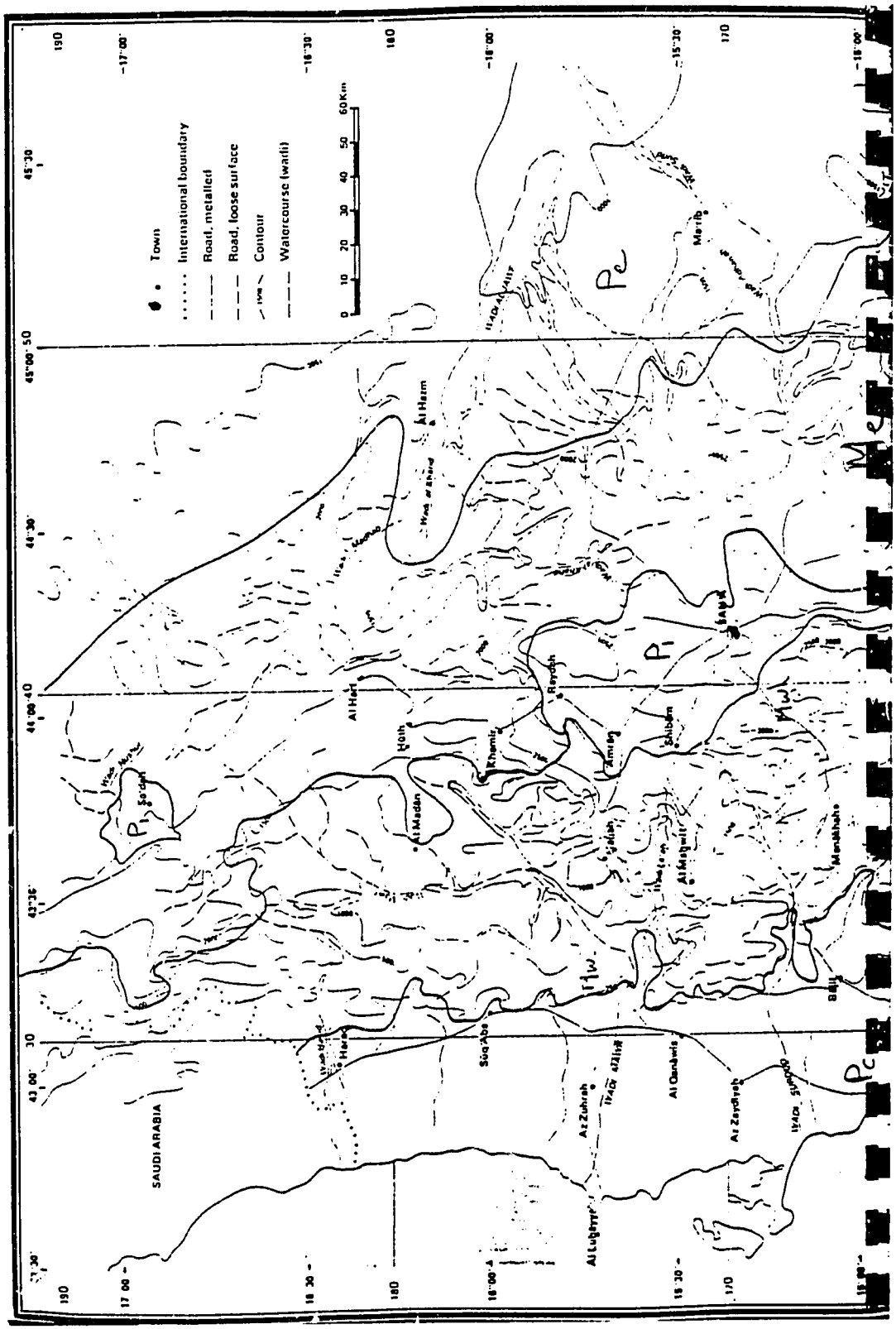

Figure 2.1.1 Environmental map of Yemen.

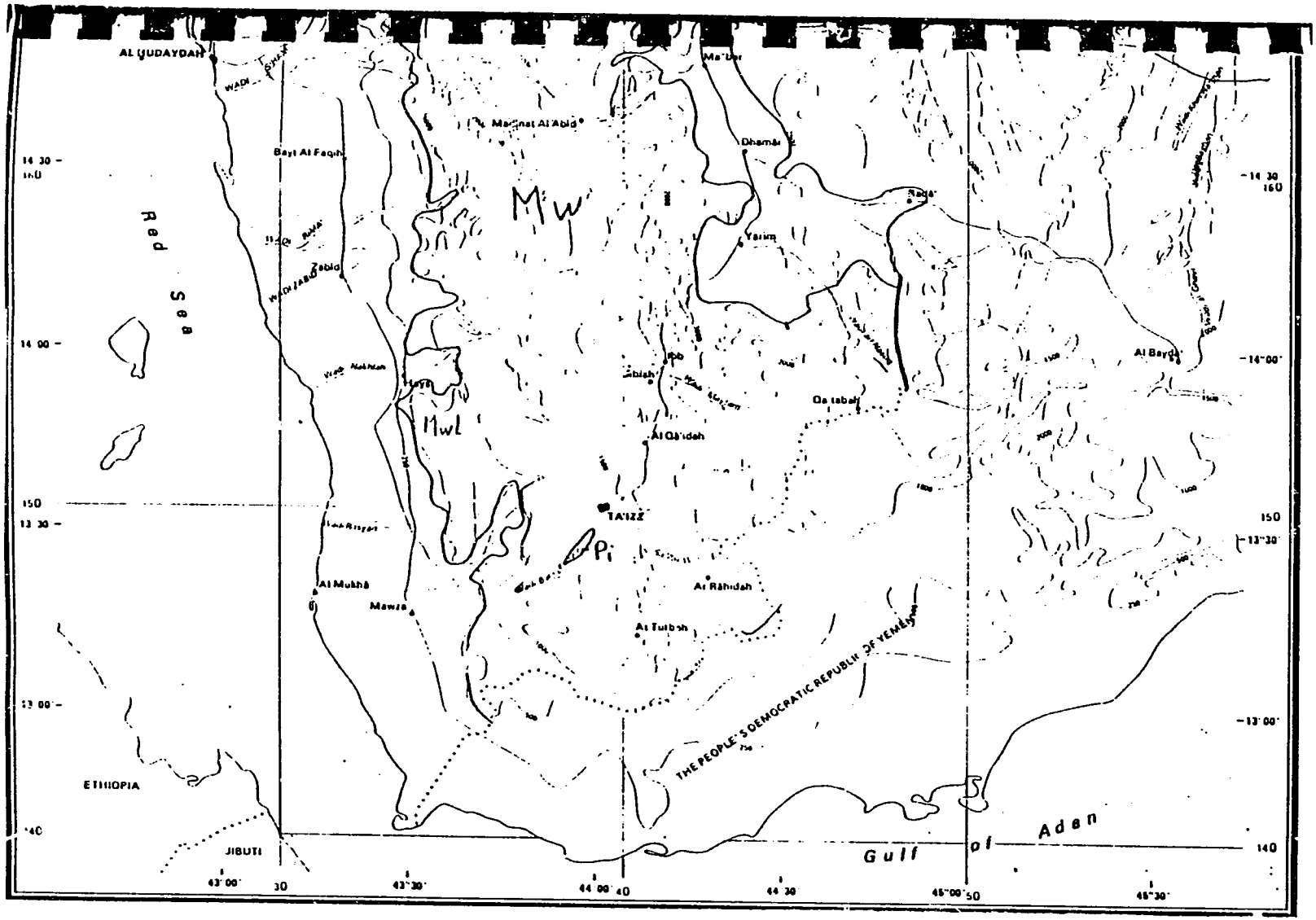
AL HUDAYDAH
Bayt Al Faqih
Zabid
Red Sea
Mwl
Pi
TA'IZZ
Al Mukhā
Mawza
Al Qā'idah
Ar Rāhidah
At Turbah
Dhamār
Yarīm
Sadā
Al Bayḍā'
Qa'tabah
THE PEOPLE'S DEMOCRATIC REPUBLIC OF YEMEN
ETHIOPIA
JIBUTI
Gulf of Aden
14 30
14 00
13 30
13 00
43°00'
43°30'
44°00'
44°30'
45°00'
45°30'

Figure 2.1.2 National vegetation map of Yemen (1:500,000). (From Scholte, Kessler and al-Khuledi, in prep.)

Preliminary legend:

Pc Tihama coastal plain
- Pc. 1 Mangrove, Avicennia woodland
- Pc. 2 Sabkha, Suaeda-Aeluropus sparse dwarfshrubland
- Pc. 3 Palm groves, Phoenix-Hyphaene woodland
- Pc. 4 Saltbushland, Salsola-Odyssea dwarfshrubland
- Pc. 5 Aerva sparse dwarfshrubland
- Pc. 6 Commiphora-Rhigozum open woodland and bare land
- Pc. 7 Dactyloctenium cultivation area (irrigated)
- Pc. 8 Ziziphus-Dobera cultivation area (rainfed)

Mw Western mountains

Tihama foothills and lower mountains (1000 meters)
- Mwl. 1 Adenium sparse dwarfshrubland
- Mwl. 2 Basins (At Tur, east of Suq Abs, Wadi Zabid, etc.)
- Mwl. 3 Acacia tortilis sparse dwarfshrubland
- Mwl. 4 Trichilea - Anisotes (shrub) woodland
- Mwl. 5 Acacia tortilis sparse dwarfshrubland

Medium altitude mountains (1000-1800 meters, shrubs dominate)
- Mwm. 6 Euphorbia dwarfshrubland
- Mwm. 7 Acacia asak-Grewia shrub woodland
- Mwm. 8 Ibb
- Mwm. 9

High mountains (1800 meters, dwarfshrubs dominate)
- Mwh. 10 Hyparrhenia-Psiadia grassland
- Mwh. 11 Juniperus-Cichorium dwarfshrubland (2800 meters?)

Pi Highland plains
- Pi. 1 Al Qa'adah, Qa Haql, Qa Shaharah (1800 meters)
- Pi. 2 Sa'da, Qa Bakil, still frost 1800-2200 meters
- Pi. 3 Microchloa grassland (plains of Rada, Dhamar and Sana'a, severe frost) 2200 meters

Me Eastern mountains

High mountains in western part
- Me. 1 "volcanic communities" (2000 meters)
- Me. 2 "volcanic alpine communities" (2800 meters)
- Me. 3 Chrysopogon sparse grassland "metamorphic communities," high and wet, cultivated, (Rada-Al Bayda)
- Me. 4 "sandstone communities," high and wet (Sana'a, Rada)
- Me. 5 Euphorbia balsamifera sparse dwarfshrubland

Low mountains in eastern part
- Me. 6 Commiphora myrrha "volcanic communities" low (Marib)
- Me. 7 Acacia nubica sparse grassland (metamorphic)
- Me. 8 Acacia nubica sparse grassland, major wadis
- Me. 9 Acacia etbaica "sandstone communities" (Sa'da)
- Me. 10 "limestone communities"

Pe Eastern desert plain
- Pe. 1 Acacia Tortilis woodland
- Pe. 2 Alluvial Fans, cultivated
- Pe. 3 "Alluvial Fans", rather bare (no red on image, blue colored)
- Pe. 4 Maerua crassifolia open woodland and bare land
- Pe. 5 Calotropis Bare sand dunes

The coastal area is influenced by the oceanographic structure of the Red Sea. The major surface circulation is wind driven with Indian Ocean water entering the Bab al Mandib for much of the year under the influence of southerly winds. A counter current of warmer, more saline water flows out at depth beneath the inflow. This flow reverses under the influence of summer northerlies. Circulation in the Red Sea is generally counter-clockwise with a northerly flow past the Yemen coast. Tidal range is generally low (0.5 meters) but sea level is higher (up to 1.5 meters) in the winter months. Sea penetration inland is therefore greater in the winter months which, due to the very flat profile of the coast results in a significant seasonal variation in the extent and conditions of the intertidal zone (*Figure 2.1.1.1*).

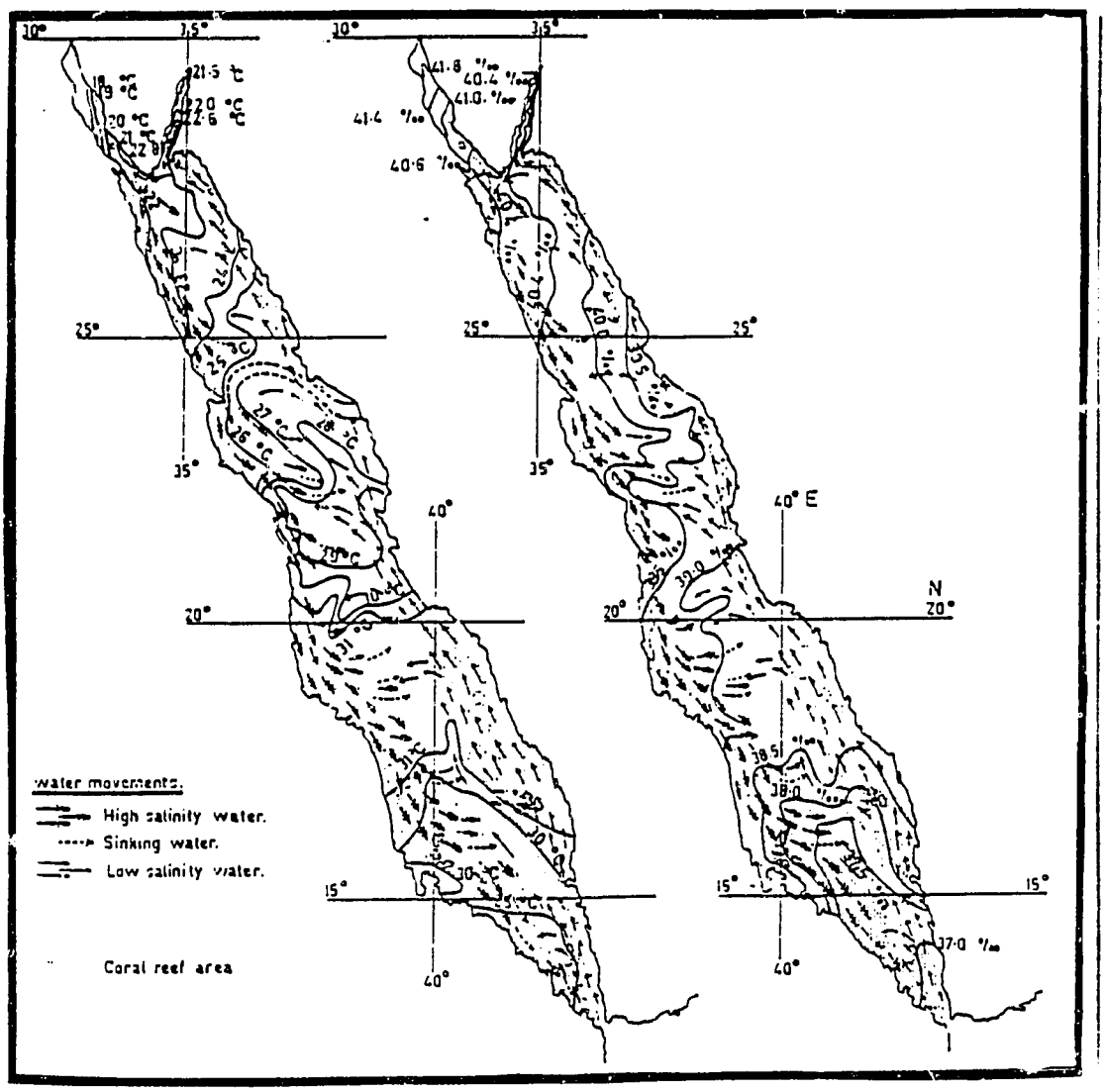

Figure 2.1.1.1 Circulation in the Red Sea inferred from the temperature (left) and salinity (right) observations of POLA 1895-1896 and 1897-1898 (after Luksch 1901a).

Sea temperature and salinity are generally high (28°-32°C and 37-42 ppt respectively) and may be more extreme in sheltered, shallow coastal areas and lagoons.

The physical profile and geologic origins of the Tihama coast exert a profound influence on the ecosystems there. The Tihama plain and adjacent coastal shelf consist of extensive alluvial deposits with a very flat relief. Changes in sea level during the Pleistocene periodically inundated and exposed the coastal area resulting in extensive accumulation of evaporates and rendering much of the coastal soil highly saline. The alluvial sands and silts have very little hard rock exposure along the coast, although fossil reef rock does occur. There is a gradient of sediment type from north to south with light-colored, medium and course sands predominating south of Hodeidah and silty muds predominating to the north.

Exposure to prevailing wind and waves is greater in the south where the coastal shelf is narrower (5-10 kilometers). North of Hodeidah the Salif peninsula, Kamaran Island, and numerous islands on the wide northern shelf (up to 40 kilometers) provide a more sheltered coastal environment.

The mainland coastline is approximately 750 kilometers in length and there are approximately 225 kilometers of coast on the more than 25 islands offshore (*Figure 2.1.1.2*). The area of coastal shelf of less than 30 meters depth is approximately 9,000 square kilometers and the total shelf area (to 200 meters) is estimated at 11,200 square kilometers. The offshore islands can be conveniently grouped as follows:

- Islands of the southern Farasan group
- Islands of the northern shelf
- Offshore oceanic islands
- Small islands adjacent to the coast. See Annex 5.A.1. for list

Within this area, seven biotopes have been identified (modified from Barratt *et al.*1987a):

- Sabkha
- Freshwater dependent vegetation
- Mangrove
- Intertidal flats
- Reefs (coral and algal/rock)
- Seagrass and soft bottom
- Open ocean

Barratt *et al.* (1987a) grouped these biotopes into seven ecosystems in which these biotopes are combined in different proportions (*Table 2.1.1.1*).

These ecosystems are determined by exposure to wave action, relief, substrate types and the interface of freshwater and marine water tables. South of Hodeidah the interface between fresh and salt water is offshore allowing the development of freshwater supported ecosystems (palm groves, marshes) in isolated locations. Similar conditions may also occur where the major wadi systems approach the coast. North of Hodeidah the interface occurs inland behind the wide Sabkha region and the water lies very close to the surface (perhaps 1-4 meters). Considerable evapotranspiration of groundwater occurs in this area and the groundwater is more sensitive to saline intrusion and contamination by excessive groundwater extraction.

The distribution of the major biotypes and organisms is discussed in great detail in Ormond (1987) and is summarized with additional information in Section 2.2 below.

The coast superficially presents a flat and rather unattractive aspect with saltbush plain, bare sabkha and muddy intertidal flats grading into each other. Despite this uniform appearance the region supports considerable biological resources and the conservation and careful management of essential ecosystems is critical for the ecologic and economic stability of the area.

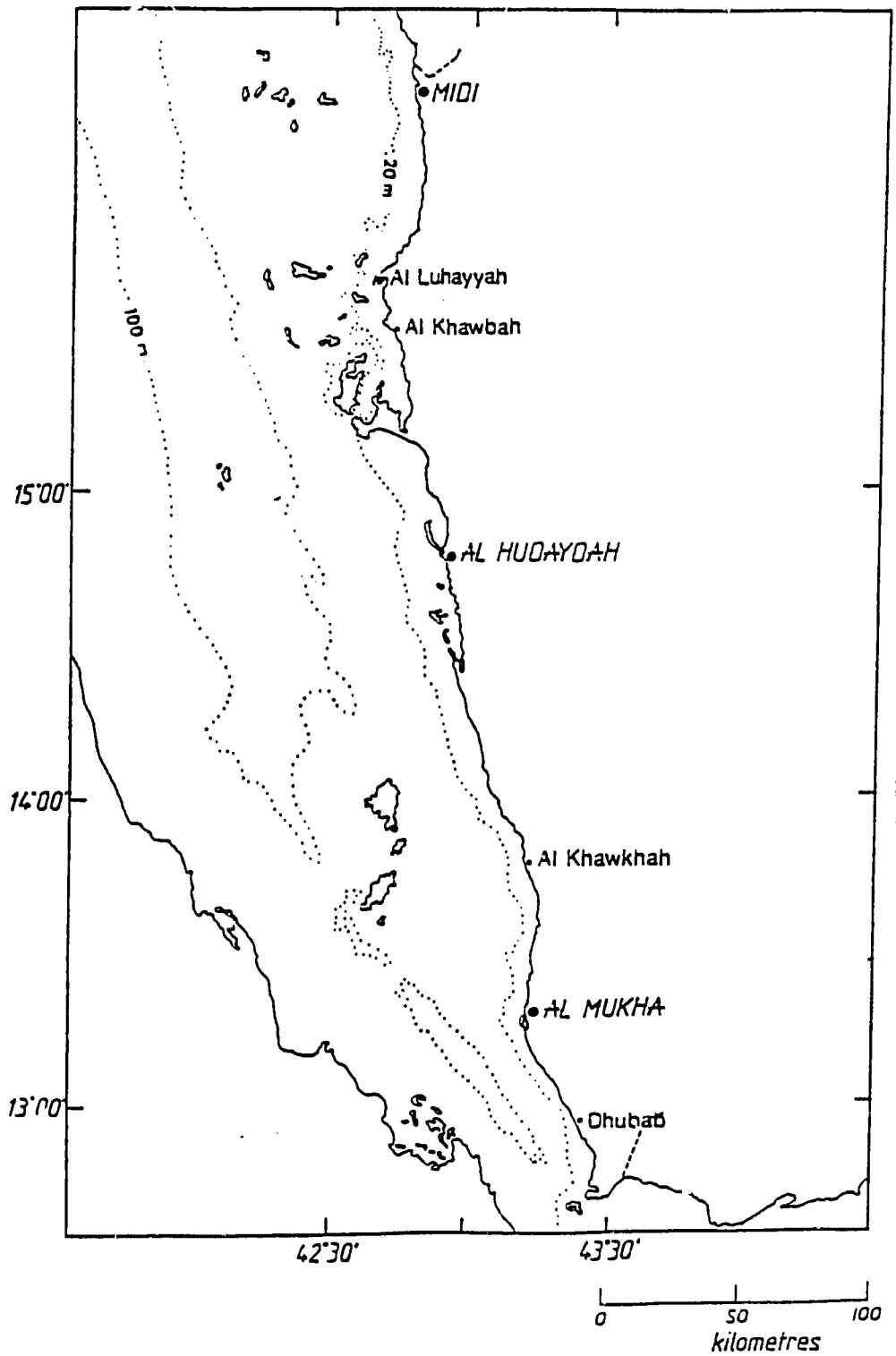

Figure 2.1.1.2 A general map of the ROY coastline.

Table 2.1.1.1 Major terrestrial, intertidal and shallow sublittoral coastal zone system/biotope associations in the ROY (From Barratt *et al.* 1987a, *Table 4.2*).

Biotope	System						
	1	2	3	4	5	6	7
Saltmarsh					+	+	?
Sabkha	+			+	+	?	?
Mangrove	+			+	?	?	?
Seagrass/other soft substrates	+	+	+	+	?	?	?
Coral reef	+	+				?	?
Other reef	+	+	+	+			?
Open sea (pelagic)	*	?	?	?	?	?	+

* - Benthic disturbance in intermediate water depths.

Key: 1 - exposed reef and sand beach/bar
2 - semi-open lagoons
3 - semi-closed lagoons
4 - lower intertidal flats
5 - upper intertidal flats
6 - freshwater influence
7 - open sea

2.1.2 Tihama foothills

The Tihama foothills range from 300-500 meters up to about 1,000 meters. These include several major wadi systems with alluvial sediments. The average temperature is similar to that of the coastal zone, with high humidity and heavy dew in the winter. The main distinctions are between the basement rocks of the foothills, the fluvial and aeolian deposits of the intermontane basins, fluvial deposits in the wadi systems, and steep slopes often inhospitable to agriculture.

2.1.3 Western escarpment

The range of elevation between 1,000-1,600 meters consists primarily of basement rocks underlying Mesozoic sediments. The average annual temperature is 25°C, precipitation ranges up to 600 millimeters, and humidity is more moderate than in the foothills. This zone has been subject to deforestation due to high demands for fuel wood. Terrace cultivation is extensive and grazing is active. The slopes and ridges of sedimentary and volcanic rocks between 1,600 and 2,200 meters are heavily terraced. The average temperature here is 20°C and precipitation is over 1,000 millimeters with high humidity, mists and fogs. This is prime agricultural land due to the high moisture availability, and therefore the zone of highest population density. The highest point in the mountain chain is Jabal Nabi Shu'ayb at about 3,766 meters. At the lands above 2,200 meters winter frosts are common, although the effects are modified somewhat by the terrace systems.

2.1.4 Central highlands

The Central Highlands has a temperate climate with declining rainfall on a south-north transect. While annual rainfall may be 1,800 millimeters near Taiz and Ibb in the south, this can be as little as 200 millimeters per year in the north near Sa'da. The highlands consist of a series of basins, with a major pass (Samra) between Taiz and Ibb. The plains are heavily cultivated and primary land for the increased focus on tubewell irrigation. Frost is common in much of the area.

2.1.5 Eastern plateau

The eastern part of Yemen becomes progressively drier and inhospitable to agriculture toward the east. The rocky slopes descend from about 2,200 meters to 1,300 meters. The annual temperature is 25°C with winter frost potential and low (about 200 millimeters) rainfall of irregular patterns. Humidity is low here. There are slopes, semi-desert dwarf shrubland, dune systems and a few wadi systems. The most important wadi now has a modern dam constructed at Marib.

2.2 Survey of flora

Collection and field study of Yemeni flora has been conducted since the late 18th century. The major collections are housed at the Royal Botanic Garden, Edinburgh, Kew Gardens and the British Museum (Natural History) in London. A list of species is provided in Annex 4. A preliminary herbarium has been established in Dhamar (Schoite and al-Khuleidi 1989) by Dr Abdul Rahman Dubaie. Useful bibliographic sources are noted in the index to Annex 1. This section outlines the range of flora regionally, highlighting those areas which have received the most field study.

The vegetation of Yemen is a mixture of that found on the African continent (belonging to the tropical, Sudanian plant geographical region), and that found in the Afro-Asian desert regions (of the extratropical, Saharo-Arabian plant geographical region). The Saharo-Arabian element predominates in the regions with an arid climate (the Tihama coastal plain and the eastern plateau); the Sudanian element predominates in the western escarpment with a semi-arid or semi-humid climate (*Figure 2.2.1*).

The flora of the ROY is species-rich. An estimated 1700 plant species occur. This species diversity is a result of considerable climatic changes in former periods enabling different species to survive in the large variety of ecological habitats that the country offers. Humans have also introduced some plant species to the natural vegetation.

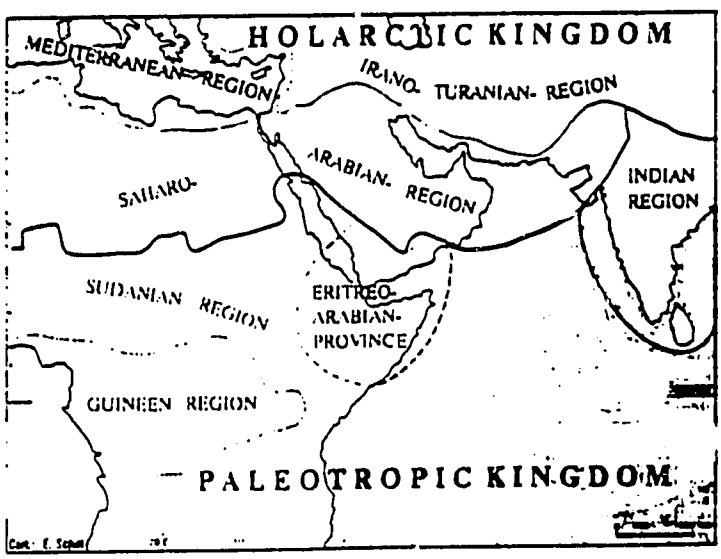

Figure 2.2.1 Plant geographical regions of the Near East and Northeast Africa (after Zohary 1973).

Less than one-third of these plants belong to the Saharo-Arabian plant geographic region; the remaining species are of African origin (Sudanian region). Of the later group, a high degree of similarity exists with the vegetation of East Africa. This is the reason for distinguishing the so-called Eritreo-Arabian plant geographic region (Zohary 1973), which comprises the two Yemens, Ethiopia, Somalia, Djibouti and southwest Saudi Arabia (*Table 2.2.1*).

Precise data on the number of endemic species in Yemen are not available, but probably these number about one hundred with between two and three hundred species endemic to southwest Arabia. It will take years to sort out the taxonomic status of many species. This is because many are assumed to be equivalent to East African species, although this is not always the case with further study. A partial list of endemic plant species can be found in *Table 2.2.1*.

Table 2.2.1 Partial list of plant species endemic or near-endemic to southwest Arabia.

Aloe vacillans	*Caralluma penincillata*
Aloe fleurentinorum	*Pavetta longifolia*
Aloe inermis	*Thymus laevigatus*
Aloe niebuhriana	*Abrus bottae*
Aloe vera	*Andropogon crossotos*
Aloe rivieri	*Anisotes trisulcus*
Aloe rubroviolaca	*Barleria hispinosa*
Aloe tomentosa	*Cichorium bottae*
Aloe vacillans	*Commiphora kataf*
Aloe sabaea	*Eleusine floccifolia*
Euphorbia ammak	*Melania velutina*
Euphorbia cactus	*Ormocarpum yemense*
Euphorbia inarticulata	*Teucrium yemense*
Euphorbia parciramulosa	*Stachys yemensis*
Euphorbia quarad	*Verbascum bottae*
Euphorbia fruticosa	*Acacia geradii*
Jatropha variegata	

The important rare species are listed in *Table 2.2.2* below.

Table 2.2.2 Plant species rare and/or local in distribution in Yemen.

Aloe sp.	*Euphorbia fruticosa*
Caralluma sp.	*Delosperma harazanium*
Huernia sp.	*Crinium yemense*
Duvalia sp.	*Acacia laeta*
Juniperus procera	*Alkana orientalis*
Plectranthus hadiensis	*Adansonia digitata* (baobab)
Oncoba spinosa	*Dracaena ombet* (dragon's blood)
Ochna inermis	

2.2.1 Flora of the marine environment

The most detailed study of the flora of the marine environment is to be found in Barratt *et al.* (1987a), which is summarized below. The information here follows the format of the seven biotypes defined

in section 2.1.1. above. A valuable visual representative of dominant species in the marine and coastal is provided by al-Hubaishi and Müller-Hohenstein (*Figure 2.2.1.1*).

Sabkha

Sabkha is a distinctive coastal habitat consisting of bare, saline mud with a crust of dry sand and mud. *Sabkha* occurs above the high tide line and may be separated from the intertidal area by a narrow beach or dune line. *Sabkha* are usually devoid of animal life but maintain crusts of blue green algae. The strongly sulphurous smell of the muddy black sediments beneath the crust suggest an active sulphur-reducing bacterial flora is present. *Sabkha* is the most common habitat type along the ROY coast covering an estimated 413 kilometers (58 per cent) of the mainland coast.

Freshwater dependent vegetation

Palmgroves. Where the freshwater table occurs near the surface at the coast, an association of domestic date palms and Doum palms occurs. Other large shrubs and trees found especially in wadi beds include *Salvadora persica*, *Tamarisk* sp., and *Acacia tortilis*. This habitat occurs where wadis intersect the coast and constitute an important refuge for people, domestic stock and birds. Coastal palm groves are found from Al Urj to Ras Katenib north of Hodeidah, from Nakhaylah to Wadi Rima, at the mouths of Wadi Zabid and Wadi Nakhlah, and between Al Zahari and Yakhtul.

Reed beds. In a few coastal lagoon systems, where tidal flushing alternates with freshwater seepage, reed beds (*Scirpus* sp.) with associated salt tolerant grasses (*Ruppia* sp.) are found. This habitat is only reported from the vicinity of al Fazzah at the mouth of Wadi Zabid and Al Zahari (Ormond 1987). This rare habitat is of high significance to migrating birds (Brockie 1985; Rands *et al.* 1986) and is thus of high priority for protection.

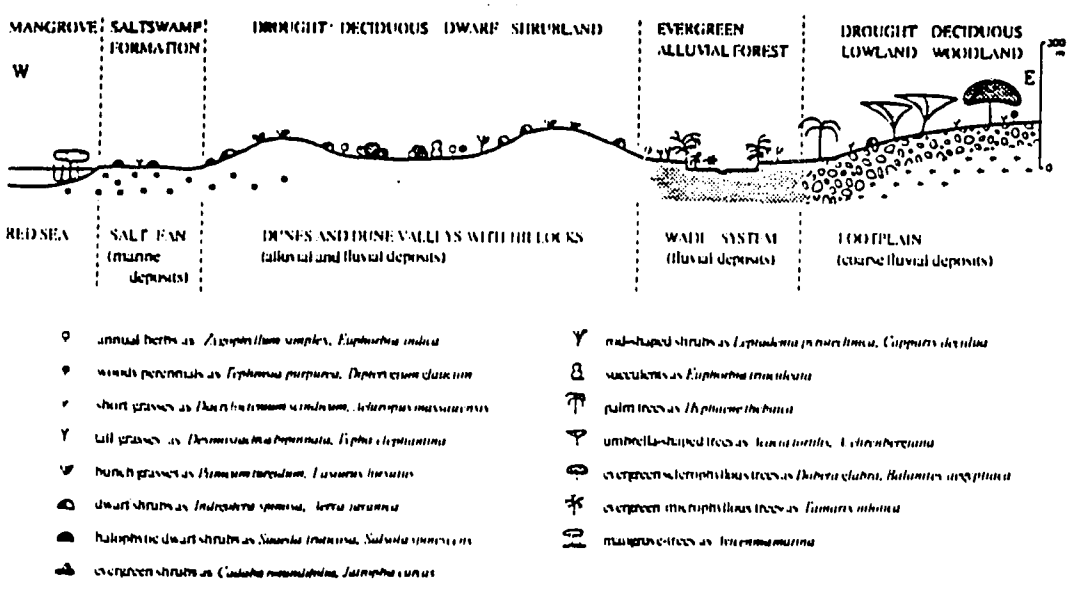

Figure 2.2.1.1 Natural vegetation in the ecosystems of the Tihama.

Intertidal flats

In areas of low profile and sheltered exposure, the intertidal area can be 500-1000+ meters wide. This area is usually a uniform expanse of rippled muddy sand and may support some sea grass (*Halodule uninervis*). A micro algal crust is generally present and supports populations of molluscs (*Cerithium* sp.) that may reach high density. In addition, the infauna of burrowing worms, clams and crustaceans is very rich and provides abundant feeding for wading birds. Many of these organisms are nocturnal, cryptic or only active at high tide. A list of mollusc species assembled by Barratt *et al.* (1987a) is given in Annex 5. The assemblage of mollusc species (over 40 in all) is typical of sandy environments of the Red Sea.

Mangroves

One species of mangrove, *Avicennia marina*, predominates along the coast and is distributed in a narrow discontinuous band from Al Urj to Midi. Scattered stands occur south of Al Urj in sheltered locations. Another species, *Rhizophora mucronata*, is reported only from a small island in Khor Katib near Hodeidah. The mangrove fringe of 100-200 meters occurs between the intertidal mudflats and the *sabkha* behind it and is influenced by seasonal changes in sea level, tidal inundation, protection from wave energy, and salinity. *Avicennia* can grow in saline and hypersaline waters, but the stands are significantly denser near Al Urj and Yakhtul in association with freshwater seepage.

Mangroves provide significant nutrient inputs to coastal waters as their leaves, reduced to detritus, are transported seawards. Within the mangrove stands molluscs (5 sp) and crabs (8 sp) predominate, reducing mangrove leaves to detritus and providing food for other species. Juvenile shrimp and juvenile mullet (commercial species) invade the mangroves at high tides. A mudskipper *Periophthalmus* sp. is found in pools and channels among the mangroves.

The mangrove areas are affected by cutting for wood and browsing by camels but, except for areas adjacent to settlements, the impact is small. Comparison of recent coastal surveys with Landsat photos from 1973 indicate the area of mangrove may actually be increasing, and the size distribution of trees also indicates recent regeneration and recolonization (Scholte, pers. comm.). There is a very close correlation between the distribution of mangroves and the shrimp fishing areas of Yemen, and it is presumed that this relationship reflects the significance of mangroves in the production of edible detritus and possibly the nursing areas for shrimp.

Sea grasses

Nine species of sea grasses are identified from Yemen. A list of species is given in Annex 4. The most abundant species are *Thalassia hemprichi*, *Halodule uninervis*, and *Cymodocea* sp. Sea grass development is limited in most areas by the soft unconsolidated sediments, high turbidity, and restricted tidal inundation for part of the year. Areas where shallow waters are sheltered by the islands, reefs and sand bars support sea grass. Ormond (1987) estimates that sea grasses were present in 42 per cent of the examined quadrats in his field study.

Sea grass beds are of primary importance for the support of marine fauna and commercial fisheries. Sea grass leaves are eaten directly by green turtles and dugongs, while leaf detritus and epihytic alga feed a diverse array of invertebrates that are in turn food for commercial fish species such as Lethrinus. Sea grass detritus also supports shrimp.

Areas of particular importance for sea grass occur in Bahr Ibn Abbas and Khor Ghulafiqua and in the shelter of offshore islands and banks.

Coral reefs

Coral reefs are <u>not</u> extensive in the ROY coastal zone (Barratt *et al.* 1987a). The rarity of hard substrates, seasonally strong winds and turbid waters, and the effects of occasional freshwater runoff limit both the extent and diversity of corals. Exceptions are found at Ras Isa, near Hodeidah, Khawr

Ghulayfiqah and south of Mocha. The offshore islands, particularly the larger and more distant islands like the Hanish group, Jabal Attar and Zubair islands, are presumed to support more extensive reefs but remain unsurveyed. Barratt *et al.* (1987a) report 15 species, most of which are foliose or branching corals in the genera Acropora, Montipora and Porites.

Corals are generally found growing on exposed reef rock as fringes stabilizing the outer edge of the littoral zone. Barratt *et al.* (1987a) report a north-south differentiation in reef structure with the area north of Hodeidah dominated by coraline algae and sargassum and the southern region south of Khawkah having fewer algae and more coral. They estimate that 25 per cent of the mainland coast supports some coral growth, although the per cent substrate covered is usually quite low (0.4.-12 per cent) except south of Mocha.

Due to their restricted abundance, coral reefs are probably less important to marine productivity and fisheries than the sea grass, mangrove and intertidal communities. However, they provide a valuable structural and stabilizing component that protects the other communities. The offshore and island reefs support some artisanal fishing and those few areas (e.g. Ras Isa, Mocha) with better reef developments have a potential value for recreation and tourism.

The vegetation of the Tihama foothills

The Tihama foothills are situated between the coastal lowlands and the escarpment areas within the elevation range c. 300 meters to 1000 meters above sea level. The most important ecological factor for the development of plants in the Tihama foothills is – like almost everywhere else – water. The dominant plant formation on hills, slopes and pediments is a drought-deciduous lowland and submontane woodland with only a few evergreen plants, some succulents, bottle trees, a shrub-layer, composed of many different species and only a sparse ground vegetation. According to soil conditions and the amount of rainfall, different communities usually mingled in a mosaic pattern are found. On the slopes a raingreen woodland is dominated by the scattered umbrella-shaped *Acacia tortilis* and some other *Acacia* species on higher elevations between 500 and 1000 meters above sea level, such as *Acacia mellifera*, *A. asak* and *A. abyssinica*. Other important trees are *Commiphora myrrha*, *C. opobalsamum*, *C. kataf* and *Berchemia discolor*. Short-stemmed and multi-branched shrubs are usually widely spaced but sometimes form small thickets. Among these, on higher elevations (above 500 meters) are *Dodonaea viscosa*, *Lawsonia inermis*, *Grewia velutina*, *G. populifolia*, *G. villosa*, *Barleria bispinosa*, *Hibiscus micranthus* and *Maytenus senegalensis*. On lower hills and on the pediments, where the vegetation cover is only very sparse, and *Acacia tortilis* is the only remarkable tree, *Anisotes trisulcus*, *Aerva javanica*, *Premna resinosa*, *Abrus bottae*, *Ormocarpum yemenense*, *Maerua crassifolia*, *Grewia tenax*, *Cadaba glandulosa* and *C. farinosa* are the dominant shrubs.

The ground cover of annual and perennial herbs and grasses and xerophytic dwarf shrubs is usually scanty and contains *Blepharis ciliaris*, *Dactyloctenium scindicum*, *Ecbollium linnaeanum*, *Ruellia patula*, *Fagonia indica*, *Seddera arabica* and *Indigofera spinosa*. In the silty and sandy basins, which benefit by run-off from the higher slopes, another plant formation, a mainly evergreen woodland with one dominant sclerophyllous tree, *Dobera glabra*, is typical.

The landscape in the Tihama foothills is characterized by the contrast between the dry, brown hills and the green fertile valleys. Again the wadi systems and their deposits offer a special environment for plant growth because of this much better and regular water supply. An evergreen seasonal lowland and submontane forest with microphyllous, sclerophyllous and broad-leaved trees is the most important plant formation.

2.2.2 Tihama foothills

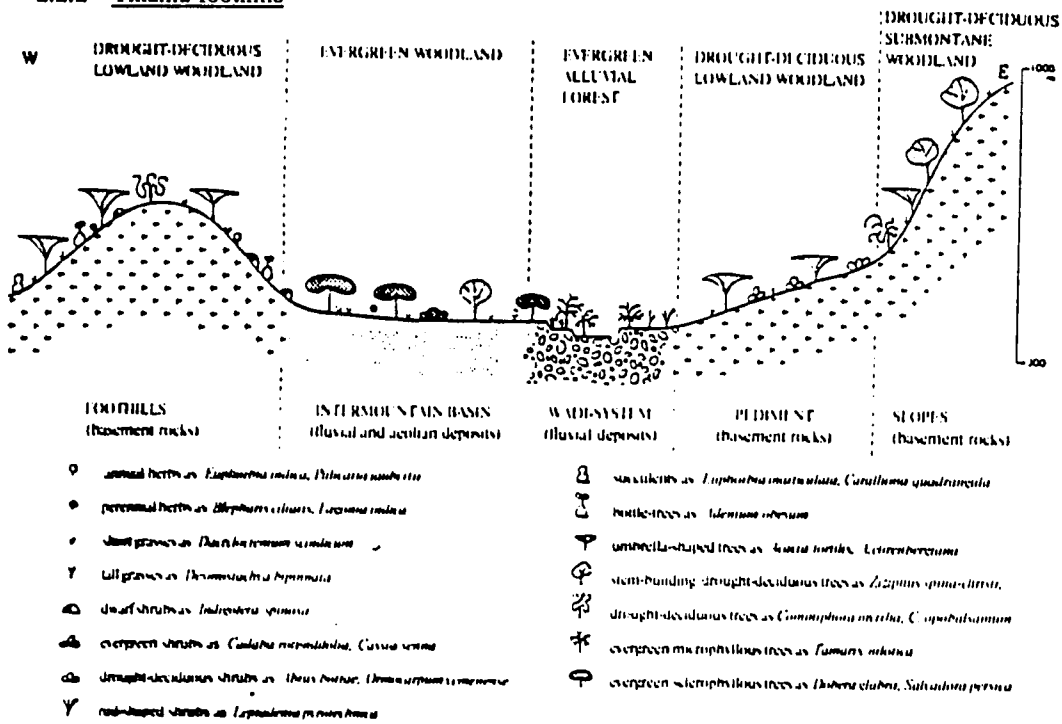

Figure 2.2.2.1 Ecosystems of the Tihama – foothills and their natural vegetation.

The vegetation of the lower escarpment

The whole escarpment area ranges from 1000 to c. 2200 meters of altitude. Although this usually very steep access to the highlands sometimes has an extent on only few kilometers from the west to the east, the climatic changes are very distinct and so, too, are the changes in the vegetation cover.

Although different plant communities are to be found in the lower part of the escarpment area, they almost all belong to one main plant formation: a drought-deciduous submontane woodland, mixed with few evergreen trees and shrubs, some succulents, lianas and bottle-trees; there is only a sparse ground vegetation of different herbs and grasses. This deciduous woodland differs in its floristic composition according to the exposure of the slopes. The main species of the tree layer are *Acacia asak* and *A. mellifera* and some of the *Commiphora* species already present in the Tihama foothills such as *C. kataf* and *C. myrrha*. Very characteristic here is *Commiphora abyssinica*, one of the myrrh resin-producing trees.

On the western slopes with higher rainfall, scattered individuals of *Ficus salicifolia*, *Berchemia discolor*, *Trichilia emetica* and *Phoenix reclinata* can be found among these trees, although there are only few relic woodlands on some of the more inaccessible and therefore not cultivated slopes. On terraces and fields, trees like *Cordia abyssinica*, *Terminalia brownii* and others provide shade for the crops. *Breonadia salicina* trees are found growing naturally or have been planted and cared for by farmers for their timber. Sometimes these trees are lopped like the also highly valued *Ziziphus spina-christi*, especially during the dry seasons of the year.

Dominant shrubs in these woodlands are *Grewia velutina*, *G. tenax*, *Ochna inermis*, *Cadia purpurea*, *Carissa edulis*, *Pterolobium stellatum*, *Hibiscus micranthus* and *Oncoba spinosa*. In the ground vegetation throughout the year the grass *Hyparrhenia hirta* is very widespread.

2.2.3 Western escarpment

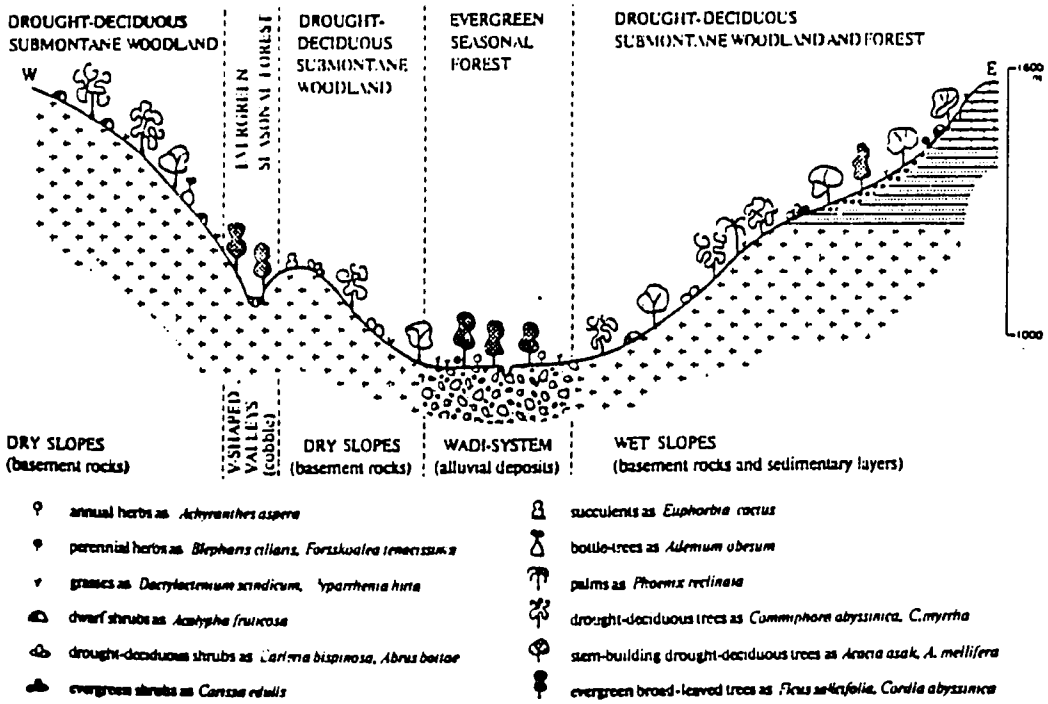

Figure 2.2.3.1 Ecosystems of the lower escarpment and their natural vegetation.

In rain-shadow areas, the woodlands have more park-like aspect and are much poorer in their floristic composition. *Acacia mellifera* and *Commiphora abyssinica* dominate in a tree layer not higher than 5 meters, but most of the other tree species mentioned above are absent. Here the most common shrubs are *Anisotes trisulcus*, *Barleria bispinosa*, *Jatropha spinosa*, *Acalypha fruticosa* and *Abrus bottae*. The ground layer consists mainly of herbs like *Blepharis ciliaris*, *Commicarpus plumbagineus*, *Forsskaolea tenacissima* and such different grasses as *Cenchrus*, Dactyloctenium scindicum *ciliaris*, *Cynodon dactylon* and *Themeda triandra*.

On rocky outcrops a large number of succulents and climbers can be found such as the bottle-tree *Adenium obesum*, *Aloe vera*, *Kalanchoe lanceolata*, *Adenia venenata* and *Cissus rotundifolia*. However, the most characteristic succulent for this environment is *Euphorbia cactus* which forms large and sometimes pure stands near settlements.

The larger valley bottoms are heavily cultivated. Here the trees grow around the edges of the fields and the flood basis. Most frequent are *Ficus sycomorus*, *F. salicifolia*, *Tamarindus indica* and *Ceiba pentandra*, specially in the Wadi Sharaz between Hajjah and Kuhlan. Coffee trees are usually shaded by the huge *Ficus vasta* and *Cordia abyssinica*.

The vegetation of the higher escarpment

The higher part of the escarpment area ranges between 1600 and c. 2200 meters, although the peaks and ridges of the watershed zone may reach several hundred meters higher. The main reason for this boundary, however, lies not in relief properties or geological structures bit in a very simple but important climatic factor. In these altitudes between 2000 and 2200 meters above sea level, frost occurs more or less regularly during all winter months, limiting the life conditions for all tropical lowland and most of the tropical submontane plant species.

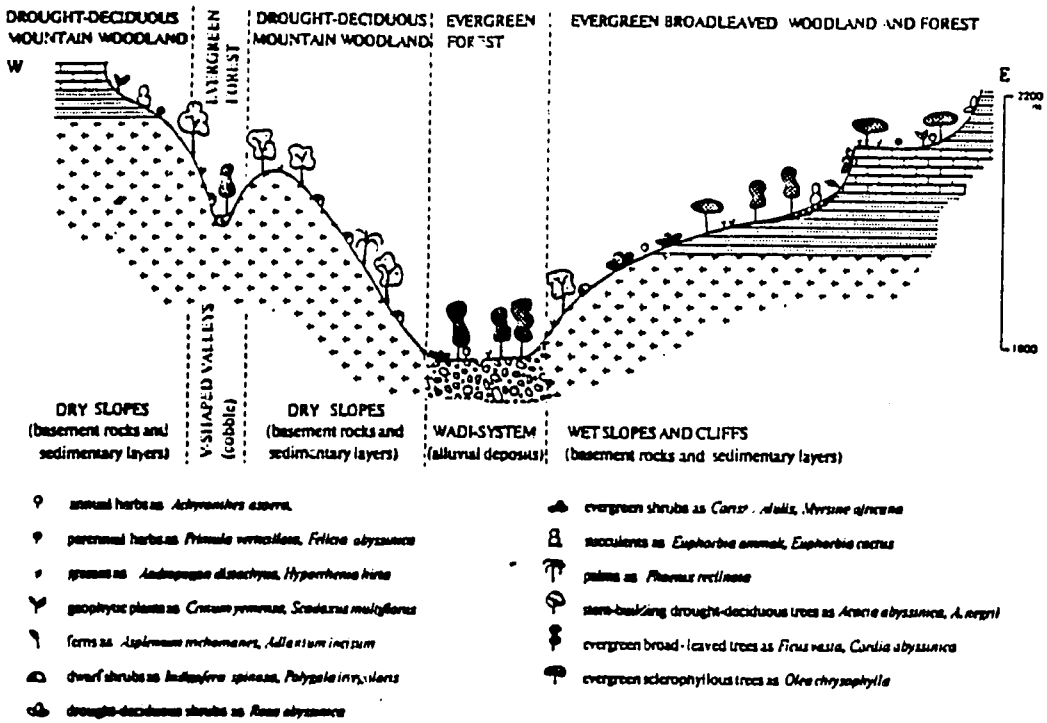

Figure 2.2.3.2 Ecosystems of the higher escarpment and their natural vegetation.

After thousands of years of clearing and forest exploitation, it is very difficult to name the most important plant formations of the higher escarpment area. However, a few woodland relicts remain in usually inaccessible places. They belong to either an evergreen broad-leaved woodland or thicket with many sclerophyllous trees and shrubs, seldom exceeding an average height of 5 to 6 meters, or – on the driest sites on the eastern slopes – to a drought-deciduous mountain woodland. In only very few places remnants of a real tropical broad-leaved cloud forest with some epiphytes and parasitic plants and a ground cover of hygromorphic herbs can be found.

Although trees and shrubs on terrace walls and rocky places show a very scattered mosaic of different communities, it is possible to differentiate between two main woodland communities. The first one, a xerophyllous community on the drier slopes again is dominated by an Acacia species, *Acacia negrii*, which sometimes is associated with *Acacia abyssinica* and *A. gerrardii*. In the shrub layer *Carissa edulis, Cadia purpurea, Hibiscus micranthus, Dodonaea viscosa, Myrsine africana, Barleria prionites, Plectranthus barbatus* and *Phoenix reclinata* are rather common. In open stands along dry roadsides *Withania somnifera* and *Lycium shawii* may occur. The ground cover is characterized by spiny dwarf shrubs and inedible herbs such as *Indigofera spinosa, Felicia abyssinica, Polygala tinctoria, Euphorbia schimperiana, Striga hermonthica* and such grasses as *Andropogon distachyus, Hyparrhenia hirta* and *Pennisetum setaceum.* The second one, a hygrophilous community on the wetter slopes, consists of a large number of mainly evergreen trees and shrubs such as *Olea chrysolphylla, Buddleja polystachya, Ehretia abyssinica, Rhus abyssinica, Pterolobium stellatum, Dichrostachys glomerata, Sageretia and* Rosa abyssinica *thea.* Some of the species names indicate that these plants also occur in the highlands of Ethiopia. On rocky places, *Ficus palmata, Centaurothamnus maximus* and *Primula verticillata* are very common. The ground cover contains herbs of Mediterranean affinity such as *Celsia bottae, Campanula edulis, Crassula alba* and the lovely flowering geophytes *Crinum yemense* and *Scadoxus multiflorus.*

The vegetation of the highland and the high mountains

The highlands and the highest mountain chains are the result of block faulting along a north-south axis parallel to the Red Sea. The Precambrian basement, mainly granites and gneiss, has been lifted so high that sometimes these rocks lie at the surface, especially in the southern part of Yemen.

During a long the period the highland has been even more heavily cultivated than the escarpment area. therefore it is very difficult to reconstruct the natural plant cover. It can only be postulated as a "savanna"-like open woodland with a large number of spiny and thorny species. Leaf-reduction and succulent life forms are again very common. The main plant formation is a drought-deciduous mountain woodland. But only a few woodland relicts are still to be found and these very often are not natural. Only in the north of Yemen, between Huth and Sa'dah, due to the smaller population, some nearly natural woodland communities have been preserved. The dominant tree species are again Acacia such as *Acacia negrii* and *A. gerrardii.* Occasionally, may be found *Buddleja polystachya, Cordia abyssinica, Olea chrysolphylla, Ficus palmata* and *Juniperus excelsa* which forms extensive woodlands in the Asir Mountains in Saudi Arabia but is very rare here. Among the shrubs *Grewia mollis, Carissa edulis, Ehretia obyssinica, Myrsine africana* and *Rosa abyssinica* are the most common.

2.2.4 Central highlands

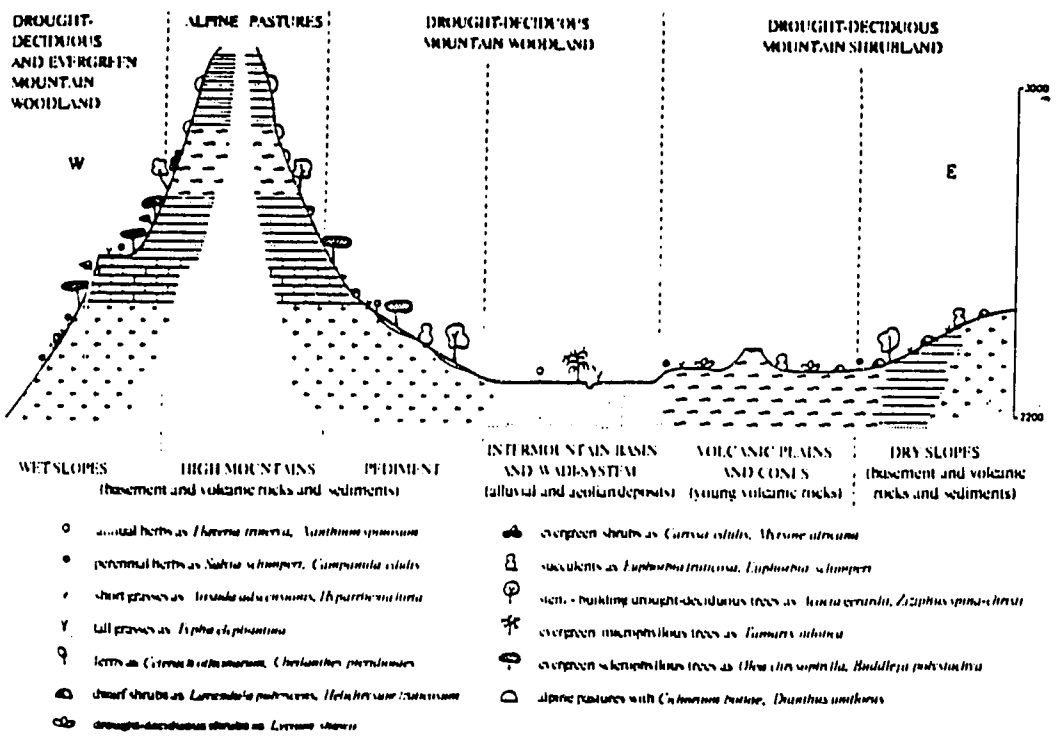

Figure 2.2.4.1 Ecosystems of the highland and the high mountains and their natural vegetation.

Usually the mountain plains are cleared and cultivated, and the bordering rocky slopes and lava fields are overgrazed. In the generally sparse vegetation cover, nevertheless, a large number of different small shrubs, herbs and grasses show that the Highland communities were once floristically very rich. The most important species are *Lycium shawii, Euphorbia fruticosa, E. schimperi, E. schimperiana, Kleinia semperviva, Fagonia indica, Commicarpus sinuatus, Helichrysum fruticosum, Salvia schimperi, S. merjamae, Lavandula pubescens, L. coronopifolia, Echium longifolium, Reichardia tingitana, Hyparrhenia hirta* and *Aristida adscensionis.* Near well-watered places the plant cover can be very dense with *Flaveria trinerva, Mentha longifolia* and *Xanthium spinosum* as the most characteristic species. At higher altitudes but still below the timberline, which probably lies somewhere between 2800 and 3000 meters, the plant cover is usually denser and there are many endemics, such as *Macowania ericifolia, Delosperma harazianum, Cichorium bottae, Teucrium yemense, Crinum yemense,* as well as some which can also be found in the highlands of Ethiopia such as *Campanula edulis, Pterocephalus frutescens, Felicia abyssinica* and *Crassula alba.* Some ferns such *Ceterach officinarum, Cheilanthes pteridioides* and *Adiantum capillus-veneris* and the attractive *Primula verticillata* grow on wet places below shady rocks; *Centaurothamnus maximus* is rather common on the otherwise bare cliffs. In the highest mountains above the timberline, the dominant plant formations are alpine pastures and meadows, rich in forbs and grasses. On several occasions during the winter season they may be covered with snow for a few hours or days. In these natural grasslands *Eleusine floccifolia* and *Pennisetum setaceum* are important grasses and *Dianthus uniflorus, Micromeria biflora* and *Craterostigma pumilum* frequently form small patches.

The vegetation of the eastern semidesert and desert

The transition from the eastern highland plateau to the semidesert and desert is locally very abrupt and usually marked by several accentuated steps, leading from altitudes of more than 2000 meters to about 1300 meters around Marib.

The eastern mountain slopes and the desert plateau are too dry for any tree cover. Therefore the most important plant formation on rocky and stony sites is a semidesert drought-deciduous open dwarf-shrubland with a few evergreen plants and succulents. The shifting dunes only exceptionally bear some isolated plants which contribute to their fixation. At the foot of large dunes and in the valleys between the dunes an episodical desert forb formation (acheb) develops after rainfall in gaps between the perennial desert plants.

A most characteristic plant community of the eastern escarpment is dominated by shrubs of *Euphorbia balsamifera.* Other perennials in this open community are *Lycium shawii, Farsetia longisiliqua, Lavandula coronopifolia, Fagonia indica* and some succulents as *Euphorbia schimperi* and *Caralluma petraea.* The most important grasses associated with this community are *Stipagrostis ciliata* and *S. obtusa.*

On the stony Hammada plains the vegetation cover with the same species is still more open. Only very few trees grow on places with an exceptionally good water supply. So in some ravines single trees of *Acacia tortilis, A. hamulosa* and *A. oerfota* can still be found, if not cut down for firewood. In dune fields, sand-binding shrubs and grasses such as *Leptadenia pyrotechnica, Calligonum comosum* and *Panicum turgidum* are frequent. After rainfall, annual herbs such as *Plantago ciliata* and *Anastatica hierochuntina* from dense stands for only a few days.

In the bigger wadi systems, relics of a riparian woodland can still be found and, again, it is *Tamarix nilotica,* forming small but dense thickets. On the lower riverine terraces and islands out of mixed fluviatile deposits, the umbrella-shaped *Acacia tortilis* and *A. hamulosa* occur, as well as the very characteristic shrub *Rhazya stricta* and a number of grasses – found already in the Tihama – such as *Arundo donax, Desmostachya bipinnata* and the rush *Juncus acutus.* The halophytes *Salsola imbricata* and *Suaeda aegyptiaca* sometimes indicate salinity of the soils.

2.2.5 Eastern plateau

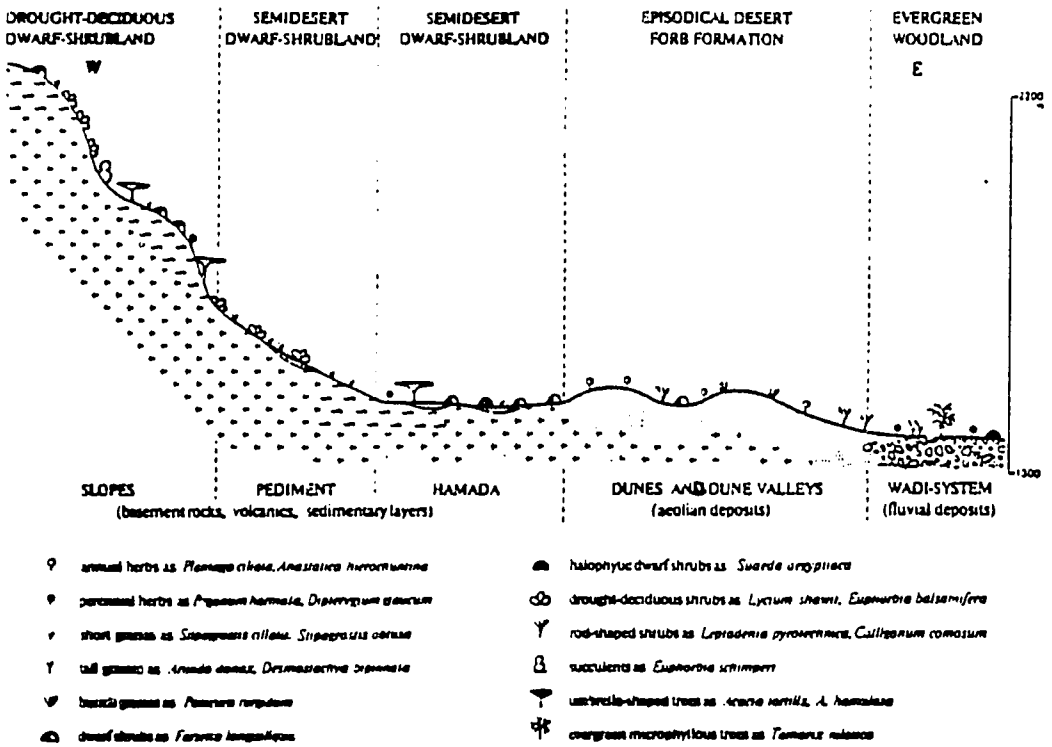

Figure 2.2.5.1 Ecosystems of the eastern semidesert and desert and their natural vegetation.

2.3 Survey of fauna

Although there has been no systematic study of the fauna of Yemen, the available information indicates it has the highest diversity of vertebrate land fauna for the Arabian Peninsula. There is a connection with the fauna of the Asir province of southwest Saudi Arabia. The combination of a varied topography and climate, as well as proximity to Africa, has allowed for a diverse fauna with strong affinities to both Africa and Asia. However, the long history of human settlement and agricultural transformation of the landscape has led to a reduction of larger vertebrates, particularly mammals.

The vertebrate fauna is of considerable significance scientifically, since the African components (such as leopard, viverrids (e.g. white-tailed mongoose) baboon, and hyrax) have been isolated for at least 18,000 years. There is already some genetic divergence from African stocks, with local geographical races of the leopard, baboon, genet, white-tailed mongoose, rock rat, and grass rat. A brief and preliminary guide to recorded vertebrate species in Yemen is presented in *Table 2.3.1.*

A number of species are unique or endangered in Yemen, especially given the pace of destruction to the environment (i.e. deforestation, terrace system collapse, pollution potential). A list of the charismatic megafauna is noted in *Table 2.3.2.*

2.3.1 Large and small mammals

The large mammal fauna of Yemen has been seriously depleted in the present century. Leopards, wolves, hyaenas, and three species of gazelle are now only rarely seen, and the leopard and dorcas gazelle may actually be extinct. The major cause of this depletion is the increase in access and

communications to remote areas and the widespread availability of high powered rifles since the civil war of the mid-sixties. Indiscriminate shooting of large mammals has seriously reduced their numbers and rendered the few survivors extremely wary of humans.

Table 2.3.1 Recorded vertebrate species from Yemen.

Type	No. of species	No. of endemic to SW Arabia	No. of rare or endangered
Mammals	55		
Bovids (including Antelopes)	6	1	5
Bats	15		?
Carnivores	10	0	7
Rodents	14	3	?
Others	11		?
Birds	c. 350	13	18
Reptiles	65		
Turtles	6	0	4
Snakes	18	0	3
Lizards	33	6	4
Amphibians	8	1	2
Freshwater fish	43	0	2

* Endangered or threatened either locally or worldwide.

The loss of the large mammal fauna is probably irreversible without a major commitment to areas of protected habitat and possibly an intensive re-introduction program similar to the oryx re-introduction in Jordan and Oman. Probably the most interesting animal from a conservation standpoint is the gazelle, of which three species have been recorded. According to information obtained by Paul Scholte, gazelles have recently been observed in: (1) the area of Zuhrah, northeast of Hodeidah in an uncultivated tamarisk woodland; (2) the dwarf shrubland between Mocha and Bab al Mandib, which is an area of restricted access; and (3), in an area southwest of Madinat al Sharq (c. 1200 meters) in inaccessible mountains with *Commiphora kataf* woodland. The Queen of Sheba's gazelle is especially significant as an indigenous species known only from a small area near Taiz.

In contrast, the small mammal fauna is probably intact and the highly diverse topography maintains small refugia in which species like baboons, mongooses, hedgehogs, hyrax and rodent fauna can survive. The steep slopes of the Tihama foothills inhibit agriculture and other human activities and therefore support such refugia; at least three species unique to southwest Arabia occur there, namely King Jird, Large Aden Gerbil and Black-tufted Gerbil.

2.3.2 Bats

Yemen supports a diverse bat fauna (15 species) of mostly African affinities. The distribution and abundance of bats remains almost completely unknown and their importance to agricultural systems unrecognized. Two species of Fruit Bat are important in the fertilization of some commercial trees (Papaya, mango) and the distribution of seeds of many tree species important for other wildlife, including nearly all *Ficus* species. Insectivorous bats eat approximately their own weight in insects each night. A single 20-gram bat will therefore eat nearly 8 kilograms of live insects a year (the

equivalent of several million mosquitoes or flies). The insect control potential of healthy bat populations is rarely considered in agricultural economics.

Table 2.3.2 Charismatic megafauna: special and endangered species in Yemen.

Leopard	*Panthera pardus nimr*
Caracal	*Felis caracal*
Lesser Kudu	*Tragelaphus imberbis*
Dorcas Gazelle	*Gazella dorcas*
Arabian Gazelle	*Gazella gazella*
Queen of Sheba Gazelle	*Gazella bilkis*
Ibex	*Capra ibex*
Wolf	*Canis lupus*
Jackal	*Canis aureus*
Ruppell's Sandfox	*Vulpes rueppelli*
Hamadryas Baboon	*Papio hamadryas*
African Small-spotted Genet	*Genetta felina*
Striped Hyaena	*Hyaena hyaena*
White-tailed Mongoose	*Ichneumia albicauda*
Honey Badger	*Mellivora capensis*
Dugong	*Dugong dugon*
Green Sea Turtle	*Chelonia mydas*
Hawksbill Sea Turtle	*Eretmochelys imbricata*
Bald Ibis	*Geronticus eremita*
Arabian Bustard	*Ardeotis arabs*
Philby's Rock Partridge	*Alectoris philbyi*
Arabian Red-legged Partridge	*Alectoris melanocephala*
Arabian Woodpecker	*Dendrocopos dorae*
Arabian Accentor	*Prunella fagani*
South Arabian Wheatear	*Oenanthe (lugens) lugentoides*
Yemen Thrush	*Turdees menachensis*
Yemen Warbler	*Parisoma buryi*
Arabian Golden Sparrow	*Passer euchlorus*
Arabian Waxbill	*Estrilda rufibarba*
Arabian Serin	*Serinus rothschildi*
Yemen Serin	*Serinus menachensis*
Golden-winged Grosbeak	*Rhynchostruthus socotranus*
Yemen Linnet	*Carduelis yemensis*

2.3.3 Marine mammals

No systematic studies of marine mammals exist for Yemen. Harrison (1985) reports a dugong skull from Khobah and some general sources give an indication of species expected in the Red Sea (e.g. Leatherwood and Reeves 1983). A list of species that might occur in the region is given in Annex 5. Twenty-one species are on the list for the northern Indian Ocean, but it remains unclear how many of these penetrate the Bab al Mandib into the Red Sea.

In the course of a field trip to the Tihama region between 27 November-30 November 1989, additional information was obtained from conversation with fishermen and some specimens of stranded marine mammals collected or examined.

Cetaceans

Fishermen generally recognize dolphins under the name "*dolpheen*" or "*drafila*" and whales as "*Houut*," "*Shiartan*" or "*Bataan*." Informed fishermen at Hodeidah and Khoba recognize three kinds

of dolphin. *Khubaar* are said to be common and *Taribah* and *Jubah* less so. *Jubah* are said to be carnivorous on the other two and may represent *Pseudorca crassidens*, a larger dolphin common in the Indian Ocean and known to prey on other dolphins. A stranded *Sousa chinensis* (Humpback dolphin) was identified as *Khubaar* at Khoba.

Dolphin skulls tentatively ascribed to *Sousa chinensis* were found near Mandar, 10 kilometers south of Hodeidah (one specimen) and between Khobar and Luhayyah (five specimens). One specimen ascribed to *Tursiops truncatus* or *T. aduncus* was found at Mandar.

The mounted skeleton of a baleen whale and parts of another baleen skeleton were examined at the University of Sana'a and tentatively ascribed to *Baleanoptera edeni* (Brydes whale). Both animals were reported to have been stranded near Hodeidah. A mounted specimen in the university collection from Salif is a juvenile of either *Delphinus delphis* or *Stenela* sp.

Fishermen reported that they rarely catch dolphins in their nets and do not take or eat them. They seemed generally well disposed toward dolphins, describing how the dolphins will accompany moving boats. We heard one report of *Khubaar* (*Sousa*?) stealing fish from nets but this was not thought serious. Interactions with fisheries therefore seem minimal at present.

Both of the confirmed species (*Sousa chinensis* and *Tursiops* sp.) are common inhabitants in shallow coastal waters of the region and could be potentially affected by marine pollution or extensive habitat alteration.

Dugong

Fishermen at Khawkah in the south were not familiar with the dugong (local name *Tawilah*). At Hodeidah they knew it but not well and reported it more common further north. Khobah and Luhayyah fishermen were familiar with dugong. Parts of a skull from the beach at Khobar were found during this study and the skin of a dugong approximately 1.4 meters long that had been brought to the GCFD some months previously was examined and photographed. Dugongs are reported to be rare and shy in the coastal waters from Luhayyah north, particularly around the northern offshore islands. Most informants reported single sightings or small groups of two-three dugongs, but one man said he had seen a group of "30 heads." Dugongs are not reported to be caught or eaten, although one specimen was brought (dead) to the Khobar fisheries office.

There seems to be extensive pastures of sea grass suitable for dugong from Ras Isa north. The dugong population here is probably continuous with that reported from the Farasan Islands in Saudi waters.

2.3.4 Sea turtles

Four species of sea turtles have been described from Yemen (Walczak 1975). The Green Turtle *Chelonia mydas*, Hawksbill *Eretmochelys imbricata*, Olive Ridley *Lepidochelys olivacea*, and Leatherback *Dermochelys coriacea*.

Of these, *Lepidochelys* and *Dermochelys* are rare and not known to nest. The green turtle and the hawksbill are more common and resident with some nesting reported.

Fishermen in ROY do not differentiate between the species, referring to all as *Sulahif* or *Zugar*. It is probable that hawksbill is more common around the islands and coral reefs and the green turtle on sea-grass areas, but this needs confirmation. Nesting of sea turtles was reported from the Hanish group, Jebel Zugar (Turtle Island) and the many small islands north of Hodeidah. Nesting was said to be most common in the winter months.

Specimens of dead stranded hawksbills of approximately 40 cm and 15 cm shell length were observed north of Khobah indicating that this area supports a feeding population of mixed age. Barratt *et al.* (1987a) report that the shells of green turtles were widespread along the coast, being present at 26 per cent of the sites they examined. Turtle remains, presumably the result of exploitation for local use, were more common south of Khawkah and a concentration of ten green turtles was observed feeding in a 0.5 kilometers section of coast north of Al Ru'ays.

Sea turtles were reported to be occasionally c ·ptured in fishing nets and some of these are retained and eaten, although many are said to be released alive. The shrimp fishery operating from Hodeidah in the Ras Ketenib and Kamaran Bay areas report regular capture of sea turtles, mostly green turtles (Walczak 1975) of all sizes. Most are returned to the water alive.

Sea turtle eggs are taken for local consumption when found and it is not possible to evaluate the impact of this activity. Reports of a significant nesting of green turtles on Kamaran Island could not be confirmed.

The proper evaluation of sea turtle distribution and numbers in Yemen must await a systematic study by aerial survey and visits to the offshore islands. This cannot be conducted at present.

The coastal shelf appears to be a feeding ground for both green and hawksbill turtles in moderate numbers and the combined nesting on the offshore islands may add up to a significant world population.

These populations appear to be quite sparse and should probably be considered as part of the larger populations residing also in the Dahlak archipelago (Sudan), Farasan Islands (Saudi Arabia) and throughout the Red Sea littoral. The region as a whole is an important area for hawksbills as they are relatively unpersecuted for shell in the region. One old fisherman in Luhayyah described an active fishery for shell that was exported, but this fishery seems to have been inactive for several decades.

2.3.5 Birds

For a small country Yemen has a very rich avifauna. Over 350 species have been recorded compared to about 420 in the vast and better studied area of Saudi Arabia.

The main reasons for this richness are:

1. Wide range of habitats, largely the result of the range of elevations and climate.
2. Geographic isolation by sea and deserts, resulting in 13 endemic or near-endemic species.
3. Country's position at the transition zone of three biogeographic regions: Ethiopian, Oriental and Palearctic, resulting in a mixture of species from all three.
4. Strategic position at foot of Arabian peninsula, thus acting as a flyway for migrant birds, notably birds of prey and waders.

From the 350 bird species recorded in Yemen, seven groups are of particular importance. These are:

1. Globally threatened species
   a. Bald Ibis *Geronticus eremita*: Yemen is probably a vital wintering area for a small population and may possibly even be their breeding ground. The retention of grazing marshes, especially in the Taiz area is critically important.
   b. Lammergeier *Gypaetus barbatus*: A widespread, resident vulture in the highlands.

c. White-eyed Gull *Larus leucophthalmus*: Occurs throughout the year on the coast and may well breed on the off-shore islands. The main threats are oil pollution and destruction of nesting colonies through man's activities.

2. Species endemic to southwest Arabia

Yemen holds significant, and in most cases the major, populations of 13 species unique to southwest Arabia. For a small country to be so richly endowed with endemic birds adds greatly to its international significance.

With the exception of the Arabian Golden Sparrow, all species occur in the highlands. The demise of the terracing systems could adversely effect several as the resultant soil erosion will cause loss of trees, notably Acacias. Acacias in the highlands, even isolated trees or clumps, are important for Arabian Woodpecker, Yemen Thrush, Yemen Warbler, Arabian Serin, Golden-winged Grosbeak and Yemen Linnet.

3. Seabirds

The biological richness of the Red Sea and the offshore islands of Yemen combine to make an ideal feeding and breeding area for seabirds: notably Red-billed Tropicbird, Masked Booby, Brown Booby, Sooty Gull and possibly White-checked Tern. The globally threatened White-eyed Gull may also breed there. All these species plus many others feed in the relatively shallow inshore waters along the coast of Yemen.

Oil pollution, disturbance from military training activities and port developments may all have an adverse effect on the seabirds. The lack of recent information on the status of these birds in Yemen makes specific recommendations impossible. However, priority should be given to an ornithological survey of the offshore islands.

4. Waterbirds

Freshwater habitats are rare in Yemen. Concentrations of ducks and grebes occur in just two areas (both recently created sewage lagoons) and rarely exceed 1000. These, together with the new dam at Marib, may result in a notable increase in the numbers of waterbirds in winter; they have already led to some species breeding for the first time.

For wading birds the coast is important, particularly where wadis reach the sea. Whilst comprehensive counts have not been undertaken it would appear that the biologically rich mudflats are particularly important for the following species: Crab Plover, Greater Sand Plover, Lesser Sand Plover, Sanderling, Little Stint, Curlew Sandpiper, Bar-tailed Godwit, Gray Plover and Redshank.

Storks, herons and egrets also occur on passage in small to moderate numbers but no important concentrations have been discovered. White Storks winter in small numbers at freshwater sites and breeding species include Abdim's Stork (on Tihama rooftops), Reef Herons (coast), Cattle Egrets (trees on Tihama and foothills), Green-backed Heron (mangroves), and Pink-backed Pelicans (mangroves) though none have been censused. Despite the close proximity of many breeding colonies to villages and human activities, there is no evidence of interference or persecution.

The highest conservation priority concerning waterbirds is of course the Bald Ibis, mentioned above under 'Globally threatened species'.

5. Raptors

Raptors frequently suffer more than other species in terms of both direct (e.g. pesticide pollution) and direct persecution. However, fortunately neither is common in Yemen. As a consequence there appears to be a healthy raptor population with some 17 resident species and a further 15 occurring

regularly on passage or in winter. The limited information suggests that the country is an important flyaway, at least in autumn, for migrant Steppe Eagles, Buzzards and Black Kites passing from their Palearctic breeding grounds to their main wintering area in East Africa. Clearly there is an international responsibility to ensure that these birds are unmolested.

6. Migrant and wintering passerines

Over 220 species have been recorded on migration in Yemen and mention has been made already of the waders, White Storks and raptors. A number of passerines or near-passerines also occur on migration and/or in winter in what appear to be significant numbers. These are Bee-eater, Short-toed Lark, Swallow, Tawny Pipit, Yellow Wagtail, White Wagtail, Gray Wagtail, Black Redstart, Redstart, Stonechat, Isabelline Wheatear, Pied Wheatear, Olivaceous Warbler, Menetries' Warbler, Desert Lesser Whitethroat, Chiffchaff, Isabelline Shrike and Great Gray Shrike.

7. The Arabian Bustard

Within the Arabian Peninsula Yemen is probably now the only country with a self-sustaining population of Arabian Bustards. This may in fact be partly supplemented by migrants crossing the Red Sea. It may be threatened from hunting on the Tihama, the only place it occurs.

A full systematic list of bird species recorded in Yemen is given in Annex 5. A summary of the species for which Yemen is of particular significance globally and within Arabia is presented in *Table 2.3.3* together with an indication of each species status.

Table 2.3.3 Bird species, and their status, for which Yemen is of particular global and Arabian significance.

	1	2	3	4	5	6	7	8
Little Grebe				RB		BL		
Audubon's Shearwater			WI					
Red-billed Tropicbird						BL		
Masked Booby						BL		
Brown Booby						BL		
Pink-backed Pelican		BI				BL		
Green-backed Heron						BL		
Goliath Heron		BI		RB		BL		
Hammerkop		BI						
Abdim's Stork		BI				BL		
Bald Ibis			WI				WL	RED
Black-shouldered Kite		BI		RB		BL		
Black Kite		BI						
Lammergeier		BI						
Bateleur		BI		RB		BL		
Dark Chanting Goshawk		BI				BL		
Gabar Goshawk		BI		RB		BL		
Shikra		BI		RB				
Buzzard			WI					
Tawny Eagle		BI						
Steppe Eagle			WI					
Verreaux's Eagle		BI		RB		BL		
Sooty Falcon				RB		BL		
Philby's Rock Partridge	•	BI						
Arabian Red-legged Partridge	•	BI						
Helmeted Guineafowl		BI				BL		
Demoiselle Crane								RED

continued

Table 2.3.3 continued

	1	2	3	4	5	6	7	8
Arabian Bustard		BI		RB		BL		
Crab Plover			WI					
Caspian Plover								RED
Slender-billed Curlew								RED
Sooty Gull						BL		
White-eyed Gull		BI				BL		
Swift Tern						BL		
Lesser Crested Tern						BL		
White-cheeked Tern						BL		
Chestnut-bellied Sandgrouse		BI				BL		
Crowned Sandgrouse				RB				
African Collared Dove		BI						
Red-eyed Dove		BI						
Dusky Turtle Dove		BI						
Bruce's Green Pigeon		BI						
Jacobin Cuckoo		BI						
Klaas's Cuckoo		BI		RB				
White-browed Coucal		BI				BL		
Senegal Scops Owl				RB				
Barn Owl				RB				
Hume's Tawny Owl				RB		BL		
Plain Nightjar		BI				BL		
Nubian Nightjar		BI				BL		
Alpine Swift		BI						
Palm Swift		BI				BL		
Gray-headed Kingfisher		BI						
White-throated Bee-eater		BI						
Abyssinian Roller		BI				BL		
Gray Hornbill		BI						
Arabian Woodpecker	•	BI				BL		
Singing Bush Lark		BI				BL		
Red-capped Lark		BI						
Red-rumped Swallow		BI						
Richards Pipit		BI		RB				
Tawny Pipit			WI					
Long-billed Pipit		BI						
Arabian Accentor	•	BI				BL		
Black Bush Robin		BI						
Black Redstart			WI					
Stonechat		BI						
Isabelline Wheatear			WI					
Red-breasted Wheatear		BI						
South Arabian Wheatear	•	BI						
Little Rock Thrush		BI						
Yemen Thrush	•	BI				BL		
Yemen Warbler	•	BI				BL		
Menetries Warbler			WI					
Arabian Warbler		BI				BL		
Brown Woodland Warbler		BI						
Gambage Dusky Flycatcher		BI						
African Paradise Flycatcher		BI				BL		
Nile Valley Sunbird		BI						
White-breasted White-eye		BI						
Black-headed Bush Shrike		BI						
Isabelline Shrike			WI					
Arabian Golden Sparrow	•	BI				BL		
Lesser Rock Sparrow		BI						

continued

Table 2.3.3 continued

	1	2	3	4	5	6	7	8
Ruppell's Weaver		BI						
Arabian Waxbill	*	BI				BL		
Zebra Waxbill		BI				BL		
African Silverbill		BI						
Arabian Serin	*	BI						
Yemen Serin	*	BI						
Golden-winged Goosbeak	*	BI				BL		
Yemen Linnet	*	BI						
African Rock Bunting		BI						

Key: 1 - * endemic to southwest Arabia
2 - BI international important numbers (breeding): >20% of Arabian population
3 - WI international important numbers (non-breeding): >20% of Arabian population
4 - BR rare breeder (<300 pairs): best guess
5 - DB declining breeder
6 - BL localized breeder: occurring in a small number of areas/specialized habitats
7 - WL localized non-breeder (excluding species with number <1000, e.g. grebes, ducks which utilize man-made wetlands)
8 - RED a world Red Data Book species

NB Arabia is defined as the whole Arabian Peninsula north to and including Syria and Iraq.

3. ENVIRONMENTAL POLICY

3.1 Institutional responsibilities

In the government of Yemen there is no single ministry or organization concerned with the broad spectrum of environmental issues. In 1987 the Environmental Protection Council (EPC) was created with the mandate to coordinate environmental policy. However, responsibilities for various aspects of the environment, particularly those of direct relevance for biological species, are primarily focused with the MAF, which has departments concerned with wildlife, forestry and fisheries. The MOMR is also directly concerned given the potential for environmental damage from offshore oilspills or damage along the pipeline. The MOE has incorporated some environmental education in the national curriculum, particularly regarding tree planting and conservation of trees. Although Sana'a University faculty is involved in research on Yemen's flora and fauna, there is no formal institution within the university for analysis or monitoring of species.

3.1.1 Environmental Protection Council (EPC)

A decree issued by the Office of the Prime Minister in February 1987 (Annex 6.A) established the EPC in the MMH. This council consists of 11 executive members from various ministries and government agencies, chaired by the Minister of MMH. The General Director of Environmental Health in MMH serves as the undersecretary of the EPC. The EPC is charged with developing policy, proposing legislation, coordinating necessary studies, promoting educational initiatives of environmental awareness and coordinating government agencies concerned with environmental protection. As its location in the MMH suggests, the focus on the EPC is on issues of environmental pollution, hazardous waste, and protection of the environment from a health perspective.

The EPC is attached to the Department of Environmental Health in the MMH. This department is currently subdivided into three parts: (1) Food Control and Sanitation; (2) Solid Waste Management and Vector Control; and (3) Health Education. Theoretically, there is an Environmental Health Section in each of the 170 field offices of the MMH in the country. Thus far the focus has been on environmental health, and waste collection and disposal for major cities and towns.

In November 1987, a mission from the Government of the Netherlands (Dept. of Development Cooperation, Ministry of Foreign Affairs) visited Yemen to define the urgent environmental issues facing the country (The Netherlands 1987). This mission recommended support for the newly formed EPC, which included one resident technical advisor, external consultants as needed, local contracts for studies and educational materials, equipment and in-country training. The formal project proposal entitled "Support to the Secretariat of the Environmental Protection Council" was fixed at DFl.1,625,000 over two and half years. The technical advisor began work in Yemen in 1989.

In August 1989 the contractor for the project of the Government of the Netherlands submitted a "Base Document" of the Environment for the EPC (Haskoning 1989). The major programs identified as significant for the EPC include: water management, control of desertification, abatement of industrial impacts on the environment, hazardous wastes, marine pollution, sanitation, legislation and educational activities, and institution building. These activities are directed primarily at potential hazards to Yemen's biological resources. No conservation programs for species, habitats or specific geographical locations have been formulated.

In establishing workplans for the operation of the EPC, six committees have been formed. These will focus on the following priority issues: (1) water, food and sanitation; (2) industry; (3) agriculture (e.g. desertification, erosion control, pest management, reforestation); (4) land-use; (5) marine environment; (6) health and education; and (7) legislation. The Committee on Marine Affairs is mandated to consider wildlife conservation in the marine environment. Among the donors supporting the EPC either

directly or through relevant projects are the Government of the Netherlands (technical support to the EPC), UNEP (preparation of workplans and various experts), and UNEP/FAO (desertification measures). Efforts are underway to support environmental education. On March 20, 1989, UNDP, CPO and MMH sponsored an environmental workshop in Sana'a to discuss the agenda for environmental protection in Yemen (Klaver and Rupert 1989).

3.1.2 Directorate of Fisheries (DOF)

The Directorate of Fisheries exists within the MAF to promote economic use of the fisheries resources of Yemen. The Directorate has a small office and staff in Sana'a but most activities are centered on a subunit of the Directorate – the General Corporation for Fisheries Development (GCFD) located at Hodeidah. GCFD has a chairman and managing director and has divisions of Research and Statistics, Extension, Administration and Finance, Personnel, etc. It carries out the major functions in the DOF. These are defined as the collection of fisheries statistics, the operation and maintenance of cold stores, and fish markets, and technical assistance to the traditional fishery sector.

Fishery development does not appear to be a high priority within MAF and the government. Office facilities in both Sana'a and Hodeidah are spartan and fishery development plans seem haphazard. There did not appear to be any significant resource management function. Despite this low priority status in MAF, many of the personnel seem well-trained and attempt to do a proper job.

A large World Bank project in the late seventies funded improved fishing ports at Midi, Khobar, Hodeidah, Khawkah and Mokha. The GCFD has attempted to develop a fishing capacity independent of the traditional sector by funding its own boats and crews. This venture is said to be of limited success.

DOF seems at present to be in a holding pattern while the responsibility for fisheries development are passed to the private sector.

3.1.3 Ministry of Oil and Mineral Resources (MOMR)

Responsibilities for assessing the potential environmental impact of the pipeline, as well as damage from oil spills, are based in the MOMR. The land portion of the pipeline is covered in the department concerned with the pipeline and refinery, while the potential for offshore spills is in the department of planning. Since the creation of the EPC, the MOMR has contracted this council for assistance and coordination regarding necessary studies.

The EPC, through its expatriate advisor, has drawn up plans for a World Bank-funded Environmental Impact Assessment. These plans are currently being discussed in the MOMR, but no decision has been made. The Secretary of the EPC has suggested a role for the Marine Affairs Committee, originally established in 1987. This committee is not active at present. Given the lack of any government or private agency to deal with a spill or extensive pollution, it is not advisable to wait until a formal agenda is agreed upon for an Environmental Impact Assessment.

3.2 Legislation regarding flora and forestry

Yemen has not passed any specific legislation to safeguard or conserve its flora, nor is there yet a national law that addresses the wholesale cutting of trees for fuelwood throughout the country. The creation of legislation to protect the trees is said to be complicated by traditional tribal law which allows individuals to own trees and covers communal rights to plants. However, in some cases traditional law or custom may be used to protect plants, as in the case of the protected pasture or *mahjur* (Kessler 1988). There are also cases where sheikhs have banned commercial cutting of wood

within a tribal area, or actions have been taken by local councils to prevent commercial cutting in a community.

Existing legislation at the national level has been prompted exclusively by agricultural concerns. For example, law no. 98 of 1969 set up a general directorate in the MAF for plant protection and control of pests. Law no. 40 of 1981 further refined the issue of plant protection by establishing a plant protection unit in ROYG. This is primarily to prevent the import of infected plant or seed material and/or potential crop pests.

3.3 Legislation regarding wildlife

The primary legislative concern regarding fauna in Yemen is the commercial interest in fishing and livestock. The laws regarding fish and the marine environment have been summarized by Barratt *et al.* (1987a). The major laws dealing with the development of fishing in the Red Sea are laws no. 30 of 1964 and no. 20 of 1978. Law no. 7 of 1980 led to the establishment of the General Corporation for Fishery Development (GCFD), a government agency designed to function in part as a commercial fishing company in the Tihama. The GCFD is linked, but not identical, with the Directorate of Fisheries in the MAF.

The general issue of protecting the animal resources in the country is dealt with in law no. 88 of 1976. Although this was primarily directed at domestic animals and fowl, it specifically mentions wild birds as in need of protection. However, no provisions are made in the law for actual conservation of wildlife.

The only previous legislation regarding wildlife in Yemen is law no. 40 of 1977 (see Annex 6.B). This was a complete ban on hunting gazelles in Yemen for ten years. Since this law has expired, no new legislation has been accepted to protect the gazelles.

For the past five years the MAF has been in the process of proposing major wildlife conservation legislation. This has recently been rejected by the People's Constituent Assembly, which found it outside the development priorities of the government. It is not likely that the law will be revised for resubmission in the near future without assistance from the newly formed EPC. The law, as written, identifies a range of species in need of conservation, although the reasons for such action are not clearly stated. The animals covered include: gazelles, ibex, oryx (which is undoubtedly extinct in Yemen), wolves and hyaenas, foxes and wild cats, wild donkeys (said to exist on Kamaran Island), baboons and wild birds (especially endemic species). The legislation is designed to strengthen the nascent Department of Wildlife and Zoos in the Directorate of Animal Resources in the MAF.

3.4 Summary

Responsibilities for the environment, including biological resources, are spread out in the government structure. In 1987 the EPC was created to coordinate and develop environmental policy, but this council has little expertise apart from the issue of environmental health. Primary concern for wildlife and fisheries is with the MAF, while the MOMR has responsibility for environmental damage from oil spills or breaks in the pipeline. There is no adequate legislation covering protection of forests, wildlife or natural habitats in Yemen.

4. ENVIRONMENTAL EDUCATION AND AWARENESS

4.1 Programs in government ministries

There is no office in the MOE directly concerned with educational curricula on the environment, although some materials developed in other ministries have been incorporated in school texts and materials. The EPC contains a Committee for Environmental Education which has published a working paper covering potential use of the media, including television programs already sponsored by the MAF and MOH. Concerning the biolcgical resources of Yemen, two projects within the MAF have developed educational materials and media presentations. These relate to the Directorate of Forestry for a tree-planting campaign and the Directorate of Animal Resources regarding rare and endemic bird species in the country.

4.1.1 Efforts to promote awareness of deforestation and the tree planting campaign

The Directorate of Forestry in the MAF, in conjunction with a project funded by The Netherlands through DHV Consultants, has taken an active role in raising awareness of deforestation as a major environmental problem. In 1988 a National Tree Planting Campaign was undertaken in Yemen (see MAF, Forestry 1988). A budget of 2,000,000 Yemeni riyals was used to create educational materials and for media promotion, as well as material support for tree planting. Among the specific outputs of this campaign were:

- A 32-minute video entitled "Man and the Environment" (*Al-Nas wa-al-biya*) in Arabic and English. This was locally produced in the MAF and broadcast March 5, 1988 on ROY television. Some 36 copies were released to relevant projects and organizations. The focus of the film was on the impact of deforestation and desertification.
- A campaign brochure in Arabic entitled "*Al-Khadra.*" This was distributed as an insert in the national newspaper, *Al-Thawra*, on March 5, 1988. Some 20,000 copies were made. This brochure contained a statement from the President of the ROY on the importance of conserving Yemen's environment, several short articles for popular reading, illustrations, a poem, quotes from the Quran on the environment, and reference to the book *Al-Ashjar* ("The Trees") prepared for public schools.
- The educational booklet *Al-Ashjar* was distributed in 1988 and 1989 in 100,000 copies for use in schools and on projects. This is an attractively designed and illustrated booklet answering common questions about trees and their use in Yemen.
- Instruction leaflet on planting and maintenance of trees in 10,000 copies.
- Poster on the value of trees in 3000 copies.
- Calendar with photographs and messages related to trees and forestry in 4000 copies. Some 2500 of these were distributed outside of Sana'a.
- Small sticker with the logo for the campaign in 5000 copies.
- A guide to Yemeni trees in Arabic entitled *Dalil ashjar al-ghabat.* This was distributed in August 1989 as an illustrated reference book covering many of the common trees in the country.
- Various articles in local newspapers and television coverage of the campaign.
- Development of slide presentation for the MAF on various flora and fauna of the country.

4.1.2 Efforts to promote bird conservation

Through initiatives of the ICBP and the Ornithological Society of the Middle East, several expeditions were made to Yemen in the 1980s (Rands *et al.* 1986). In this process an official of the Directorate of Animal Resources received a short training course on conservation at the International Council for Conservation Education in 1987. This official returned to develop several educational materials through the MAF. These include:

- A booklet in Arabic on Yemen's 13 endemic species of birds and the importance of their conservation (see al-Ba'adani 1987) in 2000 copies. This is an illustrated guide to these endemic species and where they are to be found.
- A sticker with the logo of Bird Conservation initiative in 5000 copies.
- A poster of Yemen's endemic bird species.
- A slide show of Yemen's birds and the variations of environment within the country.
- A calendar with pictures of Yemeni birds.

4.2 Media

[TO ADD]

4.2.1 Television and radio

The national station of the ROY, located in Sana'a, takes an active role in broadcasting documentaries and weekly programs on development issues. The Committee for Environmental Education in the EPC has proposed the use of several existing radio and television programs for promoting environmental awareness. These include:

1. *The Family Program*, aimed in large part at women. This could be done through dramatic means or interviews.
2. *The Interlude in the Countryside Program*, especially for issues of environmental degradation, pesticide use, desertification and deforestation.
3. *Religious programming*, dealing with religious arguments for conservation of the country's resources (see Annex 15).
4. *The Students Program and the Youth Program*, aimed at young people.
5. *The Agricultural Program*, especially for deforestation.
6. *The Science Program*, especially for biological species in Yemen.

4.2.2 Video production

Various departments in the MAF have equipment and personnel for producing videos for use in training and education. The main responsibility falls within the Directorate of Extension and Communications, which maintains a collection of videos and films relevant to Yemen's natural environment. The Directorate of Forestry, through the FAO project, has its own video production resources and has recently completed a short video on the natural forest stands in Jabal Bura. A video on trees was prepared by the Directorate of Forestry through the National Tree Planting Campaign in 1988.

4.2.3 Journalism

Yemen has an active community of journalists with two major daily newspapers, *Al-Thawra* and *Al-Jumhuriya*. In addition there are local magazines, some directly concerned with development and agricultural issues. These media were enthusiastic in support of the National Tree Planting Campaign. Many of the journalists have contact links with MAF officials and faculty at Sana'a University.

4.3 NGO development

As of yet there is no formal Yemeni NGO concerned with environmental issues, nor is there a formal scientific society in the country. However, there is interest by some officials and private citizens in formation of an association to promote conservation messages from outside the formal government structure. The expatriate group referred to as the Nature and Ornithological Society of Yemen is not a formal organization and is totally dependent on individual expatriate initiatives.

4.4 Summary

The main points addressed in this chapter may be summarized as follows:

1. There has been virtually no production of educational materials and promotion of environmental awareness outside of specific donor-initiated projects within the MAF. Due to lack of coordination there has been duplication of expensive equipment within MAF projects.

2. The EPC is currently developing workplans to promote awareness through its Committee for Environmental Education.

3. The MOE cannot at this point take the initiative in developing curricula and materials for environmental education, although it has incorporated materials made available from various ministries.

4. The only significant thrusts in conservation of biological species have been programs within the MAF to promote tree-planting and to promote awareness of endemic and endangered birds in the country. The favorable response to both these initiatives highlights the potential for efforts directed at other issues in conservation of biological resources.

5. There is interest in Sana'a University in teacher training curricula for the promotion of conservation education, but thus far no specific programs have been developed.

6. There is a recognized potential for the use of religious principles within Islam for the promotion of conservation. These principles, which can be effectively woven into existing media presentations, are outlined in Annex 15.

5. IMPACT OF DEVELOPMENT ON BIOLOGICAL RESOURCES

5.1 Overall development policy

Biological resources are part of a functioning ecosystem in Yemen that includes a major transformation of the natural environment. Initiatives to protect a particular species of plant or animal will have little effect in the long run if the overall environment is being damaged. Biological diversity in the country is very vulnerable to human presure. It is not a case of finding pristine wilderness to protect, but rather in Yemen there is a delicately balanced ecosystem in which the terrace system is the most vulnerable point. The centuries of effort that has transformed often harsh landscape into arable land have altered the plant and animal communities to such an extent that a collapse of the terrace system would have disastrous consequences on biological resources from the western escarpment down into the productive land of the Tihama.

It has become quite clear in the past decade that the environment in the country is undergoing extensive destruction, as is most readily seen from the declining water sources and tree cover. The causes for this are many and, thus, it is not possible to single out any one factor as central. Much of this destruction has occurred outside the control of ROYG or the development community. However, in some cases the policy and projects have exacerbated the degradation rather than stopping or slowing it. The environment, as such, is largely ignored in development policy. This chapter explores some of the reasons for this and what the ultimate impact will be on the future of biological diversity in Yemen.

The overall development of the country over the past two decades has proceeded without the services and coordinating functions of a strong central government. Much of the basic rural infrastructure, apart from the major road network, has been initiated and paid for by local communities. It is important to note that in general the rural population prefers to live in the rural areas. The remarkable energy of cooperative development in Yemen is a striking testimony to the fact that most Yemenis are trying to improve their way of life while still remaining at home. The large numbers of Yemeni men who have worked abroad have made it possible for rural Yemen to remain a viable place to live. Many of these migrants are now returning to rural Yemen.

While the actual building up of the country has largely occurred without governmental guidance or directive, numerous donors have tried to develop the capability of governmental institutions through technical assistance and external funding. Donor activities in the country have not been coordinated in a formal sense, but there has been a dominant focus on economic productivity. As a result progress is defined exclusively in economic terms. In the agricultural sector, which is recognized as the primary economic base of the country, this has led to a focus on new varieties of cash crops on irrigated land. This is a rational policy given the critical development needs of the country. The policy issue at present, however, is to what extent productivity can be sustained within the limitations of the country's natural resource base. The economics cannot be separated from the ecology.

In order to understand the ecology of Yemen, it is necessary to study the highland terrace system and related wadi spate network stretching from the western escarpment to the coastal zone. The productive base of this wide region. in which the majority of the country's population lives, has for centuries been in a delicate and vulnerable state of balance. Without maintenance of the terraces, farming systems and water management regimes, virtually all of the productive land would naturally revert to a rocky and barren landscape, an upper catchment scoured of all soils, a gravel-strewn wadi bed with no surface perennial flow, and a domino sequence of degradation down into the Tihama.

5.2 Case study of Wadi Zabid

Throughout Yemen's long history one of the most important agricultural regions has been centered on Wadi Zabid. In the early 1970s this wadi was the first to be developed with foreign expertise and funding. A major development study was commissioned by UNDP (Tesco *et al.* 1971-1973) for the modernization of the irrigation system, primarily along the lower reaches of the wadi. As a result a number of concrete dams were constructed and a major World Bank-funded initiative began. The development here served as a model for feasibility studies of most of the other important wadis descending into the Tihama.

Theoretically, Wadi Zabid should have been a case of study of what modern technology and irrigation systems could improve on an already productive agricultural base. However, the World Bank expenditures of some $50 million over nine years in the development of the Tihama are now viewed as unjustified in a recent audit of the project. Faulty design and implementation has made Wadi Zabid a prime example of how a traditional system has been progressively destroyed rather than improved. In real terms less land is under production along the wadi today than before the project started. The inappropriate concrete dams constructed in the wadis are paralleled by the persistent social problems inherent in the allocation of wadi flow.

The problem in Wadi Zabid, which is now graphically illustrated, is that the environment and the traditional responses to this in the region were ignored. Wadi Zabid as an ecosystem was created through centuries of experience in which relatively simple, but often effective, means were used to cope with the intense, short-duration storms in the area. At the top of the system, the upper catchment, a system of terraces served to check erosion from rainfall on slopes of up to 30o incline. The terraces represented a massive investment in time and energy, but they provided an ingenious response to an otherwise inhospitable landscape. The associated water management system of walls, spillways and cisterns served to direct surface flow to check erosion and at the same time increase the moisture content of the fields beyond the direct rainfall.

The resultant spate flow from the catchment was controlled along the wadi to allow for effective irrigation by temporary barrage structures diverting spate and perennial flow through channel networks on either side of the wadi. The successive and interdependent exploitation of the flow in the wadi bed continued down the system and out onto the coastal alluvial fan. At the lower end of the systems relatively large field basins (c. 2-5 hectares) were bounded by high banks (2-3 m) so massive that variable spate flow could be spread through the system in a relatively ordered sequence. In the farthest reaches of the wadi, where at times only one flood a year could be expected, the spate was traditionally supplemented by rainfall (c. 150-250 millimeters). Excess water in the system drained through the subsoil to replenish the major coastal aquifer systems.

The households and communities extracting a livelihood from this environment combined a productive grain and tree cropping system with rotational grazing that allowed for sustainable browse and fuel for local needs. The farming systems were for the most part subsistence-oriented at the top of the system, but control of the spate allowed for cash crops of coffee, various fruits and sorghum further along the system. Population density was not significant and the ecosystem easily supported the farming and grazing activities.

Today the delicate balance of the ecosystem has been lost and the wadi as a whole is in an advanced state of degradation. Setting aside the various economic and social reasons for abandonment of the terraces and consequent erosion damage, it is essential to underscore the economic and social costs of a productive base literally being washed away. The issue is not one of land simply being too marginal to warrant production, but rather the loss of an option to use the environment in any productive way.

The upper-catchment terrace system collapse has been augmented by wholesale devastation of virtually all tree and vegetative ground cover throughout the catchment, as commercial fuel wood sales to the

cities became the only alternative cash crop. The acacia cover said to be dense even in the late sixties has been transformed into barren, soiless escarpment with a massive potential for sheet, rill, and gully erosion onto already crumbling terrace systems below. Local estimates of 60-70 per cent woody biomass extraction over the whole catchment are confirmed by World Bank surveys and aerial photography interpretation (Millington 1988). Slow-growing juniper forests, capable of harvesting as much moisture from winter fog as they receive in rainfall, markedly ameliorating the dessication that accompanies vegetation removal, have also been decimated for building material and fuelwood. The impact on rural household energy costs, already a significant proportion of budgets, will continue to grow as the basic stock dwindles and consumption increases. But the stark reality is one of a virtually treeless landscape within a decade as expressed by *Figure 5.2.1.*

However, the far more serious effect of the combination of upper escarpment terrace collapse and deforestation is the consequent unravelling of the very fabric of the whole ecosystem, i.e. the incipient breakdown of the entire water management system upon which the man/landscape environment has depended over the centuries (see Varisco 1982 for a description of the traditional water management system).

Discussions with tenant farmers, landowners, and sheikhs in the upper catchment, upper and lower wadis, and the alluvial Tihama, combined with photographic and video observation on the ground and down the length of the wadi by helicopter, point to a total breakdown of the whole catchment water, cultivation and landscape system. This domino effect, triggered by the economic and physical collapse of upper catchment sorghum production is compounded by deforestation and virtually uncontrollable wadi floods.

The highly productive agroforestry systems with their essential diversion and canal structures in the upper wadi have been virtually destroyed by spate surges that have either covered the lands nearest the wadi with up to 20 feet of gravel, or physically swept away upwards of 70 per cent of all cultivated land in the upper wadi reaches. This has eliminated significant fruit and coffee plantations and ruined the livelihoods of small farmers formerly dependent on the controlled spate and perennial wadi flow.

In the lower wadi reaches, the cummulative effect of more intense spate surges along the whole catchment means that the damage to formerly productive, three crop-per-year lands is even more severe. The previously narrow wadi channels (30-50 wide) supported irrigated lands which extended 150-250 meters on each side, down the length of the lower wadi. Between 60-80 per cent of these lands are now covered by gravel or washed away. A group of twenty farmers interviewed for a recent environmental film had lost seven-eights of their entire lands in the past ten years, with an estimated 750,000 Yemeni riyals in lost annual earnings. This occurred in just one 500 meters section of the wadi. Half of this damage had occurred only two years previously, and the remaining lands are vulnerable to any new floods.

The impact of this process extends to the lower central wadi lands within 20 kilometers of the coast. The large capital investments in fixed barrages, which have provided increased and more reliable spate waters for a minority of farmers in the upper Tihama, have reduced the flows reaching the lower wadi lands. Farmers there have responded with a massive increase in pump irrigation in this area, and because of the combination of less inflow and greater extraction, groundwater studies now indicate a significant risk of saltwater intrusion from the sea, permanently destroying some of these highly productive soils, and threatening coastal vegetation and palm groves.

The effect of this ecosystem collapse on biological diversity is obvious. The vegetative cover associated with the traditional farming systems has declined dramatically. Stands of trees, vital to numerous fauna in the region have virtually been eliminated. The habitats critical for birds, for example, have been severely damaged. Large mammals, including gazelles, have almost all been eliminated by a combination of heavily hunting pressure and habitat deterioration, except for remote areas.

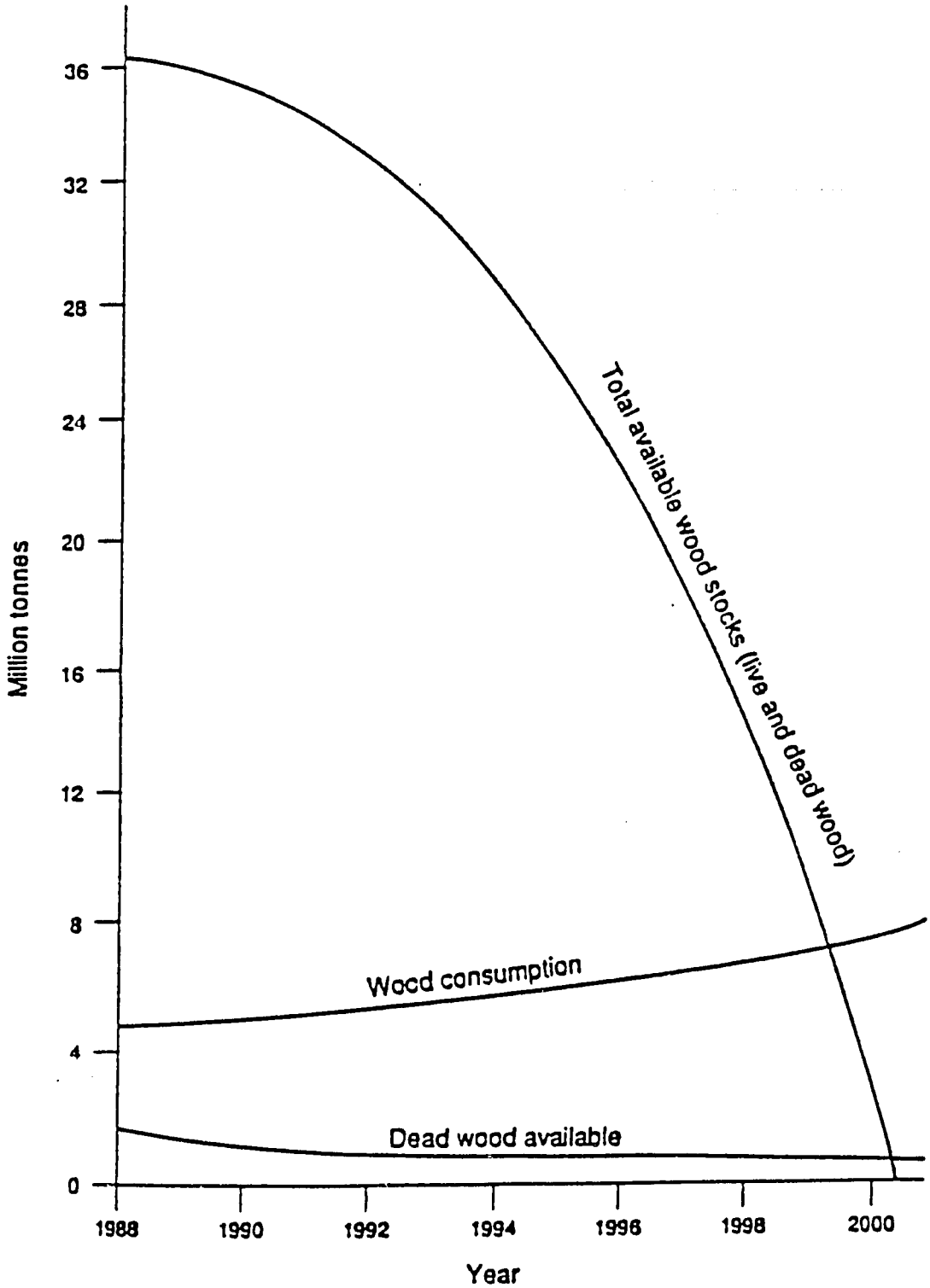

Figure 5.2.1 Projected fuelwood stocks (Millington 1988:48).

5.3 Integrated development policy and the environment

The case study of Wadi Zabid, which is symptomatic of the western escarpment as a whole, points to a major flaw in previous development efforts. The delicate balance of the terrace system ecosystem has been ignored as if its abandonment would have no serious effect. In addition to the lack of efforts to stabilize the terraces, whether through traditional crops or new direct-seed agroforestry crops, there has been an exclusive focus within the agricultural sector on the irrigation sector, both tubewell and wadi flood control at the lower reaches.

The social and economic consequences of the terrace system collapse have not been addressed. As this report is being written, considerable World Bank funds are being spent on removing canal silt from the lower part of Wadi Zabid. But this is ultimately a losing battle. The essential question, which is at the heart of the policy issue, is why there has been such a sudden increase in soil erosion, why the wadi is filling up with gravel, why the terraces are literally disappearing with each new flood and why the remaining scant tree cover continues to dwindle.

In a social sense, the collapse of this highland terrace system, will force a significant portion of the rural population (perhaps half in the region) off the land. These people will have little choice but to migrate to the cities of the country, which are already suffering from overcrowding in relation to existing services and water supply. Sana'a, the capital, has grown 175 per cent in 14 years, a rate of about 15 per cent per year. In the last decade almost a million new Yemani men have been added to the workforce. The option of work abroad in the Peninsula (which has been widespread and common over the last two decades) has itself largely eroded away as more Yemeni men return from abroad than can find employment there. These people will not be absorbed in the urban areas, nor will the service sector provide sufficient employment.

In an economic sense, the loss of marginally productive catchment terrace systems will eventually impact on existing irrigated land as the erosion proceeds relentlessly down the wadi system. Even now the cost of removing silt in the downstream parts of the wadi is an enormous economic burden that requires external funding at a time when such funding is increasingly hard to justify. At the same time, the overexploitation of groundwater, especially in the Tihama, is jeopardizing the sustainability of irrigated production in many parts of the country.

The point of this argument about collapse of the terrace system in a study of biological diversity is to draw attention to the extreme vulnerability of the ecosystem in which the remaining species of plants and animals must function. The threat to these species is also a threat to economic productivity in the future and the survival of a rural population in the most populated region of the country. Thus, to conserve either species or habitats, it is first necessary to redefine existing development priorities to save the environment before the degradation is complete and irreversible.

The cumulative effect of years of neglect of the terrace system and rainfed agriculture cannot be counteracted in a short period of time. However, there are practical steps that can be taken to reclaim productive land and allow the vegetative cover to return. It is the contention of this team that in order to help the hardest hit communities save their land, in a literal sense, it is necessary for ROYG and the donor community to recognize the overriding significance of environmental degradation in the future of Yemen's productive base. Thus, a major conclusion and recommendation of this report is that there be a fundamental shift in development policy away from the exclusive focus on increased irrigation from declining water sources to a major revival of the rainfed and wadi spate systems that support the majority of Yemeni farmers. The outline of an environmentally-sound policy that focuses on sustainable economic growth is provided in Section 6.1 and 7.2.2.1 below.

5.4 Coastal development

Development activities along the Tihama coast are currently having only a modest impact on biological resources and the opportunity exists to guide coastal zone management to avoid large negative impacts and maintain productive coastal ecosystems. Ormond (1987) reports large scale urban and industrial development on only 12 per cent of the coastline. Smaller scale influences such as small settlements, fishing and roads are noted for 20-60 per cent of the coast. The following direct effects of development are noted:

1. *Development of Ports and Urban Centers* at Hodeidah and Mocha is generating the usual environmental impacts on local coastal environments. Building, coastal alteration by dredging and bulkheads, disposal of garbage and sewage are all relatively uncontrolled. These effects remain restricted to the immediate environs of these developing ports.

2. *Development of industries.* Small scale service industries (welding, construction, manufacturing of small items) are concentrated in the two urban areas (Hodeidah and Mocha) and some larger industries are planned or in operation. Concrete production, chemical industries based on oil, natural gas and salt and food processing (fish canning, bottled drinks, flour milling) are all concentrated at Hodeidah and Mocha. This industrial development has the potential to generate pollutants and waste water disposal problems.

3. *Power generation.* A large power plan has been constructed on the coast at Ras Katenib and another exists in Mocha. Release of hot waters from power plants can have significant local effects on marine systems particularly corals and sea grasses. No evaluation of the effect of these plants has been made.

4. *Petroleum storage and export.* The outlet for Yemen's oil field is the terminus of the oil pipeline at Ras Isa. There are also significant fuel-oil bunkering facilities at Hodeidah and Mocha and smaller fuel stores at the new fishing ports of Midi, Khobar, and Khawkah. Spillage of crude oil and fuel oil during bunkering and tanker-filling activities is a virtual certainty. The challenge is to ensure that these inevitable spills are minimized and contained to reduce environmental damage.

   The coastal biotopes, particularly mangroves, sea grasses, and corals are particularly sensitive to oil pollution. The enclosed nature of Kamaran Bay and Bahr Ibn Abbas and the north flowing currents mean that a major spill at Ras Isa will devastate some of the most productive coastal ecosystems in Yemen.

5. *Fisheries development.* The increase of facilities and upgrading of equipment in the artisinal fishery is likely to lead to increased impacts on marine fisheries resources, particularly nearer to the new facilities. Slow-growing resident species such as grouper and sharks are likely to be more affected by these activities. There may also be increased incidental catch of marine mammals and sea turtles.

   Development of industrial scale fisheries has a greater potential for disrupting the ecosystems on which marine resources depend. In addition to increased catch efficiency exceeding sustainable yields, industrial trawl fisheries exert an indirect effect by physically disrupting sea grass beds and by causing excessive mortality of non-target species and juveniles discarded as 'by-catch'. Ratio of by-catch to retained shrimp can be as high as 10:1 in shrimp fisheries. Industrial scale trawling also causes incidental catch and mortality of sea turtles.

6. *Road building.* The widespread use of four-wheel drive vehicles has made virtually the whole coastline accessible by rough tracks, many of which pass along the upper beach zone. There is

a spreading network of improved gravel and tarmac roads radiating from major centers and a natural tendency is to upgrade existing tracks. Two effects can follow:

a. Road building and off-roads have the potential to disturb coastal habitats, destroy ground cover and so increase soil erosion, and increase sedimentation to adjacent marine communities.

b. Increased access will increase the general impact by people of litter, fishing pressure dune and vegetation degradation and destruction or disturbance of wildlife (for instance, aggregations of migrating birds).

7. *Tourist development.* There is already some development of facilities for tourists in the coastal area. Because much of the coast appears unattractive, this development will be concentrated on these few areas where palm groves, clear water and sandy beaches occur. It should be possible to channel these facilities toward integration and conservation of local resources. However, at Khawkha there is already a telling contrast between one rather attractive tourist accommodation set comfortably into a palm grove and another nearby that has cleared the palms and installed rather sordid (though air-conditioned) cottages.

8. *Tree cutting.* Deforestation is a significant problem throughout Yemen wherever larger trees occur. To date, the mangroves have been spared large scale cutting, but if the trees are all cut inland and the economic incentive is sufficient, mangroves may also come under pressure.

In addition to direct effects, several development activities may have indirect impact on coastal diversity.

1. Water diversion and water extraction projects. The large scale extraction of ground water by tubewells and the diversion of wadi runoff with barrages to support agriculture reduce the fresh water input at the coast. Effects are likely to be reduction in nutrient input from flooding, and changes in ground water salinity that will alter the present balance of salt tolerant and salt sensitive communities. Both of these may significantly affect productivity of coastal systems and indirectly affect fisheries resources.

2. Agricultural development. Conversion of traditional agricultural systems to large scale farming with a greater dependency on fossil fuels, fertilizer and biocides is proceeding rapidly in the Tihama. This activity is largely isolated from the coast by the band of saline of soil and halophytic shrubs except at major wadi mouths. Nevertheless, runoff and contamination by pesticides and biocides and sediment loading from soil loss in the upper watersheds may negatively impact marine diversity.

6. CONSERVATION PRIORITIES FOR BIODIVERSITY

It is widely recognized within ROYG and the donor community that the country is facing a variety of environmental problems. This is particularly evident in the case of declining water tables in productive areas, as well as the emerging hazards from pollution and pesticides. Given the range of needs which development policy must deal with, it is understandable that attention has been focused on those aspects of the environment that most directly affect human health and economic productivity. This chapter approaches the environment not as a development issue in these narrow terms, but rather in light of the essential linkage between the country's biological resources and its national development in all aspects. In this sense conservation is not limited to a particular species or biological community, but rather at the functioning ecosystem on which both biological and human resources ultimately depend.

The most critical observation about conservation needs within Yemen is that the environment, in all respects, is more vulnerable today than at any other time because of the very process of economic and infrastructure development. The various regions of the country represent the most diverse and rich variety of fauna, flora and indigenous agricultural crops for the entire Arabian Peninsula, and in fact for much of the general region. This is relatively easy to document, but it is a far more difficult task to demonstrate to both ROYG and the donor community the critical importance of conserving this diversity.

Given the lack of a coherent or coordinated policy regarding the future use of Yemen's biological resources, it is difficult to prioritize in a systematic way the conservation needs. This chapter will highlight the critical conservation issues, which necessarily extend beyond the biological resources *per se*, and will address the significance of these issues in human and economic terms. Finally, a specific plan of action will be outlined for dealing with conservation in general and with specific conservation needs. Having defined the needs, the following chapter will contain a range of recommendations to address these.

6.1 Development policy

Conservation of biological species in Yemen cannot be successfully advanced if it is perceived as an issue peripheral to the overall development policy of both ROYG and the donor community. While some policy makers may recognize the importance of sustaining the country's rich environment, this is still approached with an add-on mentality. The placement of the EPC within the MMH is a prime example that environmental issues are addressed as problems arising within a specific development field; in this case environmental protection is directed almost exclusively at immediate threats to human health. The almost total lack of action, both in terms of funding and personnel, within the MAF on conservation of indigenous species and crops is further evidence that conservation is not given priority until a particular crisis in economic terms arises. This is understandable given the development context of the nation, but such a de-facto lack of environmental policy in fact jeopardizes the anticipated productive growth in the country.

For the first few decades of Yemen's overall development, policy has been dictated by short-term goals and immediate crises. For obvious reasons, it has not been possible to stem the virtual tide of destruction and degradation of the natural resources - land, water and biological - that result from an undirected and uncoordinated process of development. The irony, however, is that historically Yemen is one of the best examples anywhere of an economic productive base within a sustainable natural environment. Apart from the long-established deforestation of the country, conservation has traditionally been an integral part of the agricultural system and use of natural resources. While it is not possible to maintain this traditional economic and social milieu, it is essential that development policy today recognize the essential and integral interdependence of the people and their natural environment.

From an ecological perspective, in which productivity and economic growth must be grounded in conservation of the natural resources on which these ultimately depend, the critical shortcomings of both the policy and *de facto* process of development within Yemen are:

1. Focus on short-term economic growth, exclusively irrigated agriculture, and reaction to crises.

2. Failure to assess the costs-economic and human- of the accelerated process of infrastructure development and economic production on degradation of the natural resource base.

3. Failure of policy makers to communicate with individuals at the community level, where the environmental problems are of most immediate concern; lack of work on practical initiatives that can be implemented by the private sector and local communities.

4. Failure to address conservation of the environment as a basic human need in a country where the vast majority of the people totally depend on the natural resource base for survival and economic growth.

6.2 Institutional development

The donor community and ROYG must necessarily work through formal institutions within the country for promoting conservation and implementing specific projects. However, it is important to find mechanisms for funding and supporting local initiatives from the bottom up. At present the EPC has the broad mandate to coordinate environmental policy, although responsibilities for specific issues regarding biological resources are located primarily in the MAF. The EPC has support from The Netherlands, but it currently has minimal capabilities to address issues apart from environmental health and related protection needs. There is no emphasis on the natural resource base in a state of degradation, nor with specific programs for the media. The lack of adequate legislation from ROYG at this stage, coupled with the limitations of the EPC as organized, complicates the introduction of specific conservation measures. The role of CPO in assisting the EPC to coordinate environmental policy between the various concerned ministries is unclear. The potential for coordination with the CLCCD and local councils is also undefined.

In terms of biological resources, the Directorate of Forestry in the MAF has funded project support for the critical issue of deforestation. However, there is currently no personnel or project support to the Directorate of Animal Resources in the MAF regarding wildlife.

Within formal government institutions the shortcomings at present include:

1. Inability of the newly created EPC at present to effectively cover the range of environmental problems and to coordinate between concerned ministries.

2. Lack of effective legislation on many key aspects, e.g. wildlife conservation, to direct and support the EPC and concerned ministries.

3. Almost total lack of trained personnel in conservation issues within Yemen's institutions.

4. Apparent lack of coordination between government institutions and Yemeni expertise (e.g. at Sana'a University) regarding biological resources in the country.

5. Lack of coordination between government institutions and local councils on environmental problems.

6. Present inability of any formal government institution to coordinate or absorb a major project initiative in conservation of biological resources.

Although government ministries and agencies have responsibilities for environmental policy and implementation of projects, the scientific assessment of the country's biological resources will in the future be primarily by Yemeni scientists, especially those affiliated with the national university. Sana'a University has only a very limited number of Yemeni faculty trained in biology and more specifically trained in conservation. In fact the Faculty of Science has received little development aid and few foreign scholarships. There is also at present no scientific society or formal conservation group within the country, although Yemenis with advanced degrees in the sciences are returning annually to work with the country. The formation of a conservation-oriented NGO with Yemen would greatly assist in ensuring government action on environmental issues.

6.3 Conservation awareness

One of the fundamental barriers to promotion of conservation of biological species in Yemen is the failure of policy makers to understand or demonstrate the significance of the environment for both the people and sustainable productivity in agriculture and rangeland use. General seminars have been held in Sana'a to address environmental issues, but none have dealt with biological resources apart from the issue of deforestation. Proposed legislation on wildlife conservation has failed to be passed for over five years, because it has not been demonstrated to the legislators to be relevant within the nation's development priorities.

In formal education, conservation hardly exists as an idea. The MOE has adopted materials from the National Tree Planting Campaign, and this may serve as a model for future conservation-related components of the public school curricula. Apparently no publications have been done or conservation stressed in religious schooling, although there is firm support for conservation of natural resources in Islam (Annex 15). Sana'a University offers courses on botany, zoology and marine environments, but conservation has little practical relevance in the curricula at present. The library has very limited texts and periodicals on conservation related to biological resources (Annex 7).

In a non-formal sense there has been promotion of certain issues of conservation, but these have been piecemeal and almost entirely dependent on expatriate support. The media have been successfully used for conservation awareness in tree-planting, and there is interest and opportunity within the Yemeni media for production of programs on conservation directed at a general audience. The EPC has a committee examining potential initiatives with the media in creating awareness of conservation.

The focus on the media is probably the best approach for the conservation of biological resources because of the direct impact of the media throughout the country and the slow response of government institutions. While policy makers must be made aware of the environmental consequences of certain development initiatives, those most likely to respond to conservation messages are the people who are seeing their natural resources literally disappear around them. The added advantage in Yemen is the active role taken by many local councils and cooperatives in lobbying various government agencies to meet demonstrated needs at the local level.

6.4 Critical areas

The environment of Yemen has undergone great stress in the past three decades, so that there are areas where the diversity of species must be conserved in the immediate future. Available data are not sufficient to determine how critical the need is for protection of particular areas, although a list of key areas for conserving sites of international importance for birds has been prepared (Rands *et al.* 1986). There was insufficient time for quantitative analysis of any locality during this project. However, a

number of areas and sites have been noted as potential refuge or protected areas; these are briefly assessed below.

6.4.1 United Nations list of national parks and protected areas

The World Conservation Monitoring Centre (Cambridge, England) recently contacted the MAF for updated information on its current list of potential areas for protection within Yemen (Annex 9).

This list cites one proposed site (Kamaran Island) and 23 recommended sites, although there is no indication of why these have been proposed or by whom or of what the immediate need for protection is. As such this list is without much practical value. Specific areas, some of which are not mentioned in the list, are identified for protective initiatives in Section 7.1.6 below.

6.4.2 Defining a critical area

The main problem in identifying critical areas with biological diversity is that the standards for defining the need for protection have not been articulated. In some cases it may simply be the result of an expatriate taking a weekend trip to an interesting area. In a sense all of Yemen is vulnerable in that the pace of deforestation has virtually destroyed the forest cover and isolated trees in each environmental zone to some degree. It is obvious that some areas are in visibly critical need of protection, particularly areas with terrace system collapse or exposed to road development and increased exploitation. Other areas may be more-or-less protected for the present because of inaccessibility, strong community interest, or minimal population pressure.

What is needed is not simply a grocery list of potential sites, but a mechanism whereby the environmental context is not ignored in future infrastructure and economic expansion. At present only the EPC would seem to have the mandate for developing such an environmental watchdog capacity. There is obviously a critical need for development of a conservation data center in the country.

6.4.3 Defining the level of protection

Yemen has yet to designate any particular area or site as a protected environmental area, wildlife refuge, nature reserve or national park. Other states on the Arabian Peninsula, e.g. Saudi Arabia, Bahrein and the U.A.E., have created such protected areas. While the concept of such a protected area in Yemen is valid, it is premature to designate any particular area in the absence of any institutional framework to initiate, operate, or maintain the protection.

A complicating factor for some areas in need of protection is that the land may be privately owned and not readily available to be placed under government authority. Given the lack of funding within ROYG and the lack of mechanisms for establishing protected areas, it may be most appropriate at the present time to focus on protection at the community level. For example, the local development council and sheikhs of Bura have taken steps to prevent outsiders from entering the valley to cut down the plentiful trees supply there. This initiative was in response to local outrage, rather than a move from a formal government ministry. Similarly, the sheikh of Khardan in the upper catchment of Wadi Zabid worked with the local community to ban tree-cutting in the community some eight years ago. A fine of 1000 Yemeni riyals was to be levied at anyone cutting trees. As a result of this protection the ground cover and vegetation has been renewed and some animals have begun to return.

6.4.4 Prioritizing critical areas

One way of attempting to prioritize areas and sites in need of some kind of protection is to focus on the potential threats to biological resources in the country today. Among the factors contributing to a decrease in diversity, and in some cases a virtual collapse of the resource base, are extensive tree cutting, location of buildings and factories, the associated exploitation patterns following road

construction and increased local traffic, abandonment of terrace systems, over-grazing, and potential oil spills or pollution. Those areas where several of these factors operate at once are obviously in a vulnerable state.

It is also useful to point out that some areas of restricted access for military or security reasons actually contribute to the conservation of species. Thus, the restrictions on travel and development for most of the islands off the Red Sea coast may create a de-facto nature reserve. The same is true for the area south of Mawza, where gazelle can still be found.

Special attention should be paid to more careful management planning and monitoring of the coastal zone, because this area is undergoing rapid development with the pipeline and refinery at Salif, uncoordinated but still low-key tourist facilities, port enlargement, factory construction, and increases in commercial fisheries. While the Tihamah Development Authority (TDA) has overall responsibility for development in the coastal zone, the activities of TDA do not always involve the local councils, nor do they appear to benefit the local communities directly. The planning process must address the social needs of coastal fishermen and peasants, who are clearly among the poorest and most distressed segments of the population.

6.5 Critical species

The primary source of information on critical or endangered species in Yemen is the outdated IUCN listing, which has not received verification through field research in a formal manner. Since certain species are defined as endangered apart from their exact status in Yemen, it is easier to list critical species than to define critical ecotypes or communities. A distinction needs to be made between "flagship" species, which often receive a lot of media attention and interest abroad, species with significant economic importance or potential in the country, and species upon which a range of other species or an entire community may directly depend.

6.6 Crop genetic diversity

One of the unique aspects of Yemen's biological and indigenous agricultural species is the range of genetic diversity. This is especially evident in the documented diversity for the main subsistence (and prime cash crop for fodder) crop of sorghum (*dhura*). The USAID-sponsored National Sorghum and Millet Crop Improvement Program of the late 1970s collected 4,500 native sorghum varieties, of which 50 were tested at 18 locations over a two year period in Yemen. The technical conclusion of these tests and analysis was that locally adapted types from Yemen were more productive than available hybrid sorghum types developed for conditions outside of Yemen (University of Arizona 1981) Given the importance of sorghum historically in Yemen (Varisco 1985) and its continued production on the bulk of rainfed and a substantial portion of irrigated land, preservation of this diversity is important both for Yemen and potentially for other regions where this crop is still of significance.

Although research is still in a preliminary stage, it is clear that in the range of environmental zones of the country there is great diversity of species and ongoing discoveries of new variants unique to Yemen. Two interesting plants in this regard are the aloes and *Adenium obesum*, both of which are found at virtually all elevations.

6.7 Sustainable fisheries and coastal management

At present there is no legislation to protect the coastal region from indirect development. As a result there is a danger that certain critical habitats, such as mangrove swamps, may be destroyed as land is cleared for new buildings, industrial sites or recreation. The mangrove areas are very important in the

production of edible detritus for shrimp. Development of industrial scale fisheries has a great potential for disrupting the ecosystems on which the fish, shrimps and other marine fauna depend. Even the widespread use of four-wheel drive vehicles will disturb and degrade the coastal beaches. In parts of the Tihama the trees and scrubs are being bulldozed away at an alarming rate. This is having a drastic effect on the limited efforts at present to stabilize the dunes.

6.8 Summary

The main conservation priorities for conservation of biological diversity in Yemen may be summarized as follows:

6.8.1 Current development policy emphasizing short-term economic goals and agricultural productivity on irrigated land has contributed in large degree to the degradation of the environment and diversity of flora and fauna in the country.

6.8.2 The EPC, MAF and Sana'a University are the main institutions which deal most directly with the country's biological resources. All of these institutions are at present unable to carry out conservation initiatives without technical assistance and/or external funding. The lack of legislation is especially critical at this stage.

6.8.3 Conservation awareness can be raised through modest means and by effective use of the media. Initiatives directed at people in general may have greater effect on changing or creating environmental policy than attempts to influence policy makers directly at the present time.

6.8.4 The criteria for defining critical areas or biotypes and the mechanisms for protecting these are lacking within ROYG.

6.8.5 There are critical or endangered species of international and of local interest, although it is difficult to prioritize some of these given the current level of data.

6.8.6 Genetic diversity is a major feature of a variety of species across the varying environmental zones. This is especially the case for the major subsistence and significant cash crop of sorghum.

7. RECOMMENDATIONS FOR CONSERVATION OF BIOLOGICAL RESOURCES

Recommendations regarding environmental issues in Yemen have come from a variety of donors, including USAID (Speece 1982; Varisco 1987:41-47), UNEP (Gubara 1985), OSME (Rands *et al.* 1986), The Netherlands (1987), Ormond *et al.* (1987), and for specific projects dealing with land, water or biological resources. This chapter focuses on recommendations for conservation of biological diversity within Yemen, both in the broad perspective of environmental policy and specific project initiatives. The first set of recommendations are for ROYG and foreign donor organizations in general. Specific recommendations are then given for USAID/Sana'a and AID/Washington. However, certain of the general recommendations may also be relevant for AID.

7.1 General recommendations

There is a fundamental and overriding need for defining conservation of biological resources as an integral part of sustained economic growth and social welfare within Yemen. This will require movement on two fronts simultaneously: (1) working with policy makers to respond to conservation issues; and (2) communicating conservation in culturally meaningful terms to the Yemeni people. The focus of these efforts should be to promote conservation of biological resources as an important development issue and to assist the ROYG in coordination of effective policy, legislation, and institutional support for environmental issues. Specific project initiatives for this broad goal include:

7.1.1 Representation from the International Union for the Conservation of Nature and Natural Resources (IUCN) World Conservation Union

INITIATIVE: Discussion with ROYG officials and a variety of concerned citizens indicates that membership of a Yemeni institution in IUCN is feasible, especially since most of the other countries of the Arabian peninsula have affiliation. It is recommended that a representative or team from IUCN visit Yemen to discuss affiliation and the potential role of IUCN in conservation issues vis-a-vis ROYG and non-governmental organizations or concerned citizen groups. IUCN is especially important because it can deal both with governmental and NGOs in future conservative coordination and initiatives. This would provide an institutional channel for other conservation organizations to work through.

IMPLEMENTATION: A formal request for a visit by an IUCN official should be coordinated through the EPC. The IUCN official should be accompanied by a representative from an affiliate institution in the Arabian Peninsula. Perhaps Dr Muhammad Kassas, a former head of IUCN, may be available. Meetings in Yemen should be arranged with the Foreign Minister (Dr al-Iryani), the EPC (Dr Abdul Rahman Mu'assib), Minister of Agriculture (Dr Nasser al-Aulaqi), relevant directorates of the MAF (e.g. Animal Resources, Fisheries and Forestry), relevant directorates in the MOMR (e.g. Planning, and Refineries, Oil and Storage), Dean of Faculty of Science (Dr Ali Shekeil), and concerned faculty at Sana'a University. The purpose of the mission should be to discuss affiliation with IUCN and possible project initiatives to be supported through IUCN and related international conservation organizations.

Specific initiatives that IUCN may be able to address are the following:

1. Relevant initiatives through the joint IUCN-WWF Plants Conservation Programme. This could include: training of a Yemeni official in the MAF or from Sana'a University in the 6-week course for on-site conservation coordinated at the University of Birmingham; funding of field projects on a particular plant species with significant genetic diversity or economic potential, especially for medicinal plants; provision of relevant conservation publications of IUCN to Sana'a University library or the MAF Documentation Center.

2. Technical assistance for coastal zone assessment and planning. This should be coordinated with the activities of the Red Sea and Gulf of Aden Program.

3. Technical assistance for developing local TV programming on conservation issues of significance in Yemen. This should be coordinated with the EPC and the Ministry of Information.

4. Field survey of the biological resources and existing human use systems of the islands off the coast of Yemen. This would complement the earlier research of Rands *et al.* (1986) and Ormond *et al.* (1987).

7.1.2 Support for the EPC

INITIATIVE: The EPC is currently supported by aid from The Netherlands. However, it has no personnel or expertise to pursue conservation of biological resources apart from the issue of environmental health. It is recommended that CPO take the initiative in assisting the EPC to: (1) obtain necessary assistance and expertise not presently covered by The Netherlands; and (2) assisting the EPC in defining a program for coordination of concerned ministries and institutions dealing with biological resources.

IMPLEMENTATION: CPO should consult The Netherlands aid program to determine the needs for dealing with conservation of species and for additional assistance or cooperation with other donors.

Assistance is especially needed for writing appropriate legislation and codes related to wildlife conservation and habitat protection. It is essential that a Natural Resource Ecologist be assigned to the EPC to deal with biological resources and overall environmental degradation. This Ecologist should develop a monitoring system of environmental problems, as well as plans for a conservation data center.

It is recommended that the Committee on Marine Affairs be convened to address the monitoring and management of the marine environment to deal with future oilspills, identify coastal habitats and species in danger, and promote sustainable fisheries. Further, there is a need for the EPC to have access to expertise and appropriate footage in promoting conservation through the media. One effective way to focus the issue is by a media-wide focus on National Environment Day (October 14). A sample proposal has been made by al-Ba'adani (1989).

7.1.3 Institutional support for the Department of Wildlife and Zoos in the MAF

INITIATIVE: Responsibility for wildlife conservation lies within the Directorate of Animal Resources in the MAF. At the present time there are no personnel or specific projects oriented towards conservation, since the focus on the directorate is on livestock and poultry. Yemen is one of the only countries in the region not to have a zoo or botanical garden.

IMPLEMENTATION: The Directorate at present could not absorb a specific conservation project with existing capabilities. It is recommended that a scholarship for long-term training be given to a qualified Yemeni candidate specifically to focus on wildlife conservation. This person would return to head the Department of Wildlife. Previously, ICBP arranged for an official of this Directorate received a short-term training course at I.C.C.E. in England. This resulted in publications and media presentations relevant to the country's endemic and endangered birds (see Section 4.1.1). A similar short-term training course should be made available to the Directorate or through the EPC. Plans for a national zoo at this time would be premature.

7.1.4 Institutional support for the Directorate of Fisheries

INITIATIVE: Despite UNDP assistance to the fisheries industry in the 1970s, this sector is not operating smoothly. Research and monitoring capabilities appear to be minimal. The impact of GCFD practices, particularly in marketing, on local fishermen has a number of negative elements. Coastal fishermen are among the poorest part of the population.

IMPLEMENTATION: At a policy level there is a need to examine the role and operation of the GCFD as a government or quasi-governmental organization. The potential for fishing cooperatives and private sector fishing companies needs to be examined. Current fish and shrimp marketing practices also need to be assessed for impact on the poor coastal fisherman. The commercial aspect of fisheries should be separated from the necessary governmental role in monitoring fish reserves on a seasonal basis, regulating and registering fishery boats, and improving the marketing and storage facilities for fisheries along the coast. A study to assess the privatization of the GCFD or encourage small-scale fishing cooperatives should be done. This study should look at the economic and social issues involved. The study could be coordinated through the Center for Privatization.

7.1.5 Institutional support for Sana'a University for conservation and research related to biological resources

INITIATIVE: The Faculty of Science currently has little or no financial support for research on Yemeni species or work on conservation of biological resources (Annex 7). There is interest within the Faculty of Science for assistance with proposed biological research by faculty and students on Yemeni species. Plans are also underway to establish a herbarium, and there is a need for a collection facility or museum devoted to natural history, particularly fauna. The National Museum in Sana'a is currently planning a Natural History Section in its expansion plans. A Dutch team is currently addressing this issue. While there are some faculty capable of carrying out research relevant for eventual conservation initiatives, funding and equipment are very limited and not covered by existing donor projects.

Several existing biological research proposals from faculty at Sana'a University were documented in a previous assessment (Varisco 1987:43-44), although none have yet received funding. The specific proposals relevant to conservation of biological diversity are:

1. National Botanical Survey of Yemen. As this reports documents, a number of foreign researchers and Yemeni specialists have been collecting botanical data. Paul Scholte and Abd al-Wali al-Khuleidi have recently completed a national vegetation map for the country and this can serve as a framework for future effort at the national level. Dr Ahmed al-Hubaishi and Dr Abdul Rahman Dubaie of the Faculty of Science have a continuing interest in such a botanical survey on a systematic basis. This would be an important step in further defining critical areas and species of flora in the country.

2. National Herbarium at Sana'a University. The government of the Netherlands has taken the lead in proposing a national herbarium for Yemen (Seegeler *et al.* 1987; Scholte and al-Khuleidi 1989), although a formal agreement has yet to be made. The project in Dhamar of RLIP has established an herbarium at the field site, but the need is for a central, well-equipped center in Sana'a University. Dr Dubaie of the Faculty of Science has also established a personal collection of plant species from his field experience in the country. Steps should be taken immediately to provide necessary storage equipment for specimens already collected.

3. Field Research Projects. Several faculty members have proposed projects for collection and analysis of Yemeni flora and fauna. These projects include the study of land vertebrates (Dr Safadi), study of critical habitats (Dr Aboud), and the study of indigenous medicinal plants (Annex 12).

IMPLEMENTATION: Institutional support to strengthen the Faculty of Science in reference to conservation of biological diversity should be approached in three ways:

1. At least two scholarships for graduating biology students (i.e. one in zoology and one in botany) for degree work abroad with a focus on the conservation aspect of each field. These should be given to qualified candidates who will return upon graduation to teach within the Faculty. The large number of female botany students may make it possible to propose at least one female candidate.

2. External support for specific research proposals from appropriate organizations such as ICBP, IUCN and WWF. One such proposal is outlined in detail in Annex 12 for a study of the Economic Viability of Indigenous Plants (EVIP).

3. Upgrading of library at Sana'a University for necessary publications and periodicals relating to biological resources in the region and conservation methods (Annex 7).

4. Coordination with the proposed Technology Transfer and Training Institute (T3I), a self-supporting science and technology program through possible USAID support.

5. Funding and assistance for an operational greenhouse for the Department of Biology. This would be used for student training in botany, scientific analysis of Yemeni species and planting trials for plants with potential economic value.

7.1.6 Technical support for MOMR

The potential damage to the marine environment near the pipeline terminus at Salif is acute. The primary threat is that of spillage from oil tankers. Hunt Oil recently conducted an assessment of environmental impact for the pipeline terminus area, but this report was not available at the time of this study. It is important that ROYG take steps to enhance oil-spill containment capacity, which the BDA team was unable to assess. A further recommendation is development of a tank flushing and waste oil recovery unit at the pipeline terminus. This would remove the need for tankers to pump oily balast water into the sea. A model project is operational at Mina al Fahal in Oman. Efforts should be coordinated with the MOMR and EPC.

7.1.7 Raising conservation awareness through the media

INITIATIVE: The Yemeni media (television, radio and print) have shown interest and expertise in providing documentary or special programming on selected conservation issues, e.g. deforestation. There are existing programs, particularly through the MAF and potentially through the EPC, on which the issue of conservation of Yemen's biological resources could be presented.

It is not sufficient to simply supply conservation documentaries developed for other countries or merely translated/dubbed into Arabic. It is essential that Yemeni staff be interested in the writing, filming and editing of both short spots and documentary programs.

IMPLEMENTATION: A previous USAID-funded study recommended a Yemeni Documentary Film on Wildlife Conservation (DOCON) in which the experience of an African country could be portrayed first-hand by a Yemeni film crew (Varisco 1987:44-45). This could be achieved at relatively little cost and through the technical support of ICBP and the WWF regional office in Kenya.

Given the interest of the EPC in using the broadcast media, technical assistance could be provided to the EPC to assist in the development of appropriate conservation spots and/or documentaries. This could be done with existing equipment and personnel in the MAF or the national media.

Yemeni journalists are eager for story ideas relevant for development issues in the country. Thus, the provision of news releases on conservation activities or specific species should be provided to the major Yemeni newspapers.

7.1.8 Critical areas for conservation

The United Nations List (Annex 9) contains some 24 sites for protective status in Yemen. Many of these are offshore islands, which are in fact probably not in immediate danger due to restricted access for military and security reasons. Other areas are too broad or poorly defined to be considered in a practical sense.

Based on a very brief and incomplete assessment of areas proposed as critical or in danger, it is possible to recommend a few preliminary sites as potential protected or restricted-use areas.

7.1.8.1 The location of a "national park" or "preserve" in the formal sense requires that the area essentially be unowned government land or land not currently under active agricultural production. The primary candidate for such a park is Jabal Bura, specifically the first 5 kilometers at the entrance of the valley (Annex 10). This land is of relatively easy access from the coastal roads and is virtually unpopulated except at the higher slopes. National park or protected area status would protect the tree cover and the wealth of biological diversity for both flora and fauna here. This is a refuge area for baboons and some of the endemic bird species of the country. The tourism potential here is great, since it is within a two-hour reach of Hodeidah. However, a legal protected status is imperative to establish guidelines for economic development, tourist use and scientific analysis in the valley. It is recommended that a study team design the potential for a national park in Jabal Bura, assessing existing governmental capabilities, local community investment and interest, tourism potential and necessary legislation. This could be coordinated by ICBP, IUCN or possibly through the U.S. National Park Service. The team should be familiar with other parks (e.g. Asir National Park in Saudi Arabia) and nature reserves (e.g. al-'Ayn Zoological Park in the U.A.E.) in the Arabian peninsula.

7.1.8.2 Research by Ormond *et al.* (1987) has identified 16 coastal sites recommended for special management due to their biological, environmental or recreational importance. These are listed below and identified on an accompanying map (*Table 7.1.7.2.1*).

In addition to Ormond's list, the BDA team has identified several other critical coastal areas. One is a non-cultivated area near al Zuhrah, northeast of Hodeidah, where undisturbed tamarisk woodland may still support gazelle. Another is in the Tihama plain between Mocha and Bab al Mandib, with virtually undisturbed dwarf shrub and grassland, Gazelles and other large mammals may occur here. This area is already protected in the sense that it is restricted for access due to security reasons. Selected areas for some sort of protected status or limitations on land-use can be identified in each region, particularly along some of the major wadi systems.

7.1.9 Critical species for conservation

[This will include various birds, gazelle, ibex(?), etc.]

7.1.10 Conservation of genetic diversity

[especially for plants with medicinal, food or fodder value]

Table 7.1.7.2.1 Coastal areas recommended for special management (from Ormond *et al.* 1987, *Figure 6.1*).

Location		Habitat	Species	Fishing	Recreation	Scientific	Impact
1	Oreste point	mangrove seagrass flats sand beach/dune	birds	+	sandy beach	+	-
2	Khawr north of Habl	mangrove seagrass flats sand beach	birds		sandy beach	+	-
3	Al Luhayyah region	mangrove seagrass	birds	+		+	urban fishing
4	Ukban I	sand beach coral reef raised reef	birds	+	sand beach snorkelling	+	fishing
5	North Ibn Abbas	mangrove	Pelican nesting	+		+	fishing
6	Bahr Ibn Abbas	reefs seagrass mangrove	birds	+		+	fishing
7	Isa peninsula	coral reef		+	sandy beach snorkelling	+	?
8	Al 'Urj to Hodeidah	silt flat palms etc. sand beach	birds	+	sand beach watersports		urban
9	Al Manzar to Ghilayfiqah	silt flat dunes sand beach palms etc.	birds	+	sand beach	+	-
10	Lagoons north of Al Mujaylis to Al Fazzah	palms & reeds	birds	+			farming
11	Qatabah to Abu Zahr	sand beach palms coral areas	birds	+	sand beach watersports	+	farming fishing
12	Al Khawkhah to Bab-el-Mandab	rock substrate	turtle	+		+	fishing
13	North Al Mawahij	coral reef	turtle	+	snorkelling	+	fishing
14	Marsa al Fajrah to south of Ar Ru'aya	sand beach palms mangrove		+	watersports fishing sand beach	+	fishing
15	South of Yakhtul to north Al Mukha	coral reef		+	snorkelling	+	fishing power stn urban
16	South Al Mukha to Dhubab and south	coral reef	turtle	+	snorkelling	+	fishing

7.1.11 High visibility conservation initiative

INITIATIVE: A previous USAID-funded study on wildlife conservation priorities for Yemen recommended a high visibility conservation project to promote immediate interest and build on the natural pride of Yemeni citizens in their cultural heritage (Varisco 1987:45-46). It is proposed that a

feasibility study be done for preservation of the gazelle and/or the ibex in a selected region of Yemen. These two animals are of major importance in the natural and cultural history of Yemen.

IMPLEMENTATION: A draft proposal for Project Gazelle in Yemen is included in Annex 11.

7.1.12 The rhino horn issue

A major issue in wildlife conservation that concerns Yemen is the use of rhinoceros horn (rhino horn) for the making of traditional dagger hilts. There are no rhinoceros in the country so this is not an issue relevant to the country's own biological diversity. However, interest in external funding wildlife conservation initiatives is linked with the international concern for the status of the rhinoceros in the wild. It has been estimated that almost half of the rhino horn on the market in the past three decades has ended up in Yemen. A USAID-funded study by WWF in 1987 reviewed the issue and recommended that initiatives to reduce or eliminate the continued use of rhino horn in the country be linked to a strategy for addressing Yemen's own wildlife conservation needs (Varisco 1987, 1989a, 1989b). It was noted that ROYG has banned the import of horn and that at present relatively little new horn is entering the country. Several specific project initiatives were presented in the report and some of these are restated in this BDA.

The need for action on the rhino horn issue at this time in Yemen is not at the policy or legislative level, but rather should be focused on reducing consumer demand. A previous USAID-funded report outlined an Alternative Dagger Handicraft Materials (ADHM) Project in conjunction with the office for the Preservation of the Old City of Sana'a (Varisco 1987:42). This would involve trials with alternative horn, bone or synthetic materials using local craftsmen in the Sana'a market. It could be coordinated with the Preservation Project for the old city of Sana'a.

7.2 Recommendations for USAID

AID recognizes the importance of maintaining and conserving biological resources as part of the development process. This is reflected both as a matter of policy at the CDSS level and in evaluation and identification of specific projects. The primary initiative for conservation in this respect is the Conservation of Biological Diversity (CBD) Project between AID and WWF-U.S., signed in 1988 (USAID-1988). This is a $28.4 million project with a LOP of ten years worldwide. The following recommendations relate first to initiatives within the scope of the CBD or general initiatives in biological diversity; following these are recommendations regarding the existing portfolio of USAID/Sana'a.

7.2.1 Conservation of Biological Diversity Project (CBD)

1. INITIATIVE: Work with Peace Corps/Sana'a in developing conservation initiatives at the community level. Suggested areas of cooperation include tree-planting and terrace stabilization or erosion control, educational program for villagers regarding the effects of afforestation, assistance to small-scale coastal fishermen for farming cooperatives or in marketing, cultivation or collection and marketing of herbs and medicinal plants, etc.

2. INITIATIVE: Technical Assistance for host country Faculty of Sana'a University in preparing and submitting proposals for research and practical projects on local species. There is a need to assist in obtaining funding for existing proposals, as outlined above in Section 7.1.5. These could be funded in part with PL480 funds for local commodities and needs.

3. INITIATIVE: Assistance of the Nature Conservancy and the World Conservation Monitoring Centre in adopting the model of a Conservation Data Center for the EPC or Sana'a University. This is a critical need for monitoring the rapid environmental degradation in Yemen.

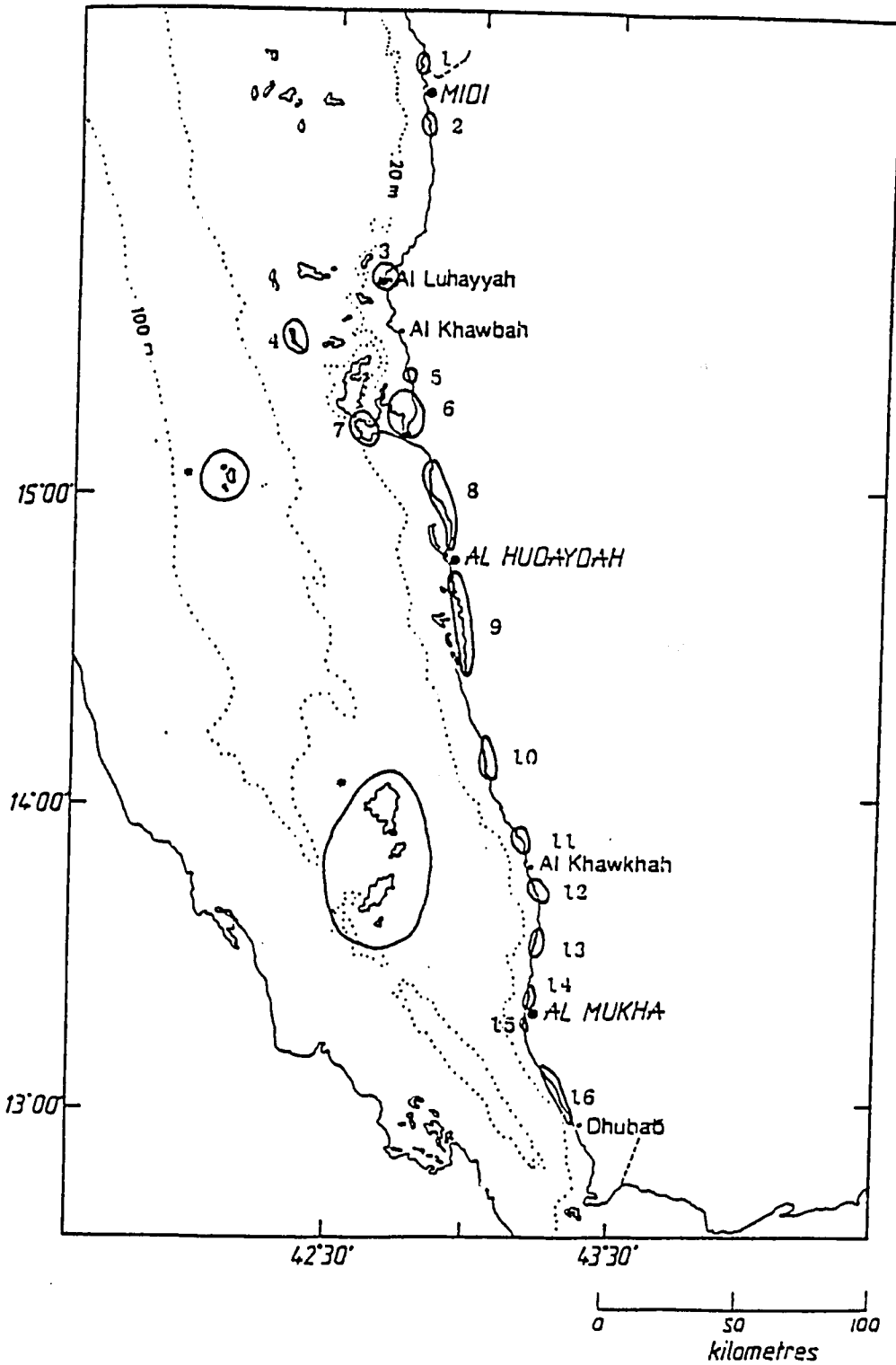

Figure 7.1.7.2.1 Areas recommended for special management within the framework of a preliminary ROY CZMP.

4. INITIATIVE: Assistance for a pilot project to create a protected area with a core area and managed buffer zone in a critical habitat, e.g. Jabal Bura. This should be coordinated with the Directorate of Forestry which has a project in the area (see Section 7.1.8), and with the appropriate office of IUCN and with ICBP.

5. INITIATIVE: Policy dialogue with the EPC and relevant ROYG institutions to demonstrate the economic value of protected areas and conservation. This should examine the potential for private operation of protected areas or sites.

6. INITIATIVE: Assistance to Sana'a University, Faculty of Science in the study and cataloguing of animal and plant species, both for the herbarium, greenhouse and a repository and/or museum for fauna. This should be coordinated through Dr Ali Shekeil, Dean of Science, and members of the Department of Biology, especially Dr Abdul Rahman Dubaie.

7.2.2 USAID/Sana'a program portfolio

The current planning of USAID/Sana'a does not include any major projects or initiatives in conservation of biological species. There are some limited opportunities for using existing projects to promote some of the conservation priorities defined in chapter 6. None of the existing projects appear to be directly damaging the biological diversity of Yemen. However, the negative aspects of current overall agricultural policy, as outlined in chapter 5, need to be further studied for current planning of future initiatives in the agricultural sector.

7.2.2.1 Policy analysis of sustainable agricultural production within a stable ecosystem

INITIATIVE: As outlined in Chapter 5, the current degradation of Yemen's environment is exacerbated by an agricultural development policy focused on tubewell irrigation and cash crops requiring large amounts of water. Although this is largely the result of factors outside donor control, neither ROYG nor a donor such as USAID can ignore the ongoing collapse of the terrace and rainfed agricultural system. The need is for sustainable economic growth within the limitations of the natural resource base and this should be stressed in a new policy analysis study.

IMPLEMENTATION: USAID/Sana'a has already requested assistance for an update of the major Agricultural Sector Assessment conducted in 1982. Significant changes in the economic and political sectors of the country justify a major new assessment of agricultural policy. It is important that a key reference in such an assessment be the impact of existing policy and practices on the environment, particularly the highland terrace and related wadi spate systems now in an advanced state of decline. This assessment should address the medium and long-term economic costs of overexploitation of aquifers through unregulated irrigation and the loss of productive land down the wadi systems. Such an assessment will be able to address important issues in current economic policy and in existing mechanisms for assisting communities and farmers to save their land and livelihood.

Among the economic and social issues that should be addressed in this study are the following:

1. The role of subsidies on imported grain in accelerating abandonment of traditional sorghum terraces (rainfed and spate) and the consequent collapse of the terrace ecosystem. While local grain production has not risen substantially since the early 1970s, grain imports have risen dramatically. The related health issue of a shift from wholegrain local cereals to imported white flour in the diet also needs to be addressed. The building of white bread factories that can only utilize imported grain is a symptom of the lack of a policy to stimulate local production.

2. The social and economic costs of forcing large segments of the rural sector off the land and out of agricultural production. The urban areas and service sector will not be able to meet the influx if the terrace ecosystem continues its present rate of decline.

3. The economic costs of mining water resources. Analyses of productivity in tubewell irrigation systems are flawed if they do not cost out the eventual loss of water in an area and the ever-increasing costs of raising water from declining water tables.

4. The economic and environmental costs of deforestation at the present pace, in which the existing woody biomass may disappear in twenty years. It is important to see the link between the current focus on fuelwood as a cash crop and the long-term decline and subsequent erosion of the terrace and wadi spate systems. The abandonment of whole terrace systems in the upper catchments is forcing the population, in the now-classic Sahelian pattern, to turn on the environmental resource base for immediate cash flow.

5. Flaws in economic analyses which fail to account for medium-term costs associated with environmental degradation, or which are based on a misunderstanding of current cropping and marketing practices. For example, a recent USAID study failed to factor in the fodder value of sorghum, which is up to seven times the grain value.

6. Costs of removal of silt in the spate systems and flood damage to productive land due to collapse of the terrace-wadi ecosystem.

7. Foreign exchange costs of permanent reduction in land availability for local production.

8. Cost-benefit analysis of focus on institution building in the MAF heavily reliant on expatriate expertise with minimal outreach to farmers, through the existing channels of local councils.

The policy analysis or agricultural sector assessment team must include a natural resource economist capable of costing environmental degradation in the medium- and long-term.

7.2.2.2 Development Training III Project

The existing Development Training III Project (PCD 1999) is engaged in training individuals for teaching and faculty positions in universities throughout Yemen. This will include training of 90 Phd's, 104 MA's and 140 BA's, in addition to short-term technical training abroad. It is recommended that two post-graduate scholarships be designated for graduating students of the Biology Department, one in zoology and one in botany, of Sana'a University. These would be for graduate degree study with a conservation focus in zoology and botany respectively. The purpose of this training is to staff the Biology Department with Yemeni professors who have practical orientation to conservation of biological species, as well as the necessary academic background in each discipline. This should be coordinated through Dr Ali Shekeil, Dean of the Faculty of Science at Sana'a University. Given the high concentration of female botany students, the proposed scholarship for a botanist should be targeted for a Yemeni women.

7.2.2.3 Educational Development Support Project

The Educational Development Support Project (PCD 1997) is focused on improving the efficiency and effectiveness of primary education in north Yemen. Within the existing planned outputs for science curricula attention should be paid to the scientific basis for environmental problems in the country (e.g. deforestation, terrace erosion). A short training course for an MOE official or teacher on the use of environmental education at the primary level should be provided.

7.2.2.4 Agricultural Development Support Program (ADSP): CORE

The ADSP/CORE Project (PCD 1992) is concerned with improving the capacity of the government to plan and implement a natural agricultural program. In the area of policy planning, attention needs to be paid to the environmental consequences of MAF policy (see 7.2.2.1). Relevant publications on the

environmental issues in agricultural policy should be obtained for the DLRC through existing contacts of CID and Colorado State University.

7.2.2.5 Farming Practices for Productivity (FPP)

This new project (PCD 1997) is focused on increasing production of high-value cash crops by raising the productivity of land, labor and water resources. Although the focus is on technical assistance through technology transfer, there is a component for Support Systems for Agriculture which will be centered in the Directorate of Planning and Statistics in the MAF, as well a reserve fund for locust control.

The Initial Environmental Examination for the FPP Project Paper (USAID September 1989, Annex 6) concluded that the project would have a twofold impact on the environment. First, criteria have been established to control pesticide use in accordance with EPA rules. It was stated that the targeted orchard ecosystems had limited biological diversity and thus there was a reduced chance for adverse effects on the biological species. Second, it was argued that increased irrigation efficiency would have a positive effect overall, although it was not possible to argue that the literal mining of water supply will be decreased.

As designed the FPP poses little direct threat to the overall biological diversity of Yemen. However, in that this will be the major USAID initiative in the agricultural sector over the next eight years, it is important to address the environmental implications of an exclusive focus on short-term productivity on irrigated land. The future state of the terrace farming system, on which the bulk of the farming population depends, must be addressed for the long term. As noted above in Section 7.2.2.1, an analysis of current agricultural policy should address the need for other initiatives in the agricultural sector that directly curtail the wholesale abandonment and consequent erosion of much of the country's terrace systems. One such initiative, alternative low-cost seed varieties for terrace stabilization, is outlined in Annex 14. A pilot project using PL480 funds with TDA for use of tandem, elevated bubble-irrigation systems would help protect the fragile environment along roads in the coastal region. This initiative within the mission should be encouraged.

7.2.2.6 Small Project Assistance Program

This continuing project is designed to fund small-scale (up to $10,000) community projects in conjunction with Peace Corps Volunteers. A number of possible interventions could be developed to help interested local councils to take practical measures for terrace stabilization (Annex 14) and wadi flood damage control. Relevant proposals from Peace Corps/Sana'a relevant to conservation of the environment should be encouraged by the Mission.

7.2.2.7 PL480 Funding

A number of the initiatives noted above, as well as other projects to conserve Yemen's biological species, could be funded through existing PL480 funds. This would be especially useful for conservation-related initiatives, which are often difficult to implement through existing projects within the mission. It is recommended that the Environmental Officer of the Mission review the potential for use of PL480 in the initiatives outlined above. The highest potential would appear to be for the EPC, which was recently formed but still lacks the capabilities to coordinate environmental policy in the country. Funds could also be channeled through the CLCCD in conjunction with a PCV community project.

ANNEX 1

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This bibliography contains both references cited in the report and relevant sources for future study of Yemen's biological resources. An index is provided for easy access to the sources. An effort has been made to distinguish useful references, but this is not a comprehensive bibliography.

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RHINO HORN ISSUE

Martin (1987); Varisco (1987, 1988, 1989a, 1989b)

VEGETATION MAP OF YEMEN

Scholte, Kessler, al-Khuleidi (in prep.); Kesseler and al-Khuleidi (1987)

ANNEX 2

BIODATA OF TEAM MEMBERS AND CONSULTANTS

PRIMARY ICBP TEAM

Dr Daniel Martin Varisco (Team leader and Anthropologist)
- Ph.D., 1982, University of Pennsylvania
- 11 consulting assignments in development issues of Yemen and Egypt
- Project coordinator for 1987 Rhino Horn Conservation Study for WWF and USAID
- Field research on land and water resource use in a Yemeni valley (1978-1979)
- Publications in *Oryx, Arabian Studies, Arabica, Int. J. of Middle East Studies, Tools and Tillage, Studia Islamica, Dirasat Yamaniya, al-Ma'thurat, al-Sha'biya*, etc.

Dr James Perran Ross (Marine Biologist)
- Ph.D. (Zoology), 1976, University of Florida
- Director of Research and Conservation at the Caribbean Conservation Corporation
- Extension marine research and conservation experience in the Caribbean, Saudi Arabia and Oman
- Project Director for WWF marine turtle survey in Oman (1977-1979)
- Numerous scientific and popular publications

Anthony Milroy (Agricultural Engineer)
- Director of Arid Lands Initiative (Hebden Bridge, West Yorkshire, UK)
- Project Director, ODA-funded Agricultural Technology Project in Taiz (1972-1976)
- Arid Land and Rural Development Consultant with experience in East Africa, Southern Africa, Australia and the Middle East
- Producer of environmental film on Yemen's traditional agriculture and recent environmental degradation

EDITOR

Dr Michael R. W. Rands (Conservationist and Ornithologist)
- D. Phil. (Zoology), 1982, Oxford University
- Programme Director for the International Council for Bird Preservation with management responsibility for over 60 field projects in Europe, the Middle East, Asia, Africa and South America
- Chairman of the Ornithological Society of the Middle East (OSME) and leader of the OSME Yemen Expedition 1985 to YAR
- Conservation research and field studies carried out in Yemen, Turkey, Nepal, Zimbabwe, Kenya, Dominica and Seychelles.

CONSULTANTS IN YEMEN

Dr Abdul Rahman S. Dubaie (Botanist)
Dr Mousa al-Safadi (Zoologist)
Dr Salih al-Etreby (Oceanographer)
Dr Naim Dowadar (Oceanographer)
Dr Abdullah Maktari (Lawyer)
Muhammed Abd al-Rahim Jazm (Folklorist, Historian)
Paul Scholte (Ecologist, Botanist)
Chrisje van Schoot (Development Expert)
Scott Rolston (Historian of Science)

ANNEX 3

ORGANIZATIONS AND INDIVIDUALS CONTACTED IN YEMEN

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Michael F. Lukomski, Deputy Director
Benjamin Hawley, Program Officer
Jonathan Addleton, Deputy Program Officer
Mansour Shamiri, Program Assistant
Abdulali Alshami, Program Assistant
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Jamil Ahmed Raja', Director of Fisheries
Husayn Lu'lu', Chairman, General Corporation for Fisheries Dev., Hodeidah
Ali Abdullah Zoum, General Manager, GCFD
Ibrahim Mohammed Hassan, GCFD
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MINISTRY OF MUNICIPALITIES AND HOUSING

Abd al-Rahman al-Muassib, Director, EPC
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CONFEDERATION OF LOCAL COOPERATIVE COUNCILS FOR DEVELOPMENT

Muhammad Mujahid, Sana'a
Ali Muhammad al-Batili, Head of Local Council for Bura
Sheikh Ahmed Hoomdah, Head of Local Council for Khawbah
Ahmed Omar Makhawi, Head, Local Council for Luhayya

SANA'A UNIVERSITY

Dr Ali Shekeil, Dean, Faculty of Science
Dr Muhammed al-Muneeri, Head, Department of Biology
Dr Naim M. Dowidar, Professor of Oceanography
Dr Abdul Rahman Dubaie, Professor of Botany
Dr Yahya al-Abud, Professor of Zoology
Dr Mousa al-Safadi, Professor of Zoology
Dr Salih al-El-Etreby, Professor of Oceanography
Dr Ahmed al-Hubaishi, Director of Plant Virus Protection Unit
Dr Salih Khirbash, Professor of Geology
Dr Hamed al-Nakhl, Professor of Marine Chemistry
Dr Khalid Abdullah al-Thawr, Professor of Geology
Dr Taj al-Din al-Ansi, Professor of Chemistry
Dr Hussein Shieh, Professor of Zoology

CONSORTIUM FOR INTERNATIONAL DEVELOPMENT

Dana Thomas, CORE Team Leader

RANGE AND LIVESTOCK IMPROVEMENT PROJECT, DHAMAR

Paul Scholte, Expert in Range Economy

RADA' INTEGRATED RURAL DEVELOPMENT PROJECT, RADA'

Christje van Schoot

ANNEX 4

YEMEN'S FLORA

Although considerable research has been done on the flora of Yemen, the only systematic survey of the extensive literature is by Miller *et al.* (1982). The taxonomic status of many Yemeni species has not been established by detailed studies in a herbarium. The following information is arranged by gross category and then by species. This compilation is meant to provide an indication of the diversity; it is not a systematic study for the country as a whole. For more complete listings of species known in Yemen, see Schwartz (1939) and Scholte and al-Khuleidi (1989). This annex is divided into three parts: (A) a listing of major species according to gross category; (B) forestry and fuelwood trees; (C) selected species discussed in greater detail.

A. LISTING OF MAJOR PLANT SPECIES IN YEMEN

This section is based primarily on the works of Kessler and al-Khuleidi (1987) with additional information supplied by Paul Scholte, Dr Abdul Rahman Dubaie, al-Hubaishi and Müller-Hohenstein (1984), etc.

The format follows that of Kessler and al-Khuleidi (1987) with the following legend:

- a Arabic name (note that there many be considerable variation
- e Ecological characteristics of species
- u Uses made of species, primarily in grazing, fuelwood, etc.
- m Medicinal use and possible pharmacological properties (based primarily on Fleurentin and Pelt 1982)
- p Possible poisonous properties (based primarily on Verdcourt and Trump 1969)
- L Indicate Arabic name may be only local

The following code is used in the listing for citations to the literature:

- E: Arabische Pflanzennamen aus der Flora von Aegypten
- F: Arabische Pflanzennamen aus der Flora von Yemen (Forsskal)
- A: Arabische Pflanzennamen aus der Flora von Yemen und Sued Arabien (Schweinfurth)
- B: Arabische Pflanzennamen aus der Flora von Biskra (Algerien)

All compiled in: Schweinfurth, G. (1912)

- W: Chaudhary, S. A. and R. Revri (1983).
- J: Al-Hubaishi, A. and K. Mueller-Hohenstein (1984)
- S: Migahid, A. M. (1978)
- R: Wetinga, E. and D. P. Thalen (1980).
- O: Fleurentin, J. and J. M. Pelt (1982).

I: Townsend, C. C. and E. Guest (1980).

D: Dubaie, Abdul Rahman (1989)

M: Jazm, Muhammad Abd al-Rahim (Annex 8)

V: Varisco, Daniel Martin (1982)

CH: Koch (1983?)

K: Kessler (1987)

W: Henry (1976)

1. Trees, shrubs and dwarfshrubs

Acacia asak (Forssk.) Willd. (Leguminosae)

a 'asaq (FJ)

e Tree occurring in the mountains west of the Montane Plains at elevations lower than 2,000 meters on often steep, rocky slopes; generally not common near villages.

u Browsed by goats and camels. Intensively used as large firewood; the trees can often be observed to have been lopped.

Acacia negrii Pic. - Ser. (Leguminosae)

a talh (SJRO)

e Tree occurring in the Montane Plains at elevations from 2000-2700 meters, on rocky slopes, especially at relatively moist places (lower slopes, in gullies, near springs etc.).

u Browsed by goats and camels. Intensively used as large firewood; the trees can often be observed to have been lopped and might have been more widespread if no intensive cutting took place.

m The gum of the tree contains polysaccharides and enzymes which can be used in a cough mixture as a cure for bronchopulmonary infections and as an analgesic.

Acacia nilotica (L). Willd. (Leguminosae)

a qarad (RO)

e Tree occurring in the Montane Plains and in the mountains to the west, mostly at elevations lower than 2000 m; it is not very common and occurs in wadis mostly.

u Browsed by goats and camels. Intensively used as large firewood; timer (D).

m The gum of the tree contains polysaccharides and enzymes which can be used in a cough mixture as a hypoglycaemic agent; food (D).

Acacia mellifera (Vahl) Benth. (Leguminosae)

a suba (FAJ)

e Tree occurring in the mountains west of the Montane Plains until the Tihama foothills at elevations lower than 1800 meters on often steep, rocky slopes.

u Browsed by goats and camels. Intensively used as large firewood, timber (D).

Acanthus arboreus Forssk. (Acanthaceae)

a sannafa (FAJ)

e Large, spiny shrub occurring in the Montane Plains and to the west, on steep rocky slopes and on slopes around agricultural fields, especially at relatively moist locations.

u Browsed by goats and camels and the young and green by sheep. When dried out it is collected as firewood.

Achyranthes aspera **L. (Amaranthaceae)**

a hamshad (FR)

e A common annual weed of relatively moist places as in orchards and around irrigated agricultural fields, occurring in the Montane Plains and to the west, until into the Tihama foothills.

u Grazed by sheep.

Adenium obesum **(Forskk.) Roem. and Schult. (Apocynaceae)**

a 'adan (FASJR), dubiyat al'urg (V)

e Large succulent shrub with conspicuous pink flowers, occurring in the mountains west of the Montane Plains at elevations lower than 1800 meters on rocky slopes and down into the Tihama foothills.

u Possibly to some extent grazed by goats and camels. Parts of the plants are cut off to be used as firewood.

p The bark and fleshy parts of the trunk are used in preparing arrow poison in Africa; there are reports that flowers and leaves are poisonous for livestock.

m Medicinal use of flowers (D).

Aerva javanica **(Burm. f.) Juss. (Amaranthaceae)**

a ra'a (WJO)

e A perennial dwarfshrub, commonly occurring in the Montane Plains and to the west until the Tihama lowlands, on not too steep rocky slopes and plateaus, on silty plains and on (old) fallowlands.

u Grazed by sheep and goats when green. Collected as small firewood. The flowers and leaves are pubescent and very soft and are collected to be put in pillows for use in the mafraj.

m The inflorescence contains betacyanin which has narcotic and hypnotic properties.

Aloe sabaea **Schweinf. (Liliaceae)**

a qubab (FJ)

e A small tree occurring in the mountains west of the Montane Plains until in the Tihama foothills, at elevations up to 3000 meters on steep, rocky slopes mainly, especially at difficult accessible places.

u Probably hardly browsed. Intensively cut to be used as large firewood which seems the reason that the tree is mostly found at relatively inaccessible slopes.

Aloe vaccillans **Forssk. (Liliaceae)**

a subbar (EFAJRO)

e A succulent shrub with thorns on the leaves, occurring in the Montane Plains and to the west at elevations above 2000 meters on often steep, rocky slopes and plateaus.

u Very little browsed. Intensively used as large firewood; shrubs are then completely cut off at ground level. The juice in the succulent leaves has many medicinal uses: it is used as an eye-cure, for stomach problems and to cure liver diseases. Dried out leaves are crushed with salt to be given to sheep.

m The leaves contain glycoside which is used as an antiseptic plaster to cure wounds.

***Anarrhinum orientale* Benth. (Scrophulariaceae)**

a bir el jamal (meaning: "camel wheat")

e A dwarfshrub occurring in the Montane Plains on not too steep rocky slopes and plateaus and on (old) fallowlands.

u Grazed by sheep when green. Collected as small firewood.

***Andrachne aspera* Spreng. (Euphorbiaceae)**

a iqulit or 'ushra

e A dwarfshrub occurring in the Montane Plains on rocky slopes and plateaus and on plains with sandy or silty soils.

u Intensively grazed by sheep throughout the year; as a result of its habitus and deep tap-root it appears not susceptible to overgrazing.

***Artemisia* spec. (Compositae)**

a hallal

e A shrub occurring in the Montane Plains and to the west, at rocky locations but also on (old) fallowlands.

u Probably hardly grazed because of a strong scent. Intensively collected for firewood.

***Atriplex* spec. (Chenopodiaceae)**

a rughl or qataf (EBS)

e Shrub-species introduced in the Montane Plains and to the east, on rocky plains and not steep rocky slopes as well as on abandoned terraces and croplands where the cultivation of crops is no longer practised.

u Grazed by livestock, especially in the dry season when these shrubs still have their leaves which have a good forage quality. Collected as firewood.

***Barleria induta* C. B. Clarke (Acanthaceae)**

a shakhat (FAJ)

e A spiny shrub occurring in the mountains west of the Montane Plains on often steep, rocky slopes at elevations lower than 2200 meters.

u Browsed by goats and camels and possibly sheep. Not much collected for firewood.

***Becium capitatum* Auct. (Labiatae)**

a sa'atif or sindi

e A dwarfshrub commonly occurring in the Montane Plains and to the west at elevations above 2000 meters on rocky slopes and plateaus.

u Grazed by sheep and goats when green. Intensively collected as small firewood.

***Becium* spec. (Labiatae)**

a 'aziat fatima (L) meaning "gift of Fatima")

e A dwarfshrub occurring in the western Montane Plains and to the west at elevations above 1800 meters on rocky slopes mainly.

u Grazed by sheep and goats when green. Collected as small firewood. Used as a scent due to its strong and pleasant smell, explaining the meaning of the Arabic name.

***Bidens biternata* (Lour.) Merr. a\ ' Sheriff (Compositae)**

a haksa

e A small, probably annual shrub occurring in the mountains west of the Montane Plains at high elevations.

u Probably grazed by livestock when green.

***Blepharis ciliaris* (L) B. L. Burtt (Acanthaceae)**

a shawk (baiatha) (ESJ)

e A low, spiny perennial forb, common in the Montane Plains, mainly on rocky plateaus, where grazing may be very intensive; it also seems to occur at lower elevations and down to the Tihama lowlands.

u Grazed by sheep and goats when green but protected from overgrazing by its spiny leaves.

***Cadia purpurea* (Picc.) Ait. (Leguminosae)**

a himrar (A)

e A shrub that can reach 2 meters in height, occurring in the mountains west of the Montane Plains at elevations below 200 meters on often steep, rocky slopes.

u Grazed by goats and camels. Collected as large firewood, except on difficult accessible slopes.

***Calotropis procera* (Ait.) Ait. f. (Asclepiadaceae)**

a 'aushar (EFSJO)

e A shrub than can reach 4 meters in height, occurring in the Montane Plains, to the east, and to the west until in the Tihama lowlands; usually at rocky disturbed locations (along roadsides, wadibeds, irrigation works etc.).

u Grazed by goats and camels, firewood (D), timber (D).

m The latex in the leaves is toxic and contains cardenolides; it is used as an antiseptic for skin infections and local anaesthetic. It is also said to cure toothache.

p Feeding experiments with rabbits have shown that the latex is toxic only in large doses. Calotropin has been extracted from the latex, which can cause death by paralysis.

***Caralluma quadrangula* (Forssk.) N.E. Br. (Asclepiadaceae)O**

a zaruwa al jarwa (L) meaning: "teats of a dog")

e A succulent shrub occurring in the Montane Plains and to the west, o often steep, rocky slopes and plateaus; generally not present near villages.

u Hardly grazed by livestock. Collected as firewood, except on places that are not accessible.

m The sap of the stems is used as an ophthalmic antiseptic.

***Chenopodium schraderanum* Roem. and Schult. (Chenopodiaceae)**

a 'aznab

e An annual week occurring in the Montane Plains, to the east, and to the west at elevations above 1600 meters on (old) fallowlands and adjacent rocky areas, especially at much disturbed sites.

u Intensively grazed by livestock.

Cichorium bottae **Deflers (Compositae)**

a mirrar

e A low, sod-forming perennial forb with a conspicuous blue flower occurring in the Montane Plains on (old) fallowlands and cropland borders.

u Intensively grazed by livestock throughout the year apparently well adapted to severe grazing (it has a long central tap-root).

Cissus rotundifolia **(Forssk.) Vahl (Vitaceae)**

a halqa (FJ)

e A leafy, perennial shrub occurring in the mountains west of the Montane Plains until the Tihama lowlands at relatively moist and often rocky locations (Wadibed borders, under cliffs, along terraces).

u Grazed by livestock when green (especially camels). Crushed leaves are used in sauces.

Commicarpus boisseri **(Heim.) Cuf. (Nyctaginaceae)**

a rafraf

e A shrub occurring in the Montane plains, and to the east, and to the west until the Tihama foothills, on (old) fallowlands and adjacent rocky areas; not common near villages.

u Grazed by livestock when green. Intensively collected as small firewood.

Commiphora **spec. (Burseraceae)**

a bisham (FARJ)

e A tree occurring in the mountains west of the Montane Plains on often steep, rocky slopes at elevations below 200 meters.

u Browsed by goats and camels. Intensively used as large firewood; the trees can often be observed to have been lopped. The bark is cut to collect the gum which is used as incense and for other purposes.

m Commiphora myrrha (Nesr.) Engl.: The gum has balsamic properties; aromatic oil is used as an antiasthma, and resin is used as an antihemoptysic tranquillizer.

Convolvulus arvense **L. (Convolvulaceae)**

a simmin

e An annual weed occurring in the Montane Plains, to the east, and to the west, on recent fallowlands and cultivated fields.

u Intensively grazed by livestock.

Cordia abyssinica

a 'affar

u Timber and shading (D)

Cucumis prophctarum **L. (Cucurbitaceae)**

a hantal

e An annual weed occurring in the Montane Plains, to the east, and to the west on relatively moist fallowlands and cultivated fields.

u The leaves are grazed by livestock. The seeds in the fruits are crushed with salt to be given to sheep (vitamins?).

m Triterpenes in the shoots are used against skin diseases (abscess).

p Several species of the genus Cucumis are known to be highly toxic to animals and humans. From the fruit pulp of this species, myriocarpin has been extracted, which causes death when over-dosing. Small doses of the fruits induces diarrhoea of varying severity among livestock.

Datura stramonium **L. (Solanaceae)**

a manj (FWR)

e A shrub occurring in the western Montane Plains and to the west until the Tihama foothills, at disturbed and relatively moist locations mainly.

u Hardly grazed due to its unpleasant smell. The sap of the leaves and seeds is used as a narcotic and to stop pain.

m Alkaloids from the sap of leaves and seeds are toxic (depressors) of the parasympatic system) and have hypnotic, analgesic and sedative properties and can be used as an insect repellent.

p Especially the seeds contain numerous alkaloids. There are no records of deaths among livestock from this plant, but experiments have shown that it can cause death when consumed in high quantities. Drying does not destroy the alkaloids.

Dianthus uniflorus **Vahl (Caryophyllaceae)**

a 'aud halba (meaning "for halba")

e A low, perennial cushion-forming forb occurring in the Montane Plains on rocky slopes and plateaus.

u Intensively grazed by livestock; apparently well adapted to intensive grazing (it has a long tap-root). The roots are collected to be used in the halba.

m The roots contain vitamins.

Echinops spinosissimus **Turra (Compsitae)**

a (shawk) bura

e A spiny thistle-like perennial dwarfshrub occurring in the Montane Plains, to the east, and to the west, on (old) fallowlands and adjacent rocky areas as well as invading heavily grazed rocky slopes and plateaus and plains with sandy or silty soils are with a gravelly surface.

u Occasionally grazed by sheep and goats, especially when herders crush the spiny leaves and seedheads so as to reduce its spinyness.

Erucastrum arabicum **Fisch. and Mey. (Cruciferae)**

a halqam

e An annual weed, commonly occurring in the Montane Plains mainly, on (old) fallowlands and adjacent rocky areas, and disturbed sites.

u Grazed by livestock when green and when dry.

Eucalyptus **spec. (Myrtaceae)**

a qafur (EO)

e Tree-species introduced throughout the ROY, in villages and along roads mainly.

u Grazed by livestock when green. Wood used for construction purposes and as large firewood. The leaves have a good smell and are used for various purposes.

m The leaves and flower buds contain an aromatic oil which has bronchopulmonary, antiseptic and insecticidal properties and are used as such.

Euphorbia ammak **Schweinf. (Euphorbiaceae)**

a 'amaq (AJO)

e A succulent shrub reaching heights up to 4 meters, occurring in the mountains west of the Montane Plains at elevations above 1600 meters on often very steep, rocky slopes.

u Hardly grazed by livestock. Intensively collected as large firewood around villages and along roads mainly.

m The latex of the succulent leaves is toxic and is used against camel mange and against warts.

Euphorbia cactus **Ehrenb. (Euphorbiaceae)**

a ghulak or qassas (FJO)

e A succulent, spiny shrub reaching heights up to 1.5 meters, occurring in the mountains west of the Montane Plains on often very steep, rocky slopes.

u Hardly grazed by livestock, Intensively collected as large firewood around villages and along roads mainly.

Euphorbia inaequilatera **Sonder (Euphorbiaceae)**

a labban (EFABSWRI) (meaning "milk")

e A low, creeping annual forb occurring in the Montane Plains and to the east, on (old) fallowlands, rocky plateaus and on sandy or gravelly plains; often at places that are heavily grazed.

u Intensively grazed by livestock throughout the year; protected from overgrazing by its low, creeping habitus. The leaves contain a milky white sap which appears not to be used.

Euphorbia inarticulata **Schweinf. (Euphorbiaceae)**

a saiab (AJ)

e A succulent spiny shrub reaching heights up to 1.5 meters, occurring in the mountains west of the Montane Plains at elevations lower than 1800 meters, on often very steep, rocky slopes.

u Hardly grazed by livestock. Intensively collected as firewood around villages and along roads mainly.

Euphorbia schimperiana **Scheele (Euphorbiaceae)**

a shawthab (WJ)

e An annual weed occurring in the Montane Plains and to the east on (old) fallowlands and adjacent rocky areas and disturbed sites (along roads, in gullies, along cropland borders, etc.).

u Ungrazed by livestock due to the milky white juice. The toxic milky white sap makes the skin thick and appears to be used as a narcotic.

m The sap of the plant is used as a thirst preventative.

Euryops pinifolius **Steud. (Compositae)**

a sabr

e A woody dwarfshrub commonly occurring in the Montane Plains on often steep, rocky slopes and plateaus; not common near villages.

u Hardly grazed by livestock due to its needle-like, small leaves. Intensively collected as firewood.

Fagonia indica **Burm. f. (Zygophyllaceae)**

a haluwa (ESWR)

e A spiny annual or short-lived perennial shrub occurring in the Montane Plains, to the east, and to the west, on (old) fallowlands and adjacent rocky areas, plains with sandy or silty soils or a gravelly surface; especially where heavy grazing occurs.

u Little grazed by livestock due to its spiny leaves. Collected as small firewood.

m The shoots contain harmine which is a central nervous system stimulant and is locally used as an antiparalytic.

Ficus salicifolia **Vahl (moraceae)**

a itaib (O)

e A leafy, tall shrub occurring in the mountains west of the Montane Plains until into the Tihama foothills from elevations below 2400 meters, at relatively moist places, on rocky slopes (gullies, ditches etc.).

u grazed by sheep goats.

m The sap contains furocoumarin which is a photosensitiser and is used as an ophthalmic antiseptic.

Flaveria trinervia **(Spreng.) Mohr (Compositae)**

a sabr al himar (L) meaning: "patience for the donkey"?) Montane Plains at relatively moist locations on fallowlands, in cultivated fields, in wadibeds, etc.

u Intensively grazed by livestock.

Gomphocarpus fruticosus **(L.) Ait. f. (Asclepiadaceae)**

a sibbia (FAJO)

e A woody shrub occurring in the Montane Plains on rocky slopes and plateaus sometimes invading (old) fallowlands.

u Grazed by livestock though it contains milky white latex. Collected as small firewood. The sap is used as a medicine, to cure places where the skin has become bare.

m The leaves contain cardenolides which are used as an antiseptic and has spasmolytic and cardiac stimulating properties.

p The latex is weakly poisonous, when give to sheep in the form of a drench over a period of five days it causes death.

Grewia tenax **(Forssk.) Fiori (Tiliaceae)**

a khadar (FJR)

e A tree occurring in the mountains west of the Montane Plains until into the Tihama foothills, on often steep, rocky slopes.

u Browsed by goats and camels. Intensively used as large firewood; the trees can often be observed to have been lopped.

Helichrysum somaliense **Balf.f. (Compositae)**

a laif (a)

e A small dwarfshrub commonly occurring in the Montane Plains and to the east on relatively dry rocky slopes, – plateaus and plains; not common near villages.

u Grazed by livestock when green. Collected as small firewood.

Heliotropium longiflorum **Jaub. and Spach. (Boraginaceae)**

a shubram

e An annual weed occurring in the Montane Plains and to the west on (old) fallowlands and adjacent rocky areas.

u Grazed by livestock when green.

Hypoestes forskalei (Vahl) Roem. and Schult. (Acanthaceae)

a sawrab (AR)

e A dwarfshrub occurring in the Montane Plains and to the east, on rocky slopes mainly, often at locations that are heavily grazed.

u Grazed by livestock when green. Collected as small firewood. The leaves are crushed and the sap mixed with milk to be used as an insect repellent.

Indigofera arabica Jaub. and Spach. (Leguminosae)

a zahra al mara'a (meaning "flower of the range")

e A low, creeping perennial forb with a conspicuous red flower occurring in the Montane Plains and to the east, on (old) fallowlands and rocky plateaus; often at places that are heavily grazed.

u Intensively grazed by livestock throughout the year; protected from overgrazing by its low, creeping habitus and deep tap-root.

Indigofera spinosa Hochst. (Leguminosae)

a 'awsaj (or zarb) (LO)

e A spiny, dwarfshrub occurring in the mountains west of the Montane Plains at elevations lower than 2000 meters until the Tihama lowlands, at various locations.

u Little grazed, by goats mainly.

m The leaves contain glycosides and flavonoids which are used as an ophthalmic antiseptic.

Juniperus procera L.

a 'ar-'ar (EBSJ)

e A tree rarely occurring in the Montane Plains only, at high elevations (above 2300 meters), on steep rocky slopes mainly, where it usually does not grow larger than 3 meters high, but occasionally encountered in a village where it can grow into a large tree.

u Probably not intensively grazed by livestock. Intensively collected for firewood which will be the main reason of its present rareness; timber (D).

Kleinia odora (Forssk.) DC. (Compositae)

a khuth'air

e A succulent shrub occurring in the Montane Plains and to the west until into the Tihama foothills on (steep) rocky slopes and plateaus; in the Montane Plains seldom near villages.

u Not intensively grazed by livestock. Intensively collected for firewood.

m The whole plant is used as an amulet (planted on graves).

Lasiosiphon somalensis Blatter (Thymelaceae)

a shawzab (L)

e A dwarfshrub occurring in the Montane Plains and the east, on dry rocky slopes, plateaus and plains; often at locations which are heavily grazed.

u Grazed by livestock when green. Collected as small firewood. The sap extracted from the leaves can be used as soap but it also used to make tea against constipation.

p Various species of the genus Lasiosiphon are reported to be very poisonous. Some plants are used as a purgative.

Lavandula pubescens **Decne. (Labiatae)**

a dhafar or fahita (SO)

e A dwarfshrub occurring in the Montane Plains and to the east, on dry rocky slopes and plateaus, often at locations which are heavily grazed.

u Not intensively grazed by livestock because of its strong smell. Collected as small firewood. The leaves are used to give taste to the coffee.

m The shoots contain an aromatic oil which has antiseptic and diuretic properties and promote the production of bile; this sap is used as a cure for bronchopulmonary infections and a diuretic.

Lycium shawii **Roem. and Schult. (Solanaceae)**

a 'awsaj (or zarb) (SEFBRO)

e A spiny shrub occurring in the eastern Montane Plains and to the east, on not steep rocky slopes, plateaus and plains with silty soils or a gravelly surface as well as an old fallowland where it is often an indication of heavy grazing.

u Grazed by livestock when green. Intensively collected as firewood.

m The leaves are used against kidney stones.

Malva parviflora **L. (Malvaceae)**

a khubbiz (JWEABSRI) (meaning: "baker"?)

e A small annual weed occurring throughout the ROY at disturbed, level areas like orchards, croplands, wadiöeds, but also sandy plains and flats.

u Intensively grazed by livestock. The seeds are said to taste very good.

Meriandra benghalensis **Benth. (Labiatae)**

a duru

e A shrub reaching 2 meters in height, occurring in the mountains west of the Montane Plains on rocky slopes mainly.

u Hardly grazed by livestock because of its strong smell. Collected for firewood around villages and along roads. The leaves which smell very strong, are ground with salt and given to sheep; it is said to be a cure against liverfluke.

Myrsine africana **L. (Myrsinaceae)**

a shawhat

e A shrub reaching 2 meters in height, occurring in the mountains west of the Montane Plains on often steep, rocky slopes.

u Grazed by goats and camels. Collected as large firewood around villages and along roads.

Onopordon sibthorpianum **Boiss. and Heldr. (Compositae)**

a shawk al hanash (WAJ) (meaning: "thorn of snakes")

e A spiny annual or short-lived perennial thistle occurring in the Montane Plains at relatively moist places on (old) fallowlands and irrigated croplands.

u Not intensively grazed by livestock. Not intensively collected as firewood.

Opuntia spp.

a balas Turki

e Prickly pear introduced within last 200 years.

u Hedge, fruit, medicinal use for pimple (V).

Ormocarpum yemense Gillet (Labiatae)

a rahd

e A shrub reaching 3 meters in height occurring in the mountains west of the Montane Plains until into the Tihama foothills, on often steep, rocky slopes.

u Grazed by goats and camels. Collected as large firewood around villages and along roads mainly.

Otostegia fruticosa (Forssk.) Schweinf. (Labiatae)

a shaqab (O)

e A dwarfshrub occurring in the Montane Plains mainly, at rocky locations, often as an indication of heavy grazing.

u Grazed by livestock when green. Collected as small firewood.

m The leaves are used an antiparalytic.

Oxalis corniculata L. (Oxalidaceae)

a hamd (EFAWO)

e A small annual forb occurring in the Montane Plains and to the west at rocky locations and on old fallowlands; especially at relatively moist locations.

u Grazed by livestock throughout the year.

m the shoots are used as an antivertigo.

p Several species of Oxalis contain large quantities of salts of oxalic acid and have caused serious illness in humans and fatalities in sheep. Of this species, records of sheep poisoning are available from Uganda and Australia.

Peganum harmala L. (Zygophyllaceae)

a harmal (WEBSROI)

e A shrub occurring in the Montane Plains and to the east, at disturbed sites, heavily grazed plains and (old) fallowlands; it can be considered an indicator of human settlement.

u Not intensively grazed by livestock, probably only when the shrub has dried out and range grazing is scarce. Collected as firewood throughout the year.

m The seeds contain alkaloids which are a central nervous system stimulant and are used as an amulet and as an haemostatic.

Pisum spec. (Leguminosae)

a faratha (L)

e A leguminous, creeping forb rarely occurring in the Montane Plains at relatively moist and rocky locations where grazing frequency is not high.

u Intensively grazed by livestock.

Plantago lanceolata L. (Plantaginaceae)

a wathana (E)

e A leafy, annual herb occurring in the Montane Plains and to the west, at moist croplands and recent fallowlands. This species may be called 'talab' as an indication of moist locations where liverfluke infestations occur (see Sonchus oleraceus).

u Intensively grazed by livestock.

***Plantago ovata* Forssk. (Plantaginaceae)**

a baiatha (L)

e A small perennial forb occurring in the Montane Plains and to the east, at relatively moist locations on old fallowlands and uncultivated plains.

u Intensively grazed by livestock throughout the year.

***Psiadia arabica* (DC.) Vatke (Asclepiadaceae)**

a fattah (AR)

e A woody dwarfshrub occurring in the Montane Plains and to the west at elevations above 2000 am, on steep, rocky slopes mainly but also on rocky plateaus.

u Grazed by livestock when green. Intensively collected as small firewood. The leaves, which have a sticky surface, are used to strap broken limbs; the sap of the plant seems to be used against bloat in sheep.

***Pulicaria crispa* (Forssk.) Oliver (Compositae)**

a 'ansif (JRO)

e A dwarfshrub occurring in the Montane Plains, to the east, and to the west until into the Tihama lowlands, on (old) fallowlands and adjacent rocky areas mainly, not common near villages.

u Grazed by livestock when green. Intensively collected as small firewood. The leaves have a strong smell and are collected to be used in "laban" and "salta".

m The whole plant is used for various purposes: for digestive disorders, as an antipyretic, an analgesic, an antimalarial and as an appetite stimulant.

***Reichardia tingitana* (L.) Roth (Compositae)**

a labban (EW)

e An annual weed occurring in the Montane Plains at relatively moist places on (old) fallowlands and croplands and adjacent rocky areas.

u Intensively grazed by livestock.

m The leaves, containing a milky white sap, are used against liver disorders.

***Rhynchosia minima* (L.) DC. (Leguminosae)**

a iqlit (L)

e A small, annual, or short-lived perennial, leguminous forb occurring in the Montane Plains on rocky slopes and plateaus where grazing is not very frequent.

u Intensively grazed by livestock.

***Ricinus communis* L. (Euphorbiaceae)**

a tubsha'

e A large, leafy shrub occurring in the mountains west of the Montane Plains mainly, but can be found throughout the ROY, usually at disturbed and relatively moist locations. Also planted in villages and gardens.

u Grazed by livestock. Collected for firewood. Especially grown as the seeds contain oil which is mainly used as a laxative (castor oil), but no commercial plantings are found.

m The seeds contain oil which has purgative properties and is used as a laxative. Castor oil also has many industrial uses.

p Poisonings of humans and livestock have been recorded from most parts of the world due both to eating the seeds and the leaves. A mildly toxic crystalline alkaloid has been isolated from the leaves.

Rosa abyssinica **R. Br. (Rosaceae)**

a huwjam (or zarb) (F)

e A shrub with thorns reaching 2 meters in height, not common occurring in the Montane Plains and to the west at elevations above 1800 meters, generally at very rocky places, not in the vicinity of villages.

u Grazed by livestock when green. Intensively collected as large firewood explaining its present rareness. The berries can be eaten and the sap may be used as a paint.

m The flower buds contain an aromatic oil which can be used against headache.

Rumex nervosus **Vahl (Polygonaceae)**

a 'uthrub (FAS)

e A leafy, often large shrub occurring in the western Montane Plains and to the west at elevations above 1800 meters, at relatively moist rocky places (terraceland borders, roadsides, along gullies, moist rock slopes etc.).

u Grazed by livestock, especially goats and camels. Intensively collected for use as firewood and for other purposes: it is used to bind the qat (keep it moist) as well as other foodstuffs; the leaves are said to be good to eat when cooked.

m The inflorescence contains a tannin which is used as an ophthalmic antiseptic; the leaves contain anthracene gylcoside which is used as a hypoglycaemic agent and cure for acne.

Sageretia thea **(Osbeck) M.C. Johnst. (Rhamnaceae)**

a 'awsaj (or zarb)

e A spiny shrub reaching 2 meters in height, rarely occurring in the western Montane Plains and more commonly to the west at rocky locations mainly.

u Grazed by livestock when green. Intensively collected as firewood on the Montane Plains and elsewhere near villages and along roads.

Salvia macrosyphon **Boiss. (Labiatae)**

a mismas

e A dwarfshrub with conspicuous flowers, occurring in the Montane Plains on old fallowlands and adjacent rocky areas mainly.

u Grazed by livestock when green. The flowers can be sucked as they contain very tasteful nectar.

Satureja biflora **(D. Don) Benth. (Labiatae)**

a shajar es shai (meaning: "tree of tea")

e A dwarfshrub occurring in the Montane Plains on rocky slopes and plateaus mainly.

u Grazed by livestock when green. From the leaves tea is made which is used to put on wounds.

m The shoots contain sap with antiseptic and antifungal properties and are used as such.

Solanum incanum L. (Solanaceae)

a nugam (W)

e A leafy shrub with small thorns, occurring in the western Montane Plains and to the west until into the Tihama foothills, at disturbed, rocky places as well as along roads, near villages etc.

u Little grazed, probably by goats and camel only. Collected as firewood, but not preferred. The berries are said to be a little poisonous, they are chewed against toothache, ringworm, snake-bite, earache and syphilis.

p The species is frequently considered to be very poisonous but there appears to be little proper evidence. Native fruits have been shown to be non-toxic to goats, sheep and rabbits although immature fruits did cause death. The toxic substance isolated is solanine.

Solanum nigrum L. (Solanaceae)

a 'animnima (FJO)

e An annual weed occurring in the Montane Plains mainly, but can be found throughout the ROY, on (old) fallowlands and croplands and invading adjacent rocky areas.

u Intensively grazed by livestock. The berries are said to be a little poisonous.

m The shoots contain gluco-alkaloids which are toxic. They are used against headache.

p The toxic substance solanine has been isolated from this plant (see solanum incanum).

Solanum sepicola Dun. (Solanaceae)

a hadaq (daq) (FASWJR)

e A dwarfshrub with small thorns, occurring in the Montane Plains and to the East, on relatively dry (old) fallowlands, invading adjacent rocky areas, and common on rocky slopes that are heavily grazed.

u Little grazed by livestock. Collected as small firewood. The berries are said to be a little poisonous.

Sonchus oleraceus L. (Compositae)

a talab

e An annual weed occurring in the Montane Plains at moist locations on fallowlands and croplands, along irrigation channels, at places with water seepage etc.

u Grazed by livestock when allowed to by herders. It is commonly believed that this plant is poisonous (it contains milky white sap) and causes liverfluke disease among sheep. It can be regarded as an indicator of conditions that are suitable for the presence of the snail Limnaea truncatula which is an intermediate host of the liverfluke.

Tamarix aphylla (Jusl.) Karst. (Tamaricaceae)

a athl (EFAI)

e A tree occurring in the Montane Plains and to the east along the borders of fields, irrigation channels and roads in wadis. It is tolerant of aridity and of salt.

u The tree is not browsed. The wood of the trees was used mainly for construction purposes (including boats, but nowadays it is mostly used as large firewood. Of each tree, only a limited number of separate trunks are cut each time; for hedges and fences (D), medicinal use (D).

Teucrium yemense Defl. (Labiatae)

a khawdas (L)

e A dwarfshrub occurring in the Montane Plains on rocky slopes and plateaus.

u Grazed by livestock when green. Tea is made of the leaves and drank to clean the blood.

***Thymus serpyllum* L. (Labiatae)**

a za'atar (EFAO)

e A low, cushion-forming forb occurring in the Montane Plains at elevations above 2200 meters at (very steep) rocky locations and on plains with sandy or silty soils or a gravelly surface.

u Grazed by livestock throughout the year. The plant smells very good and leaves are collected to be put in laban and sahawiq. The leaves may also be crushed with sesame to make a paste to be eaten with bread.

m The stems and leaves contain an aromatic oil which has antiseptic, spasmolytic and anthelmintic properties and is used as an anthelmintic, for inner hygiene and as a spasmolytic.

***Tribulus terrestris* L. (Zygophyllaceae)**

a quttaba (WFASJOI)

e An annual weed with spiny seeds occurring throughout the ROY on (old) fallowlands mainly, but can be found at various cultivated and disturbed locations and invading adjacent rocky areas and sandy plains.

u Intensively grazed by livestock when green. The seeds are crushed and the sap is said to be a medicine against bilharzia.

m The leaves contain steroids which have a haemolytic effect and are used as a diuretic; the whole plant contains sapogenin which is used against kidney-stones and works anti-inflammatory.

p The plant appears to be toxic during a very short time in its (short) lifecycle and only under certain weather conditions. There are reports of sheep dying from eating this plant. Essentially, the toxicity leads to a photosensitivity syndrome as a result of an accumulation directly under the skin of a certain pigment due to liver damage.

***Urtica* spec. L. (Urticaceae)**

a hariqa (EBS) (meaning "fire")

e A dwarfshrub occurring in the Montane Plains at disturbed, rocky places mainly.

u Grazed by livestock when green. Collected as small firewood. The leaves and seeds are avoided by people as they strongly irritate the skin.

***Withania somnifera* (L.) Dun. (Solanaceae)**

a 'ubab (WAFJO)

e A shrub occurring throughout the ROY, at disturbed places mainly.

u Grazed by livestock when green. Collected as firewood. The leaves are used as a medicine and put on wounds.

m The roots contain steroid lactones which is an antitumour agent and is used for dental analgesic.

***Xanthium spinosum* L. (Compositate)**

a shawk turki (Meaning: "Turkish thorn")

e A spiny annual thistle occurring in the Montane Plains and towards the west at disturbed and relatively moist locations in wadis mainly (fallowlands, wadibeds, etc.).

u Little grazed by livestock. Collected as small firewood.

Ziziphus spina-christi (L.) Willd. (Rhamnaceae)

a sidr (EABSJ)

e A tree occurring in the mountains west of the Montane Plains until into the Tihama lowlands at various locations.

u Grazed by goats and camels. The berries are good to eat and are harvested and sold by children. The wood is used for construction purposes and as large firewood; timber (D).

m The leaves contain triterpenes and mucilage which have bronco-emollient properties and are used as an antiseptic and antipruritic.

2. Grasses and sedges (Gramineae and Cyperaceae)

Andropogon greenwayi Napper

a thayil

e A sod-forming perennial grass occurring in the Montane Plains and to the west at elevations above 2000 meters at relatively moist places (between large rocks, on abandoned terraces, on borders of agricultural fields, etc.).

u Intensively grazed throughout the year; apparently well adapted to severe grazing.

Andropogon sp.

a hashish (ahmar)

e A perennial grass commonly occurring in the Montane Plains at locations varying from steep, rocky slopes to (old) fallowlands.

u Intensively grazed throughout the year; apparently well adapted to severe grazing.

Aristida adscensionis L.

a sha'ara

e A small annual or short-lived perennial grass, commonly occurring in the Montane Plains, to the east, and to the west, at locations varying from not too steep, rocky slopes to recent fallowlands, apparently invading heavily grazed locations.

u Intensively grazed throughout the year, apparently well adapted to intensive grazing.

Brachiaria eruciciformis (Sm.) Griseb.

a wubl nubani

e An annual grass occurring in the Montane Plains and to the west on (old) fallowlands and invading adjacent rocky areas.

u Intensively grazed by livestock.

Cenchrus ciliaris L.

a hashih (abiad) or subla (athail) (meaning "tail of a fox")

e A common perennial grass occurring in the Montane Plains to the east, and to the west at non-steep rocky locations, on (old) fallowlands and uncultivated plains with a gravelly surface.

u Intensively grazed by livestock throughout the year; apparently well adapted to severe grazing.

Chrysopogon plumulosus Hochst.

a hashish (ahmar)

e A perennial grass occurring in the eastern Montane Plains on often dry and steep, rocky slopes like those of volcanic cones and lava flows, as well as on rocky plains.

u Intensively grazed by livestock throughout the year.

Coelachyrum poaeflorum **Chiov.**

a qurrana (L)

e A sod-forming perennial grass occurring in the Montane Plains on non-steep, rocky slopes and plateaus.

u Intensively grazed by livestock throughout the year.

Cynodon dactylon **(L.) Pers.**

a wubl (R)

e A soloniferous, perennial grass commonly occurring in the Montane Plains, to the east, and to the west, on (old) fallowlands, on cultivated fields and adjacent rocky areas and plains with sandy or silty soils; it is the first grass to appear on agricultural fields after ploughing.

u Intensively grazed by livestock throughout the year; well adapted to severe grazing as a result of its soloniferous and rhizomatous properties, though the roots are often dug up by sheep and fields can be regularly ploughed.

Cyperus conglomeratus **Rottb.**

a quras (E)

e A small perennial sedge occurring in the Montane Plains to the east, and to the west, at high elevations mainly, on rocky slopes and plateaus.

Eleusine floccifolia **(Forssk.) Spreng.**

a sarraq

e A perennial grass occurring in the Montane Plains at relatively moist locations (wadibeds, terraces, irrigation canals, etc.).

u Not severely grazed by livestock as the leaves are relatively rough and hard.

Elyonurus muticus **Kuntze**

a hashish (ahmar)

e A perennial grass occurring in the Montane Plains on often steep, rocky slopes; often in cracks between large rock outcrops.

u Not severely grazed by livestock as a result of the often difficult accessible locations where it occurs.

Enneapogon schimperianus **(Hochst. ex A. Rich.) Renvolze**

a sha'ara

e A small perennial grass occurring in the Montane Plains and to the east on rocky slopes and plateaus and relatively dry plains.

u Intensively grazed by livestock throughout the year.

Eragrostis papposa **(Roem. and Schult.) Steud.**

a sha'ara

e A small annual or short-lived perennial grass commonly occurring in the Montane Plains, to the east, and to the west, at locations varying from not too steep, rocky slopes to (old) fallowlands; apparently invading heavily grazed locations.

u Intensively grazed throughout the year, apparently well adapted to intensive grazing.

***Heteropogon contortus* Beauv. ex Roem and Schult.**

a hashih (ahmar)

e A tall, perennial grass occurring in the Montane Plains, mainly on rocky slopes which are not too heavily grazed.

u Grazed by livestock throughout the year.

***Hyparrhenia hirta* (L.) Stapf**

a hashish (ahmar)

e A tall, perennial grass occurring in the Montane Plains and the west until into the Tihama foothills, on rocky slopes mainly, but also on old fallowlands and abandoned terraces.

u Grazed by livestock throughout the year.

***Microchloa indica* (L.F.) Hackel**

a qirrial (L)

e A small annual or short-lived perennial grass commonly occurring in the Montane Plains and to the east at rocky locations and on old fallowlands which are often heavily grazed.

u Intensively grazed by livestock throughout the year; apparently well adapted to heavy grazing.

***Oropetium minimum* (Forssk.) Chiov.**

a 'azaf

e A perennial grass occurring in the Montane Plains and to the west at elevations above 2000 meters, at very rocky locations, often rooted in rockcracks at relatively inaccessible places.

u Not intensively grazed by livestock due to the rough surface of the leaves. The grass is however sometimes cut to be fed to cows, but also to make brooms.

***Pennisetum villosum* R. Br.**

a zabad

e A sod-forming perennial grass occurring in the Montane Plains, at relatively moist locations mainly, on (old) fallowlands, cropland borders, along irrigation ditches and invading adjacent rocky areas.

u Intensively grazed by livestock throughout the year though the leaves have a rather rough surface.

***Scirpus brachyceras* Hochst.**

a 'azaf

e A strong sedge reaching heights up to 1.5 meters occurring in the Montane Plains and towards the west, at moist places like wadibeds, low-lying plains, gullies, etc.

u Ungrazed (possibly little grazed by goats and donkeys). Cut to be used for making brooms.

***Stipagrostis ciliata* (Desf.) de Winter**

a hashish (ahmar)

e A tall perennial grass occurring in the Montane Plains and towards the east at relatively dry locations on rocky slopes but mainly on plains and old fallowlands with sandy or silty soils.

u Intensively grazed by livestock throughout the year.

Tetrapogon villosum Desf.

a hashish (ahmar)

e A perennial grass commonly occurring in the Montane Plains and to the east, on non-steep rocky slopes and plateaus that are mostly heavily grazed.

u Intensively grazed by livestock throughout the year but surprisingly well adapted to heavy grazing.

Themeda triandra Forssk.

a hashish (ahmar)

e A tall perennial grass occurring in the Montane Plains and to the west until into the Tihama foothills, on steep rocky slopes mainly, where grazing is not too frequent.

u Intensively grazed by livestock throughout the year.

3. Sea grass species reported from Yemen (Barratt *et al.* 1987a)

In approximate order of abundance and indicating habitat.

Halodule uninervis	Hardy colonist of shallow sand silt and mud
Thalassia hemprichii	Dominant sea grass of water 1-5 meters rubble and sand
Cymodocea rotundata	Dominant 1-6 meters on silty
Cymodocea serrulata	Dominant on muddy bottoms
Halophila stipulacea	Deeper waters sand and silt
Halophila ovalis	Uncommon in waters
Thalassodendron ciliatum	2-20 meters
Syringodium isoetiholium	Uncommon

B. FORESTRY AND FUELWOOD TREES

1. Major fuelwood trees and shrubs

Acacia asak (K,CH) (common)
Acacia cyanophylla Lindl. (CH)
Acacia gerrardii Benth (CH)
Acacia mellifera (K,CH,SKT) (common)
Acacia nilotica (L.) Willd. ex Del. (CH,SKT)
Acacia origena (formerly *negrii*) (SKT) (lopped)
Acacia pachyceras (SKT) (lopped)
Acacia tortilis (SKT)
Acanthus arboreus (SKT)
Aerva javanica (K)
Aloe vaccilans (K) (common)
Anarrhinum orientale (K)
Becium capitatum (K)
Becium capitatum (SKT)
Cadia purpurea (K)
Caralluma "ephedra" (K)
Caralluma sp. (K)
Commiphora sp. (K) (common)
Echinops spinosissimus (K)
Euphorbia sp. (K) (uncommon)
Euryops pinifolius (K)
Juniperus procera Endl. (CH)
Kleinia odora (K)
Lavandula pubescens (K)
Lycium shawii (K)
Helichrysum somaliense (K) (uncommon)
Myrsine africana (K)
Ormocarpum yemense (K)
Otostegia fruticosa (K)
Peganum harmala (K) (uncommon)
Psiadia arabica (K,SKT)
Pulicaria crispa (SKT)

Pulicaria orientalis (K)
Rumex nervosus (K)
Salvia aegyptiaca (K) (uncommon)
Schinus molle L. (CH)
Solanum sepicola (K) (uncommon)
Solanum unguiculatrum (K)
Ziziphus spina-christi (L.) Desf. (CH)

2. Major lumber and construction trees

Acacia gerrardii Benth. (CH)
Acacia negrii (CH)
Cordia abyssinica (CH,M)
Cupressus sempervirens L. (CH) (boat-building)
Dracaena ombet (SKT) (used for bee hives)
Eucalyptus camaldulensis Dehng. (CH)
Eucalyptus globulus Labill. (CH)
Ficus capensis (H)
Hyphaene thebaica (S) (used in Tihama for thatching huts)
Juniperus procera Endl. (CH)
Tamarindus indicus (H,SKT)
Tamarix sp. (H,SKT)
Terminalia sp. (H)
Trichilia emetica (H)
Ziziphus spina-christi (L.) Desf. (CH,SKT,M)

3. Trees primarily used on sand dune terrace stabilization

Acacia cyanophylla Lindl. (CH) (from Australia)
Acacia sp.
Atriplex sp.
Azadirachta indica
Balanities aegytuaca
Casuarina equisetifolia L. (CH,D)
Cordia abyssinica
Cupressus sempervirens L.
Eleagnus augustifolia L. (CH)
Eucalyptus camaldulensis Dehng. (CH,D)
Eucalyptus globulus Labill. (CH)
Hyphaene sp.
Juniperus sp.
Parkinsonia aculeata
Phoenix sp.
Pinus sp.
Prosopis sp.
Salvadona sp.
Schinus molle L. (CH,D)
Tamarix aphylla (L.) Karst. (CH)
Tanarubdyrs ubduca
Ziziphus sp.

C. SELECTED SPECIES

Baobad *Adansonia digitata* L., fam. Bombacaceae

The baobad tree is a large crowned tree which grows up to 18 meters in height. This is the largest living tree in Africa and may survive over a thousand years. It grows up to 1500 meters altitude and can survive on as little as 250 millimeters annual rainfall. The wood is not widely used, but the leaves and fruits have many purposes in Farica.

Only one tree has been reported in Yemen (Koch 1983) near the Taiz–Al-Turba road. This has a trunk of over 20 meters in circumference and is about 12 meters high. This is said to be the largest tree in Yemen and perhaps the Arabian Peninsula.

Dragon's Blood Tree *Dracaena ombet*

This is an umbrella-shaped tree about 3-4 meters. It is sometimes known as the "mist" oasis tree because it is able to abstract moisture out of fog. Practically, this means that in addition to the regular

rainfall, there is extra water available for the tree itself and surrounding plant cover. Thus, removal of these trees represents a serious desiccation of the environment.

In Yemen it only occurs in inaccessible places in the northwest and eastern parts. Scholte (1988) observed it on steep mountains 100 kilometers north of Al-Suwadiyah and in an area south of Markhah, both in Al-Bayd Governorate. It has been extensively cut in Al-Bayda because bee hives are made out of the main trunk. Trees have also been observed near Hajja on a slope west of the town. There are a few specimens at Al-Abbaysah, northeast of Suq Abs, but only in inaccessible areas. John Evans noted that these were common west of Sa'da on the flank of Jebel Minamar.

Ombet is a vulnerable and possibly endangered species in much of East Africa, where only scattered trees remain. It is not clear whether the Yemeni species is really *ombet*, since no specimens have been systematically compared in the African species.

A different species of dragon's blood tree (*D. cinnabari*) is common on the island of Socotra off South Yemen (Cronk 1985).

ANNEX 5

YEMEN'S FAUNA

This annex contains lists of species found in Yemen, with the focus on marine fauna, mammals, birds, and terrestrial vertebrates.

A. MARINE FAUNA

1. List of islands of Yemen's coastal zone (north to south; in some cases the sovereignty is undetermined or in dispute)

Group A – Offshore islands of the southern Farasan group

Rumayn
Barri
Sumayr
Jazirat Duqaylah
Fasht

Group B – Islands of the northern shelf

Zaha (group of 5 islets)
Lubwan
Hamar
Antuhash (group of 4 islets)
Kutama
Al-Urmak
Al-Uqban
Al-Budi
Kamaran
Rishah

Group C – Offshore oceanic islands

Jebel A'Tayr
Zubayr group:
Jebel Zubayr
Haycock
Saba + 5 others
Hanish group:
Hanish as Jabel Zuqar Saghir
Hanish al-Kabir
Suyuul Hanish

Group D – Small islands adjacent to the coast

Ras Mujamilah
Several others

2. Molluscs of Yemen (from Barratt *et al.* 1987a)

Molluscs of unvegetated sands

Bivalves

Anadara secticostata
Mactra lilacea
Trachycardium lacunosum
Glycymeris striatularis
Diplondonta ravayensis
Cardita bicolor
Pinctada margaritibera
Barbatia helbingii
Tivela damaoides
Gari maculosa
Pinna muricata
Chlamys ruschenbergerii
Spondylus exilis
Chama pacibica

Gastropods

Strombus tricornis
Tibia insulaechrab
Olica bulbosa
Volema pyrum
Bulla ampulla
Murex scolopax
Nassarius arcularius

Molluscs of hard substrates

Nerita albicilla
Cypraea turdus
Cypraea grayana
Trochus erythraeus
Cypraea annulus
Cypraea caurica
Planaxis sulcatus
Chicoreus virgineus

Molluscs of the mangroves

Cerithidae cingulata
Volema pyrum
Strombus tricornis
Terebralia palustris
Cassidula sp.
Littorina scabra
Haliotis pustulata
Trochus erythraeus
Nerita polita
Nerita undata
Cerithium punctatus
Strombus erythraensis
Strombus gibberulus
Strombus mutabilis
Nassarius clatheratus
Conus arenatus
Conus tesselatus
Modiolus auriculatus
Pinctada margaritifera

Molluscs of the seagrass

Strombus tricornis
Tibia insulaechorab
Cerithidea cingulata
Volema pyrum
Codakia sp.
Anodontia sp.
Atrina vexillum
Pinna muricata
Natica albicens
Natica arcularius
Strombus gibberulus
Strombus mutabilis
Lambis truncata
Conus tesselatus
Conus achatinus
Conus taeniatus
Chicoreus virgineaus
Cerithium scabradum
Cypraea annulus
Cypraea moneta

3. **Species commonly associated with mangroves in the eastern seaboard of the Red Sea (from Barratt *et al.* 1987a)**

Molluscs

Cerithidea cingulata	Very common everywhere, except in the most extreme environments
Clypeomorus bifasciatus	Common though less so than *C. cingulata* above
Littorina scabra	Often abundant on mangrove pneumatophores
Planaxis sulcata	Sometimes abundant on and around mangroves
Saccostrea culcullata	Abundant on mangrove pneumatophores at certain sites

Crustaceans

Metopograpsus messor	Common and abundant around mangrove pneumatophores, but not restricted to this habitat
Sesarma guttatum	As above, though not recorded outside the mangrove habitat
Macrophthalmus depressus	Common in wet mangrove substrates
Uca inversa	Orange-clawed Fiddler Crab, found in drier regions of mangroves
Uca lactea	Found in wetter regions (e.g. lower transects) and may possibly be excluded by *U. inversa* from upper, drier areas
Uca urvillei	Less common than *U. inversa* and *U. lactea* above and distributional pattern not obvious
Ocypode saratan	Usually abundant in sandy areas, both around mangroves and on exposed sandy beaches
Dotilla sulcata	Common in wet, muddy areas, both around and outside mangroves

Fish

Periophthalmus koelreuteri	A mudskipper whose distribution may be limited by latitude and in the presence of drainage/tidal channels in well developed mangrove stands

4. Morphological types/species associations for Yemen corals (from Barratt *et al.* 1987a)

Species	Branching	Foliose	Encrust	Massive
Acropora corymbosa	+			
Acropora haimei	+			
Acropora hemprichi	+			
Acropora nasuta	+			
Acropora valenciennes	+			
Echinopora spp.			+	
Faviid spp.				+
Galaxea spp			+	
Montipora aequituberculata		+		
Montipora stellata	+	+	+	
Montipora verrucosa	+			
Pavona cactus	+	+		
Porites annae	+			
Porites spp.			+	
Stylophora pistillata	+			

5. Dominant crustaceans and principal biotopes (Barratt *et al.* 1987a)

	Rocky shores	Sand beaches	Mud and mangrove	Coral
Grapsidae				
Grapsus albolineatus	+			
Metopograpsus messor	+		+	
Perisesarma guttatum			+	
Ocypodidae				
Dotilla sulcata			+	
Macrophthalmus depressus	+		+	
Macrophthalmus grandidieri			+	
Ocypode saratan		+		
Uca inversa		+		
Uca lactea albimana			+	
Uca urvillei		+		
Uca vocans		+		
Xanthidae				
Eurycarcinus sp.	+			
Eriphia smithii	+			
Etisus laevimanus				+
Leotodius exaratus	+			
Phymodius granulatus	+			+
Pilumnidae				
Pilumnus vespertilio	+			
Trapeziidae				
Trapezia cymodoce				+
Portunidae				
Portunus pelagicus	+	+	+	
Alpheidai				
Alpheus lobidens	+	+		
Alpheus lottini			+	
Porcellanidae				
Petrolisthes boscii	+			
Diogenidae				
Clibanarius longitarsus			+	
Hippidae				
Emerita holthuisi		+		
Stomatopoda				
Gonodactylus demani	+			

6. Fish

List of commercial fish in Yemen (Walczak 1976)

Caranx ignobilis	Jack
Scomberoides commersonnianus	Queen fish
Scomberomorus commerson	King fish
Thunnus obesus	Big eye tuna
Euthynnus affinis	Little tuna
Rastrelliger kanagurta	Mackeral
Sphyraena jello	Baracuda
Rachycentron canadum	Cobia
Thryssa setirostis	Whiskered anchovy
Sardinella sp.	Sardine
Sardinops agax	
Rhynchobatus djiddensis	
Psettodes erumei	
Ephinephelus tauvina	Grouper
Valamugil	Mullet
Lethrinus chrysostomus	Emperor bream
Lethrinus lentjan	Emperor bream
Lethrinus miniatus	Emperor bream
Lutjanus sebae	Snapper
Lutjanus sanguineus	Snapper
Lutjanus bohar	Snapper
Lutjanus spp.	Snapper
Nemipterus japonicus	Threadfin
Upeneus sp.	Goatfish
Pomadasys opercularis	Grinl
Heniochus acuminatus	Butterfly fish
Platax orbicularis	Bat fish
Centriscus scutatus	Razorfish
Antennariidae	Frogfish
Fistularia	Cornet fish
Cheilinus	Wrasse
Labroides	Wrasse
Gymnothorax	Moray

Marine fish list of Yemen (El Etreby 1989)

Family:	
Orectolobidae	*Stegostoma faciatum*
Carcharhinidae	*Carcharhinus sorrah*
Sphyrnidae	*Sphyrna mokarran*
Pristidae	*Pristis cuspidatus*
Rhinobatidae	*Rhyncobatus granulatus*
"	*Rhyncobatus* djiddensis italics
Rhinobatidae	*Rhyncobatus* stego
Myliobatidae	*Aetomyleus nichofii*
Dasyatidae	*Dasyatis* sp.
"	*Gymnura* sp.
Acanthuridae	*Acanthurus bleekeri*
Ariidae	*Arius thalassinus*

Belonidae	*Ablennes hians*
Carangidae	*Scomberoides commersonnianus*
"	*Alectis indicus*
"	*Carangoides caeruleopinnatus*
"	*Carangoides fulvoguttatus*
"	*Allectis ciliaris*
"	*Decapterus macarellus*
Chanidae	*Chanos chanos*
Chirocentridae	*Chirocentrus nudus*
Clupeidae	*Sardinella albella*
"	*Sardinella gibbosa*
Cynoglossidae	*Paraplagusia bilineata*
Diodontidae	*Lophodiodon calori*
"	*Diodon holocanthus*
Drepanidae	*Drepane punctata*
Echeneidae	*Echeneis naucrates*
Gerreidae	*Gerres oyena*
Pomadasyidae	*Pomadasys multimaculatus*
"	*Pomadasys argenteus*
Hemiramphidae	*Hemiramphus far*
Holocentridae	*Holocentrus spinifer* ?
"	*Sargocentron spiniferum* ?
Lethrinidae	*Lethrinus mahsena*
"	*Lethrinus elongatus*
"	*Lethrinus nebulosus*
Lutjanidae	*Lutjanus bohar*
"	*Lutjanus argentimaculatus*
"	*Lutjanus fulviflammus*
"	*Lutjanus lineolatus*
"	*Lutjanus malabaricus*
"	*Lutjanus gibbus*
Mugilidae	*Valamugil seheli*
"	*Mugil cephalus*
"	*Valamugil cunnesius*
Nemipteridae	*Nemipterus japonicus*
"	*Scolopsis ghanam*
Ostraciidae	*Tetrosomus gibbosus*
Fistularidae	*Fistularia villosa*
Platacidae	*Platax orbicularis*
Platycephalidae	*Psettodes evumei*
Psettodidae	*Cociella crocodila*
Rachycentridae	*Rachycentron canadum*
Scaridae	*Hipposcarus harid* ??
Scombridae	*Rastrelliger kanagurdta*
"	*Scomberomorus commerson*
"	*Thunnus tonggol*
Scorpaenidae	*Pterois russellii*
"	*Scorpaenopsis gibbosa*
Serranidae	*Cephalopholis oligosticta*
"	*Cephalopholis sexmaculata*
"	*Epinephelus areolatus*
"	*Epinephelus chlorostigma*
Siganidae	*Siganaus rivulatus*
"	*Siganaus luridus*

Sphyraendidae	*Sphyraena barracuda*
"	*Sphyraena forsteri*
Tetraponidae	*Terapon jarbua*
"	*Canthigaster* spp.
"	*Arothron* spp.
Trichiuridae	*Trichiurus lepturus*
"	*Trichiurus haunela*

Freshwater fish (El Etreby 1989)

The freshwater fishes of Yemen are widely distributed all over the high and low lands either in flood streams in summer through the rainy season or in scattered pools left in the dry season in winter. All the freshwater fishes identified till now related to one family "Cyprinidae" and three genera "Garra & Cyprinidon & Barbus".

The fish species are:

1. *Garra tibanica tibanica*
2. *Cyprinidon acinaces*
3. *Barbus arabicus*
4. *Barbus exulatus*

The most interesting freshwater body present is the lake established after the construction of the Mareb Dam in the eastern desert. The area of this lake at maximum storage level will be about 30 square kilometers. The creation of this mass of water in an arid zone will affect the environmental parameters of the area and thus the fauna and flora around it. The advantage of this man-made work is the flourishing of fish and other aquatic fauna and flora in the new environment of the lake.

7. Marine mammals (FAO)

Balaenoptera physalus	Fin whale
Balaenoptera musculus	Blue whale
Balaenoptera edeni	Bryde's whale
Megaptera novaeangliae	Humpback whale
Mesoplodon pacificus	Longman's beaked whale
Ziphius cavirostris	Cuvier's beaked whale
Physeter macrocephalus	Sperm whale
Kogia breviceps	Pygmy sperm whale
Kogia simus	Dwarf sperm whale
Steno bredanensis	Rough-toothed dolphin
Sousa chinensis	Indo-Pacific Hump-backed dolphin
Peponocephala electra	Melon-headed whale
Feresa attenuata	Pygmy killer whale
Psuedorca crassidens	False killer whale
Globicephala macrorhynchus	Short-finned pilot whale
Tursiops truncatus	Bottlenose dolphin
Grampus griseus	Risso's dolphin
Stenella coeruleoalba	Striped dolphin
Delphinus delphis	Common dolphin
Neophocaena phocaenoides	Finless porpoise
Dugong dugon	Dugong

Table 5.1 Localities of amphibians and reptiles of ROY in addition to mammals.

Province	No.	Area	Latitude	Longitude	Altitude	Notes
I	1	Taiz	13°34'N	44°02'E	1300 m	Province center
TAIZ	2	Ausaifera	13°34'N	44°02'E	1150 m	North Taiz
	3	Qa'idah	13°43'N	44°08'E	1400 m	North Taiz
	4	Dimanah Khadeer	13°27'N	44°09'E	1100 m	South-east Taiz
	5	wadi Warazan	13°28'N	44°16'E	1000 m	South-east Taiz
	6	Al-Turbah	13°12'N	44°08'E	1420 m	South Taiz
	7	wadi Barakani	13°19'N	44°55'E	1150 m	South Taiz
	8	wadi Dabab	13°26'N	43°54'E	1150 m	South Taiz
	9	Hajdah	13°38'N	43°47'E	870 m	West Taiz
	10	wadi Rassian	13°35'N	43°46'E	650/850 m	West Taiz
	11	Al-Barh	13°26'N	43°42'E	750 m	South-west Taiz
	12	Maqubanah	13°28'N	43°40'E	550/750 m	South-west Taiz
	13	Mawza'ah	13°13'N	43°31'E	150/200 m	South-west Taiz
	14	Beer Ebn Alwan	13°18'N	43°20'E	75 m	South-west Taiz
	15	Mukha	13°19'N	43°15'E	00	South-west Taiz
	16	Qutayn	13°33'N	43°30'E	250/350 m	West Taiz
II	17	Ibb	13°58'N	44°12'E	1900 m	Province center
IBB	18	Auadi	13°59'N	44°35'E	1900 m	East Ibb
	19	wadi Bana	14°15'N	44°25'E	2370 m	North-east Ibb
	20	Al-Siyani	13°49'N	44°10'E	1800 m	South-west Ibb
	21	Kutab	14°13'N	44°17'E	2400 m	North Ibb
	22	Robat-Sha'rey	14°15'N	44°14'E	2500 m	South-west Yariem
	23	Yariem	14°22'N	44°22'E	2500 m	30 km South Dhamar
	24	Qa'tabah	14°27'N	44°52'E	1360 m	South-east Ibb
III	25	Bayda	13°57'N	45°36'E	1900 m	Province center
BAYDA	26	Radah	14°27'N	44°52'E	1360 m	Dh. ar-Byda Road
IV	27	Dhamar	14°37'N	44°22'E	2300 m	Province center
DHAMAR	28	Hammam Ali	14°36'N	44°09'E	2600 m	West Dhamar
	29	Ma'ber	14°48'N	44°17'E	2250 m	30 km North Dhamar
	30	Sana'a	15°21'N	44°12'E	2100 m	Province center (Capital)
	31	Mazbah	15°22'N	44°10'E	2130 m	North-west Sana'a
	32	Beni-Hushaish	15°28'N	44°22'E	2200 m	East Sana'a
	33	Hadah	15°18'N	44°10'E	2260 m	South-west Sana'a
	34	Bait Bous	15°16'N	44°10'E	2200 m	South Sana'a
	35	Belad Al-Rous	15°12'N	44°13'E	2250 m	South Sana'a
	36	Jabal Nabi-Shu'aib	15°18'N	44°05'E	3000 m	West Sana'a
	37	wadi Harran	15°27'N	44°04'E	2100 m	West Sana'a
	38	wadi Bou'an	15°14'N	43°59'E	2650 m	50 km West Sana'a
V	39	Mafhaq	15°07'N	43°54'E	1550 m	Sana'a-Hudi.RD
SANA'A	40	Rima	15°00'N	44°05'E	1650 m	West Ma'ber
	41	wadi Ezone	15°02'N	43°43'E	2500 m	South Manakhah
	42	Manakhah	15°04'N	43°45'E	2600 m	Sana'a-Hudi.RD
	43	wadi Rima and Madinet Al-Abid	14°39'N	43°37'E	1450 m	West Ma'ber
	44	wadi Rum-rum	15°07'N	44°18'E	2200 m	Manakhah areas
	45	Senhan	15°18'N	44°18'E	2200 m	South-east Sana'a
	46	wadi Al-Qabil	15°25'N	44°08'E	2000 m	North-west Sana'a
	47	Ma'mer	15°33'N	44°05'E	2300 m	30 km North-west Sana'a
	48	Amran	15°38'N	43°55'E	2300 m	50 km North-west Sana'a
	49	Dauham	15°42'N	43°50'E	2500 m	Sana'a-Hajah RD
	50	Ridah	15°52'N	44°01'E	2450 m	70 km North Sana'a

continued

Table 5.1 continued

Province	No.	Area	Latitude	Longitude	Altitude	Notes
	51	Khamer	16°00'N	43°56'E	2480 m	100 km North Sana'a
	52	Houth	16°17'N	43°53'E	1800 m	North Sana'a
	53	Al-Har[illegible]	16°22'N	44°05'E	1520 m	North-west Sana'a
	54	wadi Habash	16°12'N	44°10'E	1450 m	North-west Sana'a
VI	55	Ma'rib	15°24'N	45°17'E	1250 m	Province center
MA'RIB	56	wadi Dam-Marib	15°25'N	45°22'E	1200 m	East Sana'a
	57	Qusoon Al-Galagel	15°30'N	45°23'E	1250 m	East Sana'a
VII	58	Al-Gouf	16°05'N	45°10'E	1100 m	Province center
AL-GOUF	59	Barratt	16°12'N	44°50'E	1200 m	North-east Sana'a
VIII	60	Mahweet	15°30'N	43°30'E	2300 m	Province center
	61	Shebam	15°31'N	43°53'E	2600 m	North-west Sana'a
	62	wadi Al-Ahgor	15°31'N	43°52'E	2300 m	North-west Sana'a
	63	Tawilah	15°29'N	43°43'E	2810 m	North-west Sana'a
	64	Shallal Bani-Saad	15°10'N	43°24'E	765 m	130 km West Sana'a
	65	wadi Surdood	15°13'N	43°25'E	250/350 m	Mahweet/Hudeidah
	66	wadi Qala'iah	15°19'N	43°21'E	250/350 m	Mahweet/Hudeidah
	67	wadi Shagar	15°20'N	43°21'E	250/350 m	Mahweet/Hudeidah
	68	wadi Hatab	15°24'N	43°21'E	250/350 m	Mahweet/Hudeidah
IX	69	Hajah	15°40'N	43°36'E	2650 m	Province center
HAJAH	70	wadi Ain-Ali	15°40'N	43°36'E	2500 m	Hajah area
	71	wadi Sharess	15°44'N	43°36'E	2200 m	Hajah area
	72	wadi Kha'ifah	15°39'N	43°34'E	1200 m	West Hajah
	73	wadi Zorah, Dahban and Shahre	15°38'N	43°28'E	600/800 m	West Hajah
	74	Al-Tur	15°37'N	43°22'E	500/600 m	West Hajah
	75	wadi Moor	15°39'N	43°18'E	230/350 m	Hajah/Hudeidah
	76	Abs	15°05'N	43°00'E	100 m	North-west Hajah
X	77	Hudei'dah	14°48'N	42°57'E	00	Province center
HUDEI'DAH	78	Al-Khukhah	13°47'N	43°16'E	00	coastal area
	79	wadi Zabid	14°12'N	43°22'E	200/350 m	East Zabid
	80	wadi Ramah	14°22'N	43°27'E	500/600 m	North-east Zabid
	81	Bait Al-Faqih	14°32'N	43°17'E	200 m	South-east Hudeidah
	82	Manzar village	14°42'N	42°59'E	00	South Hudeidah
	83	Sukhnah	14°48'N	43°26'E	350 m	South Bajil
	84	Marawi'ah	14°49'N	43°07'E	60 m	East Hudeidah
	85	Al-Bazra	14°51'N	42°59'E	50 m	North Hudeidah
	86	Bajil	15°03'N	43°15'E	250/300 m	North-east Hudeidah
	87	Uig village	15°07'N	42°51'E	00	coastal area
	88	Kadan	15°14'E	43°17'E	150/300 m	North Bajil
	89	Kadan	15°14'N	42°43'E	00	coastal area
	90	Kamaran Island	15°21'N	42°33'E	50/75 m	North-west Hudeidah
XI	91	Sa'dah	16°58'N	43°45'E	1800/1950 m	Province center
SA'DAH	92	wadi Mahdi and Magnif	17°05'N	43°33'E	195 m	North Sadah
	93	Ju Amlah and Jabal	17°07'N	43°34'E	1950 m	North Sadah
	94	Jabal Khazain	17°01'N	43°37'E	2000 m	Sadah area
	95	Jabal Khatarin	16°44'N	43°49'E	1980 m	South Sadah
	96	wadi Itlah	17°10'N	43°33'E	1930 m	North Sadah
	97	wadi Yeslem	17°16'N	43°29'E	1830 m	North Sadah

B. TERRESTRIAL FAUNA

The numbers given after the names of amphibians, reptiles and mammals are the localities shown in *Figure 5.B.1.* The capital letters given after some mammal species indicate their status: R = rare, E = endemic, D endangered, C = of commercial significance.

1. Amphibians and reptiles of Yemen (Al-Safadi 1989)

Amphibians

Order: Salientia
Family: Bufonidae

1. *Bufo arabicus* (Heyden 1827) 1-13, 16-30, 32-43, 45-75, 79-81, 83, 86, 88, 91, 92, 96, 97.
2. *Bufo dhufarensis* (Parker 1931) 83, 85, 88.
3. *Bufo scorteccii* (Balletto and Cherchi 1970) 39.
4. *Bufo tihamicus* (Balletoo and Cherchi 1973) 14, 79, 83, 85, 88.

Family: Hylidae

1. *Hyla savingnyi* (Audouin 1829) 5, 19, 22, 29, 30, 38, 48, 62, 70, 71.

Family: Ranidae

1. *Rana ridibunda* (Pallas 1771) 61-33.
2. *Euphlyctis ehrenbergii* (Peters 1863b) 1-3, 5, 7, 8, 10-12, 17-19, 25, 28, 30, 37, 43, 50, 62, 64-73, 75, 79, 80, 89, 92, 93, 95.

Reptiles

Order: Testudines
Family: Testudinidae

1. *Geochelone sulcata* (Miller 1799) 72, 79.

Family: Cheloniidae

1. *Chelonia mydas* (Linnaeus 1758) Red Sea
2. *Eretmochelys imbricata* (Linnaeus 1766) Red Sea

Family: Pelomedusidae

1. *Pelomedusa subrufa* (Lacepede 1788) 1, 5, 7, 8, 19, 60, 65, 67, 68, 71-73, 75, 79, 80, 83.

Order: Squamata
Family: Gekkonidae

1. *Hemidactylus flaviviridis* (Ruppell) 1, 88.
2. *Hemidactylus turcicus* (Linnaeus 1758) 84, 88.
3. *Hemidactylus yerburii* (Anderson 1895) 1, 30, 64.
4. *Pristurus crucifer* (Valenciennes 1861) Along coastal regions, 15, 73, 82, 77, 85, 87, 89.
5. *Pristurus flavipunctatus* (Ruppell 1835) 1, 8, 30, 33, 36, 61.
6. *Pristurus popovi* (Arnold 1982) 47, 49.
7. *Pristurus rupestris* (Blanford 1874) 1, 8, 30, 33, 36, 61.
8. *Pristurus saada* (Arnold 1986) 31, 53, 91, 93.
9. *Pristurus mazbah* (Al-Safadi 1989) 31.
10. *Ptyodactylus hasselquistii* (Donndorff 1798) 65, 66, 86, 88.

11. *Stenodactylus yemenensis* (Arnold 1980) 77, 84.

Family: Agamidae

1. *Pseudotrapelus sinaita* (Heyden 1827) 72, 74.
2. *Stellio adramitana* (Anderson 1896) 1-9, 12, 16, 17, 19, 21, 23, 27, 30, 36, 46, 61, 62.
3. *Stellio yemenensis* (Klausewitz 1954) 30, 33-36, 38-39, 42, 46, 47, 48, 51-52, 55-56, 60, 63, 69-71.
4. *Uromastyx aegyptius microlepis* (Blandford 1874) 58, 59.
5. *Uromastyx benti* (Anderson 1894) 13, 15.
6. *Uromastyx ocellatus philbyi* (Parker 1938) 58, 59.

Family: Chamaeleonidae

1. *Chamaeleo calyptratus calcarifer* (Peters 1869) 30, 46, 47.
2. *Chamaeleo calyptratus calyptratus* (C. and A. Dumeril 1851) 1-3, 5, 19, 30, 31, 38, 46, 62, 69-71, 90.
3. *Chamaeleo chamaeleon orientalis* (Parker 1938) 1-3, 5, 8, 9, 19, 30, 31-33, 35, 46, 47.

Family: Scincidae

1. *Chalcides ocellatus* (Forskal 1775) 84, 88, 90.
2. *Eumeces taeniolatus* (Blyth 1854) 4, 5, 8, 66, 73.
3. *Eumeces yemenensis* (Al-Safadi 1989) 4, 5, 8, 10, 11, 66-68, 73.
4. *Mabuya brevicollis* (Wiegmann 1837) 1-9, 12, 17, 19, 27, 46, 47, 5-57, 60-63, 65-69, 71-75, 79, 80, 83, 84, 86, 88, 90.
5. *Mabuya tessellata* (Anderson 1985) 6, 12, 62.
6. *Scincus hemprichii* (Wiegmann 1837) 84, 86.
7. *Scincus mitranus mitranus* (Anderson 1871) 55-58.

Family: Lacertidae

1. *Acanthodactylus boskianus* (Daudin 1802) Widespread in all regions, mainly: 15, 16, 65-68, 73-84, 86-88 and also 30-36, 46.
2. *Acanthodactylus yemenicus* (Salvador 1982) 1, 4-8.
3. *Latastia longica data-andersonii* (Boulenger 1921) 4, 5, 7, 8, 29.
4. *Mesalina guttulata* (Licatenstein 1823) 21, 30, 31, 36, 47.
5. *Phliochortus neumanni* (Matschie 1983) 1, 4, 5, 7, 8.

Family: Varanidae

1. *Varanus exanthematicus* (Bosc 1792) 5, 7, 8, 9, 19, 24, 40.
2. *Varanus griseus* (Daudin 1802) 65-68, 74-75, 79-80, 83-84, 86, 88.

Family: Leptotyphlopidae

1. *Leptotyphlops nursii* (Anderson in Boulenger 1896) 1, 41, 79.

Family: Boidae

1. Eryx *colubrinus colubrinus* (Hasselquist in Linnaeus 1758), 30, 38.
2. *Eryx jayakari* (Boulenger 1888b), 55, 59.

Family: Colubridae

1. *Coluber rhodorhachis rhodorhachis* (Jan 1865) 12, 15, 30, 33-36, 46, 77, 88, 91 and 11, 19, 39, 42, 64, 71.

2. *Coluber variabilis* (Boulenger 1905) 74, 83.
3. *Dasypeltis scabra* (Linnaeus 1758) 1, 20, 30, 38.
4. *Lamprophis fuliginosus arabicus* (Parker 1930) 1, 11, 42, 44.
5. *Lytorhynchus gasperetti* (Leviton 1977) 84, 86, 88.
6. *Natrix tessellata tessellata* (Laurenti 1768) 36, 38.
7. *Psamopphis schokari schokari* (Forskal 1775) 1, 5, 8, 15, 29, 30, 42, 65, 67, 68, 77, 82, 83.
8. *Spalerosophis diadema cliffordi* (Schlegel 1837) 30, 38, 65, 76.
9. *Telescopus dhara dhara* (Forskal 1775) 5, 38, 64, 83, 88.

Family: Atractaspididae

1. *Atractaspis microlepidota andersonii* (Boulenger 1905) 5, 8, 19, 46, 71.

Family: Elapidae

1. *Naja haje arabica* (Scortecci 1932) 1, 5, 8, 19, 28, 30, 38, 46, 47, 62, 70, 72, 94, 95.

Family: Viperidae

1. *Bitis arietans arietans* (Merrem 1820) 1, 5, 8, 30, 59, 83, 91.
2. *Cerastes cerastes gasperettii* (Leviton and Anderson 1967) 55-59, 55-59, 65-79, 84, 86-88.
3. *Echis coloratus* (Gunther 1878) 55-59, 91.
4. *Echis pyramidum* (E. and I. Geoffroy and St Hilaire 1827) 83, 84, 86, 88.

2. Mammals in Yemen (Al-Safadi 1989)

Order: Insectivora (Insectivores)
Family: Erinaceidae

1. *Paraechinus aethiopicus oniscus* (Thomas 1922) 2, 4, 5, 7, 12, 13, 25, 26, 30, 37, 62, 69, 53, 91, 97.
2. *Paraechinus hypomelas niger* (Blanford 1878) 12, 21, 26, 80, 86, 88.

Order: Hyracoidae
Family: Procaviidae

1. *Procavia capensis jayakari* (Thomas 1892) 1, 8, 9, 17, 20, 25, 28, 42, 40-42, 31, 36, 37, 60-63, 70-73, 50-54, 93-95.

Order: Artiodactyla
Family: Bovidae

1. *Capra ibex* (Linnaeus 1758) (subspecies *arabica* 13, 25, C,R,D.
2. *Gazella gazella* (Pallas 1766) (spp. *arabica* 13, 14, 24, 56, 58, C,R,D.
3. *Gazella dorcas* (Linnaeus 1758) (spp. *saudiya* 25, C,R,D
4. *Gazella subgutturosa marica* (Guldenstaedt 1780) 25, 56, 58, C,R,D.
5. *Gazella bilkis*. 25, 55-58, C,R,D.
6. *Tragelaphus imberis* (lesser Kudu)

Order: Carnivora
Family: Canidae

1. *Canis aureus aureus* (Linnaeus 1758) (jackal) 5, 24, 25, 26, 34, R,D.
2. *Canis Lupus arabs* (Pocock 1934) (wolf) 5, 24, 26, 64, 68, 32, R,D.
3. *Vulpes vulpes arabica* (Thomas 1902) (fox) In most Yemen regions. C,R,D.

4. *Vulpes rueppelli sabaea* (Pocock 1934) (Ruppell's Sand Fox). In most Yemen regions. C,R,D.
5. *Vulpes cana* (Blandford's Fox ?) C,R,D.

Family: Viverridae

1. *Ichneumia albicauda albicauda* (G. Cuvier 1829) (White-tailed Mongoose). In most Yemen regions. C,D.
2. *Genetta felina granti* (Thomas 1902) (genet). 1-12, 17, 20, 24, C,R,D.

Family: Hyaenidae

1. *Hyaena hyaena sultana* (Pocock 1934) (Striped Hyaena). In all Yemen mountains. D.

Family: Mustelidae

1. *Mellivora capensis*

Family: Felidae

1. *Felis silvestris gordoni* (Harrison 1968) (wildcat) 1, 4, 5, 7, 17, 17, 20, D.
2. *Felis margarita harrisoni* (Hemmer, Grubb and Groves 1976) (Sand Cat) 56, 58, R,D.
3. *Caracal caracal schmitzi* (Matschie 1912) (caracal) 2, 5, 6, 9, 24, R,D.
4. *Panthera pardus nimer* (Hemprich and Ehrenberg 1833) (leopard). 24, 25, C,R,D.

Order: Lagomorpha
Family: Leporidae

1. *Lepus capensis cheesmani* (Thomas 1921) (hare). In all Yemen regions. C.

Order: Rodentia
Family: Hystricidae

1. *Hystrix indica indica* (Kerr 1792) (porcupines). In most mountain regions. C.

Order: Rodentia
Family: Cricetidae

Gerbillus Cheesmani	Cheesman's Gerbil
Gerbillus famulus	Black Tufted Gerbil
Gerbillus henleyi	Pygmy Gerbil
Gerbillus nanus	Baluchistan Gerbil
Gerbillus poecilops	Large Aden Gerbil
Meriones rex	King Jird

Family: Muridae

Acomys cahirinus	Cairo Spiny Mouse
Acomys russatus	Golden Spiny Mouse
Arvicanthis niloticus	African Grass Rat
Acomys dimidiatus	Rat
Mus musculus	House Mouse
Praomys fumatus	Last African Rock Rat
Rattus rattus	House Rat, Ship Rat, Black Rat

Family: Dipodidae

Jaculus jaculus	Lesser Egyptian Jerboa

Tachybaptus ruficollis	Little Grebe
Podiceps nigricollis	Black-necked Grebe
Puffinus pacificus	Wedge-tailed Shearwater
Puffinus lherminieri	Audubon's Shearwater
Phaethon aethereus	Red-billed Tropicbird
Sula dactylatra	Masked Booby
Sula leucogaster	Brown Booby
Phalacrocorax nigrogularis	Socotra Cormorant
Pelecanus onocrotalus	White Pelican
Pelecanus rufescens	Pink-backed Pelican
Botaurus stellaris	Bittern
Ixobrychus minutus	Little Bittern
Nycticorax nycticorax	Night Heron
Butorides striatus	Green-backed Heron
Ardeola ralloides	Squacco Heron
Bubulcus ibis	Cattle Egret
Egretta gularis	Western Reef Heron
Egretta garzetta	Little Egret
Egretta alba	Great White Egret
Ardea cinerea	Gray Heron
Ardea purpurea	Purple Heron
Ardea melanocephala	Black-headed Heron
Ardea goliath	Goliath Heron
Scopus umbretta	Hamerkop
Ciconia nigra	Black Stork
Ciconia abdimii	Abdim's Stork
Ciconia ciconia	White Stork
Plegadis falcinellus	Glossy Ibis
Geronticus eremita	Bald Ibis
Threskiornis aethiopicus	Sacred Ibis
Platalea leucorodia	Spoonbill
Phoenicopterus ruber	Greater Flamingo
Tadorna ferruginea	Ruddy Shelduck
Tadorna tadorna	Shelduck
Anas penelope	Wigeon
Anas strepera	Gadwall
Anas crecca	Teal
Anas platyrhynchos	Mallard
Anas acuta	Pintail
Anas querquedula	Garganey
Anas clypeata	Shoveler
Aythya ferina	Pochard
Aythya nyroca	Ferruginous Duck
Aythya fuligula	Tufted Duck
Pernis apivorus	Honey Buzzard
Elanus caeruleus	Black-shouldered Kite
Milvus migrans	Black Kite
Gypaetus barbatus	Lammergeier
Neophron percnopterus	Egyptian Vulture
Gyps fulvus	Griffon Vulture
Gyps rueppellii	Rüppell's Vulture

Torgos tracheliotus	Lappet-faced Vulture
Aegypius monachus	Black Vulture
Circaetus gallicus	Short-toed Eagle
Terathopius ecaudatus	Bateleur
Circus aeruginosus	March Harrier
Circus cyaneus	Hen Harrier
Circus macrourus	Pallid Harrier
Circus pygargus	Montagu's Harrier
Melierax metabates	Dark Chanting Goshawk
Micronisus gabar	Gabar Goshawk
Accipiter nisus	Sparrowhawk
Accipiter badius	Shikra
Accipiter brevipes	Levant Sparrowhawk
Buteo buteo	Buzzard
Buteo rufinus	Long-legged Buzzard
Aquila pomarina	Lesser Spotted Eagle
Aquila clanga	Spotted Eagle
Aquila rapax	Tawny Eagle
Aquila nipalensis	Steppe Eagle
Aquila heliaca	Imperial Eagle
Aquila chrysaetos	Golden Eagle
Aquila verreauxii	Verreaux's Eagle
Hieraaetus pennatus	Booted Eagle
Hieraaetus fasciatus	Bonelli's Eagle
Pandion haliaetus	Osprey
Falco naumanni	Lesser Kestrel
Falco tinnunculus	Kestrel
Falco columbarius	Merlin
Falco subbuteo	Hobby
Falco concolor	Sooty Falcon
Falco biarmicus	Lanner
Falco cherrug	Saker
Falco peregrinus	Peregrine
Falco pelegrinoides	Barbary Falcon
Alectoris philbyi	Philby's Rock Partridge
Alectoris melanocephala	Arabian Red-legged Partridge
Ammoperdix heyi	Sand Partridge
Coturnix coturnix	Quail
Coturnix delegorguei	Harlequin Quail
Numida meleagris	Helmeted Guineafowl
Turnix sylvatica	Little Button Quail
Rallus aquaticus	Water Rail
Porzana porzana	Spotted Crake
Porzana pusilla	Baillon's Crake
Crex crex	Corncrake
Gallinula chloropus	Moorhen
Fulica atra	Coot
Grus grus	Crane
Anthropoides virgo	Demoiselle Crane
Ardeotis arabs	Arabian Bustard
Hydrophasianus chirurgus	Pheasant-tailed Jacana
Haematopus ostralegus	Oystercatcher
Himantopus himantopus	Black-winged Stilt

Recurvirostra avosetta	Avocet
Dromas ardeola	Crab Plover
Burhinus oedicnemus	Stone Curlew
Burhinus capensis	Spotted Thick-knee
Cursorius cursor	Cream-colored Courser
Glareola pratincola	Collared Pratincole
Charadrius dubius	Little Ringed Plover
Charadrius hiaticula	Ringed Plover
Charadrius alexandrinus	Kentish Plover
Charadrius mongolus	Lesser Sand Plover
Charadrius leschenaultii	Greater Sand Plover
Charadrius asiaticus	Caspian Plover
Pluvialis dominica	Lesser Golden Plover
Pluvialis squatarola	Gray Plover
Hoplopterus spinosus	Spur-winged Plover
Chettusia leucura	White-tailed Plover
Calidris canutus	Knot
Calidris alba	Sanderling
Calidris minuta	Little Stint
Calidris temminckii	Temminck's Stint
Calidris subminuta	Long-toed Stint
Calidris acuminata	Sharp-tailed Sandpiper
Calidris ferruginea	Curlew Sandpiper
Calidris alpina	Dunlin
Limicola falcinellus	Broad-billed Sandpiper
Philomachus pugnax	Ruff
Lymnocryptes minimus	Jack Snipe
Gallinago gallinago	Snipe
Gallinago media	Great Snipe
Gallinago stenura	Pintail Snipe
Limosa limosa	Black-tailed Godwit
Limosa lapponica	Bar-tailed Godwit
Numenius phaeopus	Whimbrel
Numenius tenuirostris	Slender-billed Curlew
Numenius arquata	Curlew
Tringa erythropus	Spotted Redshank
Tringa totanus	Redshank
Tringa stagnatilis	Marsh Sandpiper
Tringa nebularia	Greenshank
Tringa ochropus	Green Sandpiper
Tringa glareola	Wood Sandpiper
Xenus cinereus	Terek Sandpiper
Actitis hypoleucos	Common Sandpiper
Arenaria interpres	Turnstone
Phalaropus lobatus	Red-necked Phalarope
Stercorarius parasiticus	Arctic Skua
Larus hemprichii	Sooty Gull
Larus leucophthalmus	White-eyed Gull
Larus ichthyaetus	Great Black-headed Gull
Larus ridibundus	Black-headed Gull
Larus genei	Slender-billed Gull
Larus fuscus	Lesser Black-backed Gull
Larus argentus	Herring Gull

Gelochelidon nilotica	Gull-billed Tern
Sterna caspia	Caspian Tern
Sterna bergii	Swift Tern
Sterna bengalensis	Lesser Crested Tern
Sterna sandvicensis	Sandwich Tern
Sterna hirundo	Common Tern
Sterna repressa	White-cheeked Tern
Sterna anaethetus	Bridled Tern
Sterna saundersi	Saunders' Little Tern
Chlidonias hybridus	Whiskered Tern
Chlidonias niger	Black Tern
Chlidonias leucopterus	White-winged Black Tern
Rhynchops flavirostris	African Skimmer
Pterocles lichtensteinii	Lichtenstein's Sandgrouse
Pterocles coronatus	Crowned Sandgrouse
Pterocles exustus	Chestnut-bellied Sandgrouse
Columba livia	Rock Dove
Columba arquatrix	Olive Pigeon
Streptopelia roseogrisea	African Collared Dove
Streptopelia semitorquata	Red-eyed Dove
Streptopelia turtur	Turtle Dove
Streptopelia lugens	Dusky Turtle Dove
Streptopelia senegalensis	Palm Dove
Oena capensis	Namaqua Dove
Treron waalia	Yellow-bellied Green Pigeon
Psittacula eupatria	Alexandrine Parakeet
Psittacula krameri	Ring-necked Parakeet
Clamator jacobinus	Jacobin Cuckoo
Chrysococcyx caprius	Didric Cuckoo
Chrysococcyx klaas	Klaas's Cuckoo
Cuculus canorus	Cuckoo
Centropus superciliosus	White-browed Coucal
Tyto alba	Barn Owl
Otus senegalensis	African Scops Owl
Bubo africanus	Spotted Eagle Owl
Athene noctua	Little Owl
Strix butleri	Hume's Tawny Owl
Caprimulgus inornatus	Plain Nightjar
Caprimulgus nubicus	Nubian Nightjar
Caprimulgus europaeus	Nightjar
Caprimulgus aegyptius	Egyptian Nightjar
Apus apus	Swift
Apus melba	Alpine Swift
Apus caffer	White-rumped Swift
Apus affinis	Little Swift
Cypsiurus parvus	Palm Swift
Halcyon leucocephala	Gray-headed Kingfisher
Merops albicollis	White-throated Bee-eater
Merops orientalis	Little Green Bee-eater
Merops superciliosus	Blue-cheeked Bee-eater
Merops apiaster	Bee-eater
Coracias garrulus	Roller
Coracias abyssinicus	Abyssinian Roller

Upupa epops	Hoopoe
Tockus nasutus	Gray Hornbill
Jynx torquilla	Wryneck
Dendrocopos dorae	Arabian Woodpecker
Mirafra cantillans	Singing Bush Lark
Eremopterix nigriceps	Black-crowned Finch Lark
Eremalauda dunni	Dunn's Lark
Ammomanes cincturus	Bar-tailed Desert Lark
Ammomanes deserti	Desert Lark
Alaemon alaudipes	Hoopoe Lark
Melanocorypha bimaculata	Bimaculated Lark
Calandrella cinerea	Red-capped Lark
Calandrella brachydactyla	Short-toed Lark
Galerida cristata	Crested Lark
Riparia riparia	Sand Martin
Riparia cincta	Banded Martin
Ptyonoprogne fuligula	African Rock Martin
Ptyonoprogne rupestris	Crag Martin
Hirundo rustica	Swallow
Hirundo daurica	Red-rumped Swallow
Delichon urbica	House Martin
Anthus novaeseelandiae	Richard's Pipit
Anthus campestris	Tawny Pipit
Anthus similis	Long-billed Pipit
Anthus trivialis	Tree Pipit
Anthus cervinus	Red-throated Pipit
Motacilla flava	Yellow Wagtail
Motacilla citreola	Citrine Wagtail
Motacilla cinerea	Gray Wagtail
Motacilla alba	White Wagtail
Pycnonotus xanthopygos	Yellow-vented Bulbul
Hypocolius ampelinus	Gray Hypocolius
Prunella fagani	Arabian Accentor
Cercotrichas galactotes	Rufous Bush Chat
Cercotrichas podobe	Black Bush Robin
Luscinia luscinia	Thrush Nightingale
Luscinia megarhynchos	Nightingale
Luscinia svecica	Bluethroat
Irania gutturalis	White-throated Robin
Phoenicurus ochruros	Black Redstart
Phoenicurus phoenicurus	Redstart
Cercomela melanura	Blackstart
Saxicola rubetra	Whinchat
Saxicola torquata	Stonechat
Oenanthe isabellina	Isabelline Wheatear
Oenanthe bottae	Red-breasted Wheatear
Oenanthe oenanthe	Wheatear
Oenanthe pleschanka	Pied Wheatear
Oenanthe hispanica	Black-eared Wheatear
Oenanthe deserti	Desert Wheatear
Oenanthe moesta	Red-rumped Wheatear
Oenanthe xanthoprymna	Red-tailed Wheatear
Oenanthe lugens persica	Mourning Wheatear

Oenanthe lugens lugentoides	South Arabian Wheatear
Oenanthe monacha	Hooded Wheatear
Oenanthe leucopyga	White-crowned Black Wheatear
Monticola rufocinerea	Little Rock Thrush
Monticola saxatilis	Rock Thrush
Monticola solitarius	Blue Rock Thrush
Turdus menachensis	Yemen Thrush
Turdus philomelos	Song Thrush
Parisoma buryi	Yemen Warbler
Cisticola juncidis	Fan-tailed Warbler
Prinia gracilis	Graceful Warbler
Scotocerca inquieta	Scrub Warbler
Acrocephalus shoenobaenus	Sedge Warbler
Acrocephalus palustris	Marsh Warbler
Acrocephalus scirpaceus	Reed Warbler
Acrocephalus stentoreus	Clamorous Reed Warbler
Acrocephalus arundinaceus	Great Reed Warbler
Hippolais pallida	Olivaceous Warbler
Hippolais languida	Upcher's Warbler
Hippolais icterina	Icterine Warbler
Sylvia cantillans	Subalpine Warbler
Sylvia mystacea	Ménétries's Warbler
Sylvia nana	Desert Warbler
Sylvia leucomelaena	Arabian Warbler
Sylvia hortensis	Orphean Warbler
Sylvia nisoria	Barred Warbler
Sylvia curruca curruca	Lesser Whitethroat
Sylvia curruca minula	Desert Lesser Whitethroat
Sylvia communis	Whitethroat
Sylvia borin	Garden Warbler
Sylvia atricapilla	Blackcap
Phylloscopus umbrovirens	Brown Woodland Warbler
Phylloscopus fuscatus	Dusky Warbler
Phylloscopus sibilatrix	Wood Warbler
Phylloscopus neglectus	Plain Willow Warbler
Phylloscopus collybita	Chiffchaff
Phylloscopus trochilus	Spotted Flycatcher
Muscicapa striata	Spotted Flycatcher
Muscicapa gambagae	Gambaga Flycatcher
Terpsiphone viridis	African Paradise Flycatcher
Turdoides squamiceps	Arabian Babbler
Anthreptes metallicus	Nile Valley Sunbird
Nectarinia habessinica	Shining Sunbird
Nectarinia osea	Orange-tufted Sunbird
Zosterops abyssinica	White-breasted White-eye
Oriolus oriolus	Golden Oriole
Tchagra senegala	Black-headed Bush Shrike
Lanius isabellinus	Isabelline Shrike
Lanius collurio	Red-backed Shrike
Lanius minor	Lesser Gray Shrike
Lanius excubitor	Great Gray Shrike
Lanius senator	Woodchat Shrike
Lanius nubicus	Masked Shrike

Corvus splendens	Indian House Crow
Corvus ruficollis	Brown-necked Raven
Corvus rhipidurus	Fan-tailed Raven
Onychognathus tristramii	Tristam's Grackle
Cinnyricinclus leucogaster	Amethyst Starling
Sturnus vulgaris	Starling
Creatophora cinerea	Wattled Starling
Passer domesticus	House Sparrow
Passer euchlorus	Arabian Golden Sparrow
Petronia dentata	Bush Petronia
Ploceus galbula	Rüppell's Weaver
Estrilda rufibarba	Arabian Waxbill
Amandava subflava	Zebra Waxbill
Euodice cantans	African Silverbill
Serinus rothschildi	Arabian Serin
Serinus menachensis	Yemen Serin
Rhynchostruthus socotranus	Golden-winged Grosbeak
Carduelis yemenensis	Yemen Linnet
Bucanetes githagineus	Trumpeter Finch
Emberiza striolata	House Bunting
Emberiza tahapisi	Cinnamon-breasted Rock Bunting
Emberiza cineracea	Cinereous Bunting
Emberiza hortulana	Ortolan Bunting

4. Insects of Yemen

Butterflies

Pontina glauconome glauconome (Klug)
Anaphaeis aurota aurota (Frabricus)
Colotis calais amatus (Fabricius)
Colotis phisadia phisadia (Godart)
Colotis danae eupompe (Klug)
Colotis daira daira (Klug)
Colotis evagore evagore (Klug)
Nepheronia buqueti buchanani (Rothschild)
Eurema hecabe solifera (Butler)
Eurema brigitta brigitta (Stoll)
Syntarucus pirithous (Linne)
Tarucus yheophrastus (Fabricius)
Euchrysops osiris (Hopffer)
Freyeria trochylus (Freyer)
Danaus chrysippus (Linne)
Hypolimnas misippus (Linne)
Junonia hierta cebrene (Triman)
Ypthima asterope (Klug)
Pedopidas thrax (Hubner)

Moths (Lepidoptera)

Family Geometridae

Hemidromodes sabulifera triforma (Wiltshire)
Brachyglossina
Scopula ochroleucaria (H-S)
Pseudosterrha paullula (Swinhoe)
Family sphingidae
Hippotion celerio
Family Lymantriidae
Euproctis fasciata susanna (Staudinger)
Casama innotata (Walker)
Family Nuctuidoce
Selepa docilis (Butler)
Auchenisa cerurodes (Hampson)
Beihania anartoides (Warnecke)
Acrobyla kneuckeri (Rebel)
Anoba triangularis (Warnecke)
Rhynchina albiscripta (Hampson)

ANNEX 6

ENVIRONMENTAL LEGISLATION

A. LAW ESTABLISHING EPC (ENVIRONMENTAL PROTECTION COUNCIL)

Prime Ministerial Decree no. 7 issued in 1987 for establishing an Environmental Protection Council

Article 1 – Description: The following expressions represent the meanings of each given hereunder:

A. The environment: the system that includes living things such as humans, animals and plants and whatever is surrounding it from air, water and soil and any solid, liquid or gaseous matter or radiation and moveable and fixed structures constructed by humans.

B. Polluting factors and materials: any material that is solid, liquid, gaseous, smoke, steam, fragrance, noise, radiation, heat, fire by lightning or earthquakes, whether these constitute, directly or indirectly, factors to the pollution of the environment.

C. Environmental pollution: the substance of any of the materials or polluting factors in a small quantity for a period of time that may cause reaction with itself or other, directly or indirectly, and affect the environmental health.

D. Environmental protection: prevention of pollution or lessening of it; controlling it and preserving the environment.

Article 2 – The EPC is to be constituted as follows:

1. Minister of Municipalities and Housing as a Chairman
2. Minister of Health as a Vice Chairman
3. Deputy Advisor, Deputy Legal Office as a member
4. Deputy Chief of Staff for Military Affairs as a member
5. Deputy Interior Minister for Internal Security as a member
6. Deputy Minister of Municipalities and Housing as a member
7. Deputy Minister of Agriculture and Fisheries as a member
8. Deputy Minister of Economy and Supply for Economic Sector as a member
9. Chairman of the Board of Port Authority as a member
10. General Director of Physical Planning in the Ministry of Municipalities as a member
11. General Director of Environmental Health in the Ministry of Municipalities as a member, recorder and undersecretary to the Council

Article 3

The Council is to issue an internal rule to organize its tasks, set up permanent or temporary sub-committees or special teams to study the issues within its mandate, and make use of local or foreign experts.

Article 4

The EPC undertakes the following tasks:

1. Proposing the general policy of environmental protection from pollution that would safeguard industrial and civil expansion and the utilization of natural resources;

2. Preparing the laws, systems and regulations and the special conditions for environmental protection and following these up;

3. Proposing an integrated workplan relative to the environmental protection in the near and distant future as well as proposing training of local staff on the ways and means of environmental protection;

4. Coordinating between the entities concerned, following this up, and evaluating activities as well as preparing an annual report on the environmental situation in the country;

5. Study the problems arising from environmental pollution and proposing reasonable solutions to them. Stopping any plant or factory that may continue to be hazardous to the environment;

6. Setting up a general frame for the educational program for the environment with the aim of bringing awareness to the people and interesting them individually or collectively to participate in environmental protection;

7. Coordinating with regional and international organizations concerned with environmental protection for the purpose of gaining from this experience and scientific research in the field of the environmental protection.

Article 5

The Chairman is concerned with the following:

1. Representing the Council in international conferences concerned with environmental affairs or determining who may represent it;

2. Presenting periodic reports to the Cabinet Council on the works and activities of the Council.

Article 6

The General Directorate for Environmental Health at the Ministry of Municipalities and Housing is the executive body of the Council for following up its decisions, recommendations and implementations. The General Manager is the recorder and the undersecretary, as well as a member in the Council.

Article 7

This decree is effective on its date of issue and is to be published in the official government gazette and all concerned authorities are to implement as specified.

Issued at the Cabinet Council
20 Jumadi Al-Thani 1407
February 19, 1987

B. Command Council Decree No. 40 in 1977 for the Prohibition of Hunting Gazelles

Article 1

The hunting of all varieties of gazelles in all parts of Yemen is forbidden for a period of ten years, in reference to any method of hunting them.

Article 2

The penalty will be imprisonment for not more than one month and payment of fines not less than 5000 Yemeni Riyals nor more than 10,000 Yemeni Riyals or one of the above two penalties. This is for everyone who breaks the law established in Article 1. this is for all cases, without exception, in whatever manner of hunting is practised.

Issued 30 Rabi' al-Awwal, 1397
March 20, 1977

ANNEX 7

FACULTY OF SCIENCE, SANA'A UNIVERSITY

The Faculty of Science at Sana'a University contains departments of oceanography and biology, the latter including botany and zoology. Of the 15 teachers in these two departments, only four are Yemeni. These two departments have received relatively little development assistance, apart from Ph.D. training in the U.S. for three of the Yemeni professors. Laboratory facilities are available, but there is no herbarium or greenhouse. Faunal specimens are kept, but collection and storage facilities are inadequate.

The courses offered in the Department of Biology include several dealing with ecology, but nothing specifically on conservation. A basic listing for the B.S. degree courses is noted in *Table 7.1.*

Table 7.1 List of courses in the Department of Biology

1	General Biology	21	Radiobiology
2	General Biology	22	Molecular Biology
3	Cell Biology	23	Phycology
4	Plant Anatomy	24	Basic Mycology and Plant Pathology
5	Chordates	25	Animal Physiology
6	Plant Physiology	26	Plant Physiology
7	Invertebrate Zoology	27	Archegoniates and Fossils
8	Genetics	28	Animal Ecology
9	Basic Bacteriology and Virology	29	Comparative Vertebrate Anatomy
10	Taxonomy of Flowering Plants	30	Plant Ecology
11	Histology and Zootechniques	31	Plant Geography and Flora
12	Vertebrate Embryology	32	Phycology
13	Plant Ecology	33	Plant Pathology
14	Entomology	34	Physiology of Plant Growth and Development
15	Animal Physiology	35	Applied Entomology
16	Taxonomy of Flowering Plants	36	Comparative Animal Physiology
17	Virology	37	Endocrinology
18	Evolution and Zoogeography	38	Animal Behaviour
19	Parasitology	39	Special Topics
20	Marine Biology	40	Seminar

The science collection of the library of Sana'a University is in critical need of updating. Virtually all the relevant texts in English were purchased in the 1970s, soon after the founding of the university with financial assistance fro Kuwait University. As can be seen in *Table 7.2* below there is virtually nothing relevant to conservation, either in texts or periodicals. It should be noted that subscriptions for many of the periodicals have elapsed, due to severe financial problems of the University.

Table 7.2 English titles in ecology, botanical ecology and zoology in the library of Sana'a University

Sana'a University: titles in botanical ecology

Ashby, M. *Introduction to plant ecology.* London. Macmillan. 1969.
Batanouny, K. H. *Ecology and the flora of Qatar.* Oxford. 1981.
Bohm, W. *Methods of studying root systems.* Berlin. Springer Verlag. 1979.
Billings, W. D. *Plants, man, and the ecosystem.* London. Macmillan. 1972.
Chuckla, R. S. (ed.) *Plant ecology.* Ram Nagar. S. Chand. 1980.
Daubenmire, R. *Plants and the environment.* New York. Wiley. 1974.
Etherington, J. R. *Environment and plant ecology.* New Delhi. Wiley Eastern. 1975.
Eyre, S. R. *Vegetation and soils.* Chicago. Aldine. 1968.
Good, R. *The geography of flowering plants.* London. Longman. 1974.
Haney, A. W. *Plants and life.* New York. Macmillan. 1978.
Hill, A. F. *Economic botany.* New York. McGraw Hill. 1952.
Line, L. *The Audubon Society book of wild flowers.* New York. Harry N. Adany 1978.
Meuller-Dambois, D. *Aims and methods of vegetation ecology.* New York. Wiley. 1974.
Rafiq, M. *Crop ecological zones of the countries of the Near East region.* Rome. Food and Agriculture Organization of the U.N. 1976.
Shukla, R. S. *Plant ecology and soil science.* Ram Nagar. New Delhi. 1977.
Tivy, J. *Biogeography.* Edinburg. Oliver and Boyd. 1971.
Willis, A. J. *Introduction to plant ecology.* London. Allen and Unwin. 1973.

Sana'a University: titles in zoology

Abu Gideiri, Y. B. *Studies in applied zoology.* Khartoum. Khartoum Univ. Press. 1985.
Boolootian, R. A. *Study guide for zoology.* New York. Macmillan. 1979.
Burns, R. D. *Laboratory explorations in general zoology.* New York. Macmillan. 1977.
Fingerman, M. *Animal diversity.* New York. Holt, Rinehart and Winston. 1976.
Fittkau, E. J. (ed.) *Biogeography and ecology in South America.* The Hague. Junk. 1969.
Gordon, M. S. (eds.) *Animal physiology: principles and applications.* New York. Macmillan. 1977.
Leftwich, A. W. *A dictionary of zoology.* London. Constable. 1973.
Vincent, B. A. L. *Animal life in Saudi Arabia.* Cermusco, Italia. Garzanti. 1982.

Sana'a University: journals in ecology and related topics

Acta Zoologica
Australian Jour. of Biol. Sci.
Biological Abstracts
Canadian Jour. of Botany
Canadian Jour. of Microbiology
Canadian Jour. of Zoology
Economic Geology
Folia Microbiologica
Geological Society of America Bull.
Geophysics
Izyestiya
– series on atmospheric and oceanic physics
– series on physics of solid earth
Jour. of Applied Ecol.
Jour. of Biol. Chem.
Jour. of Ecology
Jour. of Economic Entomology
Jour. of Experimental Zool.
Jour. of Gen. Microbiology
Jour. of the Geol. Soc.
Limonology and Oceanography
Marine Biology
Photochem. and Photobiol.
Plant Physiology
Rev. of Plant Pathology
Sedimentary Geol.

Sana'a University: titles in ecology

Afshar, H. K. *The earth's impending physical environment around the year 2000, and the problems of the developing countries.* Tehran. Tehran Univ. Press. 1973.
Battistini, R. and Richard, G. (eds.) *Biogeography and ecology in Madagascar.* Hague. Junk. 1972.
Bennet, D. P. *Introduction to field biology.* London. Arnold. 1974.
Billings, W. *Plants, man, and the ecosystem.* London. Macmillan. 1972.
Breuer, G. *Air in danger: ecological perspectives of the atmosphere.* N.Y. Cambridge Univ. Press. 1978.

continued

Table 7.2 continued

Brussard, P. F. (ed.) *Ecological genetics: the interface.* New York. Springer Verlag. 1978.
Budyko, M. I. *Global ecology.* Moscow. Progress Publishers. 1980.
Carson, R. *The silent spring.* London. Penguin. 1962.
Clarke, G. L. *Elements of ecology.* N.Y. Wiley. 1954.
Colinvaux, P. A. *Introduction to ecology.* N.Y. Riley. 1973.
Emlen, J. M. *Ecology: an evolutionary approach.* Reading, Mass. Addison-Wesley. 1973.
Fittau, E. J. *Biogeography and ecology in South America.* Hague. Junk. 1969.
Ford, E. B. *Genetics and adaptation.* London. Arnold. 1976.
Grzimek's Encyclopedia of ecology. New York. van Nostrand Reinhold Co. 1976.
Jeffers, J. N. *An introduction to systems analysis with ecological applications.* London. Arnold. 1978.
Imbrie and Newall. *Approaches to Paleoecology.*
Jorgensen, S. E. *Handbook of environmental data and ecological parameters.* Oxford. Pergamon. 1979.
Kendeigh, S. C. *Ecology with special application to animals and man.* New Delhi. Prentice-Hall of India. 1980.
Kumar, H. D. *Modern concepts of ecology.* 2nd. ed. New Delhi. Vikhas. 1977.
Kunkel, G. *Biogeography and ecology in the Canary Islands.* Hague. Junk. 1974.
Kuschel, G. (ed.) *Biogeography and ecology in New Zealand.* Ibid. 1975.
Mani, M. (ed.) *Biogeography and ecology in India.* 1974.
Monteith, J. L. *Principles of environmental physics.* London. Arnold. 1973.
Nebel, B. J. *Environmental science: the way the world works.* Englewood Cliffs, N.J. Prentice-Hall. 1981
Odum, E. P. *Ecology: the link between the natural and the social sciences.* London. Holt, Rinehart and Winston. 1975.
Odum, E. P. *Basic ecology.* Phila. Sanders College Publishing. 1983.
Poole, R. W. *An introduction to quantitative ecology.* N.Y. McGraw Hill. 1974.
Pruitt, W. O. *Boreal ecology.* London. Arnold. 1978.
Southwood, T. R. E. *Ecological methods: with particular application to the study of insect populations.* London. Chapman and Hall. 1978.
van Noordwijke, M. *Ecology textbook for the Sudan.* Khartoum. Khartoum Univ. Press. 1984.
Verma, P. S. *Cell biology, genetics, and ecology.* New Delhi. S. Chand. 1977.
Watt, K. E. *Principles of environmental science.* N.Y. McGraw Hill. 1973.
Werger, M. J. A. (ed.) *Biogeography and ecology in Southern Africa.* Hague. Junk. 1978.
Wratten, S. D. *Field and laboratory exercises in ecology.* London. Arnold. 1980.

ANNEX 8

INDIGENOUS PLANTS USED IN TRADITIONAL MEDICINE

There is a long tradition of the use of indigenous plant varieties in Yemeni medicine and various local industries. No systematic study of the indigenous medicinal plants has yet been done, although a preliminary listing was prepared by Fleurentin and Pelt (1982). A number of important Arabic texts discuss the medicinal plants of Yemen (Varisco 1989c), but there is relatively little data available on the folklore of such plants and their use.

This annex includes an initial study about the folklore of indigenous medicinal plants in Yemen. It was compiled by a contemporary Yemeni historian and folklorist, Muhammad Abd al-Rahim Jazm. Information is provided on 20 local plants in chart format as follows:

Arabic name of plant
Other Arabic names
Description of plant and its fruits and seeds
Season in which plant grows or is collected
Areas in which plant grows
Medicinal and other uses
Detailed description of use
Price in local market (if available)
Published sources which mention the plant
Proverbs and stories about the plant
Potential for commercial production or collection

This information was collected in Arabic and is included in this annex as a database. A sample of the plants described is translated below. Plans for a major study along the lines begun here are presented in Annex 12.

PLANT NAME: *sabir* (aloe)

OTHER ARABIC NAMES: see *khir*

DESCRIPTION OF PLANT AND ITS FRUITS OR SEEDS: *Sabir* grows naturally in the soil. Over time the lower fleshy leaves die off and others grow above them. At this time a thick cylindrical stalk, brown or green in color, appears. The leaves are green mixed with red. On their edges are small dentitions like the teeth of a rake, but these are not sharp. The leaves are inclined away from the stalk, which grows straight up in the air. This stalk is thick and large and covered with fibres. The sap reaches to within c. 2 cm of the tip of the leaf and is less abundant toward the top of the plant. When the plant reaches a stage of ripeness, there emerges from the middle a straight central stalk, brown in color, which is as high as 60 cm. Along this stalk are red flowers from top to bottom. When the central stalk dies, the red flowers fall off the stalk, as this turns soft and white in color.

SEASON IN WHICH PLANT GROWS OR IS COLLECTED: After the plant appears, its fleshy leaves last an entire year. The fleshy leaves and flowers are considered best in spring, as the heat begins and rainfall is more plentiful. It is considered a spring plant – in terms of practical observation – because its red flowers and seed appear in spring and die off in winter. People seek *sabir* when its leaves are full of fleshy pulp in spring. When they collect, it is said to be best at sunset, when they make large incisions along the fleshy leaf but in about half the depth. This fleshy pulp is extracted into a special broad container.

AREAS IN WHICH PLANT GROWS: This grows in all the coastal and mountainous areas of Yemen that are hot and moderately hot. The best varieties are said to come from the Tihama, Ta'izz, Ibb, Hajja, Sa'da, parts of the Sana'a region and Mahwit.

MEDICINAL AND OTHER USES: The fleshy pulp is used either fresh or dried into a hard cake for a variety of medical purposes. This is usually after it has been mixed in a concoction with other plant materials, seeds or leaves. In Yemeni folk medicine, both in the country and cities, it is generally drunk to block bleeding, especially in hot and humid areas such as the coastal region, Aden and Hadramawt. This is primarily for treating boils and related growths on the body that are common in these areas. In some parts of Yemen the fleshy part of the leaves is taken directly and applied to burned skin, especially for areas exposed on the head and neck. This is because it is thought to be useful for reducing the swelling that occurs after burns.

DETAILED DESCRIPTION OF USE: For blocking bleeding or subsiding the occurrence of boils and related growths, it is drunk. If it is dried and hard, it will be dissolved in hot water or fresh milk in half of a small glass. As a cure for burns, it will all be applied over the burn, or only half will be applied if the burn is slight. People do not repeatedly swallow it because they believe this will weaken the heart.

PRICE IN LOCAL MARKET: Not available.

PUBLISHED SOURCES WHICH MENTION THE PLANT: al-Bur'a (N.D.), al-Malik al-Muzaffar (1972).

PROVERBS AND STORIES ABOUT THE PLANTS: Not available.

POTENTIAL FOR COMMERCIAL PRODUCTION OR COLLECTION: The main value of *sabir* is for the fleshy pulp or sap. It is widely found in Yemen in a number of varieties with a long history of medicinal use.

[26 pages of Arabic text follows this introduction]

ANNEX 9

UNITED NATIONS LIST OF NATIONAL PARKS AND PROTECTED AREAS FOR YEMEN

PROPOSED SITE(S)

Kumran Islands R.

RECOMMENDED SITE(S)

Al Kadan, Dobera Parkland, Tihamah
Al Khawkhah
Al Mahwit woods
Al Mukha
Al Qutay-Jabal Bura, Tihamah
Dhubab
Hidhran marshes
Humar Island
Jabal Bura valley forest
Jabal Sabir-Wadi Thabad wadis
Wadi El Dhabab
Jabal an Nabi Shu'ayb
Ra's Katanib Island
Ras Isa MP
Shibam/Kawkaban escarpment
Ta'izz woods
Uqban (Ukban) Islands
Wadi Duba forest
Wadi Mawr, Tihamah
Wadi Rima estuary
Wadi Siham
Wadi Suq'Abs, Tihamah
Zubayr Islands
Zuqur Islands MNP

Shortcomings of list:

1. No sources on who proposed
2. Difficult to identify because of transliteration system used
3. Some areas far too large

List sent to MAF and passed to EPC. No action taken. This highlights fundamental problems with lack of institutional focus for conservation and thus need for IUCN affiliation.

ANNEX 10

CASE STUDY OF JABAL BURA

Note: Jabal Bura has been proposed by several experts as a prime area for protection of the flora and fauna. This annex contains general information based on reports by Scholte (March 1988), Hertzog (1989), Jamaleddine (1988) and observations by Varisco in November 1989.

GENERAL INFORMATION

Jabal Bura is a granite intrusive rising up in the Tihama foothills to an elevation of more than 2000 meters. This altitude is reached from the coastal plain in only a 5-kilometer distance, an indication of the steep nature of the slopes. The highest point in the district (*nahiya*) of Bura is Jabal 'Azan (2600 meters). The administrative district of Bura is bounded on the east by the mountains of Haraz, to the south by the mountains of Rayma, and to the north by Wadi Siham. Jabal Bura is located about 60 kilometers east of Hodeidah. A road enters from Wadi Rijaf for a distance of about 6 kilometers until vehicles can no longer pass. This stopping point is known as Dar al-Harf and from here one must walk or transfer goods to donkeys in order to reach the villages on the high slopes.

Given the rapid change in elevation from the coastal zone to high mountains, there is a dramatic climatic change. The rainfall is estimated at only 400-600 millimeters per annum, but in fact this is a region of high humidity so that the flora is far more varied than the rainfall would indicate. The main rainy season is from July through September, a period generally called *kharif* in Yemen. The average yearly temperature is 30°C, with a range from 15°-40°C.

The upper slopes (above 1200 meters) of Bura, where most of the population resides, are intensively cultivated and grazed. An estimated 40,000 people live in the district of Bura, although many villages still cannot be reached by vehicles. This region is famous for its coffee, although grains and other tree crops are cultivated. The lower slopes are largely uncultivated because of the steep slopes. The only use of this area is for grazing flocks and collection of fuelwood. However, a limited number of fields have been built along the car road through Wadi Rijaf.

FLORA

At the northern part of Jabal Bura is the valley of Wadi Rijaf, through which a car road now winds. This wadi is one of the best preserved examples of indigenous forest in Yemen. Most of the lower parts of this valley are dry shrubland of mainly *Anisotes trisulcus* and several succulents such as *Caralluma russeliana* and *Euphorbia* spp. At an altitude of 400-800 meters there is a dramatic change in vegetation. At 400 meters tall trees (primarily *Ficus* spp. and *Trichilea emetica*) occur in the wadi. At 600 meters *Acacia abyssinica* is dominant, but other common trees include *Combretum molle*, *Berchemia discolor* and *Trichilea emetica*. These form a forest of up to 20 meters height with a dense shrub layer of *Carissa edulis* and *Barbeya oleoides*, as well as regeneration of the dominant trees. On the higher slopes a well-developed dry scrub forest of *Acacia asak* occurs. The major trees, shrubs, grasses, herbs and succulents observed by Scholte and Hertzog include:

Trees and shrubs

Abrus bottae
Acacia abyssinica macroloba
Acacia asak
Acacia mellifera
Acacia nubica
Acacia tortilis
Acalypha fruticosa
Adenium obesum
Anisotes trisulcus
Balanites aegyptiaca
Barbeya oleoides
Berchemia discolor
Breonadia salicina
Cadia purpurea
Cahania lanifolia
Calotropis procera
Carissa edulis
Cytisus rotundifolia
Commiphora abyssinia
Commiphora kataf
Commiphora oppobalsamum
Dobera glabra
Euclea schimperi
Ficus glauca
Ficus populifolia
Ficus salicifolia
Ficus sycomorus
Ficus vasta
Grewia tembensis
Grewia tenax
Grewia velutina
Grewia villosa
Heeria reticulata ?
Hibiscus diflexi
Maytenus sp.
Mimusops laurifolia
Oleo europaea
Ozorowa insignis
Ormocarpum yemense
Pandanus odoratissimus
Phoenix reclinata
Ricinus communis
Syzgium guineense
Tamarindus indica
Tamarix nilotica
Terminalia brownii
Trichilea emetica
Ziziphus mucronata
Ziziphus spinachristi

Characteristic grasses, herbs and succulents

Actinopterys sp.
Aloe sabae (tree aloe)
Aloe vera
Aristida adscensionis
Barleria bispinosa
Blepharis ciliaris
Boerhavia diffusa
Caralluma russeliana
Caralluma spp.
Cissus quadrangularis
Cissus rotundifolia
Euphorbia cactus
Euphorbia inarticulata
Fagonia indica
Gomphocarpus fruticosus
Indigofera spinosa
Ocimum basilicum
Opuntia ficus indica
Pennisetum setaceum
Sansevieria ehrenbergii
Solanum incanum
Tephrosia purpurea
Tetrapogon cenchriiformis

FAUNA

The variety of vegetation and relative lack of human settlement in Wadi Rijaf provide a home for a wide variety of fauna. The major mammal here is the hamadryas baboon (see Annex 5), which depends heavily on forage resources in the forest, especially fruits of *Tamarindus indica* and *Acacia asak*, as well as leaves of *Grewia* spp. Sholte (year?) observed a troop of c. 50, while Varisco (year?) observed three small foraging parties in one morning. There is a rich variety of reptiles and amphibians, including an endemic species of monitor lizard, observed by Varisco (year?). A full discussion of the fauna will appear in Sholte and Evans (in press). The birds observed by Scholte and Evans (year?) in Jabal Bura include:

Bubulcus ibis	Cattle Egret
Scopus umbretta	Hamerkop
Ciconia ciconia	White Stork
Milvus migrans	Black Kite
Neophron percnopterus	Egyptian Vulture
Gyps fulvus	Griffon Vulture
Circaetus gallicus	Short-toed Eagle
Terathopius ecaudatus	Bateleur
Melierax metabates	Dark Chanting Goshawk
Accipiter gentilis	Goshawk
Accipiter nisus	Sparrowhawk
Accipiter badius	Shikra
Buteo buteo vulpinus	Steppe Buzzard
Buteo rufinus	Long-legged Buzzard
Aquila clanga	Spotted Eagle
Aquila nipalensis	Steppe Eagle
Aquila heliaca	Imperial Eagle
Aquila chrysaetos	Golden Eagle
Aquila verreauxii	Verreaux's Eagle
Hieraaetus pennatus	Booted Eagle
Hieraaetus fasciatus	Bonelli's Eagle
Falco tinnunculus	Kestrel
Falco subbuteo	Hobby
Falco peregrinus	Peregrine
Alectoris melanocephala	Arabian Red-legged Partridge
Numida meleagris	Helmeted Guineafowl
Columba livia	Rock Pigeon
Streptopelia roseogrisea	African Collared Dove
Streptopelia semitorquata	Red-eyed Dove
Streptopelia senegalensis	Palm Dove
Treron waalia	Bruce's Green Pigeon
Clamator jacobinus	Jacobin Cuckoo
Centropus superciliosus	White-browed Cougal
Otus senegalensis	African Scops Owl
Bubo africanus	Spotted Eagle Owl
Caprimulgus nubicus	Nubian Nightjar
Caprimulgus sp.	Nightjar sp.
Apus melba	Alpine Swift
Apus affinis	Little Swift
Merops orientalis	Little Green Bee-eater
Tockus nasutus	Gray Hornbill
Dendrocopos dorae	Arabian Woodpecker
Ptyonoprogne fuligula	African Rock Martin
Hirundo rustica	Swallow
Hirundo daurica	Red-rumped Swallow
Anthus similis	Long-billed Pipit
Motacilla cinerea	Gray Wagtail
Pycnonotus xanthopygos	Yellow-vented Bulbul
Cerotrichas glactotes	Rufous Bush Robin
Cerotrichas podobe	Black Bush Robin
Irania gutturalis	White-throated Robin
Phoenicurus phoenicurus	Redstart
Cercomela melanura	Blackstart

Oenanthe lugens lugentoides	South Arabian Wheatear
Monticola rufocinereus	Little Rock Thrush
Monticola solitarius	Blue Rock Thrush
Prinia gracilis	Graceful Prinia
Hippolais pallida	Oliverous Warbler
Sylvia leucomelaena	Arabian Warbler
Sylvia atricapilla	Blackcap
Phylloscopus umbrovirens	Brown Woodland Warbler
Phylloscopus trochilus	Willow Warbler
Terpsiphone viridis	Paradise Flycatcher
Turdoides squamiceps	Arabian Babbler
Anthreptes metallicus	Nile Valley Sunbird
Nectarinia habessinica	Shining Sunbird
Nectarinia osea	Orange-tufted Sunbird
Zosterops abyssinica	White-breasted White-eye
Tchagra senegala	Black-headed Bush Shrike
Lanius isabellinus	Isabelline Shrike
Lanius minor	Lesser Gray Shrike
Lanius nubicus	Masked Shrike
Corvus thipidurus	Fan-tailed Raven
Onychognathus tristramii	Tristam's Grackle
Ploceus galbula	Ruppell's Weaver
Estrilda rufibarba	Arabian Waxbill
Eudice cantans	African Silverbill
Serinus rothschildi	Arabian Serin
Carduelis yemenensis	Yemen Linnet
Emberiza tahapisi	Cinnamon-breasted Rock Bunting

CONSERVATION INITIATIVES

The presence of indigenous forest in Wadi Rijaf has led the Directorate of Forestry in the MAF to draw up plans for a protected forestry preserve in this area (Jamaleddine 1988). A member of the Local Council for Bura (Shu' 1989) has noted the importance of this area and suggested that the trees and animals be protected here and that hunting or trapping be banned. In fact the Local Council has already taken steps to ban the commercial cutting of wood here. However, it is necessary, as pointed out by the Local Council, for residents to have access to alternative fuel supplies. At present the butane gas container costs 100 Yemeni riyals and has to be carried up by donkey to most villages. There is great potential in Wadi Rijaf for observation of baboons, since they are relatively contained in a wild stretch of the valley.

ANNEX 11

DRAFT PROPOSAL FOR PROJECT GAZELLE IN YEMEN

Project rationale

Wildlife Conservation does not yet exist in Yemen, although several animal species in the country are endangered. Two of the most prominent species in the history and lore of Yemen are the ibex and gazelle. While these two ungulates once roamed freely in South Arabia, only a few gazelles are left and ibex may be extinct in the wild. The government of Yemen banned the hunting of gazelles after 1977 for a period of ten years, but it currently lacks the personnel and capabilities to protect these and other animals. The Department of Wildlife and Zoos in the Ministry of Agriculture is not yet operational. Thus, there is a great need for a catalyst project to initiate wildlife conservation in the country.

A project to return the ibex and perhaps the gazelle in Yemen would lend itself to a high-visibility media campaign, because of the natural interest of the Yemeni people in these two species. This would not only be a first step toward promotion of wildlife conservation in Yemen, but would also encourage the government to support conservation along with other development priorities. At a time when the government is interested in increasing tourism, the return of these two species would add to the natural attractions of the country. Such a project would also allow international conservation organizations to become involved in the area for the first time.

Project design

The project would begin with a feasibility study to assess the current status of the ibex and gazelle in Yemen, and design a project to protect and reintroduce these two species in the wild and/or in future government preserves.

This project should be designed along the model of the successful reintroduction of the oryx in Oman, a country with a similar environmental and cultural setting to Yemen. The ultimate success of the project will require community involvement, so it is necessary to work with government and locals councils in the design stage.

A Design Team of two individuals should include a conservation specialist familiar with the species and a social scientist with development experience in Yemen. The team will spend four weeks on a feasibility study with the following scope of work:

1. Review the literature on the ibex and gazelle in the region.

2. Visit Oman to examine the oryx project and interview Omani officials on problems and strengths of the project there.

3. Coordinate activities in Yemen with the EPC and the MAF.

4. Field trips in Yemen to locate any remaining ibex or gazelles in the wild.

5. Interviews with government officials, Yemeni community representatives, and Sana'a University Faculty on how to design the project.

6. Prepare final report on findings and recommendations.

Itinerary

1 day	Briefing in Washington at WWF, etc.; review of available literature.
2 days	Travel, Washington-Oman.
5 days	Examine oryx project in Oman.
1 day	Travel, Oman-Yemen.
3 days	Meet government officials, Sana'a University Faculty, and arrange field trip.
9 days	Field trip to locate remaining ibex and gazelles.
2 days	Discussions in Sana'a with government officials, Yemeni scholars, media, etc..
4 days	Preparation of final report and final briefings.
1 day	Travel, Yemen-Washington.

The total number of workdays will be 28.

Budget

	$
Airplane tickets for 2: Washington-Oman-Yemen-Washington $2,500 each x 2	5,000
Per diem (32 total days) 32 x 2 x $150/day	9,600
Salary (28 work days) 28 x 2 x $250/day	14,000
Local travel (field trips, etc.)	1,500
Miscellaneous (typing, xerox, etc.)	500
Total direct costs	$30,600

Preliminary bibliography

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Serjeant, R. B. (1976) *South Arabian Hunt*. London: Luzac.

Stanley-Price, Mark (1982) The Yalooni Transfer. *ARAMCO World Magazine* 33(4): 18-19.

Varisco, D. M. (1987) *Horns and Hilts. Wildlife Conservation for North Yemen*. Washington: World Wildlife Fund.

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ANNEX 12

DRAFT PROPOSAL FOR ECONOMIC VIABILITY OF INDIGENOUS PLANTS (EVIP) PROJECT

Project rationale

The diversity of flora in Yemen is considerable. Many of the indigenous plants have medicinal value in the traditional culture (see Annex 8), although most of this traditional knowledge has not been recorded. It is important that the traditional lore on plant use be recorded, before the older generations which have this knowledge die off. At the same time, it is important to determine the economic viability of harvesting or collecting certain natural species.

The purpose of this project is to define the species of plants used in Yemen for medicinal purposes, examine the use of these plants in cultural context, examine the biochemistry of selected plants, and determine the economic potential of certain Yemeni plants which may be of interest for further research or pharmaceutical companies. The ultimate goal of the project is to provide a viable economic livelihood for dealing with herbal plants at the community level. Such a project is especially urgent, since traditional knowledge of plant use is rapidly disappearing. Certain Yemeni species no doubt contain active ingredients significant for medical research (see Annex 4).

Project design

This study should focus on existing expertise in botany, pharmacology and folklore in Yemen. The team should consist of a botanist to identify Yemeni species, a folklorist to collect information on plant use and terminology, a pharmacologist to isolate the active ingredients, and a market specialist to assist in finding appropriate pharmaceutical firms. The approximate cost of the project would be $50,000 spread out over 5 months of part-time activity.

The research team would perform the following functions:

Botanist

1. Review the literature on Yemeni species.
2. Identify taxonomic status of known medicinal plants and where they are located.
3. Collect specimens for analysis in the laboratory.
4. Record local names of plants.

Folklore specialist

1. Review literature on folk medicine and herbal practices in Yemen and the region.
2. Coordinate field research with the botanist to obtain ethnographic data or folklore on the use of plants.
3. Identify medicinal plants according to use and suggest species for biochemical analysis.
4. Work with local councils and appropriate institutions in order to develop a system for collecting, processing or preserving, and marketing relevant plants.

Pharmacologist

1. Analyze specimens for biochemical composition.
2. Identify active ingredients and possible links to attributed medical value.
3. Present findings in acceptable form to pharmaceutical firm for further research c.' purchase.

Market specialist

1. Contact pharmaceutical firms for interest in identified plants.
2. Work with local community in developing viable livelihood based on collecting or farming relevant medicinal plants.

Implementation

1. Project should be implemented with assistance of Faculty from Sana'a University and other local expertise. Suggested consultants include Dr Abdul Rahman Dubaie (botanist), Dr-Nizar Ghanem (pharmacologist) and Mr Muhammed Abd al-Rahim Jazm (folklorist).
2. Outside technical assistance should be provided for both local and international marketing. Additional assistance may need to be provided in the biochemical analysis.
3. Initiate as pilot project on one or two plants in a specific location. Once economic viability is established, the need for outside technical assistance will be minimal.
4. Provide necessary equipment and short-term training to achieve goals of project. It would be advisable to provide training course in conservation to one of the Yemeni team members in advance of the project.

Work plan

1. Establish detailed scope of work and itinerary; determine and purchase necessary equipment.
2. Botanist and folklorist begin field research and identify most promising species (c. 2 months part-time)
3. Pharmacologist begins analysis of selected species (c. 2 months).
4. Marketing specialist arrives in Yemen to work with team at community level and with pharmacologist vis-a-vis international pharmaceutical firms.

Budget

	$
International Travel (U.S.-Sana'a-U.S.) 2 x $2500	5,000
Salary	
Yemeni botanist ($100/day x 40)	4,000
Yemeni folklorist ($100/day x 40)	4,000
Yemeni pharmacologist ($100/day x 20)	2,000
Pharmacologist ($200/day x 20)	2,000
Market specialist ($200/day x 20)	4,000
Training seminar at foreign herbarium	
Ticket: Sana'a-London-Sana'a	1,500
Tuition at herbarium (5 weeks)	2,000
Per diem ($100/day x 35)	3,500
Miscellaneous expenses	500
Equipment for project (includes herbarium equipment for collection and storage, camera, film)	2,000
Expandables	
Local travel	2,000
Typing, xerox, etc.	1,000
Film and processing	500
Total direct costs	$36,000

ANNEX 13

ALTERNATIVE SEED VARIETIES FOR LOW-COST TERRACE STABILIZATION

Arid-zone seed varieties available for on-farm trials, direct-seeding and nursery planting to provide fodder, fuel, building wood, food, medicine, bee forage, soil stabilization and shade:

	Fodder	Firewood	Wood for building	Food and medicine	Bee forage
FOR UPPER ESCARPMENT HIGHER RAINFALL					
Acacia aneura	yes	yes	yes		
Acacia murryana	yes			yes	
Acacia pendula	yes	yes	yes		
Acacia pruinocarpa	yes				
Acacia salicina	yes	yes	yes		
Acacia saligna	yes	yes	yes		
Atriplex amnicola	yes				
Atriplex lentiformis	yes				
Atriplex nummularia	yes	yes			
Atriplex undulata	yes				
Cassia sturtil	yes	yes			
Casuarina obesa/glauca	yes				
Ceratonia slliqua	yes	yes	yes	yes	yes
Chamaecytisus palmensis	yes				yes
Gleditsia tricanthos	yes				yes
FOR TIHAMA LOW RAINFALL					
Acacia ampliceps	yes				
Acacia holosericia	yes	yes		yes	
Acacia ligulata	yes				
Acacia stenophylla	yes				
Acacia tumida	yes				
Acacia victoriae	yes	yes			
Albizzia lebbeck	yes	yes	yes	yes	
Casuarina descasneana	yes	yes			
Casuarina equisetifolia			yes		
Dodoneae viscosa	yes		yes	yes	yes
Grewia oppositifolia	yes	yes			
Leucaena leucocephala:					
cvK8	yes	yes	yes	yes	yes
cv *cunningham*	yes	yes	yes		yes
Lysiphylum cunningharnii	yes				
Sesbania formosa	yes			yes	
Ventilago viminalis	yes				
Zizyphus jujube	yes	yes	yes	yes	yes

ANNEX 14

ISLAMIC PRINCIPLES FOR CONSERVATION OF BIOLOGICAL SPECIES
(from Ba Kader *et al.* 1983)

Plants and animals

No one can doubt the importance, great use and benefit of plants and animals for mankind. In addition, the Glorious Quran mentions the aesthetic and decorative functions of these creatures in addition to their other functions and, since peace of mind is one of the religious requirements which should be fully satisfied, God in creating all plants and animals provides pleasure and enjoyment to man so as to satisfy his peace of mind, a factor which is essential for man's proper functioning and full performance. The Glorious Quran also mentions other functions which these creatures perform and which man may not perceive, namely the mandatory function of worshipping God, declaring His praise and bowing down to Him. God said, "Seest thou not that to God bow down in worship all things that are in the heavens and on the earth – the sun, the moon, the stars, the hills, the trees, the animals ..." and God says, "There is not a thing but celebrates His praise, and yet ye understand not how they declare His glory!" and He says, "Whatever beings there are in the heavens and the earth do prostrate themselves to God – with good will or in spite of themselves."

Islam emphasizes all measures for the survival and perpetuation of these creatures so that they can fully perform the functions assigned to them, for He considers them living communities, exactly like mankind. God says "There is not an animal (that lives) on the earth, nor a being that flies on its wings, but (forms part of) communities like you." Also the Prophet (God bless him and grant him peace) has rightly shown us, through his commandments and teachings, how to rear and conserve these creatures. An ant once stung one of the Prophets who then ordered a whole colony of ants to be burned down in retaliation. God taught him in rebuke, "Thou hast destroyed a whole nation that celebrates God's praise for an ant stung thee." The Prophet of Islam also told us of a woman who would be sent to Hell because of a cat she locked up without feeding or releasing to feed on vermin of the earth." God thanked a serf who saved a dog from death by giving it water to drink, thus quenching its thirst." The Prophet of Islam has forbidden leaving animals to starve and damned a group of people who used a bird as a target.

Islam looks upon these creatures in two ways:

- As living creatures in themselves attesting to God's wisdom and omnipotence.

- As creatures subjected in the service of man and playing a vital part in the development of this world.

Hence the necessity of conserving and developing them both for their own sake and for the benefit of mankind.

Legislative Rules of Islamic Law which Govern All Procedures and Measures for the Protection and Conservation of the Environment

1. Protection, conservation and development of the environment and natural resources is a mandatory religious duty to which every Muslim should be committed. This commitment emanates from the individual's responsibility before God to protect himself and his community. It is also a common social duty which rulers, administrative and municipal agencies and organizations undertake in accordance with the responsibilities assigned to them.

2. Religious awareness and guidance in this field is necessary so that each individual may take part in the protection and development of the environment and natural resources. The aphorism transmitted by tradition says, "All people are God's dependents and He loves most those who are the most useful and beneficial to their dependents." God says, "Do no mischief on the earth after it hath been set in order" and "... but God loveth not mischief." Any deliberate or intentional damage to the natural environment and resources is a kind of mischief or corruption that is forbidden by Islam. It is rather a kind of detestable impudence which every Muslim should shun, and which every ruler or supporter should prohibit, especially if it leads to or results in general damage. The aphorism transmitted by tradition says, "He who does not show concern for the interest and good of all Muslims is not a Muslim."

3. Religious awareness and Islamic guidance includes a call to all individuals, at all levels and by all possible means, to commit themselves to Islamic morals and manners in dealing with nature, the environment and the natural resources for their sustainable use and development. The best way to achieve this is by reminding all individuals of their following religious duties:

   - No extravagance, excessive use or over-utilization.

   - No illegitimate or unlawful attempt at destroying the natural resources.

   - No damage, abuse, pollution or distortion of the natural environment in any way.

   - Construction and development of the earth, its resources, elements and phenomena through the improvement and betterment of natural resources, the protection and conservation of all existing forms of life, the cultivating of land and the reclamation and cleansing of the soil, air and water.

4. Ownership of all environmental elements is the common and shared right of all members of the Islamic community. Each is entitled to use and benefit from them without infringement, violation or delay of other members' equal rights. In this respect, needs and wants should be carefully and precisely assessed both qualitatively and quantitavely.

5. Islamic law stipulates the interference of the ruling authorities for the good and interest of all people and to eliminate common mischief and corruption. This is their original and primary duty. This interference is also determined and limited by the general rules and implications of Islamic law and jurisprudence and by the actual, lawful tasks and responsibilities assigned to them. The juristic rule in this connection is "The leader's actions are determined and dictated by the common good." There is no doubt that a leader's actions may become illegitimate and unlawful if they are based on whim and absolute autocracy with no consideration for people's interests and the common good. The state's legitimate interference is aimed at favouring the actual and essential common interests, and at the protection of those interests against any other conflicting interests.

6. The interests of the nation and the community should be preferred to the interests of individuals in the case of conflict. Any limited harm or damage to a particular individual could be accepted if it leads to a general avoidance and control of general damage to society and the environment at large. Similarly, overlooking, or even neglecting, private interest for the purpose of achieving and protecting the common interest of the public is the same as opting for the lesser evil and avoiding the greater damage by accepting the lesser. The juristic rule in this respect is "If two evils or mischiefs conflict, the lesser could be accepted to avoid and prevent the greater."

7. Interests are to be assessed and classified according to their importance and urgency. There are fundamental interests, needed interests and luxury interests. Preference and priority should be given to fundamental interests if these conflict with needed or luxury interests. In the same way, priority should be given to needed interests if these conflict with luxury interests.

8. Interests differ in degrees of actuality and urgency. There are actual or urgent interests, and projected or probable interests. It goes without saying that priority should be given to actual or urgent interests in case of conflict with any other projected or probable interests.

9. Some actions help to achieve some interests, but they may bring about similar, even heavier, damage and mischief. The juristic or doctrinal rule in this connection is "Avoidance of mischief should be given preference and should come before the achievement of interests," because the first step towards the achievement and realization of the common good is to eliminate mischief.

10. The primary duty of the ruler and his assistant, whether they are administrative, municipal or judicial authorities, is to do their best to realize the interests of individuals for the betterment of life and society as a whole. This also includes protection, conservation and development of the environment and natural resources. This process covers two major phases:

    - Prevention of damage.

    - Remedy of damage.

11. The State has the right to take all measures and actions to avoid, prevent or minimize damage before it occurs in application of the following rules: "No damage or retaliation for such damage is allowed" and "annihilating all pretexts leading to mischief."

    - The State has the right to forbid any action, whether temporary or permanent, that may lead to or result in damage or mischief. No one is entitled to stop or even spoil the community's sustainable use of any of the basic elements or resources of the environment. This applies to air pollution by smoke, and exhaust from factories and cars. It equally applies to water pollution through destruction of public wells, or the dumping of toxic materials into them to render them unsuitable or unfit for use.

    - The State has the right to limit the scope of action, its place, time, kind and quality so as to prevent, avoid, control, minimize or limit damage or restrict it to a certain place or time.

    - The State has the right to impose certain measures or technical standards to prevent the occurrence of damage, or minimize, it, or restrict it to the least and narrowest scope possible and with the least possible impact. Experts and specialists are to undertake this task, each in his own field.

12. The State has the right to take all necessary measures and actions associated with the elimination of actual damage, repair of its effects and provision of indemnity for it in application of the rules that "Damage or mischief should be eliminated and removed," "Damage or mischief should not be removed through similar damage or mischief," "Look for and resort to alternatives in case the original becomes impossible" and "Obligation or necessity does not annihilate or delay the rights of others."

    - The State, for instance, has the right to hold individuals, organizations, establishments and companies responsible for the elimination and removal of damage resulting from their activities, enterprises and projects which are needed for the welfare of the whole community and which may result in, or lead to damage to, the environment and the natural resources or elements. The rule in this connection is "Damage or mischief should be removed as much a possible."

    - The State has the right to impose moratoria on certain projects or enterprises if it realizes that such projects or enterprises will lead to, or result in, real damage to the environment that is in excess of the benefits thereof. The elimination of mischief should be given preference and priority to the fulfilment and achievement of interests. If, however, the community is in urgent

need of some action that may result in certain damage, the need in this case should be considered a necessity in so far as it permits the forbidden. Excuses and pretexts for such actions should, in this case, be carefully and precisely assessed each time, according to its own circumstances and situation. If, however, the need for such harmful actions vanishes, the authority should stop these actions or impose moratoria on them for "Whatever is permissible for a certain reason or pretext becomes null and void when that reason or pretext vanishes or becomes irrelevant."

- The State has the right to hold individuals, organizations, establishments and companies responsible for the cost of eliminating the damage resulting from unlawful activities in violation of the terms of licences, charters, permits or contracts. The juristic rule is "The user or executor is a guarantor even if his act is not deliberate or intentional." Nevertheless, individuals, organizations, establishments and companies should not be held responsible for any damage or mischief that may result from exercising their lawful and legitimate or licensed rights, within the usual and legitimate limits and in accordance with common practices. "For legal permission annihilates indemnity and guarantee" according to the juristic rule.

- The State has the right to claim damages or indemnity from individuals, organizations, establishments, and companies for avoidable damage to the physical or natural environment, resulting from unlawful activities which cannot be eliminated or recovered.

- The State has the right to censure or blame individuals, or the owners of organizations and establishments or their designees, should they infringe or violate the terms of licences, charters, permits or contracts intentionally or deliberately or through evident negligence or violation of the general policies and instructions set forth by the State for the conservation of the natural environment, its elements and its resources.