

Geobotany 25

Vegetation of the Arabian Peninsula

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CHAPTER 12

Diversity and Conservation

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"To sum up, I have not collected more than 250 species over the whole of the Immamat of Muscat. The local people say that very shortly after the rains (which occur once or twice a year) the land is covered with flowers. In any case I am convinced that in this country, the most barren in the world, it would be difficult to find more than 500 species."

Aucher-Éloy, in 1838, after his botanical excursion to Oman (Jaubert 1843).

12.1 Introduction

Not all of the early travellers and plant collectors to Arabia shared Aucher-Éloy's pessimistic musings about the barrenness of the land and its impoverished diversity, although his estimate of the number of species in northern Oman was not far wrong (Ghazanfar 1996a). Theophrastus, probably using accounts brought home by Greek sailors, wrote of the Yemeni highlands in 295 BC that "... the mountains, they say, are lofty, forest-covered and subject to snow, and rivers from

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them flow down into the plain..." (quoted in Groom 1981, from Hort 1916). Niebuhr (in the introduction to Forsskål 1775) wrote of the valley of Surdud in Yemen that "... surrounded by mountains, and profiting from cool climate and abundant water, [it] was exuberantly rich in plants...". In addition to these pleasant impressions, the great trade between southern Arabia and Europe in frankincense, myrrh and spices gained the Arabs of southern Arabia a reputation for great wealth, and their country became known as *Arabia Felix* (Groom 1981: pp. 9-11), providing the title for Bertram Thomas' well-known work (1932) of the same name.

These earlier travellers were of course correct in their time and for the corners of Arabia about which they were writing, but the landscape of the Peninsula has greatly changed during the twentieth century. The Greek sailors, Niebuhr, Forsskål and Aucher-Éloy might not recognise the same places were they able to go back today. The role of this chapter is to describe the diversity of plants in the Arabian Peninsula as we see it in the twilight of the twentieth century, and to summarise current efforts to preserve both plants and landscapes. To this end, we provide an overview of the patterns of species richness and endemism in Arabia, outline the current threats to diversity and vegetation cover, and then provide an overview of the protected areas, relevant legislation and organisations in each country of the Peninsula.

12.2 Species Richness and Endemism

Although the flora of the Arabian Peninsula is still under explored, it has received increased attention during the last two decades, and a number of regional floras and checklists have now been published (Table 12.1). From these works it is now apparent that the flora of Arabia consists of a rich and diverse grouping of plants. This is a result of past plant migrations from the Ethiopian, Palearctic and Oriental regions, possibly during more pluvial climatic conditions, combined with the climatic isolation of the montane floras following the development of the present arid regime (see section 4.2).

Both the greatest number of species and the majority of the Peninsula's endemic species occur in the mountains, which presumably provided a climatic refuge during the alternating arid and pluvial phases of the Pleistocene for those species requiring mesic conditions. The isolation of these populations by the intervening desert plains has led to vicariant evolution. Thus a number of palaeo-African and palaeo-Indo-Malesian relict species have disjunct distributions, and there are several relatively small areas with concentrations of endemic species in the western and southwestern mountains of Saudi Arabia and Yemen and in the northern and southern mountains of Oman (Ghazanfar 1994b, Miller & Nyberg 1991, see also section 4.2.3).

Table 12.1 Regional floras and checklists for the Arabian Peninsula in English.

Region/Country	Reference
Arabian Peninsula	Cope (1985, grasses), Miller and Cope (1996, vol. 1, vascular cryptogams, gymnosperms, angiosperms, Myricaceae to Neuradaceae, classification follows Engler & Prantl), Schwartz (1939)
Bahrain	Cornes and Cornes (1989), Phillips (1988)
Kuwait	Al-Rawi (1987), Boulos and Al Dosari (1994), Daoud (1985), Shuaib (1995)
Oman	Ghazanfar (1992a), Mandaville (1977, 1985, northern Oman), Miller and Morris (1988, Dhofar), Radcliffe-Smith (1980, Dhofar)
Qatar	Batanouny (1981), El Amin (1983)
Saudi Arabia	Chaudhary (1989a, grasses), Chaudhary and Cope (1983, grasses), Collenette (1985), Mandaville (1990, eastern Saudi Arabia), Migahid (1988a, 1988b)
United Arab Emirates	Western (1989), Western, Jongbloed and Böer (unpubl.)
Yemen	Balfour (1882a, 1882b, 1884a, 1884b, 1888, Socotra), Blatter (1914-1916), Boulos (1988), Gabali and Al-Gifri (1990, S Yemen), Gabali and Al-Gifri (1991, Hadhramaut), Hepper and Friis (1994), Wood (1983b, 1997)

12.2.1 SPECIES RICHNESS

The flora of the Arabian Peninsula consists of *c.* 3,500 species of vascular plants. Of these, there are *c.* 3,440 species of angiosperms, 12 species of gymnosperms and *c.* 56 vascular cryptogams (Table 12.2). The vascular cryptogams consist of a single species of *Psilotum*, (Psilotophyta, whisk ferns), 4 species of *Selaginella* (Microphylophyta, spike mosses), a single species of *Equisetum* (Arthrophyta, horsetails) and *c.* 50 species of ferns (Pterophyta). Only two genera of gymnosperms occur, *Juniperus* and *Ephedra*, distributed mainly in Saudi Arabia, Oman and Yemen. *Ephedra foliata* is the commonest gymnosperm species, distributed widely in the desert plains. The highest number of angiosperm species is found in Yemen (including Socotra), followed by Saudi Arabia, Oman, the UAE, Kuwait, Qatar and Bahrain (Table 12.3). Since a unified checklist for the recently united Yemen is not yet available, statistics for both species richness and endemism still follow the former north-south division.

Table 12.2. Number of families, genera and species in the flora of the Arabian Peninsula (adapted from Miller & Cope 1996).

	Families	Genera	Species
Vascular cryptogams	18	29	56
Gymnosperms	2	4	12
Angiosperms	<i>c.</i> 144	<i>c.</i> 1,100	<i>c.</i> 3,440

Table 12.3. Species richness in the Arabian Peninsula by country.

Country	Area (km ²)	Approximate number of species
Bahrain	660	195
Kuwait	17,818	374
Oman	270,000	1,174
Qatar	11,000	220
Saudi Arabia	2,400,000	1,800
United Arab Emirates	75,000	600
Yemen, North	190,000	1,370
Yemen, South	287,000	960

The majority of species are distributed in the families Poaceae (c. 450 spp.), Fabaceae (c. 320 spp.), Asteraceae (c. 300 spp.), Lamiaceae (c. 120 spp.), Euphorbiaceae (c. 120 spp.), Boraginaceae (c. 120 spp.), Brassicaceae (c. 115 spp.), Asclepiadaceae (c. 110 spp.), Acanthaceae (c. 110 spp.), and Scrophulariaceae (c. 100 spp.), and the largest genera are *Euphorbia* (67 spp.), *Heliotropium* (46 spp.), *Cyperus* (41 spp.), *Indigofera* (37 spp.), *Caralluma* (30 spp.) and *Convolvulus* (30 spp.) (Miller & Cope 1996). Most of the genera are monospecific and almost half the number of families are monogeneric. An analysis of species frequency per genus for the flora of Oman (Figure 12.1) is more or less applicable to the entire Arabian flora.

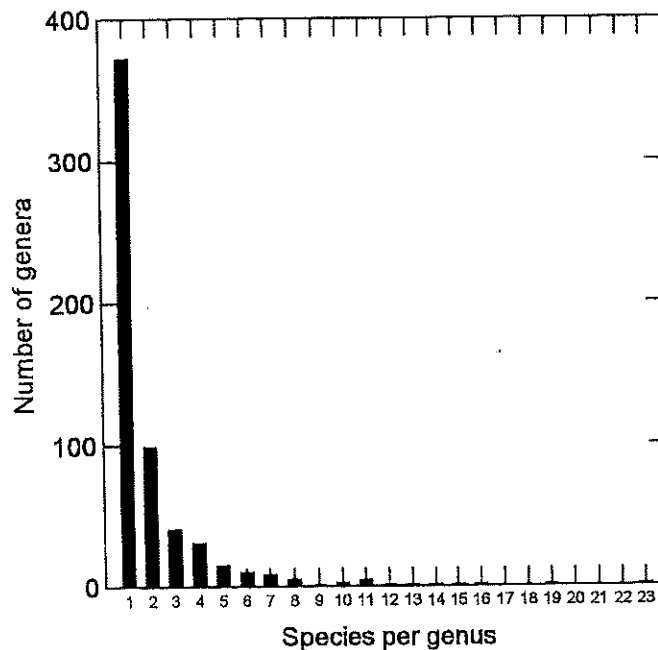


Figure 12.1 Species frequency per genus for the flora of Oman (after Ghazanfar 1992b).

Table 12.4 Endemism in the countries of the Arabian Peninsula (after Miller & Nyberg 1991). The table does not include regional endemics; i.e. those species which are found in more than one country.

Country	Endemic species (% of total species)	Endemic genera
Yemen, N	60 (4%)	Asteraceae: <i>Centaurothamnus</i>
Yemen, S	80 (8%)	Amaranthaceae: <i>Salvia</i> Lamiaceae: <i>Isoleucas</i>
Yemen, Socotra	240 (30%)	Acanthaceae: <i>Ballochia</i> , <i>Tricocalyx</i> Asclepiadaceae: <i>Duvaliandra</i> , <i>Socorranthus</i> Brassicaceae: <i>Lachnocapsa</i> Caryophyllaceae: <i>Haya</i> Cucurbitaceae: <i>Dendrosicyos</i> Rubiaceae: <i>Placoda</i> Umbelliferae: <i>Nirarathamnos</i>
Oman	75 (7%)	Asclepiadaceae: <i>Cibirhiza</i> Capparaceae: <i>Dhofaria</i> Caryophyllaceae: <i>Xerotia</i>
Saudi Arabia	35 (2%)	Asteraceae: <i>Centaurothamnus</i> Brassicaceae: <i>Dolichorhynchus</i>

12.2.2 ENDEMISM

12.2.2.1 Endemic Genera and Species

There are approximately 600 endemic species in the Arabian Peninsula, with *c.* 360 species on the mainland, of which *c.* 110 are regional endemics, and *c.* 240 species in Socotra (Table 12.4). Endemism is highest in the archipelago of Socotra, followed by the monsoon-affected escarpment mountains of southeast Yemen and Dhofar, and the mountains of the western escarpments of Saudi Arabia and northern Yemen. There is a lesser degree of endemism in the northern mountains of Oman. There are no endemic species in Bahrain, Kuwait, Qatar, or the UAE, but the Emirates shares three regionally endemic species with Oman, distributed in the foothills and wadis of the Hajar mountains.

70% of the endemic species of the Arabian Peninsula and Socotra are distributed in 15 families (Table 12.5). Many of the endemic species are succulents and form characteristic components of the vegetation of southern Arabia (see also Chapter 4). The family Asclepiadaceae is richest in endemics, with most distributed in five succulent genera: *Caralluma* (30 spp.) with 21 endemics, *Duvalia* (4 spp.) with 2 endemics, *Echidnopsis* (4 spp.) with 2 endemics, *Huernia* (6 spp.), all endemics, and *Rhytidocaulon* (4 spp.), all endemics. Similarly in the family Euphorbiaceae there are a large number of succulent endemics in the genus *Euphorbia*. Endemism is also high in the succulent family Aloiaceae.

Table 12.5. Plant families in Arabia with the highest endemism (adapted from Miller & Nyberg 1991)

Families	Approximate total number of species	Number of endemic species (% of total)
Asclepiadaceae	103	55 (53%)
Acanthaceae	104	45 (43%)
Liliaceae (incl. Aloaceae)	84	31 (37%)
Scrophulariaceae	96	35 (36%)
Lamiaceae	122	43 (35%)
Boraginaceae	119	37 (31%)
Euphorbiaceae	121	37 (31%)
Asteraceae	297	57 (19%)
Caryophyllaceae	86	11 (13%)
Leguminosae	313	28 (9%)
Brassicaceae	114	9 (8%)
Chenopodiaceae	77	5 (6%)
Poaceae	457	18 (4%)

12.2.2.2 Centres of Diversity and Endemism

Although the Arabian Peninsula does not qualify as a regional centre of endemism, the Somalia-Masai regional centre of endemism extends from eastern Africa into southern and southwestern Arabia, and the Afromontane regional centre of endemism extends from the highlands of eastern Africa into the mountains of southwestern Arabia (Figure 4.3). In addition, two subzones of the Saharo-Sindian regional zone, the Arabian regional subzone and the Nubo-Sindian local centre of endemism, are found in central Arabia and northern Oman respectively (White & Léonard 1991). In the Arabian Peninsula there are four local centres of diversity and endemism of the Somalia-Masai, two of the Afromontane and four of the Saharo-Sindian phytochoria (Boulos *et al.* 1994, Ghazanfar 1992b, in press-b, Miller & Nyberg 1991), the location, vegetation type, species richness and endemism of which are given below.

Somalia-Masai Regional Centre of Endemism

The escarpment mountains of Dhofar and the Mahra region (Dhofar Fog Oasis)

Location: Dhofar mountains (Jebel Qamr, Jebel Qara, Jebel Samhan), eastern part of the Mahra region, the surrounding Nejd desert.

Altitude: 0-2,100 m.

Typical vegetation: *Anogeissus-Acacia-Commiphora* deciduous woodland and semi-deciduous shrubs (*Olea europaea*, *Dodonaea viscosa*, *Carissa edulis*, *Rhus somalensis*), succulents (*Aloe*, *Caralluma*, *Euphorbia*, *Adenium*, *Cissus*) and semi-desert grassland.

Species richness: c. 850 spp.

Endemism: c. 90 spp., 2 endemic genera, 10.5% endemism.

Hadramaut (Yemen)

Location: Southern Yemen, Hadramaut and western part of the Mahra region.

Altitude: 1,000-2,200 m.

Typical vegetation: *Acacia-Commiphora* deciduous woodland and evergreen and semi-deciduous shrubs (*Olea europaea*, *Dodonaea viscosa*, *Carissa edulis*, *Euphorbia*), succulents (*Aloe*, *Caralluma*, *Euphorbia*, *Adenium*, *Cissus*).

Species richness: c. 700 spp.

Endemism: c. 40 spp., 5.7% endemism.

Jebel 'Ureys (Yemen)

Location: Southern coast of Yemen (c. 150 km east of Aden).

Altitude: 0-1,700 m.

Typical vegetation: Deciduous shrubland, succulent shrubland (dominated by *Euphorbia balsamifera* on the seaward facing slopes), and semi-desert grassland, succulents (*Kleinia deflersii*).

Species richness: c. 500 spp.

Endemism: c. 15 spp., c. 3% endemism.

Socotra Archipelago (Yemen)

Location: Northern part of the Indian Ocean, east of Somalia.

Altitude: Socotra, 0-1,519 m; 'Abd al Kuri, 0-850 m; Semhan, 0-779 m; Darsa 0-357 m.

Typical vegetation: Open deciduous shrubland on the coastal plains (*Croton socotranus*, *Euphorbia arbuscula*, *Dendrosicyos socotranus*, *Ziziphus spina-christi*) and lower slopes of the mountains (*Croton socotranus*, *Jatropha uncostata*), submontane, semi-deciduous thicket (*Rhus thyrsoflora*, *Buxus hildebrandtii*, *Carphalea obovata* and *Croton* spp.), and grassland and rock vegetation (*Rhus thyrsoflora*, *Cephalocroton socotranus*, *Allophylus rhoidiphyllus*, *Dracaena cinnabari*).

Species richness: 790 spp.

Endemism: c. 240 spp, 9 genera, 1 near-endemic family (Dichramaceae), 30 % endemism.

Afromontane Regional Centre of Endemism

Highlands of southwestern Arabia (Saudi Arabia and Yemen)

Location: Taif southwards to Jebel Sawdah and east to Mukayras.

Altitude: 200-3,760 m.

Typical vegetation: *Acacia-Commiphora* deciduous shrubland, evergreen shrubland (*Barbeya oleoides*, *Carissa edulis*, *Dodonaea viscosa*, *Euclea schimperi*, arborescent *Euphorbia*) and *Juniperus procera* woodland, *Juniperus procera-Erica arborea* woodland (*Kuiphofia sumarae*, *Helichrysum arvae*).

Species richness: c. 2,000 spp.

Endemism: c. 170 spp., 2 genera, 8.5% endemism.

Hajayrah mountains (Yemen)

Location: Mountains south of Taiz.

Altitude: 2,000-3,000 m.

Typical vegetation: Similar to highlands of southwestern Arabia.

Species richness: Unknown, probably c. 600 spp.

Endemism: 99 spp., incl. 8 restricted to this area, c. 12% endemism.

Saharo-Sindian Regional Zone

Northern Hijaz (Saudi Arabia)

Location: Jebel Lawz, Jebel Dibbagh, Jebel Radhwa, Jebel Shada and the southern fringe of Harrat ar Rahah (northwestern Saudi Arabia).

Altitude: 600-2,300 m.

Typical vegetation: Luxuriant vegetation along wadis with perennial water (*Hyphaene thebaica*, *Nerium oleander*, *Phragmites australis*). Open *Acacia* shrubland at lower altitudes (*A. raddiana*, *A. tortilis*, *Retama raetam*). Dwarf shrubland above c. 800 m (*Artemisia sieberi*, *Ferula* spp., *Pistacia khinjuk*, *Prunus korschinskyi*). Semi-evergreen *Juniperus phoenicea* bushland above 1,400 m on some isolated peaks. Rich in Mediterranean annual and perennial herbs and shrubs.

Species richness: Unknown; one of the two richest areas in extra-tropical Arabian endemics.

Endemism: >5 spp., including one endemic genus. The endemics are mostly high altitude species. % endemism unknown.

Harrat al Harrah

Location: Northern Saudi Arabia.

Altitude: 500-1,000 m.

Typical vegetation: Dwarf shrubs (*Haloxylon salicornicum*, *Salsola* spp., *Artemisia* spp., *Achillea fragrantissima*, *Zilla spinosa*), sand inhabiting shrubs (*Haloxylon persicum*, *Calligonum comosum*) and perennial grasses (*Stipagrostis* spp.).

Species richness: >290 spp.

Endemism: None.

Jiddat al Harases (Oman)

Location: Central Oman.

Altitude: c. 150 m

Typical vegetation: Open *Acacia* scrub (*Acacia tortilis*, *A. ehrenbergiana*), drought-deciduous shrubland (*Ochradenus harsusiticus*, *Fagonia*, *Convolvulus oppositifolia*, *Nannorrhops ritcheana*, *Hyoscyamus galgheri*).

Species richness: c. 200 spp.

Endemism: 12 spp., 6% endemism.

Hajar and Musandam mountains (northern Oman)

Location: Western and Eastern mountains of northern Oman (Jebel al Akhdar, Jebel Aswad, Jebel Bari Jabir), Musandam mountains (Jebel Harim).

Altitude: 300-3,009 m.

Typical vegetation: Western Hajar: Evergreen *Olea-Monotheca-Dodonaea* shrubland, (with *Ebenus stellatus*, *Euryops arabicus*, *Helianthemum*, *Teucrium*) open *Juniperus* woodland (*Juniperus excelsa* subsp. *polycarpus*, *Daphne mucronata*, *Berberis*, *Lonicera aucheri*). Eastern Hajar: Very open *Ceratonia oreothauma-Ziziphus hajarensis* woodland (with *Acacia* spp., *Prunus arabica*), semi-deciduous scrub (*Ebenus stellatus*, *Euryops arabicus*, *Helianthemum* spp.). Musandam: *Artemisia* scrub and open semi-deciduous bushland (*Acacia tortilis*, *Moringa peregrina*, *Prunus arabica*, *Ziziphus spina-christi*)

Species richness: c. 600 spp.

Endemism: c. 25 spp. (one of the two richest areas in extra-tropical Arabian endemics), 4.2% endemism.

12.3 Threats to Diversity and Vegetation Cover

Threats to plant species diversity and vegetation cover and biomass in Arabia are inextricably linked with graziers and the fate of the rangelands. Of all the threats to diversity and vegetation cover, that of 'overgrazing' is undoubtedly the greatest, and the degradation of rangelands at the mouths of livestock is a problem that needs to be addressed by pastoralists and conservationists alike. How severe is the situation? A detailed survey of the rangelands of Oman in 1981 concluded that "The rangelands of northern and central Oman are in a highly degraded state.." and "In southern Oman, the condition of the rangelands, particularly in Jebel Qara, is critical" (Anon. 1982). This is a statement that probably applied to a major part of the Peninsula in 1982, and certainly applies to an even greater degree as we write in 1997. In the 1970's 85% of the rangelands of Saudi Arabia were already estimated to be in a severely degraded state (Kingery 1971), and in 1985 it was estimated that 75% of the whole country was seriously eroded due to the impoverishment of the natural vegetation (Anon. 1985b).

Detailed, incontrovertible evidence for these points of view is not available, since there have been no long-term studies of rangeland quality in the region, but the evidence is there for all to see: the supplementation of the needs of large herds of domestic livestock by the use of artificial feed and water tankers during droughts, increasing numbers of feral donkeys released from toil by the acquisition of motorised transport, the dominance of plant communities by unpalatable species (see section 11.7), widespread ageing of woodlands with few if any signs of regeneration in many areas, and the surface crust of the desert plains permanently broken by ungulate hooves.

A number of recent comparative surveys indicate the general effect of protecting rangelands from grazing. After 11 years of protection, an enclosure in Abu Dhabi with mixed gravel plain and sand dune substrata had increased plant cover on both substrata compared to adjacent grazed areas, with the fodder grass *Stipogrostis plumosa* showing the greatest increase, and with decreased cover of unpalatable species such as *Zygophyllum mandavillei* (Oatham *et al.* 1995). In another enclosure in Abu Dhabi, measurable increases in cover compared to adjacent grazed areas occurred after only two years, again with increases in fodder species (Böer & Norton 1996). Both plant biomass and diversity was greater in an area of the Asir highlands following five years of protection from grazing, compared with adjacent areas estimated to receive three visits by an average of one hundred sheep and goats per week (Abulfatih *et al.* 1989). In another area of the Asir highlands, the protected areas of Hima Sabihah had a greater cover of palatable grass species and lower cover of unpalatable species such as *Asphodelus fistulosus* (Hajar 1993). An enclosure plot, designed to exclude camels but permit entry by gazelle, on sandy substratum in a sheep- and goat-free reserve in northern Saudi Arabia showed significant increase in perennial plant cover, particularly for palatable grasses, within three years of protection (van Heezik & Seddon 1995). However, enclosure plots on packed silt and on clay substrata in the same reserve

showed fewer differences compared with adjacent grazed areas (van Heezik & Seddon 1996).

Taking a wider perspective, what might we expect the overall effect of grazing on vegetation and soils to be? A global overview based on 236 studies, including arid and semi-arid sites in Africa and the Middle East (Milchunas & Lauenroth 1993), found that changes in species composition induced by grazing are proportionally greater on lands with higher productivity, with longer histories of grazing and with higher levels of grazing, in that order of importance. The relationships between grazing parameters and changes in soil organic matter and nitrogen are more complex, with no predictable relationship with changes in species composition. In addition, there is evidence in areas of low herbivore consumption for the controversial (Dyer *et al.* 1993, Painter & Belsky 1993) concepts of overcompensation by grazed plants and herbivore optimisation of plant productivity (i.e. grazing is beneficial to plants and increases community productivity). This influence is not great, though higher in sites with longer histories of grazing and low productivity. The main lessons for Arabia are (1) that the greatest effect of grazing on species composition is likely to be seen in areas of greater productivity, such as the mountains, (2) that increases in grazing pressure will decrease species diversity, and (3) that changes in species diversity cannot necessarily be used to indicate effects of grazing on soil quality. With these points in mind, it is perhaps not a coincidence that one of the most extreme effects of grazing pressure in Arabia can be seen in the mountains of Dhofar in Oman, where serious overstocking with camels, cattle and goats (Anon. 1982) has completely denuded the landscape of what, ironically, is one of the most important 'hot spots' of diversity in Arabia.

Whilst there appears to be no politically or socially acceptable answer at the moment to the 'overgrazing problem', it must be emphasized that it is not the complete elimination, but rather the reduction of grazing pressure that is required. Ungulate grazing has undoubtedly been part of the evolution of desert rangelands, but it is the degree of the current grazing pressure that is overwhelming them. At least part of the answer might lie with the traditional *hima* or *mahjur* system of communal property, whereby areas were lain aside locally as fallow lands and as areas for specific uses such as beekeeping, grass cutting or woodland protection (Draz 1969, 1978, Ghanem & Eighmy 1984, Kessler 1995, Lancaster & Lancaster 1990, Shoup 1990). Several recent conservation reports for specific areas have drawn up plans for the combination of the traditional *hima* system with modern planning for conservation areas (Abualjadayel *et al.* 1991, Ady *et al.* 1995, Ady *et al.* 1994, Kamel *et al.* 1989). In a further extension of this idea a recent land use study in Jebel Dhofar (Anon. 1995) recommended an integrated and holistic approach for managing the rangelands. In this proposed scheme local, self-defined groups of pastoralists would undertake to manage their stock and rangeland so that it recovers ecologically, and in return, the government would undertake to provide legal, technical and physical support, with initial short-term financial assistance.

Extreme grazing pressure may be the most ubiquitous and pernicious threat to diversity and vegetation cover in Arabia, but it is not the only one. Accounts for individual countries (see section 12.4) identify a number of recurring threats to nature reserves that are representative of the threats facing plant life in all areas of the Peninsula: impact of recreational activities, cutting of firewood, off-road driving, invasive alien plant species, military activities, mining, and in coastal regions, oil pollution and sewage effluent. In a sense both the flora and fauna of Arabia are suffering from 'development' in all of its forms, including urban expansion, road building and general habitat degradation. These problems came with the rapid economic expansion that began in Saudi Arabia and UAE around the middle of the century and in Oman in the early 1970s, and were exacerbated by changes in traditional grazing practices and the abandonment of many *hima* areas, in the case of Saudi Arabia by a Royal Decree which opened lands to free grazing.

Finally, the hostilities of the Gulf War had a significant environmental impact on the ecosystems of Kuwait (Al-Houty *et al.* 1993, Anon. 1992: pp. 455-463, Omar *et al.* 1995). Jal az Zor National Park and the proposed Wadi al Battin National Park and other designated conservation areas were badly damaged by troop emplacements, military manoeuvres, tank activities and mines. In addition, the formation of oil lakes destroyed the vegetation in some areas and may potentially have future impacts on the soil.

12.4 Conservation

The pace of the establishment of nature conservation areas in the Arabian Peninsula is variable from country to country, with most of the protected areas having been established within the last 15 years, and with all countries still actively considering the establishment of new reserves. The largest countries with active conservation policies, Oman and Saudi Arabia, have both produced detailed study documents containing proposals for systems of nature conservation areas (Child & Grainger 1990, Clarke 1986).

Most reserves have been created for the protection and/or reintroduction of focal animal species rather than for the protection of natural vegetation *per se*. Nevertheless, all of the established reserves and protected areas afford some sort of protection to the flora, though to varying degrees, largely dependent on whether the areas are fenced and/or adequately patrolled to control grazing incursions. Some of the areas with the highest plant diversity and endemism lie within the mountains (see section 12.2 above), but unfortunately these areas are the ones with the least amount of formal protection. The only established nature conservation areas within these regions are the Asir National Park System and Raydah in Saudi Arabia, and the Jebel Samhan Sanctuary in the Dhofar mountains, the latter established in 1997. However, the Asir National Park System lies within a highly populated area that precludes formal protection (see section 12.4.5) and Raydah has an area of only 9 km².

Table 12.6 Brief descriptions of the 1994 IUCN protected area management categories (Anon. 1994b).

Category	Description
I	Strict Nature Reserve/Wilderness Area: protected area managed for science or wilderness protection
II	National Park: protected area managed mainly for ecosystem protection and recreation
III	Natural Monument: protected area managed mainly for conservation of specific natural features
IV	Habitat/Species Management Area: protected area managed mainly for conservation through management intervention
V	Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation
VI	Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems

A list of known protected areas in the Arabian Peninsula is given below, in alphabetical order by country (see also Figure 12.2). For each area the IUCN protected area management category, the phytocoenosis in which the area lies (see Chapter 4 and Figure 4.3), the area and altitude, status, reasons for protection, physical features, climate (see Chapter 2), principal vegetation and floral features, and threats to vegetation are given. We have attempted to classify each protected area using the 1994 IUCN protected area management categories (Anon. 1994b, see Table 12.6), which are applied to sites of over 1,000 hectares (10 km²) or to offshore or oceanic islands of at least 100 hectares (1 km²) where the whole island is protected. Although the protected area systems designed within the various countries of the Peninsula do not readily map across to the IUCN categories, the use of this classification enables us to determine the total number of conservation areas of different types for the whole Peninsula (Section 12.4.8 and Table 12.7), and thus provides a comparative overview. For climate, a reference is given to the climagram for the nearest meteorological station, if available in Figure 2.6, and if representative of the area. In other cases the climate description is based on the climatic contour maps in Figures 2.7-2.11 and other sources as noted. The definition of the seasons follows that established in Chapter 2; i.e. Winter is December-March, Spring is April-May, Summer is June-September, and Autumn is October-November.

There is some unevenness in the details of the accounts both between reserves within a country and between countries, and this is simply a reflection of the incompleteness of the current botanical knowledge of our protected areas, and in some cases the difficulties involved in obtaining current information. For each country we also provide an outline of the main administrative organisations involved with vegetation matters and conservation areas, and a brief summary of the main items of relevant legislation. These are not intended to be comprehensive, and neither do they represent any 'official' view nor, in the case of legislation, any 'officially' sanctioned translations or any implication as to the current status

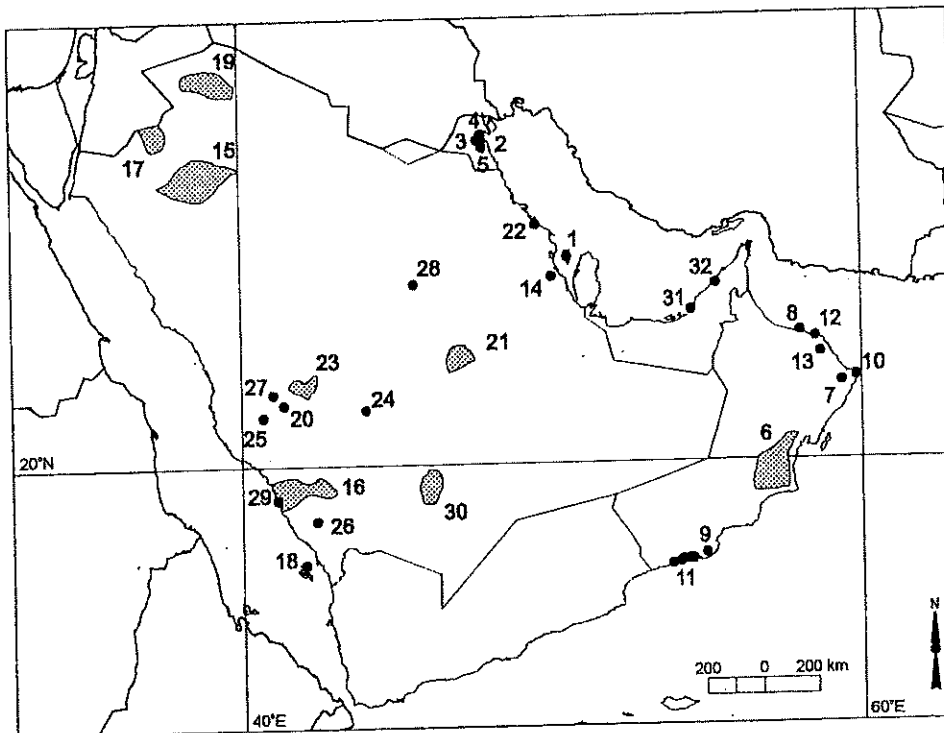


Figure 12.2 Conservation areas in the countries of the Arabian Peninsula. *Bahrain*: 1, al Areen Reserve. *Kuwait*: 2, Doha Reserve, 3, Jahra Reserve, 4, National Park of Kuwait, 5, Sulaihiya Research Station. *Oman*: 6, Arabian Oryx Sanctuary, 7, As Saleel Natural Park, 8, Dimaaniyat Islands, 9, Jebel Samhan Sanctuary, 10, Ra's al Hadd Turtle Reserve, 11, Salalah coast Nature Sanctuaries at Khawr al Mughsayl, al Baleed, Soly (Sawli), al Dahriz, Taqa, Rori (Rawri), Auqad, al Qurom al Saghir and al Qurom al Kabir, 12, Sultan Qaboos Park and Nature Reserve, 13, Wadi Sareen. *Saudi Arabia*: 14, al Hassa National Park, 15, al Khunfa, 16, Asir National Park System, 17, At Tubayq, 18, Farasan Islands, 19, Harrat al Harrah, 20, Hima Saysad, 21, Ibex Reserve, 22, Jubail Marine Wildlife Sanctuary, 23, Mahazat as Sayd, 24, Majami al Hadb, 25, National Wildlife Research Centre, 26, Raydah, 27, Sahal Rukbah, 28, Thumamah Nature Park, 29, Umm al Qamari, 30, 'Uruq Bani Ma'arid. *United Arab Emirates*: 31, Abu Dhabi Nature Reserve, 32, Khawr Dubai.

of enforcement. Rather, our intention is to provide an indication of the main ground covered within the different countries of Arabia in matters of conservation, environmental protection and rangeland management, inasmuch as they relate to plant diversity, conservation and vegetation in general.

Information on the protected areas of each country has been collated both from a variety of published and unpublished literature and from our field work. It has therefore generally not been possible to cite references in the usual way, and citations of relevant sources for each country are, where appropriate, given at the end of each country section. To the best of our knowledge, the information in this section is correct as at October 1997.

12.4.1 BAHRAIN

12.4.1.1 Relevant Legislation

Amiri Decree 20/1983. Establishment of laws for agricultural quarantine.

Amiri Decree 21/1983. Prohibits the cutting or damaging of date palms.

Amiri Decree (2/1995). Concerned with the protection of wildlife, including the formation of the National Committee for the Protection of Wildlife.

12.4.1.2 Government Agencies

Environmental Affairs (EA) of the Ministry of Housing, Municipalities and Environment. By Amiri Decree 21/1996 EA replaces the former Environmental Protection Committee. The role of EA is to achieve sustainable development through appropriate legislation, environmental and pollution monitoring, assessment of the environmental impact of development projects, and the promotion of public awareness.

Ministry of Works and Agriculture. Responsible for the implementation of Amiri Decrees 20/1983 and 21/1983 (see above).

National Committee for the Protection of Wildlife. Established by Amiri Decree 2/1995. Deals with all issues related to biodiversity, including international conventions, the protection of endangered species, and proposals for relevant laws and regulations.

12.4.1.3 Protected Areas

Al Areen Reserve (Figure 12.2: 1)

IUCN Management Category: Unassigned.

Phytochorion: Nubo-Sindian local centre of endemism of the Saharo-Sindian regional zone.

Area and altitude: 8 km², completely fenced; 3-45 m.

Status: Established in 1976 as both a park and a reserve.

Reasons for protection: To provide a refuge for endangered wildlife and a wildlife education centre. Divided into two sections, the park is open to the public and contains a representative collection of ungulate species from Arabia, Africa and Asia, whilst the reserve (4 km²) contains only native Arabian wildlife and has restricted access.

Physical features: The western section at c. 3 m above sea level consists of salt flats with aeolian sand and unconsolidated sediments in the form of small dunes. A gentle slope extends from the western edge to 45 m at the highest point to the east. This area is dissected by runnels and small wadis.

Climate: Mean annual precipitation 86 mm, mostly falling in winter-early spring; mean annual temperature 26.5°C (see climagram for Bahrain, Figure 2.6 and Table 2.2).

Vegetation: 53 recorded spp., of which 31 are perennials and 22 annuals. Most are xerophytic, a few halophytic. The site was heavily grazed prior to the erection of the fence, but the vegetation is now thriving. Seven community types have been recognized within the reserve:

(1) The *Zygophyllum qatarense* community occurs mainly in areas close to the coast which have small dunes. (2) The *Heliotropium crispum* community also occurs in the coastal areas, but where soil is relatively coarser. (3) The *Panicum turgidum* community occurs in the higher middle and eastern parts of the reserve on relatively deep soil. (4) The *Leptadenia pyrotechnica* community is mainly confined to areas with large accumulations of sand. (5) The *Sporobolus arabicus* community occurs in shallow saline depressions. (6) The *Pennisetum divisum* community occurs in long runnels and depressions. (7) The *Helianthemum kahiricum* community occurs in a small area with shallow stony-sandy soil.

Threats to vegetation: A large number of exotic trees have been planted in the reserve, changing the character of the natural vegetation.

12.4.1.4 Literature Sources

See Abbas *et al.* (1991a, 1991b), Anon. (1992: pp. 399-402) and Samour *et al.* (1989).

12.4.2 KUWAIT

12.4.2.1 Relevant Legislation

Law no. 15, 1972. Gives Kuwait Municipality the legal right to develop and protect all lands in Kuwait.

Law no. 112, 1976. Regulations concerning the import of plants and plant parts, living or dead.

Law no. 62, 1980. Gives responsibility for the protection of the environment to the Environment Protection Council. Amongst other things, the decree includes policies for protection of the environment from pollution, conservation of nature and natural resources, and the establishment of protected areas.

Decision No. 9, 1980, Ministry of Public Works. Prohibition of the uprooting or destruction of *Rhazaria epapposum*.

Law no. 9, 1988. Amending the provisions of Law no. 94 of 1983. PAAFR (see section 12.4.2.2 below) given responsibility for rangeland conservation, and the establishment and supervision of national parks.

Law no. 41, 1988. Empowering PAAFR to ban grazing in certain areas.

Decision no. 244, 1989. Stipulates the conditions for issuing grazing permits and their duration.

12.4.2.2 Government Agencies

Environment Protection Authority (EPA). Established by Law no. 21, 1995, EPA (formerly the Environment Protection Council) is in charge of environmental issues and *in situ* biological conservation.

Kuwait Environment Protection Society (KEPS). KEPS is a local non-governmental organization responsible for environmental awareness and the development of education programmes. The Wildlife Protection Committee of KEPS (established in 1994) is responsible for enhancing the public awareness of wildlife protection and conservation.

Kuwait Institute for Scientific Research (KISR). Established by Law no. 28, 1981, KISR conducts agricultural and environmental research under three divisions: Environmental and Earth Science, Water Resources and Food and Biological Resources. Conservation projects are the responsibility of the Aridland Agriculture Department in the Division of Food and Biological Resources.

Ministry of Defense (MOD). The MOD has recently become involved in *in situ* conservation by taking over the protection of Kuwait National Park.

National Committee for Wildlife Conservation. Established by the EPA in 1996. Responsible for reviewing international conventions on wildlife protection and conservation, and for recommending legislation and other measures for wildlife protection.

Public Authority for Agriculture and Fish Resources (PAAFR). Established by Law no. 94, 1983, PAAFR is responsible for agricultural development, including the management of wildlife, livestock and fisheries. The overall role of the Authority is to supervise the use of land and water for agricultural and fishery purposes so as to ensure their proper use and conservation. PAAFR was formerly a department of the Ministry of Public Works.

12.4.2.3 Protected Areas

Doha Reserve (Figure 12.2, 2)

IUCN Management Category: Unassigned.

Phytochorion: Within the Nubo-Sindian regional centre of endemism of the Saharo-Sindian regional zone, but with partly azonal vegetation.

Area and altitude: 4.5 km²; sea-level.

Status: Established, but without endorsement by law.

Reasons for protection: Bird breeding and nesting.

Physical features: Sandy sabkha associated with coastal mud flats.

Climate: Mean annual precipitation c. 110 mm, falling mostly in winter-early spring; mean annual temperature 26°C.

Vegetation: Halophytic vegetation and an important stand of *Phragmites australis*.

Threats to vegetation: None.

Jabra Reserve (Figure 12.2, 3)

IUCN Management Category: Unassigned.

Phytochorion: Within the Nubo-Sindian regional centre of endemism of the Saharo-Sindian regional zone, but with partly azonal vegetation.

Area and altitude: 2.5 km²; sea-level.

Status: Established, but without endorsement by law.

Reasons for protection: Resident and migratory birds.

Physical features: A man-made pond covered by secondary treated sewage effluent flowing across sandy sabkha to the sea, as well as a coastal zone with tidal area, mud flats, shore line and reed beds.

Climate: As for Doha Reserve, above.

Vegetation: Halophytic chenopods, with an important stand of *Phragmites australis*.

Threats to vegetation: The alteration of natural surface runoff by the construction of drainage systems causes occasional draining of the pond.

National Park of Kuwait (Figure 12.2, 4)

IUCN Management Category: VI (Managed Resource Protected Area).

Phytochorion: Within the Nubo-Sindian regional centre of endemism of the Saharo-Sindian regional zone, but also contains elements of the Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: Approximately 330 km²; 0-150 m.

Status: Designated by Kuwait Municipality Council, decision no. 87/1988, and established by PAAFR. Responsibility for protecting the area was given in 1995 to the MOD, since when the area has been completely fenced.

Reasons for protection: Allocation of an area of physical and biological importance for the conservation and management of natural renewable resources.

Physical features: Generally flat with minor undulations. The most significant physical feature is the Jal az Zor escarpment running parallel to the seashore. The escarpment forms a natural watershed. The deepest depression is Wadi Umm-Arimam which covers c. 11 km² of the northwestern corner of the park.

Climate: As for Doha Reserve, above.

Vegetation: The status of vegetation in the area is poor due to soil erosion and intensive grazing prior to establishment. Important habitats are dominated by the following plant communities: *Rhantorium*, *Haloxylon*, *Halocnemum*, *Seidlitzia*, *Nitraria* and *Zygophyllum*. Important species are *Ochradenus baccatus*, *Calligonum crinitum*, *Gynandris sisyriuchium* and *Convolvulus oxyphyllus*.

Threats to vegetation: Occasional grazing due to poor protection and fence damage.

Sulaibiya Research Station (Figure 12.2, 5)

IUCN Management Category: I (Strict Nature Reserve/Wilderness Area).

Phytochorion: Within the Nubo-Sindian regional centre of endemism of the Saharo-Sindian regional zone, but also contains elements of the Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: c. 20 km²; 75-130 m.

Status: Established in 1978 as a range management project by KISR, fenced.

Reasons for protection: For conducting range management research.

Physical features: With a gentle SW-NE slope. Northern and western boundaries subject to intrusions by mobile sand.

Climate: As for Doha Reserve, above.

Vegetation: 58 species recorded: three annual grasses, five perennial grasses, seven perennial shrubs and 43 annuals. Vegetation belongs to the *Rhanterium/Cyperus* steppe formation, and under grazing conditions is dominated by *Rhanterium epapposum* and *Cyperus conglomeratus*. Most commonly occurring annual and perennial forb species are *Astragalus schimperi*, *Attractylis carduus*, *Ifloga spicata*, *Koelipinia linearis*, *Lotus halophilus*, *Plantago boissieri*, *P. ciliata*, *Savignya parviflora*, *Schimpera arabica*, *Eragrostis glutinosa* and *Polycarpha repens*. After 10 years of protection from grazing *R. epapposum* showed a marked increase and *C. conglomeratus* declined (Omar 1991).

Threats to vegetation: None, since the site is completely protected.

Range Exclosures

There are several exclosures designated to protect specific habitats or plant species namely: Mutla, Rawdatain, Sheikh Zayed Park, Shigaya and Um al Qurayn. The vegetation in the areas are monitored by the PAAFR and is recovering from extensive damage incurred from the invasion of Kuwait during the Gulf War. The exclusion of livestock is providing permanent protection for the vegetation.

12.4.2.4 Literature Sources

See Anon. (1994a), Anon. (1992: pp. 455-463), Omar (1991, 1996) and Omar *et al.* (1994).

12.4.3 OMAN

12.4.3.1 Relevant Legislation

Ministerial Decision no. 4/1976. Provides for a total prohibition of the hunting of all birds in coastal and island regions and some species of mammals; superseded by Ministerial Decision no. 207/93 (see below).

Royal Decree 49/77. Establishment of a plant quarantine law for both the import and export of plants

Royal Decree no. 26/1979. Provides authority for the establishment of national parks and nature reserves.

Royal Decree no. 6/1980. Provides authority for the protection of national heritage, including rare groups or samples of flora and fauna.

Royal Decree no. 10/1982. Establishment of laws for the protection of the environment and prevention of pollution. Various sections have been subject to amendment by Royal decrees 63/85, 71/89 and 111/96 (for the latter, see below).

- Ministerial Decision no. 128/93.* Prohibition of the cutting of live trees and the collection and transport of dead wood except with a permit.
- Ministerial Decision no. 207/93.* Prohibition of hunting, capture or firing at wild animals including birds (supersedes Ministerial Decision no. 4/1976).
- Ministerial Notice no. 25/96.* Issued by the Ministry of Commerce and Industry. Bans the export of seeds of the frankincense tree, *Boswellia sacra*.
- Royal Decree no. 111/96.* Amends article 30 of Royal Decree no. 10/1982 (see above), prescribing increased penalties for causing damage or harm to nature reserves and the creatures therein.

12.4.3.2 Government Agencies

Directorate General of Nature Reserves (DGNR), Ministry of Regional Municipality and Environment (formerly Ministry of Environment). The DGNR was established in 1991, when it was known as the Directorate-General of Nature Protectorates. It processes the formal designation of all protected areas, preparing and implementing management plans, carrying out or commissioning field studies where necessary. Responsible for nature conservation both inside and outside protected areas, it has established a network of ranger units whose main tasks are to increase public awareness, collect field data and assist in law-enforcement. It chairs advisory specialist groups, including the Plant Group, with members drawn from various ministries. The DGNR also scrutinises all development projects for their impact on wildlife and habitats.

Directorate General of Environmental Affairs (DGEA), Ministry of Regional Municipality and Environment. The DGEA is the authority for issue of all environmental permits for development projects, with specialised sections dealing with air, noise and water pollution. The marine section is responsible, *inter alia*, for marine pollution prevention and implementing the IUCN Coastal Zone Management Project for Oman (Anon. 1986a, 1988, 1989a, 1989b, 1991). DGEA is also responsible for the development of the draft National Conservation Strategy.

Ministry of Commerce and Industry. In the past has been associated with conservation matters through its involvement with the IUCN Coastal Zone Management Project for Oman (Anon. 1986a, 1988, 1989a, 1989b, 1991).

Natural History Museum, Ministry of National Heritage and Culture. Established in 1990. Houses a variety of museum displays on natural history, a large collection of fauna and flora, and the National Herbarium of Oman with approximately 14,000 accessions covering the vegetation of the whole country.

Office of the Adviser for Conservation of the Environment (ACE), Diwan of Royal Court. Established in 1974 with the remit of designing a programme for establishing a system to bring conservation of the environment to the support of the rational development of the Sultanate's natural and human resources. ACE has played a leading role in conservation and related activities in Oman, in particular with regard to the first surveys of the flora and fauna (Harrison 1977, Reade *et al.* 1980) and to the establishment of the White Oryx Project (Stanley-Price 1989). Amongst the many other initiatives and projects with which ACE has been involved, the following have been of particular importance for the study and conservation of the vegetation of Oman: publication in both Arabic and English of books on the wild flowers of northern Oman (Mandaville 1978) and traditional uses of plants in Dhofar (Miller & Morris 1988), IUCN surveys and reports for a system of nature conservation areas (Clarke 1986) and for a Coastal Zone Management Plan (Anon. 1986a, 1988, 1989a, 1989b, 1991), a WWF/IUCN survey of the Wadi Sareen Nature Reserve (Munton 1985), and the Royal Geographical Society's multi-disciplinary study of the ecosystem of Ramlat al Wahibah (Dutton 1988b).

12.4.3.3 Protected Areas

A joint project between the IUCN and the government of Oman resulted in a report on Proposals for a System of Nature Conservation Areas (Clarke 1986), which proposed a total of 91 nature conservation areas dispersed widely throughout the country, and covering a total area of 119,798 km² (c. 40% of the land surface of Oman). Three primary classes of nature conservation areas were proposed, viz:

National Nature Reserves (NNRs): The most important type of nature conservation area, to be managed for wildlife, scientific study and the protection of geomorphological phenomena. Approximately equivalent to IUCN category I.

National Scenic Reserves (NSRs): Applied to selected areas of scenic value that have features making them potential choices for NNR status, but that already have permanent settlements within them. Equivalent to IUCN categories II - VI.

National Resource Reserves (NRRs): A temporary status for areas that have potential interest as nature conservation areas, but about which insufficient information is available. No equivalent IUCN category.

Of the 91 proposed nature conservation areas, 59 were NNRs, 20 NSRs and 12 NRRs. In practice, no areas have yet been declared as National Scenic or Resource Reserves. Of the sites recommended by Clarke (1986) three NNRs have now been declared and part or all of three NNRs (Jiddat al Harasees, Janabah Hills and North Jazir) and az Zahr NSR have been included in the Arabian Oryx Sanctuary (see below).

Arabian Oryx Sanctuary (ACE, DGNR) (Figure 12.2, 6)

IUCN Management Category: II (National Park)

Phytochorion: Within the Somalia-Masai regional subzone of the Saharo-Sindian regional zone. vegetation elements of the Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: At c. 34,000 km², the largest protected area in the Peninsula; 0-50 m.

Status: Partially protected since 1979 by staff of the White Oryx Project. Declared on 8 January 1994 by Royal Decree No. 4/1994, and inscribed on the World Heritage List in December 1994. The Arabian Oryx Sanctuary is now the responsibility of DGNR, whilst the White Oryx Project remains under ACE.

Reasons for protection: An important site for wildlife and biodiversity in general, including the Arabian oryx, houbara bustard, two species of gazelle, ibex and other threatened wildlife species. The area is also a local centre of plant endemism (see section 12.2.2.2), and has important ecological, geological and wilderness values.

Physical features: Two distinct zones within the sanctuary: the coastline and adjacent areas running up to the Huqf escarpment, and the Jiddat al Harasees plateau above and to the west of the Huqf. The Jiddat is a flat or undulating Tertiary limestone plateau at 100-150 m, bounded to the west by the sands of the Rub' al Khali, to the north by the wadis of the northern mountains, to the south by wadis that run to the coastal plain, and to the east by the Huqf escarpment and depression. There are no major drainage features on the plateau, and the main surface features are shallow sandy depressions known as *haylah*, which collect water after rain. These are the main vegetated areas. Areas between *haylah* are typically stony and highly weathered, with relatively sparse vegetation. The Huqf depression contains outcrops of sedimentary rocks of nearly all geological periods, dating back to the Proterozoic; small dunes and large areas of sabkha are interspersed between rocky outcrops.

Climate: Mean annual precipitation 39 mm, falling mainly in Spring, though inter-annual variability of rainfall very high; mean annual temperature 26.6°C (see climagram for Ja'aluuni,

Figure 2.6 and Table 2.2). A fog desert, receiving an average of 54 fog days per year (see Figure 2.13).

Vegetation: The Jiddah is recognised as a local centre of endemism (see section 12.2.2.2 above), with 12 endemic (including 1 regionally endemic) species. Although a hyperarid area, frequent heavy fogs and dews enhance water availability, with growth of many perennials supported entirely by this source during droughts. The *haylah* vegetation consists of an open *Acacia* scrub with *A. tortilis*, *A. ehrenbergiana* and *Prosopis cineraria* as the dominant structural components. *Rhazya stricta* and the endemic *Ochradenus harsusiticus* form a major component of the shrubby vegetation, and the ground cover includes, amongst other grasses, *Stipagrostis sokotrana*, which is an important food source for Arabian oryx. Other notable species include *Convolvulus oppositifolia* (endemic), *Caralluma flava*, *Nannorhops ritcheana*, *Pullicharia undulata* and *P. pulvinata* (endemic). On the coastal limestone hills the endemic shrub *Hyoscyamus gullagheri* is dominant. A detailed vegetation survey has not been carried out, but c. 200 spp. are recorded from the Jiddah, and with the inclusion of the Huqf depression and coastal areas there are c. 250 spp.

Threats to vegetation: Unrestricted grazing by camels, goats and feral donkeys; off-road driving.

As Saleel Natural Park (DGNR) (Figure 12.2, 7)

IUCN Management Category: Unassigned.

Phytochorion: Saharo-Sindian subzone.

Area and altitude: 220 km²; 100-150 m.

Status: Declared in 1997 by Royal Decree no. 50/1997.

Reasons for protection: Area with gazelle and other wildlife, and an important fossilised reef hill. It is planned that the Arabian oryx will be introduced in the Park and then some areas opened to the public.

Physical features: Flat desert plain with sand and gravel, covered with an open *Acacia tortilis* woodland.

Climate: Nearest representative station is the coastal station of Sur with mean annual precipitation of 92 mm, falling mainly in winter and early spring; mean annual temperature 29.3°C (Figure 2.6 and Table 2.2). However, being inland, as Saleel will have a greater temperature range than Sur, and greater maximum and lower minimum temperatures.

Vegetation: *Acacia tortilis* woodland with associated shrubs.

Threats to vegetation: Overgrazing by goats and camels.

Dimaaniyat Islands (DGNR) (Figure 12.2, 8)

IUCN Management Category: IV (Habitat/Species Management Area).

Phytochorion: Nubo-Sindian regional centre of endemism of the Saharo-Sindian regional zone.

Area and altitude: 200 km² of sea and seabed, including nine islands, and various rocks, reefs and offshore shoals situated 18-20 km off the Batinah coast; 0-50 m.

Status: Declared in 1996 by Royal Decree no. 23/1996.

Reasons for protection: Host to a high density of nesting seabirds and the only known osprey nesting site in the Capital Area. Known to have the largest nesting population of hawksbill turtles (*Eretmochelys imbricata*) in Oman. Green turtles (*Chelonia mydas*) and sooty falcons also nest, and there is a variety of reefs with a high diversity of corals and molluscs. The islands are free of mainland predators such as foxes, dogs, cats and rats.

Physical features: Consists largely of bare sedimentary limestone and skeletal sandy soils.

Climate: Nearest representative station is Seeb with mean annual precipitation of 86 mm, falling mainly in winter-early spring, with the occasional summer storm; mean annual temperature 28.7°C (Figure 2.6 and Table 2.2).

Vegetation: The perennial vegetation consists entirely of halophytic species, with c. 13 spp. recorded. The dominant halophytic shrub is *Suaeda monoica* which occurs in monospecific

stands on the vegetated islands. Other common species are *Suaeda aegyptiaca*, *Cyperus conglomeratus*, *Sporobolus virginicus* and *Halopyrum mucronatum*.

Threats to vegetation: Uninhabited apart from a small ranger presence on one island; there are no domestic livestock. Only potential source of threat comes from visits by tourist parties and fishermen, especially those that involve overnight camps.

Jebel Samhan Sanctuary (DGNR) (Figure 12.2, 9)

IUCN Management Category: Unassigned

Phytochorion: Somalia-Masai regional centre of endemism.

Area and altitude: 4,500 km²; 0-1,800 m.

Status: Declared in June 1997 by Royal Decree no. 48/1997.

Reasons for protection: An area of wilderness and an important site for wildlife and biodiversity. Contains the last remnants of a relatively well-preserved deciduous tropical woodland, and is also perhaps the last refuge for the Arabian leopard. Several other large mammals including the nubian ibex, hyaena, gazelle and wolf live in the mountains and the green and loggerhead turtles nest on the beaches. The area is also part of a local centre of diversity and endemism (see section 12.2.2.2).

Physical features: The area is a barren mountain massif with elevated limestone highlands rising steeply from the coast overlooking the Zalawt foothills and Mirbat coastal plains. Deep wadis and gorges intersperse the high peaks. Several water pools are present including the Andhur pools, which are of both archaeological and ecological importance.

Climate: Except for Jebel Habrer, the Sanctuary is largely outside the influence of the southwest monsoon. Salalah (20 m) and Qairoon Hariti (878 m) are the nearest meteorological stations (Figure 2.6, Table 2.2), though neither are particularly representative, both being within the influence of the monsoon. Mean annual precipitation at the lower altitudes is probably c. 50-100 mm, falling mainly in winter-early spring, with rain in some years falling in the summer, and mean annual temperature c. 26°C. Rainfall of 100-200 mm may be expected at the higher altitudes.

Vegetation: Jebel Samhan is recognised as a part of the Dhofar mountain local centre of endemism (see section 12.2.2.2), with c. 20 endemic species. The main vegetation is an open *Commiphora-Acacia* woodland with succulents, *Aloe* spp. and *Cissus quadrangularis*, and low shrubs. Species of special interest include those of *Caralluma*, *Maytenus*, *Launaea* and *Dracaena*. Endemic species include *Anogeissus dhofurica*, *Lavandula hasikensis*, *Maytenus dhofarensis* and *Salvia hillcoatiae*. The only Arabian location of *Pappia capensis* occurs on Jebel Habrer. A detailed vegetation survey has not been carried out, but >500 spp. are expected to be present, similar to the number of species recorded for the Dhofar mountains.

Threats to vegetation: Unrestricted grazing by camels, goats and feral donkeys; potential unplanned development; off-road driving.

Ras al Hadd Turtle Reserve (DGNR) (Figure 12.2, 10)

IUCN Management Category: IV (Habitat/Species Management Area).

Phytochorion: Nubo-Sindian regional centre of endemism of the Saharo-Sindian regional zone.

Area and altitude: 80 km²; 0-100 m.

Status: Declared in 1996 by Royal Decree no. 25/1996. IUCN category IV.

Reasons for protection: The Ras al Hadd peninsula forms part of a complex of turtle nesting beaches which extend south beyond Ras al Jinz to Ras al Khabbah. The beaches attract 6,000-13,000 nesting green turtles each year, and are of global importance for the species. The reserve also contains important archaeological sites.

Physical features: The northern and western parts of the reserve are principally low-lying limestone hills, dissected by wadis, and ending as low cliffs at the sea. The remainder of the Ras al Hadd peninsula is low-lying and sandy, with the generally flat relief broken by mounds that

indicate the sites of shell middens and other archaeological deposits. There are two large bays within the reserve: Khawr al Jaramah and Khawr al Hajar. The southern and western shores of both bays are backed by sabkha.

Climate: Nearest representative station is Sur, with a mean annual precipitation 92 mm, falling mainly in winter-early spring, with the occasional summer storm; mean annual temperature of 29.3°C (Figure 2.6 and Table 2.2).

Vegetation: Typical coastal and foothill vegetation. The coastal vegetation consists of a *Limonium stocksii-Sphaerocoma aucheri-Cornulaca monacantha* community, with *Cyperus conglomeratus* and *Suaeda* spp. as common associates. There are several small stands of mangrove (*Avicennia marina*) along the shore of Khawr al Jaramah. Vegetation of the foothills consists typically of *Acacia-Commiphora-Euphorbia* scrub with species such as *Lycium shawii*, *Pulicaria glutinosa* and *Ochradenus arabicus* forming the main components of the shrubby vegetation. No thorough plant survey carried out, but the estimated number of species is c. 60.

Threats to vegetation: Off-road driving, grazing of domestic livestock, camping parties.

Salalah coast Nature Sanctuaries at Khawr al Mughsayh, al Baleed, Soly (Sawli), al Dahriz, Taqa, Rori (Rawri), Auqad, al Qurom al Saghir and al Qurom al Kabir (DGNR) (Figure 12.2, 11)

IUCN Management Category: Unassigned.

Phytocorion: Somalia-Masai regional centre of endemism.

Area and altitude: Range of size of each individual *khawr* is 0.017 km² (al Qurom al Saghir) to 0.58 km² (Rawri); sea-level.

Status: Declared in June 1997 by Royal Decree no. 49/1997.

Reasons for protection: Permanent brackish water bodies maintained by a unique system of fresh over- and underground water from the escarpment mountains, and seepages of seawater, utilized for fishing, livestock watering and grazing, and irrigation; presence of mangroves; wintering grounds for c. 300 species of birds; natural scenic beauty.

Physical features: The *khawrs* (coastal lagoons) are separated from the sea by sand bars and contain brackish water of varying salinities (see sections 10.2.3 & 10.2.4). Of the nine *khawrs*, two (al Qurom al Saghir and al Qurom al Kabir) are not fed by an underground fresh water system and are therefore highly saline.

Climate: Nearest meteorological stations is Salalah, with mean annual precipitation of 85 mm, falling mainly in spring and summer; mean annual temperature 26.4°C (Figure 2.6, and Table 2.2).

Vegetation: The *khawrs* are surrounded by the Salalah coastal plains which is characterised by mounds of semi-desert, salt tolerant plants (*Cressa cretica*, *Limonium axillare* and *Urochondra setulosa*) and rocky outcrops with small shrubs and succulents (*Cassia italica* and *Cissus quadangularis*). The coastal dunes are colonized by characteristic grasses and sedges (*Cyperus conglomeratus*, *Halopyrum mucronatum*, *Sporobolus spicatus* and *S. iocladius*), satlbushes (*Atriplex farinosum*) and the trailing shrub *Ipomoea pes-caprae*. The margins of *khawrs* are lined with the grasses *Paspalum vaginatum* and *Sporobolus virginicus* and reed beds with different species (including *Juncus*, *Phragmites*, *Schoenoplectus* and *Typha*) occur at the water edge reflecting the water salinity of the *khawr*. *Khawrs* with high salinity have the mangrove *Avicennia marina*. The water vegetation consists of the submerged species *Potamogeton pectinatus*, *Najas marina*, *Ceratophyllum demersum* and *Ruppia maritima* and the macroalgae *Chara* and *Enteromorpha*.

Threats to vegetation: Unrestricted grazing by camels, especially mangroves; soil erosion and trampling by off-road driving and livestock leading to environmental degradation and reduction of plant cover and species diversity.

Sultan Qaboos Park and Nature Reserve (Figure 12.2, 12)

IUCN Management Category: Unassigned

Phytochorion: Nubo-Sindian regional centre of endemism of the Saharo-Sindian regional zone.
Area and altitude: c. 1 km²; 0-10 m.

Status: Declared by Royal Decree no. 19/81. Part of the area functions as a public park, and the remainder consists of dense mangrove stands.

Reasons for protection: An important green area, being the only khawr that lies within the immediate Capital Area.

Physical features: Flat tidal khawr, fed with underground freshwater from the landward side by Wadi Adai.

Climate: Nearest representative station is Seeb, with a mean annual precipitation of 86 mm, falling mainly in winter-early spring, with the occasional summer storm, and a mean annual temperature 28.7°C (Figure 2.6, Table 2.2)

Vegetation: The natural vegetation has been vastly altered by the construction of the park and its associated features. Where it is still preserved, the vegetation consists of halophytic shrubs of *Suaeda aegyptiaca* and *Indigofera oblongifolia* on dry calcareous sands, and *Halopeplis perfoliata*-*Aeluropus lagopoides* communities on sandy-silty soils. The important remaining natural vegetation are the mangroves, *Avicennia marina*, which form a dense fringe on the edges of the khawr, reaching up to 4 m in height.

Threats to vegetation: Probably none within the khawr itself, though any further expansion of the area as a public recreation facility would threaten the mangroves.

Wadi Sareen (ACE) (Figure 12.2, 13)

IUCN Management Category: Unassigned.

Phytochorion: Nubo-Sindian regional centre of endemism of the Saharo-Sindian regional zone.

Area and altitude: Neither area nor boundaries specifically delineated as yet, though the general area patrolled is c. 1,800 km²; 250-2,000 m.

Status: Commonly known as Wadi Sareen Nature Reserve or the Arabian Tahr Reserve, though it has not yet been officially declared as a conservation area. The area currently patrolled is part of what was proposed as the Jebel Aswad NNR by Clarke (1986). Protection is provided by rangers employed by the Diwan of Royal Court, who live within the area.

Reasons for protection: Primarily for the conservation of the regionally endemic Arabian tahr.

Physical features: Limestone mountain and wadi terrain of 300 - 2,000 m. Dominated by cliffs, steep mountain and ridge slopes and steeply incised drainage lines. At lower elevations there are scree slopes and minor hills and wadi outwash fans. At higher altitudes there is much bare rock with skeletal soils in cracks, and at lower elevations there are gravelly sands, lithosols and coarse alluvials, with alluvial gravels in the wadis.

Climate: Seeb and Sur are the nearest meteorological stations (Figure 2.6, Table 2.2), though they are not particularly representative, being at sea level. Mean annual precipitation at the lower altitudes is probably c. 100-200 mm, falling mainly in winter-early spring, and mean annual temperature c. 26°C.

Vegetation: c. 10 endemic spp., including the trees *Ceratonia oreothauma* subsp. *oreothauma* and *Ziziphus hajarensis*, the shrubs *Dionysia mira*, *Lavandula subnuda* and *Rhus aucheri*, and the annual *Pycnocycla prostrata*. There are several species rich sites around water seepages, where rare species such as the orchid *Epipactis veratrifolia*, *Lindenbergia* sp. and various ferns are found. No full vegetation survey, but the total number of species is similar to that of the northern mountains in general; i.e. c. 300 species.

Threats to vegetation: Overgrazing due to domestic livestock, though less of a problem than elsewhere since there is an agreement between the residents and ACE that grazing is restricted to certain areas.

12.4.3.4 Literature Sources

See Anon. (1982), Anon. (1986a, 1988, 1989a, 1989b, 1991), Anon. (1992: pp. 491-500), Anon. (1994a), Clarke (1986), Ghazanfar (1991a, 1992a, 1993b, in press-b), Ghazanfar *et al.* (1995), Hillcoat *et al.* (1980), Kürschner (1986c), Mandaville (1977), Munton (1985), Salm (1986, 1989) and Whitcombe (1995).

12.4.4 QATAR

We have been unable to obtain current information on the status of plant conservation in Qatar, and what information we have comes mostly from Anon. (1992: pp. 501-504). The 1993 United Nations List of National Parks and protected areas (Anon. 1994a) lists one site, Ras Asharij Gazelles Conservation Farm, an IUCN category IV site, without location information. There do not appear to be any other specific protected areas or any protected area legislation, although game reserves for wildlife breeding have been set up by the state authorities and the ruling family. No information is available on the vegetation status of these areas, though, since they are large natural areas often over 100 ha, they may be providing incidental protection for plants. Batanouny (1981) provides a basic description of the plant communities and flora. There are no plant species endemic to Qatar. The main responsibility for conservation matters appears to lie with the Environment Protection Committee, established under Law No. 4 of 1981, and the Ministry of Industry and Agriculture. Recommendations for protected area designation have been made (Anon. 1986b). Threats to the environment, and hence to the vegetation include grazing, the spread of cultivation, oil exploration and the opening up of the country through the construction of desert roads. The potential damaging effects of development in wilderness areas are obviously exacerbated in a relatively small country such as Qatar.

12.4.5 SAUDI ARABIA

12.4.5.1 Government Agencies

Meteorological and Environmental Protection Administration (MEPA). Established in 1980, MEPA has responsibility for marine conservation, environmental protection, and meteorology. Responsibility for the identification of protected areas passed to NCWCD in 1986. Part of MEPA's work, in conjunction with MAW and NCWCD, is the assessment of rangeland degradation. The Environmental Support of Nomads (ESON) Project is a programme of rangeland resource mapping and modelling for advising pastoral nomads on suitable grazing regimes. The project's pilot study focuses on four sites totalling 70,000 km² and encompassing both natural vegetation as well as traditional, semi-settled and settled nomadic lifestyles. ESON aims to make recommendations about where, which type and how many animals, and for how long to graze a particular area. Study sites encompass areas in the Qassim-Hail, Taysiyah-Jandaliyah, Nafud al Ariq and Mahazat as Sayd areas. The latter three sites include proposed and current NCWCD protected areas.

Ministry of Agriculture and Water (MAW). MAW was the principal agency legally responsible for the management and monitoring of forests, rangelands and wildlife before responsibility for protected areas was given to NCWCD (see below) in 1986. MAW has been active in the area of legislation for vegetation conservation, and the establishment of water-harvesting areas and re-seeding programmes for rangeland improvement. A number of dams have been built to improve the recharge of aquifers and to prevent erosion and flooding, and several large areas of rangeland have been fenced to serve as *in situ* seed reservoirs. A separate

Department of National Parks was created in 1983 with the mandate to establish national parks both for vegetation conservation and recreation. These were based on the system of National Parks in the USA. There is currently no mechanism for the total protection of rangelands, and MAW therefore concentrates its efforts on 32 rangeland sites, totalling approximately 200 km², all of which are fenced. Two such sites, Sahal Rukbah and Hima Saysad, are listed in the protected area summary.

National Commission for Wildlife Conservation and Development (NCWCD). The NCWCD was created by Royal Decree no. M/22 of 1986 to "Develop and implement plans to preserve wildlife in its natural ecology and to propose the establishment of proper protected areas and reserves for wildlife in the Kingdom.." (Article 3(4) of Royal Decree No. M/22). The term wildlife covers all indigenous wild plants and animals and their habitats under natural or semi-natural conditions on land and in the sea. NCWCD's first projects focussed on the protection and restoration of high profile animal species, by which it has been able to gain popular support for other, less spectacular, but equally important conservation programmes. The foundation of the NCWCD approach has been the creation of a large network of protected areas and the management of these areas in such a way as to fulfill its mandate to conserve and develop the nation's wildlife.

12.4.5.2 Relevant legislation

- 1966, *Land Development Act*. Gives MAW responsibility over the regulation of land development activities, putting a limit on the maximum acreage of land that may be utilized by individuals for agriculture.
- 1975, *Agricultural and Veterinary Regulations*. Controls the introduction of plant and animal species into Saudi Arabia and regulates the issue of health certificates.
- 1977, *Forests and Pastures Act*. Commits MAW to conserve pastures, public and urban forests, and to regulate their use. Cutting trees and shrubs for private or commercial use without a permit is prohibited, grazing is restricted to allocated sites, and no building may be erected on agricultural land.
- 1977, *National Hunting Decree Law No. 457*. Details areas with permanent hunting bans and has provided the basis for incidental protection of vegetation at sites such as the island of Umm al Qamari. Administered by the Ministry of Interior on advice from NCWCD.
- 1978, *Royal Forest Decree Law No. 1392 (incorporating National Park Law of 1977)*. Lays down regulations for the protection of forests and wildlife. Administered by MAW.
- 1979, *Water Resources Conservation Act*. Governs the control and use of water resources, with priority use granted to human and animal needs and to agricultural and industrial purposes. Enforcement is the responsibility of MAW.
- 1986, *Royal Decree No. M/22*. Commitment to the creation of a system of protected areas, with responsibility for this given to NCWCD.
- 1995, *Decree No. 128*. Lays down the regulations governing a 'Wildlife Protected Areas System', including selection, establishment and management of wildlife protected areas.

12.4.5.3 Protected Areas

The NCWCD System Plan for Protected Areas (Child & Grainger 1990) draws on information from earlier surveys by other government agencies to list a total of 103 candidate protected areas, covering a total of over 170,000 km², (8.1% of the Kingdom). By 1995 a total of 12 protected areas had been formally created, with protection from grazing by sheep and goats for over 15,000 km². Child and Grainger (1990) proposed four Protected Area types for Saudi Arabia:

Special Natural Reserve (SNR): Sites of high biological excellence. Virtually all forms of settlement and agriculture to be excluded, though some controlled forms of use, such as scientific research and low-impact recreation, may be permissible. Approximately equivalent to IUCN category I.

Natural Reserve (NR): Areas of high natural excellence managed to permit greater public access than for SNRs. Approximately equivalent to IUCN categories II or IV.

Biological Reserve (BR): Small areas of biological importance, such as water catchments, isolated stands of rare trees or localized breeding sites for key species, fully protected from man-made disturbance and administered by local authorities. BRs act as an extension of the *hima* concept. Approximately equivalent to IUCN category III.

Resource Use Reserve (RUR): Relatively large areas within which the emphasis is on resource management rather than conservation. RURs can be created and managed by local communities, with NCWCD assistance in the early stages. Approximately equivalent to IUCN category VI.

A fifth category of protected area is administered by the Ministry of Agriculture and Water:

National Park (NP): Areas of natural beauty managed primarily to provide recreational opportunities with minimal impact on natural features, but within which habitation, development and unregulated traditional resource use is permitted. Approximately equivalent to IUCN category V.

The IUCN equivalent categories are only approximate equivalents of the NCWCD and MAW protected area types, since the two systems do not map directly across in all cases, especially for those reserves which contain areas of differing designation.

Al Hassa National Park (MAW) (Figure 12.2, 14)

IUCN Management Category: V (Protected Landscape).

Phytocorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: 2,400 km²; 0-120 m.

Status: NP, recreational and regulated use zone extending for c. 70 km from Hofuf to the Gulf.

Reasons for protection: Incorporates the large al Hassa oasis and extensive areas of sandy desert and saline plains.

Physical features: Flat and undulating sandy desert and sabkha with areas of marsh, cut by numerous drainage lines.

Climate: For 1970-1986 mean annual precipitation at Hofuf is 78 mm falling mainly in winter-early spring; mean annual temperature 25.3°C (Al-Jerash 1989).

Vegetation: The al Hassa oasis encompasses c. 100 km² of marshes and drainage channels, vast date-palm groves, and sand dunes which have been stabilised by shelter-belt trees, mostly *Tamarix* and date-palms. The area between the oasis and the Gulf is mostly sandy desert with *Calligonum comosum* and *Haloxylon salicornicum* communities in deep sand. Species list incomplete.

Threats to vegetation: Moderate to heavy unregulated recreational activities, overgrazing in non-protected areas.

Al Khunfa (NCWCD) (Figure 12.2, 15)

IUCN Management Category: IV (Habitat/Species Management Area).

Phytocorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: 20,450 km², including a core protected area (Ghurrub sector) of 2,875 km²; 700-950 m.

Status: Core area SNR, other zones BR/RUR, declared in 1988.

Reasons for protection: Contains the largest remaining wild population of reem gazelle in Saudi Arabia and representative areas of the northern plains and sandstone hills on the edge of the Great Nafud.

Physical features: Gravel plateaux with isolated sandstone hills. Some deeply incised wadis and occasional salt flats.

Climate: Nearest representative meteorological stations is Jouf, with a mean annual precipitation of 63 mm falling mostly in winter-spring, occasionally in autumn; mean annual temperature 21.5°C, with occasional frosts (Figure 2.6, Table 2.2).

Vegetation: The plateaux and hills support few plants, and vegetation is largely confined to wadis and waterlines. There are rare *Acacia* trees and occasional *Tamarix* and *Atriplex leucoclada* bushes. Dwarf shrubland, dominated by chenopods including *Fraganum nudatum* and *Suaeda* spp., composites, including *Pulicaria undulata* and *Artemisia* spp., and perennial grasses including *Centropodia fragilis* and *Stipagrostis plumosa* grow in major wadis. >50 species recorded, though the list is incomplete.

Threats to vegetation: Unrestricted grazing of camels. Encroachment of centre-pivot irrigation, and of sheep and goat flocks into the core area.

Asir National Park System (MAW) (Figure 12.2, 16)

IUCN Management Category: V (Protected Landscape).

Phytochorion: Spans the Somalia-Masai and the Afromontane archipelago-like regional centres of endemism, and contains vegetation elements from both.

Area and altitude: 4,500 km²; 0-3,200 m.

Status: NP, declared in 1981.

Reasons for Protection: Vast recreational and plant conservation zone encompassing high altitude escarpment regions down to coastal plains.

Physical features: Encompassing marine and coastal areas of the flat Tihamah coastal plain and rising to granite and gneiss foothills and the Asir escarpment cut by deep wadi canyons.

Climate: Varies across the large altitudinal range of the park, with a mean annual precipitation >250 mm falling over two periods, late winter-early spring and summer, and a mean annual temperature of c. 19°C at the higher altitudes (see Abha, Figure 2.6 and Table 2.2), and at the coast a mean annual precipitation of c. 100 mm falling mainly in winter and with a mean annual temperature of c. 29°C.

Vegetation: The Asir National Park System consists of several units extending from the Asir escarpment near Abha to the Red Sea. High altitude units such as the al Sawdah National Park and the al Qarra National Park lie in the *Juniperus procera* zone, and encompass some of the best stands of this tree species in the Kingdom. The junipers form stands with *Acacia origena*, *Olea europaea*, *Nuxia oppositifolia*, *Maesa lanceolata* and *Teclea nobilis* at successively lower elevations on western slopes. The extreme lower altitudinal limit for *Juniperus procera* here is c. 1,600 m. On the western foothills and plains *Acacia* communities are prominent; *Acacia etbaica*, *A. asak*, *A. hamulosa*, *A. mellifera*, *A. johnwoodii*, *A. tortilis*, *A. seyal* and *A. oerfota* form a mosaic of communities. c. 350 species recorded from al Sawdah, but lists for other units incomplete.

Threats to vegetation: Conflicting land use claims in areas adjacent to human habitation and in areas with high densities of goats. The large area of the park system precludes formal protection.

At Tubayq (NCWCD) (Figure 12.2, 17)

IUCN Management Category: IV (Protected Landscape).

Phytochorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: Core area c. 3,000 km²; 750-1,200 m.

Status: Core area SNR, other areas NR/RUR, declared in 1989.

Reasons for protection: Contains the most northerly population of ibex in Saudi Arabia, lies within the historical range of ostrich and includes a representative area of the northern plain.

Physical features: A high sandstone plateau dropping abruptly in a steep, deeply incised escarpment, to a gravel plain with conical hills and sand drifts.

Climate: One of the nearest representative meteorological stations is Guriat (Figure 2.6, Table 2.2), with a mean annual precipitation of 53 mm falling mainly in winter-early spring, and a mean annual temperature of 19.8°C, with absolute minimum temperatures falling to c. -8°C, and with occasional frosts and snow.

Vegetation: Dwarf shrubs, including a succulent chenopod *Traganum nudatum* and a salt-accumulating shrublet *Reaumeria hirtella*, grow on the plateau, where they are most numerous along shallow runnels. The annual grass *Stipa capensis* is common on the plateau pavements. Hills and the escarpment slopes are barren, as is much of the gravel plain, except along watercourses and where shallow sand drifts support annual plants following rain. Perennial grasses such as *Centropodia fragilis* and *Stipagrostis drurii* grow on the deeper sand drifts. Canyon wadis have the greatest plant diversity, including a few *Acacia pachyceras*, numerous *Haloxylon persicum*, and dwarf shrubs such as *Haloxylon salicornicum*, *Artemisia judaica*, *Centaurea scoparia* and *Deverra trinadiata* and, following rain, many annual herbs. >141 spp., none endangered or rare, but generally with far fewer of the 'weedy' species which are so common over large areas of the Peninsula.

Threats to vegetation: Unrestricted grazing by sheep, goats and camels.

Farasan Islands (NCWCD) (Figure 12.2, 18)

IUCN Management Category: V (Protected Landscape/Seascape).

Phytocorion: Within the Somalia-Masai regional centre of endemism, but with partly azonal vegetation.

Area and altitude: Approximately 600 km²; 0-10 m.

Status: Multiple use area (SNR/NR/RUR) with some regulation of use of marine and terrestrial resources.

Reasons for protection: The islands contain high concentrations of nesting seabirds and ospreys, turtle nesting beaches, a large population of idmi gazelle, and representative examples of unusual vegetation types, including mangrove communities.

Physical features: A group of low-lying islands in the Red Sea formed from uplifted fossil coral reef. In some places the underlying salt substratum has become leached causing the overlying coral to collapse and form long narrow ravines which, together with erosion clefts, hold fine silty clay soils.

Climate: Nearest meteorological station is on the coast at Gizan (Figure 2.6, Table 2.2), with a mean annual precipitation of 129 mm, which, being on the boundary of the winter-early spring and summer rainfall systems, receives rain in both periods; mean annual temperature 30.6°C.

Vegetation: The northwestern plateau and the westward facing shores are exposed to strong prevailing winds and almost devoid of vegetation. Dwarf shrubland is most diverse and abundant in the deep ravines which cut through areas of fossil coral. In larger wadi beds there are trees and shrubs including *Commiphora gileadensis*, *Ziziphus spina-christi* and *Maerua oblongifolia*. There are two groves of *Acacia ehrenbergiana* woodland on the largest island, Farasan Kabir. Two species of mangroves (*Rhizophora mucronata* and *Avicennia marina*) grow on the coastal flats. Sabkha areas support a succulent dwarf shrub community dominated by *Limonium* spp. Endemic or near endemic species are *Glossonema* sp. aff. *boveanum*, *Cucumis* sp. aff. *prophetarum* and *Dipcadi* sp. Within the area of the proposed Naval Base on Farasan Kabir are four rare species found nowhere else in Saudi Arabia (*Micrococca mercurialis*, *Nothosaerva brachiata*, *Basilicium polystachion* and *Vahlia digyna*). Three other rare plants *Cleome noena*

subsp. *brachystyla*, *Ipomoea hochstetteri* and *Brockmannia somalensis* are found north of the port. 179 recorded spp.

Threats to vegetation: The larger islands are inhabited and the SNR is threatened by expansion of cultivation and excessive grazing. Coastal development, including a proposed naval base, threatens the mangroves. Phosphate extraction is a possibility.

Harrat al Harrah (NCWCD) (Figure 12.2, 19)

IUCN Management Category: II (National Park).

Phytochorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: 12,150 km²; 500-1,000 m.

Status: SNR/NR, declared in 1987.

Reasons for protection: Contains breeding houbara bustards, small populations of reem (*Gazella subgutturosa*) and idmi (*Gazella gazella*), and a representative portion of the most extensive basalt lava field in the Arabian Peninsula.

Physical features: Limestone overlain by basalt lava. An undulating plain at c. 850 m with occasional tall volcanic hills. Lower hills and plateaux are covered in limestone or basalt boulders and rock fragments. Small dry watercourses and larger wadis, which consist of a streambed and riverine terraces, drain the plateaux. Deep sands are deposited on the slopes of some hills.

Climate: Nearest representative stations are Turaif and Jouf (Figure 2.6, Table 2.2), with mean annual precipitation of 82 and 63 mm, respectively, falling mainly in winter-early spring, and mean annual temperatures of 18.7 and 21.5°C respectively.

Vegetation: Sparse, patchy dwarf shrub vegetation, concentrated in small drainage lines, wadis and silty depressions. There are no trees, except for the occasional *Tamarix arborea* along large stream beds. Dominant perennial shrub species include *Achillea fragrantissima*, *Artemisia monosperma*, *Artemisia sieberi*, *Astragalus spinosus*, *Calligonum comosum*, *Haloxylon salicornicum*, *Salsola* spp., *Traganum nudatum* and *Zilla spinosa*. *Capparis spinosa* is abundant on the margins of silty depressions. Perennial grasses, which include several *Stipagrostis* spp., are sparsely distributed and poorly represented, probably due to intensive camel grazing in some areas. Chert/gravel plains and rocky basalt slopes (*harrat*) and hills support few perennial plants. A community of *Haloxylon persicum* and *Calligonum comosum* grows on mobile sand drifts. In years with good rainfall there is a flush of annuals in all habitats. In *harrat* areas the edible fungus *Terfezia clavervii* (*faga*), a local delicacy, grows in association with *Helianthemum lippii*. *Faga* is highly sought after and fetches high prices in markets throughout the Kingdom. > 290 recorded spp.

Threats to vegetation: Unrestricted grazing of camels; encroachment of sheep and goat flocks on the reserve's borders; unregulated collection of *faga*.

Hima Saysad (MAW) (Figure 12.2, 20)

IUCN Management Category: Unassigned.

Phytochorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: 7 km², fenced; c. 1,000 m.

Status: RUR, non-grazing reserve created in 1985.

Reasons for protection: Protection from livestock grazing of a small area surrounding an old silted up dam.

Physical features: Undulating sand and gravel plain.

Climate: Nearest representative station is Hima Saysad, with a mean annual precipitation of 182 mm falling mainly in spring and late summer, and a mean annual temperature of 21.4°C, for 1970-1986 (Al-Jerash 1989).

Vegetation: Dominated by dense stands of *Acacia tortilis*. Species list incomplete.

Threats to vegetation: Unregulated encroachment by graziers.

Ibex Reserve (NCWCD) (Figure 12.2, 21)

IUCN Management Category: II (National Park).

Phytochorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: c. 2,000 km²; 600-1100 m.

Status: Multiple use site, including SNR, NR and RUR designations, declared in 1988.

Reasons for protection: Supports a relict population of ibex, is a suitable re-introduction site for idmi gazelle and includes representative examples of the plateau and wadis of the central Tuwayq cuesta.

Physical features: Gently undulating, predominantly limestone plateau, dissected by several deeply incised canyon wadi systems. Aeolian sand has accumulated at the mouths of the larger wadis.

Climate: Nearest stations are at Aflaj, Kharj and Yabrin, with mean annual precipitation of 48-77 mm falling in winter-early spring and mean annual temperatures of c. 25 °C for 1970-1986 (Al-Jerash 1989).

Vegetation: Little rain infiltrates the fine textured soils and rock pavements of the plateau, which is barren except for a few perennial shrubs and grasses where water accumulates in small depressions and along shallow waterlines. In the canyon wadis, rainfall runoff from the plateau provides a year-round supply of ground water to perennial plants growing along the stream beds. On lower terraces and alluvial fans, *Acacia tortilis* dominates dwarf shrub communities. Perennial species include many composites and crucifers, and grasses such as *Panicum turgidum* and *Cenchrus ciliaris*. Upper wadi terraces are sparsely vegetated with small perennial grasses, including *Stipagrostis*, *Oropetium* and *Tripogon* spp. *Haloxylon salicornicum* dominates dwarf shrub communities on drifts of aeolian sand. The standing crop of plants is considerably higher behind three fences which have been constructed to exclude domestic livestock from small areas of the wadis. Endemic or near endemic species include *Capparis spinosa* var. *mucronifolia* and *Ochradenus arabicus*. Species which are rare in Saudi Arabia include *Heteroderis pusilla*, *Salsola lachnantha* and an unusual form of *Kickxia acerbiana* with sagittate leaves. 262 recorded species.

Threats to vegetation: Quarrying and uncontrolled grazing by domestic livestock.

Jubail Marine Wildlife Sanctuary, (NCWCD) (Figure 12.2, 22)

IUCN Management Category: II (National Park).

Phytochorion: Within the Nubo-Sindian local centre of endemism of the Saharo-Sindian regional zone, but with partly azonal vegetation.

Area and altitude: Terrestrial and intertidal zone approximately 1,200 km²; marine reserve approximately 1,300 km²; 0-54 m.

Status: NR/RUR, gazetted in 1995.

Reasons for protection: Contains representative examples of all of the main habitat types found along the western Arabian Gulf coast.

Physical features: Central coastal lowlands consisting of relatively flat white sand dunes, sand sheets, sabkha and salt marshes. There is a gentle slope from east to west, and extensive areas of sand dunes blown into ridges lying north-south. The subtidal zone includes sand, mud and rock substrates and coral reefs.

Climate: Nearest representative station is on the coast at Dhahran, with a mean annual precipitation of 91 mm falling in winter-early spring; mean annual temperature 26.5 °C (Figure 2.6, Table 2.2).

Vegetation: The dunes and deep sandsheets are covered in shrubland communities dominated by *Calligonum comosum* or *Leptadenia pyrotechnica*, several dwarf shrubland communities dominated by *Haloxylon salicornicum*, *Rhanterium epapposum* or *Lycium shawii* and *Panicum turgidum* grassland. Annual plants, especially *Plantago* spp., are abundant during spring. *Zygophyllum qatarense* dominates a succulent dwarf shrub community which grows on the

shallower sandsheets that overlay saline soils. Several salt-tolerant perennial grasses are associated with this community. Annual plants are never abundant. Sabkha generally barren, but may support a succulent chenopod, *Halocnemum strobilaceum*. Salt marshes are covered in zoned communities of succulent dwarf shrubs including *Suaeda* spp., *Halocnemum strobilaceum* and *Salicornia europaea*. The muds that fringe a few protected bays support a dwarf form of the black mangrove, *Avicennia marina*. Seagrass beds of *Halodule uninervis*, *Halophila stipulacea* and *H. ovalis* grow on sandy substrates at depths of 1-20 m. *Zygophyllum mandavillei* is endemic and *Mesembryanthemum nodiflorum* rare. 179 recorded spp.

Threats to vegetation: Grazing by sheep, goats and camels. Military activity, particularly tank exercises. The coastline north of Abu Ali Island has not recovered from the oil spills of the 1991 Gulf War.

Mahazat as Sayd (NCWCD) (Figure 12.2, 23)

IUCN Management Category: I (Strict Nature Reserve/Wilderness Area).

Phytochorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: 2,244 km², completely fenced; 900-1,100 m.

Status: SNR, declared in 1988.

Reasons for protection: Reintroduction site for Arabian oryx, reem gazelle, ostrich and houbara; representative area of the Nejd pediplain physiographic region.

Physical features: Gently undulating sand and gravel plain with a few low basalt hills.

Climate: Nearest representative station at Turabah, with a mean annual precipitation of 97 mm falling in winter-spring, and a mean annual temperature of 23.1°C for 1970-1986 (Al-Jerash 1989).

Vegetation: Rapidly recovering, extensive though still patchy vegetation cover, mostly dwarf shrubland with emergent small trees of *Acacia tortilis* and other *Acacia* spp., and *Maerua crassifolia*. Robust perennial grasses, including *Panicum turgidum*, *Lasiurus scindicus* and *Octochloa compressa* are abundant on deeper sand and on low-lying ground, while *Stipagrostis* spp. are more abundant in rocky areas. Many perennial shrubs and forbs grow among the perennial grasses. *Haloxylon salicornicum* dominates on alkaline soils. *Ajuga arabica* is endemic. The number of plant species recorded in the reserve has increased from 56 at the time of fence completion in 1989, to 112 in 1990 and 156 in 1996.

Threats to vegetation: Intermittent and illegal small-scale harvesting of grasses.

Majami al Hadb (NCWCD) (Figure 12.2, 24)

IUCN Management Category: VI (Managed Resource Protected Area).

Phytochorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: c. 2,000 km²; 900-1,200 m.

Status: SNR/NR/RUR, protected since 1994.

Reasons for protection: Spectacular landscape of granite domes. Forms part of the former range of Arabian oryx, ostrich and two or three species of gazelle. Grazing rights are under dispute and the area has been given to NCWCD to manage for the public benefit.

Physical features: Junction of several major wadis among granite domes and basalt hills.

Climate: Climate contour maps (Figures 2.7-2.11) indicate a mean annual precipitation of 50-100 mm falling mainly in winter and spring, and a mean annual temperature c. 24-25°C.

Vegetation: Rainwater runs off a large area of rocky slopes into the wadis, where fresh water is close to the surface. The granite domes are barren, and the basalt hills support a few small perennial plants including *Stipagrostis* spp. Dwarf shrubland, often dominated by the grass *Cymbopogon schoenanthus*, grows in the waterlines which run off the basalt hills. As the waterlines merge into narrow wadis, trees of *Acacia tortilis*, *A. raddiana*, *A. ehrenbergiana* and *Maerua crassifolia* emerge above the shrubland. Shrubs including *Lycium shawii*, robust perennial grasses including *Cenchrus ciliaris*, *Panicum turgidum* and *Octochloa compressa* and

many dwarf shrubs grow along the riverbanks and on slightly raised terraces. Where the wadi mouths open into wide sandy plains, trees are less numerous. *Rhazya stricta*, which is not grazed by livestock, is abundant on silty areas in the major wadis. 57 recorded spp., but surveys incomplete.

Threats to vegetation: Grazing by sheep, goats, camels and feral donkeys. Poisoning and cutting of trees for firewood.

National Wildlife Research Centre, NWRC (NCWCD) (Figure 12.2, 25)

IUCN Management Category: II (National Park).

Phytochorion: Somalia-Masai regional centre of endemism.

Area and altitude: Fenced stock exclusion zone of c. 15 km²; 1,400 m.

Status: NR, declared in 1986, with stock exclusion extension created in 1993.

Reasons for protection: Research and breeding centre for Arabian oryx, houbara bustard, and ostrich. Representative portion of Asir highland rangelands.

Physical features: Lies within the narrow belt of high country known as the Asir highlands, on a gently undulating gravel and sandy plain cut by numerous shallow wadis. Isolated fragments of the crystalline rocks of the Arabian Shield protrude from the plain.

Climate: Nearest representative station is Taif, with a mean annual precipitation of 204 mm falling mainly in spring and late summer-autumn; mean annual temperature 22.9°C (Figure 2.6 and Table 2.2).

Vegetation: Typical plant communities of the inland Asir plateau, including associations of *Acacia tortilis*, *A. ehrenbergiana*, *Fagonia indica*, *Zygophyllum simplex*, *Salsola spinescens*, *Salvia aegyptiaca*, *Ajuga arabica*, *Panicum turgidum*, *Launaea mucronata*, *Indigofera spinosa* and *Polycarpha repens*, with *Citrullus colocynthis* and *Cucumis prophetarum* commonly present in depressions. *Ochradenus buccatus* increased in abundance following the removal of livestock. After spring rains there is a luxuriant growth of *Stipagrostis plumosa* and annuals, including, *Astragalus tribuloides*, *Eragrostis ciliaris*, *Malva parviflora* and *Assoon canariense*. 222 recorded spp.

Threats to vegetation: Any future expansion of ungulate breeding programmes may encroach on botanical reserve areas; some short-term encroachment by small herds of goats into the stock exclusion extension.

Raydah (NCWCD) (Figure 12.2: 26)

IUCN Management Category: Unassigned.

Phytochorion: Lies at the border of the Somalia-Masai and Afromontane archipelago-like regional centres of endemism and contains elements of both zones.

Area and altitude: 9 km²; 1,460-2,900 m.

Status: SNR designation, but RUR in practice, declared in 1989.

Reasons for protection: Representative example of the middle and upper altitudinal range of the Asir escarpment. Provides habitat for the nine endemic bird species found in Saudi Arabia.

Physical features: Steep granite and gneiss escarpment.

Climate: Nearest available meteorological station is at Abha with a mean annual precipitation of 253 mm falling at two times, in late winter-early spring and summer, and with a mean annual temperature 18.6°C (Figure 2.6, Table 2.2); at the higher elevations rainfall probably >300 mm. Frequent cloud and fog at higher altitudes and rare snow on the peaks.

Vegetation: Relatively undisturbed, mature juniper woodland dominated by *Juniperus procera* extends from the summit down to c. 1,700 m. Trees of tropical African origin, including *Nuxia oppositifolia*, *Maesa lanceolata* and *Celtis africana*, grow in well-watered gullies. *J. procera* is replaced by *Teclea nobilis* and *Tarchonanthus camphoratus* below 1,700 m. Below 1,550 m the slopes are covered in sclerophyllous scrub with trees such as *Ficus* spp., *Buddleja polystachya* and *Ziziphus spina-christi* confined to gullies. *Aloe sabaena* and other rare aloes dominate an unusual

succulent community on rocky south-facing slopes. The lowest slopes are occupied by *Acacia etbaica* xeromorphic woodland, among which grow many rare succulents, including *Caralluma* and *Ceropegia* spp. Endemic and near endemic species include *Aloe abbaica*, *Aloe rivieri* var. *gracilis*, *Ceropegia aristolochioides* subsp. *deflersiana*, *Huernia saudi-arabica*, *Sarcostemma* sp., *Senecio asirensis* and *Albuca pendula*. *Centauurothamnus maximus*, which also occurs in Yemen, belongs to an endemic Arabian genus. *Euphorbia agowensis* used to grow in the reserve, but is now believed to be extinct in Saudi Arabia. 25 other species occur which are rare in Saudi Arabia including *Rhyncosia buramensis*, *Pittosporum viridiflorum* subsp. *arabicum*, *Dombeya torrida*, *Halleria lucida*, *Hybanthus enneaspermus* and *Rhoicissus tridentata*. 347 recorded spp. **Threats to vegetation:** Unregulated grazing of cattle and goats. Livestock trampling and runoff along the unsealed road that runs through the reserve are causing soil erosion. An alien invasive, *Opuntia ficus-indica*, is spreading on the lower slopes.

Sahal Rukbah (MAW) (Figure 12.2, 27)

IUCN Management Category: Unassigned.

Phytochorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: 16 km², fenced; c. 1,000 m.

Status: RUR, non-grazing reserve created in 1985.

Reasons for protection: Investigation of the effects of removal of livestock on the regeneration of the western central desert rangeland.

Physical features: Undulating sand and gravel plain.

Climate: Nearest representative station is Hima Saysad, see Hima Saysad above.

Vegetation: The major plant community consists of *Acacia tortilis* with *Lycium shawii*, *Salsola spinescens* and *Indigofera spinosa*. 64 recorded spp.

Threats to vegetation: Absence of patrols allows fence-cutting and encroachment by graziers.

Thumamah Nature Park (RDA) (Figure 12.2, 28)

IUCN Management Category: II (National Park).

Phytochorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: c. 150 km², of which about 6 km² is fenced to exclude livestock; 500-900 m.

Status: NR, under partial protection since the time of the late King Khaled.

Reasons for protection: Protection of plants and animals in their natural environment and recreational use. There are four public campsites in the Park.

Physical features: Two spectacular limestone escarpments, separated by a plateau, dominate a gravel plain which is crossed by several shallow wadis.

Climate: Nearest representative station is Riyadh with a mean annual precipitation of 126 mm falling in winter-spring; mean annual temperature 24.8°C (Figure 2.6, Table 2.2).

Vegetation: Woodlands dominated by *Acacia pachyceras* and *Acacia ehrenbergiana* grow in the main channels of the major wadis. There are many shrubs, dwarf shrubs and perennial grasses in the undergrowth along these wadis and a profuse growth of annual plants following good rain. Dwarf shrublands, usually dominated by *Haloxylon salicornicum*, cover level ground in much of the Park. *Rhanterium epapposum* dominates a dwarf shrub community on windblown sand over limestone. Grasslands dominated by perennials such as *Panicum turgidum* and *Lasiurus scindicus* grow along wadis and waterlines and in depressions. Some gravel plains support sparse tufts of small perennial grasses, mainly *Oropetium* and *Tripogon* spp., while others are largely barren, as are the steep slopes and the escarpment. Endemic or near endemic species include *Acacia pachyceras* var. *najdensis*. 203 recorded spp.

Threats to vegetation: Grazing by camels and sheep, except in the fenced area which has been protected for almost ten years, occasional tree cutting and off-road driving.

Umm al Qamari (NCWCD) (Figure 12.2, 29)

IUCN Management Category: Unassigned.

Phytochorion: Within the Somalia-Masai regional centre of endemism, but consists largely of azonal vegetation.

Area and altitude: <0.25 km²; sea-level.

Status: SNR, protected against hunting since 1977.

Reasons for protection: Supports thousands of resident doves and other birds, including a large egret/heron colony.

Physical features: A coral atoll consisting of two small islands surrounded by a coral shelf with shallow sea. The main body of the islands are fossil coral but with some surface sand accumulation and soil formation.

Climate: Climate contour maps (Figures 2.7-2.11) and data for 1970-1986 for the station at 50 m at Kiyat (Al-Jerash 1989) indicate a mean annual precipitation of 50-100 mm falling in two periods, winter-early spring and summer (similar to the climate at Gizan, Figure 2.6, Table 2.2), and a mean annual temperature of c. 30°C.

Vegetation: Consists of two categories of plants, one dew-dependent, the other succulent. The first group forms dense thickets up to 3 m tall and is dominated by *Salvadora persica*, with *Atropis farinosa*, *Cadaba rotundifolia*, *Suaeda monoica* and *Suaeda fruticosa*. The *S. persica* is denser and taller towards the edges of the vegetated zone, becoming smaller and less frequent toward the middle of the island where the two species of *Suaeda* are more abundant. The second group is composed of scattered herbs including the succulents *Suaeda vermiculata*, *Zygophyllum album*, *Euphorbia fractiflexa* and the grass-like *Cyperus conglomeratus*. Vegetation surveys incomplete, number of species unknown.

Threats to vegetation: none.

'Uruq Bani Ma'arid (NCWCD) (Figure 12.2, 30)

IUCN Management Category: II (National Park).

Phytochorion: Arabian regional subzone of the Saharo-Sindian regional zone.

Area and altitude: c. 5,000 km², including a 2,400 km² central area from which camps, sheep, goats and most camels are excluded; 640-1,062 m.

Status: NR/BR/RUR, declared in 1994.

Reasons for protection: Suitable habitat for reintroduction of Arabian oryx, reem and idmi gazelle, and ostrich. Representative of the exposed limestone escarpment, parallel dunes and interdune corridors of the western Rub' al Khali.

Physical features: The west-facing Tuwayq escarpment terminates a narrow limestone plateau that is dissected by numerous incised wadis draining eastwards into interdune corridors. Parallel linear dunes, up to 150 m and covered in mobile red sand, separate the interdune corridors (*shiqqat*) which are filled with sand, silt or gravels.

Climate: Climate contour maps (Figures 2.7-2.11) indicate a mean annual precipitation of c. 50 mm falling mainly in winter-spring, and a mean annual temperature c. 26°C.

Vegetation: The limestone plateau is largely barren but the incised wadis support a diverse dwarf shrub community with several perennial legumes, grasses and *Acacia* spp. Perennial grasses and dwarf shrubs, including *Eragrostis indica*, grow on gravels in the interdune corridors. Dwarf shrub communities on sands are dominated by *Tribulus arabicus*. A very diffuse community dominated by a woody shrub, *Calligonum crinitum* subsp. *arabicum*, together with a sedge *Cyperus conglomeratus* and the perennial grasses *Stipagrostis drarui* and *Centropodia fragilis* grow on the dunes. Annual plants are relatively unimportant, and the increase in biomass following rain is due to the germination of perennials. Endemic or near endemic species are *Calligonum crinitum* subsp. *arabicum*, *Cornulaca arabica*, *Limnem arabicum* and *Crotalaria* sp. aff. *leptocarpa*. A rare, unusual variety (var. *divaricatus*) of *Ziziphus spina-christi* occurs. 106 recorded spp.

Threats to vegetation: Seasonally intermittent encroachment of camels into the non-grazing central area of the reserve.

12.4.5.4 Literature Sources

See Abdul-Baqi (1996), Ahmed (undated), Al-Farhan *et al.* (1994), Alwelaie (1989), Alwelaie *et al.* (1993), Anon. (1985b), Anon. (1985a), Anon. (1987), Anon. (1992: pp. 505-515), Anon. (1994a), Barth (1995), Böer (1994), Chaudhary (1980, 1995) Chaudhary and Al-Juwaid (in press), Chaudhary *et al.* (1988), Child and Grainger (1990), Collenette (1985, 1996), Draz (1969), El-Sheikh and Chaudhary (1988), Fisher (1997), Gillet and Launay (1990), Habibi (1989), Jones *et al.* (1995), Kingery (1971), König (1986), Llewellyn (1987), Mandaville (1990), Robertson (1993, 1995, 1996), Robertson and Collenette (1996), Robertson *et al.* (1996), Robertson *et al.* (1997), Seddon (1996a, 1996b), Seddon *et al.* (1994), Seddon and Khan (1996), Seddon and van Heezik (1996), Shorbagi (1996), Thouless and al Bassri (1989), Thouless and Tatwany (1989) and van Heezik and Seddon (1995, 1996).

12.4.6 UNITED ARAB EMIRATES

12.4.6.1 Relevant Legislation

Each municipality of the seven Emirates has its own environmental regulations, though there is a "Draft Proposal for a Federal Law concerning Preservation and Development of the Environment in the United Arab Emirates". It has not been possible to obtain details of the relevant legislation of each Emirate, though in general environmental and wildlife protection appears to be less developed than that of several of the other countries of the Peninsula.

12.4.6.2 Government Agencies

Arabian Leopard Trust (ALT). A non-governmental organisation mainly concerned with the preservation of the Arabian leopard, but also concerned with conservation in general, including that of plants.

Environmental Research and Wildlife Development Agency (ERWDA). Established by Law no. 4, 1996, amended by Law no. 1, 1997, the overall aim of ERWDA is to enhance the sustainable development of the environment of the Emirate of Abu Dhabi. ERWDA includes a Terrestrial Environmental Research Institute, a Marine Research Institute and a Wildlife Veterinary Research Institute. As we write in October 1997 the precise role of the Agency is not yet clear, but one of its objectives is the creation of protected areas.

National Avian Research Centre (NARC). Established by Royal Decree in 1989, and now absorbed into ERWDA, the main goal of NARC is to secure a population of the houbara bustard in Abu Dhabi that can be hunted in the traditional, sustainable way by Arab falconers. As part of this work a number of ecological projects have been undertaken on grazing, habitat degradation and restoration and vegetation surveys.

12.4.6.3 Protected Areas

Abu Dhabi Nature Reserve (Figure 12.2: 31)

IUCN Management Category: V (Protected landscape).

Phytchorion: Nubo-Sindian local centre of endemism of the Saharo-Sindian regional zone.

Area and altitude: c. 20 km², located at the eastern lagoon of Abu Dhabi island; sea-level.

Status: Nature Reserve, declared in 1987. Controlled by the police with no public access.

Reasons for protection: Important grounds for crustaceans, as a breeding site for birds and as a hatching ground for fish.

Physical features: Intertidal mudflat with both natural and artificial drainage channels.

Climate: Nearest representative station is Abu Dhabi, with a mean annual precipitation of 80 mm falling mainly in late winter-early spring; mean annual temperature 27.1°C (Figure 2.6, Table 2.2).

Vegetation: Three perennial species recorded: *Avicennia marina* and *Arthrocnemum macrostachyum* with *Cistanche tubulosa* parasitic on the roots of *A. macrostachyum*. Some unrecorded annuals probably also present.

Threats to vegetation: Prior to the proclamation of the reserve there was damage to young trees by off-road vehicles and honey collectors. Seawater channels dredged in 1987 and 1988 have caused some soil erosion and may be affecting the hydrological features of the ecosystem.

Khawr Dubai (Figure 12.2: 32)

IUCN Management Category: Unassigned.

Phytocorion: Nubo-Sindian local centre of endemism of the Saharo-Sindian regional zone.

Area and altitude: 450 hectares.

Status: Nature Reserve by Royal Decree (Dubai).

Reasons for protection: Conservation of bird life.

Physical features: Intertidal mudflats.

Climate: Nearest representative station is Dubai, with a mean annual precipitation of 116 mm falling mainly in winter-early spring; mean annual temperature 27.2°C (Figure 2.6, Table 2.2).

Vegetation: Three perennial species recorded: *Avicennia marina*, which is largely planted, *Arthrocnemum macrostachyum* and *Halopeplis perfoliata*. Some unrecorded annuals probably also present.

Threats to vegetation: Sewage effluent and the removal of mangrove litter by the Municipality.

12.4.6.4 Literature Sources

See Anon. (1992: pp. 547-550), Böer (1991, 1995, 1996a, 1996b), Böer and Griggs (1994) and Hellyer (1988).

12.4.7 YEMEN

The majority of our information on the status of conservation efforts in the country comes from Anon. (1992: pp. 551-556). This document indicated that, as of 1991, there were no protected areas in Yemen, nor any specific protected area legislation, and as far as we have been able to ascertain, this situation has not yet changed. The 1993 United Nations List of National Parks and protected areas (Anon. 1994a) has no entries for Yemen. However, despite the lack of designated areas, Yemen does appear to have an extant tradition of protected rangeland areas, known as *mahjur* in Yemen and as *hima* elsewhere, that is perhaps stronger than in other countries of the Peninsula (Anon. 1992, and references therein, Kessler 1995). The use of *mahjur* areas in the rangelands of the Dhamar montane plains in northern Yemen is integrated into the local agro-pastoral land-use system, their main importance being as forage reserves in the dry season (Kessler 1995). In comparison with adjacent communal rangelands, *mahjur* areas are characterized by a dense cover of perennial grasses, whereas the communal rangelands are dominated by dwarf shrubs. Although no information is available on the incidental role of these *mahjur* areas in protection of threatened or endemic plant species, they could clearly play an important role in vegetation conservation.

There are areas of both regional and global significance in Yemen, and it is ironic that the three most important areas of plant diversity in Arabia (see section 12.2) all lie either totally or partly within a country that has no protected areas or appropriate legislation. However, we understand that efforts to document and conserve the flora of Socotra are being jointly undertaken by the Government of Yemen and the Royal Botanic Garden, Edinburgh, and that an ethnoflora of the archipelago of Socotra is in preparation.

Table 12.7 Number of protected areas in the six IUCN protected area management categories (Anon. 1994b, see Table 12.6) and number of unassigned protected areas (see text for details), and whether or not the Convention on International Trade in Endangered Species (CITES), the UNESCO World Heritage Convention, and the Biodiversity Convention have been signed, with year of ratification, for each of the countries of the Arabian Peninsula.

Country	IUCN Categories						Unassigned areas	CITES	World Heritage	Biodiversity Convention
	I	II	III	IV	V	VI				
Bahrain	0	0	0	0	0	0	1	no	1991	1996
Kuwait	1	0	0	0	0	1	2	no	no	no
Oman	0	1	0	2	0	0	5	no	1981	1995
Qatar	?	?	?	?	?	?	?	no	1984	1996
Saudi Arabia	1	6	0	2	3	1	4	1996	1978	no
UAE	0	0	0	0	1	0	1	1990	no	no
Yemen	0	0	0	0	0	0	0	no	1980	1996
Total	2	7	0	4	4	2	13			

12.4.8 PROTECTED AREAS SUMMARY

Table 12.7 summarises the number of officially declared reserves in each country of the Peninsula using the 1994 IUCN Protected Area Management Categories (Anon. 1994b, see Table 12.6 for a description of the categories). In the Peninsula as a whole there are currently 19 protected areas in assigned categories and 13 unassigned, the latter consisting of areas <10,000 hectares, one protected area that is not yet officially designated (Wadi Sareen in Oman), and three areas in Oman that were declared in 1997. The table also indicates which of the seven countries of the region have signed the 1973 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), the 1972 UNESCO World Heritage Convention and the 1992 Biodiversity Convention. Currently the only World Heritage protected area site in the Peninsula is the Category II site in Oman, the Arabian Oryx Sanctuary.

12.5 Summary

The varied climates and topography of Arabia, in combination with vicariant evolution and biogeographic influences from Africa, the Mediterranean and Asia, have all contributed to the diversity of the present-day flora of the Peninsula. Of

the c. 3,500 species of vascular plants there is a high degree of endemism in the flora of Socotra (30%) and 2-8% endemism in other regions, notably in the monsoon-affected Dhofar/eastern Mahra region of Oman and Yemen and in the southwestern highlands of Saudi Arabia and Yemen.

Besides general threats associated with 'development', the main threat to species diversity and vegetation cover comes from overstocking the rangelands with domestic camels, cattle, goats and sheep, and in some areas from unchecked breeding of feral donkeys. Although the 'overgrazing problem', as it is commonly known, is being addressed to some extent by active conservation policies and the creation of new conservation areas, the problem is still greater than the current solutions. Besides the need for governments and conservation organisations to address the over-stocking problem directly by enforcing grazing system plans and controlling stocking density, much could be gained locally by the extension of the traditional protected area or *hima* concept.

Most of the conservation areas in the Peninsula have been declared in the last 15 years, and active conservation area policies are still being pursued. However, some of the areas of high diversity and endemism which urgently require conservation (in particular on Socotra and in mainland Yemen, the southwestern and northwestern highlands of Saudi Arabia and in the southern region of Oman) currently receive little or no formal protection.

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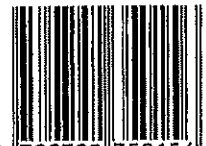
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edited by
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Vegetation of the Arabian Peninsula is the first comprehensive book on all aspects of the vegetation, phytogeography and conservation of the vast and varied region of the Arabian Peninsula. Written and edited by experts on the botany and environment of the Peninsula, this book synthesises the information available on all aspects of the flora and vegetation (including lower plants), from the mountains, sand seas, coasts, water bodies and desert plains to the plants of economic importance. The book contains chapters on the vegetation, ecology and phytogeography of the mountains, wadis, sand deserts, gravel plains, coasts and sabkhas. Chapters on climate and geology provide the background information for understanding the dynamics of the vegetation. A chapter on the diversity of plants gives details of the region's species richness and endemism, current threats to plant diversity and the measures taken in the form of protected areas and legislation in each country of the Peninsula. This book will be an invaluable reference for students, scholars and professionals interested in Southwest Asian botany.

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