Draft Environmental Profile

of

The Sultanate

of

OMAN

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An Introductory Note on Draft Environmental Profiles:

The attached draft environmental report has been prepared under a contract between the U.S. Agency for International Development (AID), Bureau of Science and Technology (ST/FNR) and the U.S. Man and the Biosphere (MAB) Program. It is a preliminary review of information available in the United States on the status of the environment and the natural resources of the identified country and is one of a series of similar studies now underway on countries which receive U.S. bilateral assistance.

This report is the first step in a process to develop better information for the A.I.D. Mission, for host country officials, and others on the environmental situation in specific countries and begins to identify the most critical areas of concern. A more comprehensive study may be undertaken in each country by Regional Bureaus and/or A.I.D. Missions. These would involve local scientists in a more detailed examination of the actual situations as well as a better definition of issues, problems and priorities. Such "Phase II" studies would provide substance for the Agency's Country Development Strategy Statements as well as justifications for program initiatives in the areas of environment and natural resources.

Comments on the attached draft report would be welcomed by US MAB and ST/FNR and should be addressed to either:

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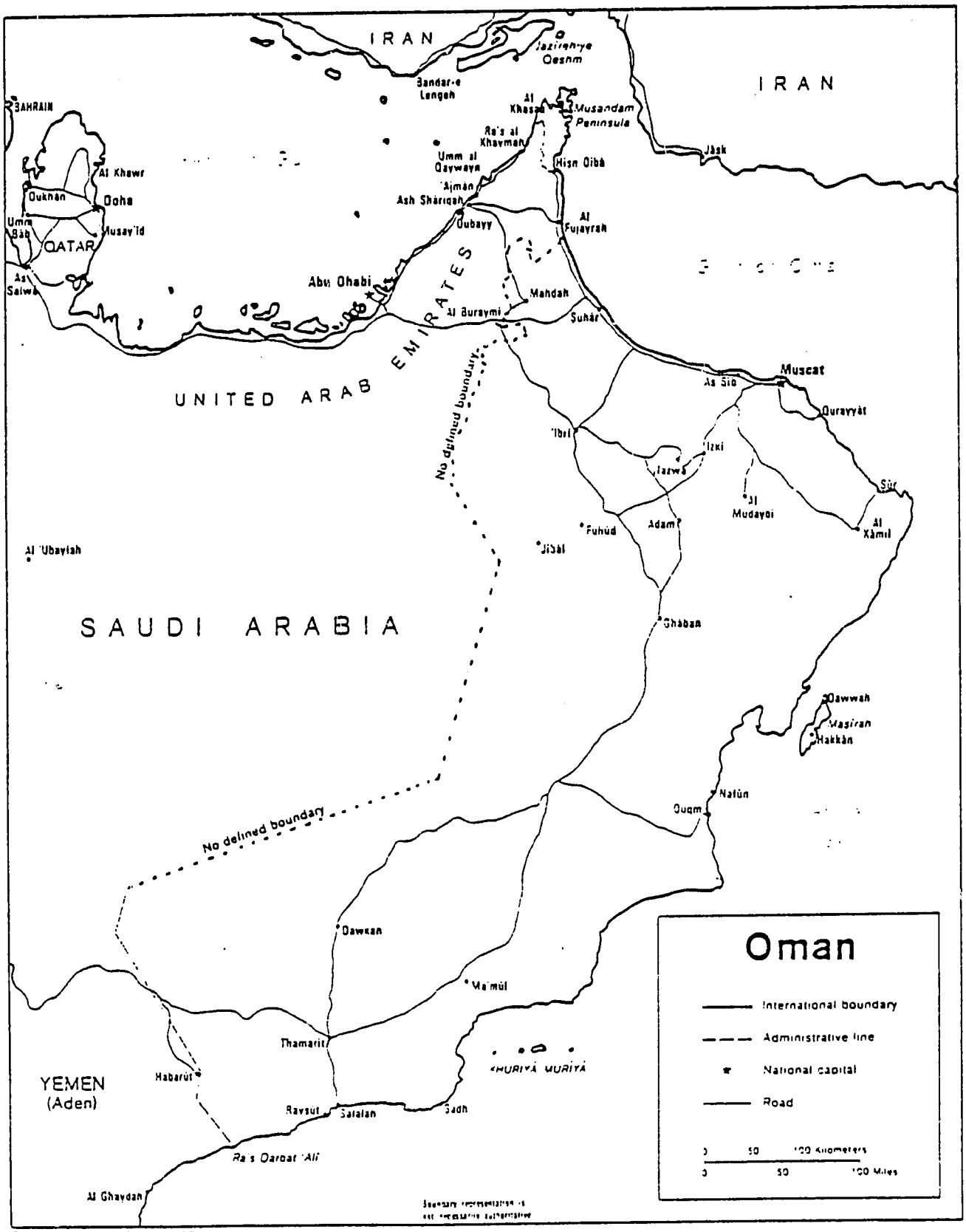

Source: Available from U.S. Government Printing Office

SUMMARY

The Sultanate of Oman lies entirely within the vast arid and semi-arid zones which stretch across North Africa and into Asia. Most of Oman receives 100 mm or less of rain annually, and even relatively "wet" areas of the country normally get less than 250 mm. Oman has the advantage of modest oil resources, which are fueling development efforts, but development is still in the beginning stages. The majority of the population resides in rural areas and engages in agriculture.

As might be expected under such circumstances, most major environmental problems concern water supplies, agricultural resources, and rural health. Major problems include:

Natural water shortages. Rainfall is not sufficient to support dryland agriculture in Oman, and irrigation water is obtained primarily from shallow aquifers and the subsurface flow of dry stream courses. These water sources can be greatly affected by prolonged drought, which is a recurrent feature of the arid climate. In addition, vast areas of the country completely lack water resources at depths accessible by traditional methods.

Overpumping and soil salinity. The introduction of modern pumps in Oman has led to widespread exploitation of groundwater at rates faster than natural recharge. In the northern coastal area, this has caused sea water intrusion into the shallow aquifers, which in turn has caused serious soil salinization problems. In the interior, the nature of the hydrological regime is such that pumps exploit water of higher salinity than that obtained by traditional methods. In this area, high salinity can become a major problem even without overpumping.

Rural health. Improved sanitation and public health programs such as malaria control could probably prevent the majority of Oman's current health problems. Malaria, gastro-enteritis, and dysentery are some of the most frequent diseases. The general lack of latrines or sewage disposal systems helps create conditions conducive to disease organisms. Unprotected water sources and such practices as washing in wells or water channels help spread disease.

Oil spills. Information is not readily available about this environmental danger, but Oman is a modest oil producer. There is some concern about the reliability of pipelines exposed to corrosion, and leaks have been reported in oil storage facilities. More significant is the intense tanker traffic through the Strait of Hormuz and the Gulf of Oman. The Sultanate reported in late 1980 that many of its beaches were polluted with tar from tanker bilgewater discharges.

Lack of trained personnel, environmental data, institutions. The Sultanate has shown that it is concerned with environmental aspects in principle. However, the country is in the beginning stages of development and still lacks manpower trained in environmental technology. In addition, progress is hampered by the nearly complete lack of detailed data on nearly every aspect of resources and environment. No country-wide comprehensive water, soil, or vegetation surveys have yet been carried out. Finally, the Sultanate is only beginning to set up institutions which watch over the environment and assess the impact of projects in the development effort.

Despite the difficulties which face Oman in the solution of environmental problems, the government has already initiated or proposed a number of projects which demonstrate its intention of solving such problems. It has also begun to issue a few laws regulating the worst abuses. Perhaps the most striking demonstration of the government's intent and certainly the most successful to date is the protection of endangered wildlife.

The government of the Sultanate has defined wildlife preservation as one of its priorities. Activity to date has focused on the Arabian tahr, the Arabian oryx, and several gazelles. Strict regulations and controls, along with the general willingness of the Omani people to comply with government directives in this sphere, have aided tahr and gazelle populations in a gradual recovery during the last several years. The Sultanate is also participating in a program to restore the oryx to its native habitat in Oman, after its disappearence in the wild at the beginning of the decade.

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1.0 Introduction

This draft environmental profile summarizes information available in the United States on the natural resources and environment of the Sultanate of Oman. The report reviews the major environmental problems of Oman and the impact of the development process upon resources and the environment. This draft report represents the first step in developing an environmental profile for use by the U.S. Agency for International Development (U.S. AID) and Omani government officials. The next step in this process should be a field study to evaluate the information presented here, obtain additional information, and define the issues, problems, and priorities in greater detail. This entire process should help provide direction in future efforts to deal with the management, conservation, and rehabilitation of the environment and natural resources.

The information and interpretations in this report are preliminary and are not intended to attain the detail and accuracy required for development planning. The report represents a cooperative effort by the Man and the Biosphere (MAB) project staff of the Arid Lands Information Center (ALIC). The primary research, writing, and analysis were done by Mark Speece, through the resources of ALIC and the University of Arizona Library. Particular thanks are extended to Dr. Michael Bonine and Majid ar-Rawahi for the use of materials obtained in Oman. The cooperation of James Corson, AID/MAB Project Coordinator, and other AID personnel is gratefully acknowledged.

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2.0 General Description

2.1 Geography and Climate[1/]

The Sultanate of Oman lies in the southeastern corner of the Arabian Peninsula. The term "Oman" referred originally to a part of the northern interior of the Sultanate. "Oman" came to mean the entire southeastern portion of Arabia to Europeans, but many inhabitants still assume that "Oman" refers to the interior. In this report, "Oman" is used for the entire Sultanate of Oman. Oman should not be confused with Trucial Oman, which became the United Arab Emirates in 1971.

Oman is bordered by the Gulf of Oman on its northern coast, and by the Arabian Sea along its eastern coast. There are inland boundaries with the United Arab Emirates (UAE) to the northeast, Saudi Arabia to the east, and the People's Democratic Republic of Yemen (also called Yemen-Aden or PDRY) to the southeast. The tip of the Musandam Peninsula is also a part of Oman, but it is separated from the rest of the Sultanate by UAE territory. Only the borders of the Musandam portion and that with the PDRY have been officially demarcated. Figures given for the area of the country therefore differ widely, ranging from 212,400 to 310,000 sq. km.

The Sultanate consists of two major inhabited portions, the northern area and Dhufar, separated by an expanse of nearly uninhabited desert (Fig. 1). These two portions have a similar progression of geographic zones in many respects. However, the climatic regime of Dhufar is tied to the monsoon climate of the Indian Ocean. Dhufar is thus somewhat cooler and wetter in the summer than the rest of the country.

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[1] Sources: Cordes and Scholz. 1980.
Hawley. 1977.
Nyrop, et al. 1977.
Pedgley. 1970.
Scholz. 1976.
Stevens. 1970.
UNESCO. 1976.
Wilkinson. 1977.

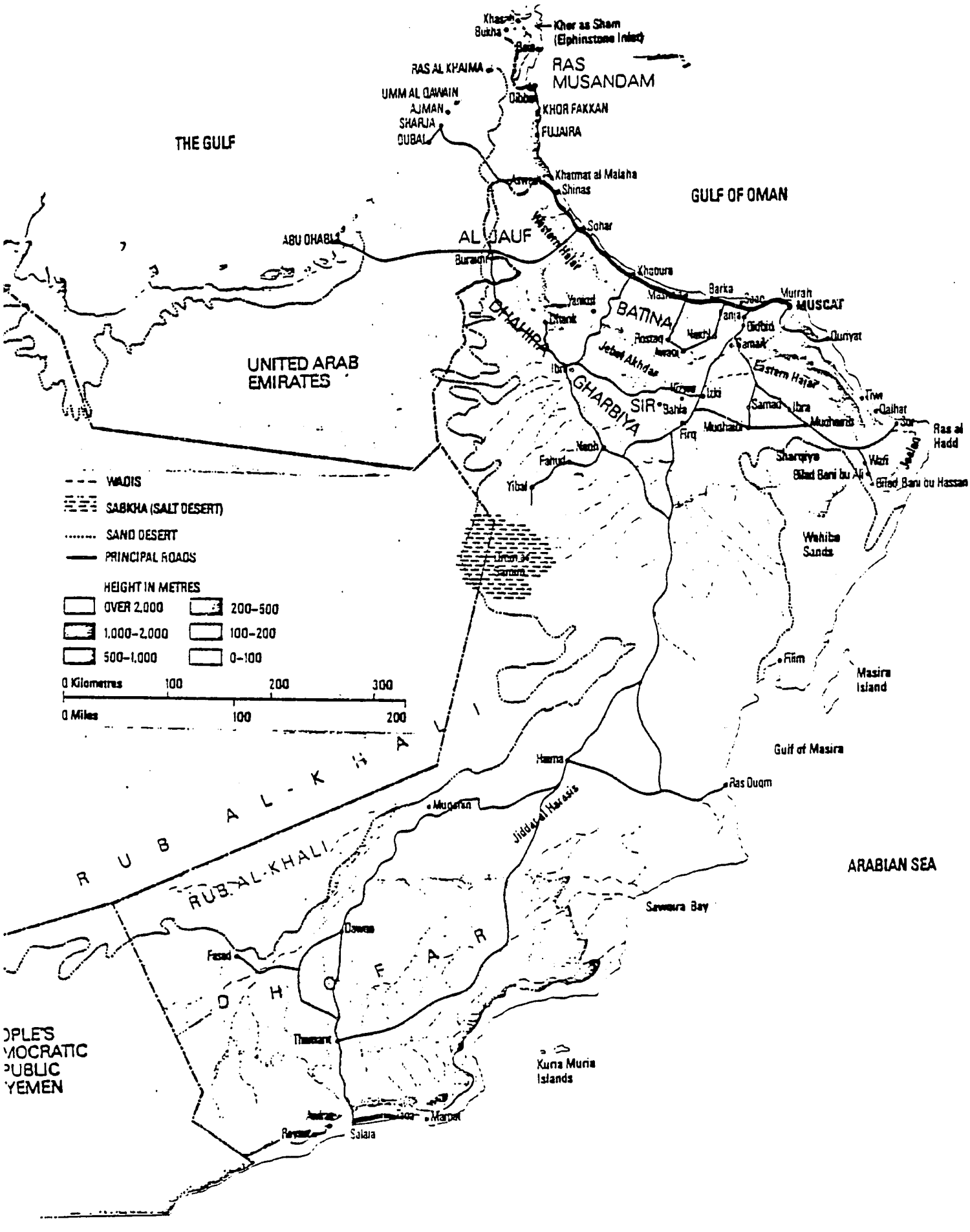

Figure 1. Towns, Roads, Major Regions
Source: Hawley. 1977.

2.1.1 Northern Coastal Area

Geographers distinguish six zones in northern Oman (Fig. 2), although much of the literature blends these into three broader regions. The Batinah is a low lying coastal alluvial plain. It extends for about 240 km from the borders of the UAE nearly to the area of Musqat, and there are pockets of this coastal plain along the coast between Musqat and Ras al-Hadd.

Air streams from the Mediterranean reach Oman in the winter by way of the Persian/Arabian Gulf, and are responsible for most rainfall in the Batinah. The Batinah gets an average of 76 to 100 mm annual rainfall. However, the average rainfall for Sohar is stated to be only 37.2 mm by UNESCO (1976). The average for Musqat (1893-1976) was 103.7 mm. Nearly three-fourths of Musqat's rain falls in December through February or March. Average rainfall can be quite erratic from year to year. For example, the figures for Musqat in 1976, 1977, 1978 were 302.3 mm, 181.3 mm, and 73.7 mm respectively.

Temperatures along the Batinah are generally high, sometimes reaching 48°C in the summer. Mean temperatures in the winter range from 15°C to 24°C. At Musqat, the monthly average maximum in January is 27.0°C and in June and July 40.9°C. Relative humidity in the Batinah may reach over 90 percent. At Musqat the average maximum humidity was above 80 percent all year, and the average minimum was never below 20 percent for the period 1952-1961. Appendix I contains more detailed climatic statistics for Musqat and several other Omani cities.

The coastward foothills and wadi (wash) region (Region III, Fig. 2) is distinguished by geographers as a transition zone between the mountains and the Batinah, and has an intermediate climate. This region is quite sparsely inhabited compared to the Batinah or the wadis of the mountains.

2.1.2 Northern Highlands

The Oman mountains extend from the Musandam Peninsula to the easternmost point of Oman at Ras al-Hadd. At either end of this arc the mountains reach the seacoast; only in the central portion does the Batinah (and the foothills region) intervene. These mountains are composed of sedimentary and volcanic rocks, forming steep escarpments cut by canyon-like valleys and broad, flat wadis. General elevations are around 1220 m, but there are extensive areas of higher elevation. Peaks in the Jabal Akhdar area, central to the chain, reach 3050 m. There are also extensive plateau areas which approach the 2000 m level.

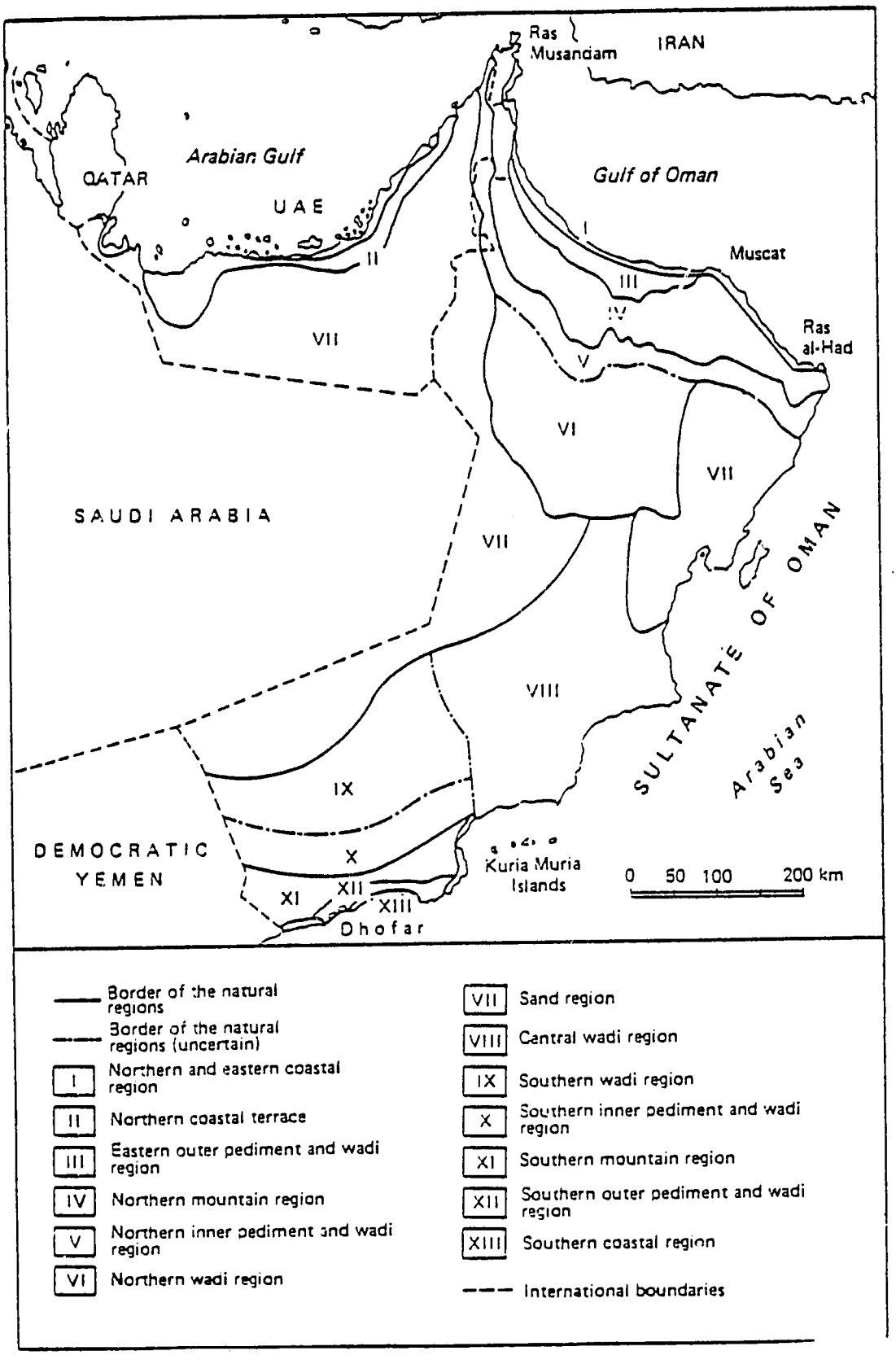

Figure 2. Geographic Zones
Source: Cordes and Scholz. 1980.

A number of major wadis run out of the highlands across the Batinah toward the Gulf of Oman. Wadi Sama'il is the only one that normally has surface flow in its lower reaches throughout the year. In particularly dry years, even this may fail. Other major wadis which cross the Batinah include (north to southeast) Jizzi, ᶜAhin, Hawasina, bani Ghafir, Farᶜa, bani Kharus, and Maᶜawil. Wadis Mijlas, Tayyin and Falaij reach the sea on the northeast coast of Oman between Musqat and Ras al-Hadd. In none of these does surface flow reach the sea except in particularly wet years or after exceptionally heavy rains.

Wadis draining inland include Dhank, Kabir, Sayfam, and Bahlah. These drain toward the Rubᶜ al-Khali. Wadis Halfain and ᶜAndam run from the central portion of the mountains to the southeast coast near Masirah. Wadi Batha and its tributaries begin in the southeastern portion of the mountains and reach the sea south of Ras al-Hadd.

Rainfall in the mountain zone is higher than along the coast, averaging 150 to 200 mm in most areas, and even somewhat higher in Jabal Akhdar. The average annual rainfall at Nizwa for 1963-1967 was 161 mm, while 139.2 mm were recorded in 1978. There is no extended record for other stations, but at Rustaq 88.3 mm were recorded in 1978, a year in which Musqat received 73.7 mm.

Oman's situation on the boundary of two meterological regions is more evident at higher altitudes than in the Batinah coastal plain. For the period 1963 to 1967 Nizwa recorded the highest rainfall in the months of April, May, and July. (28 m, 50 mm, and 30 mm respectively; yearly average = 161 mm). Smaller amounts fell in the winter (15 mm in December). However, in 1978 there were heavy rains in winter and early spring (28.9 mm January; 42.5 mm March), and only one month of heavy summer rains (51.1 mm July; year 139.2 mm). At Rustaq in 1978 rainfall was fairly evenly divided between the late winter and late summer periods.

The average humidity at Rustaq, which is on the coastal side of the mountains, varied in 1978 between 51 and 78 percent throughout the year. At Nizwa, on the inland side, humidity ranged from 45 to 71 percent for the same year. Maximum temperatures at Rustaq were a few degrees warmer in the summer and a few degrees cooler in the winter than in Musqat. The minimum temperature was a few degrees cooler year round for 1978. At Nizwa the maximums were comparable to those of Rustaq, while minimums averaged still another few degrees cooler.

2.1.3 Interior Oman

The inner foothills and wadi region is another transitional zone, sometimes classed with the mountain region, sometimes with the interior lowlands. A few records are available from stations in this area. Al-Wafi, at the eastern end of this region, received 69 mm of rainfall in 1978, nearly all of it in winter and early spring. Temperatures were similar to Rustaq or Nizwa, while humidity was somewhat higher than in either of these towns. Rainfall records from Buraimi, on the border between the Sultanate and the UAE, show an annual total of 39.5 mm, 14.8, and 77.3 mm for 1966, 1967, 1968 respectively. Most rainfall fell during winter and early spring.

The interior foothills and wadi region is the last area in the north inhabited by sedentary groups. From here to Dhufar the desert areas are frequented only by nomads. In western Oman the fringes of the Rub^{c} al-Khali form a sand region, while the east contains the extensive Wahiba sands. The north-south strip between the sand regions consists of broad, flat terraces cut by a number of shallow wadis. These are grazing lands for nomads' herds, and a few oases are scattered throughout the area.

Within this nomadic region climatological data is available from Fahud. Average annual rainfall for the periods 1956-1957; 1963-1967 was only 30 mm, with 26 mm of this evenly distributed in March, April and May. Relative humidity ranged from 23 to 51 percent. Average daily maximum temperature varied from 25°C in January to 45°C in June.

2.1.4 Dhufar

In Dhufar the geographical progression is similar though less pronounced than in the northern portion of the Sultanate. The sands of the Rub^{c} al-Khali also intrude into northern Dhufar, where the bands of the interior foothills and wadi regions begin. Climatic data from Thamarit (Midway) shows that temperatures and humidity are similar to Fahud. Rainfall figures are not available, but conditions are likely to be similar to those in Fahud. The northern slopes of the mountains lie in a rain shadow, and the vegetation is quite sparse.

The highlands of Dhufar are the eastern extension of a wider range that lies in the PDRY as well. In Dhufar the highest peaks reach about 1220 m. Beyond general observations, no detailed climatic data is available for the mountain region. The southern side receives high rainfall from the summer monsoons. Dhufar is the only place in Oman to receive a substantial amount of rainfall from these

southeast monsoons. Precipitation is higher on the southern slopes than in any other area of the country, ranging from 633 to 762 mm.

The coastward foothills and wadi region is a small transitional zone to the coastal plain in Dhufar. This plain is about 48 km long, centered on Salala, with a maximum width of about 8 km. Average annual rainfall from 1942 - 1972 was 107.9 mm at Salala, and 71.0, 116.9, and 367.7 mm for 1975, 1976, and 1977 respectively. July and August are normally the heavy rainfall months, but heavy rains can also occur during any other month between April and October. Temperature ranges are not as extreme at Salala as in most other areas of the country. The average monthly maximum lies between 26.8°C and 33.4°C (1974 - 1977). Average monthly minima may be as low as 15.0°C in the winter.

2.2 Demographic Characteristics[2/]

2.2.1 Distribution

No census has ever been taken in Oman, thus all figures are based upon estimates. World Bank estimates from 1979 place the population at 860,000 to 864,000. Of these, about 140,000 are foreign residents. There also may be as many as 38,000 Omanis working abroad. The government uses a population figure of 1.5 million for planning purposes, but is well aware of current estimates. Approximately 20 percent of the population was urban in 1978, up from 5.1 percent in 1970. The largest urban area is the region around Musqat, the capital, and Matrah. This "capital area", which includes Musqat, Matrah, Ruwi, and Sib, is being developed as one urban unit. The combined population of the capital area is about 80,000. Other towns of some importance include Nizwa (10,000), Salala (10,000), Sohar, and Sur. Oman's growth rate is estimated at 3.1 percent.

The population density for the country is estimated at about 3 persons per square km. The density on arable land however, is about 81 persons per square km. Settlements in rural areas are confined to those places where both water and cultivable land are available. The Batinah

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[2] Sources: Birks and Sinclair. 1979.
Hawley. 1977.
Middle East Annual Review. 1980.
Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. Annual Supplement. 1980.
Sultanate of Oman. 1979.
U.S. AID. 1980a.
U.S. Dept. of Commerce. 1980.
Who's Who in the Arab World 1978-79.

coastal plain is one such area, and this coastal strip is the most densely populated area of the Sultanate. In the foothills regions on either side of the mountains, as well as in the mountains themselves, settlements usually lie along the major wadis. Wadi Sama'il and the wadis around Rustaq-Awabi are two particularly populous areas. The desert areas between the northern region and Dhufar are virtually uninhabited. Dhufar itself is sparsely populated compared with the northern region.

2.2.2 Social Composition

The population is overwhelmingly Arab and Arabic speaking, and is nearly all Muslim. Nevertheless, a number of divisions within Omani society reveal influences of non-Arab peoples, differences in religious practice within Islam, different socio-economic organization, and tribal politics. In the major urban areas of coastal Oman, there are sizeable minorities of E. Indians, Pakistanis, Baluchis, and Persians. Black African influence is also evident in some urban areas, particularly in Salala. Dhufaris are also often considered distinct from the Arabs. They can probably trace their ancestry back to non-Arab peoples who inhabited southern Arabia in ancient times. The Shihuh of the Musandam Peninsula is another group which may be traced to pre-Arab populations.

The predominant religion of Oman is Ibadhi Islam, which is distinct from either the Sunni or Shi'a branches which prevail in the rest of the Muslim world. About three-fourths of the population is Ibadhi Muslim, and Ibadhism has set the tone in governmental organization and jurisprudence in Oman. About one quarter of the population is Sunni, including a few tribes which are Wahhabi. Shi'ism is practiced by a few Omanis, especially in coastal urban areas where there is Iranian influence. Another dichotomy within Omani society is the one between settled villagers and nomadic Bedouin. Bedouin range over most of the vast non-mountainous area of the Sultanate, but they number only about 30,000.

Tribalism is very much a factor in Omani society, among the settled majority as well as the nomadic Bedouin. Tribal organization is most firmly entrenched in interior areas, and often must be considered in development schemes. For example, water, land or grazing rights may be owned corporately, rather than individually.

The two traditional political divisions of Omani society, Hinawi and Ghafiri, are based upon tribal alliances, and cut across socio-economic organization or religious boundaries.

2.2.3 Public Health [3/]

Despite great strides during the last decade, there is still ample room for improvement in health standards. The crude death rate was estimated at about 19 per 1000 in 1977, an improvement over the 26 per 1000 in 1960. The death rate among children 1 to 4 years of age was about 29 per 1000 in 1979, also down from 48 in 1960. The infant mortality rate is estimated at about 142 per 1000. Life expectancy at birth is about 47 years. The poor health conditions, particularly outside the few major urban areas, may be attributed to malnutrition, lack of sanitation facilities, and general absence of knowledge about personal hygiene or preventive health measures. Severe shortages of medical personnel further contribute to inadequate health care.

Very few figures are available on incidence of disease or cause of death. Malaria was apparently the most common disease treated during 1977. Of 730,000 patients treated, 46.6 percent of the treatments were for malaria. Enteritis accounted for another 28.9 percent of these treatments. A parasite survey conducted among 2548 school children in 1977-1978 yielded 346 (13.6 percent) positive tests. Another survey conducted in the capital area showed nutritional deficiencies among students of various ages (Table 1).

Table 1. Nutritional Deficiencies

Age	6-12	13-18	19-24
Sample	12254	510	211
Deficiencies	(%age of sample)		
Vitamin B	2.0	4.0	4.7
Vitamin C	0.1	0.4	0.6
Iron	4.2	7.0	3.3
Calcium	2.6	9.0	10.9
Flurosis	0.8	6.2	6.8

Source: Autret and Miladi. 1979b.

[3] Sources: Autret and Miladi. 1979a.
Autret and Miladi. 1979b.
Hawley. 1977.
Jessop. 1979
Myrop et al. 1977.
Reid. 1978.
U.S. AID. 1980a.
U.S. AID. 1980b.
Who's Who in the Arab World 1978-79.

Comparable figures for children under 6 years of age are not available. Malnutrition and growth retardation are cited as problems for all age groups. These problems are largely due to ignorance of nutritional requirements and to intestinal parasites, rather than to lack of food (Amine 1980, Hawley 1977).

A number of other diseases are cited as present in Oman, without quantitative data about incidence. Trachoma, glaucoma, and other eye diseases are common, as were helminthiasis, poliomyelitis, tuberculosis, and various vitamin deficiency diseases. Small incidences of leprosy, cholera, and smallpox were also noted in the mid-1970s. Epidemics of cholera, measles, and influenza occur periodically. Several immunization and innoculation programs have been carried out, including efforts against smallpox, poliomyelitis, diptheria, whooping cough, tetanus, and tuberculosis.

2.3 Economic Characteristics[4/]

At first glance, Oman's per capita GDP of US $3,900 and GDP growth rate of 31 percent may indicate that the country is quite advanced in the development process. However, these figures are a reflection of Oman's modest oil exports, rather than the true state of the economy. The GDP growth rate is largely a result of oil price increases, and approximately two-thirds of the population is thought to have an annual income of less than US $300 per year. Oil revenues accounted for 61 percent of the GDP in 1979, while public administration (including defense) made up another 11 percent (Table 2). Approximately 95 percent of the value of Oman's exports was from oil, and most of the rest was from re-exports (Table 3). The only other products originating in the country were agricultural goods. Only 2 percent of the labor force is involved in the oil industry, while 50 percent are employed in services.

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[4] Sources: Birks and Sinclair. 1979.
Europa Publications. 1980.
Middle East Annual Review. 1980.
Middle East Economic Digest, Special Report. 1978.
Nyrop et al. 1977.
Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. Annual Supplement. 1980.
Sultanate of Oman. 1980a.
Sultanate of Oman. 1979.
Sultanate of Oman. no date.
U.S. AID. 1980b.
World Bank. 1979.

Table 2. Gross Domestic Product by Industrial Origin, Market Prices
Millions of Omani Rials (OR)

	1975	1976	1977	1978	1979[a]	% in 1979
Agriculture, fishing	18.1	20.0	24.0	27.1	32.0	2.7
Oil	473.7	525.0	534.8	498.4	710.0	60.6
Manufacturing	2.5	4.0	8.3	11.2	14.2	1.2
Construction	89.2	98.2	84.2	85.3	95.7	8.2
Transport, communications	23.5	29.6	28.2	33.2	36.7	3.1
Power	1.8	2.9	6.3	8.0	9.3	0.8
Wholesale, retail trade	48.1	47.0	65.5	72.2	83.0	7.1
Banking	8.9	9.4	13.3	14.5	15.4	1.3
Ownership of dwellings	9.3	14.2	18.3	21.8	26.3	2.2
Public administration, defense	55.3	78.9	83.4	105.9	131.8	11.3
Services	8.4	10.0	13.8	15.2	16.3	1.4
Total GDP	738.8	839.2	880.1	892.8	1170.7	99.9

a Provisional.

Source: Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. Annual Supplement. 1980.

Table 3. External Trade, Millions of OR

	1973	1974	1975	1976	1977	1978	1979
Imports							
Recorded	40.7	135.6	264.3	350.5	302.1	327.2	416.4
Unrecorded estimate	45.1	78.5	120.0	155.0	104.0	108.3	62.7
TOTAL	85.8	214.1	372.3	405.5	406.2	435.5	479.1
Exports							
Petroleum	114.3	418.7	438.1	543.8	545.9	521.8	745.7
Other	0.6	0.4	1.1	1.4	1.5	6.5	
Re-exports	—	—	—	6.0	12.0	24.0	43.2
TOTAL	114.9	419.1	489.2	551.2	559.4	552.3	788.9

Source: Europa Publications. 1980.

2.3.1 Agricultural Sector

Agriculture (including livestock and fishing) is still one of the most important sectors of the economy, and certainly the sector which is predominant in rural areas. Although it has contributed less than 3 percent to the GDP since the early 1970s (2.7 percent in 1979), 48 percent of the total labor force is employed in agriculture. Nearly 70 percent of the native Omani work force is active in this sector. Agriculture is still largely oriented toward subsistance. An estimated 36,000 ha (0.12 percent of Oman's surface area) are cultivated, with about 58 percent of this devoted to date palms in 1975. Alfalfa accounted for nearly another 14 percent of the cropped area. Limes and onions are other relatively important crops, while wheat and maize, tobacco, bananas, mangos, coconuts and a number of others are grown to a lesser extent.

The agricultural sector has been stagnant throughout the 1970s. There are a number of causes, including insufficient investment by both the public and private sectors, and high rates of migration from rural areas which leaves labor shortages in agricultural areas. Scarcity of water is a natural constraint which also contributes to the stagnation, particularly since the traditional irrigation system is deteriorating from lack of maintenance which exacerbates the problem. Fishing has been second only to farming in the traditional economy, and still occupies about 10 percent of the labor force. This activity has also declined over the past decade for many of the same reasons that agriculture has.

This stagnation in agriculture and fishing has come at a time when demand for food has rapidly increased. As a result Oman is becoming dependent upon imports of agricultural goods in which the country was once self-sufficient. Food, animals, beverages, tobacco, and animal and vegetable oils and fats accounted for 17.4 percent of Omani imports in 1978. The value of these imports has risen rapidly in the last decade (Table 4). Oman began to address these problems in the first five year plan (1976-1980), but budgeted only 4.4 percent of total government spending during the period directly to agriculture and fisheries. Acutal spending during the first three years of the plan was only 57 percent of the funds budgeted to agriculture. The 1981-1985 plan allocates 10.3 percent of total government expenditures to the Ministry of Agriculture and Fishing.

Table 4. Recorded Imports Classified under SITC Sections

Value in thousand Rials Omani

SITC Section	1970	1971	1972	1973	1974	1975	1976	1977	1978
0 Food & live animals	3,000 (39.5)	4,998 (36.3)	5,645 (30.2)	9,747 (24.0)	15,033 (11.1)	28,803 (10.1)	30,390 (12.1)	38,116 (12.6)	42363 (12.9)
1 Beverages & tobacco	141 (1.9)	420 (3.0)	686 (3.6)	814 (2.0)	1,585 (1.2)	3,087 (1.2)	4,827 (1.9)	6,322 (2.1)	11548 (3.5)
2 Crude materials, inedible, except fuels	76 (1.0)	263 (1.9)	293 (1.6)	782 (1.9)	2,763 (2.0)	5,628 (2.1)	5,944 (2.4)	6,414 (2.1)	4833 (1.5)
3 Mineral fuels, lubricants and related materials	340 (4.5)	955 (6.9)	910 (4.9)	1,759 (4.3)	5,073 (3.7)	10,797 (4.1)	17,138 (6.8)	21,461 (7.1)	27542 (8.4)
4 Animal & vegetable oils & fats	*	*	*	179 (0.4)	704 (0.5)	869 (0.3)	1,171 (0.5)	1,973 (0.7)	3134 (1.0)
5 Chemicals	183 (2.4)	577 (4.2)	741 (4.0)	1,837 (4.5)	5,018 (3.7)	8,999 (3.4)	9,384 (3.7)	11,139 (3.7)	13618 (4.2)
6 Manufactured goods	1,813 (23.9)	2,233 (16.2)	3,630 (19.4)	7,988 (19.6)	29,587 (21.8)	46,519 (16.4)	47,739 (19.1)	53,782 (17.8)	58649 (17.9)
7 Machinery & transport equipment	1,284 (16.9)	3,451 (25.0)	5,223 (27.9)	12,612 (31.0)	53,710 (39.6)	95,774 (36.2)	102,063 (40.8)	123,563 (40.9)	125933 (38.5)
8 Miscellaneous manufactured goods	450 (5.9)	697 (5.1)	990 (5.3)	2,858 (7.0)	11,060 (8.2)	18,292 (6.9)	22,536 (9.0)	29,425 (9.7)	31961 (9.8)
X Articles not classified	305 (4.0)	190 (1.4)	615 (3.3)	2,100 (5.2)	11,087 (8.2)	45,545 (17.2)	9,348 (3.7)	9,870 (3.3)	7640 (2.3)
TOTAL	7,592 (100.0)	13,784 (100.0)	18,713 (100.0)	40,674 (100.0)	135,578 (100.0)	264,313 (100.0)	250,540 (100.0)	302,064 (100.0)	327221 (100.0)

NOTES 1 Prior to 1975, figures for recorded imports through Salalah are not available, hence not included. For 1975, only total value is available and is included under 'Articles not classified'.

2 Import figures are calculated on the basis of c.i.f. values, and are classified according to the Standard International Trade Classification (SITC).

3 Figures in parentheses are percentages of the total value of imports

*Separate figures not available, included under section 0.

Source: Sultanate of Oman. 1979.

2.3.2 Effects of Migration on Agriculture

The impact of migration is largely felt in rural areas, and thus by the agricultural sector. Rural men often leave their villages or tribal territory to work in neighboring Arab states or in Oman's urban areas or oil fields. In one sampled population of 17,000, 74 percent of males aged 14 to 40 years were absent from home. Only 12 percent of all males over 15 years of age had not been away at least half a year as a wage earner. Even these statistics do not give a complete picture, because very often the purpose of labor migration is to gain the skills or capital to enter a higher status non-agricultural occupation. Thus, even if the migrant returns home eventually, he is usually no longer willing to be involved in agricultural work.

Lack of labor has led directly to a contraction of cropped acreage (Birks and Sinclair 1979). Winter wheat cultivation, for example, is about one-fourth as extensive as it was three decades ago. Less obvious but perhaps more significant is the declining care given to date palm husbandry, which is beginning to cause declining yields. Another result is the deterioration of the traditional irrigation system. The falaj (aflāj) system is dependent on man-made underground channels which tap aquifers in higher rainfall mountain areas and transport the water to cultivable areas. The system requires constant maintenance to operate. Migration of Omanis abroad does affect other sectors also. The Sultanate must import over half of its modern sector work force. Most of the imported labor is unskilled and could easily be filled by Omanis who are working abroad.

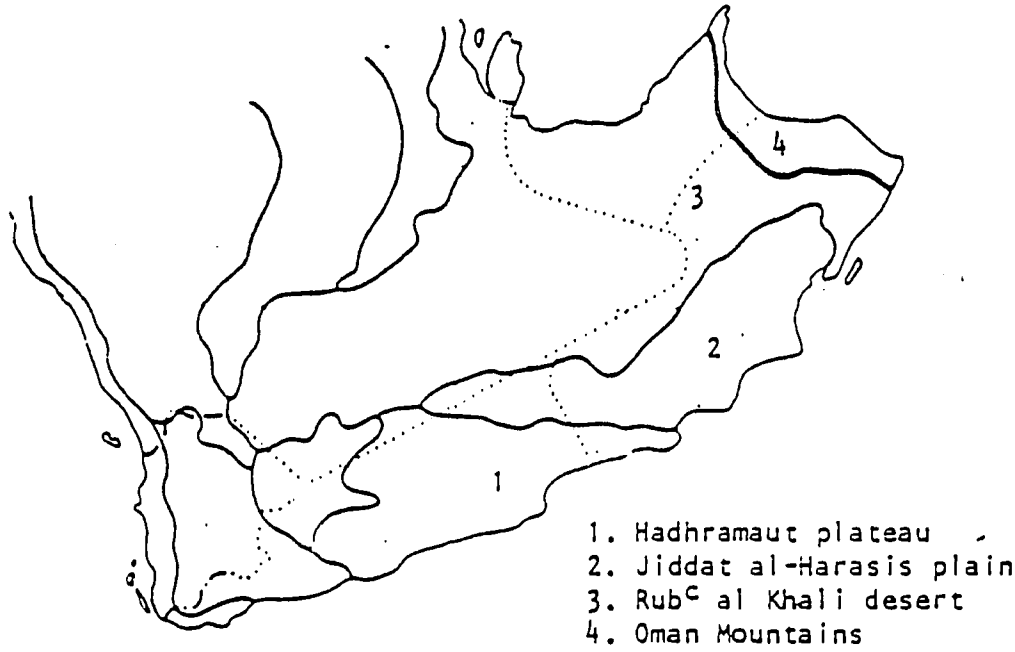
3.0 Environmental Resources

3.1 Geology and Mineral Resources

3.1.1 Geology[5/]

A UNESCO-FAO survey (UNESCO-FAO 1977) shows four broad geological regions in Oman (Fig. 3).

Figure 3. Geological Regions



Source: Adapted from UNESCO-FAO 1977.

[5] Sources: Hawley. 1977.
Morton. 1959.
Tschopp. 1967.
UNESCO-FAO. 1977.

hree of these broad regions are considered subregions of he Arabian Shield and Median Zone. The Hadhramaut plateau Region 1, Fig. 3) is situated primarily in the PDRY, with nly a small portion intruding into Dhufar. The plateau onsists mainly of tertiary rocks, including calcareous hale, limestone, and massive gypsum with chert and marly ands interbedded with limestone.

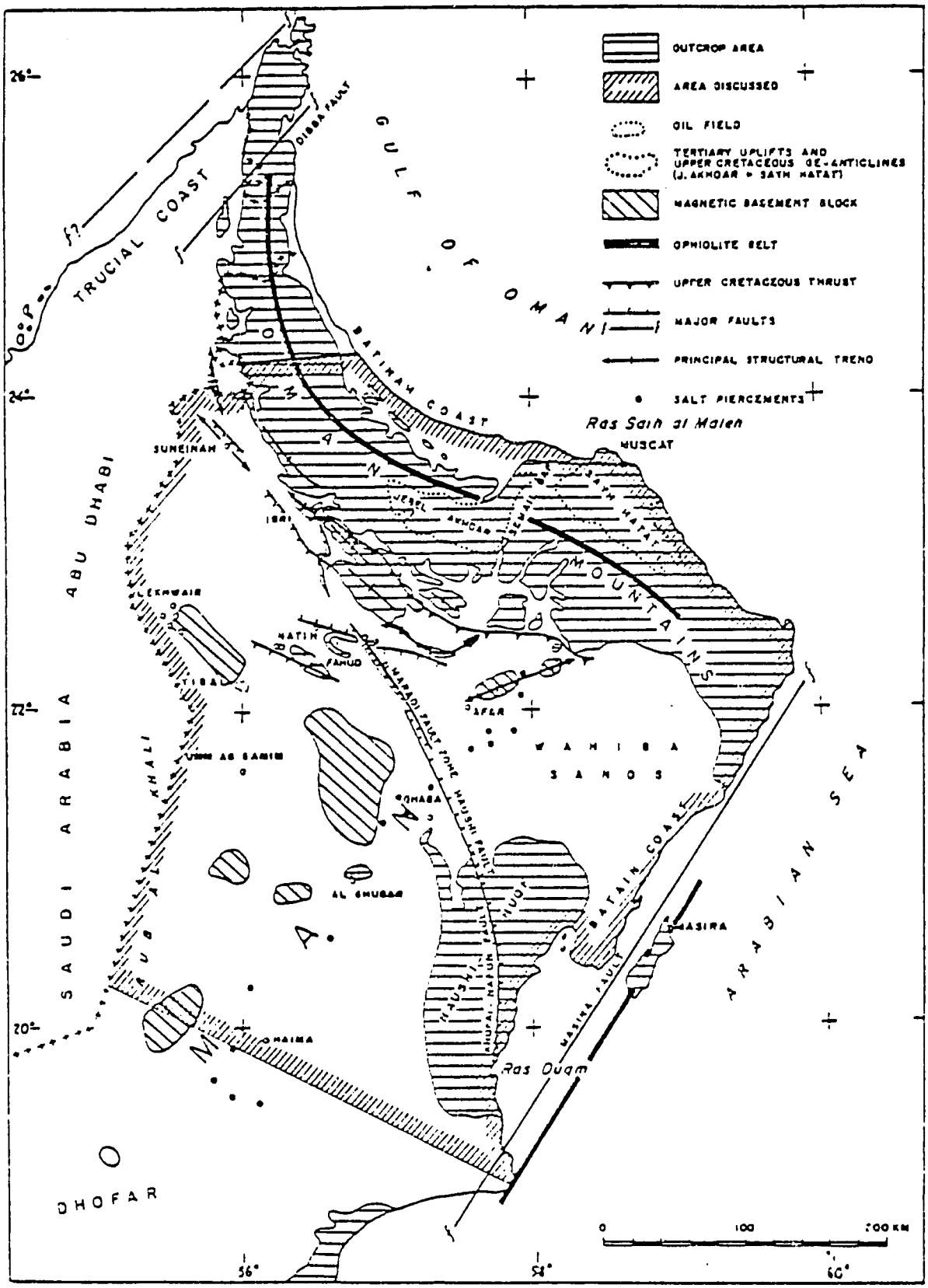
he Jiddat al-Harasis plain (Region 2, Fig. 3) is found in hufar and central Oman. This flat gravel plain is dotted ith low eroded ridges and scree hills. In the eastern art gravel overlies chalk and marl, which are in turn nderlain by Cretaceous limestone. In the southwest and orth the underlying rock is fine-grained hard limestone. obile sand dunes can also be found in a number of areas in he Jiddat al-Harasis.

he Rub^{c}al-Khali desert (Region 3, Fig. 3) covers much of he interior of the Sultanate. In this vast wasteland of ravel plains and sand deserts, the sand is mainly aeolian nd often occurs in very high, long ridges, which may be up o 150 m high and over 40 km long. The Wahiba Sands, which each the coast, are considered an extension of this desert egion.

he Oman mountains (Region 4, Fig. 3) are structurally part f the Zagros chain found in Iran. They consist of an nticline of Cretaceous rocks with a Precambrian core. he main rocks are chert, limestone, gabbro, diorite, and everal other ultrabasic rocks.

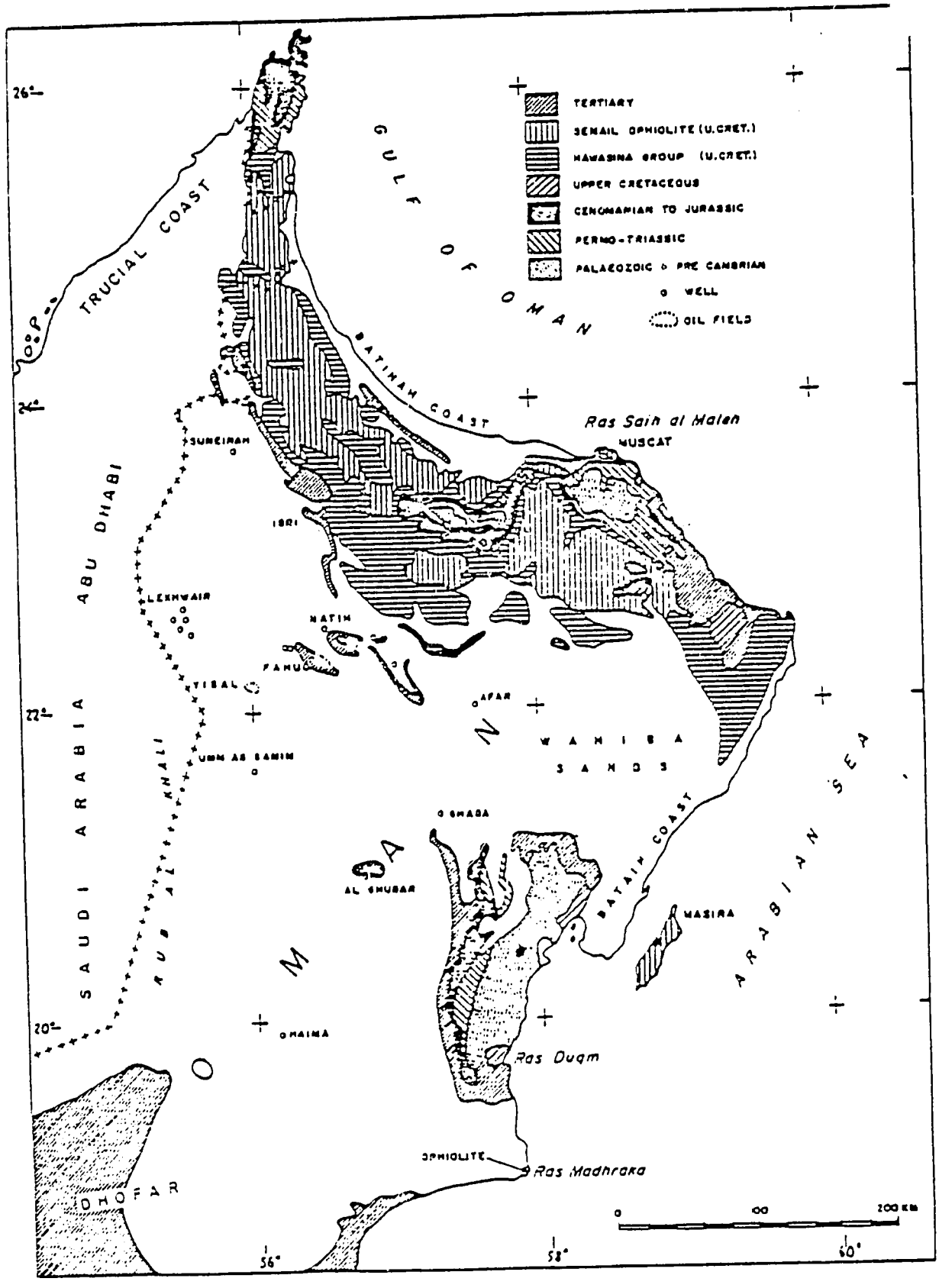
ue to interest in oil, the stratigraphy of northern Oman s known in some detail. A basement of igneous rocks has ot yet been found in the northern part of the Sultanate. t seems to be represented only in a small area of Dhufar near Murbat) and nearby on the Kuria Muria islands. Paleozoic nd pre-Cambrian to Middle Cambrian sedimentary formations re found in the Haushi Huqf area and near Jabal Akhdar nd Saih Hatat in the Oman mountains (Figs. 4, 5, 6). he base formations are characterized by sandstones, rgillaceous siltstones to silty shales, and cherty dolomites n the Haushi Huqf area. In the Oman mountains the omposition is of conglomeratic clastics containing basement ocks, followed by shallow marine sandstones and thin tidal-flat limestones and sandstones. Overlying formations include lastics and dolomitized tidal flat limestones in the aushi Huqf area. In the mountains the succession of siltstone, sandstone, and limestone bands is repeated. olomites with silicified algal stromatolites can be found n the top levels.

Figure 4. Major Tectonical Elements



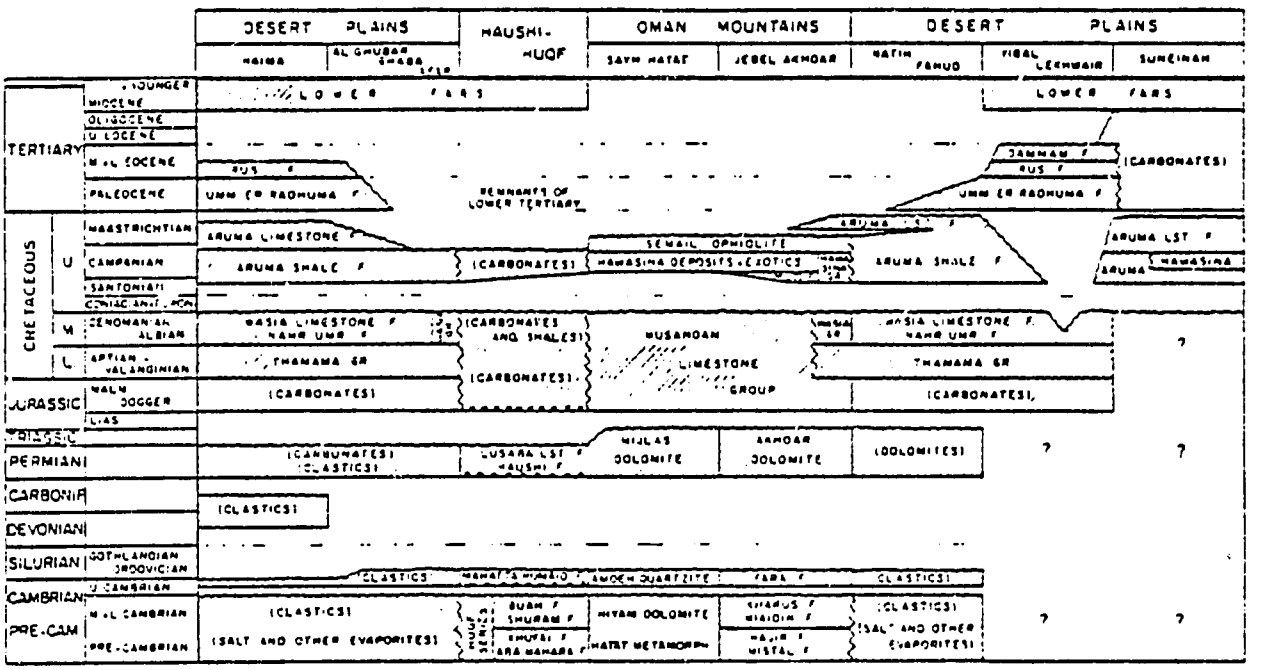
Source: Tschopp. 1967.

Figure 5. Geological Map



Source: Tschopp. 1967.

Figure 6. Stratigraphical Correlation Chart



LEGEND

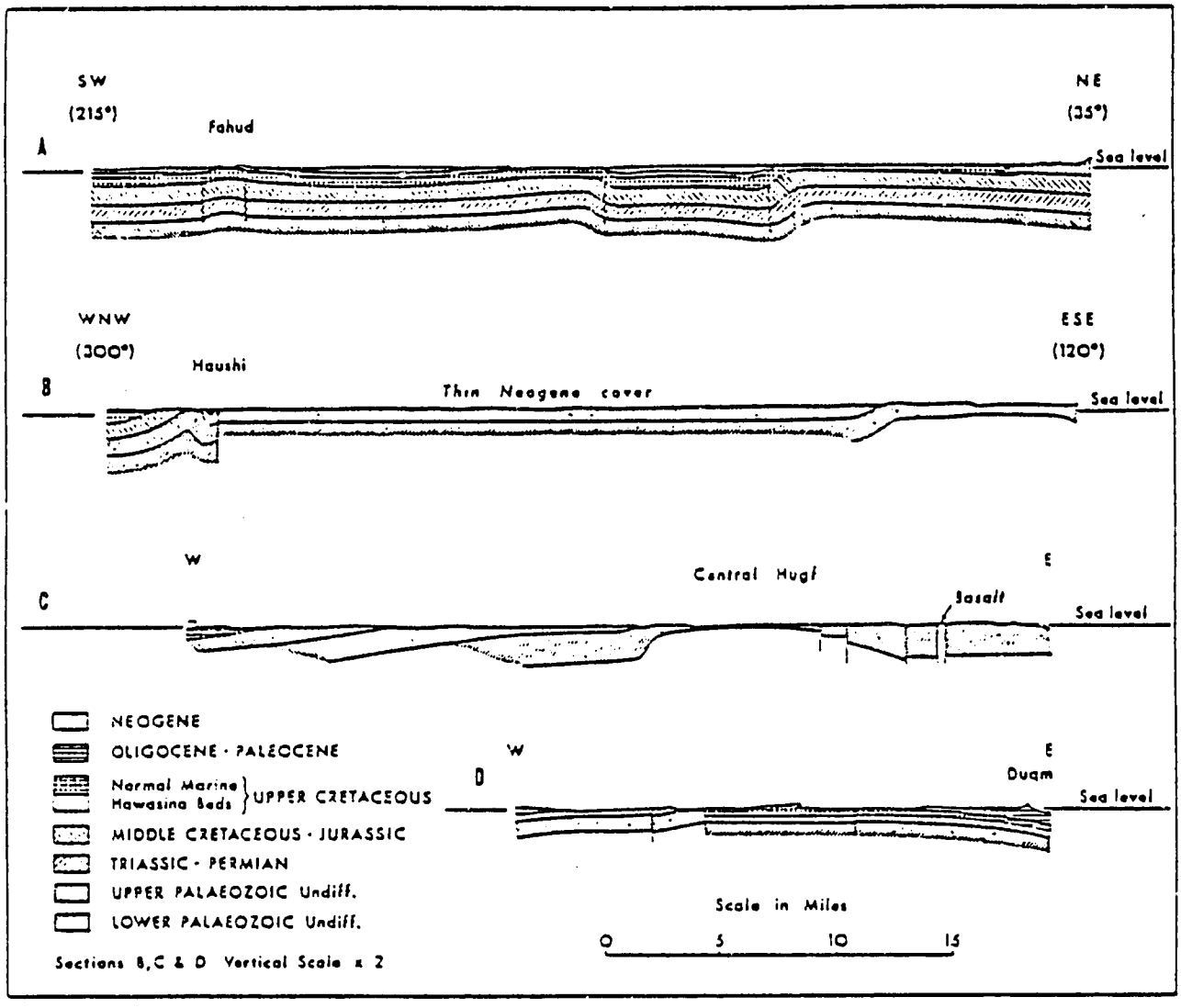
GP GROUP
F FORMATION
LST LIMESTONE
BASE CONGLOMERATE
HIATUS
DEPOSITION

Source: Tschopp. 1967.

Permo-Triassic and Jurassic to Cenomian formations are generally found in areas surrounding the pre-Cambrian formations, with additional outcrops in the Musandam Peninsula. Conglomerates, red sandstones, various limestones, and argillaceous siltstone predominate in the Haushi Huqf area through both sequences. Dolomites are most common in the Permo-Triassic formations of the mountains. Various limestone sequences then predominate in the Jurassic to Cenomanian.

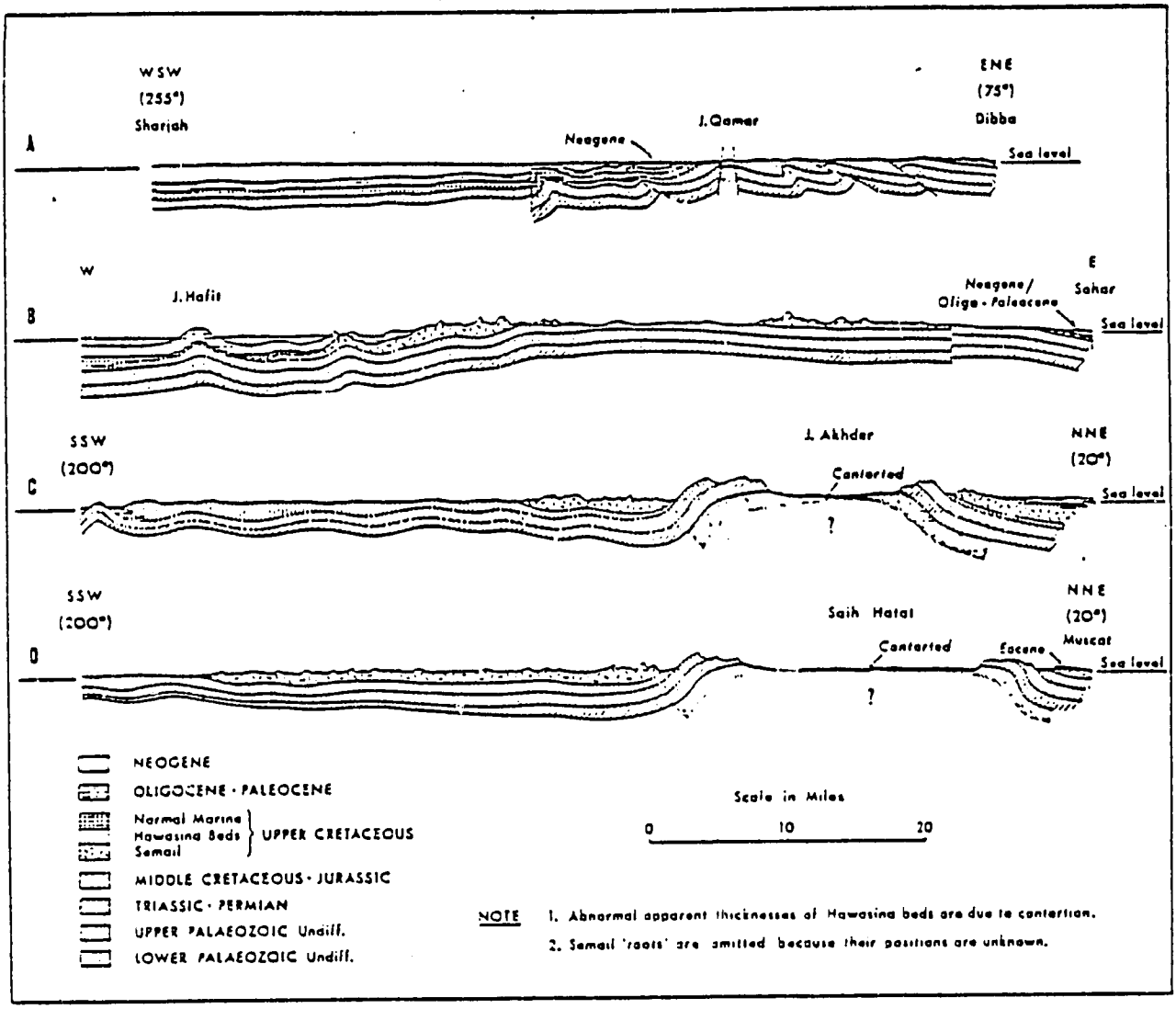
Basement block movements followed the deposition of the preceeding sequences, which resulted in several separate sequences. Most of the Oman mountains are made up of either Hawasina group deposits or Sama'il Ophiolites. The Hawasina

Figure 7. Structural Cross-Sections of Oman Foreland



Source: Morton. 1959.

Figure 8. Structural Cross-Sections of Oman Mountains



Source: Morton, 1959.

group consists of calcareous shales, limestone conglomerates, cherty limestones and shales, and radiolarites. Sama'il Ophiolites are ultrabasic extrusions, and form one of the largest almost continuous outcrops of ophiolites in the Middle East. Contacts with other rocks are seldom seen, feeder pipes or fissures have not yet been found, and thus little is known about the subsurface form and thickness of the various bodies of ophiolites. Small areas of Tertiary sequence are scattered along the fringes of the mountains and Haushi Huqf area. A large continuous area is found in Dhufar. Structural cross sections for a number of areas are shown in Figures 7 and 8.

3.1.2 Petroleum Resources[6/]

By world standards, Oman's petroleum production is not particularly large. The Sultanate pumped 14,200 thousand tons in 1980 compared to 495,000 thousand tons for Saudi Arabia or 30,000 thousand tons for Egypt (Petroleum Economist Jan. 1981). Nevertheless, oil is the most significant sector in the Omani economy in terms of contribution to the GDP. Just over 60 percent of the GDP was from oil (Table 2, section 2.3) and 95 percent of export earnings came from oil. (Table 3, section 2.3). Although the first concession was granted in 1937, exploration was interrupted by the Second World War, and did not resume until 1948. Only in 1964 was the announcement finally made that oil did exist in Oman in quantities sufficient for production. Production and export began in 1967. Since then production has fluctuated somewhat and peaked in 1976 at 133.8 million barrels (Table 5). Japan is the major purchaser of Omani oil (Table 6).

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[6] Sources: Europa Publications. 1980.
Middle East Annual Review. 1980.
Middle East Economic Digest. Special Report. 1978.
Petroleum Economist. Jan. 1981.
Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. Annual Supplement. 1980.
Who's Who in the Arab World. 1978-1979.
World Bank. 1979.

Table 5. Production of Crude Oil, Exports and Exploration Activities

	D I S T R I B U T I O N										
	1967	1969	1972	1973	1974	1975	1976	1977	1978	1979[b]	1980[b,c]
Cumulative Number of Wells											
Non-Producing (a)	50.0	80.0	134.0	174.0	207.0	194.0	220.0	240.0	293.0		
Producing	21.0	58.0	109.0	143.0	150.0	213.0	226.0	245.0	253.0		
Production											
(Thousand BBL/Day)	57.0	328.0	282.0	293.0	290.0	341.0	368.0	340.0	314.0		
(Million BBL/Year)	20.9	119.7	102.8	107.0	105.8	124.6	133.7	124.1	114.7	107.7	51.0
(Exports (Million BBL/Year)	20.9	119.2	103.2	106.9	105.8	124.8	134.3	122.0	115.9	107.6	49.3

a. Non-producing wells include dry holes, water injection and wells producible but not producing. (In 1973, out of 174 non-producing wells, six were producible.

b. Source: Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. Annual Supplement. 1980.

c. Jan-June

Source: World Bank. 1979.

Table 6. Direction of Oil Exports (in percentages)

	D I S T R I B U T I O N[a]						
	1974	1975	1976	1977	1978	1979	1980[a,b]
Japan	35.4	37.5	43.3	51.4	57.0	63.8	49.1
United States	2.9	5.8	15.8	15.4	15.3	13.2	2.4
Caribbean Islands	3.7	10.7	7.5	9.1	5.9	(c)	(c)
Netherlands	1.3	20.5	14.6	9.1	6.3	7.1	16.2
France	12.0	6.9	6.4	3.9	1.3	0.5	2.2
Norway	3.0	1.2	0.4	1.1	6.5	4.8	5.9
Sweden	1.2	0.0	0.0	1.4	0.8	(c)	(c)
Canada	11.7	3.8	6.0	3.0	0.0	(c)	(c)
United Kingdom	5.4	6.6	1.3	1.1	0.7	5.6	3.0
Other	20.9	7.0	4.7	3.6	5.2	5.0	21.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

a. Source: Quarterly Economic Review of Qatar, Bahrain, Oman, the Yemens. Annual Supplement. 1980.

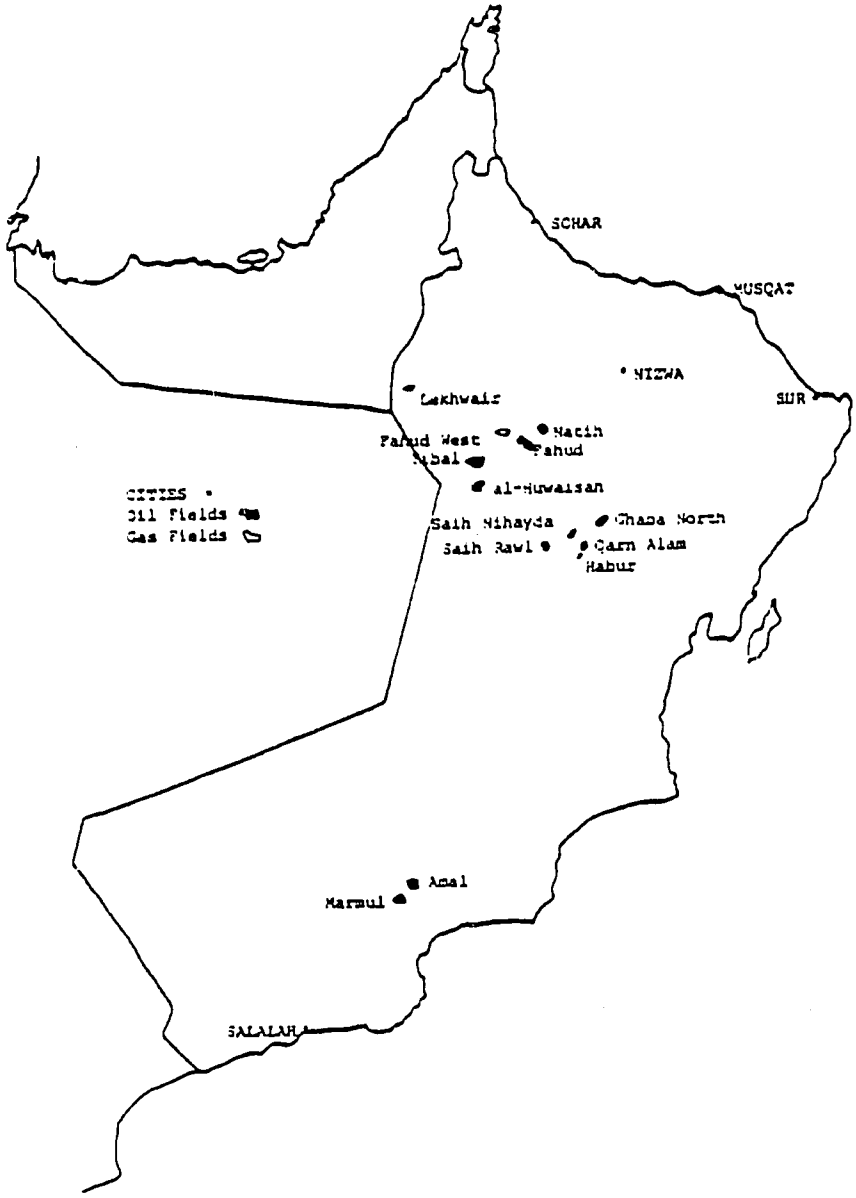
b. January-June

c. not distinguished separately in source

Source: World Bank. 1979.

Most of the currently producing fields are in the desert of the northern part of the Sultanate. The group of fields around Fahud (Fig. 9) are the largest producers. Yibal, Fahud, and Natih began production in 1967, and are connected by pipeline to Mina al-Fahal, near Matrah on the coast. Huwaisah came into production in 1971, the field around Ghaba in 1975, and Lekhwair in 1976. A number of spur pipelines connect these fields also with Mina al-Fahal. A pipeline was under construction in 1980 to connect the Dhufar fields to the main pipeline network in the north, and these fields are expected to begin production in 1981. Total recoverable reserves from all of these fields are estimated at 2.4 billion barrels, but it is likely that future exploration will discover additional fields.

Figure 9. Major Oil and Natural Gas Fields



Source: Adapted from Petroconsultants LTD. 1977.

Natural gas reserves are estimated at up to 5,000 billion cubic feet. The major fields are in the area of Fahud and Yibal. A pipeline to the coast near Musqat (Ghubra) was completed in 1978, and several liquidification plants were either recently completed or are nearing completion in 1981. Production was about 60 million cubic feet per day in 1979, but a daily yield of 140 million cubic feet is expected.

3.1.3 Other Minerals[7/]

Oman has often exported mineral resources throughout its history, which reaches back at least four millennia. Copper has always been the major mineral mined, but silver and coal were also known (Nyrop et al. 1977, Tosi 1975, Goettler et al. 1976). Although oil has become the dominant factor in the economy today, Oman is beginning to discover and rediscover a number of other minerals. A great variety have been found, but it is not yet clear whether many of them are in quantities which are economically exploitable. Mining operations are planned for several, and copper and asbestos production are expected to begin soon. Copper is found in several areas about 40 km inland from Sohar. Reserves are estimated at up to 20 million tons averaging 2.1 percent copper. Mining operations are currently beginning to exploit three of the deposits, and the government expects to produce 3,000 tons per day. A flotation mill and smelter is being built at Sohar which will produce 20,000 tons of pure copper per year.

Asbestos has also been found in the northwest mountains, and is considered to be present in commercially exploitable quantities. An asbestos cement plant and asbestos pipe factory have been built at Rusayl, but it is not clear whether these are using Omani asbestos. Chromite has been found on the coastal side of Jabal Akhdar, coal deposits are being investigated south of Sur, and manganese is present at Ras al-Hadd. Other minerals which have been reported include iron ore, lead, zinc, nickel, silver, gold, phosphate. Materials such as limestone and marble are also present in sufficient

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[7] Sources: Europa Publications. 1980.
Middle East Annual Review. 1980.
Middle East Economic Digest. Special Report. 1978.
Nyrop et al. 1977.
Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. Annual Supplement. 1980.
U.S. AID. 1980b.
U.S. Dept. of the Interior. Bureau of Mines. 1976.
U.S. Dept. of the Interior. Bureau of Mines. 1979.

quantities to support the Omani construction industry. Table 7 summarizes the reserves of minerals for those which have been investigated in any detail.

Table 7. Mineral Reserves

Mineral	Reserves (million tons)	Source	Projected Production (thousand tons/year)	Source
Copper	20	5,6	20	1,4
	12	1,2,4		
Asbestos	8-10	6		
Chromite	5-10	6		
	2	1		
Coal	10	6		
Cement			600	3
Salt			8	3
Marble			10	4

Sources:
1. Europa Publications. 1980.
2. Middle East Annual Review. 1980.
3. Middle East Economic Digest. 2 May 1980.
4. Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. Annual Supplement. 1980.
5. U.S. Dept. of the Interior. Bureau of Mines. 1976.
6. U.S. Dept. of the Interior. Bureau of Mines. 1979.

3.1.4 Minerals Policy[8]

The Sultanate is committed to a policy of Omani control over the economy, including mineral resources. Foreign investment is encouraged, but all foreign ventures must have at least 35 percent Omani participation. In the petroleum industry in particular, this policy translates into state participation. Petroleum Development Oman (PDO) is currently the only company producing in Oman. PDO is

[8] Sources: Europa Publications. 1980.
Middle East Economic Digest. Special Report. 1978.
U.S. Dept. of the Interior. Bureau of Mines. 1979.

60 percent state owned, 34 percent Shell, 4 percent Compagne Francaise des Petroles, and 2 percent Partex. Prospecting is currently being carried out by a number of other consortiums, in which Oman has 80 percent ownership. Oman is not a member of OPEC or OAPEC, but it coordinates pricing policy and requires of foreign investors benefits equal to those received by OPEC members.

The copper mining venture is 75 percent state owned, with the rest divided between Marshal Oman Exploration (Houston) and Prospection Oman (Toronto). The state owns 60 percent of the Oman Cement Co., in partnership with Kuwait. Revenue from mineral resources (only petroleum to date) are used to finance Omani development. Nearly 95 percent of the budget comes from oil income, and 15 percent of all oil revenue is set aside in a special reserve fund. Non-oil mineral development is generally considered to be one of the country's priorities. Therefore, Oman is investing a great deal in infrastructure development in order to make its mineral deposits more accessable.

3.2 Water Resources[9/]

Rainfall in Oman is quite scanty, and only in local regions of Dhufar does the yearly average exceed 250 mm (Section 2.1). There is not enough rainfall to support cultivation, and agriculture everywhere depends upon irrigation. A number of irrigation techniques have been developed in Oman, utilizing both the occasional surface water and ground water.

3.2.1 Surface Water

In addition to scarcity of rain, high evapotranspiration works against the accumulation of surface water in Oman. These high rates lead to an unfavorable water balance. Figures are not available for Oman, but conditions in low elevations are quite similar to those in the UAE, where pan evaporation rates have been estimated (Table 8). For mountainous areas in the Sultanate, the rate of potential evapotranspiration probably drops about 700 mm per 100 m increase in elevation.

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[9] Sources: Gischler. 1979.
Nyrop et al. 1977.
Sultanate of Oman. 1980a.
U.S. Army Corps of Engineers. 1979.
Wilkinson. 1977.

Table 8. Estimated Pan Evaporation Rates in Northern U.A.E.

Station	*Estimated Annual Evaporation (in mm)*	*Mean Wind Movement (km/day)*	*Remarks on station*	
Sharja	3414	154	Gulf coast	
Digdaga	3029	63	12 km inland but lies in the line of a sand-dune belt which protects it from dominant NW wind	western bajada zone
Falaj al-Mu'allā	3705	87	38 km inland	
Milayḥa	4202	104	53 km inland	
Kalbā	3241	100	Gulf of Oman coast	

Source: Wilkinson. 1977.

Under these conditions, it is not surprising that no lakes or perennial surface flowing streams exist in Oman. Surface flows occur only after the short intense rains, and since most storms are unpredictable and local in nature, only a few of the wadis may have surface water at any one time. Because the mountainous regions are characterized by bold relief and scarcity of soil and vegetation, runoff into the wadi network after such storms is quite rapid.

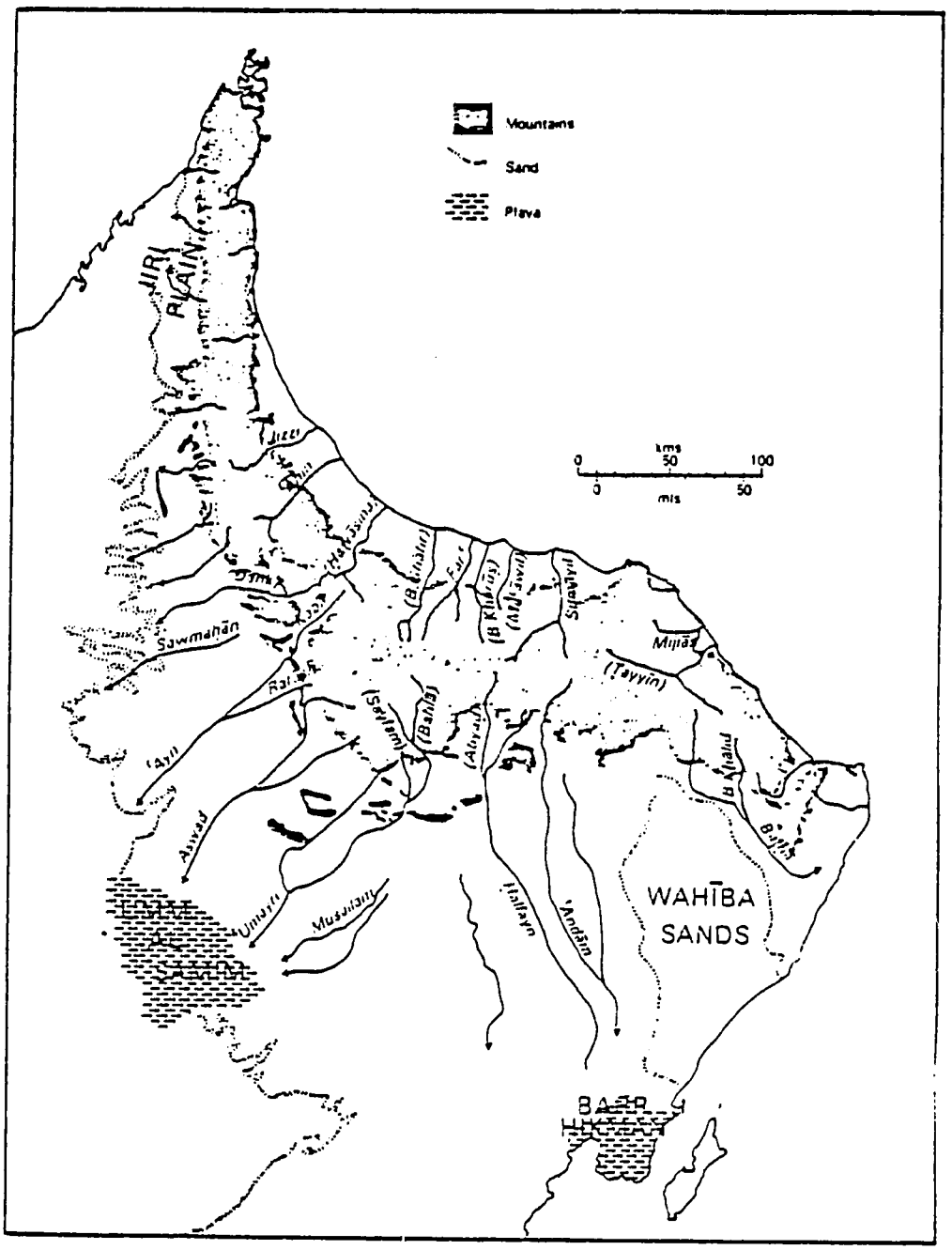
The average annual runoff available in most major wadi basins in Oman is estimated to be about 85 million cubic meters per wadi (Table 9). Except in some of the terraced areas most of this water normally runs off rapidly into the wadis before being captured for agricultural use. Sizable proportions may also be lost to the sea, or to the inland sabkhas (salt deserts) such as the Umm as-Samim or Barr Hikman (Fig. 10). It is estimated that just along the coast from Musqat to Khaburah some 95 to 162 million cubic meters of surface runoff is lost to the sea annually (Sultanate of Oman 1980, U.S. Army Corps of Engineers 1979). In a corresponding region on the inland side of the mountains, some 65 million cubic meters is thought to be lost to the desert annually.

Table 9. Estimates of Water Flow Characteristics for Major Wadis

Wadi (major tributaries)	Drainage Area (sq km)	Average Annual Rupoff (10^6 m^3)	Maximum Possible Flood (m^3/sec)	50 Year Flood (m^3/sec)	Surface Runoff Losses (10^6 m^3)
Ma^{c}awil (Sabt) (Mistal)	1050	85	1600	970	7
Far^{c}a (Sahtan)	1566	77	1750	1050	13.9
bani Kharus	1025	82	1600	960	27.7
Daygah (Tayyin)	1836	90	1900	1100	-
bani Ghafir	878	82	1300	800	21.2
Jizzi	936	84	1350	820	50.2
Dhank (Fatah)	1310	29	2400	1450	0
Hilm	403	85	880	520	-
Mu'aydin	790	90	1250	740	14.2
Bahlah (Ghul)	1046	85	1425	880	17.3
Sama'il	1800			1100	5.5-20

Source: U.S. Army Corps of Engineers. 1979.

Figure 10. Main Drainage System



Source: Wilkinson. 1977.

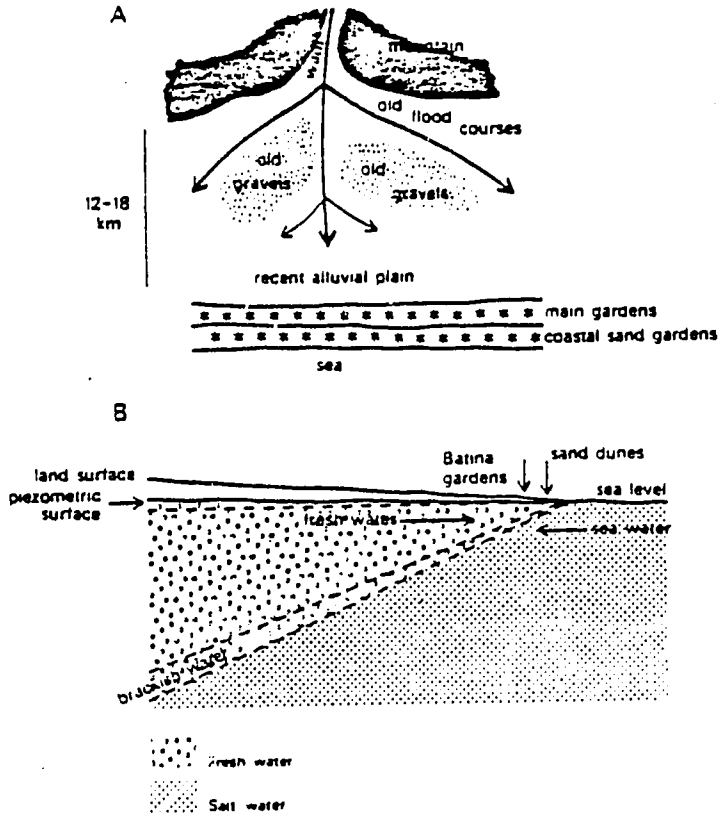
While surface flow from runoff may be intermittent, many wadis do have a perennial subsurface flow. A few wadis may also tap the underlying aquifers. In these cases, the wadi may have water at the surface in those areas where a rock bar forms a constriction in the wadi. Normally, such surface flow is highly localized, but wadi Sama'il is one notable case where surface water can usually be found in parts of the lower reaches throughout the year. The average annual daily surface flow of Sama'il in the late 1960s and early 1970s was 45,000 cubic m. However, it varied from 9,000 cubic m in 1970 to 104,000 cubic m in 1968. During drought years, surface flow may cease altogether during the summer. For example, in July 1971 the water flow receded to 2 m below the surface gravels.

3.2.2 Ground Water

A substantial amount of ground water is found under the surface of the wadis. The typical wadi channels in the mountains are steep and narrow in limestone areas, and broaden into small basins in areas of softer sediments. The fill of gravels and silts may vary from a few to several tens of meters in depth, and water is usually found in this fill. Many preliminary water surveys have been carried out in Oman (see the water section of Appendix X) that have arrived at conflicting estimates on the amount of subsurface water available in the wadis. Rough figures for wadis Nizwa and Halfain may be on the order of 5 and 10 million cubic meters, respectively.

Runoff is rapid and infiltration rates are low in the mountain areas, so that there is little underground storage except in the wadi channels. The alluvial and piedmont plains are areas with much greater storage potential. These regions consist of coarse gravels to a depth of about 100 m, overlying clayey cemented conglomerates. High infiltration potential and high transmissivity are characteristic features. Once the wadi breaks out of the rocky areas into the plain, water in the surface gravels rapidly sinks into the deep piedmont. In wadi Sama'il, where the channel starts to fan out in the alluvial zone, the water level is about 45 m below the surface, and only about 20 m above sea level. The surface of the land slopes more rapidly than does the piezometric surface, so that near the coast hand dug wells may tap the water table (Fig. 11).

Figure 11. Hydrology of the Batina Coast



Source: Wilkinson. 1977.

Inland of the mountains the hydrology is even less well known. In the bajada zone the aquifers are still semi-confined by the rocky foothills. The aquicludes are formed by marl and lie about 30 m below the surface in the UAE, but they have not been investigated in the Sultanate. Beyond the bajada is the desert foreland (see Fig. 13, Sec. 3.2.4).

In this zone, the occurrence of fresh water is related to the distribution of sand. The sandy areas have the characteristics of rapid infiltration, low capillary rise, rapid fall off of evaporation rates below the surface, and high reservoir potential. Water does not drain into depressions to form hard-pan or sabkha, but accumulates in a saturated zone at the base of the dune. Outside of local dune areas, most ground water is brackish or saline.

The total amount of water entering all these shallow aquifers in northern Oman may be on the order of 6 to 7 billion cubic meters per year. In Dhufar, perhaps 12 million cubic meters may recharge on the Dhufar plain yearly.

Estimated exploitable groundwater resources are about 650 million cubic meters per annum.

Very little is known about deep aquifers in Oman. One does exist in southwest Oman, which lies in a Tertiary formation and appears to be recharged from the Dhufar mountains. By the time this water reaches the inland desert areas, it is highly sulphurous. In the mountain areas of northern Oman, only the limestone exposures provide much opportunity for recharge of deep aquifers. A few springs tap this water at the base of the mountains where it is still fresh, but generally it becomes rapidly salinized once out of the mountains.

3.2.3 Water Quality

Water quality data is not available beyond some general observations and a few tests. In the bajada zone section of wadi Sama'il, water at about 45 m below the surface has approximately 800 ppm total dissolved solids (TDS). However, other studies suggest that in many cases, water is rapidly salinized once it enters this zone. Near the coast, the freshwater wedge (Fig. 11) becomes thinner, and water quality rapidly deteriorates. The fresh-water table on the coast is strongly dependent upon tidal cycles and seasonal variations in wadi discharge.

Water tested in the inland bajada zone had an electro-conductivity value of 1,800 micromhos (very roughly 1260 ppm T.D.S.) in one case, but in general it becomes highly salinized in this zone. Electroconductivity values may increase to 6,000 micromhos within the first 10 to 20 km from the mountains. Once into the desert zone, ground-water usually becomes even more saline, and fresh water is found only locally in sandy areas. In the sabkha areas, such as the Umm as-Samim and Barr Hikman, the water table is a meter or less below the surface. Evaporation is constant, leaving behind salts, so that salinity may range from 70,000 to 356,000 ppm (seawater is about 35,000 ppm).

3.2.4 Water Use and Management [10/]

Essentially all cultivation in Oman depends upon irrigation from groundwater supplies, as does the domestic water supply. There are three traditional methods of tapping groundwater. Wells are used throughout the country, but they are particularly common in the Batinah coastal plain. In the Batinah and most interior areas, wells are hand dug. Animal power is used to draw well water by means of a hoist and bucket. The water is dumped into a basin and then channelled to the gardens or fields. An average single hoist well may produce about 34,000 liters in a good day, or about enough to irrigate one hectare. A double hoist may produce 50 percent more water. In local areas well water may be hand drawn. Batinah coast wells are used for both irrigation and domestic water, but most interior wells are used only for domestic water.

The second major means of obtaining water is the ghayl falaj. Falaj (plural: aflaj) is an Omani term for the complete irrigation system, and may be applied to any type of system. Ghayl refers to the perennial flow in the surface gravels of a wadi. Ghayl aflaj divert this flow by means of a low bund or through a short collector gallery. Where soils are suitable, the water is diverted directly to nearby gardens or fields. Otherwise, channels are built or cut into the rock sides of the wadi, and convey the water by gravity flow to terraced or cleared areas farther away (Fig. 12)

The most distinctive irrigation system is the ganat falaj. These are horizontal tunnels dug into alluvial fans to tap the water table (Fig. 13). The tunnel section is dug using mining techniques. A vertical shaft called the mother well is sunk first to verify the existence of a suitable aquifer. A horizontal shaft is then excavated with a gradient of between 1/500 to 1/2,500. Additional vertical shafts serve for ventillation, removal of the spoil, and access for later repair and maintenance. Lower reaches of the ganat may be excavated from the surface and covered over, while the final channel leading to the village is usually on the suface (Fig. 14).

10
Sources: Birks and Letts. 1976.
Hawley. 1977.
Nyrop et al. 1977.
Sultanate of Oman. 1979.
Sultanate of Oman. 1980a.
U.S. Army Corps of Engineers. 19
Wilkinson. 1977.
Wilkinson. 1980.

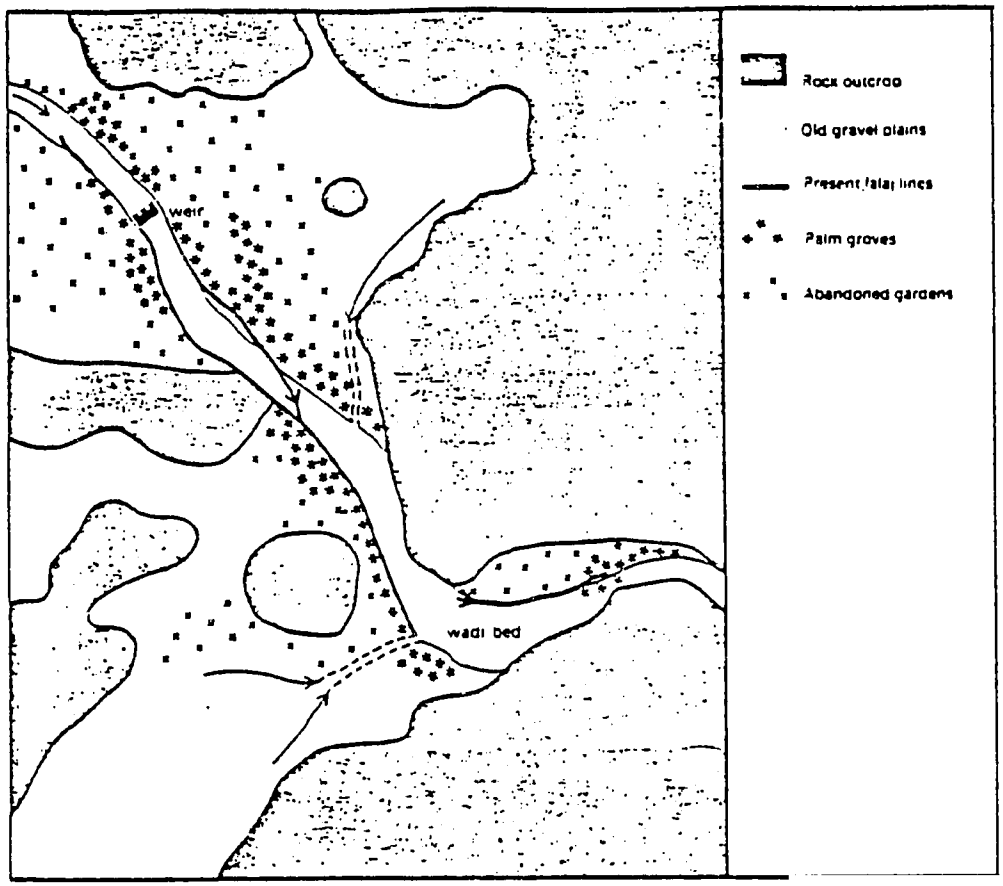


Figure 12. A Ghayl Falaj in Northern Oman

Source: Wilkinson. 1977.

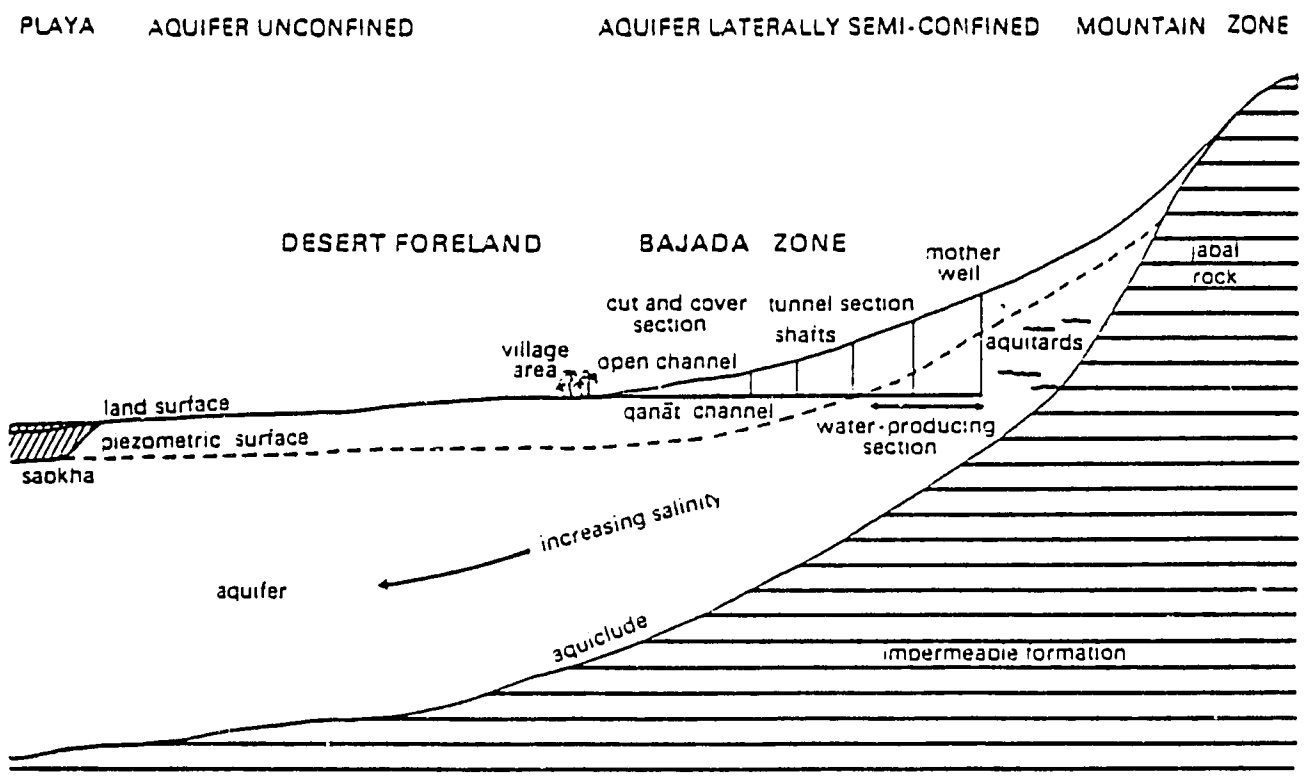


Figure 13. Qanat in Cross Section

Source: Wilkinson. 1977.

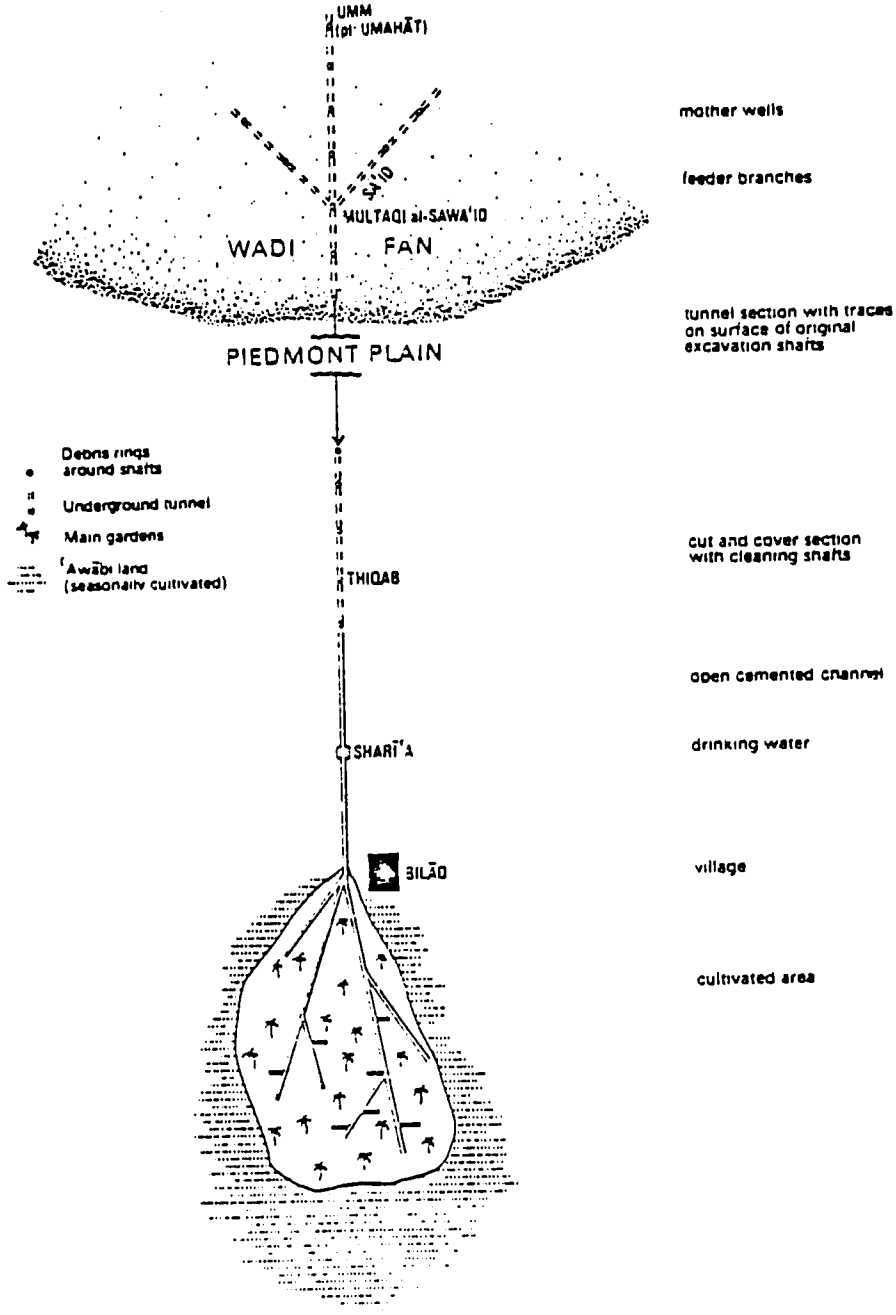


Figure 14. Qanat Plan From Above.

Source: Wilkinson. 1977.

The water yield of ganat aflaj varies greatly. In central Oman the better ganats may have a dependable base flow on the order of 60-80 liters per second. In the bajada areas base flows may be around 40 l/sec. However, the average for all working ganat aflaj is probably 15 to 20 l/sec. (Wilkinson 1977). One liter per second of base flow will support roughly one hectare of date palms, or about 200 palms.

In the past decade, Omani agriculture has been declining (cf Sections 2.3.1, 2.3.2, 4.3), and partial blame for this decline can be traced directly to the deterioration of the traditional aflaj system (Wilkinson 1977, Scholz 1977b, Birks 1977). One local cause for the drying up of the coastward ganat aflaj is that the water table is being lowered by overpumping in modern Batinah wells (Wilkinson 1977). The physical deterioration of aflaj is a more widespread cause, made worse by massive labor migration out of rural areas. Maintenance on such systems is labor intensive and must by carried out constantly (Birks and Sinclair 1979).

In the last decade, pumped wells have begun to supplement or even replace traditional methods of obtaining water. Table 10 shows the rapid increase in the number of pumps distributed by the government. Pumps are helping to alleviate labor shortages on the traditional irrigation system. However, pumps are ushering in a whole new set of potentially more serious problems. Widespread use of pumps in the interior is breaking down the sense of community which comes from shared concerns for the irrigation system (cf. Sections 3.3.1, 4.3). . In many areas, overpumping is rapidly lowering the water table, causing ganat aflaj to dry up. Overpumping in the coastal areas also causes some salt water intrusion. Overwatering is more likely with pump use, and has led to salinization of agricultural soils in some areas, especially near the coast where groundwater has higher salt content.

Estimates of total water use vary widely. Gischler (1976) gives total annual water use for irrigation as 420 million cubic m. However, the U.S. Army Corps of Engineers (1979) estimates annual use for irrigation in the northern region (which accounts for 98% or all cropland) as only 138 million cubic meters. Gischler (1976) estimates total domestic use to be 10 million cubic meters.

Table 10. Quantity and Value of Pumps distributed to Farmers

Department of Agriculture Region	1975		1976		1977		1978	
	No.	Value in R. O.	No.	Value in R. O.	No.	R. O. Value in	No.	Value in R. O.
North Batinah			33	16500	39	19200	64	32000
South Batinah			30	15000	41	20200	60	30000
Oman Interior			4	2000	36	17944	137	63000
Dhahirah			15	7500	19	3504	21	10500
Sharqiya			21	10500	24	11971	60	30000
Janubiya			28	14000	108	11110	41	19380
Musandam			—	—	—	—	5	4625
Capital area			—	—	—	—	23	11050
Co-operatives			34	17000	1	500	52	26000
Total	75	37500	165	82500	268	90429	463	225555

Source: Sultanate of Oman. 1979.

If the figures for the capital area (around Muscat-Matrah) and Salalah are any indication, water consumption can be expected to increase enormously as modern technology makes water more easily available. Consumption increased from about 0.3 million cubic meters in 1971 to about 5.1 million cubic meters in 1978 for the capital area (Table 11). While these are urban areas, water use has increased very much more rapidly than population or industrial growth. Per capita consumption is increasing simply because of easier access to water, just as overwatering of crops may occur with more convenient modern pumps.

Table 11. Water Statistics from the Capital Area and Salalah

Item	Unit	Water Department	1970	1971	1972	1973	1974	1975	1976	1977	1978
Quantity of water produced	Million Gallons	Capital Area	14.0*	85.0	171.1	218.6	301.0	358.5	429.8	1002.0	1265.3
		Wells	(14.01	(85.0)	(171.1)	(218.6)	(301.0)	(358.5)	(429.8)	(316.7)	(237.7)
		Desalination	(—)	(—)	(—)	(—)	(—)	(—)	(—)	(685.3)	(1027.6)
		Salalah	—	—	15.4**	111.4	244.5	..	..	439.9	479.4
Quantity of water consumed	Million Gallons	Capital Area	9.0*	63.0	143.3	184.4	246.3	286.8	356.8	992.8	1127.3
		Salalah	..	..	..	..	..	..	..	439.9	479.4
Water connections	Number at the end of year	Capital Area	463	1557	2435	3417	4437	5020	5832	7078	1801
		Salalah	—	—	45	156	390	..	..	..	..

* May — December 1970.
** July — December 1972.

Source: Sultanate of Oman. 1979.

3.2.5 Water Law [11/]

The basic law of the Sultanate is the Shari^{c}a, or Islamic law. This may be modified by traditional practices or occasionally by Sultanic decree. Shari^{c}a law is of the Ibadhi interpretation throughout most of Oman, but in Dhufar the Shafi^{c}i Sunni school predominates. Normally differences in interpretation are in details rather than basic concepts.

According to the basic principles of Islamic law, water carries rights comparable to land, especially if developed and used for irrigation. Water rights may be owned privately, publicly, or by religious institutions (waqf) and are normally considered to belong to the one(s) who developed the water resource. Ownership of water rights may be transferred separately from ownership of land or wells and aflaj.

s: Caponera. 1978
Wilkinson. 1977.

Certain priorities may take precedence over ownership rights. Drinking water has the highest priority, and water is free to all for this purpose, even if the well or falaj is privately owned. After this priority, private rights come into effect, and the owner has exclusive rights to the water for irrigation. Transfer of water rights is subject to community approval, particularly in the case of aflaj, which have many shareholders. Transfer is normally approved if it will not cause disruption in the community's water distribution system.

Customary law provides for the maintenance of water works and the protection of water resources. Maintenance costs are covered by a tax on shareholders, which may be in money or kind, or in contribution of water shares. In cases where one or a few individuals own a falaj, water prices may fluctuate to cover costs. Protected areas may in customary law be established around wells and aflaj to prevent groundwater depletion or water polution. Several Sultanic decrees have fortified customary law in these respects. Appendix VIII includes legislation concerning water, and Appendix IX lists governmental and other institutions concerned with water.

3.3 Soils and Agricultural Land Use

3.3.1 Soils

There have been no systematic soil surveys in Oman (Sultanate of Oman 1980). The following general observations are based on an FAO - UNESCO soil survey of South Asia (UNESCO - FAO 1977), in which a number of broad soil categories are distinguished in the Sultanate (Table 12 and Fig. 15).

Lithosol Yermosol Association (I - Y - bc). The soils of the Oman mountains are composed of lithosols intermixed with various yermosols. The lithosols tend to be in steep rocky areas, on mountains or rock outcrops. They are usually shallow, stony, and very prone to water or wind erosion. These characteristics normally make lithosols unsuitable for cultivation. The yermosols of the association occur on peneplains and alluvial terraces. Like the lithosols, they are usually shallow, stony, prone to erosion, and not particularly suitable for agriculture. Both of these soils may be cultivated in small local areas where patches of deep soil have accumulated, either naturally or through terracing.

Other Yermosol Associations. Various yermosols predominate throughout most of the remaining portions of the Sultanate. Haplic Yermosols (Yh22-1ab) are the dominant type in the Batinah and on the east coast as far south as Masirah Island. Cambic arenosols and calcic yermosols are also significantly represented in these regions, and several other soils may be found in small amounts.

Calcic Yermosols are found throughout Oman south of the northern mountains. The UNESCO - FAO soil map distinguishes three subcategories, based on the other soils associated with the Calcic Yermosols. Lithosols and Luvic Yermosols are the major associates in the most widespread region of central Oman (Yk25-1/2a). In westcentral Oman Cambic Arenosols are the major associate (Yk26-1ab). In an extensive region just south of the northern mountains the major associates are Calcaric Regosols. (Yk28-1a). Pockets of this classification may also be found in the Haushi Huqf area and interior Dhufar

A Gypsic Yermosol (Yy10-2ab) area extends into southern Dhufar from the central Hadhramaut, where this classification predominates. The major associated soils are Lithosols and Calcic yermosols. All of these yermosol areas, as in the mountains, are characterized by shallow, rocky soils. They are suitable for agriculture only in local areas where soil of sufficient depth has accumulated.

Calcaric Regosols (Rc30-1ab, Rc31-1/2ab) are found in pockets in the west central portions of the Sultanate. These are extensions of the Rub^{c} al-Khali, of which they form one of the major soil types. Calcaric Regosols are generally shallow and sandy, and in these regions dunes may be common.

Mobile sand dunes predominate along the northern border with the U.A.E. and on the east coast in the Wahiba sands region.

Gleyic Solonchaks (Zg 3-2/3a) are the saline soils of the Umm as-Samim and the sabkha area on the coast near Masirah Island.

Appendix IV presents soil profiles of four of the dominant soil types (Rc, Yh, Yk, Yy) found in Oman. However, the samples were not taken from Oman, and should be viewed as general guidelines only.

Table 12. Dominant Soil Types and Associated Soils

Map Symbol (dominant soil)	Associated Soils (>20%)	Inclusions (<20%)	Phase	Approx. Area in Oman (1000 ha)
I-Y-bc			Stony	3,226
Rc30-1ab	Qc,Yk	Z	Shifting Sand	84
Rc31-1/2ab	Z		"	77
Yh22-1ab	Qc,Yk	Rc,Jc,Z		466
Yk25-1/2a	I,Yl	Jc,Z	Lithic/ Stony	9,648
Yk26-1ab	Qc		Petro-Calcic	2,397
Yk28-1a	Rc	I	Stony	3,462
Yy10-2ab	I,Yk		Petro-gypsic	786
Zg3-2/3a	Zo			290

Note: In the example Rc31-1/2ab, Rc refers to soil type Calcaric Regosols. The number immediately following the soil type (31) is an arbitrary classification for tabulation purposes on the UNESCO - FAO map. It allows one to look up associated soils. Numbers following the hyphen (1/2) are textural class (coarse to medium). Small letters at the end (ab) refer to slope class.

INTERPRETATIONS OF SYMBOLS

Soil Types		Textural Class		Slope Class	
I.	Lithosols	1.	coarse	a.	level to gently undulating
Jc.	Calcaric Fluvisols	2.	medium	b.	rolling to hilly
Qc.	Cambic Arenosols	3.	fine	c.	strongly dissected to mountainous
Rc.	Calcaric Regosols				
Y.	Yermosols				
Yh.	Haplic Yermosols				
Yk.	Calcic Yermosols				
Yl.	Luvic Yermosols				
Yy.	Gypsic Yermosols				
Z.	Solonchaks				
Zg.	Gleyic Solonchaks				
Zo.	Orthic Solonchaks				

Source: UNESCO - FAO. 1977.

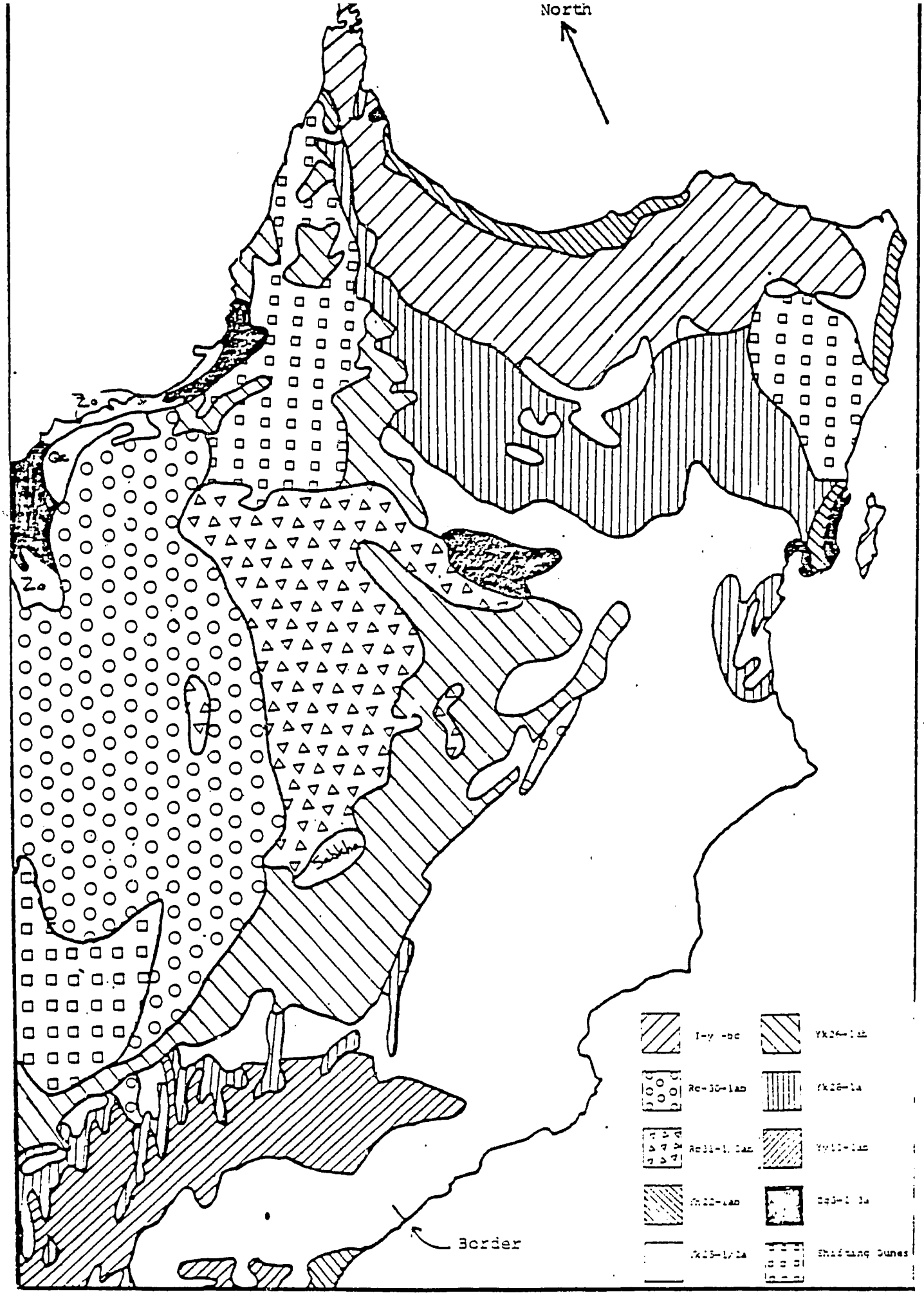


Figure 15. Dominant Soil Types

Source: Adapted from UNESCO - FAO 1977.

3.3.2 Agriculture [12/]

The proportion of Oman's surface area which is currently under cultivation is estimated to be a minute 1.3 percent of the total (Sultanate of Oman 1980). Approximately 40 percent of this 37,000 ha is located in the Batinah, and another 4.5 percent is on the eastern coast (Table 13). Soils in these areas are Haplic Yermosols of the UNESCO - FAO classification (Fig. 15). Dhufar accounts for less than 2 percent of the cultivated area. The remaining 54 percent of the cultivated area is scattered throughout the northern mountains and inland foothills regions, where Lithosol-Yermosol associations and Calcic Yermosols predominate. A detailed breakdown of the location of cultivated areas is included in Appendix IV.

Table 13. Agricultural Land under Cultivation by Region in 1978 (Hectares)

Regions	Hectares	Percentage
Batinah	14,556	39.4
Interior	567	1.5
Dhahira	6,096	16.5
Eastern coastal	1,653	4.5
Central Plateau	5,902	16.0
Sharqiya & Jaalan	3,194	8.7
Western Hajar	3,842	10.4
Musandam	400	1.1
Dhofar	700	1.9
Total	36,910	100.0

Source: World Bank. 1979.

12 Sources: Birks. 1977.
Myrop et al. 1977.
Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. Annual Supplement. 1980.
Sultanate of Oman. 1979.
Sultanate of Oman. 1980a.
U.S.AID. 1980b.
University of Arizona. 1980.
Wilkinson. 1977.
Wilkinson. 1980.
World Bank. 1979.

The Omani government estimates that another 10,000 ha may be suitable for agriculture. Half of this is thought to be in the Batinah; 4000 ha are evenly distributed between Dhahirah and Sharqiyah. Dhufar may have another 1000 ha of cultivable land (Sultanate of Oman 1980).

Major Crops. Dates are the most important single crop by tonnage and by value (Appendix III, Table 4). Figures on cropping patterns (Table 14) show the importance of dates also. In 1971 there were an estimated 1.4 million date palms in the northern interior, which is considered to have the most suitable conditions for date palm cultivation. Date palms can be found throughout the interior, but are concentrated in Dhahirah (1820 ha), Oman Proper (1770 ha), Western Hajar (1540 ha), and Sharqiyah/Ja[c]alan (960 ha). The Batinah actually has more date palms than the interior (2.0 million estimated), but yields and quality are not as high in the coastal areas (Table 15). Throughout Oman, yields have been declining rapidly in the last several decades. Yields per tree averaged 34 kg on the Batinah in 1927, and 45 kg at Sama'il. A survey taken in 1971 estimated yields per palm of 10 kg and 19 kg for the coast and interior respectively (Wilkinson 1977).

Table 14. Estimated Area under Crops

	Area Under Cultivation[c]			
	1971		1975	
Crops	Hectares	Percentage	Hectares	Percentages
Dates	13340	37.1	21000	58.3
Lucerne	5560	15.4	5000	13.9
Limes	3560	9.9	1900	5.3
Onions	3680	10.2	3500	9.7
Wheat	1200	3.3	1280	3.6
Tobacco	1000	2.8	b	
Bananas	880	2.4	b	
Mangoes	380	1.1	b	
Coconuts	200	0.6	b	
Others[a]	6200	17.2	3320	9.2
Total	36000	100.0	36000	100.0

a. Includes chickpeas, sorghum, sweet potatoes and fallow land.
b. Not distinguished separately in source.
c. The differences in area between 1971 and 1975 probably represents differing techniques of estimation rather than any substantial shifts in cropping patterns.

Sources: 1971: Sultanate of Oman. 1979.
1975: Quart. Econ. Rev. 1980.

Table 15. Average Yields of Selected Crops (tons per hectare)

	Current Yields		Potential Yields[a]
	Batinah	Interiors	
Dates	1.5	4.5	10
Alfalfa	35	45	90
Wheat	--	1.25	2
Limes	0.75	0.5	3
Onions	2.0	3.0	15

a. Achieved at Omani experimental farms.

Source: Sultanate of Oman. 1980a.

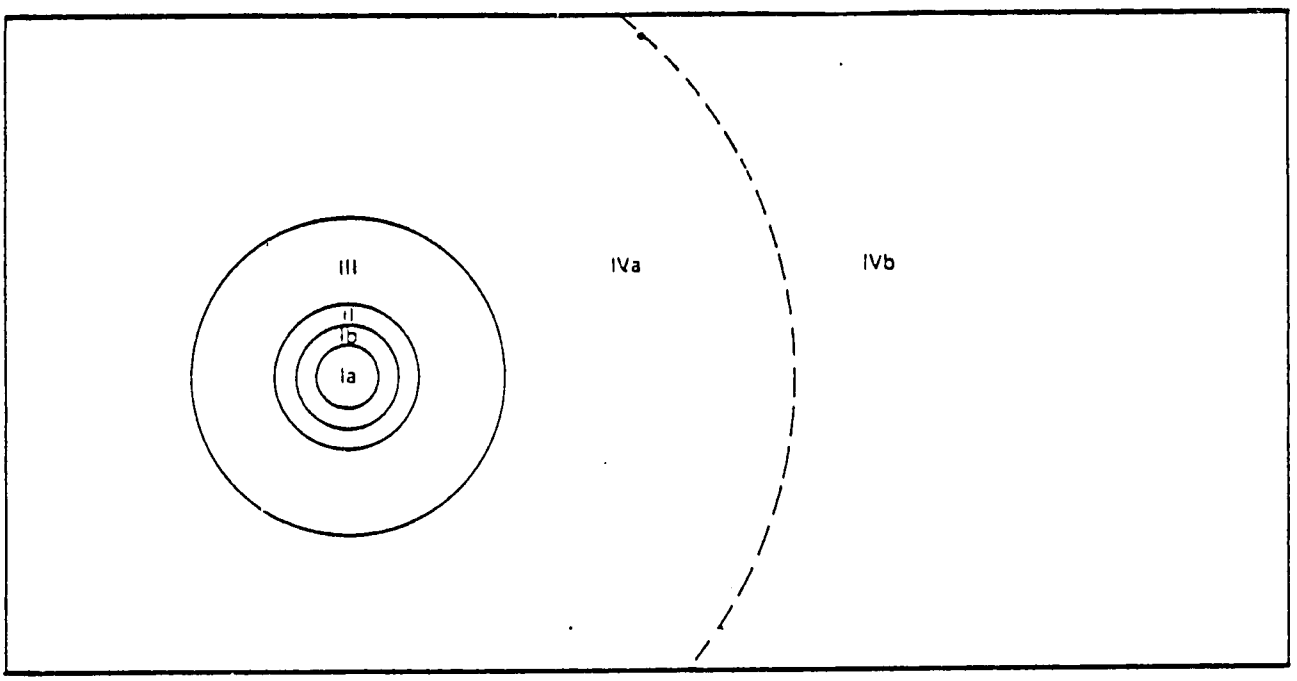
Limes are grown particularly in the Batinah and the areas around Rustaq and Hamra in the interior. In these places they are an important cash crop for export. Limes are cultivated in other areas, but primarily as a subsistance crop. Bananas are grown primarily in the Batinah and Dhufar, and mangoes are found almost exclusively in the Batinah. Coconuts grow only in the coastal plain of Dhufar.

Vegetables and fruits such as tomatoes, cucumber, peppers, and melons may be found in agricultural areas throughout the country. Dhahirah, Oman Proper, and the Batinah are the main areas, and these crops have become an important cash crop for export in these areas. Onions are concentrated in Oman proper, but can also be found throughout the rest of the country. Wheat is cultivated in Dhahirah, Western Hajar, and Oman Proper. Lucerne (alfalfa) is the primary fodder crop, and can be found throughout the Sultanate. Low quality dates, however, may also be used as fodder.

Land Tenure and Cropping Patterns. The majority of land in Oman is privately owned. However, water rights and trees may be owned separately from land. The typical pattern in the interior is individual ownership of small plots of land. The average size of holdings has been estimated to be about 4.2 ha. These holdings tend to be fragmented due to the nature of the terrain and to the functioning of Islamic inheritance law. Water, obtained from a falaj is usually corporately owned by all of the landholders. Property owners may take part in agricultural work, but may also hire laborers, both long-term and seasonal.

In the Batinah many agricultural plots are small holdings also, worked by the owner. However, this area tends to have larger farms. Many of the larger holdings are owned by absentee landlords. On the coast, water is from wells and is individually owned. Detailed figures on land tenure are not available for any region in Oman.

Cropping patterns are reflected in priorities of water use, and the date palm is clearly the major concern. Villages in the interior tend to view the land around them in a series of water use priorities, decending in importance from the date palm at the center (Fig. 16). The permanent dependable base flow of the falaj, the water which is available year round under normal circumstances, is allocated to the date palms, and in some cases other major tree crops such as limes.



Ia Permanent cultivation (tree crops)
Ib Permanent cultivation from less reliable base flow (Alfalfa)
II Seasonal crops (*'Awāḍi* land)
III Village grazing (The village *ḥaram*)
IVa Mixed-herding nomads
IVb Camel-herding nomads

The sown
The desert

Figure 16. The Villagers' View of the Land

Source: Wilkinson. 1977.

Date palms achieve maximum yields at a spacing of about 10 m between trees, or 100 trees per ha. Omani farmers are well aware of this but in most cases scarcity of water will not permit the irrigation of large areas, and the spacing is reduced to about 6 to 7 m (200 per ha). While the yield per tree declines somewhat under these conditions, the yield per unit of irrigated area is greater. Close spacing not only reduces the total area which must be irrigated, but it also reduces water loss through transmission or evaporation, and saves labor.

In times of drought, the tree crops will receive all the available water. Under normal circumstances, there is surplus water available from the base flow of a falaj, as well as seasonal surplus after the seasonal rains. The less dependable base flow is allocated to the second cropping zone, which is usually planted in alfalfa. This zone is beyond the palm groves; normally there is very little intercropping with the palms. This alfalfa zone is considered a permanently irrigated area second in priority only to the tree crops.

A third zone is for seasonal crops. These are cultivated following the seasonal rains when the falaj flow is temporarily increased. Most fruit, vegetable, and grain crops are grown in this zone. This seasonal crop zone shows the most variability over time. In particularly wet years it may be greatly extended, while in drought years it is the first zone to be abandoned. The village grazing zone lies beyond the seasonal cropping area.

In practice, these irrigated zones follow linear patterns. High priorities are upslope and lower priorities downslope, following lines of irrigation channels. Figure 17 shows typical patterns at a village during a drought.

Because conditions on the Batinah coastal plain differ, so do cropping patterns. There is usually a strip of date palm cultivation on the dunes near the shore (Fig. 11). Once established, these tap the brackish water just below the surface and require no irrigation. The dates from these trees are generally low quality and are used for fodder. However, a more important value of this strip of palms is its function as a wind break to protect palms and soils further inland from wind blown salt particles. These inland palms are the major producers in the Batinah, extending up to 3 km inland from the coastal palm belt.

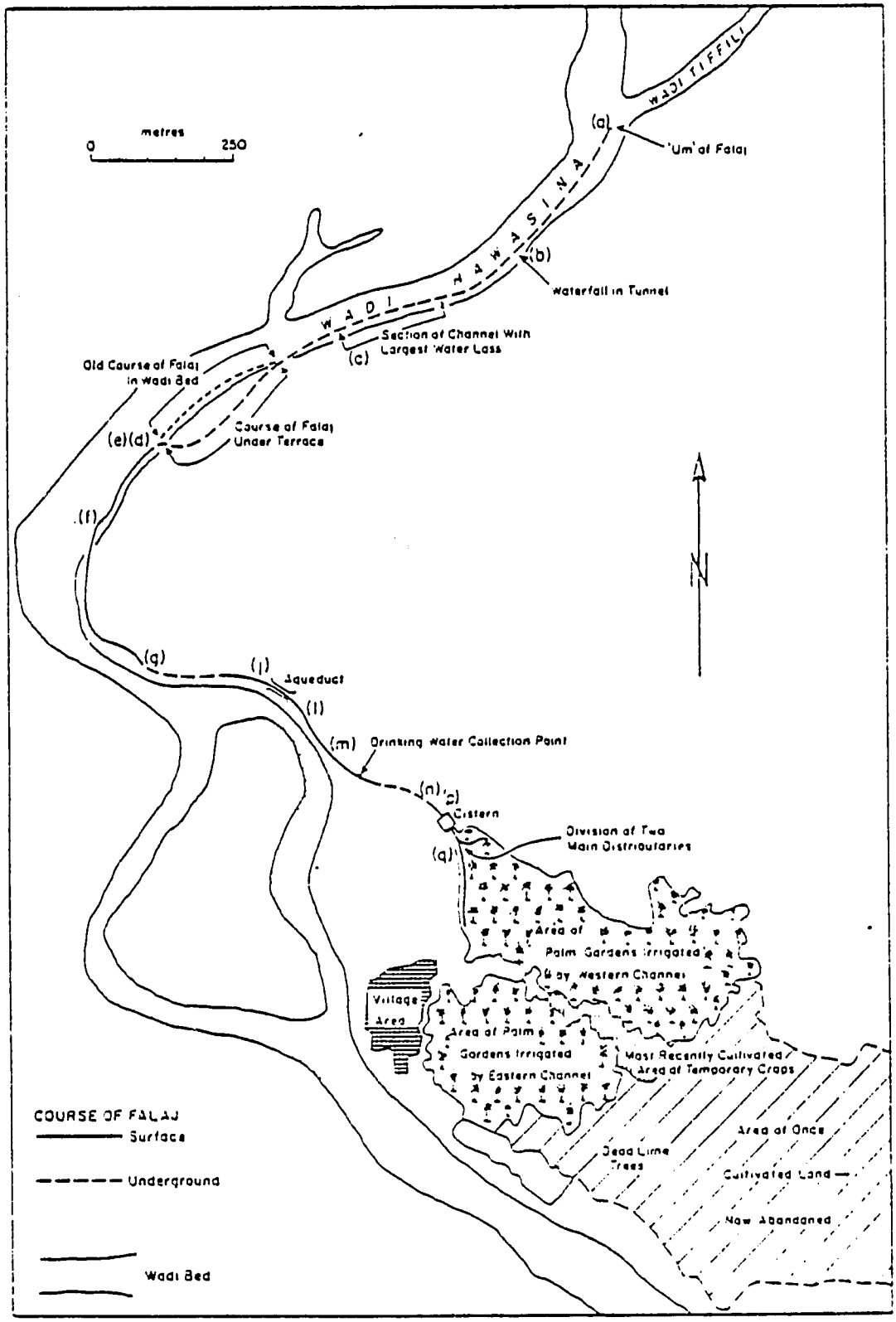


Figure 17. Ghayzayn, Wadi Hawasina. Falaj and Cropping Patterns

Source: Birks. 1977.

Recent Trends. There has been a gradual shift over the last decade toward cultivation of vegetables as cash crops. This is taking place especially on the larger holdings and on new farms which are being developed. Fertilizer and insecticide use is increasing, (Tables 16,17) again concentrated on larger holdings and newly established farms. Levels of fertilizer use rose from under 12 to about 20 kg per ha between 1974 and 1978. These rates of application are comparable to rates in Saudi Arabia and other states in the Gulf area, but are far below levels in Egypt (150.8 kg per ha 1974). Distribution of seed through extension centers and tractor use is also increasing rapidly (Tables 18,19) The Omani government has also been active in establishing experimental farms, research stations and extension centers to promote agriculture (Table 20).

Not all aspects of modernization in Oman are beneficial to agriculture. The widespread introduction of water pumps (cf Table 10) brings the danger of lowered water tables and increased groundwater salinity. Their introduction in the interior also fosters individual ownership concepts with water. This contributes to a breakdown of the social structure which is traditionally based upon village cooperation in exploitation of water and land resources. Another detriment to agriculture is the migration of labor to the oil fields or urban areas of Oman and the Gulf. Declines in date yields can be traced directly to deterioration of the falaj system through lack of maintenance and to declining labor inputs into date husbandry (Birks and Sinclair 1979).

Table 16. Quantities of Fertilizers Distributed to Farmers through Extension Centres and Departmental Headquarters

Department of Agriculture Regions	Ammonium Sulphate						Complex Fertilizers						Super phosphate calcium			Urea	[illegible]
	21% Nitrogen						[illegible]		N : P : K 15% : 15% : 15%								
	1973	1974	1975	1976	1977	1978	1973	1974	1975	1976	1977	1978	1975	1977	1978	1978	1978
North Batinah	291.0	517.3	927.3	837.4	579.9	256.0	123.0	230.4	113.7	304.1	190.3	385.0	85.6	194.9	112.1	—	42.3
South Batinah						98.3						241.2			7.7		
Oman Interior	90.0	93.3	166.5	165.3	517.7	184.7	98.0	108.4	89.1	193.2	174.9	287.5	24.0	10.1	5.9		
Dahriran	149.9	189.6	328.9	224.7	225.4	48.2	51.7	160.9	28.3	233.3	227.9	167.2	39.5	44.2	2.2		
Sharqiya	17.2	35.3	54.2	60.4	98.4	116.7	48.1	52.3	20.2	35.7	93.9	144.4	27.9	17.3	2.6		
Janubiya	—	—	4.6	73.2	15.0	—	—	—	5.4	64.4	26.1	25.9	27.4	1.6	1.4	8.9	8.1
Musandam	—	—	—	—	—	0.3	—	—	—	—	—	1.6	—	—	—		
Capital area	13.8	16.6	2.6	—	23.3	12.4	17.6	13.8	—	—	19.1	23.9	—	14.2	—		
Total	561.9	832.1	1492.1	1361.0	1659.7	716.6	368.4	565.8	256.7	390.7	732.2	1256.7	204.4	282.3	132.9	8.9	50.4

Note : In addition 1.8 tonnes of Urea (44% nitrogen) during 1972, 17.8 tonnes of Urea in 1973, 15.0 tonnes of Urea and 25.2 tonnes potassium sulphate in 1975 and 1.4 tonnes of Urea during 1978 were distributed. 393.6 tonnes of miscellaneous fertilizers were distributed to cooperative societies during 1978.

Source: Sultanate of Oman. 1979.

Table 17. Areas of Different Field Crops Treated with Insecticides for Plant Protection

Area in acres

Department of Agriculture Regions	Field Crops		Vegetables	
	1977	1978	1977	1978
North Batinah	530	3991	5666	10571
South Batinah	1630	477	1944	5259
Oman Interior	118	573	341	1097
Dhahiran	3106	—	1661	—
Sharqiya	37	326	377	822
Janubiya	351	1100	595	1205
Musandam	—	53	—	71
Capital area	—	401	—	1897
Total	5722	7031	12184	20922

Source: Sultanate of Oman. 1979.

Table 18. Improved Seed Distributed to Farmers through Extension Centers

Quantity in Kilograms

Seed	1975	1976	1977	1978	Seed	1975	1976	1977	1978
Onion	1084	1509	1509	1546	Cabbage	42	144	188	222
Raddish	554	1539	2556	2568	Egg plant	40	57	51	53
Watermelon	384	380	399	2081	Beet-root	66	35	10	71
Cucumber	155	121	176	189	Beans	27	10	140	42
Tomato	138	355	468	1470	Spinch	27	75	72	102
Sweetmelon	103	129	207	286	Cauliflower	28	22	73	91
Ladyfinger (okra)	82	253	89	322	Chilly	13	116	123	393
All types of marrow	115	150	225	405	Potatoes	2500	—	380	17819
Carrot	39	161	238	258	Others	17	54	216	8216
					Total	5394	5110	8220	36244

Source: Sultanate of Oman. 1979.

Table 19. Tractors and tractor hours rendered to farmers

Region/Centre	No. of tractors				No. of tractor hours			
	1975	1976	1977	1978	1975	1976	1977	1978
North Batinah	27	29	32	20	16933	18460	11292	9064
South Batinah				10				7065
Oman Interior	8	8	11	22	2530	4396	6021	13263
Dhahirah	14	12	11	3	5765	5410	4785	2234
Sharqiya	4	5	9	13	441	1544	3982	3628
Janubiya	18	20	21	15	3672	5147	5662	3054
Musandam	—	—	—	1	—	—	—	121
Capital Area	—	—	—	7	—	—	—	1517
Cooperatives	—	—	—	3	—	—	—	5481
Total	69	75	84	100	30341	34957	31742	50527

Source: Sultanate of Oman. 1979.

Table 20. Government Production Farms, Research Stations, Extension Farms and Centers and Nursery Gardens operating during 1978

Type of Farm/Station	Department of Agriculture Region								Total
	North Batinah	South Batinah	Oman Interior	Dhahirah	Sharqiya	Janubiya	Musandam	Capital Area	
Production farms	1	2	5	—	—	1	—	—	9
Research stations	—	2	2	—	—	1	—	—	5
Extension farms	1	—	1	—	—	—	—	—	2
Extension centres/ sub-centres	7	4	9	3	4	4	1	3	35
Nursery gardens	—	2	—	—	—	2	—	—	4

Geographical situation:

Production farms:

Sonar (agriculture), Rumais (1) (3 agriculture), Nizwa: (3 agriculture), Tanoof (agriculture), Jebel Al Akhdhar (agriculture).

Research stations:

Rumais (agriculture), Rumais (animal husbandry), Wadi Quriyat (agriculture), Wadi Quriyat (animal husbandry), Salalah (agriculture).

Extension farms:

Bahla, Buraimi.

Extension centres:

Al Mareer, Shinas, Liwa, Sonar, Saham, Al Khabura, Buraimi, Seeb, Barka, Masnaa, Rostaq, Nizwa, Manah, Izki, Hamra, Wadi Quriyat, Jebel Al Akhdahr, Sumail, Ibri, Sur, Al Wafi, Ibra, Sinaw, Khasab, Quriyat, Al Oqdain, Al Danaleez, Taqa, Al Rabat.

Extension sub-centres:

Adam, Bahla, Dank, Yunqal, Al Khafigi, Bustan.

Nursery gardens:

Rumais (fruits), Rumais (garden), Rabat (fruits), Al Jebel (fruits).

Note: The Dairy farm in Sonar and Garwiz cow farms were excluded in this table while they appeared in last year issue of the Year Book 1977, since then it has been placed under the management of the Sun Farm Company (Oman).

Source: Sultanate of Oman. 1979.

3.4 Vegetation

3.4.1 Native Flora [13/]

UNESCO - FAO Classifications. Vegetation zones of a broad region distinguished as the "Mediterranean Zone" have been mapped by UNESCO - FAO (1970). In Oman, eleven divisions of the Mediterranean Zone are represented as follows (Fig. 18):

1. Sparse ephemerophyte formations or no vegetation. Representative vegetation includes *Calligonum comosum*, *C. torophytes*, with ephemeral forms of *Aristida* spp., *Tribulus* spp., and *Fagonia* spp. after rain. This is typical of the Rub[c] al-Khali.

2. Ephemerophyte-dominated formations, with *Haloxylon salicornicum*, *Rhanterium eppaposum*, and *Salsola* spp. in the depressions. Found in west-central Oman.

3. Sands with *Calligonum* vegetation, found in the Wahiba sands and other small patches.

4. This zone appears on the UNESCO - FAO Map (1970) but is not defined. It is located in the Haushi-Huqf area in Oman and appears also on the coast of the U.A.E. These are saline (sabkha) areas, therefore the vegetation is halophytic.

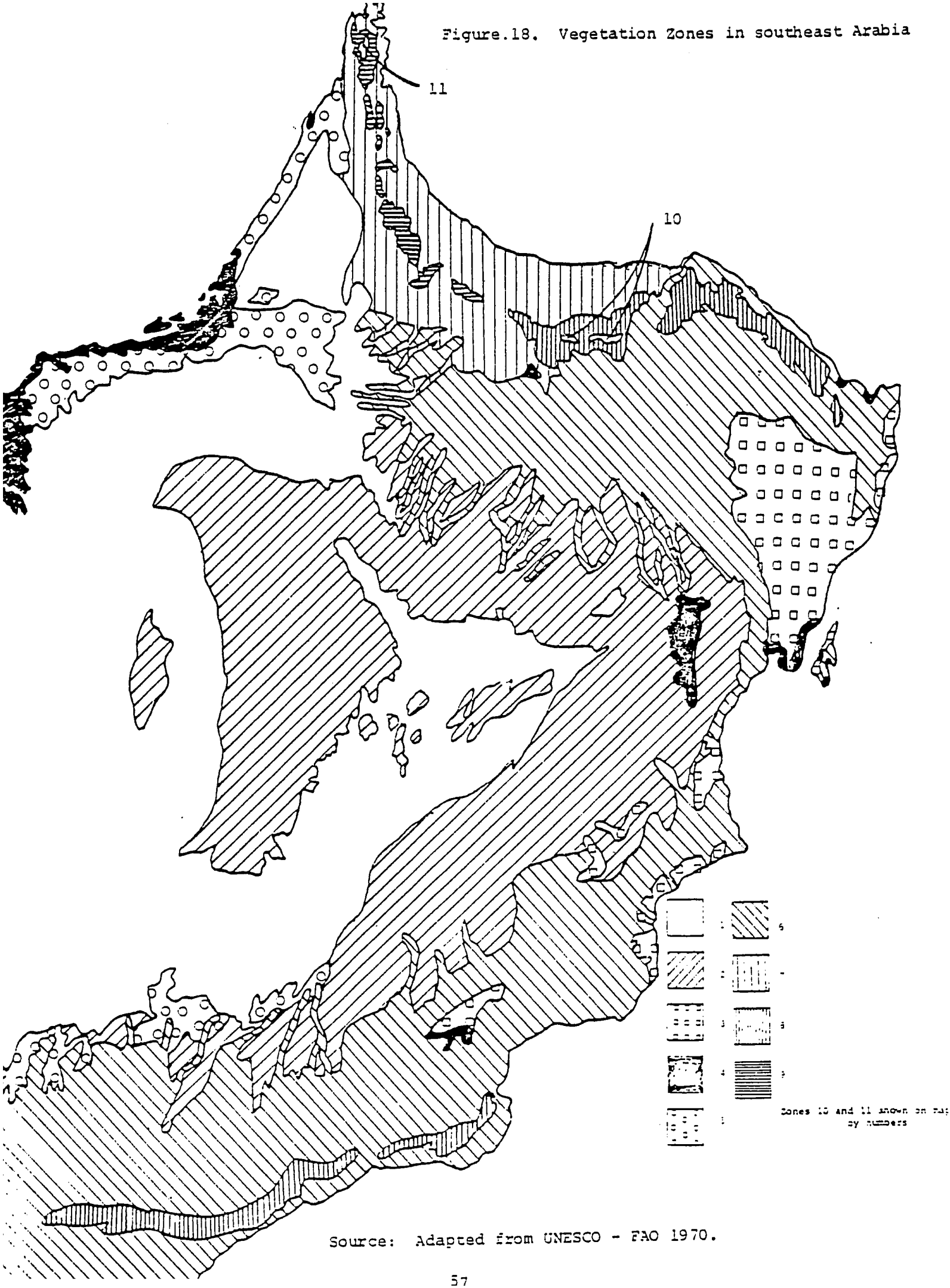
5. Perennial formations with or without ephemerophytes in accentuated desert climates. This is steppe with *Artemisia herba-alba* and *Stipa tortilis*. The zone is represented in Oman only along the borders with the U.A.E. and in extreme northwest Dhufar.

6. Formations with a tropical influence. *Acacia tortilis* and *Maerna crassifolia* are found in the foothills, *Panicum turgidum*, *Lasiurus hirsutus* in the sandy plains. A number of sub-categories are mapped in Oman without further definition.

7. Transitional formations, characterized in Oman by grass steppe with *Leptadenia pyrotechnica* and *Lycium persicum*. Coastal areas have *Panicum turgidum* and *Lasiurus hirsutus*. Sub-categories are mapped without further definition.

Sources: Gallagher and Woodcock. 1980.
Harrison. 1975.
IUCN. 1978a.
Mandaville. 1977.
Popov. n.d.
UNESCO - FAO. 1970.

Figure.18. Vegetation Zones in southeast Arabia



Source: Adapted from UNESCO - FAO 1970.

8. Bush shrub and tree pseudosteppes and savannahs and thickets. Found in Jabal Akhdar, Eastern Hajar, and Dhufar, this is mountain thorn scrub with *Euphorbia amac* and *Themeda triandra*. Sub-categories appear but are not defined.

9. Arbuscular shrub pseudosteppe. This category, found in the mountains of Western Hajar, is not defined for southeast Arabia. In Southern Iran it consists of transitional Mediterranean-biased subdesert steppe with *Pistacia khinjuk, Amygdalus scoparia, Acacia eburnea, Stipa capensis* often dominant. *Populus euphratica* is found in the valleys. *Zizyphus, Calotropis, Prosopis, Capparis, Astragalus fasciculifolius, Convolvulus, Ephedra, Acantholimon, Stellera lessertii,* and *Gymnocarpos decandron* formations are also present.

10. Forest formations occur in small patches at the highest elevations around Jabal Akhdar. In Yemen this is *Juniperus procera* forest, but it is not defined for Oman by UNESCO - FAO (1970).

11. A separate shrub or tree pseudosteppe category which occurs only in the Musandam Peninsula in Oman. In southern Iran it is characterized by *Pistacia atlantica, P. khinjuk, Amygdalus scoparia, A. horrida, Tamarix* and *Salix* in the valleys. *Artemesia maritima, Stipa barbata, Stipa lagascae, Cybopogon laniger, Hyparrhenia hirta* are also present.

Other Classifications. While the UNESCO - FAO vegetation map is helpful in placing Omani vegetation zones into a wider regional context, several factors limit its usefulness The map is based upon reports rather than fieldwork. It provides very little detail and a number of categories and sub categories are not defined at all. Furthermore, it corresponds poorly with zones delineated by most other observers, including reports based upon fieldwork. Most other sources (Gallagher and Woodcock 1980, Popov n.d.) distinguish zones more closely based on physical geography, and provide more detail. These zones are as follows:

1. Sandy Desert (roughly zones 1, 3, and 5 of Fig. 18). Characteristic vegetation includes *Calligonum comosum,* and *C. crinatum,* the principal shrubs. *Tamarix* may also occur. In the northern sandy deserts, dunes may be partially stabilized by additional shrubs such as *Leptadenia pyrotechnica, Prosopis spicigera,* and *Haloxylon salicornicus* as well as by the tussock grasses *Panicum turgidum,* and *Pennisetum dichotomum.* There may also be over 100 species of annuals which germinate after rains. These include *Cyperus conglomeratus, Limeum indicum, Dipterygium glaucum, Heliotropium persicum, Tribulus* spp., *Danthonia (Asthenatherum) forskalei, Lithospermum (Moltkiopsis)*

callosum, Monsonia nivea, Neurada procumbens, Plantago cylindrica, Emex spinosum, Rumex pictus, Chrosophora oblongifolia, Silene villosa, Medicago laciniata, and Asphodelus tenuifolius. Most annuals flower, seed, and die within a few weeks unless a second rain follows. A few, like *Tribulus* or *Heliotropium*, may last for several years. Generally, the sparse vegetation of the sandy desert becomes even more sparse to the south.

2. Desert Plains (roughly zone 2 of Fig. 18). In general, this area is barren gravel or stone plains, though *Salsola* spp. or *Fagonia parviflora* may occur. Sandy plains may have annuals such as *Neurada procumbens* and *Aristida* spp. after rains. Jiddat al-Harasis in central Oman, home of the oryx, has *Prosopis spicigera* and *Acacia tortilis* on the plains, with *Acacia ehrenbergiana* in depressions. Pasture plants such as *Eleusine compressa* and the legume *Tephrosia apollinea* also occur, especially in depressions. In Dhufar certain plants occur which are not found further north, including *Acacia nilotica* and a dwarf *Zizyphus*.

Density of vegetation is much greater along drainage lines in the desert plains, and these wadis also provide avenues of invasion for vegetation of other zones. Typical associations contain *Leptadenia pyrotechnica, Panicum turgidum, Acacia flava, Tephrosia apollinea, Chrosophora longifolia, Rhazye stricta, Aerva persica, Indigofera oblongifolia, Pulicaria* spp., *Convolvulus hystrix, Crotalaria wissmanii, Heliotropium kotschyi, Prosopis spicigera, Tamarix orientalis, Haloxylon persicum,* and *H. salicornicum*. Once into the sandy areas, vegetation in the wadis tends to by halophytic, and many of these wadis drain into sabkhas.

3. Sabkhas (zone 4 of Fig. 18). Most observers recognize sabkha vegetation not only in the eastern Haushi-Huqf and Barr Hikman areas, but also in the western Umm as-Samim. The centers of these salt flats are usually bare, but along the fringes halophytes such as *Halopeplis perfolita, Suaeda* spp., *Haloxylon salicornicum, Salsola bottae, S. cyclophylla, S. leucophylla, Traganum nudatum,* and *Zygophyllum coccineum* occur. Variations in soil salinity lead to variations in the specific composition of the plant associations. Reference to the descriptions of other zones will also show that the less halophytic of these plants generally occur away from sabkha areas entirely.

4. Interior Steppe (zone 6 of Fig. 18). The *Acacia tortilia - Panicum turgidum* community dominates this steppe area. Development of this vegetation is poor in the Dhufar region; often it occurs only in wadi beds. In the north the steppe vegetation is better developed. Around Ibri it covers the whole plain between the mountains and the desert zone, and continues into the desert

along wadis. Associated with the two characteristic plants are *Prosopis spicigera* and *Leptadenia pyrotechnica* in wadis, and *Calligonum* spp., *Haloxylon salicornicur*, *Rhazya stricta*-*phiona subulata*, *Heliotropium persicum*, *Indigofera intricata*, *Gaillonia ancheri*, *Cassia holosericea*, *Tribulus macroptorus*, *Cleome brachycarpa*, *Arnebia hispidissima*, and *Aristida* spp. throughout.

5. Northern Mountains. (zones 7,9, the northern extension of 8, and the northernmost portion of 6 of Fig. 18). Part of this zone around Jabal Akhdar has been studied in detail. At least five separate vegetation associations can be distinguished (Mandaville 1977), as shown in Table 21.

ole 21. Vegetation Zones of Central Jabal Al-Akhdar

Vegetation Zone	Altitude Range (m.)	Topography	Dominant Species	Associated Species
1. *Acacia* Desert Parkland	(0)–370–600	open exposures; flat to gentle slopes; alluvial soil	*Acacia tortilis*	*Acacia ehrenbergiana* *Ziziphus spina-christi* *Prosopis spicigera* *Pteropyrum scoparium* *Fagonia* spp.
2. Mountain *Wādi* Associations	350–1050	sand-silt, gravel, or rock *wādi* bottoms, often with boulders	*Ziziphus spina-christi* *Acacia* spp. *Ficus salicifolia*	*Prosopis spicigera* *Nerium mascatense* *Acridocarpus orientalis*
3. *Euphorbia larica* Shrub Slopes	450–1350	steep rocky slopes; shallow soil	*Euphorbia larica* *Gaillonia* sp.	*Pulicaria glutinosa* *Moringa peregrina* *Maerua crassifolia* *Physoleucas arabica* *Lavandula subnuda* *Convolvulus virgatus*
4. *Reptonia–Olea* Woodland	1350–2300	ravines or open ground; slopes moderate to steep	*Reptonia mascatensis* *Olea africana*	*Sageretia spiciflora* *Ziziphus* (?) sp. (non *spina-christi*) *Juniperus macropoda* *Clematis* (*orientalis*?) *Ebenus stellatus* *Acacia eburnea* *Dodonaea viscosa* *Ephedra intermedia*
5. Juniper Summit Zone	2300–3050	open exposures; rocky summit areas	*Juniperus macropoda* *Cymbopogon* sp.	*Dodonaea viscosa* *Euryops pinifolius* *Teucrium mascatense*

ource: Mandaville. 1977.

The Desert Parkland is a transitional zone between the interior steppe and actual mountain vegetation. As in the steppe zone, vegetation is concentrated along wadis where more water is available and soils are better developed. In addition to the major plants noted in Table 21, *Gaillonia aucheri, Rhazya stricta, Asphodelus fistulosus* occur, as well as rare individuals of *Euphorbia larica, Chrozophora oblongifolia, Pentatropis spiralis* (on *Acacia tortilis*), and *Iphiona* spp. On the inland side of the mountains *Tamarix arabica, Pteropyrum scoparium, Salsola rubescens,* and *Sclerocephalus arabicus* all occur.

Additional plants found in the Mountain Wadi Association besides those listed in Table 21 include *Fimbristylis cymosa, Scirpus litoralis, Pteris vittata, Adiantum capillus-veneris, Asphodelus fistulosus, Calotropis procera, Physorrhynchus chamaerapistum, Citrullus lanatus, Cucumis prophetarum, Phyla nodiflora, Morettia parviflora, Ricinus communis, Aristolochia bracteolata, Forskohlea tenacissima, Cassia italica, Crotalaria wissmannii, Tephrosia nubica, Indigofera coerulea* and *Tephrosia purpurea*. An *Agave* (probably *Agave sisal*), *Aloe barbadense*, and *Tecomella undulata* occur near cultivated areas and are probably not native to Oman.

In the shrub slopes zone, the associates of *Euphorbia larica* vary with altitude, slope and exposure, with stunted *Acacia tortilis* common below about 925 m. Steep hillsides between 450 and 580 m are characterized by an open shrublet community headed by *Euphorbia larica* accompanied by stunted *Acacia tortilis, Lycium shawii,* and a mix of shrublets including *Pulicaria glutinosa, Gaillonia aucheri, Fagonia indica, Teucrium mascatense, Physoleucas arabica, Lavandula subnuda,* and occasional *Acridocarpus orientalis*. *Capparis macronifolia* grows on steep rock faces, with *Maerua crassifolia* and *Moringa peregrina* on higher cliffs. There is very little grass cover, although *Cymbopogon schoenanthus* grows in a few soil-filled cracks in the rock.

On shaly slopes from 760 to 915 m *Euphorbia larica* is accompanied by stunted *Acacia tortilis* and by *Physoleucas arabica, Acridocarpus orientalis* and *Tephrosia* spp. At about 925 m elevation the *Acacia* drops out, and the *Euphorbia* is associated with *Gaillonia calycoptera* and *Gaillonia aucheri* on open exposures. At this level stunted *Ziziphus spina-christi* is still seen occasionally in the small ravines, and *Acridocarpus* is restricted to protected habitats. Other plants in this zone included scattered *Convolvulus virgatus, Helianthemum lippii, Caralluma* sp., *Physoleucas arabica, Tephrosia* sp., and *Cymbopogon schoenanthus*. Transition to the woodland zone begins above this.

The woodland zone, in addition to the major plants listed in Table 21, includes *Euryops pinifolius*, *Daphne mucronata*, *Asparagus gracilis*, *Dionysia mira*, a variety of *Diplotaxis harra*, *Lonicera aucheri*, *Cheilanth fragrans*, and *Viola cinerea*. Grasses are poorly developed below about 1950 m, but quite common above that level. Predominant grasses are *Heteropogon contortus*, *Fingerhuthia africana*, *Tripogon purpurascens*, and *Cymbopogon schoenanthus*.

The juniper summit zone (zone 10 of Fig. 18) includes, in addition to plants listed in Table 21, *Ephedra intermedia*, *Daphne mucronata*, *Clematis* spp., *Ebenus stellata*, *Dionysia mira*, *Berberis* spp., *Cotoneaster* spp., and *Polygala abyssinica*.

The Jabal Aswad mountain area south of Muscat was also surveyed (Mandaville 1977) and plant communities were similar to those of Jabal Akhdar. Variations may be attributed to the greater aridity of Jabal Aswad and its geographical isolation from Jabal Akhdar. Vegetation is more sparse, less diverse, and the juniper zone does not occur in the lower Jabal Aswad. However, some plants found in Jabal Aswad are not yet known on Jabal Akhdar including *Ceratonia* (a species of carob), *Rhus aucheri*, *Argyrolobium crotalarioides*, *Astragalus fasciculifolius*, *Amygdalus arabica*, *Anthemis odontostephana*, *Launaea* spp., *Zoega purpurea*, *Convolvulus acanthocladus*, *Salvia schimperi*, and *Stipagrostis ciliata*.

Appendix V presents a list of plants collected by the Oman Flora and Fauna Survey in 1975, which covered the Jabal Akhdar and Jabal Aswad regions.

6. Coastal Plains and Coasts. These areas are each usually distinguished as separate zones. The Batinah is the most important and extensive coastal plain. It is dry, stony, and sparsely vegetated inland, but better soils nearer the coast support more vegetation, including *Acacia tortilis*, *Zizyphus* spp., *Prosopis spicigera*, *Salvadora persica*, *Lycium*, *Pteropyrum scoparium*, and *Tamarix* spp. In sandy areas species of *Calligonum*, *Leptadenia*, *Panicum*, *Heliotropium*, and annuals such as *Asphodelus*, *Centaurea*, *Indigofera*, *Plantago* and many others occur.

Sandy beaches and wadi mouths usually support salt tolerant scrub brushes such as *Zygophyllum coccineum (Harm)*, *Salsola* spp., *Suaeda* spp. *Haloxylon salicornicum (Rimth)* and perennial grasses, and there are some thickets of *Prosopis*, *Tamarix*, and *Acacia*. Dwarf mangrove (*Avicennia marina*) occurs at the mouth of some creeks.

7. Dhofar mountains (the southernmost portion of zone 8 and adjacent areas of zone 6, Fig. 18). The lower southern foothills have myrrh *(Commiphora)* and *Jatropha* spp. Above these foothills is a discontinuous belt of broad-leaved woodland with bushes and creepers. *Delonix elata, Tamarindus indica, Cadaba longifolia, Croton conferta* are among the tree flora, but a little higher up almost pure stands of *Anogeissus dhofarica* cover the steep slopes, in places in association with the evergreen shrub *Euclea schimperi*. On the southern part of Jabal al Qamr are plateaus of *Dodonea / Euclea* evergreen woodland, with man-made clearings for grass. Certain of these plant species are endemic to Dhufar and confirm that this mountain region is biologically unique.

3.4.2 Endangered Plants

The IUCN Plant Red Data Book (1978) lists two plants which are endangered or rare in Oman: *Ceratonia* sp. nov. (Leguminosae) and *Dionysia mira* (Primulaceae). Both occur in the northern mountains. Mandaville (1977) also recommends protection for *Viola cinerea* and *Lonicera aucheri*. Appendix V includes detailed information on *Ceratonia* and *Dionysia*.

3.4.3. Range Use [14/]

Animal husbandry in several forms has traditionally been an important factor in Oman's rural economy. Table 22 gives livestock population sizes for Oman, but must be used with caution. Many sources state (without presenting figures) that livestock numbers are declining in many nomad regions. (Scholz 1977a, Scholz and Cordes 1980).

Table 22. Estimated Livestock Population

Type of livestock	1974	1975	1976	1977	1978
Goats	128.5	154.9	164.6	N.A.	216.8
Sheep	33.3	48.2	57.2	N.A.	72.6
Cows	90.5	125.9	133.8	N.A.	140.5
Camels	10.8	12.5	13.5	N.A.	15.5
Donkeys	N.A.	N.A.	N.A.	N.A.	26.3

NOTE: Figures are based on the estimated figures of 1971 taking into the consideration the national rate of growth and consumption.

N.A. - Not available.

Source: Sultanate of Oman. 1979.

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14 Sources: Birks. 1976b.
Birks and Sinclair. 1979.
Dostal. 1967.
Juneidi and Huss. 1978.
Mandaville. 1977.
Popov. n.d.
Scholz. 1976
Scholz. 1977b.
Scholz and Cordes. 1980.
Thesiger. 1959.
Wilkinson. 1977.

Livestock may be found in nearly every area of human habitation, and rural economies are seldom restricted to cultivation only or herding only. Herd composition varies according to the ecological conditions in the region. The Bedouin nomads come the closest to an economy based entirely upon herding. Camel-herding Bedouin are found in the desert wadi region (Fig. 2, Section 2.1) with vegetation as described under "desert plains" (Section 3.4.1). In the summer the nomads and their camels cluster around oases, sometimes near the fringes of the inner foothills and wadi region (region V, Fig. 2). In the winter, following the scattered rains, they move deeper into the desert, including the sandy desert regions, to utilize available pasture. *Tribulus* spp. are considered the best possible grazing vegetation. Other preferred forage plants in Oman are noted in Appendix V.

In the inner foothills and wadi region, nomads tend to have mixed herds including sheep, goats, and camels. This area is also within the fringes of the settled zone, so that many agriculturalists also may keep animals. Unlike the camel-herding Bedouin, nomads with mixed herds embark upon much shorter seasonal movements. Only occasionally will they separate the camels from the rest of the herd and take them into the desert. Usually they stay in the comparatively rich bajada zone year-round. Typical herd size among the nomadic Awamir is 5-15 camels and 30-80 sheep and goats per family. Preferred forage for camels is *Prosopis* spp. in sandy terrain and *Acacia* spp. in gravels, while smaller livestock utilize smaller plants.

In the mountains, nomads are called Shawawi. They mostly keep sheep, goats, and donkeys, and a few camels. The average herd size in one survey was 76 animals (Birks 1976b). Shawawi seasonal movements are not great as a rule; in fact, the majority utilize the same water source year-round. That movement which does take place is vertical, to take advantage of conditions at various altitudes. Some evidence suggests that goats prefer the *Cymbopogon - Heteropogon* grass association at high elevations (Mandaville 1977).

Villagers in the mountains also keep livestock, but little data is available on herd size, composition, or grazing practices. Village grazing is supplemented with such fodder crops as alfalfa or low quality dates. In coastal areas livestock are often fed dried fish.

Within the last decade nomadism in Oman has undergone great changes. Most nomads are now in various sedentary stages. One result is that herd sizes have been falling rapidly as families turn to cultivation and the labor market for their livelihood. Most desert areas that were once grazed seasonally are no longer used by domestic animals. However, in local areas, grazing may now be more intense than before. Formerly nomadic families who still keep herds tend to cluster around wells or roads, schools and clinics with their herds. The herd is to longer moved about to take advantage of pasture, but simply stays in one area. Similarly, many mountain range areas are no longer grazed, but local areas where Shawawi settle may now be under more intense pressure. If the increase in animal populations noted in Table 22 is accurate, it is in the agricultural areas where pressure on range resources is already most intense.

3.4.4 Other Uses of Vegetation [15/]

Aside from forage, the major use of vegetation in Oman is for fuelwood. There are no figures available on the magnitude of fuelwood use or its impact. General observations indicate that the favorite firewoods in desert areas are the long roots of *Tribulus* and *Heliotropium*.

In areas where bushes or small trees are prevalent, dead wood from these is used. Customary law among the Bedouin, and apparently among the villagers of the interior, forbids the cutting of live trees. This prohibition is generally followed by Bedouin and interior villagers. It begins to break down in larger towns and was never followed in the Batinah. For example, the Saih Hatat area, which used to provide firewood for Muscat and Matrah, was already largely denuded of trees and bushes by the turn of the century (Lorimer 1915).

There are a number of other specialized uses for certain plants in traditional medicine or other fields. Some of these uses and plants are listed in Appendix V.

15
Sources: Jungius. 1978
Mandaville. 1977.
Munton. 1979.
Thesiger. 1959.

3.5 Fauna

3.5.1 Mammals [16]

A list of the mammals presently known from Oman is presented in Table 1, Appendix VI. Research on Omani fauna is in the beginning stages, and the present list may well be expanded by further exploration. Summaries of the status and distribution of 5 mammals considered to be rare or endangered by the IUCN are given in Table 2, Appendix VI. Appendix VI also includes a list of mammalian ectoparasites.

Only 42 species of mammals are known to occur in Oman. Another 5 have been verified in areas so close to Oman that they may be included in the Omani fauna with a fair degree of certainty. Of these 47 species, 13 are bats, most of which occur in the northern mountain and foothills areas. Another 11 species are rodents, various species of which may be found in nearly any area of Oman. Among the species of carnivores occurring in the Sultanate are wolves *(Canis lupus arabs)* and hyaenas *(Hyaena hyaena sultana)* which are found in mountainous areas and around oases. The red fox *(Vulpes vulpes arabica)* is also found in the mountains and foothills, while the sand fox *(Vulpes rüppelli sabaea)* occurs on the fringes of the Rub' al-Khali.

The cheetah *(Acinonyx jubatus)* is most likely extinct in all of Arabia by now, but several other cats still occur. The South Arabian Leopard *(Panthera pardus nimr)* may still occur in the Dhufar and northern mountains. This leopard is listed by the IUCN (1978b) as endangered. Other cats include *Felis silvestris gordoni* in the coastward foothills and Batinah, *Felis margarita* in the inland foothills and fringes of the desert, and *Caracal caracal schmitzi* in the desert fringes.

The 8 species of ungulates include three which are on the IUCN list. The Arabian Tahr *(Hemitragus jayakari)* is found in the Jabal Akhdar and Jabal Aswad areas of northern Oman, where reserves have been set aside for its protection (Section 3.6.3). The Arabian Oryx *(Oryx leucoryx)* was once common in the Jiddat al-Harasis area of the central desert. It actually seems to have been eliminated from

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[16] Sources: Harrison. 1977.
Henderson. 1974
IUCN. 1978b.
Jungius. 1979.
Munton. 1979.

Arabia by the early 1970's, at least in the wild. However, the Arabian Oryx was preserved in several captive herds throughout the world, and work is currently in progress to reintroduce it to its native habitat (Section 3.6.3).

Gazella gazella arabica inhabits the foothills and gravel plains of the desert. Though also listed as endangered by the IUCN, populations seem to be much larger than those of the oryx or tahr. There is also a species which inhabits the sandy desert *(G. subgutturosa marica)*, and one found in the northern mountains and the Batinah *(G. gazella muscatensis)*. Nubian ibex *(Capra ibex nubiana)*, wild goat *(C. aegagrus)*, and Asiatic Mouflon *(Ovis ammon)* all occur also.

3.5.2 Avifauna[17/]

Somewhat surprisingly for so arid a country, Oman has a rich and varied avifauna. At least 372 species occur in the Sultanate (Table 3, Appendix VI), although only 74 (20%) are resident breeders (Table 23). Major habitats and the most common breeding birds of each one listed in Table 4, Appendix VI.

Table 23. Composition of Breeding Birds of Oman

	Sea-birds			Others			Totals
	N only	S only	N & S	N only	S only	N & S	
Resident	–	2	3	19	20	30	74
Migrant	2*	–	3	13†	3	1	22
Totals	2	2	6	32	23	31	96

*Includes Saunders' Little Tern, on Masirah only. †Includes Crab Plover, on Jazirat Shaghaf near Masirah, only.

N = North
S = South

Source: Gallagher and Woodcock. 1980.

[17] Sources: Gallagher. 1977.
Gallagher and Woodcock. 1980.

The vast majority of Oman's avifauna is of Palearctic origin. Only 15 landbirds are Indomalayan, of which 8 breed in Oman (Table 24). Indomalayan species tend to occur in the northern part of the country. Afrotropical species (Table 24) are represented primarily in Dhufar. Only 26 Omani landbirds are Afrotropical, 20 of which breed or may breed in the southern end of the Sultanate. Oman has no endemic birds, but the Arabian Red-legged Partridge *(Alectoris melanocephala)*, the Arabian Babbler *(Turdoides squamiceps)*, and Tristram's Grackle *(Onychognathus tristramii)* are endemic to Arabia.

Table 24. Indomalayan and Afrotropical Landbirds

Afrotropical	Indomalayan
A Species which breed or may breed in Dhofar	**A Species which breed**
Lappet-faced Vulture	Grey Francolin
Verreaux's Eagle	Red-wattled Lapwing
Spotted Thick-knee (Dikkop)	
Yellow-bellied Green Pigeon	Palm Dove
Didric Cuckoo	
Spotted Eagle Owl	Rose-ringed Parakeet
Grey-headed Kingfisher	Indian Roller
Singing Bush Lark	Purple Sunbird
Blackstart	House Crow
Blanford's Warbler*	
African Paradise Flycatcher	Indian Silverbill
Abyssinian Sunbird*	
Palestine Sunbird	
White-breasted White-eye*	**B Others**
Black-headed Bush Shrike	Indian Pond Heron
Fan-tailed Raven	Cotton Teal
Rüppell's Weaver*	Pheasant-tailed Jacana
African Silverbill	White-breasted Waterhen
Golden-winged Grosbeak*	Little Pratincole
Cinnamon-breasted Rock Bunting	Red Turtle Dove
	Koel
B Others	
Black-headed Heron	
Abdim's Stork	
Sacred Ibis	
Namaqua Dove	
Nubian Nightjar	
Wattled Starling	

*Restricted range in E Africa.

Source: Gallagher and Woodcock, 1980.

3.5.3 Herpetofauna

Forty -eight species of reptiles are known to occur in Oman (Arnold and Gallagher 1977). Geckos account for 18 of these species, and various other lizards for another 19 species. There are 4 vipers, a boa, and several other species of snakes. Two toads are known. A complete list of the herpetofauna is presented in Table 5, Appendix VI.

3.5.4 Invertebrates

Molluscs. Twelve species of land and freshwater molluscs have been recorded in Oman (Smythe and Gallagher 1977, see Table 6, Appendix VI). No species of *Bulinus* or *Biompharia*, the vectors of schistosomiasis, have yet been found. Schistosomiasis is endemic to some parts of Arabia, but apparently occurs only among immigrants in Oman.

Moths and Butterflies. Thirty-eight species of of Rhopalocera (butterflies) have been recorded from northern Oman, and 25 from Dhufar (Larsen 1977). Half of the Dhufari species are not found in northern Oman, mostly species of Ethiopian origin. Zoogeographic affinities of the butterflies of northern Oman are given in Table 25. The butterflies have not been thoroughly surveyed; the entire fauna is probably 2 to 3 times as large as what is now known.

Of the 109 species of Heterocera (moths) recorded so far, a few are known to be pests in other areas of the Middle East, where they attack *Acacia mollissima*, cotton, and vegetable crops (Wiltshire 1977a, 1977b). Their impact in Oman is not yet known. Most of the Omani moth fauna is of Eremic (Palearctic desert) origins (Table 26).

Mammalian Ectoparasites. Of the mammalian ectoparasites known from Oman, the most noteworthy is the cosmopolitan rat flea *(Xenopsylla cheopsis)*, known as the vector of bubonic plague (Thompson 1977). Other species of mammalian ectoparasites are listed in Table 7, Appendix VI.

Scorpions. Three species of scorpions have been recorded from Oman. *Hemiscorpius maindroni* has been found in Jabal Akhdar and near Muscat; *Buthotus jayakari* in Jabal Akhdar, Jabal Aswad and near Muscat. *Nebo hierichonticus* has so far been found only in Jabal Akhdar (Vachon 1977).

Table 25. Zoogeographic Affinities of the Butterflies of Northern Oman

Origin	%
Ethiopian	26
Ethiopian-cum-Oriental	21
Arabian	10
Oriental	11
Eremic	21
Palaearctic	10
Total	100
Number of species	38

Source: Larsen. 1977.

Table 26. Zoogeographic Affinities of the Moths of Oman

EREMIC	ENDEMIC	8
68	EASTERN EREMIC	43
	SAHARAN SINDIAN	15
	PAN-EREMIC	2
TROPICAL	ASIATIC TROPICAL	11
31	ETHIOPIAN TROPICAL	3
	PALEO-TROPICAL	15
	HOLO-TROPICAL	2
TEMPERATE	EURORIENTAL	6
7	HOLARCTIC	1
WORLD-WIDE	WORLD-WIDE	3
3		100

Source: Wiltshire. 1977.

3.5.5 Ichthyofauna and Fishing [18]

Only three freshwater fish are known to occur in Oman in the perennial pools of some of the oases and wadis. *Cyprinion microphthalmum* has a length of from 66 to 112 mm and is from the Iranian faunal group. *Garra barreimiae* (42-72 mm) and *Garra longipinnis* (36-52 mm) are members of the Levantine faunal group. These small freshwater fish have no economic importance.

Marine fishing has traditionally been a major industry in Oman, and still occupies about 10 percent of the population. The main Omani fishing grounds are along the southeastern coast in the Arabian Sea. The main fishing population is in the Batinah and the coast between Musqat and Ras al-Hadd (Table 27). Larger boats from villages do fish the Arabian Sea areas, but smaller ones fish locally.

Table.27. Fishing Population in Oman - 1979

Region	Wilaya	No. of Fishermen	No. of Boats
Northern Coast	Shinas	36	36
Musandam	Khasab	490	381
	Dibba	249	97
	Sub-total	775	514
Northeast Coast	Shinas	201	190
Batinah, Capital Area:	Liwa	44	37
	Sohar	477	448
	Saham	334	416
	Khaburra	136	244
	Suwaiq	437	361
	Masnah	141	134
	Barka	119	289
	Capital Area	221	462
	Sub-total	1904	2793
East Coast	Quryat	146	139
	Mudhreb	81	66
	Sur	566	111
	Bilad Bani Bu Ali	349	349
	Bilad Bani Bu Hassan	56	51
	Sub-total	1196	814
Southeast Coast	Al-Kuwais		
	Manut	300	300
	Duqm		
	Masira Island	115	115
	Sub-total	415	415
Southern Coast	Mirbat		
	Taqa		
	Salalah	1776	281
	Raysut		
	Raykhut		
	Sub-total	1776	281
	Grand Total	7376	5019

Source: Sultanate of Oman. 1980b.

[18] Sources: Banister and Clarke. 1977.
Europa Publications. 1980.
Middle East Economic Digest. Special Report. 1978.
Nyrop et al. 1977.
Sultanate of Oman. 1979.
Sultanate of Oman. 1980b.

The major development of the fishing areas has been through concessions to foreign companies. In 1976 Taiyo Fishery Company and Nissho Iwai, both of Japan, began operations, but they did not renew the concession after 1977. The companies were not satisfied with turning over 40 percent of the catch to the Omani government, and they were disappointed with the size of the catch. The Korea Overseas Fishing Company took over the concession in 1978 and is now producing about 20 tons of fish per day.

Figures on total resources are conflicting. Potential annual yields may be anywhere between 100,000 and 600,000 metric tons. The only detailed breakdown of species taken appears in figures on the catch of the Japanese and Korean companies (Table 28).

Table 28. Fish Catch (by species) by Japanese and Korean Vessels during 1976, 1977 and 1978

Species of fish	Fish catch in tonnes		
	1976†	1977	1978**
Sphyraena	63.3	220.2	75.5
Caranx sp.	207.2	423.3	487.9
Epinephelus	105.7	195.4	268.1
Saurida	395.5	159.1	98.6
Lethrinus	368.1	700.7	1144.7
Nemipterus	213.5	206.4	3.0
Pagellus	1830.7	1297.0	168.3
Decapterus	58.4	405.3	5.9
Sepia	170.8	165.2	151.3
Trichiurus	123.1	271.0	51.2
Pagrus Pagrus	1490.9	1419.7	1335.3
Evynnis	164.5	222.7	133.0
Evynnis sp.	309.4	524.4	448.6
Jonnius sp.	*	179.0	256.0
Scombers sp.	*	127.9	2.2
Others	783.9	350.7	772.7
All species	6301.0	6868.0	5394.8

*Included under others.

**Caught by Korean vessels.

†Fish catch during 1976 is for the period April — December only.

Source: Sultanate of Oman. 1979.

3.6 Conservation and Protected Areas [19]

3.6.1 Endangered Species

Government action on conservation and protected areas has been heavily oriented toward those larger species identified as endangered. The IUCN and the U.S. Fish and Wildlife Service (USFWS) list the species in Table 29 as endangered.

Table 29. Endangered Species found in Oman

Species	English Name	Source
Panthera pardus nimr (*Panthera pardus*)	South Arabian Leopard	IUCN USFWS
Hemitragus jayakari	Arabian Tahr	IUCN, USFWS
Oryx leucoryx	Arabian Oryx	IUCN, USFWS
Gazella gazella arabica (*Gazella gazella*)	Arabian Gazelle	IUCN USFWS
Gazella subgutterosa marica	Sand Gazelle	USFWS
Dugong dugong	Dugong	IUCN, USFWS
Struthio camelus syriacus	Arabian Ostrich	USFWS

Sources: IUCN. 1980b.
U.S. Fish and Wildlife Service. 1980.

[19] Sources: Gallagher and Woodcock. 1980.
Harrison. 1975.
Harrison and Gallagher. 1974.
Harrison and Gallagher. 1976.
Henderson. 1974.
IUCN. 1978b.
Jungius. 1978.
Munton. 1979.
Oryx. April 1980.
Thesiger. 1959.
U.S. Fish and Wildlife Service. 1980.
Vicker 1980.

In addition, the Syrian wild ass or onager *(Equus hemionus hemippus)*, listed by the USFWS, sometimes appears in discussion of Omani wildlife. However, it is nearly certain that the onager has been extinct in Arabia for some time, and that reports have confused them with feral domestic asses or donkeys (Harrison 1972; Thesiger 1959).

Oman is not specifically listed as part of the range of the Arabian ostrich, and no ostrich has been seen in Oman since the 1920s (Thesiger 1959). The dugong's range does include Oman according to the ICUN, but there is no information available about this sea mammal off the Omani coasts, and the government has not addressed the question. Similarly, no action seems to have been taken on the South Arabian leopard. However, Oman has moved quite forcefully and fairly successfully in recent years to protect the tahr, the oryx, and the gazelles.

3.6.2 Hunting Restrictions

Hunting has never been a primary activity in Oman and wild game has never provided the major food source to any social group. However, local people did occasionally shoot gazelle, oryx, ibex, and tahr. In the case of the tahr, hunting by local inhabitants was considered one of the factors endangering the species. In 1976 tahr hunting was completely prohibited, a restriction which has generally been strictly followed.

Restrictions on hunting oryx and gazelle were instituted much earlier. Hunting oryx from vehicles was prohibited in the early 1960s, and the decrees were renewed and strengthened once the present Sultan came to power in 1970. Omanis have generally observed the prohibitions against hunting these animals also. However, the vast desert areas which are the major habitat of the oryx and gazelle are easily accessible from neighboring countries. In the late 1960s and early 1970s the Sultanate apparently was unable to counter hunting parties which came to shoot or capture game. One such party in 1972 killed 3 oryx and captured 3 or perhaps 4. These are thought to have been the last wild oryx left in Arabia (Henderson 1974). In recent years action against such foreign entry has improved greatly, and gazelle herds seem to be recovering somewhat.

3.6.3 Protected Areas

Jabal Akhdar National Park. In 1975 plans were formulated for a national park which would offer protection to the endangered Arabian Tahr. This park was to be approximately 50 km across and 30 km from north to south, situated in Jabal Akhdar (Figure 19). The Oman Flora and Fauna Survey was commissioned to learn in detail about the tahr's habitat. It was subsequently determined that the tahr population in Jabal Akhdar was not very great, but plans for the park have gone ahead regardless. The official status of the Jabal Akhdar National Park, or of any of the following protected areas, is not clear.

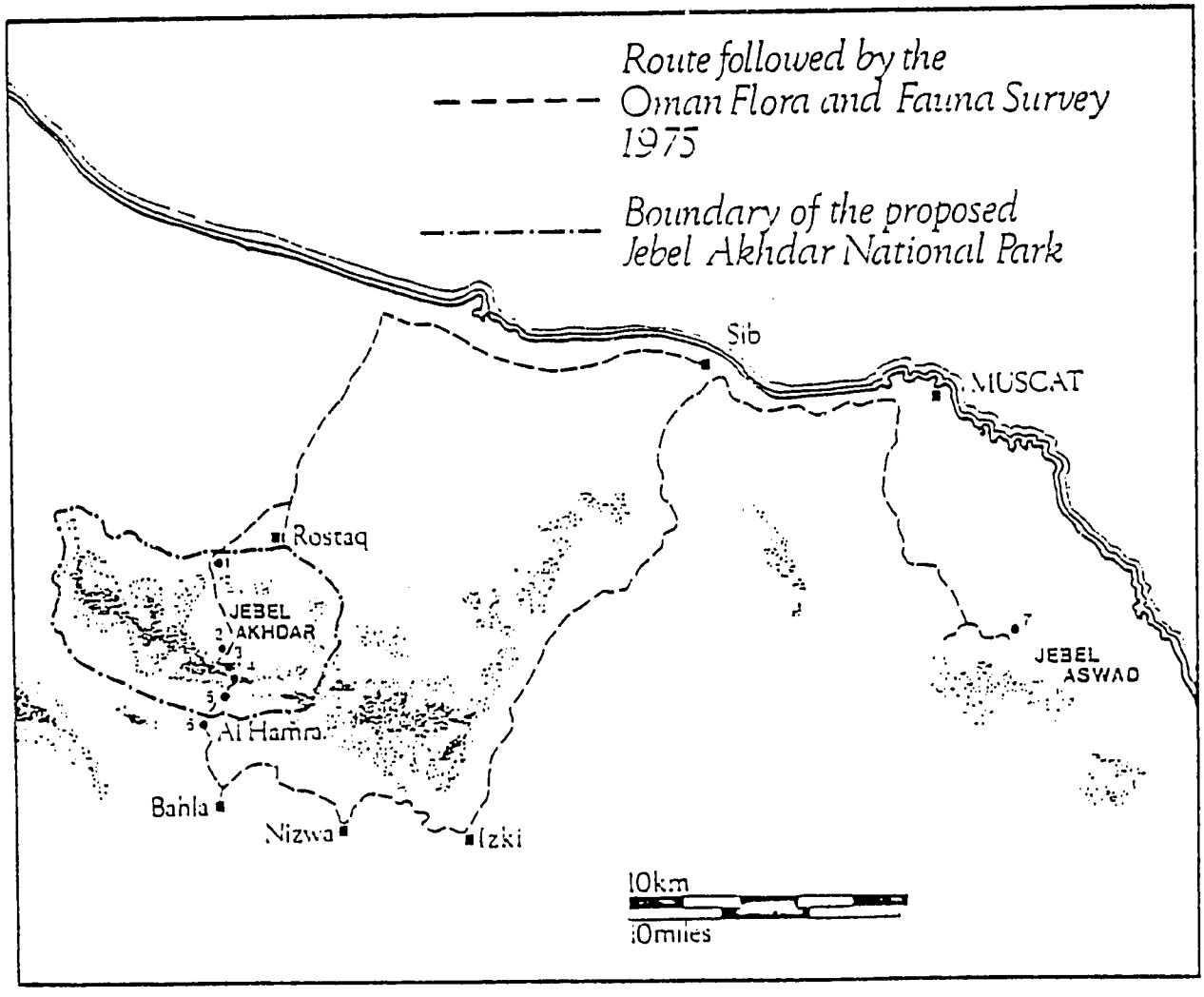

Figure 19. Proposed Area of the Jabal Akhdar National Park

Source: Harrison. 1975.

Jabal Aswad Tahr Reserve. Following the discovery that the tahr population in Jabal Akhdar was not as great as had been hoped, a second protected area was set aside for tahr. The tahr was found in greater numbers in Jabal Aswad, and the government initiated salary payments to a number of villagers in the area to act as wardens. These actions, coupled with the country-wide ban on tahr shooting, seem to have been effective. Tahr populations are recovering, and about 300-370 may have inhabited the Jabal Aswad reserve by 1978. About 2000 are believed to exist in Oman now, which is considered to be (barely) sufficient to insure survival of the species through any forseeable natural calamity such as extended drought.

Jiddat al-Harasis. Oman has just recently instituted a program to reintroduce the Arabian oryx to its native habitat, beginning with a protected area in the Jiddat al-Harasis. The area is named after the tribe which inhabits it, the nomadic Harasis. Land use patterns, herd sizes, and human population have remained stable, and reports indicate that there has been very little overgrazing. In addition, the Harasis have been charged with protection of the oryx by the Sultan. All reports indicate that they are quite eager to take on the responsibility and quite enthusiastic about the program. In March 1980, 5 Arabian oryx were flown to Oman and more were scheduled to go. The animals were to be penned initially to allow adjustment to their new environment, and it is not clear what stage the project has currently reached.

Khor Qurm Nature Reserve. An area on the coast near Musqat has been set aside as a nature reserve. Part of the area is mangrove swamp, habitat for a great variety of avifauna. Details on the status or extent of this reserve are not available.

Wadi Serin Nature Reserve. IUCN (1978a) mentions that this reserve was established in 1976 to protect the tahr, but no further information is available.

4.0 Major Environmental Problems

The Sultanate of Oman is still in the very early stages of development and has not yet had to face many of the environmental problems of the highly industrialized societies. Industrial pollution of water and air, excessive noise levels, and the like are not major concerns at present. Industrial pollution is not likely to become a major problem for a number of years, with the possible exception of oil spills.

Reflecting Omani society's continued rural orientation, present environmental problems concern water supplies for agriculture and rural domestic use, associated health problems, and soil salinization. The problem of deteriorating traditional irrigation systems is critical. This is not simply a water problem, but part of the wider decline of Omani agriculture due to changes in Omani society brought about by the country's development. Migration of rural labor is a major cause of these problems.

All of Oman's environmental problems should be viewed in the context of Oman's location in one of the world's most arid regions. Many aspects of the major environmental problems are natural, or at least greatly aggravated by natural conditions.

4.1 Water Problems[20]

While drought may greatly aggravate water supply problems as discussed below, Oman's arid environment makes water one of the major concerns even in the relatively wet years. The government is well aware of most of these problems, and has proposed projects to address many of them (Appendix VII).

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[20] Birks. 1976b.
Birks. 1977.
Cordes and Scholz. 1980.
Middle East Economic Digest. Special Report. 1978.
Nyrop et al. 1977.
Scholz. 1976.
Sultanate of Oman. 1980a.
U.S. AID. 1980b.
U.S. Army Corps of Engineers. 1979.
Who's Who in the Arab World 1978-1979.
Wilkinson. 1977.
Wilkinson. 1980.
World Bank. 1979.

4.1.1 Natural Water Shortages

Drought is a natural consequence of Oman's arid environment. Drought in Oman is usually local in nature, and there are always some areas which have been without rain or have had much less than average for several years.

Birks (1977) has studied the impact of drought on a small village in Wadi Hawasina (Western Hajar). Ghayzayn (Fig. 17) went through a drought in 1973-1975, one of the worst in decades. The drought was local in nature; other portions of western Hajar received sufficient rainfall to replenish shallow aquifers and subsurface wadi flow. Agriculture in Ghayzayn does not depend directly upon rainfall, but rather upon falaj flow. Table 30 charts the flow of Ghayzayn's falaj during the drought.

Table 30. Falaj Flow in Ghayzayn, 1973-74

Date	Flow (gal/min)[a]
November, 1973	820
June, 1974	90
July, 1974	70
September, 1974	50
(reaching village)	(30)
November, 1974	20

[a] At point f, Fig. 17.
Source: Birks. 1977.

Before the drought, Ghayzayn had about 50 ha of cultivated land. Most was under date palms, but about 10 ha was planted in wheat and alfalfa, and a small area in tomatoes and onions. About 800 gal/min of the flow was used for irrigation, and the palms in particular were well watered. As soon as June 1974 all field cropping had been abandoned, and date yields were down because the remaining water was insufficient. Some trees began to die, particularly young palms without well developed root systems. As the drought progressed, the village began to use only one falaj channel at a time, the watering cycle was extended to 14 and later 28 days rather than 7, and the cistern at the top of the fields was used to collect water to build up a head.

The water shortage also had impacts on other aspects of the environment. People became reluctant to plow, because individual plots would then absorb too much water, contrary to village

concepts of fairness. However, this cut down water penetration to the trees, allowed greater evaporative loss, fostered more rapid salt accumulation in the upper levels of the soil, and encouraged the formation of hardpan. The smaller volume of falaj flow also meant marked deterioration in the quality of drinking water.

As the drought continued, fodder had to be purchased to keep livestock alive, rather than supplied from village cultivation. This outflow of capital left no financial resources with which to pay for needed falaj repair. Finally, the combination of all factors forced more people to seek employment elsewhere to supplement falling incomes at home. The resulting lack of labor in Ghayzayn further contributed to the lack of repair of village irrigation systems.

Many areas of Oman face perennial water shortages, even without drought. In desert areas such as the Jiddat al-Harasis, there is no water at depths accessible by traditional methods. This has led to methods of dew harvesting such as collecting dew off plants or hanging sheets of cloth to collect dew. Within the last decade, the government has begun drilling deep wells and trucking water to tanks in the desert to insure adequate water for nomads' livestock. Modern mist harvesting experiments are also being carried out in Dhufar to take advantage of the misty monsoon season.

4.1.2 Overpumping

The amount of water in the shallow aquifers and subsurface wadi flows varies naturally somewhat, according to rainfall. The introduction of modern pumps into Oman, however, represents a potentially serious long term problem in the absence of strict regulation. Water is now pumped in some areas at a faster rate than the natural recharge. In the Batinah particularly, the water table has dropped throughout the 1970s, and many traditional wells have gone dry. Overpumping will also soon become a serious problem in some interior areas, causing aflaj to go dry.

Aside from the subsiding water table causing wells and aflaj to go dry, it also affects the quality of water available to agriculture. This problem is most acute in the Batinah, where sea water intrusion is common. Saline irrigation water poses an immediate risk to tree crops other than palms. Date palms are somewhat salt tolerant, but even date groves are now being destroyed, as, for example, those at Khaburah and Saham. Because of falling water tables and increased salinity, the government suspended drilling of new wells in 1978 at Sib and Ruwais in the capital area. The government has also attempted

to persuade farmers to move their fields back from the coast so that pumping will not cause increased salt water intrusion to such an extent.

4.1.3 Aflaj Deterioration

One of the potentially most far reaching problems with water and the entire agricultural sector is the deterioration of traditional irrigation systems. In most cases, a well maintained falaj is the most efficient means for extracting high quality groundwater from the shallow aquifers and subsurface wadi flow. Because salinity increases rapidly downslope in the alluvial fan, water pumped from directly under a cultivated area is invariably more saline than that available from a falaj. Furthermore, wells or deep bores often cannot supply the same quantity of water that alfaj can. Deep wells are also more liable to overpumping. The vast majority of aflaj tap only the shallow aquifers, and are constructed in such a way that it is impossible to tap water at a rate which causes rapid drops in the water table typical of pumps. Many subsurface wadi flows tapped by ghayl aflaj could not be tapped practically by wells or pumps at all. While aflaj are an efficient means of extracting water under Omani conditions, they must be well maintained. Water loss can easily be twice as great if the falaj is in poor condition, and in critical cases water flow may cease entirely. An unlined falaj tunnel at Ghayzayn could not carry water satisfactorily when the water table dropped during drought. Other underground maintenance problems include downcutting in loosely consolidated areas (a factor at Ghayzayn), mineral deposition and scaling in carbonate rock areas, and debris buildup. Aflaj surface canals may also develop leaks which are usually of no great consequence during normal years, but become critical during drought.

While in principle repairs to defective aflaj can be made, in practice they usually are not. The specialized labor required for most underground work is quite expensive by Omani standards, and villages tend to put off repairs if there is not a pressing need. Once a pressing need arises, such as drought, the capital is spent on subsistence and is not available for falaj repair. Labor migration is another cause of rural manpower shortages. Remaining rural manpower is hard pressed to maintain the same level of cultivation, let alone undertake falaj repair. These factors have fostered the spread of pumps, which require little labor. Once a village gets a pump, there is even less incentive to maintain the falaj.

4.1.4 Other Water Problems

Rapid runoff and low infiltration in mountain areas can make

short intense rainstorms cause local floods. Floods are a major cause of damage to qanat aflaj, often clogging them with silt or gravel. Floods may also wash out components of ghayl aflaj, or wash out small fields which lie on terraces near the wadi bottom. Occasionally a major flood may destroy a whole village.

Efficiency of water use should become an issue in Oman. A major proportion of the high quality water is already being tapped, so that agricultural expansion may ultimately depend more upon improving efficiency in water use than upon increasing water exploitation. Aside from questions of falaj maintenance or the advisability of promoting water pump distribution, certain practices should probably be changed. In traditional agriculture, for example, tree crops often get up to 50 percent more water than they need when surplus water is available. During droughts, farmers share water resources equally, often to the extent that everyone's water share becomes too small to support crops. These traditional concepts of fairness and landholding patterns may be difficult to change. Nevertheless, it may be possible to find a system which permits the survival of some trees rather than allowing everyone's trees to die equally.

Modern irrigation may also be inefficient. In the Salalah plain, for example, overhead crop spraying allows great water waste through evaporation. Estimates suggest that the present cropped area of about 4000 acres in the plain could be expanded to nearly 50,000 acres through more efficient irrigation management.

Information is not available on aspects of water problems in urban areas beyond a few very general observations. Water use in the Muscat - Matrah capital area and in Salalah is increasing very rapidly (Section 3.2.4; Table 11).

4.2 Soils and Vegetation

4.2.1 Soil Salinity[21]

The problems of soil salinity are directly connected to water salinity problems and the shift to pump irrigation.

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[21] Stevens. 1978
U.S.AID. 1980a.
Wilkinson. 1977.
World Bank. 1979.

The situation in the Batinah has already been noted in Section 4.1.2, but soil salinity is becoming a major problem in interior areas also. In Wadi Sayfam near Bahlah, for example, there has been a shift to pump irrigation over the last 15 years. The water directly under fields is more saline than water tapped upslope by aflaj, so that pumping has caused dramatic increases in soil salinity. Wadi Sayfam is traditionally an important cereal growing area, but if current trends continue it is likely that the soil will be too saline to support cereal cultivation within a few decades (Stevens 1978).

4.2.2 Mobile Dunes

In many local areas, particularly in oases on the fringes of sand deserts or dune fields, mobile dunes are a problem. Many villages in such regions have planted rows of palms or constructed mud brick walls to act as windbreaks, but these are in constant danger of being overrun. Since most oases, particularly the cultivated areas, are situated in hollows, they are especially vulnerable to shifting sands (Wilkinson 1977).

4.2.3 Devegetation[22]

In a survey covering the entire peninsula and Persian/Arabian Gulf region, Juneidi and Huss (1978) assert that the general trend throughout the area is toward increasing deterioration of rangeland. Causes of this deterioration include extensive plowing of marginal land for agriculture, a trend which has been accelerated by the use of modern machinery; overgrazing; extensive firewood cutting; the unplanned location of wells, so that livestock tend to concentrate in one area; and the use of trucks to transport animals to previously unaccessible range areas. Juneidi and Huss particularly stress overgrazing, and claim that intense grazing by sheep has destroyed the most desirable forage species. This destruction caused a shift to goats and camels which can utilize less desirable forage plants.

The Juneidi and Huss (1978) report was based upon field work in a number of countries, but Oman was not visited. In fact, the few figures and field observations which are available suggest

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[22] Birks. 1976a.
Harrison and Gallagher. 1976.
Juneidi and Huss. 1978.
Jungius. 1978.
Mandaville. 1977.
Munton. 1979.
Scholz. 1977a.
Wilkinson. 1977.

that the conclusions in the report do not apply to Oman at all in most aspects, and only locally in other cases. Reports from both desert areas (Scholz 1977a, Jungius 1978) and mountain areas (Mandaville 1977, Harrison and Gallagher 1976) indicate very little deterioration of range resources. Jabals Akhdar and Aswad, both of which were surveyed extensively by the Oman Flora and Fauna Survey in 1975, showed little evidence of any damage to plant communities due to grazing by either domestic or wild animals. Furthermore, if the figures in Table 22 are accurate, no shift away from sheep exists in Oman. The sheep population increased by 1.85 times between 1974 and 1978, while goat and camel populations increased by 1.69 and 1.44 times, respectively. Likewise, overcutting of firewood is not a widespread problem in the Sultanate (Munton 1979, Harrison and Gallagher 1976, Wilkinson 1977, Mandaville 1977).

In a few local areas, devegetation is a major problem. The Saih Hatat plateau behind Muscat is one of the few areas designated for widespread woodcutting and the area has been under pressure for generations. Observations on the condition of vegetation in the eastern plateau around Sig (not located by Mandaville 1977, but seems to refer to Saih Hatat) note that woodcutting, heavy grazing, and trampling by livestock have occurred for centuries and have strongly affected the appearance and composition of vegetation. Likewise, extensive clearing has taken place in the Batinah, which seems never to have observed restrictions on cutting.

The government has supported modest well drilling programs in nomadic livestock areas, and many nomads are beginning to use trucks to transport animals to pasture. In most cases, however, this does not seem to be increasing pressure on vegetation. Herd sizes are falling rapidly among both Bedouin and Shawawi populations, so that most areas of Oman are now actually under much less pressure than previously. The major concentrations of animals are in settled areas, but very little data is available on the damage done to vegetation in these areas. One factor that may keep range pressure from becoming too severe is the heavy reliance on fodder crops rather than grazing.

4.3 Agricultural Production[23/]

Most observers assert that Omani agriculture is either stagnant or declining. Certainly estimates of total cropped areas have

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[23] Birks. 1976a.
Scholz. 1978.
Sultanate of Oman. 1980a.
Wilkinson. 1980.

not changed over the last decade, while yields in most cases have gone down. Pests and disease are still a major problem in most areas, and can greatly retard production. Limes, for example, are susceptible to black flies, and date palms to metaq flies. Disease is also common among livestock, particularly diarrhea and various respiratory diseases. Chicken diseases are so rampant that many farmers simply give up trying to raise chickens (Sultanate of Oman 1980a).

Many problems in the rural sectors may be traced to changes in the structure of Omani society which occur as the country develops. As the tribal structure breaks down, villages such as Ghayzayn (Section 4.1) can no longer rely upon the wider tribal entity to help them survive a drought. As modern waterpumps orient land and water rights concepts away from community cooperation and toward individualism, most farmers can no longer count on community support within the village to help with difficulties. Although the government subsidizes pump distribution, in many cases only the richer farmers can afford pumps. The others must depend upon the traditional aflaj, without, however, the traditional organizational structure for maintaining these aflaj. Furthermore, there is a declining interest in agricultural sector investment. Agriculture was once a primary concern and one of the major means of investing surplus capital. Today 80 percent of private investment goes to the capital area rather than to rural areas. Only 4 percent of private investment goes into productive activities in Oman, and this includes factories as well as agriculture (Scholz 1978). Many problems could probably be solved simply with better management practices. One survey among the Shawawi found a death rate among livestock of about 12 percent per year. The three leading causes of death were predators (hyaena, fox and a few leopards), falling, and eating poisonous plants. Loss of kids and spontaneous abortions were as high as 60 percent. These rates could easily be lowered through more careful management (Birks 1976).

4.4 Labor Migration[24/]

Many problems in the agricultural sector are greatly aggravated

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[24] Birks. 1976a.
Birks. 1976b.
Birks. 1977.
Birks and Sinclair. 1979.
Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens. Annual Supplement. 1980.
Scholz. 1976.
Scholz. 1977b.
Wilkinson. 1977.

by rural labor migration (Section 2.3.2), which therefore has an impact upon the environment. Declines in date yields and poor care of date palms are often attributed at least partially to lack of manpower (Scholz 1977b, Wilkinson 1977). Cultivation of grain crops has also suffered; some villages (e.g. Afi) no longer grow any grain because of manpower shortages (Scholz 1976). Seasonal cropping of other foods is also being abandoned (Birks and Sinclair 1979).

Labor shortages are also a major cause of the aflaj and well deterioration discussed in Section 4.2.3. Neglect of aflaj and wells makes them more susceptible to droughts or floods, to the extent that many cases of damage attributed to these causes may actually be traced to lack of maintenance. Livestock management has also suffered. For example, women must usually take over sheepherding, but cannot go as far looking for strays. Many pastoral tribes have let herd sizes fall to only 5 percent of former levels.

4.5 Public Health Problems[25]

The majority of Oman's current health problems (Section 2.2.3) are probably preventable through improved sanitation and programs such as malaria control. The three main causes of child mortality are malaria (48%), gastro-enteritis (24%), and dysentery (16%) (Farrag 1979). Nearly 90 percent of the houses in Oman have no latrines or sewage disposal. Most houses are crowded, and in some rural areas people also keep livestock under the same roof. Refuse is commonly dumped behind the house and humans use date or lime groves near the villages as latrines. These areas become breeding grounds for flies which spread trachoma.

Water resources play a major role in public health problems. Perennial pools in wadis and oases, and wells on the Batinah coast are breeding grounds for mosquitoes which spread *Plasmodium falciparum*, the malarial organism which accounts for 90 percent of the cases in northern Oman (U.S. AID 1980b). Pilot programs carried out by the Ministry of Health with WHO assistance have been fairly successful in reducing the incidence of malaria in target areas. The control measures include use of larvicides

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[25] Cordes and Scholz. 1980.
Farrag. 1979.
Nyrop et al. 1977.
Scholz. 1976.
Scholz. 1977a.
Scholz. 1977b.
Sultanate of Oman. 1980a.
U.S. AID. 1980b.

in breeding areas, spraying residential areas, and drug prophylaxis. One problem encountered is that sudden heavy rainstorms can wash larvae out of wadi beds into unaccessable temporary breeding places. Not only are they then out of reach of spraying, but they are also removed from the larvivorous fish found in many perennial pools. There is also some evidence of increased resistance to insecticides.

Aside from its role as mosquito breeding areas, water also contributes to the spread of communicable disease. Most wells and surface channels of aflaj are uncovered and unprotected from animals. Spot tests indicate that most water from these sources is polluted to some degree. Not only are the wells and aflaj used to obtain drinking water but people also wash in them, which may further spread disease.

Some public health problems may be compounded by the processes of urbanization or sedentarization. Oman has been fortunate that social preferences and government programs have so far forestalled the widespread occurrence of shanty towns near urban areas. Nevertheless, there are some small areas of shantytown at Muscat. These communities are unplanned and often entirely without services such as sewage systems. Similarly, sedentarization of nomads usually proceeds spontaneously outside of established areas. Nomads may simply make a formerly seasonal camp permanent. Problems of animal pens and latrine areas in the midst of the dwelling area are then compounded.

4.6 Wildlife[26/]

The government of Oman has defined preservation of wildlife as one of its major concerns. Activity is directed towards the oryx, tahr, and several gazelles at present. The alarming decline in gazelle and tahr populations seems to have been reversed within the last several years, and the program to reestablish the oryx shows promise of success. The oryx was wiped out, and gazelle populations diminished primarily by the introduction of hunting with modern vehicles, airplanes, and automatic weapons. Environmental pressures and traditional tribal hunting from camels did very little to affect herds. The Sultanate took early steps to ban destructive

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[26] Harrison and Gallagher. 1974.
Harrison and Gallagher. 1976.
Henderson. 1974.
Jungius. 1978.
Mandaville. 1977.
Munton. 1979.
Vicker. 1980.

modern hunting methods among its citizens, but was unable to control the entry of foreign hunting parties. The major factor that has allowed progress in restoring populations in recent years has been tighter control of border areas. Foreign hunting parties cannot gain permission to enter Oman, and illegal entry is now fairly effectively controlled by the Border Scouts, regular army, police, and Petroleum Development Oman outposts.

The oryx and the gazelles seem not to face much pressure on other fronts. Complete bans on any kind of hunting are now in effect for citizens, and are usually observed. In fact, *Gazella gazella arabica* herds observed in the Jiddat al-Harasis seemed quite tame, indicating that they are not usually disturbed by man. This contrasts sharply with gazelle behavior observed in areas of Arabia where they are still under hunting pressure (Jungius 1978). Predator pressure is also slight, since few predators are currently found in the desert areas preferred by most gazelle and the oryx. Competition for grazing with domestic herds may have been a slight factor in local areas, but in general traditional herding did not lead to any extensive devegetation. In the Jiddat al-Harasis goats and camels can often be seed grazing near gazelle herds (Jungius 1978).

The major factor limiting populations of the tahr was the small size of its preferred mountain habitat. Competition from domestic stock and hunting were the second and third most important factors (Munton 1979). Poaching does continue to some extent, but the 1976 ban on tahr hunting is generally observed. In many major tahr areas there is little evidence that livestock is depleting vegetation, and as Shawawi herd sizes fall, this already slight pressure will decrease. Oman does not yet seem to have addressed the situation of the endangered South Arabian leopard. One problem may be that the leopard is perceived as a threat to livestock, and conservation measures would therefore not receive the popular support that the tahr, gazelle, and oryx programs have enjoyed. Smaller animals have also received little attention, but this is a worldwide problem that will be rectified only with increased scientific knowledge of the smaller animals. The Sultanate has begun to incorporate conservation issues into its educational programs, and has made wildlife conservation and research one of its priorities.

4.7 Environment and the Modern Sector

No information is available on the extent of industrial pollution accompanying Omani industrialization efforts. Similarly, there seems to have been no analysis of the impact of mining activities. There have been reports of corrosion in oil pipelines, both by the sand upon which the pipelines must often be laid, and by

saline water used in secondary recovery of oil. However, cases of leakage due to corrosion have not yet been reported. One of the oil storage tanks developed a leak in 1977 but further information is not available (Middle East Economic Digest, Special Report 1978).

Little information is available on potential oil pollution off Oman's coasts. The Sultanate does not currently possess any producing offshore wells, so the major danger is probably tanker traffic. The Persian/Arabian Gulf, the Strait of Hormuz, and the Gulf of Oman get the heaviest tanker traffic in the world, and it is common practice for tankers to deballast directly into the sea. This seawater ballast is contaminated with oil, and it is estimated that tankers en route to Saudi Arabia alone dump 400,000 tons of oil per year in this manner. The problem for Oman has been compounded by the Iraq-Iran war: tankers deballast just outside the Strait of Hormuz so that the run up the Gulf will be quicker and less costly in insurance charges. Oman has reported that the beaches along the Batinah are now contaminated with tar (Bryant 1981).

4.8 Economic Development[27]

For all practical purposes, Oman first began its development efforts in 1970. In late 1974 a Sultanic decree created the Development Council. In early 1975 the council issued a resolution defining the objectives of economic development in Oman, which are summarized as follows (Sultanate of Oman n.d.):

(a) to develop new sources of income to supplement and eventually to replace oil revenues;

(b) to increase the proportion of capital investment expended on income-generating projects, particularly in the sectors of manufacturing, mining, agriculture and fisheries;

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[27] Cordes and Scholz. 1980.
Middle East Economic Digest. 2 May, 1980.
----- 10 October, 1980a.
----- 10 October, 1980b.
----- 31 October, 1980.
----- 21 November, 1980.
----- 15-21 May, 1981.
Sultanate of Oman. n.d.
Sultanate of Oman. 1980a.
U.S. AID. 1980b.
World Bank. 1979.

(c) to effect a wider geographical distribution of investment in order that the benefits may be shared by different regions of the country, and to narrow the gap in the standards of living in different regions with special emphasis on the least developed regions;

(d) to maintain and develop the existing areas of population and to protect them against the dangers of mass immigration to these already densely populated areas and to protect the environment;

(e) to pay more attention to the development of water resources, which are of vital importance to economic progress;

(f) to develop the local human resources in order that they may be able to play a more active role in the national economy;

(g) to continue the development of basic infrastructure;

(h) to encourage trading activities by removing the obstacles which hinder their progress; these obstacles include problems of transportation, storage and limitations on competition with a view to encouraging competitive practices and keeping prices at reasonable levels;

(i) to work to achieve the basic requirements of a free economy in which the private sector plays a leading role on the basis of free competition in a market clear of monopolistic practices. To this end the introduction of incentives including reasonable tax exemptions, loans with easy repayment terms to finance productive projects, and government participation in the capital of important projects are suggested.

(j) to improve the efficiency of the government administration.

Table 31 shows a breakdown by sector of the budget for the first five-year plan, which ran from 1976 to 1980. Budget allocations were not based on identified projects in many cases, and it was often impossible to utilize allocations. For example, according to Sultanate of Oman 1980a, agricultural expenditure, which was a very small proportion of the planned budget to begin with, had fallen short of intended investments by 43 percent by 1978.

Another problem was that many projects were carried out without prior feasibility studies. Costs then turned out to be unnecessarily high if the project was successfully concluded at all. The government itself has pointed out these difficulties and has called for more care in the planning and implementation of the second five-year plan (Sultanate of Oman 1980a). Budget allocations to the ministries for the 1981-1985 plan are presented in Table 32. The planned expenditure

Table 31. Sectoral Distribution of Government Expenditures in the First Five Year Plan (Million OR)

Sector	1976	1977	1978	1979	1980	Total	Percent
Petroleum and Mining	23.3	40.0	51.0	28.0	12.0	154.3	16.5
Agriculture and Fisheries	2.6	5.9	8.5	11.5	12.5	41.0	4.4
Manufacturing	2.6	7.1	5.0	10.0	15.0	39.7	4.2
Trade and Tourism	8.7	3.2	-	-	-	11.9	1.3
Economic Infrastructure	175.2	166.6	88.6	63.8	44.5	538.7	57.7
Social Infrastructure	40.2	29.9	26.7	17.7	17.7	132.2	14.1
Financial Institutions	3.0	2.0	4.0	4.0	4.0	17.0	1.8
TOTALS	255.6	254.7	183.8	135.0	105.7	934.8	100.0

Source: Sultanate of Oman. n.d.

Table 32. Expenditure by Ministry in the Second Five Year Plan

	1981	1982	1983	1984	1985	Total
Diwan of Protocol	8.0	8.0	8.0	8.0	8.0	40.0
Governorate of the Capital	0.6	0.6	0.6	0.6	0.6	3.0
Ministry of Royal Diwan Affairs	0.5	0.5	0.5	0.5	0.5	2.5
Ministry of Foreign Affairs	3.0	3.0	3.0	3.0	3.0	15.0	
Ministry of Health	7.0	7.0	7.0	7.0	7.0	35.0
Ministry of Education	9.0	9.0	9.0	9.0	9.0	45.0
Ministry of Interior	1.4	1.4	1.4	1.4	1.4	7.0
Ministry of Communications	48.0	48.0	48.0	48.0	48.0	240.0
Ministry of Social Affairs & Labour	8.0	8.0	8.0	8.0	8.0	40.0
Ministry of Petroleum & Minerals	7.0	7.0	7.0	7.0	7.0	35.0
Ministry of Awqaf & Islamic Affairs	0.9	0.9	0.9	0.9	0.9	4.5
Ministry of Information & Youth Affairs	3.0	3.0	3.0	3.0	3.0	15.0
Ministry of Commerce & Industry	2.0	2.0	2.0	2.0	2.0	10.0
Ministry of Agriculture & Fisheries	20.0	20.0	20.0	20.0	20.0	100.0
Ministry of Justice	0.6	0.6	0.6	0.6	0.6	3.0
Ministry of National Heritage & Culture	3.0	3.0	3.0	3.0	3.0	15.0
Ministry of Land Affairs & Municipality	6.0	6.0	6.0	6.0	6.0	30.0
Ministry of Post, Telegraphs & Telephones	10.0	10.0	10.0	10.0	10.0	50.0
Ministry of Electricity & Water	29.0	29.0	29.0	29.0	29.0	145.0
Ministry of Public Works	0.5	0.5	0.5	0.5	0.5	2.5
Ministry of State for Dhofar	3.0	3.0	3.0	3.0	3.0	15.0
Office of Deputy Prime Minister for Legal Affairs	0.3	0.3	0.3	0.3	0.3	1.5
Musandam Development Committee	0.5	0.5	0.5	0.5	0.5	2.5
Other government authorities	1.0	1.0	1.0	1.0	1.0	5.0
Total	138.5	193.0	196.5	197.5	197.5	972.0

1 = RO 0.3457

Source: Middle East Economic Digest. 31 October, 1980.

likely to have the most direct impact upon problems discussed in this report is the 100 million OR (10% of the allocations) which go to the Ministry of Agriculture and Fisheries. Forty percent of this budget is for water resources development (U.S. AID 1980b). Water policies at present include government subsidies for pump purchase, and a number of well drilling projects (Appendix VII, Table 2). With groundwater depletion and salinity problems already a major concern, it seems unlikely that more pump and well projects will make matters better. Several of the project descriptions note that aflaj will go dry because of new pumping, and this deficit is to be made up by even more pumping!

Other projects, such as the proposed shallow aquifer recharge, should help to alleviate water problems in some areas if they are successfully implemented. The government has also announced that the Ministry of Petroleum and Minerals will cooperate with the Environmental Council (not identified further) to control pollution from the new refinery to be built at Mina al-Fahal (Middle East Economic Digest 15-21 May, 1981). This kind of uneven attention to environmental concerns suggests that there is no formal process of environmental impact assessment within the Omani government.

LITERATURE CITED

Amine, E. K. 1980. Oman Nutrition Status Survey. Abu Dhabi, UAE: United Nations Children's Fund, Gulf Area Office; mimeographed. ii + 95 pp.

Arnold, E. N. and M. D. Gallagher. 1979. Reptiles and amphibians from the mountains of northern Oman. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 59-80.

Autret, M. and S. Miladi. 1979a. Report on the Food and Nutrition Situation (with particular reference to children) in the Gulf Countries (Bahrain - Qatar - United Arab Emirates - Oman). Rome: FAO (En-42614-79-XB-RNEA). i + 67 pp.

-----. 1979b. Report on the Food and Nutrition Situation (with particular reference to children) in the Sultanate of Oman. Rome: FAO (EN-42618-79-XB-RNEA). i + 31 pp.

Banister, K. E. and Clarke, M. A. 1977. The freshwater fishes of the Arabian Peninsula. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 111-154.

Birks, J. S. 1976a. The Shawāwi population of northern Oman: a pastoral society in transition. Journal of Oman Studies 2:9-16.

-----. 1976b. Some aspects of demography related to development in the Middle East with special reference to the Sultanate of Oman. British Society for Middle Eastern Studies, Bulletin 3(2):79-88.

-----. 1977. The reaction of rural populations to drought: a case study from southeast Arabia. Erdkunde Bd. 31:299-305.

Birks, J. S. and S. E. Letts. 1976. The Awāmr: specialist well and falaj diggers in northern interior Oman. Journal of Oman Studies 2:93-100.

Birks, S. and C. Sinclair. 1979. Aspects of International Labor Migration in the Arab Near East: Implications for U.S. AID Policy. Washington, DC: U.S. AID (Contract No. AID/ne-c-1593). xiv + 182 pp.

Bryant, M. 1981. The fragile Persian Gulf: unchecked development threatens a vital waterway. World Press Review, March 1981, p. 55.

Caponera, D. A. 1978. Water Laws in Moslem Countries. Rome: FAO (FAO Irrigation and Drainage Paper 20/2). Vol. 2, 311 pp.

Cordes, R. and F. Scholz. 1980. Bedouins, Wealth, and Change: a Study of Rural Development in the United Arab Emirates and the Sultanate of Oman. Tokyo: United Nations University. ii + 65 pp.

Current Agricultural Research Information System (CARIS). 1978. Agricultural Research in Developing Countries. Vol. 1: Research Institutions; Vol. 2: Research Workers; Vol. 3: Research Programs. Rome: FAO.

Dostal, W. 1967. Die Beduinen in Südarabien. Eine ethnologische Studie zur Entwicklung der Kamelhirtenkultur in Arabien. Wiener Beiträge zur Kulturgeschichte und Linguistik, Bd. XVI. 199 pp.

Europa Publications. 1980. Oman. In The Middle East and North Africa 1980-81. London: Europa Publications Ltd. pp. 619-629.

Farrag, O. L. 1979. Basic Services/Community Development in Oman: Project Progress Report. Abu Dhabi: United Nations Children's Fund, UNICEF Gulf Office. 56 pp.

Food and Agricultural Organization of the United Nations (FAO). 1975. Food and Agriculture Legislation. Vol. XXIV(2):1; 77.

Gallagher, M. D. 1977. Birds of Jabal Akhdar. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 27-58.

Gallagher, M. and M. W. Woodcock. 1980. The Birds of Oman. London: Quartet Books. 310 pp.

Gischler, C. E. 1979. Water Resources in the Arab Middle East and North Africa. Cambridge: Middle East and North African Press Ltd. 132 pp.

Goettler, G. W., N. Firth, and C. C. Huston. 1976. A preliminary discussion of ancient mining in the Sultanate of Oman. Journal of Oman Studies 2:43-55.

Harrison, D. L. 1975. The Oman Flora and Fauna Survey 1975. Journal of Oman Studies 1:181-186.

-----. 1977. Mammals obtained by the expedition. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 13-26.

Harrison, D. L. and M. D. Gallagher. 1974. A park to save the Arabian tahr. Oryx 12(5):547-549.

-----. 1976. Plan for reserves in Oman. Oryx 13(3):287-288.

Hawley, D. 1977. Oman and its Renaissance. London: Stacey International. 256 pp.

Henderson, D. S. 1974. The Arabian oryx: a desert tragedy. National Parks and Conservation Magazine 48(5):15-21.

International Union for the Conservation of Nature and Natural Resources (IUCN). 1978a. The IUCN Plant Red Data Book. Morges, Switzerland: IUCN. 540 pp.

-----. 1978b. Red Data Book. Vol. 1: Mammalia. Morges, Switzerland: IUCN.

Jessop, E. 1979. My student elective: desert medicine in Oman. British Medical Journal 2(6201):1352-1353.

Juneidi, M. and D.L. Huss. 1978. Rangeland Resources of the Gulf and Arabian Peninsula Countries and their Managerial Problems and Needs. Cairo: FAO Regional Office for the Near East. 38 pp., appendices.

Jungius, H. 1978. Plan to restore Arabian oryx in Oman. Oryx 14(4):329-336.

Larsen, T. B. 1977. The butterflies of Eastern Oman and their zoogeographic composition. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 179-208.

Lorimer, J. G. 1915. Gazetteer of the Persian Gulf, Oman, and Central Arabia, Vol. 2 (parts a & b): Geographical and Statistical. Calcutta: Superintendent Government Printing, India.

Mandaville, J. P. Jr. 1977. Plants. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 229-267.

Middle East Annual Review. 1980. Oman. Saffron Walden, England: World of Information. pp. 279-290.

Middle East Economic Digest. 2 May 1980. Oman looks for private investment from abroad. 24(18):3-4.

Middle East Economic Digest. 10 October 1980a. Interview: Sultan Qabous bin Said. 24(41):19.

-----. 10 October 1980b. Oman: Oil boom to fuel new plan. 24(41):51.

-----. 31 October 1980. Oman. 24(44):30-31.

-----. 21 November 1980. Oman: Qaboos announces five-year plan. 24(47):36.

-----. 15-21 May 1981. Oman. 25(20):36.

Middle East Economic Digest, Special Report. 1978. Oman. 52 pp.

Morton, D. M. 1959. The geology of Oman. Proceedings of the Fifth World Petroleum Congress, New York. Section 1, Paper 14:277-294.

Munton, P. 1979. Arabian tahr in Oman. Oryx 15(2):145-147.

Myrop, R. F. et al. 1977. Area Handbook for the Persian Gulf States. Washington, DC: U.S. Government Printing Office (DA Pam 550-185). xiv + 447 pp.

Oryx. April 1980. Operation Oryx - End of phase one. Oryx 15(3):227.

Pedgley, D. E. 1970. The climate of interior Oman. Meteorological Magazine 99(1171):29-37.

Peterson, J. E. 1978. Oman in the Twentieth Century. London: Croom Helm Ltd. 286 pp.

Petroconsultants Ltd. 1977. Geology and Hydrocarbon Potential of the Middle East: Tectonic Map of the Middle East (1: 5,000,000). Dublin, Ireland: Petroconsultants Ltd.

Petroleum Economist. January 1981. News in brief: Middle East; Oman. 47(1):37.

Popov, G. n.d. The Vegetation of Arabia South of the Tropic of Cancer (excluding the Yemen). Mimeographed MS. 28 pp.

Quarterly Economic Review of Bahrain, Qatar, Oman, the Yemens: Annual Supplement. 1980. Sultanate of Oman. pp. 30-46.

Reid, H. 1978. Health hazards in Oman. Practitioner 220(1317): 353-354 (letter).

Scholz, F. 1976. Entwicklungstendenzen im Beduinentum der kleinen Staaten am persischen/arabischen Golf - Oman als Beispiel. Mitteilungen der Österreichischen Geographischen Gesellschaft Bd. 118(1):70-108.

-----. 1977a. Die beduinischen Stämme im östlichen Inner-Oman und ihr Regional-Mobilitäts-Verhalten. Sociologus 27(2):97-133.

-----. 1977b. Sultanat Oman: Ein Entwicklungsland im Südosten der Arabischen Halbinsel. Die Erde 108(1-2):23-74.

-----. 1978. Ziele und Ergebnisse der wirtschaftlichen und wirtschaftsräumlichen Entwicklung in den "kleinen" arabischen Erdölförderländern - Oman als Beispiel. Die Erde 109(3-4): 493-514.

Scholz and Cordes. 1980. cf. Cordes and Scholz. 1980.

Smythe, K. R. and M. D. Gallagher. 1977. Land and freshwater mollusca. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 219-225.

Speece, M. 1981. Spatial Representations of Socio-Economic Duality in Oman. Presented at the 23rd Annual Conference of the Western Social Science Association. San Diego, California, April 1981.

Stevens, J. H. 1978. Post pluvial changes in the soils of the Arabian Peninsula. In The Environmental History of the Near and Middle East since the Last Ice Age (W. C. Brice, ed.) London: Academic Press. pp. 263-274.

-----. 1970. Rainfall at Buraimi Oasis in July 1969. Meteorological Magazine 99(1171):37-39.

Sultanate of Oman. n.d. The Five Year Development Plan 1976-1980. Musqat: Development Council ix + 130 pp. (late 1975 or early 1976 from data).

-----. 1978. Statistical Year Book 1977. Musqat: Development Council, Technical Secretariat, Directorate General of National Statistics. vi + 120 pp.

-----. 1979. Statistical Year Book 1978. Musqat: Development Council, Technical Secretariat, Directorate General of National Statistics. vi + 134 pp.

Sultanate of Oman. 1980a. Agriculture Study (Vol. I). Musqat: Development Council, Technical Secretariat, Directorate General of Planning and Follow-up. vi + 38 pp. + appendices.

-----. 1980b. Fisheries Development in Oman. Musqat: Development Council, Technical Secretariat, Directorate General of Planning and Follow-up. iv + 17 pp. + appendices.

Thesiger, W. P. 1959. Arabian Sands. London: Longmans. 326 pp.

Thompson, G. B. 1977. Ectoparasites from mammals. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 227-228.

Tosi, M. 1975. Notes on the distribution and exploitation of natural resources in ancient Oman. Journal of Oman Studies 1:187-206.

Tschopp, R. H. 1967. The general geology of Oman. Proceedings of the Seventh World Petroleum Congress, Vol. 2:231-242.

UNEP. 1979. Directory of Institutions and Individuals Active in Environmentally Sound and Appropriate Technologies. Oxford: Pergamon Press. xviii + 152 pp.

UNESCO. 1976. National Science and Technology Policies in the Arab States. Paris: UNESCO. 214 pp.

UNESCO-FAO. 1963. Bioclimatic Map of the Mediterranean Zone (Map and Explanatory Notes). Paris: UNESCO. 58 pp.

-----. 1970. Vegetation map of the Mediterranean Zone (Map and Explanitory Notes). Paris: UNESCO. 90 pp.

-----. 1977. Soil Map of the World; Map and Explanatory Notes, Vol. VII: South Asia. Paris: UNESCO. 117 pp.

U.S. AID 1980a. All Data Currently Available on Oman. Washington, DC: U.S. AID, DS/DIU/ESDS, 10/21/80.

-----. 1980b. Oman Joint Commission Trip Report, A.I.D. TDY Team Visit June 17-July 2, 1980. Washington, DC: U.S. AID. Mimeographed ii + 65pp, app.

U.S. Army Corps of Engineers. 1979. Report on Water Resources Study, Phase II, and Technical Proposal for Construction of Water Recharge Projects for the Government of Oman, Ministry of Agriculture and Fisheries. Washington, DC: U.S. AID. Mimeographed.

U.S. Department of Commerce. 1980. World Population 1979: Recent Demographic Estimates for the Countries and Regions of the World. Washington, DC: Dept. of Commerce. pp. 236-237.

U.S. Department of the Interior. Bureau of Mines. 1976. The Mineral Industry of Other Countries of the Near East (Afghanistan, Bahrain, Jordan, Lebanon, Oman, Qatar, Syria, People's Democratic Republic of Yemen, Yemen Arab Republic). Washington, DC: U.S. Government Printing Office. 22 pp.

-----. 1979. Mineral Industries of the Middle East. Washington, DC: U.S. Government Printing Office. iii + 49 pp.

U.S. Fish and Wildlife Service (USFWS). 1980. Endangered and threatened wildlife and plants. Code of Federal Regulations, Title 50, Part 17, October 1, 1980: 52-83.

University of Arizona, Office of Arid Lands Studies, Arid Lands Information Center. 1980. Draft Environmental Report on Yemen (Yemen Arab Republic). Washington, DC: U.S. Dept. of State, Man and the Biosphere Program. 92 pp.

Vachon, M. 1977. Scorpions. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 209-218.

Vicker, R. 1980. The Sultan and the oryx. International Wildlife 10(3):4-11.

Who's Who in the Arab World. 1978-1979. Beirut: Publitec Editions, 1979. pp. 788-822.

Wilkinson, J. C. 1977. Water and Tribal Settlement in Southeast Arabia: A study of the Aflāj of Oman. Oxford: Clarendon Press. xvi + 275 pp.

-----. 1980. Changes in the structure of village life in Oman. In Social and Economic Development in the Arab Gulf (T. Niblock, ed.). London: Croom Helm. pp. 122-134.

Wiltshire, E. P. 1977a. Lepidoptera: Part I. Families Cossidae, Pyralidae, Geometridae, Sphingidae, Arctiidae, Lymantriidae and Noctuidae. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 155-160.

-----. 1977b. Part II. A list of further Lepidoptera - Heterocera from Oman. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 161-176.

World Bank. 1979. Oman: Current Economic Position and Prospects. Washington, DC: World Bank; Report No. 2528-OM. v + 79 pp.

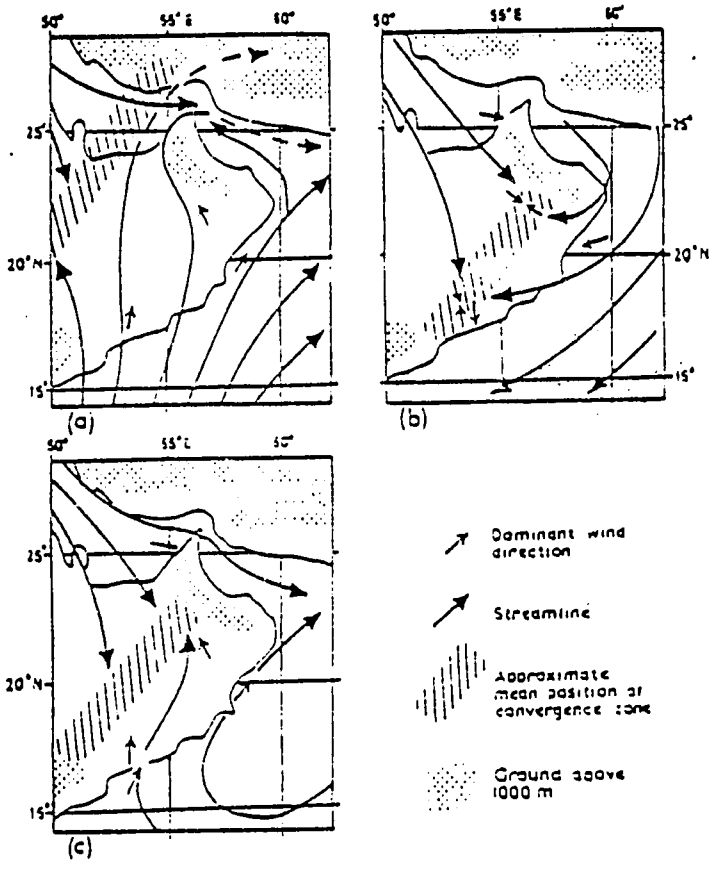
-----. 1980. World Tables from the Data Files of the World Bank. Baltimore: Johns Hopkins University Press. 474 pp.

APPENDIX I

GEOGRAPHY AND CLIMATE

1. Patterns of Wind Flow Over Oman
2. Rainfall at Selected Stations
3. Maximum and Minimum Temperatures
4. Relative Humidity
5. Climatological Data for Nizwa and Fahud
6. Climatological Data for Midway, Dhufar
7. Rainfall at Buraimi
8. Bioclimatic Regions

Patterns of Wind Flow Over Oman



SCHEMATIC PATTERNS OF WIND FLOW AT 1000 HOURS IN THE LOWEST KILOMETRE OF THE ATMOSPHERE OVER OMAN

(a) July *(b)* January *(c)* April

The flow patterns are based on observations at various heights (see Tables I–III), and it is assumed that wind direction does not change with height through the layer. Streamlines are broken where winds from the land flow above a thin surface film of air moving from a different direction.

Source: Pedgley. 1970.

2. Rainfall at Selected Stations

Rainfall in millimeters

Month	Muscat							Rostaq	Nizwa	Al Wafi	Salalah			
	Monthly averages				Monthly actuals			Actuals	Actuals	Actuals	Monthly averages	Monthly actuals		
	1893-1920	1921-50	1951-76	1893-76	1976	1977	1978	1978	1978	1978	1942-72	1975	1976	1977
January	28.3	25.2	33.7	29.0	44.5	54.0	29.5	9.5	28.9	10.5	1.0	—	—	—
February	21.3	14.5	19.1	18.7	59.5	23.7	24.5	11.5	3.3	28.5	1.0	—	1.8	—
March	15.5	5.1	11.7	11.2	53.0	6.8	17.2	19.5	42.5	2.5	6.4	—	—	—
April	10.5	3.7	10.4	8.5	35.3	16.5	1.5	3.8	2.3	22.0	4.6	—	75.2	83.2
May	0.1	0.1	6.7	2.3	—	Tr.	—	—	—	—	13.7	—	—	40.3
June	2.9	Tr.	1.7	1.7	—	8.1	—	—	1.0	—	4.0	—	—	159.0
July	0.4	0.2	4.1	1.6	8.0	Tr.	1.0	8.0	51.1	—	27.0	28.0	27.5	25.1
August	0.9	Tr.	4.6	1.9	—	0.5	—	24.0	10.1	—	26.7	21.0	10.2	23.3
September	—	—	—	—	—	—	—	12.0	Tr.	—	3.4	22.0	2.2	2.8
October	2.3	2.8	Tr.	1.7	—	—	—	—	—	—	7.6	—	—	30.5
November	8.3	7.7	6.8	7.6	—	74.7	Tr.	—	—	5.5	8.7	—	—	—
December	15.0	28.5	17.4	19.5	3.0	Tr.	—	—	—	—	3.8	—	—	3.5
Total	105.5	87.8	116.2	103.7	203.3	181.3	73.7	88.3	139.2	69.0	107.9	71.0	116.9	367.7

Tr = Trace rainfall.

Sources: Sultanate of Oman, 1979.

1. Maximum and Minimum Temperatures

Month	Muscat		Darsait		Rostaq		Nizwa		Al Wafi		Salalah			
	Monthly averages		Monthly averages		Monthly averages		Monthly averages		Monthly averages		Monthly averages			
	1952 - 61		1978		1978		1978		1978		1974 - 76		1977	
	Max°C	Mln°C	Max°C	Min°C	Max°C	Min°C	Max°C	Min°C	Max°C	Min°C	Max°C	Min°C	Max°C	Min°C
January	27.0	16.5	24.6	18.0	25.1	15.5	26.3	5.0	28.0	15.0	26.8	15.7	N.A.	N.A.
February	28.7	16.3	27.5	19.0	26.9	12.2	26.8	10.6	28.3	15.4	29.5	18.1	31.0	17.0
March	32.4	18.6	26.0	20.4	30.7	13.9	31.1	12.3	33.0	17.0	29.4	18.9	33.1	15.0
April	35.6	21.4	34.8	22.8	37.7	19.3	36.7	17.9	39.0	21.7	31.5	23.1	31.3	21.1
May	39.6	25.1	31.7	20.0	41.6	21.5	40.6	20.2	42.3	23.6	31.8	24.5	32.4	22.5
June	40.9	27.1	39.0	22.0	43.3	25.5	42.5	23.8	41.0	24.6	31.4	25.6	33.4	20.2
July	40.9	27.4	39.2	31.7	41.8	26.9	38.2	24.9	40.0	26.0	28.9	24.6	29.1	24.5
August	37.2	26.2	36.8	31.0	40.6	25.3	41.6	24.0	38.0	23.0	28.1	23.5	27.2	22.7
September	36.4	26.1	35.7	28.0	39.4	21.9	38.8	20.3	37.4	22.0	28.5	22.8	28.8	22.5
October	34.9	23.3	36.0	24.0	35.9	17.3	35.6	15.9	37.0	18.5	30.7	20.4	30.8	20.3
November	31.7	20.2	N.A.	N.A.	31.8	16.2	31.0	14.5	33.0	17.0	30.3	17.8	31.6	19.4
December	29.0	17.9	29.8	17.5	26.7	12.8	28.0	11.1	28.3	13.5	28.2	16.7	29.5	17.9

N.A. = Not available.

Sources: Sultanate of Oman. 1979.

4. Relative Humidity

Month	Muscat		Darsait	Rostaq	Nizwa	Al Wafi	Salalah			
	Monthly average		Monthly average at 09.00 hrs	Monthly average at 09.00 hrs	Monthly average at 09.00 hrs	Monthly average	Monthly average	Monthly average at 03.00 hrs and 12.00 hrs		
	1952 - 61		1978	1978	1978	1978	1974 - 76	1977		
	Max %	Min %	Average %	Average %	Average %	Average %	Average %	Max %	Min %	Average %
January	88	46	N.A.	76	71	77	59.0	N.A.	N.A.	N.A.
February	91	46	64	78	67	79.4	59.5	43.0	32.0	37.5
March	90	36	62	65	57	79.6	66.2	66.0	54.0	60.0
April	90	33	53	58	49	79	70.0	70.2	74.0	72.1
May	87	20	78	51	46	74	82.0	82.0	73.0	77.5
June	90	23	84	59	45	53	83.9	88.0	81.0	84.5
July	92	45	62	69	59	74	85.2	98.0	95.0	96.5
August	94	51	68	53	51	80	87.7	92.0	92.0	92.0
September	90	47	85	68	58	88	82.0	84.0	81.0	92.5
October	86	38	56	58	52	79	69.8	71.0	68.0	69.5
November	82	35	N.A.	57	61	78.5	57.5	54.0	50.0	52.0
December	87	44	57.5	N.A.	67	80.5	62.2	64.0	56.0	60.0

N.A = Not available.

Sources: Sultanate of Oman, 1979.

5. Climatological Data for Nizwa and Fahud

TABLE I—CLIMATOLOGICAL DATA FOR FAHUD AND NIZWA

FAHUD. 22°15'N 56°30'E. Altitude about 250 m.
Period : 1963–67, with additional rainfall 1956–57.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.	Year
*Temperature**													
Monthly mean of daily max. (°C)	25	28	34	36	41	45	44	41	40	37	32	26	36
Relative humidity													
Monthly mean of readings at 1000 h (per cent)	55	55	37	34	31	23	36	39	39	33	42	51	40
Rainfall													
Monthly means													
(a) Total (mm)	1	tr	9	9	8	tr	tr*	3	3	0	0	tr	30
(b) Rain days	<1	<1	1	3	1	<1	2	1	0	0	0	<1	10
Surface wind													
Percentage frequency of occurrence of different directions at 1000 h N	5	14	6	15	6	3	2	1	0	2	1	7	5
NE	11	0	2	3	1	1	0	3	7	11	13	0	4
E	11	4	7	5	13	5	8	15	18	9	4	2	9
SE	23	22	26	26	27	29	50	50	42	23	26	15	32
S	6	14	10	13	11	6	6	10	13	13	9	17	11
SW	0	0	0	5	3	2	3	1	2	2	2	0	2
W	6	9	4	5	9	5	2	3	0	6	4	0	4
NW	22	24	21	12	16	27	15	10	0	3	1	7	14
Calm	16	22	24	11	14	15	14	7	16	20	39	51	19
No. of observations	112	91	91	117	120	110	155	144	63	93	84	58	1270

NIZWA. 22°55'N 57°30'E. Altitude about 450 m.
Period : 1963–67.

Rainfall													
Monthly means													
(a) Total (mm)	15	3	5	28	50	1	30	5	5	6	7	2	161
(b) Rain days	1	1	1	2	2	<1	2	1	<1	<1	1	<1	11

* Including observations at nearby drilling sites. Readings corrected to altitude of Fahud using a lapse rate of 10°C/km assuming that the potential temperature does not vary horizontally within the area of the drilling sites. This is probably true since the sites differ in height by 200 m at most, whereas the convective layer probably extends to 3–5 km above the ground.
† But 75 mm fell in July 1967.

Source: Pedgley. 1970.

6. Climatological Data for Midway, Dhofar

TABLE II—CLIMATOLOGICAL DATA FOR MIDWAY, DHOFAR

MIDWAY. 18°02'N 53°55'E. Altitude about 450 m.
Period : 1956–58.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Temperature													
Monthly mean of daily max. (°C)	25	28	32	35	39	41	37	35	38	34	30	27	34
Relative humidity													
Monthly mean of readings at 1000 h (per cent)	53	40	39	38	28	25	53	45	38	35	41	54	41
Surface wind													
Percentage frequency of occurrence of different directions at 1000 h N	14	21	11	8	14	10	0	0	4	11	22	30	12
NE	2	1	3	1	1	0	0	0	0	16	9	2	3
E	7	7	5	5	1	3	0	0	4	19	13	16	7
SE	2	4	1	1	0	0	0	0	1	5	3	0	2
S	28	35	52	45	32	40	55	72	68	30	21	25	45
SW	1	0	0	4	2	2	2	3	0	2	6	3	2
W	7	7	0	3	17	7	8	2	1	6	5	9	6
NW	16	6	1	11	5	3	0	0	1	2	5	1	5
Calm	22	19	27	12	25	30	5	13	21	9	10	14	18
No. of observations	93	83	92	75	91	60	62	93	89	89	90	89	1006

Source: Pedgley. 1970.

7. Rainfall at Buraimi Oasis

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Total
1965	Gauge Not Installed										-	-	
1966	-	37.5	-	-	-	1.0	1.0	-	-	-	-	-	39.5
1967	-	-	6.4	5.9	Tr.	-	2.5	-	-	-	-	-	14.8
1968	5.0	69.8	-	2.5	-	-	-	-	-	-	-	Tr.	77.3
1969	33.5	1.3	-	4.3	-	-	6.4						46.7 (Jan.-July)

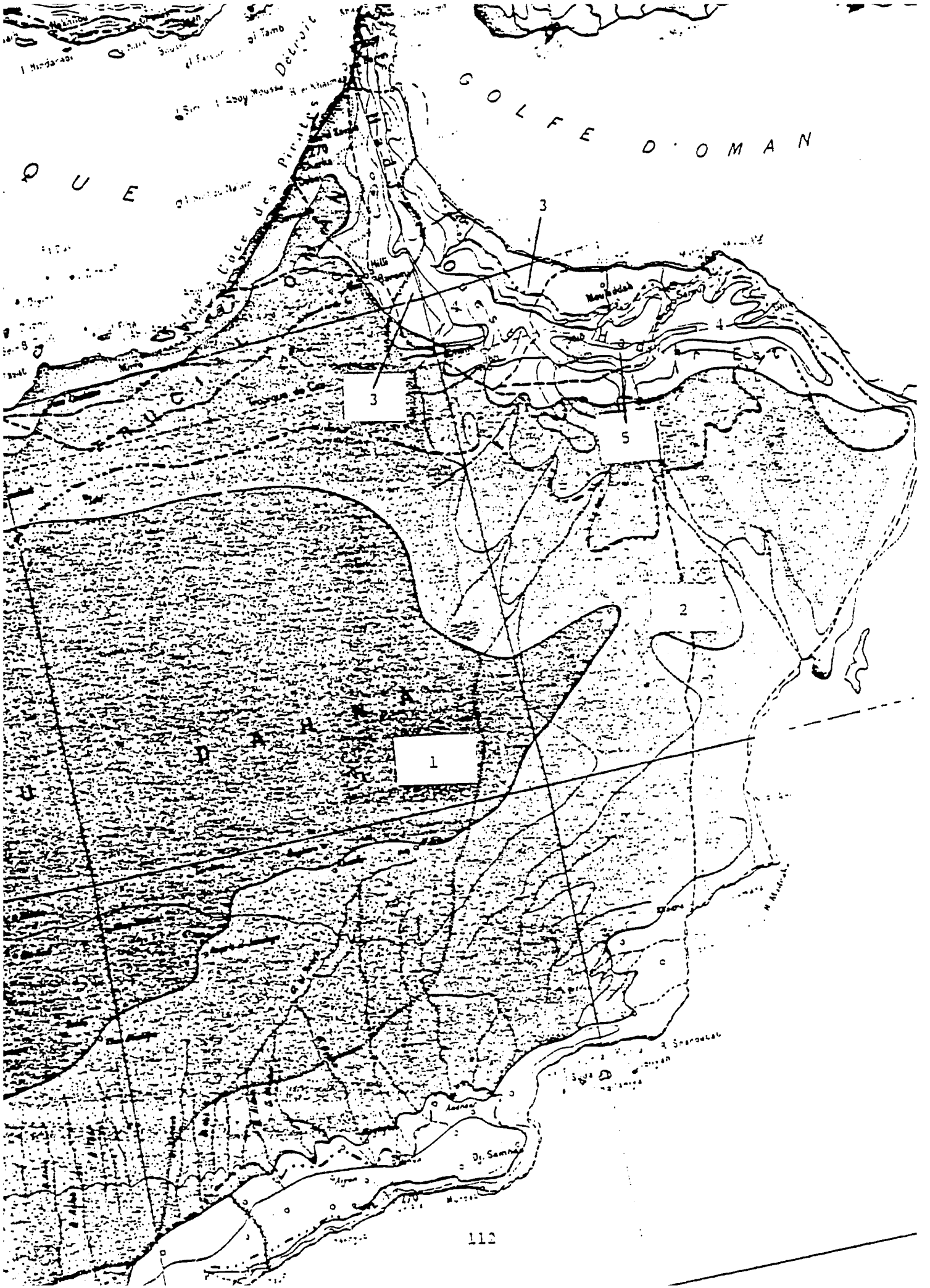
Source: Stevens. 1970.

8. Bioclimatic Regions

			Map Class
Desertic	True Desert	$355 < x < 365$[a]	1
	Desert	$300 < x < 355$	2
Sub Desertic	Dry Season Longer	$250 < x < 300$	3
	Dry Season Shorter	$150 < x < 200$	4
Mediterranean Xerothermomed		$150 < x < 200$	5

[a] x = number of physiological dry days during the dry period.

Source: UNESCO-FAO. 1963.


GOLFE D'OMAN
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APPENDIX II

DEMOGRAPHIC CHARACTERISTICS

1. Population and Growth Rates
2. Population Showing Foreign Residents
3. Rural Population Estimates
4. Miscellaneous Demographic Statistics
5. Population Pyramid for a Sample Area
6. Administrative Districts
7. Geographical Districts in Northern Oman
8. Major Tribes in Northern Oman
9. Medical and Public Health Personnel
10. Medical and Public Health Establishments

1. Population and Growth Rate

Year	Population	Year	Population	Period	Average annual growth rate
PROJECTED ESTIMATES	(1,000)	1969	635	1950-55	1.9
1950	413	1970	654	1955-60	2.1
1955	455	1971	674	1960-65	2.4
1960	505	1972	696	1965-70	2.7
1961	517	1973	719	1970-75	3.2
1962	529	1974	742	1975-79	3.0
1963	543	1975	766		
1964	557	1976	790		
1965	571	1977	814		
1966	586	1978	839		
1967	601	1979	864		
1968	618				

NOTES: 1950-79— Based on U.N. estimates and medium variant projections (U.N., 1979, p. 39).

Source: U.S. Dept. of Commerce. 1980.

2. Population Showing Foreign Residents (in thousands)

Year	Nationals	Foreign Residents	Total
1972	609	20	629
1973	626	32	658
1974	643	56	699
1975	661	91	752
1976	680	120	800
1977	700	130	830
1978	720	140	860

Mission estimates, based on 1978 national population of 720,000 and a 2.9% growth rate since 1972.

Source: World Bank. 1979.

3. Rural Population Estimates

	No. of People
Batina	200,000
Oman Proper	130,000
Dhahirah	120,000
Sharqiya	60,000
Western Hajar	35,000
Eastern Hajar	40,000
Sur and Jaalan	60,000
Jau and Buraimi	7,000
Musandam	15,000
Dhofar	55,000
TOTAL	722,000

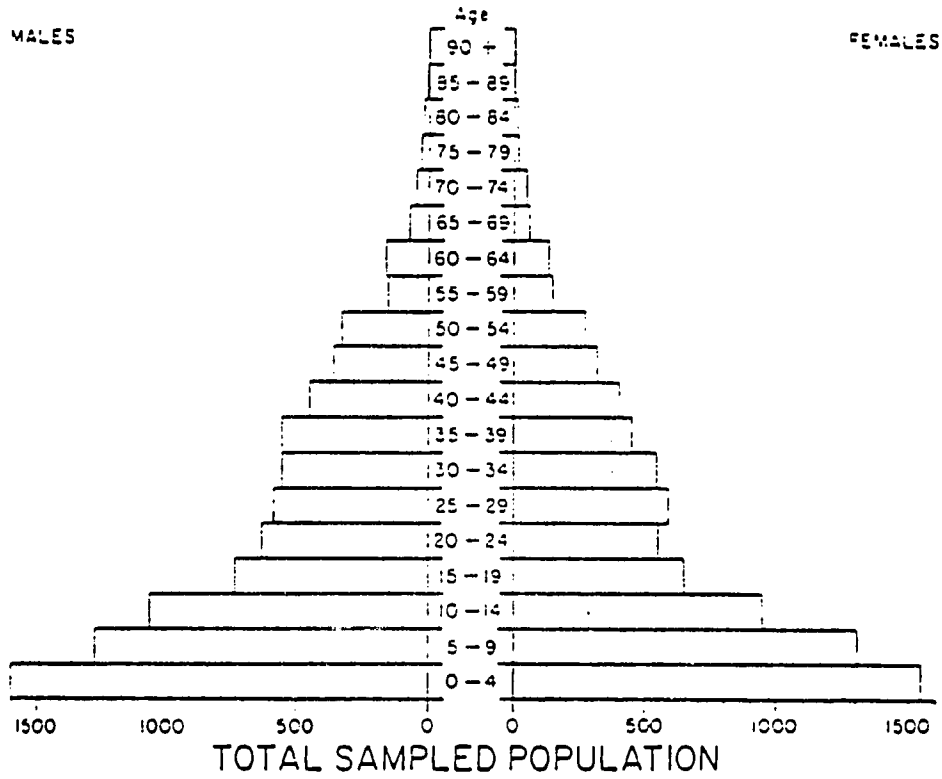
Source: Sultanate of Oman. 1979.

4. Miscellaneous Demographic Statistics			Source
Population Density (per sq. km)	3.0	(1978)	1
Population Density (per sq. km. arable land)	81.0	(1978)	1
Percent of Population Urban	20	(1978)	1
Population Growth Rate	3.1	(1979)	1
Crude Birth Rate (per 1000)	49	(1979)	1
Crude Death Rate (per 1000)	18	(1978)	3
Infant Mortality Rate (per 10000)	142	(1979)	1
Life Expectancy at birth (years)	47.0	(1978)	1
Population Structure		(1978)	1
% < 14 years	45.1		
% < 15-64 years	52.0		
% > 65 years	2.9		
Population per Practicing Physician	3933*	(1977)	1
% Literate	30	(1977)	2
Per Capita GNP (US$)	2510	(1978)	2
Labor Force (1000's)	240		

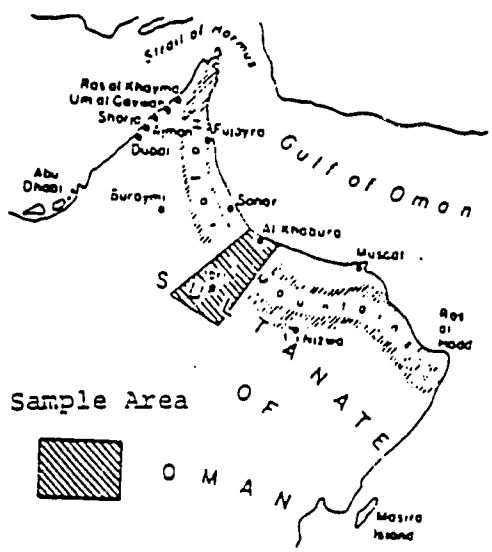
*as high as 4938 (1977) (Source 4)

Sources:
1. U.S. AID. 1980a.
2. U.S. Dept. of Commerce. 1980.
3. World Bank. 1979.
4. World Bank. 1980.

5. Population Pyramid for a Sample Area



Total population in sample area: 17,000



Source: Birks. 1976b.

6. Administrative Districts

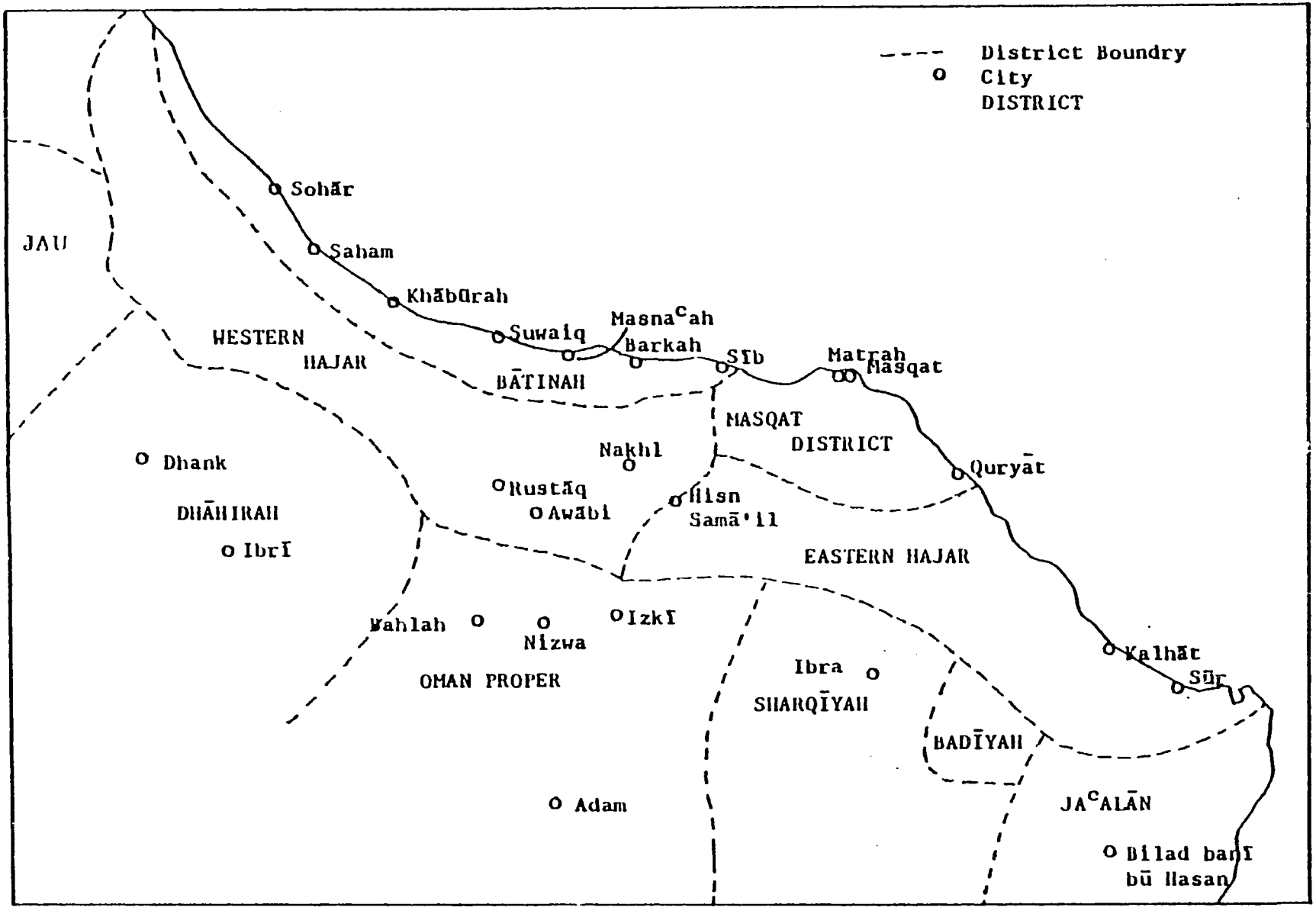
WILAYATS

The Sultanate of Oman is divided into 41 wilayats each governed by a Wali. The capital area (Muscat) is administered by governor of the capital with the assistance of Wali at Sib and a Sub-Wali at Bawshar. The other wilayats are as under:

1.	Khasab	Musandam
2.	Bayah	"
3.	Bukha	"
4.	Barka	Batinah
5.	Masnaa	"
6.	Suwaiq	"
7.	Khabura	"
8.	Saham	"
9.	Sohar	"
10.	Liwa	"
11.	Shinas	"
12.	Nakhl and Wadi Maawil	Western Hajar
13.	Rostaq	"
14.	Awabi	"
15.	Wadi Bani Khalid	Eastern Hajar
16.	Quriyat	"
17.	Wadi Dima	"
18.	Dank	Dhahirah
19.	Ibri	"
20.	Yanqal	"
21.	Hamra	"
22.	Buraimi	Jau and Buraimi
23.	Muhdah	
24.	Bahla	Oman Interior
25.	Nizwa	"
26.	Manah	"
27.	Izki	"
28.	Adam	"
29.	Sumail	"
30.	Bid Bid	"
31.	Mudaibi	Sharqiya
32.	Ibra	"
33.	Qabil	"
34.	Biddiyah	"
35.	Bilad Bani Bu Hasan	Jaalan and Sur
36.	Kamil and Wafi	"
37.	Bilad Bani Bu Ali	"
38.	Sur	"
39.	Masirah	"
40.	Dhofar	Southern

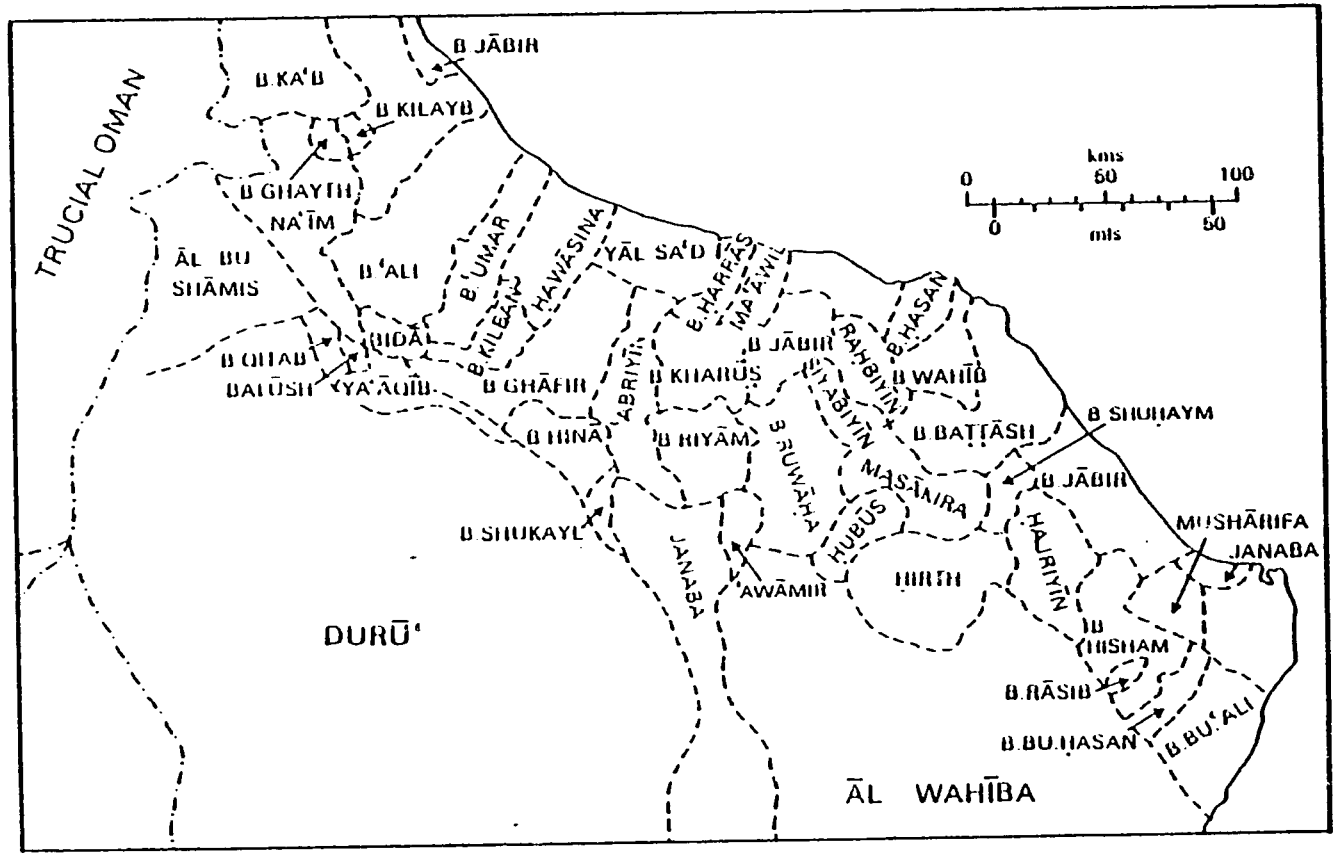
Source: Sultanate of Oman. 1979.

7. Geographical Districts in Northern Oman



Source: Speece, 1981.

8. Major Tribes in Northern Oman



Source: Wilkinson. 1977.

9. Medical and Public Health Personnel

Number at the end of

Category	1970*	1971*	1972*	1973*	1974*	1975	1976	1977	1978
Specialists	—	7	9	12	35	52	59	71	75
Doctors	13	39	52	72	115	95	101	131	133
Dentists	—	—	2	2	8	8	9	9	10
Matrons/Nurses/Assistant Nurses	2	77	115	208	335	411	522	624	659
Midwives	—	—	—	—	7	19	18	21	24
Health Assistants/School Health Visitors/Sanitary Assistants	35	46	68	84	100	88	182	190	175
Laboratory Technicians/Assistants	—	7	13	20	29	56	62	79	62
X-Ray Technicians/Assistants	-	5	7	15	33	59	42	43	45
Dental Technicians/Assistants	—	1	2	3	6	4	5	8	8
General Technicians	—	—	—	—	—	32	38	53	101
Physiotherapists	—	—	—	—	2	2	2	1	1
Pharmacists/Assistants Pharmacists	1	4	11	15	49	65	68	73	70
Medical Orderlies/Dressers	38	137	224	323	493	501	572	673	731

Figures for the year relate to number of sanctioned posts.

Source: Sultanate of Oman. 1979.

10. Medical and Public Health Establishments

Number at the end of

	1970	1971	1972	1973	1974	1975	1976	1977	1978
Hospitals	—	5	10	12	13	13	13	13	13
Health Centres	9	10	7*	5*	11	11	11	12	12
Dispensaries	10	13	27	30	32	40	42	45	47
Public Health Compounds	—	—	—	2	2	4	4	5	5
Public Health Units	—	—	—	—	—	6	9	9	13
Quarantine Units	—	—	—	—	—	6	6	7	7
Public Health Central Centres (Capital area)	—	—	—	—	—	11	12	11	12
Beds	12	218	526	664	334	1000	1252	1409	1409

Location of Government (Civil) medical and public health establishments and beds, regionwise during 1978

Hospitals : Sumail (50), Tanaam (50), Arrahma-Mutrah (118 of which 25 TB and 29 mental), Assaida-Muscat (16), Muscat (24), Nizwa (50), Sohar (50), Al Nahda-Ruwi (173), Salalah (300), Sur (50), Buraimi (50), Khoula-Mina al Fahal (185), Rostaq (50).

Health Centres : Quriyat (6), Masnaa, Ibra (24), Bukha (16), Saham (6), Barka (24), Sinaw (24), Bilad Bani Bu Ali (24), Bilad Bani Bu Hassan (24), Bayan (24), Khasab (24), Masiran (24).

Dispensaries : Sib, Barka, Shinas, Khabura, Ali, Nakhl, Adam, Oank, Kamil, Mudaibi, Ibri, Al Khod, Suwaiq, Fanja, Izki, Hamra, Manah, Ghafat, Birkat al Mawz, Dariz, Mudairib,* Taqa, Marbat, Mudhai, Thamrait (Midway), Abu Baqra, Shelim, Alga, Wafi, Muhdan (4)** Hibi (4),** Mamur, Wadi Bani Ruwaha, Awabi, Hail-Ghaf, Madha (4),** Sadha, Yanqal (4),** Taiwi, Dhalkoot, Jebel Al Akhdhar, Bidiya, Dagmar, Rekhut, Hask, Kuna Muna, Al Ashkharah.

Public Health Compounds : Sumail, Nizwa, Saham, Salalah, Buraimi.

Public Health Units : Sib, Barka, Sohar, Mudhairib Masirah Sur Dhank, Al Hamra, Quriyat, Khasab, Bilad Bani Bu Ali, Bilad Bani Bu Hassan, Al Ashkharah.

Quarantine Units: Mina-Qaboos, Mina-Raysut, Mina-Al Fahal, Sib Airport, Salalah Airport, Khatmat Al-Malahan, Wadi Hitti.

* Three health centres were upgraded to hospitals during 1972 and two more during 1973.

**Maternity centres.

NOTES: 1. Figures in brackets show the number of beds.

2. Civil hospitals outside capital area also undertake public health work where there are no separate public health facilities.

Source: Sultanate of Oman. 1979.

APPENDIX III

ECONOMIC CHARACTERISTICS

1. World Bank Economic Data Sheet
2. Structure of GDP by Sector
3. Projected GDP by Sector, 1978-1985
4. Agricultural Production
5. Composition of Imports and Principal Trading Partners
6. Employment Estimates
7. Government Employment
8. Private Sector Employment

1. World Bank Economic Data Sheet

OMAN

Economic Data Sheet 1 - Population, National Accounts, and Prices

GNP Per Capita - 1977 (US$) 2510

	1950	1955	1960	1965	1966	1967	1968	1969	1970	1971
Population (Total, midyear, thousands)	413.0	453.0	505.0	571.0	587.0	603.0	619.0	638.0	654.0	673.0
									At current factor cost	
GDP by industrial origin	..	..	..	13.7	14.2	14.3	15.1	16.1	16.6	16.6
Agriculture	..	..	..	•	0.4	12.0	50.7	69.4	71.5	73.9
Mining	..	..	..	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Manufacturing	..	..	..	5.2	5.7	8.3	7.3	7.7	10.6	20.4
Construction	..	..	..	•	•	•	•	•	0.1	0.3
Electricity, gas, and water	..	..	..	0.3	0.3	0.4	0.6	0.6	0.7	2.1
Transport and communications	..	..	..	0.8	0.8	1.1	1.5	2.2	2.2	3.5
Trade and finance	..	..	..	0.5	0.6	0.6	1.3	1.9	2.3	4.1
Public administration and defense	..	..	..	2.0	2.1	2.0	2.1	2.1	2.5	3.8
Other branches	..	..	..	22.8	24.2	38.8	78.7	100.0	106.8	125.1
GDP at factor cost[b]	..	..	0.6	0.7	0.7	0.8	1.0	1.2	1.1	1.1
Net indirect taxes	..	..	15.8	22.8	24.2	38.8	78.7	100.0	106.8	125.1
GDP at market prices	..	..								
									At constant factor cost	
GDP by industrial origin (constant 1978 prices)	..	..	..	..	..	..	..	..	..	..
Agriculture	..	..	..	..	..	..	..	..	..	..
Mining	..	..	..	..	..	..	..	..	..	..
Manufacturing	..	..	..	..	..	..	..	..	..	..
Construction	..	..	..	..	..	..	..	..	..	..
Electricity, gas, and water	..	..	..	..	..	..	..	..	..	..
Transport and communications	..	..	..	..	..	..	..	..	..	..
Trade and finance	..	..	..	..	..	..	..	..	..	..
Public administration and defense	..	..	..	..	..	..	..	..	..	..
Other branches	..	..	..	..	..	..	..	..	..	..
GDP at factor cost[b]	..	..	..	..	..	..	..	..	..	..
Net indirect taxes	..	..	105.3	134.5	141.5	233.2	427.8	537.6	556.3	561.0
GDP at market prices	..	..								
									At current market prices	
Resources and expenditures			15.8	22.8	24.2	38.2	59.5	78.7	51.8	101.1
GNP	..	..	..	..	..	-3.6	-19.2	-23.3	-25.0	-24.0
Factor payments to abroad (net)	..	..	15.8	22.8	24.2	38.8	78.7	100.0	106.8	125.1
GDP	..	..	..	..	..	5.7	11.8	11.9	21.0	40.2
Imports of goods and N.F.S.[c]	..	..	..	..	..	13.1	55.2	74.8	78.7	52.3
Exports of goods and N.F.S.[c]	..	..	..	..	..	24.4	55.1	37.3	49.1	93.0
Total resources	..	..	..	..	..	20.6	21.4	22.9	20.7	21.4
Private consumption	..	..	..	..	..	1.7	3.3	5.1	13.7	28.0
General government consumption	..	..	..	..	..	12.1	9.9	9.3	14.7	35.8
Gross domestic investment	..	..	..	..	..					
									At constant market prices	
Resources and expenditures (constant 1978 prices)			105.3	134.5	141.5	213.4	323.5	412.3	428.1	453.4
GNP	..	..	•	•	•	-21.3	-104.3	-125.3	-130.2	-107.8
Factor payments to abroad (net)	..	..	105.3	134.5	141.5	235.2	427.3	537.6	558.3	561.0
GDP	..	..	..	..	..	..	..	..	..	..
Imports of goods and N.F.S.	..	..	..	..	..	..	..	..	..	..
Exports of goods and N.F.S.	..	..	..	..	..	98.6	77.3	60.8	97.4	132.4
Total resources	..	..	..	..	..	55.3	49.7	51.7	43.2	42.6
Private consumption	..	..	..	..	..	4.4	3.7	11.3	29.3	51.7
General government consumption	..	..	..	..	..	26.9	19.4	17.8	25.9	58.1
Gross domestic investment	..	..	..	..	..					
									At current market prices	
Investment financing						12.1	9.9	9.3	14.7	35.8
Gross domestic investment	..	..	..	..	..					
Gross national savings (excluding net current transfers from abroad)	..	..	..	..	..	12.9	34.3	48.7	47.4	53.7
Net balance of goods and services	..	..	..	..	..	0.3	24.4	39.4	32.7	18.1
Gross national savings (including net current transfers from abroad)	..	..	..	..	..	..	..	..	..	..
Domestic price indexes (1970=100)										
Consumer price (or retail price) index[d]	..	..	..	..	..	..	..	..	..	..
Wholesale price index	..	..	..	..	..	..	..	..	..	..
Implicit GDP deflator	..	..	75.1	87.5	89.1	85.9	95.8	96.9	100.0	116.1
									Rials Omani per US dollar	
Foreign exchange rate	0.357	0.357	0.357	0.357	0.357	0.382	0.417	0.417	0.417	0.415

a. 1961-70. b. GDP at market prices. c. 1972-77. d. 1967-70. e. 1972-77 goods only. f. 1972=100. g. 1975-77.

1 (con't.) World Bank Economic Data Sheet

1972	1973	1974	1975	1976	1977	1950-60	1960-70	1970-77	
						Average annual growth rate (percent)			
697.0	719.0	742.0	766.0	790.0	814.0	2.0	2.6	3.2	(Total, midyear, thousands)
(millions of rials Omani)						As percentage of GDP			
17.9	17.6	18.4	19.1	21.9	24.1	..	31.2[a]	4.2	Agriculture
78.4	94.5	407.7	486.8	530.4	534.8	..	45.2[a]	63.2	Mining
0.3	0.6	2.0	2.1	4.0	8.3	..	0.2[a]	0.5	Manufacturing
22.6	24.0	58.2	98.1	96.6	88.4	..	13.5[a]	11.4	Construction
0.7	0.9	1.2	1.8	5.0	6.3	..	0.0	0.5	Electricity, gas, and water
3.2	4.4	12.3	23.5	25.0	28.2	..	0.9[a]	2.8	Transport and communications
4.6	9.2	37.5	60.9	61.5	67.9	..	2.5[a]	6.9	Trade and finance
11.0	13.1	43.6	53.0	71.0	83.4	..	2.0[a]	7.8	Public administration and defense
5.0	6.0	10.7	17.7	25.2	32.1	..	4.4[a]	2.9	Other branches
141.7	170.3	591.6	753.0	840.6	873.5	..	100.0	100.0	GDP at factor cost[b]
1.8	1.7	2.3	0.5	4.5	4.8	..	1.7	0.5	Net indirect taxes
141.7	170.3	591.6	753.0	840.6	873.5	..	100.0	100.0	GDP at market prices
(millions of rials Omani)						Average annual growth rate (percent)			
..	22.0	21.6	21.6	21.9	21.7	..	..	-0.1[c]	Agriculture
..	423.8	419.9	494.2	530.4	492.4	..	..	5.5[c]	Mining
..	0.8	2.2	2.1	4.0	7.8	..	..	66.5[c]	Manufacturing
..	38.4	51.6	82.6	96.6	94.0	..	..	27.3[c]	Construction
..	1.0	2.2	3.3	5.0	7.9	..	..	64.1[c]	Electricity, gas, and water
..	8.1	13.7	23.1	25.0	25.6	..	..	41.5[c]	Transport and communications
..	12.7	41.8	60.2	61.5	61.8	..	..	42.5[c]	Trade and finance
..	14.1	46.9	57.0	71.0	83.4	..	..	48.7[c]	Public administration and defense
..	9.4	12.9	17.7	25.2	29.2	..	..	34.1[c]	Other branches
..	528.3	612.8	761.8	840.6	823.4	..	..	12.8[c]	GDP at factor cost[b]
..	..	..	..	..	..	..	..	..	Net indirect taxes
616.1	528.3	612.8	761.8	840.6	823.4	..	19.5	6.8	GDP at market prices
(millions of rials Omani)						As percentage of GDP			
106.6	112.0	452.8	579.1	681.0	721.3	100.0	75.1[d]	78.2	GNP
-35.1	-58.3	-136.8	-173.9	-179.6	-152.2	..	-21.9[d]	-21.8	Factor payments to abroad (net)
141.7	170.3	591.6	753.0	840.6	873.5	..	100.0[d]	100.0	GDP
57.6	85.3	211.7	348.4	383.8	392.9	..	18.4[d]	42.8	Imports of goods and N.F.S.[e]
83.6	114.9	419.1	489.2	551.2	559.4	..	68.3[d]	66.0	Exports of goods and N.F.S.[e]
118.2	144.3	398.8	630.9	695.9	731.1	..	48.1[d]	79.1	Total resources
36.7	38.1	38.0	85.4	54.8	115.9	..	26.4[d]	11.4	Private consumption
39.5	62.2	186.6	322.5	385.6	388.4	..	7.5[d]	39.5	General government consumption
42.0	44.0	174.2	223.0	255.5	226.8	..	14.2[d]	28.2	Gross domestic investment
(millions of rials Omani)						Average annual growth rate (percent)			
463.5	443.2	450.8	586.1	681.0	684.5	..	15.8	7.3	GNP
-152.6	-85.1	-162.0	-175.7	-179.6	-138.9	..	..	..	Factor payments to abroad (net)
616.1	528.3	612.8	761.8	840.6	823.4	..	19.5	6.8	GDP
..	..	..	..	..	..	..	..	..	Imports of goods and N.F.S.
..	..	..	..	..	..	..	..	..	Exports of goods and N.F.S.
225.6	201.4	459.5	689.8	695.9	691.1	..	..	35.4	Total resources
74.1	50.3	36.9	78.5	54.8	109.2	..	..	9.5	Private consumption
84.2	83.0	191.6	354.7	385.6	368.1	..	..	48.3	General government consumption
67.3	68.1	231.0	256.8	255.5	215.8	..	..	38.7	Gross domestic investment
(millions of rials Omani)						As percentage of GDI			
42.0	44.0	174.2	223.0	255.5	226.8	..	100.0	100.0	Gross domestic investment
30.4	11.7	228.2	171.2	220.6	217.0	..	311.5	98.5	Gross national savings (excluding net current transfers from abroad)
-11.6	-32.3	54.0	-51.8	-34.9	-9.8	..	211.5	-3.5	Net balance of goods and services
..	..	..	..	..	..	..	..	..	Gross national savings (including net current transfers from abroad)
						Average annual growth rate (percent)			
100.0	153.4	202.7	183.5	201.1	215.2	..	..	13.3[f]	Consumer price (or retail price) index[f]
..	..	..	..	..	..	..	..	..	Wholesale price index
119.8	167.7	502.6	514.6	520.8	532.6	..	2.4	34.6	Implicit GDP deflator
(annual average)									
0.384	0.349	0.345	0.345	0.345	0.345				Foreign exchange rate

Source: World Bank. 1980.

2. Structure of GDP by Sector

Structure of Gross Domestic Product
(% of GDP at Current Market Prices)

	1967	1970	1971	1972	1973	1974	1975	1976	1977*
Agriculture, fisheries, etcetera	36.9	15.5	13.4	12.1	9.9	3.1	2.4	2.4	2.5
Oil & mining	30.9	67.0	59.0	54.3	55.8	68.4	64.1	62.6	60.8
Construction	21.4	9.9	16.3	16.1	14.2	10.2	12.1	11.7	12.0
Public administration	1.5	2.2	3.2	7.8	7.7	8.2	7.5	9.4	8.7
Others	9.3	5.3	7.9	9.8	12.5	10.1	13.8	13.9	15.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

*Preliminary estimates

Source: Middle East Economic Digest. 1978.

3. Projected GDP by Sector, 1978-1985

	Est.	Projected		Sectoral Shares (%)			Average Growth Rates (%)
	1978	1981	1985	1978	1981	1985	1979-85
Agriculture	21.1	28.7	51.3	2.6	2.8	4.5	13.5
Oil	458.9	512.4	433.1	57.4	50.8	38.3	-0.8
Mining	-	-	12.0	-	-	1.0	.
Manufacturing	8.8	13.4	36.0	1.1	1.3	3.2	22.2
Utilities	10.8	16.4	28.7	1.4	1.6	2.5	15.0
Construction	83.5	141.8	172.8	10.4	14.1	15.3	11.0
Services	105.9	157.0	242.0	13.4	15.6	21.4	12.5
Government Services	110.1	139.0	156.0	13.7	13.8	13.8	5.1
G.D.P.	799.1	1,008.8	1,131.9	100.0	100.0	100.0	5.1
(Non-oil G.D.P.)	340.2	496.4	698.8	42.6	49.2	61.7	10.8

Source: World Bank. 1979.

4. Agricultural Production

(In millions of tons and millions of Rials Omani)

Commodity	1975		1976		1977		1978*	
	tons	RO'000	tons	RO'000	tons	RO'000	tons	RO'00
Fresh dates (Ruttab)	5.0	1,250	5.0	1,500	3.0	1,500	5.0	1,500
Preserved dates (Tamur)	45.0	3,600	40.0	3,600	35.0	3,500	42.0	3,780
Fresh limes	0.2	36	0.2	40	0.2	60	0.3	60
Dry limes	2.0	1,400	1.8	1,440	1.6	1,440	1.8	1,440
Bananas	9.0	1,350	9.0	1,800	10.0	2,000	12.0	2,400
Mangoes	1.5	450	1.5	600	1.5	600	1.5	600
Wheat	1.6	360	1.6	400	1.3	390	1.1	275
Onions	6.0	360	6.0	480	6.5	520	6.5	520
Meat	1.4	1,400	1.5	1,800	1.5	2,250	2.55	2,460
Milk, eggs	..	1,300	..	1,500	..	1,800	4.53	1,574
Tomatoes	2.0	700	2.0	800	2.5	1,250	2.8	1,250
Tobacco	0.9	720	0.9	720	1.0	800	1.0	800
Fish	23.0	5,750	26.0	6,500	28.0	7,000	29.0	7,250
Other fruits & vegetables	..	500	..	800	..	1,000	..	1,200
Total		19,176		21,980		24,110		25,105

Source: World Bank. 1979

*1978: Sultanate of Oman. 1980a.

5. Composition of Imports and Principal Trading Partners

RECORDED IMPORTS
(RO '000)

PRINCIPAL COMMODITIES

	1977	1978
Food and live animals	38,116	42,363
Beverages and tobacco	6,322	11,548
Crude materials (inedible) except fuels	6,414	4,833
Mineral fuels and lubricants	21,461	27,542
Animal and vegetable oils and fats	1,973	3,134
Chemicals	11,239	13,618
Basic manufactures	53,732	58,649
Machinery and transport equipment	123,563	125,933
Miscellaneous manufactured articles	39,295	39,601
TOTAL	302,065	327,221

PRINCIPAL TRADING PARTNERS

	1977	1978
Australia	7,612	6,249
Bahrain	7,981	9,043
Belgium	1,635	2,129
France	6,318	9,214
Germany, Fed. Repub.	19,612	20,810
India	14,710	14,534
Iran	1,796	1,643
Italy	6,229	6,637
Japan	41,056	50,749
Kuwait	1,117	732
Netherlands	14,249	8,045
Singapore	6,713	8,121
United Arab Emirates	44,330	51,405
United Kingdom	69,755	67,696
U.S.A.	21,579	20,660
TOTAL (incl. others)	302,064	327,221

EXPORTS

Non-oil exports consist mainly of limes, dates, fish and tobacco: 1972 RO 394,100; 1973 RO 609,049; 1974 RO 430,300; 1975 RO 1,073,231; 1976 RO 1,409,500; 1977 RO 1,527,900; 1978 RO 3,322,900.

Source: Europa Publications. 1980.

6. Employment Estimates (in thousands)

	1977			1978		
	Ghanaians	Expatriates	Total	Ghanaians	Expatriate	Total
Agriculture & Fisheries	85.0	1.0	86.0	80.0	2.0	82.0
Non-Agricultural	52.0	71.0	123.0	61.0	98.0	159.0
Private Sector	28.0	65.0	93.0	33.5	82.5	116.0
Government /1	24.0	6.0	30.0	27.5	15.5	43.0
Total	137.0	72.0	209.9	141.0	100.0 /2	241.0

/1 Includes defense and police.

/2 It is necessary to clarify what might appear to be differences between the work permits data on expatriate employees (114,000 in 1978) in the private sector employment and the mission's estimate of total expatriate employment (100,000). The work permit data shows the total number of expatriates who held employment at some point in time during 1978. They do not take into account those expatriates who left the country during the year or those who joined the labor force for less than 12 months. The mission's estimate of expatriate employment is the equivalent of 100,000 man-years, i.e. 100,000 expatriates employed full time for a full year.

Source: World Bank. 1979.

7. Government Employment

Year	Total	Nationals	Expatriates	Expatriates as Percentage of Total
1966	1,100	1,013	82	7.5
1967	1,200	1,115	85	7.1
1968	1,250	1,158	92	7.4
1969	1,350	1,253	97	7.2
1970	1,750	1,630	120	6.9
1971	3,112	2,857	255	8.2
1972	5,318	4,765	553	10.4
1973	9,073	7,403	1,670	18.4
1974	12,035	9,035	3,000	24.9
1975	15,147	10,967	4,180	27.6
1976	22,311	15,668	6,643	29.8
1977	26,765	17,269	9,496	35.5
1978	29,900	18,548	10,452	36.0

Source: World Bank. 1979.

8. Private Sector Employment

Year	Total	Nationals	Expatriates	Expatriates as Percentage of Total
1972	35,000	20,500	14,000	40.0
1973	47,000	24,000	23,000	48.9
1974	65,000	25,000	40,000	61.5
1975	93,000	28,000	65,000	69.9
1978	116,000	33,500	82,500	71.1

Source: World Bank. 1979.

APPENDIX IV

SOILS AND AGRICULTURE

1. Representative Profiles of Soils Occuring in Oman
2. Cultivated Area by District

Table 1. Representative Profiles of Soils Occuring in Oman

CALCARIC REGOSOL	Re
Desert soil to Regosol intergrade	Kuwait
Ergus, 1969	Profile No. 5, p. 60
Location	Northwest of Mutla, approx. 29°N, 48°E
Altitude	About 90 m
Physiography	Undulating
Drainage	Excessive
Parent material	Sand
Vegetation	Mediterranean semidesert shrubs
Climate	3.2, hot subtropical desert

Profile description

A	0–4 cm	Pale brown (10YR 6.3) to brown (10YR 5/3) moist; loamy sand; weak platy; loose; strongly calcareous; a thin whitish gravel layer on the surface.
Ck1	4–70 cm	Pale brown (10YR 6/3) to brown (10YR 5/3) moist; sand; single grain; loose; more calcareous than the horizon above.
Ck2	70–95 cm	Pale brown to very pale brown (10YR 6.5/3) to yellowish brown (10YR 5/4) moist; sand; single grain; loose; strongly calcareous.
C	95–150 cm	Light grey to very pale brown (10YR 7/2.5) to light grey (10YR 7/2) moist; sand; single grain; loose; moderately calcareous.

CALCARIC REGOSOL

Kuwait

Horizon	Depth cm	pH	Cation exchange me %							CaCO3 %
		H2O / KCl	CEC	TEB	V% BS	Ca	Mg	K	Na	Al	H	
A	0—4	8.2	6.1									10.31
Ck1	4—30	8.4	4.30									12.93
Ck1	30—70	8.1	5.40									11.37
Ck2	70—95	8.3	5.30									11.28
C	95—130	8.3	5.10									0.95
C	130—150	8.4	5.70									0.92

Horizon	Soil ratio	Organic matter				Particle size analysis %					Flow. zone
	E.C.	% C	% N	C/N	% OM	Stones	Sand	Silt	Clay	Texture	
A	0.45					16.42	13.97	9.58	6.45	Loamy sand	
Ck1	0.38					16.81	15.70	7.93	6.37	Loamy sand	
Ck1	1.20					6.72	18.40	3.91	5.99	Loamy sand	
Ck2	0.20					9.45	19.73	4.42	5.35	Sand	
C	0.28					11.31	72.66	2.37	4.97	Sand	
C	0.35					8.09	13.77	0.22	3.81	Sand	

HAPLIC YERMOSOL Yh

Typic Camborthid Pakistan

Ahram, 1968 p. 161 and 170
Location About 12 km northeast of Jhang Saddar, 31° 20'N, 72° 25'E
Altitude About 200 m
Physiography Nearly level flood plain
Drainage Well drained
Parent material Calcareous, mixed alluvium
Vegetation Under irrigated general cropping
Climate B.2, hot subtropical desert

Profile description

Ap 0-15 cm Dark greyish brown (10YR 4/2) moist and light brownish grey (10YR 6/2) dry; loam; massive; slightly sticky, slightly plastic, friable moist, hard dry; few medium, fine and common very fine interstitial pores; moderately calcareous; few medium and fine roots; clear smooth boundary; pH 8.4.

Bw1 15-46 cm Brown to dark brown (10YR 4/3) moist and pale brown (10YR 6/3) dry; silt loam; weak coarse and medium subangular blocky; slightly sticky, slightly plastic, friable moist, slightly hard dry; few medium, common fine and many very fine tubular pores; thin nearly continuous cutans in pores; moderately calcareous; common worm casts; few medium and common fine roots; clear smooth boundary; pH 8.2.

Bw2 46-69 cm Brown to dark brown (10YR 4/3) moist and pale brown (10YR 6/3) dry; few fine faint yellowish brown (10YR 5/6) mottles; silt loam; weak coarse subangular blocky; slightly sticky, slightly plastic, friable moist, slightly hard dry; few fine and many very fine tubular pores; moderately calcareous; few worm casts; few fine and many very fine roots; clear smooth boundary; pH 8.2.

BC 69-80 cm Brown to dark brown (10YR 4/3) moist and pale brown (10YR 6/3) dry, few fine faint yellowish brown (10YR 5/6) mottles; silt loam; very weak coarse subangular blocky with few laminations of very fine sandy loam; slightly sticky, slightly plastic, friable moist, slightly hard dry; few fine and many very fine tubular pores; moderately calcareous; few coarse sand pockets; few worm casts; few fine and many very fine roots; clear wavy boundary; pH 8.2.

C 80-94 cm Brown to dark brown (7.5YR 4/2) moist; few fine distinct yellowish brown (10YR 5/6) and few fine faint dark yellowish brown (10YR 4/4) mottles; silt loam (approaching silty clay loam); massive; sticky, plastic, firm moist, hard dry; few fine and many very fine tubular pores; few very fine kankers; few laminations moderately calcareous; few worm casts; few fine roots; clear wavy boundary; pH 8.2.

2C 94-137 cm Brown (10YR 5/3) moist; few medium distinct yellowish brown (10YR 5/6) and few fine faint olive brown (2.5Y 4/4) mottles; very fine sandy loam; massive and weak thin platy; slightly sticky, slightly plastic, very friable moist, slightly hard dry; common fine and very fine tubular pores; few sand specks; few very fine kankers; moderately calcareous; few fine roots; abrupt smooth boundary; pH 8.2.

3C 137-140 cm Brown to dark brown (7.5YR 4/2) moist; few medium faint dark yellowish brown (10YR 4/4) and few fine distinct yellowish brown (10YR 5/8) mottles; silty clay; massive; sticky, plastic, firm moist, very hard dry; few fine and common very fine tubular pores; few sand specks; few fine kankers; moderately calcareous; pH 8.4.

HAPLIC YERMOSOL
Pakistan

Horizon	Depth cm	pH		Cation exchange me %								CaCO3 %
		H2O paste	KCl	CEC	TEB	% BS	Ca	Mg	K	Na	Al	H	
Ap	0—15	8.1											
Bw1	15—46	8.4											
Bw2	46—69	8.2											
BC	69—80	7.9											
C	80—94	7.9											
2C	94—137	7.9											

Horizon	Soil water	Organic matter				Particle size analysis %				Flocc. index
	E.C.	% C	% N	C:N	% OM	Sand	Silt U.S.	Clay	Texture	
Ap	1.1					47	35	18	Loam	
Bw1	0.66					7	67	26	Silt loam	
Bw2	1.3					2	71	27	Silt loam silty clay loam	
BC	1.8					4	69	27	Silt loam silty clay loam	
C	2.2					3	66	31	Silty clay loam	
2C	2.4					9	62	29	Silty clay loam	

CALCIC YERMOSOL	Yk
Typic Calciorthid	Iraq
Van de Weg, 1967	p. 28-29 and analytical data tables
Location	One km north of Darband Sofla, approx. 34°N, 45°E
Altitude	About 600 m
Physiography	Nearly level to very gently sloping piedmont plain
Drainage	Well drained
Parent material	Mixed, calcareous alluvium
Vegetation	Originally Mesopotamian steppe; now under wheat, dryland farming.
Climate	S.S. subtropical semiarid Mediterranean

Profile description

Ap	0-15 cm	Yellowish brown (10YR 5/4 dry, 4/2 moist) clay loam; cloddy, breaking into granular structure; hard; some pores and roots; smooth gradual boundary.
Bwk1	15-35 cm	Brown (7.5YR 5/4) clay loam; fine weak angular blocky structure; hard; a few lime mycelia and spots; a few roots; smooth gradual boundary.
Bwk2	35-70 cm	Brown (7.5YR 4/4) silty clay; moderate coarse angular blocky structure; many lime mycelia and lime points; a few roots; compact horizon; smooth gradual boundary.
BCk	70-140 cm	Brown (7.5YR 4/4) silty clay; strong coarse angular blocky structure; many mycelia and lime points; compact horizon; some thin clay cutans.

Note: Colours given are for moist soils. All horizons are calcareous.

CALCIC YERMOSOL

Iraq

Horizon	Depth cm	pH		Cation exchange me %								CaCO₃ %
		H_2O paste	KCl	CEC	TEB	% BS	Ca	Mg	K	Na	Al	N
Ap	0—15	7.5		50.0						0.45		16.65
Bwk1	15—35	7.6		46.0						0.53		17.70
Bwk2	35—70	7.6		48.0						0.51		23.33
BCk	70—140	7.7		46.0						0.61		29.78

Horizon	Sol. salts	Organic matter				Particle size analysis %					Floc. index	CaSO₄
	E.C.	% C	% N	C/N	% O.M.	Stones	Sand	Silt U.S.	Clay	Texture		
Ap	48	1.21					31.0	38.6	30.4	Clay loam		10.39
Bwk1	48	0.12					39.6	36.0	24.4	Loam		11.73
Bwk2	49	0.31					31.0	36.4	32.6	Clay loam		11.76
BCk	50	0.30					37.0	38.4	24.1	Loam		11.75

Horizon	Soluble cations and anions									
	Ca	Mg	Na	K	Sum cations	CO_3	HCO_3	Cl	SO_4	Sum anions
Ap	6.6	1.9	1.05	—	9.05	0	3.0	2.0	4.6	9.6
Bwk1	5.0	0.5	1.1	—	6.6	0	2.0	2.0	3.0	7.0
Bwk2	4.5	0.5	1.1	—	6.1	0	2.0	2.5	1.5	6.0
BCk	2.0	3.0	1.4	—	6.4	0	1.0	4.0	1.6	6.6

CALCIC YERMOSOL Yk

Saline gypsiferous desert soil Kuwait

Ergun, 1969 Profile 35, p. 57

Location Northwest of Sadda, approx. 29°N, 48°E

Altitude About 90 m

Physiography Rolling to undulating

Drainage Imperfect to poor

Parent material Gypsiferous and calcareous sandy clay loam

Vegetation Mediterranean semidesert shrub

Climate BW, hot subtropical desert

Profile description

Ah	0-11 cm	Pale brown (10YR 6/3) to brown (10YR 5/3) moist; sandy loam to sandy clay loam; massive; friable; strongly calcareous.
Bwck	11-34 cm	Light yellowish brown to brownish yellow (10YR 6/5) to yellowish brown (10YR 5/5) moist; weak fine granular; sandy clay loam; $CaCO_3$ concentration; strongly calcareous.
BCck	34-70 cm	Light brownish grey to light yellowish brown (2.5Y 6/3) to light olive brown (2.5Y 5/4) moist; sandy clay loam; more $CaCO_3$ accumulation than horizon above.
Ccky	70-100 cm	Light grey (2.5Y 7/2) moist; sandy clay loam; gypsum and $CaCO_3$ particles; moderately calcareous.

CALCIC YERMOSOL

Kuwait

Horizon	Depth cm	pH		Cation exchange me %								$CaCO_3$ %
		H_2O	KCl	CEC	TEB	% BS	Ca	Mg	K	Na	Al	H
Ah	0—11											
Bwck	11—34											
BCck	34—70											
Cckγ	70—100											

Horizon	Sol. salts	Organic matter				Particle size analysis %				Fiber. index
		% C	% N	C/N	% OM	Sand	Silt	Clay	Texture	
Ah						68.0	12	20	Sandy loam, sandy clay loam	
Bwck						69.0	12	19	Sandy loam	
BCck						56.0	20	24	Sandy clay loam	
Cckγ						57.0	9	34	Sandy clay loam	

GYPSIC YERMOSOL Yy

Typic Gypsiorthid Iraq

F.H. Altaie. 1963 p. 119 and 120

Location About 50 km north of Baghdad

Altitude About 250 m

Physiography Nearly level, high Tigris terrace

Parent material Gravelly gypsiferous old alluvium

Vegetation Extensive grazing: *Artemisia scoparia, Plantago ovata, Stipa capensis, Achillea santolina L.* and others

Climate Mean annual temperature 23°C, mean annual rainfall 150 mm

Profile description

Ah	0–6 cm	Dark brown (7.5YR 4/4) moist; loam; weak medium platy structure; very friable moist; calcareous; little gravel; low organic matter, very many fine roots; clear smooth boundary.
Cy1	6–20 cm	Brown (7.5YR 5/3) moist; mixed gypsiferous materials; granular; friable moist; calcareous; low organic matter; no roots; gradual smooth boundary.
Cy2	20–50 cm	Dark brown (7.5YR 4/3) moist; mixed gypsiferous materials; friable moist; granular; calcareous; no roots; diffuse smooth boundary.
Cy3	50–80 cm	Brown (7.5YR 5/3) moist; mixed gypsiferous materials; friable moist; granular; slightly calcareous; little gravel; diffuse smooth boundary.
Cy4	80–110 cm	Brown (7.5YR 5/3) needle-like mixed gypsiferous materials; very low in lime; about 10% gravel; diffuse smooth boundary.
Cy5	110–170 cm	Brown (7.5YR 5/3) moist; needle-like mixed gypsiferous materials; very low in lime; about 20% gravel; diffuse smooth boundary.
Cy6	170–500 cm	Brown, mixed gypsiferous soils; about 70% gravel; thin bands of sand.

GYPSIC YERMOSOL

Iraq

Horizon	Depth cm	pH H2O	pH KCl	CEC Silt	CEC Clay	% BS	Ca	Mg	K	Na	Al	Gypsum	$CaCO_3$ %
Ah	0—6	7.6		13.0	62				0.6	0.1		1.1	23.2
Cy1	6—20	7.7		6.8	36				0.2	0.1		50.9	5.3
Cy2	20—50	7.7		6.2	41				0.2	0.3		48.2	2.9
Cy3	50—80	7.7		5.8	29				0.1	0.3		56.7	1.2
Cy4	80—110	7.6		7.6	20				0.1	0.4		55.1	1.5
Cy5	110—170	7.8		8.2	36				0.2	0.8		44.8	5.2

Horizon	Soil water	Organic matter % C	Organic matter % N	Organic matter C/N	Organic matter % OM	Stones	Sand	Silt	Clay	E.C.	P ppm
Ah					0.34		30	49	21	2.9	4.4
Cy1					0.43		32	49	19	3.1	1.9
Cy2					0.25		39	46	15	4.9	1.9
Cy3					0.11		48	32	20	3.5	3.9
Cy4							44	31	25	3.5	3.9
Cy5							46	31	23	3.8	2

Horizon	Soluble cations and anions me/l Ca^{++}	Mg^{++}	Na^{+}	Cl^{-}	SO_4^{--}	HCO_3^{-}	Fe_2O_3 %
Ah	32.0	1.2	1.3	1.8	29.2	1.3	
Cy1	34.0	1.2	1.5	1.8	31.8	1.0	0.35
Cy2	32.8	1.6	4.4	6.4	31.8	0.8	0.04
Cy3	31.6	2.0	4.1	6.4	31.0	0.8	0.35
Cy4	32.0	2.0	4.8	6.4	32.2	0.4	
Cy5	31.6	1.6	7.1	9.0	32.0	1.3	0.35

Source: UNESCO - FAO. 1977.

Table 2. Cultivated Area by District 1971

Location	Area (hectares)
Batinah:	
Shinas	1358
Liwa	1219
Sohar	2624
Saham	1672
Khaburah	2320
Suwaiq	2009
Masna^{c}ah	1300
Barkah	1252
Sib	695
Matrah-Musaqt	107
Total	(14556)
Interior:	
Jau & Buraimi:	
Nuwai, Sharm, Khabd, Mahdah	
Buraimi, Saarah, Etc.	403
Bu Baqarah, Qabil, Harmuzi	
and Al-Raihani	164
Total	(567)
Dhahira:	
Dhank	1767
Ibri	1795
Al-Hubi	74
Hamra	884
Rahlah	1576
Total	(6096)
Eastern Region:	
Quryat	1102
Tiwi	155
Wadi Bani Khalid	396
	(1653)

Cultivated Areas by District , cont.

Location	Area (hectares)
Oman Proper:	
Nizwa	1675
Izki	912
Manah	1500
Birkat al Mawz	155
Adam	234
Sama'il	942
Bid bid, Fanja, Wadi Hajari	484
	(5902)
Sharqiya & Jaalan:	
Al-Mintrib	678
Ibra & Wadi Hagar	625
Mudaibi	732
Samad	759
Ja'alan & Sur	400
	(3194)
Western Hajar:	
Rustaq	1844
Nahkl	955
Awabi	393
Wadi Jizi, Wadi Al-Hilti, Wadi Rajmi, Wadi Zabin, Wadi Suq, Sharm, Etc.	650
	(3842)
Musandam	400
Dhofar (mostly coastal plain)	700
TOTAL OMAN	36910

Source: Sultanate of Oman. 1980.

APPENDIX V

FLORA

1. Systematic List of Plant Species Collected by the Flora and Fauna Survey of Oman 1975
2. IUCN Endangered and Rare Plants in Oman
3. Desirability of Selected Range Plants
4. Plant Uses in Northern Oman

Table 1. Systematic List of Plant Species Collected by the Flora and Fauna Survey of Oman 1975.

Species listed with an asterisk (*) were collected only below 450 m. A double asterisk (**) indicates a species collected only in or around cultivated or otherwise disturbed areas. Area of collection focused on Jabal Akhdar and Jabal Aswad, but included the coast near Mina al-Fahal, foothills areas around Nizwa, Izki, and Rustaq, and Wadi Sama'il.

Spermatophytes

RANUNCULACEAE
- *Clematis orientalis* L. ?
- *Ranunculus muricatus* L.**

MENISPERMACEAE
- *Cocculus pendulus* (J. R. & G. Forst.) Diels

BERBERIDACEAE
- *Berberis* sp.

PAPAVERACEAE
- *Fumaria parviflora* Lam.**

CRUCIFERAE
- *Carrichtera brassicoides* (L.) DC. **
- *Diplotaxis harra* (Forssk.) Boiss.
- *Diplotaxis harra* var. *virgiflora* (DC.) O. E. Schulz
- *Eruca laticalycina* (Boiss.) Boiss. * **
- *Farsetia aegyptia* Turra
- *Moricandia parviflora* Boiss.
- *Notoceras bicorne* (Ait.) Amo
- *Physorhynchus chamaerapistrum* (Boiss.) Boiss.
- *Sisymbrium erysimoides* Desf.

CAPPARIDACEAE
- *Capparis mucronifolia* Boiss.
- *Capparis spinosa* var. *puberula* Zoh.
- *Cleome arabica* var. *micrantha* Boiss.
- *Cleome scaposa* DC.
- *Cleome* sp.
- *Dipterygium glaucum* Decne. *
- *Maerua crassifolia* Forssk.

RESEDACEAE
- *Ochradenus auchery* Boiss.
- *Ochradenus baccatus* Del.
- *Oligomeris linifolia* (Vahl) J. F. Macbr. *
- *Reseda aucheri* var. *bracteata* (Boiss.) Abd.

CISTACEAE
- *Helianthemum lippii* (L.) Pers.

VIOLACEAE
- *Viola cinerea* Boiss.

POLYGALACEAE
- *Polygala abyssinica* R.Br. ex Fresen.
- *Polygala erioptera* DC.
- *Polygala masicatensis* Boiss.

CARYOPHYLLACEAE
- *Arenaria leptoclados* (Reichb.) Guss.
- *Dianthus* sp.
- *Robbairea delileana* Milne-Redh.
- *Saponaria harbata* Barkoudah
- *Silene apetala* Willd.
- *Silene conoidea* L. **
- *Silene schimperiana* Rohrb.
- *Spergula fallax* (Lowe) E. H. L. Krause
- *Stellaria media* (L.) Vill. **

ILLECEBRACEAE
- *Cometes surattensis* Burm.f.
- *Gymnocarpos decandrum* Forssk.
- *Herniaria hirsuta* L. *
- *Paronychia arabica* (L.) DC.
- *Sclerocephalus arabicus* Boiss. *

PORTULACACEAE
- *Portulaca oleracea* L. **
- *Portulaca quadrifida* L. **

TAMARICACEAE
- *Tamarix arabica* Bunge

MALVACEAE
- *Abutilon fruticosum* Guill. & Perr.
- *Gossypium hirsutum* var. *punctatum* (Schumach.) J. B. Hutch. **
- *Hibiscus micranthus* L.f.
- *Malva parviflora* L.
- *Malvastrum coromandelianum* (L.) Garcke * **
- *Pavonia arabica* Steud. & Hochst. ex Boiss.
- *Sida cordata* (Burm.f.) Boiss.-Waalk * **

STERCULIACEAE
- *Melhania muricata* Balf.f.

Plant Species, cont.

TILIACEAE
Corchorus depressus (L.) Christens. *
Corchorus trilocularis L. **
Grewia erythraea Schweinf.
LINACEAE
Linum corymbulosum Reichb.
MALPIGHIACEAE
Acridocarpus orientalis A. Juss.
ZYGOPHYLLACEAE
Fagonia bruguieri DC.
Fagonia indica Burm.f.
Tribulus pentandrus Forssk.
Zygophyllum simplex L.
GERANIACEAE
Erodium cicutarium L. **
Erodium malacoides (L.) L'Herit.
Geranium mascatense Boiss.
Monsonia heliotropoides (Cav.) Boiss.
Monsonia nivea (Decne.) Decne. ex Webb
Oxalis corniculata L. **
RUTACEAE
Haplophyllum tuberculatum (Forssk.) A. Juss.
Ruta chalepensis var. bracteosa (DC.) Boiss.
BURSERACEAE
Commiphora quadricincta Schweinf.
RHAMNACEAE
Sageretia spiciflora (A. Rich.) Hutch. & Bruce
Ziziphus spina-christi (L.) Willd.
Ziziphus or Paliurus sp.
SAPINDACEAE
Dodonaea viscosa Jacq.
ANACARDIACEAE
Mangifera indica L. **
Rhus aucheri Boiss.
MORINGACEAE
Moringa peregrina (Forssk.) Fiori
LEGUMINOSAE
Acacia eburnea Willd.
Acacia ehrenbergiana Hayne
Acacia tortilis (Forssk.) Hayne ?
Argyrolobium crotalarioides Jaub. & Spach
Argyrolobium roseum Jaub. & Spach
Astragalus eremophilus Boiss.
Astragalus fasciculifolius Boiss.
Astragalus fatmensis Hochst.
Astragalus tribuloides var. minutus Boiss.
Astragalus sp.
Cassia italica (Mill.) Lam.
Cassia sophera L.
Ceratonia sp. nov.
Crotalaria persica (Burm.f.) Merr. *
Crotalaria wissmannii Schwartz
Dalbergia sissoo Roxb.
Ebenus stellata Boiss.
Indigofera arabica Jaub. & Spach
Indigofera argentea Burm.f. *
Indigofera articulata Gouan.
Indigofera coerulea Roxb. var. coerulea
Indigofera hochstetteri Baker *
Indigofera intricata Boiss. *
Indigofera oblongifolia Forssk.
Lotononis platycarpos (Viv.) P.-Sermoli *
Lotus garcinii DC. *
Lotus schimperi Steud. ex Benth. *
Medicago orbicularis (L.) Bart.
Melilotus indicus (L.) All.
Prosopis spicigera L.
Ptycholobium plicatum (Oliv.) Harms
Rhynchosia schimperi (Steud. & Hochst.) Boiss. *
Taverniera glabra Boiss.
Tephrosia haussknechtii Bornm. *
Tephrosia nubica subsp. arabica (Boiss.) Gillett
Tephrosia persica Boiss. *
Tephrosia pentaphylla Roxb.
Tephrosia purpurea (L.) Pers.
Vicia sativa L. **
ROSACEAE
Amygdalus arabica Oliv.
Cotoneaster sp.
MYRTACEAE
Myrtus communis L. **
LYTHRACEAE
Ammania baccifera L.
CUCURBITACEAE
Citrullus lanatus (Thunb.) Mansf.
Cucumis prophetarum L.
Corallocarpus schimperi (Naud.) Hook.f.
FICOIDACEAE
Aizoon canariense L.
Gisekia pharnaceoides L. *
UMBELLIFERAE
Ammi majus L. **
Pycnocycla aucheriana Decne. ex Boiss.
Pycnocycla sp. nov. ?
Scandix pecten-veneris L. **
CAPRIFOLIACEAE
Lonicera aucheri Jaub. & Spach
DIPSACACEAE
Scabiosa olivieri Coult.
RUBIACEAE
Callipeltis cucullaria var. aspera Boiss. & Buhse
Gaillonia aucheri (Guill.) Jaub. & Spach
Gaillonia calycoptera (Decne.) Jaub. & Spach
Gaillonia hymenostephana Jaub. & Spach
Galium ceratopodum Boiss.
Galium setaceum subsp. decaisnei (Boiss.) Ehrendf.
Kohautia retrorsa (Boiss.) Brem.
Gen. nov.
COMPOSITAE
Anthemis odontostephana Boiss.
Blumea bovei (DC.) Vatke
Centaurea sinaica DC. *
Centaurea solstitialis L.
Cichorium intybus L. * **
Conyza stricta Willd.
Crepis foetida subsp. commutata (Spreng.) Babcock
Echinops spinosissimus Turra
Echinops sp.
Eclipta prostrata (L.) L.
Euryops pinifolius A. Rich.
Filago pyramidata L.
Flaveria trinervia (Spreng.) Mohr. **
Helichrysum sp.
Iphiona horrida Boiss.
Iphiona sp.
Lactuca dissecta D. Don.
Lasiopogon muscoides (Desf.) DC.
Launaea capitata (Spreng.) Dandy
Launaea intybacea (Jacq.) Beauverd *
Launaea massauensis (Fres.) Kze. *
Launaea procumbens (Roxb.) Dandy
Launaea spinosa (Forssk.) Schultz Bip.
Osteospermum vaillantii (Decne.) T. Norl.
Phagnalon viridifolium Decne.
Phagnalon sp.
Pulicaria arabica (L.) Cass.
Pulicaria glutinosa (Boiss.) Jaub. & Spach
Pulicaria orientalis Jaub. & Spach * **
Reichardia tingitana (L.) Roth
Senecio flavus (Decne.) Schultz Bip.
Urospermum picroides (L.) Desf.
Vernonia cinerascens Schultz Bip.
Vernonia cinerea (L.) Less. **
Vernonia sp.
Volutaria sp.
Zoegea purpurea Fresn.
CAMPANULACEAE
Campanulaceae sp.
PLUMBAGINACEAE
Dyerophytum indicum (Gibs. ex Wight) Kuntze
PRIMULACEAE
Anagallis arvensis L. subsp. arvensis
Dionysia mira Wendelbo
SAPOTACEAE
Reptonia mascatensis (A.DC.) Radlk. ex Schwartz
OLEACEAE
Olea africana Mill.
APOCYNACEAE
Nerium mascatense DC.
Rhazya stricta Decne. *
SALVADORACEAE
Salvadora persica L.
ASCLEPIADACEAE
Calotropis procera (Willd.) R.Br.
Caralluma sp.
Glossonema edule N.E.Br.
Pentatropis spiralis (Forssk.) Decne. *
Pergularia tomentosa L.
Periploca aphylla Decne.
GENTIANACEAE
Centaurium pulchellum (Sw.) Druce
BORAGINACEAE
Arnebia hispidissima (Lehm.) DC. *

Plant Species, cont.

Echiochilon thesigeri Johnst.
Gastrocotyle hispida (Forssk.) Bunge
Heliotropium calcareum Stocks
Heliotropium kotschyi (Bunge) Gürke *
Heliotropium lasiocarpum Fisch. & Mey. **
Heliotropium ramosissimum Sieb. & Lehm. *
Heliotropium rariflorum Stocks
Lappula spinocarpos (Forssk.) Aschers.
Megastoma pusillum Coss. & Dur.
Paracaryum intermedium (Decne.) Lipsky
Trichodesma africanum (L.) Lehm.
Trichodesma stocksii Boiss.

CONVOLVULACEAE
Convolvulus acanthocladus Boiss.
Convolvulus arvensis L. **
Convolvulus prostratus Forssk.
Convolvulus ulicinus Boiss.
Convolvulus virgatus Boiss.
Convolvulus virgatus var. subaphyllus Boiss.
Ipomoea batatas (L.) Lam. * **
Ipomoea obscura (L.) Ker
Seddera latifolia Steud. & Hochst.

SOLANACEAE
Datura metel L.
Lycium shawii Roem. & Schultes
Solanum incanum L.
Solanum luteum Mill. **
Solanum nigrum L.
Withania somnifera (L.) Dunal

OROBANCHACEAE
Orobanche ramosa L.

SCROPHULARIACEAE
Anticharis arabica Endl.
Bacopa monnieri (L.) Pennel
Celsia sp.
Kickxia hastata (R. Br.) Dandy
Kickxia ramosissima (Wall.) Janchen
Linaria micrantha (Cav.) Hoffm. & Link
Lindenbergia fruticosa Benth.
Misopates orontium (L.) Raf.
Oinama arabica Sp. Moore
Scrophularia arguta Ait.
Schweinfurthia papilionacea (Burm. f.) Boiss.
Verbascum sp. * **

Veronica polita Fries.

BIGNONIACEAE
Tecomella undulata (G. Don.) Seem.

ACANTHACEAE
Barleria candida Nees
Barleria hochstetteri Nees
Blepharis ciliaris (L.) B. L. Burtt
Ecbolium viride (Forssk.) Alston

VERBENACEAE
Avicennia marina (Forssk.) Alston *
Lantana petitiana A. Rich.
Phyla nodiflora (L.) Greene
Verbena officinalis L. **

LABIATAE
Endostemon tenuiflorus (Benth.) Ashby
Lavandula subnuda Benth.
Micromeria biflora (Buch.-Ham.) Benth.
Ocimum hadiense Forssk. **
Physoleucas arabica Jaub. & Spach
Salvia aegyptiaca L.
Salvia macilenta Boiss.
Salvia schimperi Benth.
Teucrium mascatense Boiss.
Teucrium stocksianum var. incana (Aitch. & Hemsl.) Hedge and Lamond

PLANTAGINACEAE
Plantago afra L.
Plantago amplexicaulis Cav.
Plantago ciliata Desf.
Plantago major L. **
Plantago ovata Forssk.

NYCTAGINACEAE
Boerhavia diffusa L.
Boerhavia elegans Choisy
Boerhavia elegans Choisy var. stenophylla Boiss.
Boerhavia repens var. viscosa Choisy

AMARANTHACEAE
Achyranthes aspera L.
Aerva javanica (Burm. f.) Juss. ex Schultes
Amaranthus graecizans subsp. silvestris (Vill.) Brenan
Amaranthus viridis L.
Pupalia lappacea (L.) Juss.

CHENOPODIACEAE
Chenopodium album L. **
Chenopodium murale L. **
Cornulaca amblyacantha Bunge *
Cornulaca sp. *
Salsola bottae Jaub. & Spach
Salsola rubescens Franch. *
Salsola schweinfurthii Solms-Laub. *
Schanginia hortensis (Forssk.) Moq.-Tand. *
Haloxylon salicornicum (Moq.) Bge. ? *

POLYGONACEAE
Calligonum sp. *
Emex spinosa (L.) Campd. **
Pteropyrum scoparium Jaub. & Spach
Rumex vesicarius L.

ARISTOLOCHIACEAE
Aristolochia bracteolata Lam.

THYMELAEACEAE
Daphne mucronata Royle

EUPHORBIACEAE
Andrachne aspera Spreng.
Andrachne telephioides L.
Chrozophora oblongifolia A. Juss.
Euphorbia arabica Steud. & Hochst. ex Boiss.
Euphorbia falcata L.
Euphorbia granulata Forssk.
Euphorbia helioscopia L. **
Euphorbia indica Lam. **
Euphorbia larica Boiss.
Euphorbia peplus L. * **
Euphorbia schimperiana Scheele **
Phyllanthus maderaspatensis L.
Ricinus communis L.

MORACEAE
Ficus palmata Forssk.
Ficus salicifolia Vahl.

URTICACEAE
Forsskaolea tenacissima L.

JUGLANDACEAE
Juglans regia L. **

SALICACEAE
Salix sp.

GNETACEAE
Ephedra intermedia Schrenk & C. A. Mey.

CONIFERAE
Juniperus macropoda Boiss.

ORCHIDACEAE
Epipactis veratrifolia Boiss.

LILIACEAE
Agave sp. **
Aloe barbadensis Mill. **
Asparagus gracilis Royle
Asphodelus fistulosus var. tenuifolius (Cav.) Baker
Dipcadi erythraeum Webb & Berth.
Dipcadi unicolor (Stocks) Baker ?

COMMELINACEAE
Commelina albescens Hassk. **

JUNCACEAE
Juncus sp.

TYPHACEAE
Typha domingensis Pers.

POTAMOGETONACEAE
Potamogeton nodosus Poir.

CYPERACEAE
Cyperus conglomeratus Rottb. *
Cyperus sp.
Fimbristylis cymosa R. Br.
Fimbristylis ferruginea Vahl
Scirpus litoralis Schrad.

GRAMINEAE
Aristida abnormis Chiov.
Aristida adscensionis L.
Aristida mutabilis Trin. & Rupr. *
Aristida procera Hochst. forma
Asthenatherum forsskalii (Vahl) Nevski *
Avena barbata Pott ex Link **
Brachiaria leersioides (Hochst.) Stapf
Brachiaria deflexa (Schumach.) Hubbard & Robyns
Bothriochloa ischaemum (L.) Keng.
Bromus japonicus Thunb.
Bromus sp.
Catapodium tuberculosum Moris
Cenchrus ciliaris L.
Cenchrus pennisetiformis Steud. & Hochst.
Chrysopogon aucheri (Boiss.) Stapf
Coelachyrum brevifolium Nees

Plant Species, cont:

Cymbopogon schoenanthus (L.) Spreng.
Cymbopogon sp.
Cynodon dactylon (L.) Pers.
Dactyloctenium aegyptium (L.) Beauv. **
Dactyloctenium aristatum Link *
Dactyloctenium scindicum Boiss.
Dichanthium annulatum (Forsk.) Stapf
Digitaria nodosa Parl.
Echinochloa colonum (L.) Link *
Enneapogon desvauxii P. Beauv.
Enneapogon persicus Boiss.
Enneapogon schimperianus (Hochst. ex A. Rich.) Renv.
Eragrostis barrelieri Daveau
Eragrostis ciliaris (L.) R. Br.
Eragrostis minor Host.
Eragrostis papposa (Roem. & Schult.) Steud.
Eragrostis sp.
Eremopogon foveolatus (Del.) Stapf
Fingerhuthia africana Lehm.
Heteropogon contortus (L.) Beauv. var. *glabra*
Hyparrhenia hirta (L.) Stapf
Lophochloa phleoides (Vill.) Bor **
Lophochloa pumila (Vill.) Bor
Panicum antidotale Retz. **
Panicum coloratum L.
Pennisetum orientale Rich.
Pennisetum setaceum (Forsk.) Chiov.
Poa sinaica Steud.
Polypogon monspeliensis (L.) Desf. **
Saccharum sp.
Schismus barbatus (L.) Thell. *
Setaria verticillata (L.) Beauv. **
Sporobolus arabicus Chiov.
Sporobolus minutiflorus Link **
Sporobolus spicatus (Vahl) Kunth * **
Stipa sp.
Stipagrostis ciliata (Desf.) de Winter
Stipagrostis hirtigluma (Steud.) de Winter
Tetrapogon villosus Desf.
Trachynia distachya (L.) Link
Tragus berteronianus Schult.
Tragus racemosus (L.) All.
Tricholaena teneriffae (L.f.) Parl.
Tripogon purpurascens Duthie
Triticum sp. **

Pteridophytes

EQUISETACEAE
Equisetum ramosissimum Desf.
POLYPODIACEAE
Actiniopteris radiata (Sw.) Link
Adiantum capillus-veneris L.
Cheilanthes catanensis (Cos.) Fuchs
Cheilanthes persica Decne.
Cheilanthes fragrans (L.f.) Swartz
Pteris vittata L.

Lichens

VERRUCARIACEAE
Dermatocarpon lachneum (Ach.) A.L. Sm.
COLLEMATACEAE
Collema sp.
LECANORACEAE
Candelariella sp.
Squamarina gypsacea (Sm.) Poelt
LECIDEACEAE
Lecidea decipiens (Hedw.) Ach.
Toninia albomarginata Lesd.
Lecideaceae sp.

Source: Mandaville. 1977.

Table 2. IUCN Endangered and Rare Plants in Oman

Ceratonia sp. nov.

STATUS. Endangered. It is known from one population of under 100 trees, occurring within 0.5 km, and scattered individuals, making up a total of approximately a further 100 trees, over about 50 km of very arid, mountainous country. No regeneration has been observed during extensive field work in the area over the last few years; any young plants had clearly died from grazing or possibly from lack of rain. The goats also eat the leaves and pods of the mature trees. The Bedu by tradition do not cut the branches of the plant, but rather beat them to provide leaves for fodder, a practice that is not considered to be detrimental to the survival of the trees.

DISTRIBUTION. Oman; confined to a few localities in the mountains between Muscat and Sur.

HABITAT AND ECOLOGY. On rocky limestone mountain slopes, less often on plateau tops. It only occurs between c. 900 m and 1800 m, being restricted to north-facing sites except at the extreme south of its range where it has been found on slopes facing west. The older trees tend to grow out from under sheltered rocks. Its most characteristic associates are species of *Olea*, *Reptonia* and *Acacia*.

CONSERVATION MEASURES TAKEN. The largest population is in the Wadi Serin Nature Reserve, established in 1976 for the threatened Arabian Tahr (see section 3.6.3). Within the reserve grazing by goats is still allowed. A detailed conservation survey of the region and of its ecology in relation to the Tahr was made during 1976 to 1978.

CONSERVATION MEASURES PROPOSED. Protection of parts of the reserve from grazing by goats and the creation of further reserves in the region. The species should also be brought into cultivation.

BIOLOGY AND POTENTIAL VALUE. Before July 1945, the only member of the genus *Ceratonia* known was the Carob, *C. siliqua* L. In that month a new species, which has not yet received a name, was collected in former British Somaliland. Then, during the Oman Government Flora and Fauna Survey, in April 1975 the Omani species was discovered by Mandaville. This plant may or may not be distinct from the Somali one. It is known that the Bedu find the fruits and seed palatable.

DESCRIPTION. A rather untidilty-branched tree up to 8m. Bark dark grey, rough. Leaves pinnate, with up to 20 narrowly elliptic-oblong leaflets. Inflorescences spicate. Flowers dioecious. Male flowers: calyx small, green, petals 0, anthers reddish tinged. Female flowers: ovaries grey-tomentose, stigmas reddish. Mature fruits dark reddish-purple, flattened, somewhat twisted, bullate.

Dionysia mira Wendelbo

STATUS. Rare, It is confined to high-altitude limestone cliffs, along c. 300 km of mountain range. It tends to occur in low numbers; for example in the principal locality of a *Ceratonia* sp. nov. only 10-20 individuals of *D. mira* were found and, following detailed exploration of the mountain range where it occurs, this may be considered as a typical population. It is not eaten by goats, presumably because most of the plants are inaccessible to them; the only possible threat would be collecting of the plants for horticulture. It is said, however, to be eaten by the Arabian Tahr and is known locally as Shajarat al-Wa'al (Tahr Bush).

DISTRIBUTION. Oman; locally distributed on the north slopes of Jabal Akhdar and J. Aswad, the latter being the small part of the nountain range between Muscat and Sur, which lies south west of the town of Kuryaat. The species may also occur on the north of the Jabal Beni Jabir, due west of the village of Bimmah.

HABITAT AND ECOLOGY. Above 1200 m on steep to vertical and overhanging north faces of limestone rock, often growing in sheltered spots that are moist from dripping water during part of the year. No other species are associated with it.

CONSERVATION MEASURES TAKEN. See *Ceratonia* sp. nov.

CONSERVATION MEASURES PROPOSED. None required, other than discouraging collecting now that it is in cultivation.

BIOLOGY AND POTENTIAL VALUE. With its delicate yellow flowers this species is one of the floristic attractions of the region. Although difficult to grow, all *Dionysia* species are of interest to specialist growers of alpine plants. This species is also of scientific interest and has been described as the most primitive in the genus coming close to the *Floribundae*

section of *Primula*. It is of distributional interest being the only species of *Dionysia* to be found south of the Persian Gulf, the centre of the genus being Afghanistan and Iran. The majority of *Dionysia* species appear to be restricted to very small areas, in several instances to a single mountain or locality.

CULTIVATION. It is being grown at the Royal Botanic Gardens, Kew, U.K., where it appears to flower throughout the year and has been propagated successfully from leaf cuttings. It is proving easier to grow than was expected.

DESCRIPTION. Subshrub with long slender branches. Leaves mainly clustered in the lower portion, oblong-lanceolate to oblanceolate, 2.5-7.5 cm long, crenate to sharply serrate on the margin, covered by white, powdery farina on the lower surface. Inflorescence on erect stems up to 30 cm high, of 3-12 whorls each with 5-7 stalked flowers subtended by lanceolate or linear bracts; calyx narrowly bell-shaped, deeply lobed, c. 11 mm long; corolla yellow, with a slender tube 15-17 mm long and 5 spreading, oval-obovate lobes.

Source: IUCN. 1978a.

Table 3. Desirability of Selected Range Plants

GRASSES, GRASS-LIKE PLANTS, LEGUMES AND HERBS	
Scientific Name	Class
Cymbopogon schoenanthus	D
Cyperus conglomeratus	L
Danthonia forskali	L
Lasiurus hirsutus	D
Panicum turgicum	D
Pennisetum dichotomum	L
Tribulus spp.	D
SHRUBS AND TREES	
Acacia flava	L
Acacia tortilis	L
Artemisia herba-alba	L
Calligonum comosum	L
Calotropis procera	UP
Dodonaea viscosa	U
Dipterygium glaucum	D
Euphorbia ammak	UP
Ficus salicifolia	U
Haloxylon persicum	L
Haloxylon salicornicum	L
Indigofera oblongifolia	D
Lycium persicum	U
Maerua crassifolia	D
Olea africanca	L
Prosopis specigera	D
Rhanterium epapposum	D
Rhiza stricta	UP
Salsola tetrandra	D
Salvadora persica	U
Tamarindus indica	U
Tamarix articulate	U
Ziziphus spina-christi	D
Zygophyllum coccineum	L

Class
D= Desirable
L= Less desirable
U= Undesirable
UP= Undesirable and Poisonous

Source: Juneidi and Huss. 1978.

Table 4. Plant Uses in Northern Oman

PLANT	USE
Aloe barbadense	used medicinally to prepare a cooling eye ointment
Ecbolium viride	twigs are used to make tooth cleaners
Cassia sophera	used medicinally as a tea for stomach ache
Petropyrum scoparium	eaten as a tonic to "strengthen the blood"
Pergularia tomentosa	used in leather making
Andrachne aspera	used medicinally
Monsonia heliotropoides	used as snake bite remedy
Anticharis arabica	used as a soap in washing
Carthamus tinctorius	used in dying and cosmetics
Moringa peregrina	seeds used for oil
Caralluma sp.	pounded to make tea for "liver ailments"
Olea africana	fruits used to make poultices for livestock wounds and sores
Indigofera coerulea	used as a dye
Ephedra intermedia	used in ointment for sores
Calligonum[a]	roots used to make camel sticks (riding sticks)
Tecumella undulata	wood used for implements
Daphne mucronata	used for fiber in bindings
Agave sp.	Leaf fiber used in rope making
Commiphora quadricincta	a medicinal gum similar to frankincense

Source: Mandaville. 1977.

[a]Thesiger. 1959.

APPENDIX VI

FAUNA

1. Mammals Recorded in Oman
2. IUCN Endangered and Rare Mammals in Oman
3. Checklist of the Birds of Oman
4. Habitats of Breeding Birds in Oman
5. Reptiles and Amphibians of Northern Oman
6. Land and Freshwater Molluscs of Northern Oman
7. Mammalian Ectoparasites of Oman

Species marked with an asterisk (*) have been recorded in areas near Oman and are likely to occur in Oman also.

Species	English Name	Range
Insectivora		
Paraechinus aethiopicus dorsalis	Ethiopian Hedgehog	Batinah, Dhufar
P. hypomelas niger	Brandt's Hedgehog	northern mountains
Suncus murinus sacer	House shrew	near Musqat
Chiroptera		
Rousettus aegyptiacus arabicus	Egyptian Fruit Bat	Musqat (also Hadhramaut in PDRY)
Rhinopoma muscatellum	Oman Mouse-tailed Bat	northern Oman mountains and foothills
Taphozous nudiventris zayidi	Zayid's Sheath-tailed Bat	northern Oman
T. perforatus	Tomb Bat	northern Oman
Asellia tridens tridens	Trident Bat	throughout the country
Triaenops persicus macdonaldi	Persian Leaf-nosed Bat	northern Oman
Myotis emarginatus desertorum	Notch-eared Bat	seaward foothills of northern mountains
Eptesicus bottae omanensis	Botta's Serotine	northern mountains
E. nasutas batinensis	Sind Serotine Bat	northern Oman
Pipistrellus bodenheimeri	Bodenheim's Pipistrelle	seaward foothills of northern mountains
P. kuhli ikhwanius	Kuhl's Pipistrelle	northern Oman
* *Otonycteris hemprichi*	Hemprich's Long-Eared Bat	Ras al-Khaimah, UAE
Rhinolophys blasii	Blasius' Horseshoe Bat	northern mountains
Carnivora		
Canis lupus arabs	Wolf	throughout
Vulpes vulpes arabica	Common Red Fox	throughout
* *V. rüppelli sabaea*	Rüppell's Sand Fox	Dubai, UAE; may occur in northern sandy desert
Mellivora capensis pumilio	Honey Badger; Ratel	Dhufar
Ichneumia albicauda albicauda	White-tailed Mongoose	Batinah; seaward foothills
Hyaena hyaena sultana	Striped Hyaena	Batinah; Dhufar
Felis silvestris gordoni	Gordon's Wildcat	northern Batinah and seaward foothills

Mammals Recorded in Oman, cont.

	Species	English Name	Range
	F. margarita	Sand Cat	northern inland foothills; central desert
*	*Caracal caracal schmitzi*	Caracal Lynx	UAE
	Panthera pardus nimr	Leopard	mountains and foothills (northern and Dhufar)
	Hyracoidea		
	Procavia syriaca jayakari	Jayakar's Hyrax	Dhufar
	Artiodactyla		
	Hemitragus jayakari	Arabian Tahr	northern mountains
	Capra ibex nubiana	Nubian Ibex	throughout
*	*C. aegagrus*	Wild Goat	UAE
	Ovis ammon	Asiatic Mouflon; Argali; Red Sheep	northern Oman
	Oryx leucoryx	Arabian Oryx	central desert areas; inland foothills (northern and Dhufar)
	Gazella gazella arabica	Arabian Gazelle	central desert; interior Dhufar
	G. gazella muscatensis	Musqat Gazelle	northern Oman
	G. subgutturosa marica	Rhim	northern interior foothills; central deserts
	Lagomorpha		
	Lepus capensis omanensis	Oman Hare	northern Oman
	Rodentia		
	Jaculus jaculus vocator	Three-toed Jerboa	Batihan; northern interior
*	*Arvicanthis niloticus naso*	Nile Rat	PDRY; possible record from Dhufar
	Rattus rattus rattus	Black Rat; House Rat	northern Oman

Mammals Recorded in Oman, cont.

Species	English Name	Range
Mus musculus gentilulus	House Mouse	northern Oman
Acomys dimidiatus homericus	Spiny Mouse	northern mountains
Gerbillus nanus arabium	Baluchistan Gerbil	Dhufar; central desert
G. nannus setonbrownei	Seton-Browne's Gerbil	Batinah
G. dasyurus gallagheri	Gallagher's Gerbil	Masirah Island; UAE
G. cheesmani arduus	Cheesman's Gerbil	Dhufar; central deserts
Meriones libycus arimalius	Libyan Jird	northern interior
M. crassus crassus	Sundevall's Jird	northern Oman

Source: Harrison. 1977.

Table 2. IUCN Endangered and Rare Mammals in Oman

1. South Arabian Leopard (*Panthera pardus nimr*)

STATUS. Endangered. Confined to mountains and hills in the Arabian peninsula. Its populations have declined as a result of persecution, principally by shepherds on account of stock thefts. It receives no legal protection within its range except in Israel.

DISTRIBUTION. Mountainous and hilly terrain of the southern part of the Arabian peninsula from the Asir highlands in the west, southwards into the mountains of Yemen, eastwards to the Qara mountains of Dhufar, through Oman into the northeastern UAE, but the racial status of Oman leopards in insecure. May also occur in northern Saudi Arabia, where one was killed in the 1960's. Distribution of the leopard within its overall range has diminished in recent decades, particularly in the east.

POPULATION. Numbers not known, except in the Judean hills, where 6-7 are known and one was recently photographed. Populations are certainly low and its survival is remarkable considering the persistence with which it is hunted by shepherds, because of stock thefts, and the organized persecution which it meets in human populated areas.

HABITAT. Mountainous and hilly country; rarely occurs in coastal lowlands. It is hunted or driven from areas of human habitation.

CONSERVATION MEASURES TAKEN. Protected only in Israel and Jordan. Included in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973; trade in these animals between acceding nations is subject to severe restriction, trade for primarily commercial purposes is banned.

CONSERVATION MEASURES PROPOSED. Protection should be enforced as far as possible, and the wild prey species allowed to build up larger populations.

2. Arabian Tahr *(Hemitragus jayakari)*

STATUS AND SUMMARY. Endangered. Found only in the mountains of northern Oman. Seriously depleted by excessive hunting and competition from domestic goats which have invaded its habitat. Now protected by law; an experimental reserve with 10 wardens has been established. A two-year study has led to recommendations for the long-term management of the reserve and conservation measures in the Sultanate as a whole.

DISTRIBUTION. Oman; possibly Abu Dhabi. Formerly ranged throughout the hilly and mountainous sections of Oman at the southeastern corner of the Arabian peninsula. Now recorded from northern Musandam Peninsula to the mountains of Sharqiah near the village of Fins in the southern part of the northern Oman mountain range. Notable small populations occur in the Jebel Akhdar range, and the Hajar ash Sharqi area (Jebel Aswad-Jebel Abyadh) in northern Oman; and possibly still in Jebel Hafit, an isolated outlier of the Hajar al Gharbi, on the borders of Oman and Abu Dhabi.

POPULATION. Less than 2000. The tahr reserve at Jebel Aswad is thought to hold 300-370 and there are constant reports of tahr in other areas of the Jebels Akhdar and Hajar ash Sharqi. In 1974, there was believed to be a fair population in the Hajar ash Sharqi. They are reported to be absent from the highest areas of Jebel Akhdar but to exist in an area extending from the main range to Wadi Sahtan (Al Hamya). The extensive mountain area of Oman is difficult of access and reports of tahr, generally by tribesmen, tend to be vague, but many more tahr may survive in the mountains than was thought two years ago. In January 1977, a group of 4 tahr (3 females and 1 immature male) were seen in Jebel Sarti/Jebel Haju . Exploration of Oman for tahr continues and it is hoped to discover more populations, especially in the large unknown mountain region to the north of Jebel Akhdar.

HABITAT AND ECOLOGY. Rocky, rugged, precipitous mountains with tree and shrub cover in steep wadis and other sheltered places. Optimum tahr habitat is considered to be between 1000 and 1800 m on the north facing slopes which have greater rainfall, lower temperatures and more shelter than other areas. This habitat has an especially diverse flora (several species being unique to Oman), and acts as

a buffer to the sporadic drought conditions typical of arid Oman. Tahr are seen singly, in pairs, or in trios of male, female and young. Males (and possibly females also, or male-female pairs) are believed to be territorial. Tahr have a catholic diet but seem to prefer certain specific plant parts such as seeds, fruits and new growth. Evidence suggests that the tahr is largely crepuscular or nocturnal in the hot summer months.

THREATS TO SURVIVAL. Three main constraints on tahr numbers: 1) potential tahr habitat is of naturally limited occurrence; 2) most important, competition from domestic goats which have a similar diet; 3) numbers in goat-free optimum tahr habitat are limited in some areas by shooting which continues in spite of a Sultan's ban. Studies in the Jebel Aswad reserve indicate that the tahr comes under great pressure during drought, either because of lack of suitable food; an increase in the competition from domestic goats and sheep for what food and water there is; or because the limited number of waterholes on which the tahr is dependent make it vulnerable to hunters waiting at the waterholes.

CONSERVATION MEASURES TAKEN. Protected by decree in Oman, 1976. Two preliminary surveys for a proposed national park in the Jebel Akhdar have been made. An experimental tahr reserve with 10 wardens has been established in the Jebel Aswad, south of Muscat, by the Oman Goverment. The Government, jointly with IUCN/WWF, sponsored a two-year project (1976-78) for an expert to study the tahr in the reserve and elsewhere in Oman, and this has led to recommendations for the long-term management of the reserve and for protective measures in the Sultanate as a whole.

CONSERVATION MEASURES PROPOSED. Implementation of the project proposals which recommend that a series of reserves should be established where shooting of tahr is actively prevented, and which are maintained free of domestic stock. The target population of these reserves is recommended to be about 1750 tahr, of which 500 would be females of breeding age. Four areas harbouring 950 tahr are suggested for establishment of reserves as soon as possible; a further reserve of approximatley 100 sq. km of optimum tahr habitat is suggested to complete the target figure.

IUCN Endangered and Rare Mammals in Oman, cont.

3. Arabian Oryx *(Oryx leucoryx)*

STATUS. Endangered. Seriously depleted throughout range by over-hunting. Either close to extinction or actually extinct in the wild; some isolated groups may still occur in parts of Oman. Approximately 80 captive animals are held in six collections.

DISTRIBUTION. Formerly found over most of the Arabian Peninsula wherever suitable habitat existed; from Mesopotamia westward to the Sinai Peninsula and perhaps as far north as the Syrian desert. In recent years only reported from a small part of Oman, in a quadrilateral about 400 km east to west and 160 km north to south, to the east of 52°50', with perhaps some isolated groups outside this section, notably in the Duru and Wahiba country to the east of the Rub al-Khali.

POPULATION. Numbers in the wild estimated at less than 200 in 1969, but none have been reported since 1972, when three were killed and four captured by unidentified hunters in southern Oman. The species' decline became apparent at the end of the last century when it survived in only two parts of the Arabian Peninsula. By the early 1950's, the northern population, which occupied the region known as the Great Nafud, had disappeared and the southern population of the Rub al-Khali had greatly decreased. Hunting has been the principal cause of its decline. Its meat is greatly esteemed, its hide valued as leather and other parts are used for medicinal purposes, and great prestige is attached to its capture. The expansion of the oil industry with new roads, motor vehicles, aeroplanes and modern firearms along with poaching by local people have perhaps now exterminated this oryx.

HABITAT. Gravel-plain deserts interspersed with sand and stones around the fringes of the sand desert where the vegetation on which it feeds is more abundant. It can go a long time without drinking, and cover much distance in its search for grazing. It uses its hooves and horns to scrape out depressions under bushes or alongside dunes for shade and concealment.

CONSERVATION MEASURES TAKEN. Protected by law, but enforcement has been difficult. In 1962 the Fauna Preservation Society, with the aid of grants from WWF and the Shikar Safari Club undertook Operation Oryx, which captured three wild Arabian oryx in the eastern part of the former Aden Protectorate. These animals, with others donated by H.M. King Saud of

of Saudi Arabia, the Ruler of Kuwait, and the Zoological Society of London, formed the nucleus of the World Herd of Arabian Oryx at Phoenix Zoo, Arizona, as a precaution against extinction of wild stocks. Included in Appendix I of the Convention of International Trade in Endangered Species of Wild Fauna and Flora, 1973; trade in these animals between acceding nations is subject to severe restriction, trade for primarily commercial purposes is banned.

CONSERVATION MEASURES PROPOSED. Propagation in captivity for eventual reintroduction to selected areas within its natural range is the aim of the World Herd project, but selection of a safe habitat where it can survive in the wild still poses insuperable problems at present. It is hoped in the not too distant future to establish one or more captive breeding herds in the Middle East as a first step towards such reintroduction.

REMARKS. In 1976, at least 162 captive animals were held in at least a dozen zoos and private collections of which 45 were in the World Herd at Phoenix, Arizona, 18 at Los Angeles Zoo, California, 13 at San Diego Zoo, California (on loan from the World Herd), and 86 in various parts of Arabia, including 41 (possibly over 50) in four or more collections in Abu Dhabi, 38 in two collections in Qatar, 5 in Riyadh Zoo, Saudi Arabia, and 2 in Dubai.

4. Arabian Gazelle *(Gazella gazella arabica)*

STATUS. Endangered, because of excessive hunting and habitat degradation.

DISTRIBUTION. Formerly occupied an extensive area of the Arabian Peninsula, but its range has been greatly reduced. It is now found in the Sinai and the western mountains and foothills of Saudi Arabia, southern Arabia and Yeman, and on some islands of the Red Sea.

POPULATION. Numbers unknown but severely depleted following indiscriminate hunting, including the use of motorized vehicles. The use of this animal for food is also a factor in its decline.

HABITAT. The common species of the coastal plains throughout the Arabian Peninsula where acacia trees occur. Also found on the highland gravel plains of the interior.

CONSERVATION MEASURES TAKEN. In 1952 was reported as abundant on the plains of Dhofar and rigidly protected by the Sultan of Oman.

CONSERVATION MEASURES PROPOSED. Surveys and research should be conducted to determine population, forage preferences, habitat requirements, range conditions and so on as a basis for preparing management plans for this gazelle. Serious consideration should be given to artificial propagation with subsequent translocation to suitable range provided management plans have been prepared.

REMARKS. The subspecies of this gazelle are not sharply defined in the region; even the limited number of named forms are clearly integrated. The extremes, *G.g. gazella* in the north-west and *G.g. muscatensis* in the south-east, are distinguishable only on average from the intervening populations of *G.g. arabica*.

5. Dugong (*Dugong dugong*)

STATUS. Vulnerable. Uncontrolled exploitation has seriously depleted dugong populations throughout most of the species' wide range in the Indo-Pacific region.

DISTRIBUTION. The shallow coastal waters of the Indo-Pacific region from the New Hebrides westwards to Suez, from the Philippine Islands in the north to Madagascar in the south, also the Persian Gulf and Red Sea.

POPULATION. Total population sizes unknown, herds of several hundred reported in the past, now rare over almost its entire range and approaching extinction in some regions. Large populations are still found in northern Australian waters, and the east coast of Africa may be next in importance. Uncontrolled hunting (principally local hunting, although commercial operations have been pursued in the past in India, Sri Lanka and Australia) has been the main cause of the dugong decline. The main products are meat and oil. Netting is a major threat to dugongs, and accidental deaths in nets employed in some tropical fisheries (e.g. Sri Lanka) and in shark nets used to reduce shark numbers near swimming beaches in Queensland have been locally significant . Pollution and sedimentation of the seagrass beds on which dugongs feed is an important threat. A lesser threat may result from disturbance by humans (e.g. use of power boats, seismic exploration). Cyclones and typhoons may cause mortality.

HABITAT. A strictly marine species; inhabits sheltered, shallow tropical and subtropical coastal water. They feed in inter-tidal and sub-tidal areas. Their main foods are sea grasses of the families Potamogetonaceae and Hydrocharitaceae although they will feed on algae if sea grasses are scarce. Recent aerial surveys indicate that dugongs migrate, although they may also occur as local residents. During calm weather they will move from protected into exposed waters.

CONSERVATION MEASURES TAKEN. Totally protected by law in many

of the countries in which it occurs, but with few exceptions, protection is inadequately enforced. Endangered Species of Wild Fauna and Flora, 1973; trade in these animals between acceding nations is subject to severe restriction, trade for primarily commercial purposes is banned. Included in Class A of the African Convention (1969) i.e. it may be hunted or collected only on the authorization of the highest competent authority, if required in the national interest or for scientific purposes. Research programmes on dugongs presently include an established program at James Cook University, Queensland; a program in Kenya supported by UNDP; and a world-wide conservation program, funded by WWF and the United States Government, which has initiated several field surveys and produced a bibliography on recent Sirenia.

CONSERVATION MEASURES PROPOSED. Increased support for biological studies and field surveys of dugong populations. Research on population dynamics, movements, reproduction, and growth are particularly important. An extensive series of marine reserves that would include both resident dugong populations and serve as refuges for migrating ones should be established. With adequate protection, many populations could probably be rebuilt and manage to provide sustained yields of meat and other products.

Source: IUCN. 1978b.

Table 3. Checklist of the birds of Oman

All species at present admitted to the Oman List are listed here, including naturalised escaped species. Alternative English names have been omitted.

The presently known status of each species is indicated thus:

- sb = breeding resident (often with local seasonal movements)
- mb = migrant breeder, breeding visitor
- pm = passage migrant
- sv = summer visitor (not breeding)
- wv = winter visitor (not breeding)
- s) = a few or occasional in summer (not breeding)
- w) = a few or occasional in winter (not breeding)
- v = vagrant, scarce visitor
- ? = query, or status uncertain.

The sequence and scientific nomenclature generally follow K. H. Voous, *List of Recent Holarctic Bird Species*, London: Academic Press for British Ornithologists' Union, 1977

NON-PASSERIFORMES

Podicipedidae

Tachybaptus ruficollis	Little Grebe	sb pm wv
Podiceps cristatus	Great Crested Grebe	wv
Podiceps nigricollis	Black-necked Grebe	pm wv

Procellariidae

Bulweria fallax	Jouanin's Petrel	sb?
Puffinus carneipes	Pale-footed Shearwater	sv
Puffinus pacificus	Wedge-tailed Shearwater	sv?
Puffinus lherminieri persicus	Persian Shearwater	sb?

Hydrobatidae

Oceanites oceanicus	Wilson's Storm-petrel	sv
Pelagodroma marina	White-faced Storm-petrel	sv
Fregetta tropica	Black-bellied Storm-petrel	sv

Phaethontidae

Phaethon lepturus	White-tailed Tropicbird	sb
Phaethon aethereus	Red-billed Tropicbird	sb

Sulidae

Sula dactylatra	Masked Booby	sb
Sula leucogaster	Brown Booby	v

Phalacrocoracidae

Phalacrocorax carbo	Great Cormorant	wv
Phalacrocorax nigrogularis	Socotra Cormorant	sb sv

Pelecanidae

Pelecanus onocrotalus	White Pelican	v

Ardeidae

Botaurus stellaris	Bittern	pm wv
Ixobrychus minutus	Little Bittern	pm (w) sb?
Nycticorax nycticorax	Night Heron	pm wv
Butorides striatus	Little Green Heron	sb pm
Ardeola ralloides	Squacco Heron	pm wv
Ardeola grayii	Indian Pond Heron	pm wv
Bubulcus ibis	Cattle Egret	v or sv wv
Egretta gularis	Western Reef Heron	sb pm wv
Egretta garzetta	Little Egret	pm wv (s)
Egretta alba	Great White Egret	wv (s)
Ardea cinerea	Grey Heron	pm wv (s)
Ardea purpurea	Purple Heron	pm wv
Ardea goliath	Goliath Heron	v or wv
Ardea melanocephala	Black-headed Heron	v

Ciconiidae

Ciconia abdimii	Abdim's Stork	v
Ciconia ciconia	White Stork	pm (w)

Threskiornithidae

Plegadis falcinellus	Glossy Ibis	pm wv (s)
Threskiornis aethiopicus	Sacred Ibis	v
Platalea leucorodia	Spoonbill	pm wv (s)

Phoenicopteridae

Phoenicopterus ruber	Greater Flamingo	pm wv (s)

Anatidae

Cygnus columbianus bewickii	Bewick's Swan	v
Anser albifrons	White-fronted Goose	v
Anser anser	Greylag Goose	v
Tadorna ferruginea	Ruddy Shelduck	pm wv

Checklist of the birds of Oman, cont.

Tadorna tadorna	Shelduck	PM WV
Nettapus coromandelianus	Cotton Teal	WV (S)
Anas penelope	Wigeon	PM WV
Anas strepera	Gadwall	PM WV
Anas crecca	Teal	PM WV
Anas platyrhynchos	Mallard	PM WV
Anas acuta	Pintail	PM WV
Anas querquedula	Garganey	PM WV
Anas clypeata	Shoveler	PM WV
Haematomella angustirostris	Marbled Teal	V
Netta rufina	Red crested Pochard	V
Aythya ferina	Pochard	PM WV
Aythya nyroca	Ferruginous Duck	PM WV
Aythya fuligula	Tufted Duck	PM WV

Accipitridae

Pernis apivorus	Honey Buzzard	V OR PM
Milvus migrans	Black Kite	PM WV BR?
Neophron percnopterus	Egyptian Vulture	BR PM WV
Gyps fulvus	Griffon Vulture	PM WV
Torgos tracheliotus	Lappet-faced Vulture	WV BR?
Aegypius monachus	Black Vulture	PM WV BR
Circaetus gallicus	Short-toed Eagle	PM WV BR?
Circus aeruginosus	Marsh Harrier	PM WV
Circus cyaneus	Hen Harrier	PM (W)
Circus macrourus	Pallid Harrier	PM (M)
Circus pygargus	Montagu's Harrier	PM (M)
Accipiter gentilis	Goshawk	V
Accipiter nisus	Sparrowhawk	PM WV
Buteo buteo	Buzzard	PM (W)
Buteo rufinus	Long legged Buzzard	BR PM WV
Aquila pomarina	Lesser Spotted Eagle	V
Aquila clanga	Spotted Eagle	PM WV
Aquila rapax (orientalis)	Steppe Eagle	PM WV (S)
Aquila heliaca	Imperial Eagle	PM WV
Aquila chrysaetos	Golden Eagle	WV
Aquila verreauxii	Verreaux's Eagle	BR
Hieraaetus pennatus	Booted Eagle	PM (M)
Hieraaetus fasciatus	Bonelli's Eagle	BR PM WV

Pandionidae

Pandion haliaetus	Osprey	BR PM WV

Falconidae

Falco naumanni	Lesser Kestrel	PM (W)
Falco tinnunculus	Kestrel	BR PM WV
Falco amurensis	Manchurian Red footed Falcon	PM
Falco subbuteo	Hobby	PM (S)
Falco concolor	Sooty Falcon	BR PM (W)
Falco biarmicus	Lanner	?
Falco cherrug	Saker	PM WV (S)
Falco peregrinus	Peregrine	PM WV BR?
Falco pelegrinoides	Barbary Falcon	BR PM?

Phasianidae

Alectoris chukar	Chukar	BR
Alectoris melanocephala	Arabian Red legged Partridge	BR
Ammoperdix heyi	Sand Partridge	BR
Francolinus pondicerianus	Grey Francolin	BR
Coturnix coturnix	Common Quail	PM (M)

Rallidae

Rallus aquaticus	Water Rail	PM (W)
Porzana porzana	Spotted Crake	PM WV
Porzana parva	Little Crake	PM WV
Porzana pusilla	Baillon's Crake	PM WV
Crex crex	Corncrake	PM
Amaurornis phoenicurus	White breasted Waterhen	V
Gallinula chloropus	Moorhen	BR PM WV
Fulica atra	Coot	PM WV (S)

Gruidae

Grus grus	Common Crane	V
Anthropoides virgo	Demoiselle Crane	V

Otidae

Tetrax tetrax	Little Bustard	V
Chlamydotis undulata	Houbara	BR PM WV

Jacanidae

Hydrophasianus chirurgus	Pheasant-tailed Jacana	WV (S)

Haematopodidae

Haematopus ostralegus	Oystercatcher	PM WV (S)

Recurvirostridae

Himantopus himantopus	Black winged Stilt	PM WV (S)
Recurvirostra avosetta	Avocet	PM WV (S)

Dromadidae

Dromas ardeola	Crab Plover	BR PM WV

Burhinidae

Burhinus oedicnemus	Stone Curlew	PM WV
Burhinus capensis	Spotted Thick knee	BR?

Glareolidae

Cursorius cursor	Cream coloured Courser	PM WV
Glareola pratincola	Pratincole	PM (M)
Glareola nordmanni	Black winged Pratincole	V OR PM
Glareola lactea	Little Pratincole	V OR PM WV

Charadriidae

Charadrius dubius	Little Ringed Plover	BR PM WV
Charadrius hiaticula	Ringed Plover	PM WV (S)
Charadrius alexandrinus	Kentish Plover	BR PM WV(S)
Charadrius mongolus	Lesser Sand Plover	PM WV (S)
Charadrius leschenaultii	Greater Sand Plover	PM WV (S)
Charadrius asiaticus	Caspian Plover	PM
Charadrius morinellus	Dotterel	V
Pluvialis dominica	Lesser Golden Plover	PM WV (S)
Pluvialis apricaria	Golden Plover	V OR PM WV
Pluvialis squatarola	Grey Plover	PM WV (S)
Hoplopterus spinosus	Spur winged Lapwing	V
Hoplopterus indicus	Red wattled Lapwing	BR
Chettusia gregaria	Sociable Lapwing	V
Chettusia leucura	White tailed Lapwing	PM WV
Vanellus vanellus	Lapwing	V OR WV

Scolopacidae

Calidris alba	Sanderling	PM WV (S)
Calidris minuta	Little Stint	PM WV (S)
Calidris temminckii	Temminck's Stint	PM WV
Calidris subminuta	Long toed Stint	PM WV
Calidris ferruginea	Curlew Sandpiper	PM WV (S)
Calidris alpina	Dunlin	PM WV (S)
Limicola falcinellus	Broad billed Sandpiper	PM WV
Philomachus pugnax	Ruff	PM WV (S)
Lymnocryptes minimus	Jack Snipe	PM WV
Gallinago gallinago	Common Snipe	PM WV (S)
Gallinago media	Great Snipe	V OR PM
Gallinago stenura	Pintail Snipe	V OR PM WV
Limosa limosa	Black tailed Godwit	PM WV (S)
Limosa lapponica	Bar tailed Godwit	PM WV
Numenius phaeopus	Whimbrel	PM (W)
Numenius tenuirostris	Slender billed Curlew	V
Numenius arquata	Curlew	PM WV (S)
Tringa erythropus	Spotted Redshank	PM WV
Tringa totanus	Redshank	PM WV (S)
Tringa stagnatilis	Marsh Sandpiper	PM WV (S)
Tringa nebularia	Greenshank	PM WV (S)
Tringa ochropus	Green Sandpiper	PM WV (S)
Tringa glareola	Wood Sandpiper	PM (M)
Actitis ciniereus	Terek Sandpiper	PM WV (S)
Actitis hypoleucos	Common Sandpiper	PM WV (S)
Arenaria interpres	Turnstone	PM WV (S)
Phalaropus lobatus	Red necked Phalarope	PM WV
Phalaropus fulicarius	Grey Phalarope	PM? WV?

Stercorariidae

Stercorarius pomarinus	Pomarine Skua	PM WV
Stercorarius parasiticus	Arctic Skua	PM WV
Stercorarius longicaudus	Long tailed Skua	V
Stercorarius skua	Great Skua	SV (W)

Laridae

Larus hemprichii	Sooty Gull	BR BR PM
Larus leucophthalmus	White eyed Gull	V
Larus ridibundus	Great Black headed Gull	PM WV (S)
Larus ridibundus	Black headed Gull	PM WV (S)
Larus genei	Slender billed Gull	PM WV (S)
Larus canus	Common Gull	V OR WV
Larus fuscus	Lesser Black backed Gull	PM WV (S)
Larus argentatus	Herring Gull	PM WV (S)

Sternidae

Gelochelidon nilotica	Gull billed Tern	PM WV (S)
Sterna caspia	Caspian Tern	PM WV (S)
Sterna bergii	Crested Tern	BR BR PM
Sterna bengalensis	Lesser Crested Tern	PM (S) (W)
Sterna sandvicensis	Sandwich Tern	PM SV WV
Sterna dougallii	Roseate Tern	BR
Sterna hirundo	Common Tern	PM (S) (W)
Sterna repressa	White cheeked Tern	BR PM (W)
Sterna anaethetus	Bridled Tern	BR PM (W)
Sterna fuscata	Sooty Tern	V
Sterna albifrons	Little Tern	PM?
Sterna saundersi	Saunders' Little Tern	BR PM
Chlidonias hybrida	Whiskered Tern	PM (S) (W)
Chlidonias niger	Black Tern	V
Chlidonias leucopterus	White winged Black Tern	PM WV
Anous tenuirostris	Lesser Noddy	SV
Anous stolidus	Common Noddy	BR

Rynchopidae

Rynchops albicollis	Indian Skimmer	V

Pteroclididae

Pterocles lichtensteinii	Lichtenstein's Sandgrouse	BR
Pterocles coronatus	Crowned Sandgrouse	BR
Pterocles senegallus	Spotted Sandgrouse	BR
Pterocles exustus	Chestnut bellied Sandgrouse	BR

Columbidae

Columba livia	Rock Dove	BR
Columba oenas	Stock Dove	V
Columba palumbus	Woodpigeon	BR
Streptopelia decaocto	Collared Dove	BR PM WV
Streptopelia tranquebarica	Red Turtle Dove	V
Streptopelia turtur	Turtle Dove	BR PM
Streptopelia orientalis	Rufous Turtle Dove	PM
Streptopelia senegalensis	Palm Dove	BR PM
Oena capensis	Namaqua Dove	V
Treron waalia	Yellow bellied Green Pigeon	BR?

Psittacidae

Psittacula krameri	Rose ringed Parakeet	BR V

Cuculidae

Clamator jacobinus	Jacobin Cuckoo	V OR PM
Chrysococcyx caprius	Didric Cuckoo	BR
Cuculus canorus	Cuckoo	PM
Cuculus saturatus	Oriental Cuckoo	V
Cuculus solitarius	Red chested Cuckoo	V
Clamator glandarius	Great Spotted Cuckoo	V
Centropus senegalensis	Senegal Coucal	V

Tytonidae

Tyto alba	Barn Owl	BR

Strigidae

Otus scops	Scops Owl	PM
Otus brucei	Pallid Scops Owl	BR
Bubo bubo	Eagle Owl	BR
Bubo africanus	Spotted Eagle Owl	BR
Athene noctua	Little Owl	BR
Asio otus	Long eared Owl	V
Asio flammeus	Short eared Owl	PM

Caprimulgidae

Caprimulgus nubicus	Nubian Nightjar	PM?
Caprimulgus europaeus	Nightjar	PM (M)
Caprimulgus aegyptius	Egyptian Nightjar	PM (M)

Apodidae

Apus apus	Swift	PM (M?)
Apus pallidus	Pallid Swift	BR PM (W)
Apus melba	Alpine Swift	PM
Apus affinis	Little Swift	V

Alcedinidae

Halcyon leucocephala	Grey headed Kingfisher	BR
Halcyon chloris	White collared Kingfisher	BR
Alcedo atthis	Kingfisher	PM WV

Meropidae

Merops orientalis	Little Green Bee eater	BR
Merops superciliosus	Blue cheeked Bee eater	BR PM
Merops apiaster	Bee eater	BR PM

Coraciidae

Coracias garrulus	Roller	PM
Coracias benghalensis	Indian Roller	BR PM WV

Upupidae

Upupa epops	Hoopoe	BR BR? PM (M)

Picidae

Jynx torquilla	Wryneck	PM (M)

PASSERIFORMES

Alaudidae

Mirafra cantillans	Singing Bush Lark	RR (W)
Eremopteryx nigriceps	Black-crowned Finch Lark	RR RR WV
Eremalauda dunni	Dunn's Lark	RR
Ammomanes cinctura	Bar-tailed Desert Lark	RR
Ammomanes deserti	Desert Lark	RR
Alaemon alaudipes	Hoopoe Lark	RR
Melanocorypha bimaculata	Bimaculated Lark	RR WV
Calandrella brachydactyla	Short-toed Lark	RR (W) (S)
Calandrella rufescens	Lesser Short-toed Lark	RR WV
Galerida cristata	Crested Lark	RR
Alauda arvensis	Skylark	RR WV

Hirundinidae

Riparia paludicola	Brown-throated Sand Martin	V
Riparia riparia	Sand Martin	RR (W)
Ptyonoprogne fuligula obsoleta	Pale Crag Martin	RR RR WV
Ptyonoprogne rupestris	Crag Martin	RR
Hirundo rustica	Swallow	RR RR
Hirundo daurica	Red-rumped Swallow	RR
Delichon urbica	House Martin	RR

Motacillidae

Anthus novaeseelandiae	Richard's Pipit	V
Anthus campestris	Tawny Pipit	RR (W)
Anthus similis	Long-billed Pipit	RR
Anthus trivialis	Tree Pipit	RR (W)
Anthus pratensis	Meadow Pipit	RR (W)
Anthus cervinus	Red-throated Pipit	RR (W)
Anthus spinoletta	Water Pipit	RR WV
Motacilla flava	Yellow Wagtail	RR (W)
Motacilla citreola	Citrine Wagtail	RR WV
Motacilla cinerea	Grey Wagtail	RR WV
Motacilla alba	White Wagtail	RR WV

Pycnonotidae

Pycnonotus xanthopygos	Yellow-vented Bulbul	RR

Bombycillidae

Hypocolius ampelinus	Hypocolius	V OR RR

Prunellidae

Prunella modularis	Radde's Accentor	V

Turdidae

Cercotrichas galactotes	Rufous Bush Robin	RR
Luscinia luscinia	Thrush Nightingale	RR
Luscinia megarhynchos	Nightingale	RR
Luscinia svecica	Bluethroat	RR WV
Irania gutturalis	White-throated Robin	RR
Phoenicurus erythronotus	Eversmann's Redstart	V
Phoenicurus ochruros	Black Redstart	RR WV
Phoenicurus phoenicurus	Redstart	RR
Cercomela melanura	Blackstart	RR
Saxicola rubetra	Whinchat	RR
Saxicola torquata	Stonechat	RR (W)
Oenanthe isabellina	Isabelline Wheatear	RR WV
Oenanthe oenanthe	Wheatear	RR
Oenanthe pleschanka	Pied Wheatear	RR
Oenanthe hispanica	Black-eared Wheatear	RR
Oenanthe deserti	Desert Wheatear	RR WV
Oenanthe xanthoprymna	Red-tailed Wheatear	RR WV
Oenanthe lugens	Mourning Wheatear	RR
Oenanthe monacha	Hooded Wheatear	RR WV?
Oenanthe albonigra	Hume's Wheatear	RR
Oenanthe leucopyga	White-crowned Black Wheatear	?
Monticola saxatilis	Rock Thrush	RR (W)
Monticola solitarius	Blue Rock Thrush	RR WV
Turdus torquatus	Ring Ouzel	V
Turdus obscurus	Eye-browed Thrush	V
Turdus ruficollis atrogularis	Black-throated Thrush	WV
Turdus philomelos	Song Thrush	WV

Sylviidae

Cisticola juncidis	Fan-tailed Warbler	?
Prinia gracilis	Graceful Warbler	RR
Scotocerca inquieta	Scrub Warbler	RR
Locustella naevia	Grasshopper Warbler	V OR RR
Locustella fluviatilis	River Warbler	V
Locustella luscinioides	Savi's Warbler	V OR RR
Acrocephalus melanopogon	Moustached Warbler	V OR RR
Acrocephalus schoenobaenus	Sedge Warbler	RR
Acrocephalus agricola	Paddyfield Warbler	V OR RR
Acrocephalus stentoreus	Clamorous Reed Warbler	RR RR WV
Acrocephalus arundinaceus	Great Reed Warbler	RR
Hippolais pallida	Olivaceous Warbler	RR (S)
Hippolais olivetorum	Booted Warbler	RR RR WV
Hippolais languida	Upcher's Warbler	RR
Hippolais rama	Isleme Warbler	RR
Sylvia mystacea	Menetries' Warbler	RR (W)
Sylvia nana	Desert Warbler	RR WV
Sylvia leucomelaena	Hartlaub's Warbler	RR OR RR
Sylvia hortensis	Orphean Warbler	RR WV
Sylvia nisoria	Barred Warbler	RR
Sylvia curruca (incl *margelanica*)	Lesser Whitethroat (incl Desert Lesser Whitethroat)	RR WV
Sylvia communis	Whitethroat	RR
Sylvia borin	Garden Warbler	RR
Sylvia atricapilla	Blackcap	RR
Phylloscopus collybita	Common Warbler	RR
Phylloscopus inornatus	Yellow-browed Warbler	RR WV
Phylloscopus sibilatrix	Wood Warbler	RR
Phylloscopus neglectus	Plain Leaf Warbler	V OR WV
Phylloscopus collybita	Chiffchaff	RR (W)
Phylloscopus trochilus	Willow Warbler	RR

Muscicapidae

Muscicapa striata	Spotted Flycatcher	RR
Ficedula parva	Red-breasted Flycatcher	RR
Ficedula semitorquata	Semi-collared Flycatcher	RR

Monarchidae

Terpsiphone viridis	African Paradise Flycatcher	RR*

Timaliidae

Turdoides squamiceps	Arabian Babbler	RR

Remizidae

Remiz pendulinus	Penduline Tit	V

Nectariniidae

Nectarinia asiatica	Purple Sunbird	RR
Nectarinia habessinica	Abyssinian Sunbird	RR
Nectarinia osea	Palestine Sunbird	RR

Zosteropidae

Zosterops abyssinica	White-breasted White-eye	RR

Oriolidae

Oriolus oriolus	Golden Oriole	RR

Laniidae

Lanius senator	Black-headed Bush Shrike	RR
Lanius isabellinus	Isabelline Shrike	RR (W)
Lanius collurio	Red-backed Shrike	RR
Lanius minor	Lesser Grey Shrike	RR
Lanius excubitor	Great Grey Shrike	RR RR WV
Lanius senator	Woodchat Shrike	RR
Lanius nubicus	Masked Shrike	RR

Corvidae

Corvus splendens	House Crow	RR
Corvus ruficollis	Brown-necked Raven	RR
Corvus rhipidurus	Fan-tailed Raven	RR

Sturnidae

Onychognathus tristrami	Tristram's Grackle	RR
Sturnus vulgaris	Starling	RR WV
Sturnus roseus	Rose-coloured Starling	RR (W)
Creatophora cinerea	Wattled Starling	V

Passeridae

Passer domesticus	House Sparrow	RR
Passer hispaniolensis	Spanish Sparrow	V OR WV
Petronia brachydactyla	Pale Rock Sparrow	RR
Petronia xanthocollis	Yellow-throated Sparrow	RR RR

Ploceidae

Ploceus galbula	Ruppell's Weaver	RR

Estrildidae

Lonchura malabarica	Indian Silverbill	RR
Lonchura cantans	African Silverbill	RR

Fringillidae

Fringilla montifringilla	Brambling	V
Rhynchostruthus socotranus	Golden-winged Grosbeak	RR
Carduelis carduelis	Goldfinch	V
Rhodopechys githaginea	Trumpeter Finch	RR?
Carpodacus erythrinus	Scarlet Rosefinch	RR

Emberizidae

Emberiza striolata	House Bunting	RR RR WV
Emberiza tahapisi	Cinnamon-breasted Rock Bunting	RR
Emberiza hortulana	Ortolan Bunting	RR
Emberiza rustica	Rustic Bunting	V
Emberiza pusilla	Little Bunting	V
Emberiza aureola	Yellow-breasted Bunting	V
Emberiza melanocephala	Black-headed Bunting	RR
Miliaria calandra	Corn Bunting	RR WV

Source: Gallagher and Woodcock. 1980.

Table 4. Habitats of breeding birds in Oman

1 Mountains

a Cliffs

Egyptian Vulture, Bonelli's Eagle, Kestrel, Barbary Falcon, Rock Dove, Woodpigeon (N), Pale Crag Martin, Hume's Wheatear (N), Brown-necked Raven, Fan-tailed Raven (D), Tristram's Grackle (D)

b Hillsides, rocky wadis

Chukar (N), Arabian Red-legged Partridge, Sand Partridge, Lichtenstein's Sandgrouse, Palm Dove, Bruce's Scops Owl (N), Little Owl, Little Green Bee-eater, Indian Roller (N), Desert Lark, Long-billed Pipit, Yellow-vented Bulbul, Mourning Wheatear (D), Scrub Warbler, Arabian Babbler, Purple Sunbird (N), Abyssinian Sunbird (D), Palestine Sunbird (D), Yellow-throated Sparrow (N), Indian Silverbill (N), House Bunting

c Woodland (D)

Bonelli's Eagle, Arabian Red-legged Partridge, Palm Dove, Didric Cuckoo, Oriental Scops Owl, Spotted Eagle Owl, Grey-headed Kingfisher, Yellow-vented Bulbul, Blackstart, Graceful Warbler, Blanford's Warbler, African Paradise Flycatcher, Abyssinian Sunbird, Palestine Sunbird, White-breasted White-eye, Black-headed Bush Shrike, Ruppell's Weaver, African Silverbill, Golden-winged Grosbeak, Cinnamon-breasted Rock Bunting

d Upland grassland (D)

Singing Bush Lark, Crested Lark, Long-billed Pipit.

2 Coastal Plains

a Batinah (N)

Grey Francolin, Collared Dove, Turtle Dove, Palm Dove, Rose-ringed Parakeet, Barn Owl, Bruce's Scops Owl, Little Green Bee-eater, Blue-cheeked Bee-eater, Bee-eater, Indian Roller, Hoopoe, Black-crowned Finch Lark, Hoopoe Lark, Crested Lark, Yellow-vented Bulbul, Graceful Warbler, Arabian Babbler, Purple Sunbird, Great Grey Shrike, House Crow, House Sparrow, Yellow-throated Sparrow, Indian Silverbill.

b Salalah (D)

Collared Dove, Barn Owl, Little Green Bee-eater, Singing Bush Lark, Black-crowned Finch Lark, Crested Lark, Yellow-vented Bulbul, Graceful Warbler, Abyssinian Sunbird, Ruppell's Weaver, African Silverbill.

3 Desert and semi-desert

a Open sandy or stony desert

Coronetted Sandgrouse, Spotted Sandgrouse, Chestnut-bellied Sandgrouse, Eagle Owl, Little Owl, Black-crowned Finch Lark, Dunn's Lark (D), Bar-tailed Desert Lark (D), Desert Lark, Hoopoe Lark

b Desert with scrub and trees

Long-legged Buzzard, Houbara, Little Green Bee-eater, Arabian Babbler, Great Grey Shrike, Brown-necked Raven.

c Prosopis woods and desert oases

Grey Francolin (N), Palm Dove, Bruce's Scops Owl (N), Little Owl, Little Green Bee-eater, Crested Lark, Graceful Warbler, Purple Sunbird (N), Great Grey Shrike, House Sparrow (N).

4 Wetlands

a Inland pools and streams

Little Grebe, Moorhen, Little Ringed Plover, Red-wattled Lapwing (N), Graceful Warbler.

b Mangroves (N)

Little Green Heron, Western Reef Heron, Palm Dove, White-collared Kingfisher, Clamorous Reed Warbler, Crested Warbler, Purple Sunbird, House Crow

c Creeks and lagoons

Little Grebe, Moorhen, Kentish Plover, Red-wattled Lapwing (N), Graceful Warbler

5 Coasts

a Coastal cliffs

Red-billed Tropicbird, Sooty Falcon, Rock Dove, Pallid Swift, Pale Crag Martin, Tristram's Grackle (D).

b Islands

Red-billed Tropicbird, Masked Booby (D), Socotra Cormorant (D), Little Green Heron, Western Reef Heron, Egyptian Vulture, Osprey, Sooty Falcon, Crab Plover (N), Sooty Gull, Crested Tern, Roseate Tern, White-cheeked Tern, Bridled Tern, Saunders' Little Tern (N), Common Sandgrouse, Rock Dove, Pallid Swift

N = northern Oman only M = Masirah Island only D = Dhofar only

Source: Gallagher and Woodcock. 1980.

able 5. Reptiles and Amphibians of Northern Oman

Species	Habitat
Gekkonidae (Geckos)	
Bunopus spatalurus	mountains
B. tuberculatus	lowlands, deserts
Cyrtodactylus scaber	coastal areas
Hemidactylus turcicus	foothills, deserts
H. persicus	mountains
H. homoeolepis	foothills, desert fringe
H. flaviviridis	coastal areas
Phyllodactylus gallagheri	mountains
P. elisae	mountains
Pristurus rupestris	mountains, foothills
P. celerrimus	mountains, foothills
P. cf. flavipunctatus	mountains, foothills
P. carteri	foothills, desert fringe
P. minimus	foothills, desert fringe
Ptyodactylus hassequistii	mountains, foothills
Stenodactylus arabicus	central deserts
S. doriae	central deserts
S. leptocosymbotes	foothills, deserts
Agamidae (Agamid lizards)	
Agama sinaita	mountains
A. jayakari	foothills, desert fringe
Phrynocephalus spp.	central deserts
Uromastyx microlepis	central deserts
U. thomasi	foothills, desert fringe
Chamaeleonidae (Chamaeleons)	
Chamaelo chamaeleon	foothills, desert fringe
Scincidae (Skinks)	
Albepharus pannonicus	mountains
Chalcides ocellatus	coastal areas
Mabuya tessellata	mountains
Scincus conirostris	central deserts
S. mitranus	central deserts

Reptiles and Amphibians of Northern Oman, cont.

Species	Habitat
Lacertidae (Lacertid lizards)	
Acanthodactylus arabicus	central deserts
A. boskianus	central deserts
A. n. sp.	coastal areas
Eremias adramitana	foothills, deserts
Lacerta jayakari	mountains
L. cyanura	Musandam
Varanidae (Monitors)	
Varanus grisens	central deserts
Amphisbaenidae (Worm lizards)	
Diplometopon zarudnyi	central deserts
Leptotyphlopidae (Blind snakes)	
Leptotyphlops macrorhynchus	coastal areas
Boidae (Boas)	
Eryx jayakari	central deserts
Colubridae (Typical snakes)	
Coluber rhodorhachis	mountains
Lytorhynchus gaddi	central deserts
Malpolon moilensis	central deserts
Spalerosophis diadema	mountains, coastal areas
Telescopus dhara	coastal areas
Viperidae (Vipers)	
Cerastes cerastes	central deserts
Echis coloratus	foothills
E. carinatus	foothills, desert fringe
Pseudocerastes persicus	mountains
Bufonidae (Typical toads)	
Bufo orientalis	mountains
B. dhufarensis	mountains (also Dhufar)

Source: Arnold and Gallagher. 1977.

Table 6. Land and Freshwater Molluscs of Northern Oman

Melanoides tuberculata
Lymnaea natalensis
Laevicaulis alte
Pupoides coenopictus samavaensis
Buliminus jousseaumei
B. omanensis
B. albatusta
B. candidus
Zootecus insularis
Xeropicta derbentina
Helicella spp.
Planorbis exustus

Source: Smythe and Gallagher. 1977.

Table 7. Mammalian Ectoparasites of Oman

INSECTA

Diptera (flies)

Hippoboscidae
Lipoptena capreoli (usually found on goats, in Oman recorded on the Arabian Tahr)
Streblidae
Raymondia huberi (on bats)

Anoplura (lice)

Hoplopleuridae
Polyplax prob. *oxyrrhyncha* (on mice)
Pulicidae
Xenopsylla cheopis (on rats, mice; the vector of bubonic plague)

ACARINA

Ixoididae (ticks)

Argas (Carios) vespertilionis (on bats)
Rhinicephalus spp. (on mice)

Source: Thompson. 1977.

APPENDIX VII

PROPOSED PROJECTS OF POTENTIAL ENVIRONMENTAL SIGNIFICANCE

Table 1. Agricultural Development

Table 2. Water Projects

Source: Sultanate of Oman. 1980a.

Table 1. Agricultural Development

Animal Husbandry Projects

Objectives: to establish centers to conduct research and provide veterinary services and advice to farmers.

Activities: 1) to conduct research on sheep, goats, cattle and introduce new varieties; 2) to conduct research on traditional and new forage crops; 3) veterinary services and advice.

Budget Estimate: 2,470,000 OR (with no indication of the number of centers).

Pilot Tobacco Processing Project at Shinas

Objectives: to boost tobacco production and improve marketing as a means of raising rural incomes.

Activities: 1) a survey of the tobacco industry in the area; 2) establishment of a small industry; 3) plant breeding research; 4) establishment of curing and packing center.

Budget Estimate: 300,000 OR.

Improvement of Date and Lime Crops

Objectives: 1) to reverse decline and increase production; 2) to extend production and marketing period, research market possibilities; 3) to induce farmers to remain in sector through reviving the date and lime industries.

Activities: 1) improvement of genetic stock; 2) research on yields, quality, and disease; 3) establishment of nurseries for distribution to farmers; 4) introduction of modern planting, harvesting, processing, and marketing methods; 5) to provide advice to farmers.

Budget Estimate: 1,500,000 OR for lime project; no estimate given for date project.

Horticultural Improvement

Objectives: 1) improvement of fruits and vegetables; 2) teach- and assistance of local farmers in horticulture; 3) to reduce dependence on imports.

Table 1. Agricultural Development Continued

Activities: 1) intensive research on Omani fruits and vegetables in all major producing regions, including studies on nutritional and water requirements, adaptation of new varieties to Oman, and work on improving old methods and introducing new ones; 2) establishment of modern nurseries and orchards; 3) training of local staff.

Budget Estimate: 1,200,000 OR.

Jabal Akhdar Agricultural Development

Objectives: 1) increased production of pomegranates and grapes; 2) introduction of suitable new fruit crops; 3) extend the production and marketing period of fruits; 4) to raise the rural standard of living.

Activities: 1) establishment of a nursery in Saiq for distribution to farmers; 2) to conduct experiments and breeding program for raising fruit yields and quality; 3) to assist farmers in packing and marketing.

Budget Estimate: 500,000 OR.

Pilot Project for Sheep-Rearing at al-Kamil, Sharqiyah

Objectives: 1) to initiate a small experimental project to test the viability of sheep raising under modern conditions. If successful, a larger project will be launched. The ultimate goal is to move toward self-sufficiency in meat production.

Activities: 1) establishment of a sheep ranch; 2) sheep breeding program, utilizing both Omani and foreign sheep; 3) establishment of a veterinary post; 4) preparation of grazing land.

Budget Estimate: 500,000 OR.

Pilot Farms Project

Objectives: 1) to encourage and strengthen modern intensive farming in rural areas in order to raise the living standard and increase agricultural production. This is to be done by establishing 4 pilot farms of 4 ha each (eventually 25 farms). These farms will be distributed to Omani farmers.

Table 1. Agricultural Development Continued

Budget Estimate; 5,232,000 OR.

Agricultural Surveys and Studies

Objectives: to gain complete information on acreage and changes in acreage of Omani crops. Only very incomplete information is presently available, and current estimates are based on 1971 work. A second objective is to encourage feasibility studies in aspects of agriculture.

Activities: 1) to conduct land surveys every 3 to 4 years;
2) to use LANDSAT data to complement ground surveys;
3) to conduct regular studies on various aspects of agriculture such as labor participation, income and wages, prices, crops, livestock, poultry, etc.

Budget Estimate: 500,000 OR.

Table 2. Water Projects

Salvage of Surface Water Losses

Objectives; Salvage of storm runoff through construction of small dams to perform dispersal, diversion, and detention functions. Storm flow would then be retained for infiltration into shallow aquifers.

Benefits: Prevention of surface water loss to sea or interior desert. This will help in recharge of shallow aquifers.

Negative Effects: May hasten salt water intrusion in aquifers near the coast, but would allow for management of this situation.

Activities: Geologic mapping, exploration, construction of dams and weirs, extraction wells, pipeline to coastal areas, testing and quality analysis.

Budget Estimate: 16,380,000 OR for 9 projects at 1,820,000 OR each.

NOTE: U.S. Army Corps of Engineers (1979) presents a detailed analysis of this project. Wadi Samail is to be the pilot project.

Skimming Gallery Construction

Objectives: To develop skimming galleries for the salvage of groundwater. These are horizontal shafts, similar to aflaj, running parallel to the coast about 5 km inland. Properly operated galleries can intercept up to 95 percent of the fresh groundwater flowing toward the ocean.

Benefits: Prevention of groundwater loss to sea; capture of water in an area where high quality is ensured.

Negative Effects: Accelerated subsidence of water table in the coast downslope of gallery. Part of waters captured could be piped to areas affected.

Activities: Construction of a test gallery near Sib, to complement a surface water salvage project in wadi Samail.

Budget Estimate: 1,050,000 OR.

Table 2. Water Projects Continued

Exploration Drilling: Nizwa, Izki, Sohar, Sur

Objectives: Exploration of both shallow and deep alluvial aquifers, with eventual exploitation.

Benefits: Compilation of data in areas where almost none is available. Discovery of water resources, because Nizwa and Izki face shortages; and Sohar requires water for copper industry development.

Negative Effects: Large scale exploitation could reduce yields of aflaj and shallow wells. These reductions could be replaced through deep boreholes.

Activities: Geologic mapping, 10 wells to 300 m, testing and quality analysis.

Budget Estimate: 1,232,000 OR.

Wadi al-Batha

Objectives: Drilling wells in alluvium to salvage underflow losses and losses due to evaporation of shallow groundwater.

Benefits: Exploitation of an estimated 2-3 billion cubic m groundwater in the alluvium, control of surface water losses during periods of high flow.

Negative effects: Possible depletion of falaj flows, this could be replaced with well water.

Activities: Geological mapping, exploration, 20 test wells to 100 m, testing and analysis.

Budget Estimate: 268,000 OR.

Wahiba Sands

Objectives: Exploitation of water at the periphery of the dune region. At present, a great deal of water appears to be lost to shallow water evaporation and to the sea. Also, exploration for water in the interior of the dune field.

Table 2. Water Projects Continued

Negative Effects: None anticipated, project exploitation about balances recharge.

Activities: Geologic mapping, exploration, 20 test wells to 150 m, testing and analysis.

Budget Estimate: 449,500 OR.

Buraimi

Objectives: Exploration and development of limestone aquifers in Buraimi area. At present, well yields are declining and water quality is deteriorating due to poor management and excess pumping.

Benefits: Development of deep aquifers can compensate for declining yields from shallow aquifer wells.

Negative Effects: Possible international dispute over exploitation of water in a border area.

Activities: Phase I - shallow aquifers: inventory of wells, preparation of groundwater maps, establishment of well monitoring network. Phase II - deep aquifers: geological mapping, seismic exploration, 10 test wells to 300 m.

Budget Estimate: 334,000 OR.

Musandam

Objectives: Exploratory drilling of bedrock limestones.

Benefits: Eventual development of an estimated 0.5 billion cubic m of groundwater.

Negative Effects: None anticipated.

Activities: Geologic mapping, 10 wells to 500 m, testing and quality analysis.

Budget Estimate: 705,000 OR.

Jabal al-Qara (Dhufar) - Tertiary Limestones

Objectives: Exploration and development of the tertiary limestone aquifers in Jabal al-Qara.

Table 2. Water Projects Continued

Benefits: Development of the estimated 6 billion cubic m of good quality water in the mountains behind Salalah. Insufficient data available to estimate exploitable quantity.

Negative Effects: None anticipated.

Activities: Geologic mapping, 20 boreholes to 500 m, aquifer testing, quality analysis.

Budget Estimate: 2,280,000 OR.

Salalah Coastal Plain

Objectives: Exploration and development of groundwater under the Salalah plain which is currently lost to the sea.

Benefits: Development of groundwater, which is estimated to be at least 18 million cubic m in the central portion of the plain alone.

Negative Effects: None anticipated.

Activities: Geologic mapping, exploration, 20 wells to 100 m, aquifer testing, quality analysis.

Budget Estimate: 279,000 OR.

Capital Area - Hajar Limestones

Objectives: To explore and develop the limestone aquifers in the Capital area. One recently drilled well yields 60 liters/sec. The waters in this aquifer are presently unused, and much is lost to the sea.

Benefits: Development of the 0.5 to 1 billion cubic m of groundwater within a 25 km radius of Ruwi (Capital Area). Twenty wells could be expected to supply at least 19 million liters per day of water suitable for drinking.

Negative Effects: Exploitation may affect discharge of springs; however borehole production can compensate for these losses.

Activities: Geologic mapping, exploration and test wells, aquifer testing water quality analysis.

Budget Estimate: 1,754,000 OR.

APPENDIX VIII

Environmental Law

Sources: Caponera. 1978.
FAO. 1975.
Wilkinson. 1977.

The Sultanate does not have a comprehensive set of environmental laws. The Ibadhi Islamic Shari^{c}ah is still used as the basis for most legal decisions, and governmental laws are essentially supplemental to the Shari^{c}ah in most areas. However, the Shari^{c}ah and customary law have already addressed most of Oman's major environmental issues. For example, under these codes new water development may not adversely affect the quantity or quality of water in existing wells or aflaj, and protected areas may be established around water sources. It would probably not be difficult in most cases to extend the interpretation of existing Shari^{c}ah or customary law to cover modern situations. A few laws mentioned in the available literature are presented in Table 1. Within Oman there have been several compilations of current law, which are cited in the appropriate section of Appendix X.

Table 1. Some Environmental Laws

1.[a] Sultanic Decree of October 1970 on the establishment of the Department of Agriculture in the General Development Organisation (now the Ministry of Development)

2.[b] Act No. 4/1972 relating to the distribution of fertile lands. - 27 April 1972. - Collection of Laws in force up to 30 November 1972 [Free State distribution of fertile land to Omani citizens and families and to agricultural promotion companies.]

3.[b] Decree of the Sultan relating to territorial waters and the use of natural resources in the exclusive fishing zone. - 20 July 1972. - Collection of Laws in force up to 30 November 1972, p. 92.

4.[a] Law No. 3, 1973 (art. 11a, 11b, 11c) establishes the right of Muscat and Matrah residents to water service. The Ministry of Communication and Public Works was established and given responsibility over artesian wells, pumping stations, electric generators, and the water pipe network

5.[a] Law No. 8, 1973 empowers the Minister of Health to prohibit the use of polluted water sources, and authorizes medical authorities to stop the sale and transport of drinking water and destroy all suspect drinks.

6.[a] Sultanic Decree No. 34/74 (Chapt. 1, art. 2.1) concerns control of sea pollution as follows:

> II. Any substance of dangerous or harmful nature such as drainage water or refuse or waste or undesirable objects which when added to water shall spoil its quality or cause its change or form part of the process which causes declination of its quality or change to the extent of danger in relation to its use by man or beast or fish or plants useful to human beings shall be considered a polluted substance.

Table 1. Some Environmental Laws Continued

III. All waters containing any substance or particular concentration or water treated containing an artificial substance which changes its nature either by heat or any other means whereby if added to any water shall result in the declination of its quality or change to the extent of danger in relation to its use by human beings or any beast, fishes or plants useful to human beings shall be considered as polluted substance.

Sources: a. Capcnera. 1978.
b. FAO. 1975.

APPENDIX IX

Entities with Environmental Responsibilities

Table 1. Government Personnel

Table 2. Governmental Organization

Table 3. Government Production Farms, Research Stations, Extension Farms and Centers, Nursery Gardens.

Table 4. Functions of Selected Institutions

Table 1. Government Personnel

Head of State, Premier and Minister of Foreign Affairs, Defence and Finance:
Sultan QABOOS BIN SAID (assumed power July 24th, 1970).

CABINET

(*June* 1980)

Deputy Premier for Security and Defence: Sayyid FAHAR BIN TAIMOUR AL-SAID.

Deputy Premier for Legal Affairs: Sayyid FAHAD BIN MAHMOUD AL-SAID.

Personal Adviser to the Sultan and Governor of Muscat: Sayyid THUWAINI BIN SHIHAB AL-SAID.

Minister of Diwan Affairs: Sayyid HAMAD BIN HAMUD AL-HAMED.

Minister of Justice: Sayyid HILAL BIN HAMAD AL-SAMMAR.

Minister of State for Foreign Affairs: QAIS ABDUL MUNIM AL-ZAWAWI.

Minister of Information, Youth Affairs and Tourism: ABDULAZIZ AL-ROWAAS.

Minister of Electricity and Water: HAMOUD ABDULLA AL-HARTHY.

Minister of Posts, Telegraphs and Telephones: KARIM AHMED AL-HARTHY.

Minister of Civil Aviation, Ports and Roads: SALIM BIN NASSIR AL-BUSAIDY.

Minister of Education: YAHYA MAHFOODH AL-MANDHRI.

Minister of Land Affairs and Municipalities: AHMAD ABDULLA AL-GHAZALI.

Minister of Social Affairs and Labour: KHALFAN BIN NASSIR AL-WAHAIBI.

Minister of Awkaf and Islamic Affairs: Sheikh WALID BIN ZAHIR AL-HINAWI.

Minister of National Heritage and Culture: Sayyid FAISAL BIN ALI AL-SAID.

Minister of the Interior: Sayyid BADR BIN SAUD BIN HARIB

Minister of Commerce and Industry: MUHAMMAD ZUBAIR.

Minister of Petroleum and Minerals: SAID AHMED AL-SHANFARI

Minister of Agriculture and Fisheries: ABDEL HAFIZ SALEM RAJAB

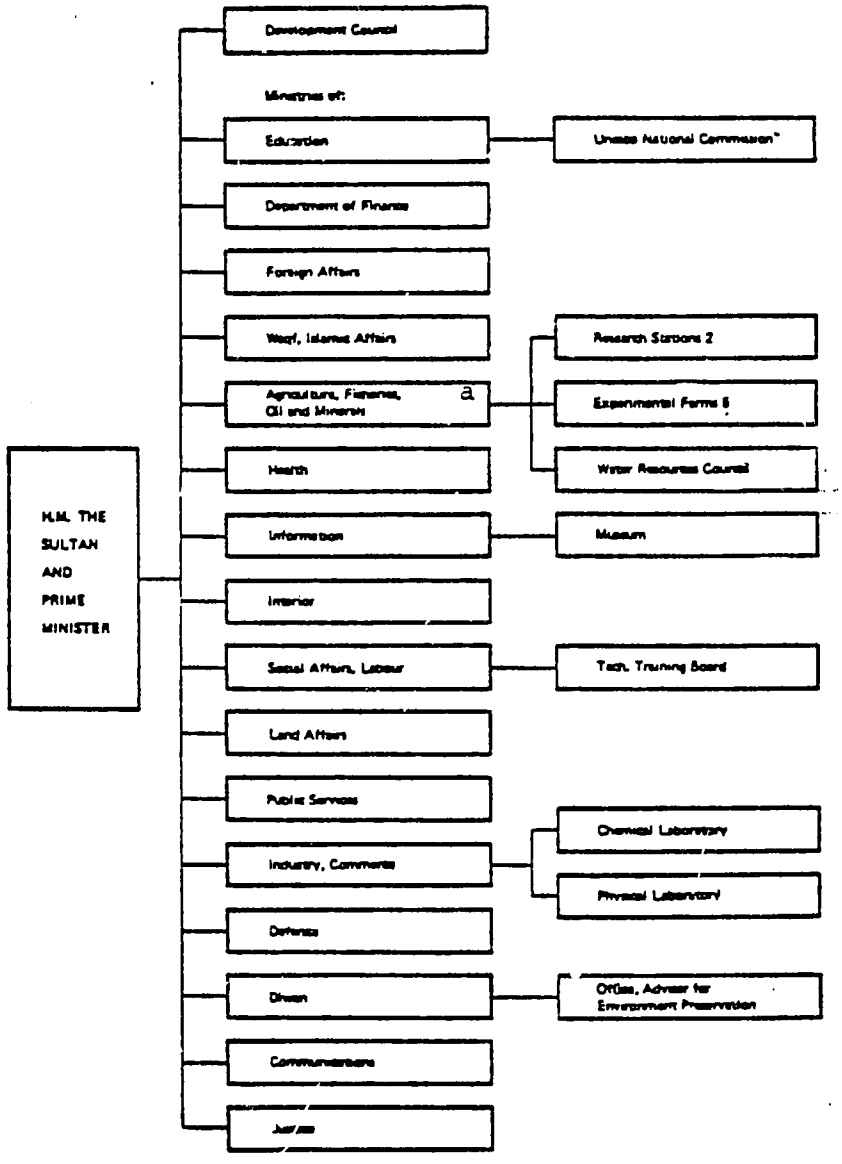
Minister of Health: Dr. MUBAREK AL-KHADOURI.

Governor of Dhofar and Minister of State: HILAL BIN SAUD AL-BUSAIDY

Minister of Public Works: ASSEM AL-JAMALI.

Source: Europa Publications. 1980.

Table 2. Governmental Organization



[a]This ministry was subsequently split into the Ministry of Agriculture and Fisheries and the Ministry of Petroleum and Minerals.

Source: UNESCO. 1976.

Table 3. Government Production Farms, Research Stations, Extension Farms and Centres and Nursery Gardens

Type of Farm/Station	Department of Agriculture Region								Total
	North Batinah	South Batinah	Oman Interior	Dhahirah	Sharqiyya	Janubiyya	Musandam	Capital Area	
Production farms	1	2	5	—	—	1	—	—	9
Research stations	—	2	2	—	—	1	—	—	5
Extension farms	1	—	1	—	—	—	—	—	2
Extension centres/ sub-centres	7	4	9	3	4	4	1	3	35
Nursery gardens	—	2	—	—	—	2	—	—	4

Geographical situation:

Production farms:

Sohar (agriculture), Rumais (1) (3 agriculture), Nizwa (3 agriculture), Tanoof (agriculture), Jebel Al Akhdhar (agriculture).

Research stations:

Rumais (agriculture), Rumais (animal husbandry), Wadi Quriyat (agriculture), Wadi Quriyat (animal husbandry), Salalah (agriculture).

Extension farms:

Bania, Buraimi.

Extension centres:

Al Mareer, Shinas, Liwa, Sohar, Saham, Al Khaburs, Buraimi, Seeb, Barka, Masnaa, Rostaq, Nizwa, Manah, Izki, Hamra, Wadi Quriyat, Jebel Al Akhdahr, Sumail, Ibri, Sur, Al Wafi, Ibra, Sinaw, Khasab, Quriyat, Al Oqdah, Al Dahaleez, Taqa, Al Rusail.

Extension sub-centres:

Adam, Bania, Dank, Yunqal, Al Khafqi, Bustan.

Nursery gardens:

Rumais (fruits), Rumais (garden), Rabat (fruits), Al Jebel (fruits).

Note: The Dairy farm in Sohar and Ganuz cow farms were excluded while they appeared in last year issue of the Year Book 1977, since then it has been [illegible] under the management of the Sun Farm Company (Oman).

Source: Sultanate of Oman. 1979.

Table 4. Functions of Selected Institutions

Oman Development Council. Chaired by the Sultan, the council is responsible for overall planning and preparation of the five-year plans. The Office of Planning of the Oman Development Council coordinates work between ministries, reviews and assesses projects submitted by the ministries.

Ministry of Agriculture and Fisheries. The Department of Agriculture conducts research and carries out production in experimental and pilot projects. Activities include soil classification, water surveys, plant protection, and operation of several pilot projects. Extension and services is another function. It is also responsible for the provision of water pumps, construction of irrigation channels, etc.

The Irrigation Department is responsible for promoting and controlling the use of irrigation water in the country.

The Water Resources Council is responsible directly to the Sultan, coordinates and plans water use and conservation for all purposes. The Water Authority, of the Water Resources Council, is responsible for collecting data, drilling exploratory wells, generally defining the water resource base.

The Agricultural Research Station at Rumais has the following programs: improvement of vegetable production, fruit improvement, field crops research, crop protection, crop and soil improvement.

The Agricultural Research Station at Wadi Quryat has the following programs: experimental trials on vegetables, development of field crops.

Ministry of Communications. The Department of Water Resources of the Ministry of Communications is responsible for ascertaining the extent of water availability in Oman through investigations carried out by various companies. It is envisaged that this Department will constitute the water resources regulatory agency to deal with the inventory of water resources, coordination and approval of water projects and water rights administration.

The Water Supply Department of the Ministry of Communications was created in 1968 to organize the supply of water in the capital area of Muscat-Matrah through well drilling and the creation of storage reservoirs.

Ministry of Health. The Department of Public Health of the Ministry of Health is concerned with environmental sanitation, including the control of water borne diseases and drinking water analyses through the Public Health Laboratory. This laboratory keeps a record of all water quality samplings by regions.

Table 4. Functions of Selected Institutions Continued

Ministry of Land Affairs. This Ministry, established in November 1971, has a Lands Division, a Registration of Properties Division and a Survey Division, which are responsible for the delimitation and registration of lands in Oman. No water rights registration takes place in this Ministry.

Ministry of Awqaf and Islamic Affairs. This Ministry, which was established in March 1973, is responsible for the registration and administration of awqaf (mortmain - religious endowment) properties, including waters so endowed. In addition, the bait al-mal (uninheritable or uninherited State properties) which form part of Government revenue and which include also water resources, are registered and administered thereby. Such a registration has been completed for bait al-mal properties and is proceeding with regard to awqaf properties.

Sources: Caponera. 1978
Cordes and Scholz. 1980.
CARIS. 1978.
UNEP. 1979.
U.S. AID. 1980b.

APPENDIX X

Selected Bibliography

1. General
2. Climate
3. Geology, Minerals, Soils
4. Flora and Fauna
5. Water Resources and Management
6. Land Use and Agriculture
7. Public Health, Social Aspects, Economy, Development

1. General

Anthony, J.D. 1976. Historical and Cultural Dictionary of the Sultanate of Oman and the Emirates of Eastern Arabia. Metuchen, N.J.: Scarecrow Press. viii + 136 pp.

Cornelius, P.F.S., N.L. Falcon, D. South, and C. Vita-Finzi. 1973. The Musandam Expedition 1971-72; Scientific Results; Part I with discussion. Geographical Journal 139(3):400-425.

Hawley, D. 1977. Oman and its Renaissance. London: Stacey International. 256 pp.

Kabeel, S.M. 1975. Source Book on Arabian Gulf States: Arabian Gulf in General, Kuwait, Bahrain, Qatar and Oman, Kuwait: Kuwait University, Libraries Dept. iii + 427 pp.

King, R. and J.H. Stevens. 1973. A Bibliography of Oman 1900-1970. Durham: University of Durham Centre for Middle Eastern and Islamic Studies. (Occasional Paper Series No. 2) 14 pp.

Landen, R.G. 1967. Oman since 1856: Disruptive Modernization in a Traditional Arab Society. Princeton: Princeton University Press. 488 pp.

Middle East Economic Digest, Special Report. 1978. Oman. 52 pp.

-----. Special Report 1980. Oman.

Nyrop, R.F. et al. 1977. Area Handbook for the Persian Gulf States. Washington, D.C. U.S. Government Printing Office (DA Pam 550-185). xiv + 447 pp.

Peterson, J.E. 1978. Oman in the Twentieth Century. London: Croon Helm Ltd. 286 pp.

Robinson, G.P.E. and H.P. May. 1974. The Musandam Expedition: Scientific Results, Part II. Geographical Journal 140(1):94-104.

Shannon, M.O. 1978. Oman and Southeastern Arabia: A Bibliographic Survey. Boston, Mass.: G.K. Hall and Co. xvi + 165 pp.

Sultanate of Oman. n.d. (Probably late 1975 or early 1976). The Five Year Development Plan 1976-1980. Muscat Development Council ix + 130 pp.

-----. 1978. Statistical Year Book. 1977. Muscat: Development Council, Technical Secretariat, Directorate General of National Statistics vi + 120 pp.

-----. 1979. Statistical Year Book. 1978. Muscat: Development Council, Technical Secretariat, Directorate General of National Statistics vi + 134 pp.

Sultanate of Oman. Development Council, Technical Secretariat, Documentation Center. 1976. Catalogue of Documents. Vol. 1. Vol. III 1977: Catalogue of Documents received in 1977; Vol. IV 1978; Catalogue of Documents received in 1978. Musqat; Development Council.

Townsend, J. 1977. Oman: The Making of a Modern State. London; Croom Helm. 212 pp.

2. Climate

Barrett, E.C. 1977. The Assessment of Rainfall in North-eastern Oman through the Integration of Observations from Conventional and Satellite Sources. Rome:FAO (AGL-MT629; access no. 37482-77W). 55 pp.

-. 1977. Weather Satellite Imagery as an Aid in Assessment of Rainfall: Lessons Learned from a Detailed Case Study in Sultanate of Oman. Presented at the 28th International Astronautical Congress, B773259, Prague, Czechoslovakia, 25 Sept. - 1 Oct. 1977. Paper No. 77-129.

Grant, K. 1978. September monsoon depression at Masirah, Oman. Meteorological Magazine 107(1272):218-222.

Horn, P.M. 1976. Rainfall in the Muscat area (in Oman Sultanate). Field Document 1. Rome:FAO (FAO-AGO-OMA/73/009; access no. 39620-76-XB). 34 pp.

-. 1978. Rainfall in Dhofar (Salalah area) to 1977 inclusive (in Oman Sultanate). Field Documents 5. Rome:FAO (FAO-AGO-OMA/77/001; access no. 39622-78-XB). 23 pp.

Horn, P.M. and J.B. Nielsen. 1977. Climate of the Batinah (1973-1977) (in Oman Sultanate). Field Document 4. Rome:FAO (FAO-AGO-OMA/77/001; access no. 39621-77-XB). 27 pp.

-. 1978. Rainfall in Oman 1977. Field Document 6. Rome:FAO (FAO-AGO-OMA/77/001; access no. 39623-78-XB). 19 pp.

Horn, P.M.; J.B. Nielsen; A. Manthri Issa; S. Salaam. 1977. Climate of Jebel Akhdar (Saiq) (in Oman Sultanate). Field Document 2. Rome:FAO (FAO AGO-OMA/77/001; access no. 40095-77-XB). 19 pp.

Pedgley, D.E. 1970. The climate of interior Oman. Meteorological Magazine 99(1171): 29-37.

Stevens, J.H. 1970. Rainfall at Buraimi Oasis in July 1969. Meteorological Magazine 99(1171):37-39.

3. Geology, Minerals, Soils

Allemann, F. and T.J. Peters. 1972. The Ophiolite-Radio-Larite belt of the north Oman mountains. Ecologae Geof. Helv. 65(3);657-697.

Davidson, D.F.; Grolier, M.J. 1978. Eastern Arabian Peninsula. U.S. Geological Survey, Professional Paper No. 1100. Washington, D.C.: USGS. 342 pp.

Fleet, A.J. and A.H.F. Robertson. 1980. Ocean-ridge metalliferous and pelagic sediments of the Semail nappe, Oman. Journal of the Geological Society 137:403-422.

Gealey, W.K. 1972. Ophiolite obduction and geologic evolution of the Oman mountains and adjacent areas. Geol. Soc. Am., Bull. 88(8):1183-1191.

Glennie, K.W., M.G.A. Boeuf, M.W. Hughes Clarke, M. Moody Stuart, W.F.H. Pilaar, and B.M. Reinhardt. 1974. Geology of the Oman mountains. Nederlands Geologisch Mijnbouwkundig Genootschap. Verhandelingen. Vol. 31, 423 pp.

Glennie, K.W., W.F.H. Pilaar, M.G.A. Boeuf, B.M. Reinhardt, and M.W. Hughes Clark. 1970. Notes to Accompany the Geological Map of the Oman Mountains. Rijswijk, Netherlands: Koninklijke/Shell Exploration en Produktie Laboratorium.

Granges International Mining. 1973. Ras al Hadd Area Oman, Manganese Deposit. Musqat: Directorate General of Petroleum and Minerals. (unpublished report).

Koninklijke/Shell Exploration en Produktie Laboratorium (KSEPL). 1969. Geologic Map of the Oman Mountains (1:500,000, two sheets; 1:250,000, three sheets).

Moody, J.D. 1974. Late Cretaceous nappes in Oman mountains and their geologic evolution: discussion and reply. Am. Assoc. Pet. Geol., Bull. 58(5): 889-898.

Morton, D.M. 1959. The geology of Oman. Proceedings of the 5th World Petroleum Congress, New York. Section 1, Paper 14:277-294.

Stadder, P.J. 1975. Cementation of Pliocene-Quaternary fluviatile clastic deposits in and along the Oman mountains. Geol. Mijnbouw 54(3-4):148-156.

Stevens, J.H. 1978. Post pluvial changes in the soils of the Arabian Peninsula. In: The Environmental History of the Near and Middle East since the Last Ice Age. (W.C. Brice, ed.) London: Academic Press. pp. 263-274.

Tschopp, R.H. 1967. The general geology of Oman. Proceedings of the 7th World Petroleum Congress, vol. 2;231-242.

Vita-Finzi, C. and P.F.S. Cornelius. 1973. Cliff sapping by mollusks in Oman. J. Sediment. Petrol. 43 (1):31-32.

4. Flora and Fauna

Arnold, E.N. 1972. Lizards with northern affinities from the mountains of Oman. Zool. Meded. R. Mus. Nat. Hist. Leiden. 47:111-128.

Arnold, E.N. and M.D. Gallagher. 1977. Reptiles and amphibians from the mountains of northern Oman. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 59-80.

Banister, K.E. and Clarke, M.A. 1977. The freshwater fishes of the Arabian Peninsula. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 111-154.

Budnichenko, V.A. 1974. The Feeding of Saurida-undosquamis and Saurida-tumbil Synodontidae along the Oman coast. Journal of Ichthyology 14(2): 267-272.

Davies, F.G. 1978. A new species of Launaea (Castanosperma) (Compositae) from Oman. Kew Bull. 33(2):294.

Gallagher, M.D. 1973. Report of a Short Reconnaissance of Parts of the Proposed National Park in Oman, 14-20 March 1973. Unpublished report, deposited in the IUCN library, Morges, Switzerland, and at the Linnean Society of London.

-. 1977. Birds of Jabal Akhdar. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 27-58.

Gallagher, M.D. and T.D. Rogers. 1980. On some birds of Dhofar and other parts of Oman. In The Scientific Results of the Oman Flora and Fauna Survey 1977 (Dhofar). Journal of Oman Studies, Special Report 2 (in press).

Gallagher, M. and M.W. Woodcock. 1980. The Birds of Oman. London: Quartet Books. 310 pp.

Griffiths, C.I. and Rogers, T.D. 1975. An interim list of the birds of Masirah Island, Oman. Duplicated typescript. Copy at the British Museum (Natural History), Tring. Revised typescript issued privately in 1976.

Griffiths, W.A.C. 1975. A Bibliography of the avifauna of the Arabian Peninsula, the Levant and Mesopotamia. Army Bird-watching Soc. Periodic Publ. No. 2. (Addendum No. 1 dated 1978, and No. 2 dated 1979, published by Orn. Soc. Middle East.)

Harrison, D.L. 1964. The Mammals of Arabia. Vol. 1: Introduction. Insectivora. Chiroptera. Primates. London: Ernest Benn Ltd. 192 pp.

Harrison, D.L. 1968. The Mammals of Arabia, Vol. 2: Hyracoidea, Artiodactyla. London: Ernest Benn Ltd. pp. 193-381.

-----. 1968. The Mammals of Arabia, Vol. 3: Lagomorpha, Rodentia. London: Ernest Benn Ltd. xvii + pp. 382-670.

-----. 1975. The Oman Flora and Fauna Survey 1975. Journal of Oman Studies 1:181-186.

-----. 1977. Mammals obtained by the expedition. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 13-26.

-----. 1979. New species of Pipistrelle bat (Pipistrellus, Vespertilionidae) from Oman, Arabia. Mammalia 43(4):573-576.

Harrison, D.L. and M.D. Gallagher. 1974. A park to save the Arabian tahr. Oryx 12(5):547-549.

-----. 1976. Plan for reserves in Oman. Oryx 13(3):287-288.

Harrison, D.L. and M.C. Jennings. 1980. Occurrence of the Noctule, Nyctalus noctula Schreber, 1774 (Chiroptera, Vespertilionidae) in Oman, Arabia. Mammalia 44(3):409-410.

Henderson, D.S. 1974. The Arabian oryx: a desert tragedy. National Parks and Conservation Magazine 48(5):15-21.

Hills, D.M. 1979. Mammals previously unrecorded from the Sultanate of Oman, Arabia. Mammalia 43(4):567-568.

Honeywell, R.A. and Honeywell, G.E. 1976. Birds of the Batinah of Oman. Published privately; P.O. Box 4668, Ruwi, Oman.

Jungius, H. 1978. Plan to restore Arabian oryx in Oman. Oryx 14(4): 329-336.

Larsen, T.B. The butterflies of eastern Oman and their zoogeographic composition. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report: pp. 179-208.

Lavranos, J.J. and K.V. Mortimer. 1970. Rhytidocaulon fulleri, a new Stapeliad from the Dhofar Coast, Muscat and Oman, Southern Arabia. National Cactus and Succulent Journal 25(1):3-4.

Luther, R. 1974. The Cowries of Oman. Hawaii Shell News 22(8):6.

Mandaville, J.P. Jr. 1977. Plants. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 229-267.

Mandaville, J.P. and D. Bovey. 1978. Wild Flowers of Northern Oman. London: Bartholomew Books. 64 pp.

Munton, P. 1979. Arabian tahr in Oman. Oryx 15(2):145-147.

Popov, G. n.d. The Vegetation of Arabia South of the Tropic of Cancer (Excluding the Yemen). Mimeographed MS. 28 pp.

Ross, J.P. 1981. Hawksbill Turtle *Eretmochelys-imbricata* in the Sultanate of Oman. Biological Conservation 19(2):99-106.

Sale, J.B. 1978. Dhofar flora and fauna survey. World Wildlife Yearbook 1977-1978:126-127.

Smythe, K.R. and M.D. Gallagher. 1977. Land and freshwater mollusca. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 219-225.

Thompson, G.B. 1977. Ectoparasites from mammals. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 227-228.

Tjeder, B. and A.R. Waterston. 1977. *Ptyngidricerus venustus* n.sp. from Oman and Iran (Neuroptera: Ascalaphidae). Entomol. Scand. 8(2):304-319.

Vachon, M. 1977. Scorpions. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 209-218.

Vicker, R. 1980. The Sultan and the oryx. International Wildlife 10(3): 4-11.

Wiltshire, E.P. 1977a. Lepidoptera: Part I. Families Cossidae, Pyralidae, Geometridae, Sphingidae, Arctiidae, Lymantriidae and Noctuidae. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 155-160.

-. 1977b. Part II. A list of further Lepidoptera - Heterocera from Oman. In The Scientific Results of the Oman Flora and Fauna Survey 1975. The Journal of Oman Studies, Special Report. pp. 161-176.

5. Water Resources and Management

Barret, E.C. 1978. Use of weather satellite data in evaluation of national water resources, with special reference to Sultanate of Oman. Presented at Committee on Space Research (COSPAR) 21st Plenary Meeting, Innsbruck, Austria 29 May - 10 June 1978.

Caponera, D.A. 1975. Report to the Government of the Sultanate of Oman on Water Legislation and Administration. Rome:UNDP/FAO Project "Water Resources Centre" (OMA/73/009).

FAO. 1976. Development of New Land for Irrigated Agriculture in Oman - Soil and Land Classification; Soil and Water Management. Soil and Water Management Field Document No. 4. Rome:FAO.

-. 1976. National Standards of Soil and Water Analysis in Oman. Soil and Water Management Field Document No. 1. Rome:FAO.

Gibb, Alexander and Partners. 1975. Water Resources Survey of Northern Oman: Final Report. Vol. I: Main Report. Musqat: Ministry of France.

-. 1976. Water Resources Survey of Northern Oman: Final Report; Vol. II, App. A: Rainfall and Meteorology; Vol. III, App B: Survey Water Flow; Vol. IV, App. C: Geology and Hydrogeology; Vol. V, App. D: Survey of Water Use in Villages; Vol. VI, App. E: Water Chemistry and Isotope Studies. Musqat: Ministry of Finance.

Halerow, William and Partners. 1975. Dhofar Land and Water Resources Development, Final Report. Main Report; Annex 2: Water Resources and Irrigation. Salalah: Dhofar Development Department.

-. 1977. Surveys and Investigations for Land and Water Resources - Dhofar. Summary of Water Resources. (A series of Addendum to Annex 2, Dhofar Land and Water Resources Development, Final Report). Salalah: Wali of Dhofar.

Horn, P.M. 1977. Wadi Semail Surface Water Balances, 1974-1977. Water Resources Field Document No. 9. Rome:FAO.

-. 1978. Water Resources of the Salalah plain. An interim reappraisal (surface water balance). Field Document 8. Rome:FAO. (FAO-AGO-OMA/77/001; access no. 39624-78-XB). 32 pp.

Hydroconsult. 1975. Wadi Samail Aquifer Studies. Musqat: H.M. Properties.

Ilaco. 1975. Water Resources Development Project Northern Oman. Final Report (2 vols.) Musqat: Ministry of Communications, Water Resources Centre.

Letts, S.E. 1979. Groundwater and its Present Day Use in Part of Northern Oman. Oxford: University of Oxford (unpubl. Ph.D. dissertation).

Maktari, A.M.A. 1975. Water Laws in the Sultanate of Oman. Unpublished report for the FAO Legislation Branch.

Reade, D.G. 1980. Development of the water resources of Oman for agriculture. FAO Field Document No. 14. Muscat: Food and Agriculture Organisation of the United Nations, and Water Resources Department, Ministry of Agriculture and Fisheries.

Renardet-Sauti ICE. 1974. Water Supply of the City of Sur. Feasibility Study. Musqat: Ministry of Development.

-----. 1975. Water Resources in Northeast Oman. Interim Report, General Summary; Annex A: Climatology; Annex B: Geophysical Report; Annex C: Hydrogeology; Annex D: Water Chemistry. Musqat: Ministry of Communications.

Sultanate of Oman, Secretariat of the Water Resources Council. 1978. Flood Hydrology of Northern Oman. Musqat: Water Resources Council.

-----. 1978. Oman Water Code. Musqat: Water Resources Council.

-----. 1978. Resources Survey Review. Musqat: Water Resources Council.

Sultanate of Oman, Water Resources Council. 1978. Water Resources Council Reference Library Index. Musqat: Water Resources Council.

U.S. Army Corps of Enigneers. 1979. Report on Water Resources Study, Phase II, and Technical Proposal for Construction of Water Recharge Projects for the Government of Oman, Ministry of Agriculture and Fisheries. Washington D.C.: U.S. AID Mimeographed.

Wilkinson, J.C. 1974. The Organisation of the Falaj Irrigation System in Oman. University of Oxford School of Geography, Research Paper No. 10.

-----. 1977. Water and Tribal Settlement in South-east Arabia: A study of the Aflaj of Oman. Oxford; Clarendon Press. xvi + 275 pp.

6. Land Use and Agriculture

Birks, J.S. and S.E. Letts. 1979. Some problems of agricultural development in the Sultanate of Oman. Journal of the Gulf and Arabian Peninsula Studies 5(18):157-169.

Burdon, D.J. 1973. Current Problems and Prospects for Agricultural Development in the Sultanate of Oman, Vol. 6: Water Resources. Rome FAO/UNDP.

Donnelly, J.; L.P. Joyner; O. Graham-Jones; and C.P. Ellis. 1980. A comparison of the complement fixation and immunofluorescent antibody tests in a survey of the prevalence of Babesia Equi and Babesia Caballi in horses in the Sultanate of Oman. Tropical Animal Health and Production 12(1):52-60.

Dutton, R. and J. Simpson. 1977. Producing honey with *Apis florea* in Oman. Bee World 58(2):71-76.

Dutton, R.W. and J.B. Free. 1979. The present status of beekeeping in Oman. Bee World 60(4):176-185.

F.A.O. 1975. Report of the FAO/UNDP Programming Mission to Oman Food and Agriculture Sector. Programming Mission Series No. 12. Rome: FAO (DDF-H3487; access no. 30487-75-MR). 95 pp.

-. 1979. Regional Fishery Survey and Development Project: Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates. Report of the second ad hoc working group on survey technique and strategy. Rome:FAO. 21 pp. (FAO-FI:DP/RAB/71/278/5)

Gibb, Alexander and Partners. 1974. Water Resources Survey of Northern Oman. Final Report, Soils and Agriculture Studies Summary. Muscat: Ministry of Communications.

-. 1975. Water Resources Survey of Northern Oman. Final Report. Soils and Agriculture Studies. Vol. 2: Soil Renaissance, Semi-detailed surveys; Vol. 5: Annex to Agricultural Studies Rights, Irrigation Production, Human Rights; Vol. 6: Annex to Agriculture Studies Infrastructure, Socio-Economic Development. Muscat: Ministry of Communications.

Halerow, William and Partners. 1975. Dhofar Land and Water Resources Development, Final Report. Annex 1: Soils and Land Capability; Annex 3, Vol. 1: Agriculture and Main Text; Annex 3, vol 2: Agriculture and Marketing; Annex 4: Economic Appraisal. Salalah: Dhofar Development Department.

Hedger, R.S.; I.T.R. Barnett; and D.F. Gray. 1980. Some virus diseases of domestic animals in the Sultanate of Oman. Tropical Animal Health and Production 12(2):107-114.

Juneidi, M. and Huss, D.L. 1978. Rangeland Resources of the Gulf and Arabian Peninsula Countries and their Managerial Problems and Needs. Cairo: FAO Regional Office for the Near East. 38 pp., appendices.

Mellor, P.S. 1978. Biting flies (*Lyperosia minuta*, with much smaller numbers of *Musca crassirostris*) attacking cattle in the Dhofar province of the Sultanate of Oman. Tropical Animal Health and Production 10(3):167-169.

Randall, J.E.; G.R. Allen and W.F. Smith-Vaniz. 1978. Regional Fishery Survey and Development Project: Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates. Rome: FAO. 226 pp. (FAO-FI:DP/RAB/71/278/3)

Renardet-Sauti ICE. 1975. Water Resources in Northeast Oman. Interim Report, Annex E: Pedology; Annex F: Agriculture; Annex G: Market Survey. Musqat: Ministry of Communications.

Sato, I. and K. Kagawa. 1977. Information and materials - present situation and some problems on crop production of Sultanate of Oman (in Japanese) Japanese Journal of Tropical Agriculture 21(1):45-52.

Sultanate of Oman. 1980a. Agriculture Study (Vol. I). Musqat: Development Council, Technical Secretariat, Directorate General of Planning and Follow-up. vi + 38 pp + appendices.

-. 1980b. Fisheries Development in Oman. Musqat: Development Council, Technical Secretariat, Directorate General of Planning and Follow-up. iv + 17 pp + appendices.

Underhill, J.P. 1978. Tomato cultural and varietal investigations in the Sultanate of Oman. IRI Research Institute Bulletin No. 49. 60 pp.

Vittoz, J. 1979. La palmier - dattier en Oman (The date palm in Oman: cultivation, irrigation) Fruits 34(10):609-621.

Waller, J.M.; and J. Bridge. 1978. Plant diseases and nematodes in the Sultanate of Oman. PANS 24(3):313-326.

Williams, I.H. 1979. Beekeeping in the Sultanate of Oman. American Bee Journal 119 (7):510-511.

7. Public Health, Social Aspects, Economy, Development

Amine, E.K. 1980. Oman Nutrition Status Survey. Abu Dhabi, UAE: United Nations Children's Fund, Gulf Area Office; mimeographed. ii + 95 pp.

Autret, M. and S. Miladi. 1979a. Report on the Food and Nutrition Situation (with particular reference to children) in the Gulf Countries. (Bahrain - Qatar - United Arab Emirates - Oman) Rome:FAO (EN-42614-79-XB-RNEA) i + 67 pp.

-. 1979b. Report on the Food and Nutrition Situation (with particular reference to children) in the Sultanate of Oman. Rome:FAO (EN-42618-79-XB-RNEA). i + 31 pp.

Birks, J.S. 1976a. The Shawāwi population of northern Oman: a pastoral society in transition. Journal of Oman Studies 2:9-16.

-. 1976b. Some aspects of demography related to development in the Middle East with special reference to the Sultanate of Oman. British Society for Middle Eastern Studies Bulletin 3(2):79-88.

-. 1977. The reaction of rural populations to drought: a case study from southeast Arabia. Erdkunde Bd. 31:299-305

-. 1979. The geographical mobility of a rural Arab population: some implications of changing patterns. Journal of Tropical Geography 48:9-18.

Birks, J.S. and S.E. Letts. 1976. The Awāmr: specialist well and falaj diggers in northern interior Oman. Journal of Oman Studies 2:93-100.

Birks, J.S. and C.A. Sinclair. 1978a. The Sultanate of Oman: Economic Development, the Domestic Labour Market and International Migration. (World Employment Programme Working Paper WEP 2-26/WP 28). Geneva:ILO

-. 1978b. The Sultanate of Oman: International Migration Project Country Case Study. Durham: University of Durham, Department of Economics.

-. 1979. Aspects of International Labor Migration in the Arab Near East: Implications for USAID Policy. Washington, D.C.: USAID (Contract No. AID/ne-c-1593) xii + 132 pp.

Cordes, R. and F. Scholz. 1980. Bedouins, Wealth, and Change: a Study of Rural Development in the United Arab Emirates and the Sultanate of Oman. Tokyo: United Nations University. ii + 65 pp.

Dostal, W. 1967. Die Beduinen in Südarabien. Eine ethnologische Studie zur Entwicklung der Kamelhirtenkultur in Arabien. Wiener Beiträge zur Kulturgeschichte und Linguistik, Bd. XVI. 199 pp.

Dostal, W. 1972. The Shihuh of northern Oman: a contribution to cultural ecology. Geographical Journal 138(1):1-7.

Farrag, O.L. 1979. Basic Services/Community Development in Oman: Project Progress Report. Abu Dhabi: United Nations Children's Fund, UNICEF Gulf Office. 56 pp.

El-Mallakh, R. 1972. Economic requirements for development, Oman. Middle East Journal 26(4):415-427.

Scholz, F. 1976. Entwicklungstendenzen im Beduinentum der Kleinen Staaten am persischen/arabischen Golf - Oman als Beispiel. Mitteilungen der Österreichischen Geographischen Gesellschaft. Bd. 118(1) pp. 70-108.

-. 1977a. Die beduinischen Stämme im östlichen Inner-Oman und ihr Regional-Mobilitäts-Verhalten. Sociologus 27(2):97-133.

-. 1977b. Sultanat Oman: Ein Entwicklungsland im Südosten der Arabischen Halbinsel. Die Erde 108(1-2):23-74.

-. 1978. Ziele und Ergebnisse der wirtschaftlichen und wirtschafträumlichen Entwicklung in den "kleinen" arabischen Erdölförderländern - Oman als Beispeil. Die Erde 109(3-4):493-514.

Sultanate of Oman. 1974. Volume of Laws in Application for 1973 (Arabic). Musqat: Ministry of Interior and Justice, Directorate of the Official Gazette.

United Nations. Department of International Economic and Social Affairs. 1978. National Experience in the Formulation and Implementation of Population Policy, 1960-1976: Oman. New York: U.N. Department of International Economic and Social Affairs. 29 pp.

U.S.AID. 1980a. All Data Currently Available on Oman. Washington, D.C. U.S. AID, DS/DIN/ESDS, 10/21/80.

-. 1980b. Oman Joint Commission Trip Report, A.I.D. TDY Team Visit June 17-July 2, 1980. Washington, D.C.: USAID. Mimeographed ii + 65 pp., app.

Wilkinson, J.C. 1980. Changes in the structure of village life in Oman. In Social and Economic Development in the Arab Gulf (T. Niblock, ed.) London: Croom Helm. pp. 122-134.

World Bank. 1977. Oman - Transformation of an Economy. Vol. I: Main Report; Vol. II: Main Secteral Development; vol. III: Statistical Annex; Washington, D.C.: IBRD,

-. 1979. Oman: Current Economic Position and Prospects. Washington, D.C.: World Bank; Report No. 2528-OM. v + 79 pp.