Terrestrial environments

of Abu Dhabi Emirate, United Arab Emirates

هيئة البيئة - أبوظبي
Environment Agency - ABU DHABI

مبادرة ابوظبي العالمية للبيانات البيئية
Abu Dhabi Global Environmental Data Initiative

terrestrial environments

of Abu Dhabi Emirate, United Arab Emirates

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- البيانات
- الأدوات والأساليب
- التوعية
- بناء القدرات
- السياسة

الأوراق القطاعية

خلال السنوات الماضية قامت مختلف القطاعات المعنية بشؤون البيئة بتجميع كم من المعلومات المتنوعة بعدة صور تصف ما هو معروف عن البيئة في إمارة أبوظبي ودولة الإمارات العربية المتحدة والخليج العربي. خلال المرحلة الأولى لمبادرة أبوظبي العالمية للبيانات البيئية، تم تنظيم سلسلة من ورش العمل في عام ٢٠٠٥ لجمع المعنيين من هذه المنظمات ، لتحديد القطاعات ذات الصلة، ووضع إطار العمل لكل ورقة قطاعية، ومعالجة الاحتياجات الاجتماعية والاقتصادية والبيئية الرئيسية في إطار كل القضايا المتعلقة في القطاع . من خلال هذا الورش، تم إعداد ثماني ورقات لقطاعية ونشرها:

- التلوث وإدارة النفايات
- القوانين والسياسات البيئية
- الموارد المائية
- الجغرافيا الطبيعية لإمارة أبوظبي
- البيئة البحرية والساحلية
- التراث التاريخي والأثري والثقافي
- التطور الاقتصادي والسكاني
- التعليم والتوعية البيئية

وتم إعداد قطاع إضافي كجزء من البرنامج الأصلي، ومع ذلك، وسيتم نشرها للمرة الأولى كجزء من المرحلة الثانية:

- البيئات البرية وموارد الأرض

و لأن الأوراق القطاعية هي مجموعة من أفضل المعارف المتاحة المتعلقة بالقطاعات البيئية والاجتماعية-الاقتصادية الرئيسية وتمثل أساس كافة المخرجات التي سيتم إصدارها لاحقا كجزء من المرحلة الثانية للمبادرة، تم مراجعة الأوراق القطاعية الأصلية. وتم خلال ورشة العمل الدولية التي عقدت في عام ٢٠٠٧ تحديد ما يلي:

- بشكل عام، تم إعداد الأوراق القطاعية الأصلية بشكل جديد قدم فيها مجموعة قيمة من المعلومات
- لم تصل مشاركة الشركاء والجهات المعنيين إلى الحد المخطط له
- تم أعداد الأوراق القطاعية بدون دعم كافي من الهيئة أو الشركاء والجهات المعنيين، وبالتالي، كان على مؤلف الورقة القطاعية تحمل عبء إعداد ورقة هذا القطاع في وقت زمني محدود نوعا ما
- في بعض الحالات كانت البيانات المستخدمة قديمة نسبيا
- لم يتم إضفاء الطابع المؤسسي على عملية جمع البيانات وتبادلها

تهدف مراجعة المبادرة في إطار المرحلة الثانية إلى معالجة هذه الثغرات، فضلا عن غيرها من الثغرات التي تم تحديدها كجزء من الأوراق الأصلية. ولأن تنفيذ مهمة فرق العمل تم كجزء من المرحلة الثانية من البرنامج، فقد تم تقديم الدعم على جميع المستويات لمساعدة موظفي هيئة البيئة – أبوظبي والشركاء والجهات المعنية على معالجة وتحديد الثغرات، وجمع البيانات وإجراء التحليلات وتطوير مخرجات البيانات المكانية، وبناء العلاقات مع الشركاء والجهات المعنيين، وفي نهاية المطاف ، إعداد الورقة القطاعية وتنقيحها.

وتشكل الأوراق القطاعية مصدرا قيما للمعلومات البيئية والاجتماعية والاقتصادية لأبوظبي وتم استخدمها لمراجعة وتنقيح تقرير حالة البيئة لإمارة أبوظبي فضلا عن إعداد الأطلس البيئي لأبوظبي (النسختين المطبوعة والتفاعلية).

ولمزيد من المعلومات حول المبادرة أو للوصول لنسخة الكترونية من الأوراق القطاعية، يرجى زيارة الموقع الإلكتروني في www.agedi.ae.

ما هي مبادرة أبوظبي العالمية للبيانات البيئية ؟

تم إطلاق مبادرة أبوظبي العالمية للبيانات البيئية في الثاني من سبتمبر ٢٠٠٢ خلال مؤتمر القمة العالمي للتنمية المستدامة الذي عقد في مدينة جوهانسبرغ بجنوب إفريقيا من قِبل دولة الإمارات العربية المتحدة، كمبادرة شراكة من الصنف الثاني، لتكون أداة مبتكرة لتنفيذ الأحكام المتعلقة بالبيئة والواردة في الفصل ٤٠ من جدول أعمال القرن ٢١ وفي الأهداف الإنمائية للألفية.

وفي أوائل عام ٢٠٠٧ ، نظمت بأبوظبي ورشة عمل دولية لاستعراض الانجازات التي حققها برنامج المبادرة ووضع خطة إستراتيجية لمدة خمس سنوات. وعلى هذا النحو، بدأت المرحلة الثانية من المبادرة في عام ٢٠٠٨ بناءا على ما تم انجازه في المرحلة الأولى، في حين تم معالجة الفجوات التي تم تحديها من خلال المعلومات التي وفرتها الجهات المعنية خلال ورشة العمل.

ولا تزال الرؤيا التي تعمل وفقها المبادرة في المرحلة الثانية هي "وضع وتنفيذ نماذج عملية يمكن تكرارها وتكييفها من أجل إنشاء هيكل أساسي للبيانات البيئية المكانية عالية الجودة، للمساهمة في توفير القاعدة العلمية لاتخاذ القرارات". وسيتم في المرحلة الثانية استخدم الدروس المستفادة لتحقيق نجاح أفضل في تنفيذ المبادرة في مرحلته الثانية.

وسيركز البرنامج الحالي على وضع سلسلة من المخرجات التي تتناول قضايا محددة في حين يتم تحقيق نتائج مؤسسية معينة، بما في ذلك:

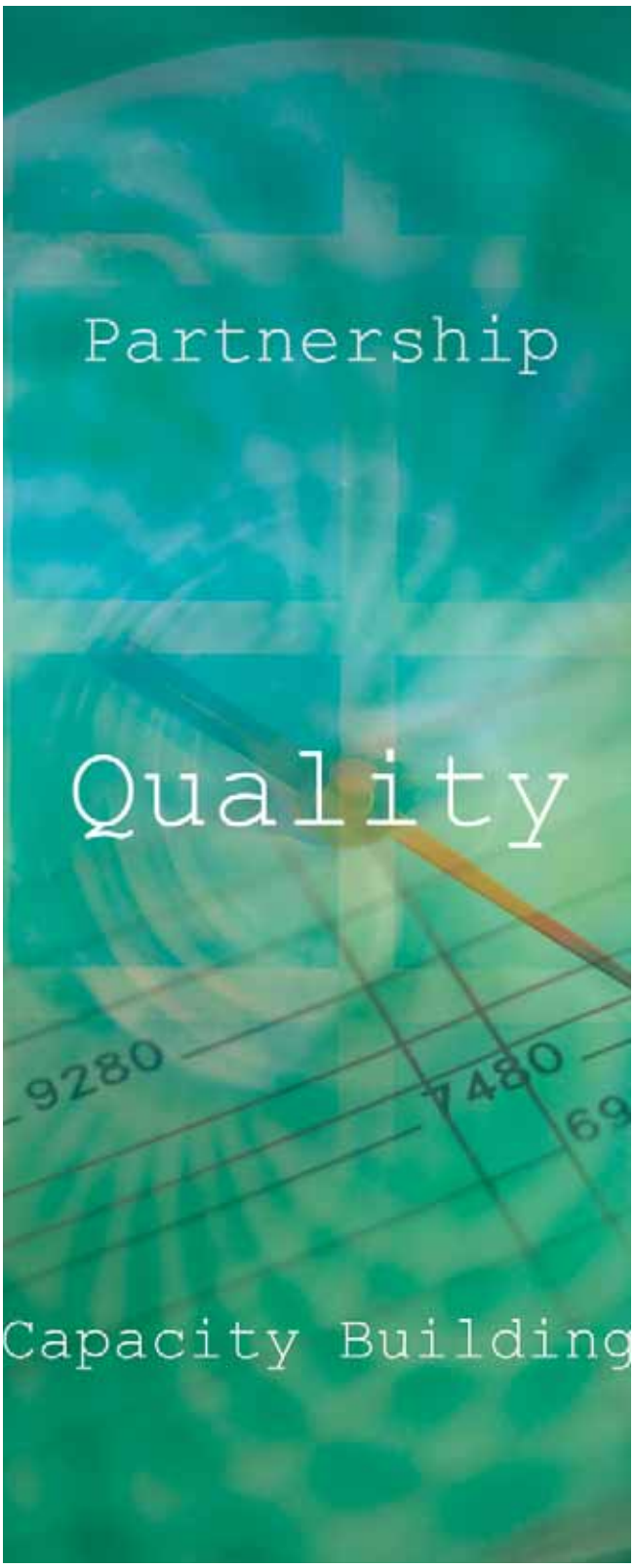
١. توفير بيانات بيئية أكثر جودة
٢. تحديد الثغرات في البيانات والأولويات
٣. تنسيق أقوي وشراكات لتبادل البيانات
٤. أساليب وأدوات أفضل للمعلومات
٥. ربط الإستراتيجية والتشغيل بشكل أفضل
٦. تحسين البنية التحتية البشرية والتقنية
٧. مؤسسة أقوي بشكل عام

والمخرجات التي تم تحديدها في إطار عملية التنمية هي أمور مترابطة ومتعاقبة مع المخرجات الأولية لدعم المعلومات والتفاهمات التي تصب في الأنشطة اللاحقة. وهي تشمل ما يلي :

- مراجعة الأوراق القطاعية وقاعدة المعرفة
- مراجعة وتنقيح تقرير حالة البيئة
- الأطلس البيئي التفاعلي
- تعزيز بوابة البيانات المكانية
- تحسين الموقع الالكتروني
- مؤشر الأداء الحكومي لابوظبي
- برامج وضع الإستراتيجية

ولضمان تحقيق نتائج ايجابية وتوفير الموارد التقنية الكافية للقيام بتطوير المخرجات، تم إنشاء مجموعة من فرق العمل بهدف تجميع الموارد لدعم فرق كل مخرج من المخرجات المبادرة. وتشمل هذه ما يلي :

What is AGEDI ?



The Abu Dhabi Global Environmental Data Initiative (AGEDI) program was fashioned around the United Nations World Summit for Sustainable Development (WSSD) Type II Partnership in 2002 as a tool to support the environmental provisions of Chapter 40 of Agenda 21 and the Millennium Development Goals.

In early 2007, an international workshop was conducted in Abu Dhabi to review the accomplishments of the AGEDI program and develop the next five year strategic plan. As such, AGEDI Phase II began in 2008 building off the accomplishments of the initial phase, while addressing gaps identified through stakeholder input during the workshop.

The vision of AGEDI Phase II remains to be a "replaceable, networked, adaptive and working model for the development and use of high quality spatial environmental data by all users within the Emirate of Abu Dhabi that will support sustainable decision and policy making." Phase II will use lessons learned to better guide the successful implementation of AGEDI in its second phase.

The focus of the current program is to develop a series of interrelated products that address specific issues while achieving certain institutional outcomes, including:

1. Better current and quality environmental data
2. Identification of data gaps and priorities
3. Stronger coordination and data sharing partnerships
4. Better information methods and tools
5. Better links between strategy and operation
6. Improved human and technical infrastructure
7. Stronger organization overall

The specific products under development are interdependent and sequential, with early products yielding information and understandings that feed into subsequent activities. These include the following:

- Sector Paper Review and Knowledgebase
- SoE Review and Refinement
- Environmental Atlas
- Interactive Environmental Atlas
- Geospatial Portal Enhancement
- Website Refinement
- EPI for Abu Dhabi
- Programs Alignment Strategy

To ensure positive outcomes and adequate technical resources for carrying out the product development, a series of task forces were established as pooled resources to support each product team. These include:

- Data
- Tools and Methods
- Outreach
- Capacity Building
- Policy

Sector Papers

Over the years, different organizations compiled a variety of information in many forms that describe what is known about Abu Dhabi, the UAE and the Arabian Gulf Region. Through the initial AGEDI phase, a series of workshops were developed in 2005 to bring together stakeholders from all these organizations, identify the sectors that were relevant, design a framework for each Sector Paper, and address the key environmental and socioeconomic issues relevant under each sector. Through this effort, eight Sector Papers were completed and published:

- Waste Management and Pollution
- Environmental Policy and Regulation
- Water Resources
- Physical Geography
- Marine and Coastal Environment
- Paleontological and Archaeological Resources
- Population, Development and Economy
- Environmental Education and Awareness

One additional sector was scoped as part of the original program, however, will be published for its first time as part of AGEDI Phase II:

- Terrestrial Environment

Because the Sector Papers are a collection of the best available knowledge pertaining to key environmental and socioeconomic sectors and serve as the basis for all subsequent products to be developed as part of AGEDI Phase II, a review of the original Sector Papers was conducted. Already known through the international workshop held in 2007 was:

- Overall, the original papers were done well and provided a wealth of information
- Stakeholder participation did not reach the level originally intended
- Sector Papers were developed without much agency or stakeholder support, and therefore, became the burden of the Sector Paper authors under a fairly limited timeframe
- Data used was outdated in some cases
- Data collection and sharing did not get institutionalized

The review under AGEDI Phase II sought to address these gaps, as well as the other gaps already identified as part of the original papers. Because the Task Forces were implemented as part of the Phase II program, support was provided at all levels to assist EAD staff and stakeholders in addressing and identifying gaps, collecting data, conducting analyses and developing spatial products, building stakeholder relationships, and ultimately, developing a refined Sector Paper.

The Sector Papers are a source of valuable environmental and socioeconomic information for Abu Dhabi and were used to review and refine the State of the Environment (SoE) report for Abu Dhabi as well as develop the Abu Dhabi Environmental Atlas (both hard-copy and interactive versions).

For more information and online versions

For more information about AGEDI or to access online versions of the Sector Papers, please visit the AGEDI website at www.agedi.ae

ويتمثل الهدف الرئيسي للمبادرة في تعزيز القدرة على جمع وتقييم وإدارة البيانات البيئية في إمارة أبوظبي، الأمر الذي سيؤدى إلى زيادة إسهام البيانات في تحسين السياسات وصناعة القرارات البيئية.

وفي إطار هذه المبادرة، تكفلت هيئة البيئة - أبوظبي بإعداد سلسلة من الدراسات الفنية لجمع معلومات عن العناصر الأساسية للبيئة في صورة «أوراق عمل قطاعية» تشمل (٩) قطاعات بيئية واقتصادية واجتماعية. وهذه الورقة، التي تركز على البيئة البرية للإمارة، هي واحدة من هذه الأوراق القطاعية التسع في حين تغطي الأوراق الأخرى القطاعات التالية: الموارد المائية؛ التطور الاقتصادي والسكاني؛ الموارد البحرية والساحلية؛ النفايات والتلوث؛ الجغرافيا الطبيعية؛ التراث التاريخي والأثري والثقافي؛ التعليم والتوعية البيئية؛ القوانين والسياسات البيئية.

وتوفر هذه الأوراق القطاعية المدخل الرئيسي لإعداد تقارير عن حالة البيئة والتي ستقوم الهيئة بتحديثها بشكل منتظم. وتهدف هذه التقارير إلى تسليط الضوء على الاتجاهات السائدة في الأداء البيئي وتقييم التأثيرات الواقعة على البيئة. وتعتبر العملية المستمرة لجمع وتحليل وتفسير ونشر البيانات والمعلومات البيئية وسيلة فعالة تمكن صناع القرار من رصد التغيرات في الظروف البيئية، وتحديد درجة فعالية السياسات والبرامج، ومقارنة أداء إمارة أبوظبي مع الدول والبلدان الأخرى.

البيئات البرية وموارد الأرض


Photo by HABITAT

تقدم هذه الورقة وصفاً للبيئات الغنية والمتنوعة والموائل الطبيعية لإمارة أبوظبي والمجموعة الكبيرة من الأنواع النباتية والحيوانية التي تعيش فيها. وبالرغم من الظروف المناخية القاسية، التي تتميز بدرجات حرارة مرتفعة جداً، وهطول الحد الأدنى من الأمطار، والرياح الجافة المستمرة، والتربة الصخرية والرملية والمالحة، إلا أن أبوظبي لا تزال موطناً لحوالي ٠٠٤ نوع من النباتات الوعائية، و ٠٥ نوعاً من الثدييات و ٦١٤ نوعاً من الطيور و ٥٥ نوعاً من الزواحف، وحوالي ٠٠٠٤-٠٠٠٥ نوع من اللافقاريات. وتعيش هذه النباتات والحيوانات في مجموعة من البيئات الطبيعية والاصطناعية التي تسبب الإنسان في تكوينها والتي تشمل الموائل الساحلية والداخلية، والسبخات، والكثبان الرملية والبحار والجبال والأودية وواحات المياه العذبة، والعديد من البيئات الفريدة في المنطقة. وبالإضافة إلى الجمال الطبيعي والفوائد الكامنة في التنوع البيولوجي الغني، فلنباتات وحيوانات أبوظبي قيمه عالية بسبب استخداماتها الاجتماعية والاقتصادية المتعددة، والتي تشمل على سبيل المثال، الطب، والاحتفالات الثقافية والسياحية والترفيهية. ومع ذلك، فأبوظبي، كغيرها من الدول سريعة النمو، تعاني من مخاطر جمة على صحة وسلامة عناصر محددة من البيئة البرية الطبيعية، بالإضافة إلى تزايد المخاطر التي تهدد بتعرض هذه البيئات للتغير، أو التدهور، أو في بعض الحالات القصوى التدمير بشكل يصعب معه استعادتها إلى حالتها الطبيعية.

ويعود تدهور أو فقدان الموائل والأنواع لأسباب عديدة، وقد حددت هذه الورقة بعض أهم هذه الأسباب والتي تشمل النمو السكاني السريع وما يرتبط به من التنمية الحضرية والصناعية والزراعية، والإفراط في استغلال الموارد الطبيعية (الإفراط في الرعي، واستخراج المياه الجوفية والترفيه). فالاستمرار والبقاء في البيئة الطبيعية القاسية لأبوظبي يعتبر تحدياً كافياً لنباتات وحيوانات الإمارة، إلا أن أكثر المخاطر التي تهدد بقاء واستدامة الموارد الأرضية ونبات وحيوانات المنطقة هي من صنع الإنسان.

ومن العوامل التي تجعل من الصعب اتخاذ إجراءات عملية وفعالة لحماية هذه الموارد هو عدم وجود معلومات - فبكل بساطة لا نعرف ما يكفي عن أنواع النباتات والحيوانات والبيئات التي تعيش فيها، أو العوامل والظروف التي تشكل ضغطاً على هذه الموائل. وللمساهمة في التصدي لهذه الفجوة في المعلومات والبيانات، أطلقت هيئة البيئة - أبوظبي مبادرة أبوظبي العالمية للبيانات البيئية في مؤتمر القمة العالمي للتنمية المستدامة في جوهانسبرغ في عام ٢٠٠٢. وكانت هذه المبادرة أول مبادرة شراكة من الصنف الثاني في العالم العربي.

TERRESTRIAL ENVIRONMENT SECTOR PAPER

EXECUTIVE SUMMARY

Photo by HABITAT

This paper describes Abu Dhabi's rich and diverse natural habits and the wide range of plant and animal species that thrive in them. In spite of its harsh physical conditions, characterized by exceedingly high temperatures, minimal rainfall, persistent drying winds and rocky, sandy, saline soils, Abu Dhabi is still home to approximately 400 species of vascular plants, 50 species of mammals, 416 bird species, 55 species of reptiles, and between 4,000 and 5,000 species of invertebrates. These plants and animals co-exist in a range of natural and man-made habitats that include coastal and inland sabkha (salt flats), sand seas and dunes, mountains and wadis and freshwater oases, several of which are unique to the region. In addition to the natural beauty and benefits inherent in rich biodiversity, Abu Dhabi's flora and fauna are valued for a range of social and economic uses in, for example, medicine, cultural ceremonies and tourism and recreation. However, in common with most of the world's developed states, and especially in those that are growing as rapidly as Abu Dhabi, the health and viability of certain elements of the emirate's natural terrestrial environment are under strong and increasing threat of being altered, damaged and, in some extreme cases, irreversibly destroyed.

Degradation or loss of habitats and individual species has many causes, and this paper identifies rapid population growth and associated urban, industrial and agricultural development, excessive exploitation of natural resources (over-grazing, groundwater extraction and recreation) and a weak regulatory framework as being among the most significant. Surviving in Abu Dhabi's harsh natural environment is challenging enough for the emirate's plants and animals, but by far the most serious threats to the viability and sustainability of the region's terrestrial flora and fauna are man-made.

One factor that makes it particularly difficult to prescribe effective and practical conservation measures is lack of information – we simply do not know enough about the plant and animal species that live here, the habitats in which they live, or the conditions and circumstances that are putting pressure on those habitats. To help address this data and information gap, the Environment Agency - Abu Dhabi (EAD) launched The Abu Dhabi Global Environmental Data Initiative (AGEDI) at the World Summit on Sustainable Development in Johannesburg in 2002. AGEDI was the first Type II Partner ship Initiative in the Arab world.

The primary objective of AGEDI is to strengthen and enhance Abu Dhabi Emirate's local capacity to collect, analyze and use multi-sectoral environmental data and information to improve the decision-making process. Under AGEDI, EAD has undertaken to prepare a series of technical papers that will present the most complete and up-to-date information about conditions, issues and opportunities in 9 different environmental sectors. This paper, which focuses on the emirate's terrestrial environment, is one of those 9 sector papers. The other 8 cover the following sectors: water resources; population, development and economy; marine and coastal resources; waste and pollution; physical geography; paleontology and archaeology; environmental education; and policies and regulations. The 9 sector papers provide basic input for the preparation of State of the Environment reports (SOE) which EAD will update on a regular basis. The main purposes of developing SOE reports are to highlight trends in environmental performance and assess how well impacts on the environment are being managed. The continuous process of collecting, analyzing, interpreting and publishing environmental data and information is a valuable mechanism through which decision-makers can monitor changes in environmental conditions, review the effectiveness of policies and programs, and compare the performance of Abu Dhabi against that of other states and countries.

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1 INTRODUCTION


Photo by HABITAT

Abu Dhabi is one of 7 emirates that together comprise the United Arab Emirates (UAE). The emirate is situated in the Eastern corner of the Arabian Peninsula. It overlooks the Gulf of Oman to the East and the Persian Gulf to the North. The Persian Gulf and the Gulf of Oman are linked by the Hormuz Strait. UAE is bounded by the Persian Gulf to the north, Sultanate of Oman and Saudi Arabia to the south, the Gulf of Oman and Sultanate of Oman to the east, and Qatar and Saudi Arabia to the west. The UAE is located between latitudes 22 degrees and 26.5 degrees north, and longitudes 51 degrees and 56.5 degrees east. Map 1 shows the location and major features of Abu Dhabi. The UAE is a Federal country that was created on the 2nd of December, 1971. The federation comprises seven Emirates: Abu Dhabi, Dubai, Sharjah, Ajman, Umm Al Quwain, Ras Al Khaimah and Fujairah. The seven Emirates vary in terms of size, population, economic resources and degree of development. UAE covers a total area of 83,600 km2.

Abu Dhabi is the largest of the seven Emirates, with an area of 67,340 km2 excluding the islands, constituting 86.67% of the UAE total area. Dubai is the second largest Emirate in UAE and Ajman is the smallest Emirate with an area of only 259 km2. Table 1.1, describes the total UAE area distribution among the seven emirates.

Table 1-1: Land Area of Emirates of UAE

Emirate	Area in Sq Km	% of UAE area
Abu Dhabi	67,340.0	86.67
Dubai	3,885.0	5.00
Sharjah	2,590.0	3.33
Ajman	259.0	0.33
Um Al Quwain	777.0	1.00
Ras Al Khaimah	1,683.5	2.17
Fujairah	1,165.5	1.50
Total Land Areas (Excluding Islands)*	77,700.0	100.00
UAE Total Area	83,600.0	

Source: Ministry of Economy - Planning Sector

* Area of islands is 5,900 Sq. Km.

The population of the UAE has been growing in leaps and bounds, from 2.41 million in 1995 (Ministry of Planning) to 3.77 million in 2005 (official 2005 Census website at http://www.tedad.ae/english/index.html). Of this total, Abu Dhabi's population rose from 942,463 in 1995 to 1,292,119 in 2005. During this 10 year period, growth in the UAE has averaged 7.9% annually.

The climate of the region is bi-seasonal, characterised by high temperatures and low rainfall. The summers (May to October) are distinctly hot, with daytime temperatures regularly exceeding 40 °C. Rainfall occurs occasionally during the summer, but is generally restricted to the cooler winter months (November to April) when temperatures can drop to 4 °C in some areas at night (and even lower in the mountains).

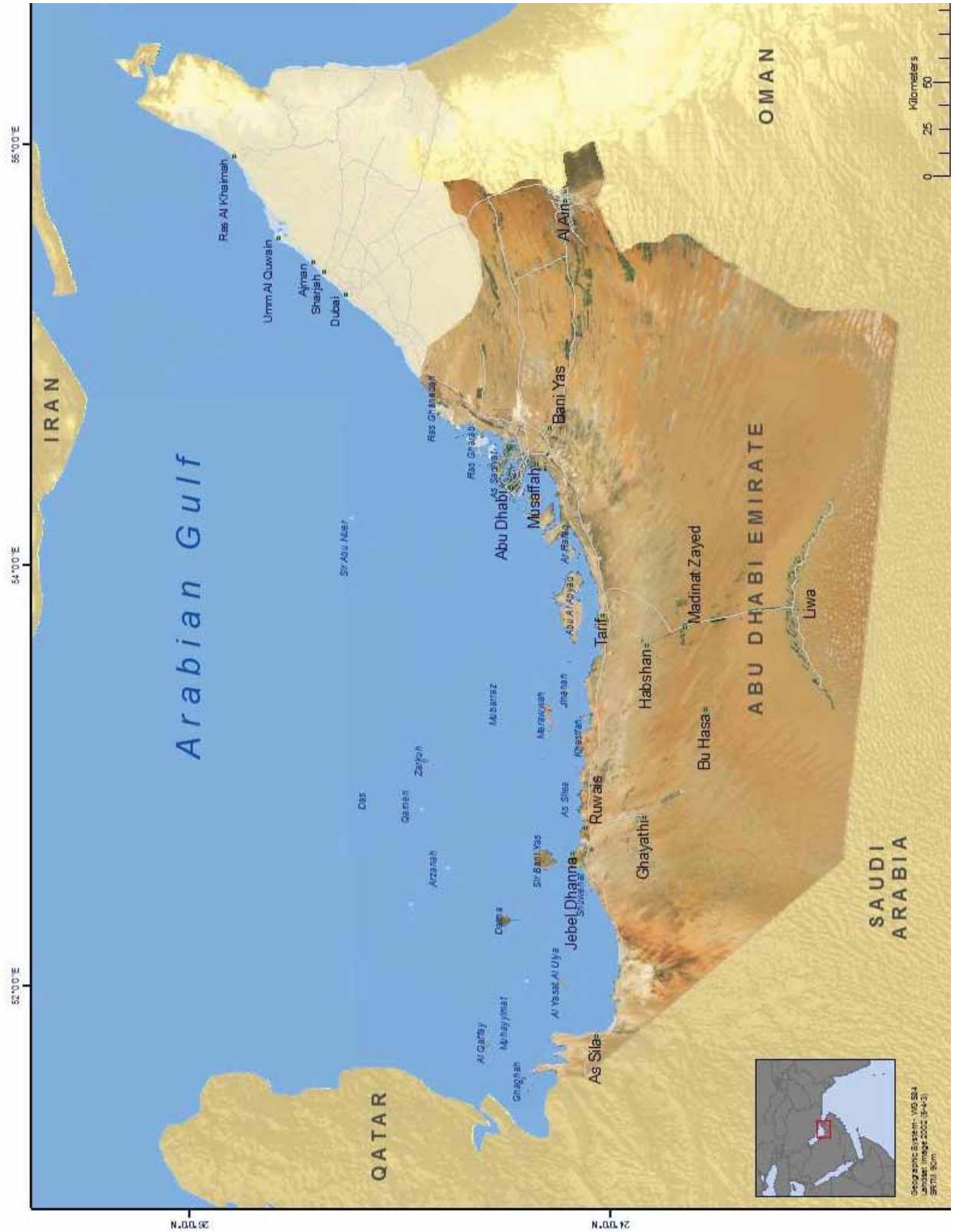
Annual rainfall amounts vary according to location, but precipitation generally decreases from north-east to south-west. The mountainous areas receive most rainfall (long-term annual mean of about 154 mm in Masfut, ranging from 4 to 479 mm), about 80 mm in coastal areas such as Abu Dhabi and Dubai, but substantially less in more western and southern parts of the country.

The landscape of Abu Dhabi is dominated by low-lying, sandy desert and salt flats (sabkhas). To the east of the Emirate, the Hajar Mountains rise sharply above the surrounding landscape to an elevation of about 2,000 m. The natural landscape of region includes wide range of terrestrial habitat types, and these can be broadly classified as follows: inland sand sheets and dunes, piedmont alluvial and interdunal plains, mountains and wadis, coastal sand sheets with dwarf shrub vegetation, coastal and inland sabkha. Important anthropogenic habitat types, such as oases, farmland, forestry plantations and urban areas account for a relatively small proportion. These major habitat types can often be further subdivided into more specialised ones, each with their own specific abiotic features, vegetation and fauna.

The natural heritage of Abu Dhabi is being threatened by urbanization, infrastructure development, population growth, and over-grazing which are all resulting in habitat loss and degradation, species loss and the depletion of groundwater resources.

This sector paper is one of 9 sector papers that EAD has produced. Other sectors covered by the series include marine and coastal, physical geography, waste and pollution, policy and regulation, population, development and economy, paleanthology and archaeology, and environmental education. The Terrestrial Environment sector paper describes the natural habitats, flora and fauna of Abu Dhabi Emirate. It also identifies the main issues and problems that are threatening the natural heritage of Abu Dhabi Emirate on the one hand, and the policy, legislation and conservation management efforts that are being adopted to fight those threats. At the same time the paper provides a general framework for future conservation measures and makes recommendations that hopefully will contribute to future local and national conservation efforts. All 9 sector papers are contributing to the State of the Environment process as part of the Abu Dhabi Global Environmental Data Initiative (AGEDI).

Map 1: Reference map of Abu Dhabi



2 NATURAL HISTORY AND HUMAN SETTLEMENT

Photo by HABITAT

The early history of the formation of the landscape of Abu Dhabi emirate is witnessed by both palaeontological and archaeological evidence. For a more detailed description see the AGEDI sector paper on Palaeontology and Archaeology by Beech and Hellyer, 2006.

A wide variety of palaeontological sites exist within Abu Dhabi emirate. Cretaceous fossils (dating between 144 and 66.4 million years ago) consist of marine fossils such as sea urchins, shells and corals. These are principally found in the area of Jebel Hafit in the Eastern Region. These indicate that marine deposits covered the area at that time.

Late Miocene fossils (dating to around 6-8 million years ago) are located within the Baynunah formation along the coast and interior of Abu Dhabi emirate between Rumaitha in the east to Jebel Barakah in the west (Whybrow & Hill, 1999; Beech & Hellyer, 2005). Recent work in early 2006 at Umm al-Ishtan and close to Bida al-Mutawa demonstrates that the Baynunah Formation extends further west and south than originally determined by earlier palaeontological research. Fossils have been discovered from a large number of sites. Animals represented include freshwater molluscs, freshwater catfish, freshwater turtles and terrestrial tortoises, crocodiles and birds (including ostrich, egret and darter). Largest amongst the fossil mammalian remains are bones from proboscideans/elephants (mainly from the four-tusked *Stegotetrabelodon syrticus*, together with a type of Mastodon and Deinothere). The odd-toed ungulates include two species of primitive three-toed horse (*Hipparion*) and a rhinoceros. Even-toed ungulates include pigs, hippopotami, cattle, antelopes, gazelle and giraffe. Carnivore fossils included sabre-toothed cat, hyena and wolverine. Other animals represented include an Old World monkey, a new gerbil species named *Abudhabia baynunensis*, a cane rat, a jerboa, an Old World rat and an undetermined shrew.

Together, these fossils demonstrate that Abu Dhabi was once a land of fertile plains within which broad rivers flowed through savannah grasslands, the plains being dotted with acacia trees, somewhat akin to modern day East Africa.

In addition to the fossil bearing sites, a series of track way sites have also been recently identified at Mleisa, Niqa and Bida al-Mutawa (Higgs, Gardner & Beech, 2005). These track ways have hundreds of footprints made by some type of proboscidean, as well as other animals, in the case of the Niqa site. Further study of these sites is required but initial investigations suggest that they too may date to the Late Miocene period.

Pleistocene marine fossils have been identified in the form of fossil mangrove pneumatophora, present in some coastal areas and on offshore islands. Fossil corals have also been identified on the island of Marawah. Some of these relate to periods of higher sea-levels in the past.

The Arabian Gulf is a comparatively shallow modern sea which has only filled up since around 18,000 years ago. Prior to that, it was a shallow basin with a river valley running down its eastern side, parallel to the modern day Iranian coastline. This means that many old archaeological sites are probably masked or destroyed by the inundation of the Gulf. Although archaeological stone artifacts, of probable Palaeolithic date, have been identified elsewhere in the United Arab Emirates, in Sharjah, (as well as elsewhere in Arabia), they have not been identified with any certainty in the Emirate of Abu Dhabi.

The earliest archaeological sites so far known within Abu Dhabi date to the early Holocene period, about 7,500 years ago. This period is known as the Late Stone Age, Neolithic or Ubaid period, and dates from around 7,500 years ago up until just over 5,000 years ago (5500-3200 BC). Traces of these early inhabitants of Abu Dhabi can be found on the coast and islands, as well as the desert interior. Key coastal sites include sites MR1 and MR11 on Marawah Island and site DA11 on Dalma Island (Beech et al. 2005; Flavin & Shepherd, 1994; Beech & Elders, 1999). Ubaid pottery is known from these sites, a clear sign of contacts with southern Mesopotamia at that time, or at least with traders in the central Gulf, who were themselves in contact with Ubaid cultural groups. The economy of these sites was based primarily on the exploitation of marine resources, although the communities also kept domestic animals such as sheep and goat (Beech, 2004).

Key Neolithic sites located in the desert interior can be found in the Umm az-Zamul region (Kallweit et al., 2005). These are aceramic but have substantial lithic assemblages and stone structures focused in particular locations. As known elsewhere in the Rub al-Khali, these may relate to settlement activities adjacent to ancient lakes which the Neolithic pastoral nomads exploited on a regular basis.

Little evidence of fourth millennium BC occupation has been found on the coast and islands of Abu Dhabi. The Hafit period (3200-2600 BC) is named after the well-built stone tombs present in their hundreds on the slopes of Jebel Hafit near Al Ain, and the Hajar Mountains of neighbouring Oman. Pottery found within these tombs includes small painted vessels of a type known as Jemdet Nasr. This is an archaeological site located near Babylon in southern Iraq, famous for its polychrome pottery which was produced in the late 4th millennium BC. The main evidence for this period in Abu Dhabi has so far been found well inland, although a few possible Hafit-type pottery sherds have been identified close to Abu Dhabi Airport. It is striking that a completely different picture emerges from coastal settlements on the coastline of Oman. Here there is abundant evidence for coastal occupation during the fourth millennium BC with extensive coastal shell middens from Ra's al-Hamra to Ra's al-Hadd and beyond. The archaeology of this period in the Gulf has been referred to by some authors as the "Dark Millennium". It seems that a marked climatic deterioration caused dramatic changes of subsistence and settlement patterns in the Gulf around 4000 BC.

Some time in the late Fourth Millennium BC, however, knowledge of a major technological innovation arrived in the region, that of how to mine and smelt the copper ores found in the Hajar mountains. This marked the beginning of the local Bronze Age. The most important Bronze Age site located in the coastal region of Abu Dhabi is on the island of Umm al-Nar, situated just to the east of Abu Dhabi Island (Frifelt 1992, 1995). This type site gives its name to the chronological period known as Umm al-Nar (2600-2000 BC). The port of Umm al-Nar acted as a terminal for copper exports to Mesopotamia. Evidence of the Umm al-Nar civilisation has subsequently been discovered throughout the UAE and northern Oman.

Within the interior, the most important group of archaeological sites dating to the Bronze Age is found in Hili, just to the north of the centre of Al Ain. During the second half of the 3rd millennium BC (2500 - 2000 BC) the inhabitants of Southeast Arabia lived in sun-dried mud-brick houses and buried their dead in stone-built collective graves. The site designated as Hili 1, located next to the Grand Tomb, was once a high tower, standing several metres above the ground. This building had a thick circular wall embracing several rooms which were served by a well located in the centre of the structure. It was surrounded by a moat. A similar building, known as Hili 10, with a central well was also discovered near the main entrance of the park. A third building, known as Hili 8, located outside the south eastern corner of the park wall, was excavated by a French team (Cleuziou 1989). It seems to have had the same or an even more important role. This period marks the beginning of settled life and farming in the oases.

Collective tombs from the Umm an Nar period dating to the second half of the 3rd millennium BC are known today at many sites in the UAE, but most importantly at both Hili and the island of Umm al-Nar. At Hili, there are three tombs

inside the park and several others outside. Hili Grand Tomb, located in the middle of the park, is over 4000 years old and was probably in use for two or three hundred years. Evidence from collective graves from the same period in the region indicates that hundreds of people would have been buried here over a long period of time. A particularly interesting discovery at the Hili site was the existence of a pit-grave, known as Tomb N, adjacent to one of the smaller above ground circular tombs. This was found to contain many objects such as pottery, stone vessels and ornaments, all dating to the very end of the third millennium BC. Tomb N contained perhaps as many as six hundred individuals, buried over a period of 100 to 200 years.

Another important site located in the eastern region of Abu Dhabi emirate is Bida Bint Saud. This is situated to the north of Hili, some 25km from the city of Al Ain. The high rocky plateau rises some 40m above the surrounding area. A number of Hafit, Umm al-Nar and Iron Age graves have been also excavated here. A large public mud-brick building has been excavated here dating to around three thousand years ago. It is thought that this may have served as a place to control the distribution of water since about 150m south of this building a falaj (underground water tunnel) was discovered and partly excavated. A second falaj has also been discovered in the same region. The existence of both falajes indicates that the area of Bida Bint Saud played a major role in the history of the Eastern Region of Abu Dhabi. The discoveries also provide important evidence that the falaj system was indigenous to the region, being introduced during the Iron Age some 3000 years ago (Al-Tikriti, 2002).

Evidence of occupation during the middle Bronze Age, known as the Wadi Suq period (2000-1600 BC), around 4,000 years ago, has been found on several of Abu Dhabi's islands, including Ghaghah, Sir Bani Yas, Marawah, Rufayq, Umm al-Nar and Balghelam. There is little evidence of occupation of the deserts during this period, perhaps due to climatic change, and less rainfall, and some of the islands in the Western Region may have been used as temporary way-stations or trading settlements by sailors from Bahrain (ancient Dilmun), on their way to Hormuz. Occupation in the Wadi Suq period is also attested from Al Ain, in particular from a long collective grave excavated in the 1970s in the Qattara oasis. There is, however, relatively little evidence of occupation during this period. This may be related, in part, to the fact that outwash from the Hajar Mountains may have deposited several metres of gravel and soil over other Wadi Suq sites in the Al Ain area.

Only ephemeral settlement traces from the Late Bronze Age (1600-1250 BC) have been identified on the coast and islands of Abu Dhabi, and the pattern of occupation in this region during this period is, at yet, poorly understood. Insofar as the inland areas around Al Ain are concerned, once again sites may have been covered by outwash from the mountains. Given the relative abundance in the Al Ain area of sites from the Jebel Hafit and Umm al-Nar periods, which preceded the Wadi Suq and Late Bronze Age periods, and from the Iron Age, which followed, it is considered likely that the area continued to be occupied, even if few sites have yet been identified. A falling in the water table has, however, been identified during this period, and this may have affected patterns of settlement.

The term "Iron Age" is technically a misnomer, as the inhabitants of the UAE continued to use copper rather than switching to the new metal, presumably because of the ready availability of copper in the mountains. Only sparse evidence from the Iron Age (1250-300 BC) has been found on the coastline and islands of Abu Dhabi, many appearing to be temporary campsites or way-stations relating to maritime trade, and perhaps occupied on only a seasonal basis. Many of the major Iron Age sites so far discovered in the UAE, including Rumeilah and Hili, both in Al Ain, and at Muweilah and Thuqaibah in Sharjah and Khatt in Ra's al-Khaimah, lie inland near the Hajar Mountains and supplies of subterranean water. This period coincides with the first use of 'falaj' underground water systems. The well-preserved sites in the Al Ain area, including villages, as at Rumeilah, cemeteries, as mentioned earlier at Bida Bint Saud, and a fortress, at the northern tip of Jebel Hafit, are indicative of extensive settlement, while other Iron Age sites recently discovered by interested amateurs in the sands north-east of Al Ain, as at Jabeeb, suggest that the area suitable for settlement was then larger than it was at later periods.

Important evidence of occupation during the Late Pre-Islamic period (300 BC - 300 AD) of many of Abu Dhabi's islands during the few centuries just prior to the coming of Islam has been identified. Among islands where sites from this period have been found are Abu al-Abyadh, Abu Dhabi, Balghelam, Dalma, Marawah, Qarnein, Sir Bani Yas, Yasat al-Ulya and Yasat Sufla. Inland, there are again some indications from the Al Ain area, although, once again, much evidence may be buried beneath the existing city.

One of the most important sites from the Sasanian period (300-632 AD) is located on Sir Bani Yas Island, where the pre-Islamic Christian monastery discovered during excavations in the early to mid 1990s is the only physical evidence yet known in south-eastern Arabia of the presence of Christian communities before Islam (King 1997, 1998). Excavations which took place during 1993-1996 uncovered a church

constructed within a walled monastic complex. A number of associated courtyard villas were also excavated from the surrounding area of the monastery. These all appear to have been occupied during the sixth and seventh centuries AD, being abandoned shortly after the arrival of Islam, perhaps because its inhabitants became Muslims or moved away. There is textual and archaeological evidence of the presence of the Nestorian Church in the north-east Arabian Peninsula, Mesopotamia and Iran during this period, although Sir Bani Yas is the furthest east site so far identified. A number of other Nestorian churches have been identified in the Gulf, notably at Failaka in Kuwait and Jubail in Saudi Arabia, but Sir Bani Yas is the first to be clearly identified with a related monastic settlement.

Study of the Islamic Period (750 AD to 19th century) is hampered by the lack of local written records for Abu Dhabi. Arab travelers like Ibn Battuta, Al-Idrisi and Yaqut passed through or dealt with the region but they made little reference to the UAE, apart from mentioning the major trading ports of Julfar (Ra's Al Khaimah) and Dibba. The climate of the region became increasingly arid, perhaps prompting inhabitants to turn to a semi-nomadic lifestyle that subsequently lasted for much of the period until the coming of oil in the 1960s, except in the relatively well-watered areas around Al Ain. Some earlier settlements on offshore islands, such as Yasat al-Ulya and Ghaghah, as well as on Sir Bani Yas, appear to have been abandoned by around the beginning of the Islamic period. For the bulk of the interior, no settlement, or, indeed, occupation is attested for the whole of the period from the end of the Late Stone Age until the Late Islamic period, although it continued in the Al Ain area.

One interesting site, not yet studied in detail, is located at Mantiqa al-Sirra, in the Western region, to the east of Medinat Zayed (Czastka & Hellyer, 1994). This is a large fortified settlement with apparent abandoned wells nearby, and with pottery suggesting an occupation date in the Late Islamic period. Further work is required to determine both its function and the reasons for its abandonment, although a slight harshening of the climate or reduction of the already sparse rainfall may have been responsible.

Sites have been found throughout the Emirate of Abu Dhabi dating to the Recent Islamic period (19th-20th century), although they are, not surprisingly, less common in the desert areas. The nature of the sites varies from evidence of burning and pottery scatters suggesting the presence of occasional campsites to areas of more extensive fireplaces, stone structures including outline mosques, water catchment systems, shell middens and pottery scatters which probably represent at least frequent seasonal occupation. The number of sites from this period testifies to the importance of the pearling industry in the pre-oil era. Pearling may have reached a peak in the late 18th and 19th Centuries. Among key sites is a shell midden (piles of opened and abandoned pearl oyster shells) on the island of Abu al-Abyadh which was once over three kilometres long, containing many millions of shells (Hellyer and Hull 2002). The presence of Chinese porcelain and other imported pottery on some island sites demonstrates that, besides being involved in fishing and pearling, the people also took part in regional trade and in other economic activities.

An important coastal site dating to the Later Islamic Period are the sulphur mines discovered at Jebel Dhanna (King, 2003). This complex of sulphur mines with around 150 individual mine shafts probably date to the 18th Century AD, and are the only sulphur mines known in Eastern Arabia. The sulphur was probably largely exported, for the manufacture of gunpowder.

Buildings from the recent historical period are rare on the coastline and islands of Abu Dhabi. Key sites include the Bayt al-Muraykhi (a pearl trader's house) and al-Dawsari, al-Muraykhi and al-Muhannadi mosques in Dalma town on Dalma Island. The stone walled mosques on Liffiya, Marawah and Bu Sharah, as well as number of stone outline mosques on coastal islands also form an important architectural group. In the Liwa oases, permanent settlement appears to have commenced by the 16th or 17th Century AD, and certainly by the 19th Century AD mud-brick forts had been built. In the Al Ain area, the continued availability of water, through *falaj* systems, made permanent occupation, associated with agriculture, feasible. A number of the built architectural monuments in Al Ain, such as the forts, (restored by the Department of Antiquities and Tourism, now part of the Abu Dhabi Culture and Heritage Authority) date to the 19th or early 20th Centuries, while the *falaj* systems may be of a much earlier date, albeit frequently repaired.

Recent settlement on the island of Abu Dhabi dates from the mid-18th Century, and a number of buildings were constructed in the 19th and early 20th Centuries, including a fort, mosques and domestic dwellings, although few survive. A key impetus for the 19th Century building may have been increased prosperity resulting from the pearling trade. Sadly, few traces of recent historical architecture survive. Those buildings which do remain, such as the important group of buildings on Dalma, provide us with an important link to life in Abu Dhabi during the pre-oil era.

3 MAJOR TERRESTRIAL HABITAT TYPES

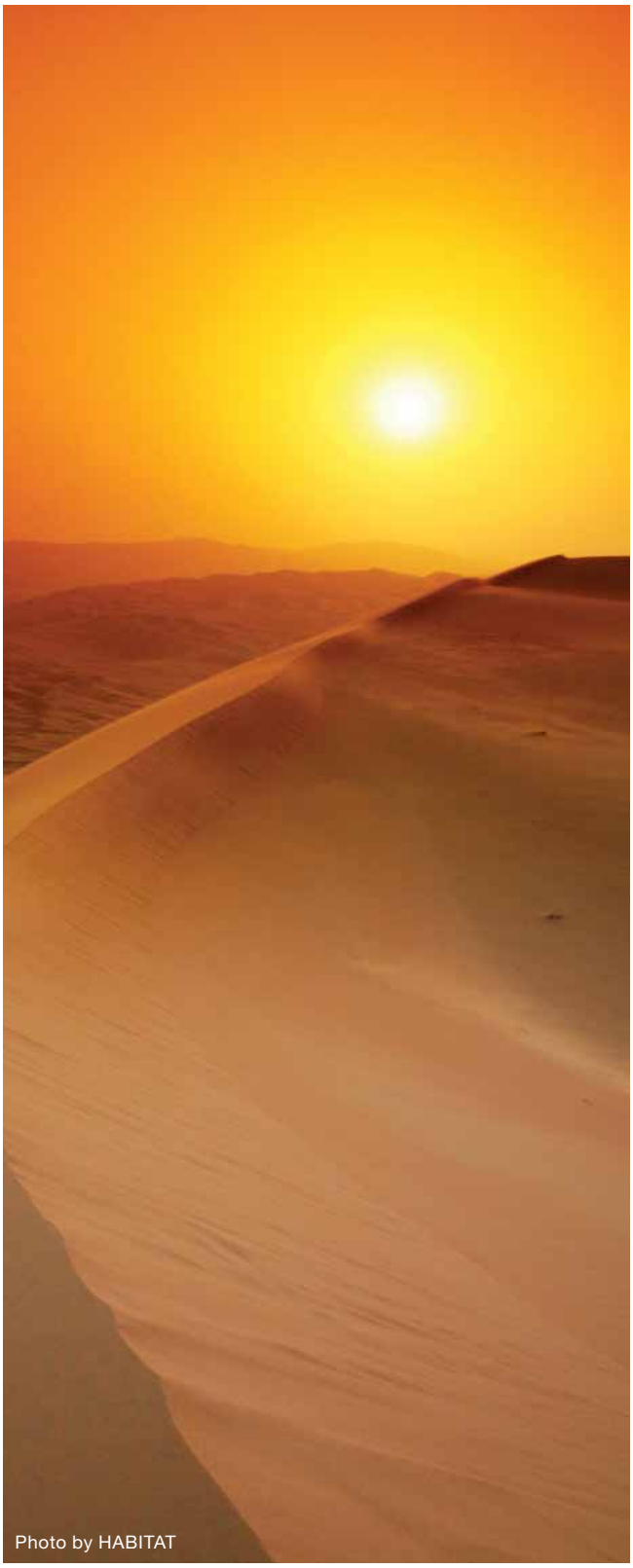


Photo by HABITAT

The landscape of the UAE is dominated mainly by low-lying, sandy desert, but extensive salt flats (sabkha) occur in coastal areas, and in the east, the Hajar Mountains rise sharply above the surrounding landscape to an elevation of about 2000 m. A significant proportion of the roughly 3.8 million inhabitants live in towns and cities located long the coast, leaving much of the interior sparsely populated.

The climate of the UAE is of a bi-seasonal Mediterranean type and characterised by high temperatures and low rainfall. The summers (May to October) are distinctly hot, with daytime temperatures regularly exceeding 40 °C. Rainfall occurs occasionally during the summer, but is generally restricted to the cooler winter months (November to April) when temperatures can drop to 4 °C in some areas at night (and even lower in the mountains). Frosts are unknown. Seasonal fluctuations in temperatures are less well pronounced along the coast, where they are buffered by the maritime influence.

Annual rainfall amounts vary according to location, but precipitation generally decreases long a north-east to south-west gradient. The mountainous areas receive most rainfall (long-term annual mean of about 154 mm in Masfut, ranging from 4 to 479 mm), about 80 mm in coastal areas such as Abu Dhabi and Dubai, but substantially less in more western and southern parts of the country (data obtained from BÖer, 1997). Even within a given region, rainfall is often highly localised, with certain areas regularly receiving lower or higher amounts than adjacent ones.

Temporal variation in the rainfall pattern is a feature which, due to the relatively low total amounts received even in wet years, has a much more decisive influence on biological activity than, for instance, in more temperate regions of the world. In some years, rainfall amounts well in excess of long-term mean values are recorded, whereas in other years there may be no significant precipitation at all. For instance, over a 23-year observation period (1970-1992) in Al Ain, total annual rainfall ranged from 1 to 303 mm, with a long-term mean of 100 mm (BÖer, 1997).

Rainfall is most effective for the vegetation when it occurs during the cooler part of the year, primarily because key stages of growth and development take place during this period, as outlined below, but also due to the fact that less water is lost to evaporation. Potential evaporation (*i.e.* that water which would evaporate if present) far exceeds precipitation in most parts of the country by a factor of about 20, indicating the high degree of stress to which organisms are exposed.

Coastal regions experience high humidity, especially in the summer months, but the interior has a much drier climate. Mists frequently cover the mountains, but are also a common occurrence in some desert regions, such as to the south and west of Abu Dhabi Island. Dewfall is a common phenomenon in coastal localities. Many plants on coastal dunes have shallow, lateral rooting systems that enable them to exploit this regular input of moisture.

Due to the harsh climatic conditions, soils are generally extremely poor in organic matter, and biological activity is low. The properties of the little-altered parent material (sand, silt, gravels, bedrock) therefore exert a dominant influence on species composition of the vegetation, and in turn, on the fauna in most parts of the country. Although these soils are often rich in certain nutrients, they are highly deficient in nitrogen, primarily due to the lack of organic material. Soil fertility is therefore extremely low.

Soil salinity is a factor restricting or exerting a highly selective effect on plant growth not only in many coastal areas, but also inland, particularly on interdunal plains. Problems of salinity have been exacerbated in recent decades due to a more widespread use of irrigation water and inappropriate land-use.

As much of the landscape is too inhospitable for human activities, natural terrestrial habitat types occupy by far the larger part of the country. These can be broadly classified as follows: inland sand sheets and dunes, piedmont alluvial and interdunal plains, mountains and wadis, coastal sand sheets with dwarf shrub vegetation, coastal and inland sabkha. Important anthropogenic habitat types, such as oases, farmland, forestry plantations and urban areas account for a relatively small proportion. These major habitat types can often be further subdivided into more specialised ones, each with their own specific abiotic features, vegetation and fauna.

Vegetation is one the key attributes of the landscape, and as primary producers, plants provide the food on which all organisms ultimately depend, either directly (as in the case of herbivores), or indirectly. Most major habitat types are characterised by certain plant assemblages, a notable exception being sabkha.

The severe climatic conditions, though, mean that vegetation cover is generally sparse, particularly in areas with exceptionally low rainfall, and has been further reduced by severe overgrazing. The limited number of plant species involved, the relatively broad ecological tolerances of many key perennials and the fact that some potentially suitable species do not appear for years under unfavourable rainfall conditions are factors that serve to complicate vegetation classification in many desert habitats. Communities tend to be named after the dominant perennial species present, sometimes along with the co-dominant species. There has been some attempt to describe, delimit and classify certain vegetation communities according to the phytosociological approach of Braun-Blanquet (1928), as commonly practised in Central Europe, but such studies remain rather few in number, probably due to the inherent difficulties outlined above. Roshier *et al.* (1996) used multivariate procedures to obtain a basic classification of some important plant communities of the desert interior of the UAE. However, all these attempts remain preliminary.

Figure 3-1: Coastal Cliffs

Figure 3-2: Low Sand Dunes

3.1 Coastal Zone

The coastline of mainland UAE extends for about 650 km, and comprises the Arabian Gulf coast in the north, and the Gulf of Oman coast to the east. The Arabian Gulf coastline is predominantly flat, with warm, shallow waters. Natural deep-water harbours occur mainly on the eastern coast. The UAE possesses at least 200 islands, most of which are rather small and flat. However, Zirku Island attains a maximum altitude of 160 m, even though it is only about 8 km² in size. Specialised habitats of the coastal zone include mangroves, saltmarsh, tidal flats with cyanobacterial mats, sandy and rocky beaches, coastal flats and low sand dunes, sabkha, cliffs and rocky headlands. See Figures 1 and 2, which represent both cliffs and low coastal sand dunes.

Halophytic perennials predominate in the coastal vegetation, although locally, annuals such *Biernertia cycloptera, Suaeda aegyptiaca* and *Zygophyllum* simplex may be more conspicuous. Succulent, semi-woody dwarf shrubs are the main life-form, with most species belonging to the Chenopodiaceae. Widespread species include *Arthrocnemum macrostachyum, Halocnemum strobilaceum, Halopeplis perfoliata, Salsola drummondii, S. imbricata* and *Suaeda vermiculata*. Members of the genus Zygophyllum (Zygophyllaceae) are also a conspicuous feature of many coastal locations, and mangroves are developed in a number of inter-tidal areas. True grasses (*Poaceae*) also play an important role in the vegetation cover, especially salt-tolerant representatives of the genera *Sporobolus* and *Aeluropus*. *Zygophyllum qatarense* is the host plant of two striking parasitic plants, namely *Cynomorium coccineum* and *Cistanche tubulosa*. The two species are particularly common along the coastal areas, but also occur inland. Furthermore, Cistanche is frequently associated with *Haloxylon salicornicum* and appears abundantly in wet years or where there is a regular supply of water. Occasionally it even grows on the roots of *Arthrocnemum macrostachyum* and *Halocnemum strobilaceum*.

Sea grasses are a unique group of plants because they are the only flowering plants capable of thriving permanently submerged in the sea. Three species are known to occur in the coastal waters of the UAE, *Halodule uninervis*, *Halophila ovalis* and *H. stipulacea*. Although often overlooked due to their marine existence, even casual visitors to beaches will be familiar with sea grass litter that is washed up in large quantities at the water's edge. This litter provides important microhabitats for numerous coastal organisms, and it contributes to the soil development of coastal substrates (Phillips, 2002).

Coastal vegetation is extremely productive, especially when compared to other terrestrial habitats in the UAE. Despite the fact that the vegetation is home to a relatively high number of species, the individual stands tend to be species-poor or even monospecific, i.e. carpets of one particular species usually dominate over large areas.

The main factors controlling the distribution of plant species and community composition along the coast are:

- Salinity of the water and/or substrate,
- Frequency and extent of inundation, and
- Water-holding capacity of the substrate.

Often, a distinct zonation of the vegetation can be readily observed. Where there is pronounced small-scale heterogeneity in abiotic factors, the vegetation forms corresponding mosaics.

An overview of the zonation of coastal vegetation of Arabia is provided by Deil (1998). The halophytic vegetation of the UAE corresponds mainly to situation he describes for Qatar, with species such as *Arthrocnemum macrostachyum, Halocnemum strobilaceum* and *Halopeplis perfoliata* very common in salt-marsh environments (*i.e.* with frequent inundation), *Suaeda vermiculata* and *Limonium axillare* in more specialised conditions. *Salsola drummondii* is locally abundant on the coastline, growing on coastal plains and slightly raised barrier berms created by tidal action and occasionally on coastal jebels. *Juncus rigidus* is a very local species that occurs predominantly in a coastal saltmarsh between Dhayah and Rams (Ras Al Khaima), where it forms dense, monospecific stands.

Mangroves are well-developed along parts of the coastline of the UAE, and impressive stands can be observed at a number of localities, including Abu Dhabi Island.

Chenopods are the main constituents of the vegetation in more saline coastal habitats, and important species are listed above. Further inland, where the influence of the sea recedes, *Zygophyllum qatarense* often covers wide expanses in which other species are occasionally interspersed. The coastal white dunes are home to a high diversity of plants, including a profusion of annuals that thrive after winter rains. Dwarf shrubs and perennial grasses dominate the vegetation physiognomically. An informative transect through the coastal dunes and sabkhas in the vicinity of Dubai was described by Deil & Müller-Hohenstein (1996). The dunes close to the coast are colonized by a local community in which the dwarf shrubs *Sphaerocoma aucheri* and *Cornulaca monacantha* are important constituents. The vegetation of the dunes is treated in more detail below (see “Sand sheets and dunes”).

3.2 Coastal and Inland Sabkha

Sabkha’ is an Arabic term referring to flat, salt-encrusted desert that is usually devoid of any significant plant cover. The high concentration of salts on the sabkha surface prevents the growth of most plant species, and as a consequence, landscapes dominated by sabkha appear distinctly barren. This accumulation of salt is possible in areas where the water table lies close to the surface. As a broad distinction, it is possible to distinguish between coastal and inland sabkha. With the former, saline water is provided by the tidal action of the sea, with the latter, episodic flooding takes place after the infrequent rainfall events, sometimes leading to the formation of large ephemeral lakes, (see Fig. 3.3)

A detailed, up-to-date overview of sabkha ecology has recently been produced by Barth & B?er (2002), and a contribution specifically dealing with the sabkha vegetation of the UAE is expected shortly (Brown, 2004).

Figure 3-3: Coastal Sabkha

Figure 3-4: Inland Sabkha

Plant species associated with sabkha are restricted mainly to the margins, with halophytes predominating. Some plants are able to germinate on the sabkha surface after heavy rainfall, because this leads to a temporary reduction in salt concentrations. For instance, the moderately salt-tolerant *Zygophyllum qatarense* can germinate under such conditions, and once the plants have gained a foothold, they can probably survive for years in a state of dormancy by discarding their succulent leaves. After further heavy downpours, they develop new leaves and resume growth.

Chenopods are typically found on the edges of sabkha, including *Agriophyllum minus, Arthrocnemum macrostachyum, Bienertia cycloptera, Salsola imbricate* and *Seidlitzia rosmarinus*. *Halopeplis perfoliata* is probably the most salt-tolerant of halophytes and common in moist depressions around coastal sabkha. It also occurs on inland sabkha in some areas, such as in the vicinity of Sweihan and the Liwa Crescent. The plants often turn red, and are therefore easily spotted. The tamarisks *Tamarix aucheriana* and *T. nilotica* are found both on coastal and inland sabkha. *Limonium axillare*, a common psammophytic shrub along some stretches of the coastline, is also occasionally encountered on inland sabkha, especially where there is a thin veneer of sand on the surface. The chenopod *Anabasis setifera* is a characteristic pioneer species of reclaimed sabkha in coastal areas.

3.3 Sand Sheets and Dunes

Sand sheets and dunes of different types cover by far the largest proportion of the UAE, ranging from vast, flat expanses to the impressive mega-dunes which are a prominent feature, especially in the south of the country.

As a broad generalisation, it is possible to distinguish between two types of sand based on its source. Coastal white sands are derived from recent marine sediments and are rich in carbonate. Apart from dominating many coastal areas, drifts of wind-blown white sands are occasionally found up to 50 km from the present coastline. Cemented sand dunes forming rocky outcrops occur in many scattered localities along a broad coastal zone. The siliceous sands that cover large tracts of the inland are the product of a long process of weathering of quartz. This substrate is poor in carbonate and varies in colour. Sand grains that have a coating of haematite (an iron oxide) range from pink to red in colour, depending on the thickness of this coating. Otherwise the siliceous sands are yellowish to grey. The lack of carbonate probably has an important influence on vegetation composition.

In contrast to the situation in more temperate regions of the world, sand, especially where it is stable, provides a favourable substrate for plant growth in warm, arid to semi-arid climates. This can be attributed primarily to water being held immediately below the surface, a process that is greatly aided if there is a certain amount of silt (finer-grained substrate) in the subsurface layers, as is often the case with stabilised sand sheets. Although the surface layers may dry out rapidly due to evaporation, water can be held in the subsurface for considerable periods of time, where it remains available for plant roots. In other words, such sand sheets act as reservoirs for water in the short to medium term.

However, unstable sandy substrates, such as mobile dunes, are less amenable to plant growth for two main reasons. First, these substrates are composed almost entirely of relatively coarse-grained sand, and this allows the rapid penetration of water to greater depths where it is then inaccessible for many plants. However, there is often a distinct zone of plant growth developed at the base of such dunes due to water seepage. Second, only few species can come to terms with the constantly changing surface conditions of mobile sandy substrates. Seeds that become buried deep in the sand are not able to germinate. Plants that do germinate have to be resistant at the highly sensitive seedling stage to a variety of adverse conditions, such as lack of water, abrasion from wind-blown sand (sand-blasting) and frequent burial and the removal of sand from around them. Mobile sands are therefore usually very sparsely vegetated by perennials in the main, and the contribution of desert annuals, even after heavy rainfall, is generally insignificant, both in terms of species numbers and cover.

Coastal white sands, which tend to be rather stable, often have a relatively high coverage of vegetation. Of particular importance are the open xeromorphic grasslands dominated by the perennial tussock grass *Panicum turgidum* that form what has been described as a 'coastal white sand community'. This community extends along a narrow coastal band northwards into Kuwait. In the UAE, common perennial associates include the dwarf shrubs *Cornulaca monacantha, Helianthemum lippii, Heliotropium kotschyi* and *Sphaerocoma aucheri*, as well as the graminoids *Coelachyrum piercii, Cyperus arenarius*, *Pennisetum divisum* and *Sporobolus iocladus*. Coastal sands are often rich in annuals, particularly after wet winters, with species such as *Arnebia hispidissima, Eremobium aegyptiacum, Herniaria hemistemon, Hippocrepis areolata, Launaea capitata, L. mucronata, Lotus halophilus*, *Plantago boissieri* and *Silene villosa* sometimes abundant. Brown *et al. (2007) have recently given a floristic overview of one of the best remaining sites of this highly endangered habitat type in Abu Dhabi emirate. Rhanterium epapposum* was once a common dwarf shrub in many north-eastern parts of the country, and the main component of the *Rhanterium epapposum community. Deil & Müller-Hohenstein (1996) state that this shrub was still common in low dune systems in Dubai emirate as recently as 1987. Overgrazing has led to the disappearance of the species in many locations. Even where it still persists, it is often only possible to find flowering plants where they are protected from grazing.*

Further inland, as the maritime influence diminishes, vegetation coverage of the sand becomes patchier, but not necessarily less interesting, and a number of important communities can be encountered. *Prosopis cineraria* ('ghaf') is an impressive tree of dunes in the eastern part of Abu Dhabi emirate where it forms characteristic groves ('ghaf forests', *Prosopis cineraria*-community). Further eastwards, it also occurs locally on alluvial plains. The western distribution limit of this species on the Arabian Peninsula is between Sweihan and Abu Dhabi. Natural forests are deteriorating rapidly due to direct destruction and disturbance, but also on account of excessive water extraction and serious overgrazing. The latter in particular appears to be preventing natural rejuvenation of the stands. Although germination could take place after heavy rainfall events, it is doubtful whether the seedlings would survive the voracious appetite of the ubiquitous goats, sheep and camels, especially as livestock camps have been established near or in many ghaf forests. Young trees that do become established invariably originate from root suckers, often some distance from the mother plant, *i.e.* by vegetative means.

The sedge *Cyperus conglomeratus* is one of the most ubiquitous species of sands in the UAE. It forms monotonous, species-poor to species-rich stands over large areas (*Cyperus conglomeratus-community). Typical accompanying perennials include Dipterygium glaucum* and *Limeum arabicum*. *Cyperus* itself is also a common associate in other communities. As it is generally less palatable, the species has almost certainly been able to withstand the heavy grazing characteristic of recent decades better than some true grasses, such as *Centropodia forskaolii, Panicum turgidum* and *Pennisetum divisum*. Observations in the Al Wathba Protected Area indicate that mass germination of *Cyperus* takes place after heavy rainfall in the late spring, when temperatures are already quite high again. However, many seedlings will die prematurely if sufficient rainfall is not forthcoming to sustain growth during the sensitive early stages of establishment. Stands of the shrubby tree *Haloxylon persicum* ('ghada') occupy a geographically distinct and well-delineated area south of Abu Dhabi City, where they form a characteristic species-poor plant assemblage (Haloxylon persicum community), in which *Haloxylon salicornicum* is co-dominant, at least locally.

Frequent fog in the region enables the growth of lichens on the bark of H. persicum shrubs. The vegetation of these 'dew-forests' (Hellyer & Aspinall, 1999) is able to comb out droplets of water from the atmosphere, which then fall to the ground beneath the plants. The same 'auto-

watering mechanism' has been described from other parts of the world, for instance from the montane pine forests on the Canary Islands (Kunkel, 1993). The stands of Haloxylon persicum are of outstanding conservation value due to the limited extent of their distribution in the UAE, especially as they appear reasonably intact. Similar stands also occur locally in the central and northern parts of Saudi Arabia, as well as in the eastern Province, but apart from the one area reported for the UAE, the species appears to be absent from south-east Arabia.

Moving into the southern half of the country, *Cornulaca arabica* is the key species of a characteristic dwarf shrub community on the lower flanks of dunes in the Rub Al Khali. This *Cornulaca arabica*-community, in which *Cyperus conglomeratus* also plays a prominent role, is widespread throughout the Liwa Crescent, Umm az-Zamul and the south-west. The precise taxonomy of *Cornulaca* is not entirely clear: some authors regard it as conspecific with *C monacantha*, but others, including Mandaville (1990) and ourselves, treat it as a distinct species that is endemic to the Rub Al Khali, extending locally into the northern part of Abu Dhabi emirate. Another characteristic plant of the Rub Al Khali and one that appears to be widespread in the Liwa / Umm az-Zamul area is *Calligonum crinitum*, a species that has been largely overlooked in the UAE and confused with *Calligonum comosum.* Mandaville (1990) suggests that the former is typical of the higher dunes of the Rub Al Khali, whereas the latter is associated with the lower dunes and sand sheets further north. *Tribulus arabicus (Tribulus 'omanense')* is a perennial herb that is widespread on deep, undulating sand sheets in the southern half of the country, sometimes forming extensive stands *(Tribulus arabicus-community)*, and is invariably accompanied by *Cyperus conglomeratus.* The morphological variability of *Tribulus arabicus* plants, even amongst those growing in close proximity to each other, has resulted in much taxonomic confusion. For this reason, the species that is now often referred to as *'Tribulus omanense'* in the UAE is probably best regarded as belonging to the T. *arabicus*-complex. Irrespective of its precise identity, it is an extremely important grazing plant for domestic livestock and possibly also for wild gazelles.

Figure 3-5: Sand sheets

Figure 3-6: Sand Dunes

3.4 Piedmont Alluvial and Interdunal Plains

Plains are a common landscape feature in many parts of the UAE. In the vicinity of the Hajar Mountains, they occur as wide, flat expanses that are covered in alluvial detritus consisting of coarse rocks, pebbles and gravels. As a broad generalisation, the substrate of the piedmont alluvial plains becomes finer with increasing distance from the mountains. Sand is often intermingled with this coarser material. Significant deposits of pebbly substrate also occur in the far west near Sila and around Sabkha Matti, probably originating from the highlands of western Saudi Arabia.

In other parts of the country, plains are intimately associated with dune systems, where they form a loosely connected network of interdunes of varying size. The substrate of these interdunes is sandy to gravelly, depending on the location, and often displays elevated levels of salinity compared with the adjacent sand dunes. Firm crusts of 'gatch' can also form due to evaporative processes, creating a mosaic of different types of substrate. Inland sabkha is frequently developed where the groundwater occurs close to the surface, or in larger depressions in which rainwater accumulates. On the edges of some plains, rocky outcrops have been exposed by deflation.

The physiognomically dominant vegetation of the piedmont alluvial plains is characterised by small trees, dwarf shrubs and succulents. The typical species of rocky and gravelly plains in the north-eastern part of the UAE is Acacia tortilis ('samr'), a flat-topped tree that forms extensive stands (*Acacia tortilis* community). Good examples of open Acacia woodland can be seen on the Madam Plain or on the east coast. The species is also the most conspicuous floristic component of the lower mountain ranges, especially up to about 200 - 300 m a.s.l. Common associates include the shrubs *Lycium shawii* and *Gaillonia aucheri* (= *Jaubertia a.*), as well as the succulent cactus-like *Euphorbia larica* and semi-succulent *Ochradenus arabicus*. In eastern parts of the country and in Oman, *Prosopis cineraria and Acacia ehrenbergiana* regularly occur together with *A. tortilis on alluvial plains. A. ehrenbergiana* also occurs on sandy to silty interdunal plains in a few scattered localities in the east of Abu Dhabi emirate and in Emirate of Dubai. *Rhazya stricta ('harma') is generally regarded as a gravel plain species, and one that is restricted to the east of the country, for instance around Al Wagan and Jebel Hafit. Due to its toxicity, it is shunned by grazing animals, and as a result, has probably increased in recent decades as a direct consequence of overgrazing of more palatable species. Sand deflation resulting from the decline of dwarf shrubs and grasses has probably also contributed to the expansion of* Rhazya. The *'Rhazya stricta*-community' can be regarded as a degradation stage of other communities, such as those of *Acacia tortilis* and *Haloxylon salicornicum*.

Both *Haloxylon salicornicum* and *Aerva javanica* are often associated with *Rhazya*. *Calotropis procera* (ushar), an extremely fast-growing, toxic tree that can begin producing flowers at an early age, is a species of alluvial plains and low dunes, often where there is a high level of human disturbance. It is abundant in some parts of the country, particularly in the north-east. For instance, large populations of this species fringe the roads north of Al Ain towards Dubai and Sharjah. Further west, it becomes increasingly rare, with only isolated occurrences around Abu Dhabi and Sweihan.

A number of shrubs and dwarf shrubs play an important role in the vegetation of both alluvial and interdunal plains. *Haloxylon salicornicum* is a chenopod found predominantly throughout the north of the Arabian Peninsula where it is the main constituent of the *Haloxylon salicornicum* community, dominating extensive tracts of desert. In the UAE, it occurs in the northern half of the country where it is common on sandy, gravelly and rocky plains, as well as sand sheets. It is conceivable that *Haloxylon salicornicum* is one of several species that may have benefited somewhat over recent decades as a result of increased grazing pressures, as it is less palatable than, for instance, *Rhanterium epapposum* or *Panicum turgidum*. However, in the absence of other species, camels do heavily browse this subshrub and may therefore contribute towards its decline.

Despite its name, *Haloxylon salicornicum* is only slightly tolerant of salt, and as a result, is absent from communities in which halophytes play a major role. As soil salinity increases, the species is replaced by *Zygophyllum qatarense*, but an intergrading of *Haloxylon* and *Zygophyllum* can be observed over quite large areas where soil conditions allow, with *Haloxylon salicornicum* usually confined to the slightly higher, less saline ground, and *Zygophyllum* in the hollows. *Zygophyllum qatarense* regularly dominates on interdunal plains that are influenced by elevated soil salinity. Deil (2000) indicates that *Zygophyllum mandavillei*, a very similar species to *Z. qatarense* and one that was thought to be widespread in the interior of the UAE, is actually restricted to a small area of southern Arabia.

Other regular associates on interdunal plains include the perennials *Fagonia indica (= F. ovalifolia)*, a small woody plant, *Heliotropium digynum*, found mainly on sandy interdune corridors, and *H. acciferum*, a plant that tolerates more saline, gravelly substrates. The rather species-poor annual vegetation of the interdunal plains is dependent on winter rainfall. In years of low precipitation, desert annuals may not even geminate at all. High soil salinity is another factor that restricts the potential occurrence of many annuals. Inland sabkha is frequently developed in the interdunes, and vegetation may be completely lacking there.

Figure 3-7: Alluvial Plain

Figure 3-8: Interdunal Plain

3.5 Mountains and Wadis

The Hajar Mountains, the major mountain system of southeastern Arabia, extend some 700 km from the Musandam Peninsula in the north to close to the Wahiba Sands (eastern Oman) in the south-east. These mountains are located in the east of the country, near the Gulf of Oman coast, and transverse the UAE from north to south. The main watershed runs along this N-S axis, so that alluvial debris has been deposited along a parallel strip at the base of the mountains on either side. These layers of alluvium have important repercussions for vegetation development, as already described.

The mountains rise abruptly and are dissected by numerous wadis. Apart from small pockets of humus that are able to accumulate in rock fissures, the protection of rocks and other sheltered locations, there has been virtually no development of humus-rich soils on the mountain slopes, leaving the underlying parent material exposed. Due to the sparseness of perennial vegetation cover, the spectacular mountain scenery often appears distinctly barren at first sight. However, this initial impression is misleading because many wadis and the high mountain plateaux can support relatively lush vegetation. Furthermore, the mountainous areas contain the highest diversity of plant life compared to any other habitat type in the UAE, with composites (Asteraceae), grasses (Poaceae) and umbellifers (Apiaceae) represented by a relatively high number of species.

On the lower mountain slopes, *Acacia tortilis* and *Euphorbia larica* are ever-present, and accompanied by a number of perennials such as *Gaillonia aucheri, Lycium shawii, Pulicaria glutinosa, Ochradenus aucheri, Physorrhynchus chamaerapistrum* and *Tephrosia apollinea*. *Capparis cartilaginea* and *C. spinosa* are two species with large, leathery leaves that occur scattered throughout the mountains, the former often hanging from calcareous rocky cliffs.

With increasing elevation, *Acacia* gradually disappears and is rarely encountered above 500 m, although *Euphorbia* remains common at much higher altitudes. Trees such as *Moringa peregrina* and *Ficus cordata* ssp. *salicifolia* become more prominent on rock debris, especially near wadis.

The shrub *Dodonaea viscosa* is widespread and common throughout the mountains, often reaching the summits. In the far north-east of the country, the Arabian almond (*Amygdalus arabica)* is an important constituent of the vegetation above 1000 m. Further south, olive trees (*Olea europaea*) are locally common in high mountain situations. Increased precipitation and lower temperatures lead to a more favourable climate for plants at higher altitudes. This is most vividly documented by the conspicuous presence of poikilohydric plants, in particular lichens and bryophytes. The widespread mountain fern *Onychium divaricatum* is also a sure indicator of more favourable mesoclimatic conditions. Wadi beds are often extremely rich floristically, especially in their lower reaches, where a combination of different types of substrate, pronounced spatial heterogeneity in micro topography and microclimate, light availability and regular access to water create a mosaic of favourable microhabitats. *Acacia tortilis* fringes the margins of many wadis, regularly occurring in wadi beds on elevated banks, and is frequently accompanied by *Lycium shawii* and *Gaillonia aucheri.* The latter is often associated with the superficially similar *Pteropyrum scoparium* in wide wadi

beds, as well as on adjacent gravel plains and rocky slopes. *Zizyphus spina-christi* (Christ's Thorn) is a common tree in wadis and on rocky slopes at lower altitudes ascending to about 1,500 m.

In contrast, *Acridocarpus orientalis* is a small tree only known from Jebel Hafit in the UAE, where it grows in the upper reaches of Wadi Tarabat. In wet winters, the wadis abound with a profusion of annuals, and particularly common, even in drier years, is *Asphodelus tenuifolius*, a lily-like

Figure 3-9: Mountains

Figure 3-10: Wadi

plant with numerous small white flowers. The only known species of orchid in the UAE, *Epipactis veratrifolia*, thrives in moist shady conditions along the banks of wadis and artificial watercourses, typically accompanied by the fern *Adiantum capillus-veneris*. *Nerium oleander (oleander) and the grass Saccharum ravennae* form a distinct community in the deeply incised, canyon-like wadis at higher altitudes, as described by Deil & Müller-Hohenstein (1996).

3.6 Freshwater Habitats

Natural freshwater habitats are generally rare in the UAE, being largely confined to the mountains where there are a number of permanent streams and rockpools. Typical aquatic plants encountered in such locations include *Potamogeton lucens, P. pectinatus, Najas marina* and *Zannichellia palustris*. *Arundo donax* and *Juncus socotranus* occur in moist conditions throughout the mountains. Temporary streams are more common, with wadis carrying flowing water for a few hours after heavy rainfall. Depending on the subsequent weather conditions, the pools that remain after rain may persist for weeks or months, before eventually drying out.

A number of artificial aquatic habitats have been created in recent years, such as Al Wathba Lake near Abu Dhabi Island. This lake, now a protected area, contains a mixture of brackish and fresh water. *Phragmites australis* (reed), a cosmopolitan species, forms dense stands there. The species is tolerant of salinity, but sensitive to water movement, which is why it is most often found by standing bodies of water, including smaller ones, even on damp ground caused by excess irrigation water. Members of the genus *Tamarix* (tamarisks) are characteristic of saline habitats where the water table is close to the surface, often far inland.

Figure 3-11: Freshwater

Figure 3-12: Freshwater vegetation

3.7 Oases and Modern Agricultural Farms

Freshwater oases are found scattered throughout the country, for instance on the plains on either side of the Hajar Mountains, and in many desert locations of Abu Dhabi emirate. The largest desert oasis occurs in the Liwa Crescent, which is in fact a series of individual oases stretching for more than 100 km. Of significant cultural interest are the irrigation systems used to provide water for the oases. On the piedmont and coastal plains, oases are usually irrigated by a '*falaj*' system. Underground water is tapped from the edge of the mountains and then diverted along open channels to its point of destination, a system that dates back at least 3,000 years in the UAE. With the corresponding 'ghayl' system in the mountains, water is extracted from the upper reaches of the wadi bed, fed along open watercourses built into the sides of the wadi and channelled to terraced fields. Apart from date palm plantations, fields in the mountains provide habitats for many wild species, especially when they are left fallow. Associated with these agricultural habitats are a host of plant species that are able to take advantage of the more favourable moisture conditions and shade afforded by the cultivated plants.

Figure 3-13: Plantation Forest

Farms have sprung up in desert areas where there is a sufficient water supply (*e.g.* Liwa), and fields of *Chloris gayana* (Rhode's grass) are dotted around the country. Typical wildflower species of the agricultural areas include *Anagallis arvensis, Chenopodium murale, Eruca sativa, Euphorbia peplus, Fumaria parviflora, Melilotus indica, Portulaca olereaca, Oxalis corniculata, Rumex dentatus, Sida urens, Sisymbrium erysimoides, S. irio, Sporobolus spicatus*, and *Vicia sativa*.

In recent decades, intensive efforts have been undertaken to establish forestry plantations, especially in Abu Dhabi emirate. Many of the tree species used in these plantations are indigenous, and numerous wild species, both animal and plant, have been able to take advantage of this new type of habitat. However, for various reasons, not least for the sheer amount of water needed to sustain the trees, these plantations remain of highly dubious ecological benefit.

3.8 Urban Environments

The rapid expansion of urban areas in recent years has inevitably resulted in the destruction of large expanses of pristine landscape. However, a whole range of species, both plants and animals, has been able to invade newly created urban habitats, often profiting from large-scale greening programmes and the widespread use of irrigation water. Some of these plant species are indigenous to the UAE, including *Aeluropus lagopoides* and *Sporobolus spicatus* (both common in irrigated urban areas), others, such as *Cressa cretica* (garden beds), *Coronopus didymus* and *Fimbristylis* sp. (both locally abundant in lawns in Abu Dhabi), *Euphorbia prostrata, E. serpens* and *Sonchus oleraceus*, probably not. Urban habitats offer a fascinating opportunity for studying 'invasive' species, especially as investigations so far have been fairly limited.

Figure 3-14: Urban Fringe

4 SPECIES DIVERSITY


Photo by HABITAT

4.1 Flora

The landscape of Abu Dhabi Emirate is dominated mainly by low-lying, sandy desert, but extensive salt flats (sabkha) occur in many coastal areas. Gravelly plains also cover wide areas in both the far west and east of the Emirate. Mountains are absent, a notable exception being the impressive Jebel Hafit near Al Ain, an outlier of the Hajar mountain range.

The climate is of a bi-seasonal Mediterranean type and characterised by high temperatures and low rainfall. According to (Middleton & Thomas, 1997), the climate of most of the Emirate can be classified as hyper arid, with a narrow coastal belt that is slightly less extreme. The summers (May to October) are distinctly hot, with daytime temperatures regularly exceeding 40 °C. Rainfall occurs occasionally during the summer, but is generally restricted to the cooler winter months (November to April) when temperatures can drop to 4 °C in some areas at night. Annual rainfall amounts vary according to location, but in general, precipitation is somewhat higher in the east than in western parts of the Emirate. In addition, temporal variation is a pronounced feature of the rainfall pattern. For instance, over a 23-year observation period (1970 - 1992) in Al Ain, total annual rainfall ranged from 1 to 303 mm, with a long-term mean of 100 mm (B?er, 1997).

Due to its general paucity, even in wetter years, rainfall has a much more pronounced influence on biological activity than in more temperate regions of the world. It is most effective for the vegetation when it occurs during the cooler part of the year, primarily because key stages of growth and development take place during this period.

Coastal regions experience high humidity, especially in the summer months, but the interior has a much drier climate. Mists are a common phenomenon in some desert regions, such as to the south and west of Abu Dhabi Island, and dewfall occurs frequently in many localities. A number of plants on coastal dunes have shallow, lateral rooting systems that enable them to exploit this regular input of moisture.

Due to the harsh climatic conditions, soils are generally extremely poor in organic matter, and biological activity is low. The properties of the little-altered parent material (sand, silt, gravels, bedrock) therefore exert a dominant influence on the species composition of the vegetation, and in turn, on the fauna in most parts of the Emirate. Although these soils contain many nutrients, they are highly deficient in nitrogen, primarily due to the lack of organic material, and as a consequence, soil fertility is extremely low.

Soil salinity is a key factor exerting a highly selective effect on plant growth, not only in many coastal areas, but also inland such as on interdunal plains where sabkha is developed. Problems of salinity have been exacerbated in recent decades due to inappropriate application of irrigation water and unsuitable land-use practices.

Despite an increasing level of agricultural activity and afforestation, natural terrestrial habitat types are prevalent throughout much of the Emirate, although often quite degraded. These can be broadly classified as follows: tidal flats, beaches and coastal cliffs, mangroves, coastal plains, coastal sand sheets, coastal and inland sabkha, inland sand sheets and dunes, inland plains (piedmont alluvial and interdunal), mountains, rocky exposures and wadis. Anthropogenic habitat types, such as oases, farmland, forestry plantations and urban areas, account for a relatively small proportion of the surface area of the Emirate. These major habitat types can often be further subdivided into more specialized ones, each with its own specific abiotic features, vegetation and fauna.

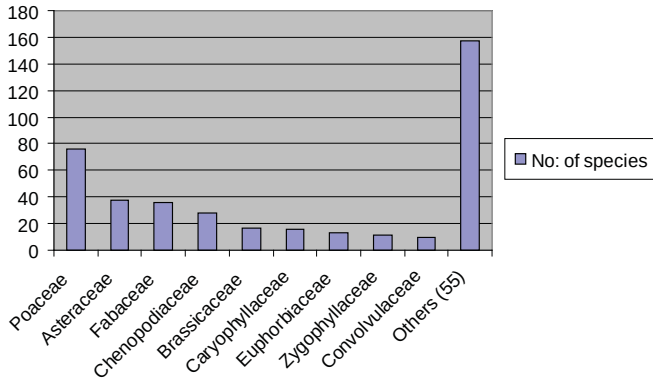
4.1.1 Vascular plants

Up until very recently, the flora of Abu Dhabi Emirate was poorly known. The pioneering work of the English language teacher A.R. Western, which culminated in the publication of the book The Flora of the United Arab Emirates - an Introduction (Western, 1989), has served as a major stimulus for floristic research in the UAE. This remarkable achievement provided a first detailed overview of the natural vegetation and flora of the country. A broad spectrum of work has also been undertaken by Benno Boer, much of it conveniently contained in Boer (1999). Recently, a new guide to the flora of the country has been published, The Comprehensive Guide to the Wildflowers of the United Arab Emirates (Jongbloed, 2003), incorporating the work of several active and enthusiastic botanists. This impressive publication mentions 667 species of plants that are known to the UAE. A further eight freshwater and three marine species need to be added to the list, giving a total of 678 species (representing 86 families), compared with 501 known just 15 years previously (see Western, 1989). Based on all available literature sources, it seems that Abu Dhabi Emirate itself is home to about 400 species (see CITES Appendix I). Refer to the official CITES website at http://www.cites.org/eng/app/index.shtml. CITES appendices are lists of species afforded different levels or types of protection from over-exploitation.

This rather low number of species compared to the UAE as a whole is a reflection of the fact that a large number of species are restricted to the Hajar Mountains in the eastern part of the country, mainly beyond the borders of Abu Dhabi Emirate. Important families in terms of species numbers are the Poaceae, Fabaceae, Asteraceae and Chenopodiaceae **(Figure 4.1)**. Species-poor families that are of great ecological significance, mainly because they contain dominant elements in the natural vegetation, include the Cyperaceae *(Cyperus conglomeratus)*, Mimosaceae *(especially Acacia tortilis and Prosopis cineraria),* Verbenaceae *(Avicennia marina)* and Zygophyllaceae *(Zygophyllum qatarense, Z. simplex).*

Much basic research on the flora remains to be done. Not only is the region still generally under-researched, but fundamental taxonomic problems surround not just a few, but many species occurring in the UAE, so that substantial changes in the checklist of UAE species will be inevitable. The current information on species distribution throughout the Emirate is also of a general nature, with many areas only rarely visited by naturalists with sufficient botanical knowledge. In addition, many species may not even appear in years of low rainfall, making the task of preparing accurate distribution maps even more difficult.

Figure 4-1: Main plant families and number of species in Abu Dhabi Emirate



A Biogeography of the vascular plants

In accordance with the phytogeographical division of Arabia by Léonard (1989), Abu Dhabi Emirate lies within the Saharo-Sindian regional zone. This phytochorion can be further divided into two subzones, which, however, are not sharply delimited. The Nubo-Sindian local centre of endemism is restricted to a narrow coastal belt, whereas inland areas fall within the Arabian regional subzone. The Nubo- Sindian phytochorion corresponds to the Sudanian region of Zohary (1973), whereas the Arabian regional subzone covers largely the same area as Zohary's Saharo-Arabian region. Typical genera of the Arabian regional subzone include, amongst others, *Medicago, Ononis*, *Spergularia* and *Silene*. These are largely derived from a Mediterranean stock, with *Astragalus, Calligonum* and various chenopods as Irano-Turanian derivatives.

Characteristic of the Nubo-Sindian local centre of endemism, which is well developed in the east of the Emirate, extending some way inland, is xero-tropical vegetation in which trees play an important role. In Abu Dhabi Emirate and eastern Arabia in general, Acacia tortilis is a prominent element, restricted to this region. Other characteristic taxa include *Calotropis procera, Capparis* spp., *Cleome* spp., *Cymbopogon* spp., *Halopeplis perfoliat, Indigofera* spp., *Lasiurus scindicus, Launaea* spp., *Leptadenia pyrotechnica, Panicum turgidum*, *Pennisetum divisum*, *Periploca aphylla, Salvadora persica* and *Tephrosia* spp.

Furthermore, many taxa in the Emirate show floristic links to Makran in southern Iran and also to Pakistan. These are referred to as Omano-Makranian elements (Kürschner, 1986). The natural western distribution limits of a number of these species are the Hajar Mountains, including Jebel Hafit. Such elements include *Gaillonia aucheri, Physorrhynchus chamaerapistrum, Pseudogaillonia hymenostephana* and *Tephrosia apollinea*. The natural range of others, for example, Prosopis cineraria ('ghaf'), extends slightly further westwards, not quite reaching Abu Dhabi island. *Salsola drummondii* and *Sphaerocoma aucheri* occur up to just beyond the Saudi Arabian border in the west.

Within the Emirate, even away the mountains, there are subtle differences in the climatic conditions which have a marked effect on the distribution of plant species. The flora of coastal white dunes is a good example, which becomes increasingly poorer in species from Dubai to Abu Dhabi Island. This is probably due to a slight decrease in rainfall and possibly marginally higher winter temperatures towards the south-west.

4.1.2 Ferns, bryophytes and lichens

According to Jongbloed (2003), eight species of fern occur in the UAE, although on the basis of her own distribution maps, several of these are only present in neighbouring Oman. Seven of the species are restricted to the Hajar Mountains where they grow in partially shaded habitats. However, they are absent from Jebel Hafit. In fact it appears as if only one species of fern may actually grow in Abu Dhabi Emirate, namely *Ophioglossum polyphyllum*. It is locally common in some coastal areas in the vicinity of Dubai, and probably occurs just over the border in Abu Dhabi. Kürschner & B?er (1999) provide a list of 22 species of bryophytes for the UAE, 15 mosses and 7 liverworts. All of these species were collected from the mountains in the east of the country, including Jebel Hafit, and a more detailed search there will inevitably lead to further discoveries. The fact that no species were recorded from desert habitats emphasises the unfavourable growth conditions for these organisms. However, as a number of bryophyte species are ephemeral, it cannot be ruled out that some do occur in desert or urban environments, especially after heavy and prolonged rainfall.

No published information is so far available on the lichen flora of the UAE, although a number of species have now been collected from various locations in the country, including Abu Dhabi Emirate, by the author. The majority of species occurs on rocks and compacted soil in rock crevices in the wadis of Jebel Hafit, as well as on coastal rocks, particularly on the Sila'a Peninsula. Lichens have also been collected from the islands of Zirku, Arzanah and Marawah. Furthermore, many jebels and exposures of aeolianite near the coast support up to a handful of lichen species, the most conspicuous of which being *Buellia subalbula*. Two species (*Arthonia* sp. and *Caloplaca cerina* agg.) have been found growing on the bark of Haloxylon persicum south-west of Abu Dhabi Island. In addition, an unidentifiable species of *Arthonia* occurs on some trees in coastal areas. The richest lichen flora in the region occurs to the east of the Emirate above 1000 m a.s.l. in the Hajar Mountains.

4.1.3 Dominant vegetation types

A. Mangroves

Walsh (1974) defines mangroves as a woodland formation below the high-tide mark. They require a fine-grained alluvial substrate and shores free of strong wave activity in order that the seedlings are not carried away by the current. Mangroves are typical of tropical areas, where summer temperatures are not too extreme. Only one species of mangrove, *Avicennia marina* occurs naturally in the UAE, possibly due to the harsh summer climate, although there is speculation that in the past, a second species, *Rhizophora mucronata*, also thrived in some areas. In Abu Dhabi Emirate, the main stands of mangroves are found east of Abu Al Abyad island, with isolated occurrences further to the west (for instance,

Figure 4-2: The mangrove, *Avicennia marina* with numerous pneumatophores

immediately west of Jebel Dhanna). The trees rarely exceed 3 to 4 m in height. The stands are much denser than any mainland vegetation type in the Emirate, and are extremely important habitats for marine life and many species of bird. The roots anchor the trees firmly in the mud, and the upper parts of the roots grow out of the water as characteristic 'pneumatophores' **(see Figure 4.2).** Their primary function is to absorb air and transport it to the roots beneath the water. *Avicennia marina* is a C3 species and transpires large amounts of water. Since the uptake of dissolved salts cannot be reduced to any significant degree, the accumulation of toxic concentrations of salt in their aerial organs is potentially a serious problem for the plants. This problem has been overcome by the presence of salt-excreting glands on the leaf surface, which as a consequence is often coated in a whitish layer of salt.

B. Coastal vegetation

Figure 4-3: *Cynomorium coccineum*, a parasitic plant on halophytes, common along the coast

The coastline of Abu Dhabi Emirate lies exclusively on the Arabian Gulf, whereas the eastern coast of the UAE is located on the Gulf of Oman. The Arabian Gulf coast is predominantly flat, with warm, shallow waters. However, in some areas, especially in the west, rocky cliffs in excess of 20 m are a prominent landscape feature. The major habitat types of the coastal zone include mangroves, salt marsh, intertidal flats with cyanobacterial mats, rocky cliffs and headlands, sandy, gravelly and rocky beaches, sabkha and coastal sand sheets.

Halophytic perennials, belonging mainly to the *Chenopodiaceae*, but also *Zygophyllum qatarense*, play a major role in the coastal vegetation. Most of these species are succulent, semi-woody dwarf shrubs. Occasionally, halophytic annuals such as *Biernertia cycloptera, Suaeda aegyptiaca* and *Zygophyllum simplex* are more conspicuous. True grasses (Poaceae) can also dominate the vegetation locally, especially salt-tolerant representatives of the genera *Halopyrum, Aeluropus* and *Sporobolus*.

Zygophyllum qatarense, and occasionally chenopods, for instance *Arthrocnemum macrostachyum* and *Halocnemum strobilaceum*, are the host plants of two striking parasitic species, namely *Cynomorium coccineum* (Figure 4.3) and *Cistanche tubulosa. The two parasites are particularly common in coastal areas, but also occur inland.* Cistanche is frequently associated with Haloxylon salicornicum in desert situations.

When compared to many terrestrial habitats, the coastal vegetation of the Emirate is extremely productive. Although it is often quite species-rich, a striking feature of halophytic vegetation is that the individual stands tend to be species-poor or even monospecific, *i.e.* one species can occupy large patches (Figure 4.4). Abrupt changes in key abiotic factors are reflected in corresponding changes in the vegetation cover, leading locally to the formation of small scale vegetation mosaics and a characteristic zonation of the vegetation. The main abiotic factors controlling community composition in coastal habitats are salinity of the water and/or substrate, frequency and extent of inundation and the water-holding capacity of the substrate.

Figure 4-4: Vegetation with *Salsola drummondii* and *Anabasis setifera*

Figure 4-5: Cyanobacterial mat

Close to the coastline in sheltered locations, gelatinous cyanobacterial mats form biological soil crusts and dominate over wide areas **(Figure 4.5)**. These mats, which overlie a sandy substrate, are rather thin and have a warty surface. A veneer of Aeolians and accumulates on the surface of these mats locally, and higher plants such as *Halopeplis perfoliata* and *Halocnemum strobilaceum* are then able to colonise them.

With increasing distance from the coastline, the ground gradually rises and the surface becomes more permanently covered with sand. *Zygophyllum qatarense* is the dominant species on such sand sheets, attaining cover values in excess of 75 % in favourable situations. It is occasionally accompanied by *Halopeplis perfoliata*, which becomes more prominent around the edges of hypersaline depressions. In the far west of the country, a community in which Suaeda vermiculata, *Seidlitzia rosmarinus, Salsola cf. arabica* and *Zygophyllum qatarens*e co-dominate colonises sand sheets close to the coast.

In salt-marsh environments, species such as *Arthrocnemum macrostachyum, Halocnemum strobilaceum, Halopeplis perfoliata, Limonium axillare* and *Suaeda vermiculata* are locally very common. *Salsola drummondii* is also frequent in many sections of the coastline.

The sands close to the coast are derived from recent marine sediments. They are rich in carbonate and, as a result, appear distinctly white. Wind-blown drifts of these coastal white sands are occasionally found up to 50 km from the present coastline. Cemented sand dunes forming rocky exposures occur in many scattered localities along a broad coastal zone. Coastal white sands often have a relatively high coverage of vegetation. Of particular importance are the open xeromorphic grasslands dominated by the perennial tussock grass *Panicum turgidum*, forming what has been described as a ‘coastal white-sand community’.

In Abu Dhabi Emirate, where it is best developed in the north-east towards Dubai, common perennial associates include the shrubs Calligonum comosum and *Leptadenia pyrotechnica*, the dwarf shrubs *Rhanterium epapposum* (locally) and *Heliotropium bacciferum*, and the graminoids *Lasiurus scindicus*, *Pennisetum divisum, Stipagrostis plumose* and *Cyperus conglomeratus*. After wet winters, the coastal sand sheets are often rich in annuals, particularly in the north-east of the Emirate, with species such as *Eremobium aegyptiacum*, *Lotus halophilus, Neurada procumbens, Plantago boissieri* and *Silene villosa* sometimes abundant.

C. Vegetation of sabkha (coastal and inland)

Sabkha is originally an Arabic term referring to flat, salt-encrusted desert that is usually devoid of any significant plant cover. The high concentration of salts on the sabkha surface prevents the growth of most plant species, and as a consequence, landscapes dominated by sabkha appear distinctly barren **(Figure 4.6)**. This accumulation of salt is possible in areas where the water table lies close to the surface.

Coastal sabkha is a major landscape feature in Abu Dhabi Emirate, and extends for over 300 km from near Sila’a, close to the border with Saudi Arabia in the west, to the border with the Emirate of Dubai in the east. The maximum width

Figure 4-6: Coastal Sabkha devoid of vegetation

of coastal sabkha is about 25 km, intergrading with inland sabkha in some parts of the Emirate. Although sabkha occurs in deserts throughout the world, the coastal sabkha of Abu Dhabi as the best example of this landform type to be found anywhere, and deserving of World Heritage status. It lies less than a few metres above high-tide level. After heavy rainfall or severe northerly coastal storms in association with high tides, parts of the sabkha may become flooded for up to several weeks.

Large inland salt flats, often referred to as 'inland sabkha', are found in various parts of Abu Dhabi Emirate. Sabkha Matti is the largest of these not only in the Emirate, but also on the Arabian Peninsula. It is located in the far west, extending from the coast some 100 to 150 km inland into neighbouring Saudi Arabia. Satellite imagery shows it to cover an area of about 5000 km². Inland sabkha also occurs in the south and east of Abu Dhabi Emirate, particularly in the Al Khatam, Umm az-Zamul and Liwa areas, where it is developed on interdunal plains. Inland sabkha too is often flooded after heavy rainfall, with temporary lakes persisting for weeks. Plant life is mainly restricted to the margins of the sabkha, with halophytes predominating. Some plants are able to germinate on the sabkha surface after heavy rainfall, because this leads to a temporary reduction in salt concentrations. For instance, the moderately salt-tolerant *Zygophyllum qatarense* can germinate under such conditions, and once the plants have established a foothold, they can probably survive for years in a state of dormancy by discarding their succulent leaves when salt concentrations rise above a certain threshold level. After further heavy downpours, they are able to develop new leaves and resume growth.

Chenopods typically found on the edges of sabkha include *Agriophyllum minus, Arthrocnemum macrostachyum, Bienertia cycloptera, Salsola imbricata* and *Seidlitzia rosmarinus. Halopeplis perfoliata* is probably the most salt-tolerant of halophytes and common in moist depressions around coastal sabkha. It also occurs on inland sabkha in some areas, such as in the vicinity of Sweihan and the Liwa Crescent. The plants often turn red, and are therefore easily spotted. Tamarisks (*Tamarix* spp.) are found on both coastal and inland sabkha. *Limonium axillare*, a common psammophytic shrub along some stretches of the coastline, is also occasionally encountered on inland sabkha, especially where there is a thin veneer of sand on the surface. The chenopod *Anabasis setifera* is a characteristic pioneer species of reclaimed sabkha in coastal areas, sometimes together with extensive stands of *Salsola drummondii*, such as near Khalifa City close to Abu Dhabi.

D. Vegetation of the sands

Sand sheets and dunes cover by far the largest proportion of the Emirate, ranging from vast, slightly undulating expanses to the impressive mega-dunes which are a prominent feature in the south of the country. In contrast to coastal white sands, the siliceous sands that cover large tracts of the inland are the product of a long process of weathering of quartz. This substrate is poor in carbonate and varies in colour. Sand grains that have a coating of haematite (an iron oxide) range from pink to red in colour, depending on the thickness of this coating. Otherwise the siliceous sands are yellowish to grey. The lack of carbonate probably has an important influence on vegetation composition.

Unlike in more temperate regions of the world, sand, especially where it is stable provides a favourable substrate for plant growth in warm, arid to semi-arid climates. Although evaporation may cause the surface layers to dry out rapidly after rainfall, water is held immediately below the surface, a process that is greatly aided if there is a certain amount of silt (finer-grained substrate) in the subsurface layers, as is often the case with stabilised sand. In other words, such sands act as reservoirs for water, which remains available to plant roots for substantial periods, long after the surface layers have dried out.

However, unstable substrates, such as mobile dunes, are less amenable to plant growth for two main reasons. First, they are composed almost entirely of relatively coarse-grained sand, and this allows the rapid penetration of water to greater depths where it is then inaccessible for many plants. Second, only a few species can come to terms with the constantly changing surface conditions of mobile dunes. Seeds that become buried deep in the sand are not able to germinate. Plants that do germinate have to be resistant at the highly sensitive seedling stage to a variety of adverse conditions, such as lack of water, abrasion from wind-blown sand (sandblasting) and frequent burial, and the removal of sand from around them. Mobile dunes are therefore usually very sparsely vegetated by perennials, and the contribution of desert annuals, in terms of both species numbers and cover, is generally insignificant, even after heavy rainfall.

The sedge *Cyperus conglomeratus* is one of the most ubiquitous species of sandy substrates in the UAE. It forms monotonous, species-poor to species-rich stands over large areas (*Cyperus conglomerates* community). It is also a common associate in other communities. Typical accompanying perennials include *Dipterygium glaucum* and *Limeum arabicum*, although the latter is largely absent from most coastal, areas. As it is generally less palatable, Cyperus has almost certainly been able to withstand the heavy grazing characteristic of recent decades better than many true grasses such as *Centropodia forsskaolii*, *Panicum turgidum* and *Pennisetum divisum.*

The characteristic tree of sand sheets and dunes in the eastern part of the Emirate is *Prosopis cineraria* ('ghaf'), which forms small groves or 'forests' (*Prosopis cineraria*-community- (**Figure 4.7)**. The tree exploits water stored deep in the sand. Further to the east, where precipitation is higher, the tree also occurs locally on alluvial plains. The western distribution limit of this species on the Arabian Peninsula is between Sweihan and Abu Dhabi. The remaining natural ghaf forests probably represent relict populations of the species, and are deteriorating rapidly, mainly due to the effects of overgrazing. It is not clear to what extent the tree regenerates from seed, as germination is only likely to take place and seedlings to become established successfully after exceptionally heavy rains. Even if they do become established, the seedlings are unlikely to survive the voracious appetite of the ubiquitous goats, sheep and camels, especially as livestock camps

Figure 4-7: Natural ghaf forests *Prosopis cineraria*

have been established near or in any ghaf forests. Where the grazing pressure is less intense, young trees often develop from root suckers, *i.e.* by vegetative means.

Stands of the shrub *Haloxylon persicum* ('ghada') occupy a geographically distinct and well-delineated area south of Abu Dhabi City, where they form a characteristic species-poor plant assemblage (*Haloxylon persicum*-community) on low dunes. *Cyperus conglomeratus*, *Haloxylon salicornicum* and *Zygophyllum qatarense* are regular codominants, at least locally. Frequent fogs in the region facilitate the growth of lichens on the bark of *H. persicum*. The fine branches of the shrubs comb out droplets of water from the atmosphere, a feature that has led Aspinall & Hellyer (2004) to describe this vegetation as a 'dew forest'. This moisture accumulates on the ground beneath the plants. However, the potential benefits of this 'auto-watering mechanism' for the ghada shrubs require more rigorous investigation.

The stands of *Haloxylon persicum* are of outstanding conservation value because this is the only natural occurrence in the UAE and in eastern Arabia in general.

In the far south of the country, *Cornulaca arabica* is the key species of a characteristic dwarf shrub community on the lower flanks of dunes in the Rub Al Khali, where it is one of the few common perennials. It is still not clear whether it should be treated as a distinct species from the more widespread *Cornulaca monacantha*. This *Cornulaca arabica-community, in which Cyperus conglomeratus* also plays a prominent role, is widespread throughout the Liwa Crescent, Umm az-Zamul and the south-west. The precise taxonomy of Cornulaca is not entirely clear: some authors regard it as conspecific with *C. monacantha*, but others, including Mandaville (1990), treat it as a distinct species that is endemic to the Rub Al Khali, extending locally into the northern part of Abu Dhabi Emirate.

Another characteristic plant of the Rub Al Khali and one that appears to be widespread in the Liwa/ Umm az-Zamul area is *Calligonum crinitum ssp. arabicum*, a species that has been largely overlooked in the UAE and confused with *Calligonum comosum*. Mandaville (1990) suggests that the former is typical of the higher dunes of the Rub Al Khali, whereas *C. comosum* is more common further north.

Tribulus arabicus is a perennial herb that is widespread on deep, undulating sand sheets in the southern half of the country, sometimes forming extensive stands, and is invariably accompanied by *Cyperus conglomerates* (*Tribulus arabicus-Cyperus conglomeratus*-community). The morphological variability of *Tribulus arabicus* plants, even amongst those growing in close proximity to each other, has resulted in much taxonomic confusion. For this reason, the species that is now often referred to as '*Tribulus omanense*' in the UAE is best regarded as belonging to the *T. arabicus*- complex. Irrespective of its precise identity, it is an important grazing plant for domestic livestock and probably also for wild gazelles.

E. Vegetation of the plains

Plains of various types occur in many parts of the Emirate. As a broad and convenient generalisation, it is possible to distinguish alluvial and interdunal plains. The former are developed as wide, flat expanses in eastern parts of the Emirate at the foot of the mountains (piedmont alluvial plains), as well as in some western regions. Interdunal plains are commonly associated with sand dune systems, but it is important to bear in mind that particularly in the east, the substrate of these plains may be partly of alluvial origin.

The physiognomically dominant vegetation of the alluvial plains in the east of Abu Dhabi Emirate consists of small trees, dwarf shrubs and succulents. The typical species of the rocky and gravelly plains there is *Acacia tortilis* ('samr'), a flat-topped tree that forms extensive stands (Acacia tortilis-community-**Figure 4.8). The trees make use of the run-off water from the mountains. Common perennial associates include** *Haloxylon salicornicum* and *Rhazya stricta*. At the foot of Jebel Hafit, the small shrub *Gaillonia aucheri*, which has its western distribution limit there, is also frequent. *Acacia tortilis* is absent from the gravels in the western part of the Emirate, probably due to the lack of sufficient moisture. It cannot be ruled out, though, that it did once occur there in the not too distant past, but under the prevailing adverse climatic conditions, the stands are highly sensitive to disruption (cutting for fuel, heavy grazing pressures) and will not re-establish readily.

A second species of *Acacia, A. ehrenbergiana*, is found on sandy to gravelly plains in the east of the Emirate. It is a very local, shrubby tree, occurring in small populations near Sweihan, in Umm az-Zamul as well as a few other locations. Despite the presence of thorns, the trees are usually heavily browsed by camels, and as a result, rarely produce flowers. *Rhazya stricta* ('harma') occurs on gravelly plains in the east of the Emirate, and like *Acacia tortilis*, is absent from the west. It is a highly toxic species,

Figure 4-8: Natural *Acacia tortilis* and *Haloxylon salicornicum*

and larger herbivores therefore avoid it. As a result of higher grazing intensities in recent decades, the species has probably been able to increase at the expense of more palatable grasses and shrubs. In other words, the '*Rhazya stricta*-community' can be regarded as a degradation stage of other communities, such as *Acacia tortilis* and *Haloxylon salicornicum* communities.

A number of shrubs and dwarf shrubs play an important role in the vegetation of both alluvial and interdunal plains. *Haloxylon salicornicum* is a leafless, slightly succulent dwarf shrub that can attain a maximum height of 100 cm under favourable conditions, although it is usually less than 60 cm. It is one of the most common shrubs throughout central and northern parts of the Arabian Peninsula, where it is the main constituent of the *Haloxylon salicornicum* community, dominating large tracts of desert (Figure 23). In Abu Dhabi Emirate, it occurs mainly in the north, where it is common on sandy, gravelly and rocky plains, as well as gently undulating sand sheets.

The most extensive stands are in the north-west. Here there are few accompanying perennials, but *Stipagrostis plumosa* is a fairly frequent associate, and on sandier substrates, *Cyperus conglomeratus* may also occur.

Haloxylon salicornicum experiences its main period of vegetative growth during the hot summer months. As a result, the desert often appears surprisingly green in summer. Flowering in *Haloxylon* takes place mainly between September and November, and during the winter, numerous lightweight fruits are produced. As soon as the seeds are shed and the first rains have fallen, germination can take place. The seeds therefore require no period of dormancy.

On interdunal plains with moderately saline soils, *Zygophyllum qatarense* forms extensive, virtually monospecific stands. Above a certain threshold level of soil salinity, though, its growth too is greatly inhibited. Although *Zygophyllum* seedlings may germinate profusely after heavy rainfall on highly saline substrates, they soon die off as the substrate dries out. Particularly dense stands of the species occur on the margins of inland sabkha. Elevated soil salinity is a factor that also restricts the potential occurrence of many desert annuals. The generally rather species-poor annual vegetation of the inter-dunal plains is highly dependent on winter rainfall, and in years of low precipitation, desert annuals may not germinate at all. Typical species include *Eremobium aegyptiacum, Neurada procumbens, Savignya parviflora* and *Zygophyllum simplex*.

Figure 4-9: *Acacia tortilis* and *Euphorbia larica* in Jebel Hafit

F. Montane, wadi and 'jebel' vegetation

Jebel Hafit, an outlier of the extensive Hajar mountain range to the east, is the only true mountain in Abu Dhabi Emirate, although part of it is located in Oman. It rises sharply above the surrounding plain to just over 1000 m a.s.l. Apart from small pockets of humus that accumulate in rock crevices and similar microhabitats, there has been no development of humus-rich soils on the mountain slopes, leaving the underlying parent material exposed. Due to the sparseness of perennial vegetation cover, the mountain often appears distinctly barren at first sight. From a botanical point of view, Jebel Hafit is probably the most important site within Abu Dhabi Emirate for a number of reasons. Firstly, the mountain supports the highest floristic diversity of anywhere in the Emirate. Over one third of the roughly 380 species currently known for Abu Dhabi occur on the mountain, *i.e.* in less than 0.002% of the land area of the Emirate. Secondly, many of these species are restricted to Jebel Hafit and its immediate environs, and thirdly, several taxa have their global western distribution limits there, underlining its biogeographical significance.

On the lower slopes of Jebel Hafit, *Acacia tortilis* and *Euphorbia larica* are widespread (Figure 4.9) often accompanied by perennials such as *Gaillonia aucheri* and *Lycium shawii*. With increasing elevation, *Acacia* becomes less frequent, but still occurs close to the summit. *Euphorbia*, though, remains common at all altitudes, and is often found along natural drainage channels. *Haloxylon salicornicum* is a common dwarf shrub on the exposed mountain slopes, and another chenopod, the distinctive *Salsola rubescens*, is fairly widespread, occurring locally in large populations. *Capparis cartilaginea*, a species with large, leathery leaves, can be readily observed by the roadside up to the summit, often hanging from rocky cliffs. Other shrubs occurring on the mountain include *Periploca aphylla, Grewia erythraea* and strikingly, *Rhanterium epapposum*, a species otherwise characteristic of sandy habitats.

A distinct sequence of tree species can be observed along the course of the larger wadis of Jebel Hafit. *Acacia tortilis* fringes the margins of wadis at lower altitudes, but also grows on elevated banks in the wadi beds themselves. In the middle reaches, where there is shade for at least part of the day, Prosopis cineraria occurs, occasionally accompanied by *Zizyphus spinachristi* (Christ's Thorn). The creeper *Pentatropis nivalis* has entwined itself around at least one *Prosopis cineraria* tree in Wadi Tarabat. At higher altitudes, where the wadis are narrower and more deeply incised, *Moringa peregrina* is the distinctive tree species. In the same type of habitat, the shrub *Dodonaea viscosa* is most likely to be found. Towards the head of Wadi Tarabat, a small group of Acridocarpus orientalis trees persists. Apart from a few other individuals on Jebel Hafit, this is the only known population in the UAE. The dwarf palm *Nannorrops ritchieana* is a rare plant in the UAE, but occurs very locally on the mountain, as does *Ficus johannis ssp. johannis*.

Wadi beds are often extremely rich floristically, especially in their lower reaches, where a combination of different types of substrate, pronounced spatial heterogeneity in

micro topography and microclimate, light availability and regular access to water creates a mosaic of favourable microhabitats. Due to the occasional 'catastrophic' events, *i.e. severe flooding, wadi beds are highly dynamic habitats, not only in terms of their physical characteristics, but also regarding their floristic composition. Many species are often wiped out during torrents, but at the same time, new seeds are transported with the water and deposited in favourable microhabitats. Characteristic grasses of wadi beds are Cymbopogon commutatus* and *C. schoenanthus*, two perennial species that are often difficult to separate, especially vegetatively, as well as *Cenchrus ciliaris*.

Especially along the coast in more western parts of the Emirate, Tertiary jebels are prominent features, often surrounded by barren sabkha. These rocky exposures with flat tops vary in both area and height, but are typically up to about 5 to 10 m high, with the largest up to 60 m. Jebels represent typical island habitats and are thus of considerable research interest. A number of plant species occur on the jebels, including halophytes such as *Seidlitzia rosmarinus* and *Salsola* spp. The salinity is presumably provided by windblown saline dust from the surrounding sabkha. Also present are a number of nonhalophytic species that are otherwise absent from the surrounding area. These plants grow in small pockets of soil that accumulate behind rocks or in gullies on the smaller jebels, as well as on the plateaux of the larger ones. Among the plants are a number of desert annuals, such as *Savignya parviflora*, Eremobium aegyptiacum and the bristly, facultative perennial *Arnebia hispidissima*. Furthermore, the lily *Dipcardi erythraeum* appears abundantly on the flanks of some jebels after heavy rainfall. *Salsola drummondii* can be dominant on the tops of some larger jebels, often accompanied by *Calligonum comosum, Indigofera sp. Panicum turgidum* and *Pennisetum divisum*.

G. Vegetation of oases, farmland and plantations

Freshwater oases are scattered throughout the Emirate, in particular on the alluvial plains in the east, but also in the south close to the border with Saudi Arabia. The Liwa Crescent consists of a series of individual oases stretching for more than 100 km, and is clearly visible on satellite imagery.

Date palm plantations provide habitats for a number of wild plant species. Farms have sprung up in desert areas where there is a sufficient supply of water (*e.g.* Liwa), and fields of *Chloris gayana* (Rhode's grass) are dotted around the country. Typical wildflower species of the agricultural areas include *Amaranthus spp., Chenopodium murale, Emex spinosa, Eruca sativa, Euphorbia prostrata, Launaea procumbens, Melilotus indica, Phyllanthus rotundifolius, Portulaca olereaca, Sisymbrium erysimoides, Sporobolus spicatus* and *Trigonella hamosa*.

In recent decades, intensive efforts have been undertaken to establish forestry plantations, especially in Abu Dhabi Emirate. Many of the tree species in these plantations are indigenous, although some have been imported. A number of wild species, both animal and plant, have been able to take advantage of this new type of habitat.

H. Vegetation of inland water

Permanent freshwater habitats are virtually absent from the Emirate, but after heavy rainfall, pools may develop in wadis and on interdunal plains .However; they are devoid of true aquatic vegetation. Members of the genus *Tamarix* (tamarisks), often accompanied by *Phragmites australis* (reed), a cosmopolitan grass, occur where the water table is close to the surface, often far inland. A number of artificial lakes have been created in recent years, such as Al Wathba Wetland Reserve south-east of Abu Dhabi island. The water of this lake is mainly brackish. *Phragmites australis* forms dense stands in some parts of the lake, especially where treated sewage water is fed into the lake and salinity levels are lower, but other aquatic species appear to be absent. *Aeluropus lagopoides*, a prostrate, mat forming grass, fringes many artificial water bodies.

4.1.4 Threats to the natural vegetation and flora

The unprecedented rate of economic development in the UAE during the past decades has brought enormous prosperity to a region which had previously endured great hardship. But the speed of this development has inevitably had a serious impact on the natural environment, and conservation issues have largely been neglected in the rush for material wealth. It is particularly sad to note that much destruction of the natural environment has been unnecessary. Some form of long-term planning strategy, both on a local and on a more regional level, remains an urgent requirement to prevent further avoidable damage. A detailed account of anthropogenic factors and their impacts on natural habitats in the Emirate has recently been given by Böer (1999). Habitat loss, particularly by destruction and degradation, is the primary threat to the natural vegetation and flora, in some cases leading to marked declines in the populations of certain species.

A Construction Activities

Not only have many coastal areas suffered considerably from unnecessary development or destruction, but construction activities are having a negative effect in other sensitive parts of the Emirate. With Jebel Hafit designated as a major tourist attraction, efforts must be intensified to protect this unique mountain and its associated wadis. Some of the larger Tertiary jebels, which are a prominent feature in the west of the country near to the coast, also require protection. In certain parts of the country, there has been substantial removal and leveling of surface soils over extensive areas. This material is then transported to other sites where it is used for a variety of construction purposes, including coastal development. Currently, there is reclamation of large tracts of sabkha, a unique habitat type that is possibly best developed globally in Abu Dhabi Emirate.

B Agriculture and forestry

Although the recent massive afforestation programme throughout many parts of the Emirate is well intentioned, its benefits need to be re-assessed, as there are a number of serious problems associated with the plantations. With insufficient rainfall to support them naturally, they are entirely dependent on irrigation water. A substantial proportion of this water is derived from precious groundwater reserves, and at present, abstraction far exceeds the rates of natural recharge. The excessive abstraction of groundwater will undoubtedly have serious consequences in years to come. Already it seems as if the lowering of the water table in some areas has caused a die-back of the natural vegetation. Amongst native plants, phreatophytes, *i.e.* species that obtain their water from groundwater or water stored in the sand, are most at risk, including *Prosopis cineraria*.

Furthermore, extensive earth-moving works over huge areas are often required to prepare the ground for the trees, destroying the important natural heritage, including archaeological artifacts, in the process. Habitat fragmentation is another direct consequence of the kilometres of walls and fences that enclose the plantations, thus seriously restricting the movement of larger animals. If the role of these plantations is mainly to green the desert, then the price in terms of actual financial cost and ecological disadvantages appears disproportionately high.

Modification of general climatic conditions, as sometimes advanced by the proponents of these plantations, is wishful thinking. The paucity of rainfall in recent years is ample proof, should evidence even be required. If anything, the vast amount of the 'greenhouse gas' CO2 emitted from water desalinisation plants, which are increasingly being use to meet the rising demand for irrigation water, contributes substantially to global warming. This CO2 stems from the burning of large amounts of fossil fuels needed for the inherently energy-inefficient desalinisation process.

Enhanced soil salinisation is an inevitable result of the inappropriate irrigation techniques that are used to provide moisture to the trees. Due to large-scale mismanagement of water and soil resources in general, there have been marked increases in soil salinity in many other areas. As a consequence, it seems that plant communities less tolerant of saline conditions are being replaced by halophytic ones. This will inevitably lead to a simplification of the ecosystem, *i.e.* fewer species of plant and, as a result, fewer animal species. But not only natural plant and animal communities will be affected; the degradation of soil properties will greatly restrict the potential agricultural uses for the land.

C. Oil pollution

Oil pollution is potentially a problem in many coastal areas, and due care should be taken to prevent spills from occurring. Although there is evidence to suggest that certain ecosystems, such as mangroves, can recover from moderate or even large oil spills, the immediate impact on wildlife is often quite devastating (Böer, 1993). When oil spills occur in terrestrial habitats, the natural breakdown of the oil can be an extremely long process under the prevailing adverse climatic conditions (Brown & Porembski, 2000).

D. Invasive plant species

Invasive plant species do not pose the same problems to the natural environment as they do in more temperate regions of the world simply because of the harshness of the climate. Although a number of species have profited from anthropogenic habitats such as lawns (including *Coronopus didymus, Launaea* spp. and *Fimbristylis* spp.) and urban wasteland, these species cannot survive in the natural desert landscape where the regular input of water is lacking.

There are several species that have probably greatly expanded their populations in the far east of the Emirate, and especially in the northern Emirates where rainfall is higher. The main problematic species there is *Prosopis juliflora* (mesquite), which is able to reproduce rapidly and occupy large areas of disturbed ground and some wadis. Less of a problem are species such as *Calotropis procera* ('ushar'), an extremely fast-growing, toxic large shrub to

small tree that can begin producing flowers and fruits at an early age. This species of sandy gravel plains, which is also found in urban environments and by roadsides in the north-east of the Emirate, becomes increasing rare towards the south-west, with only isolated individuals in true desert environments. One it has gained a foothold, though, it is a persistent plant that is hard to eradicate.

4.2 Fauna

4.2.1 Vertebrates

4.2.1.1 Mammals

Abu Dhabi Emirate is diverse both in terms of landforms and in terms of vegetation structure. Consequently there are numerous habitats used by many of the native species of wildlife within the Emirate.

Forty eight species of terrestrial mammals have been recorded in The UAE. These mammals exist within 18 Families of 8 Orders (Carnivora, Artiodactyla, Perissodactyla, Rodentia, Hyracoidea, Lagomorpha, Insectivora and Chiroptera). Of these 48 species, 7 species (*Oryx leucoryx, Capra aegagrus, Capra ibexnubiana, Canis lupus arabs*, *Hyaena hyaena, Panthera pardus nimr, and Hystrix indica)* are known to be extinct in the wild.

Table 4-1: Summary of recorded mammalian taxa occuring in UAE

Order	Families	Extinct Species	Introduced Species	Total Number of Species
Carnivora	5	3	3	14
Perissodactyla	1		1	1
Artiodactyla	1	3	2	8
Rodentia	3	1	3	11
Hyracoidea	1		1	1
Lagomorpha	1			1
Insectivora	2		1	4
Chiroptera	4			8
Total	18	7	11	48

Table 4-2: Native species list of terrestrial mammals of UAE

Common Name	Scientific Name
Insectivora	
Ethiopian Hedgehog	*Hemiechinus aethiopicus*
Brandt's Hedgehog	*Hemiechinus hypomelas*
Savi's Pygmy Shrew	*Suncus etruscus*
Chiroptera	
Egyptian Fruit Bat	Rousettus aegyptiacus
Muscat Mouse-tailed Bat	Rhinopoma muscatellum
Naked Bellied Tomb Bat	Taphozous nudiventris
Trident Leaf-nosed Bat	Asellia tridens
Persian Leaf-nosed Bat	*Triaenops persicus*
Sind Serotine Bat	*Eptesicus nasutus*
Kuhl's Pipistrelle	*Pipistrellus kuhlii*
Hemprich's Long-eared Bat	Otonycteris hemprichii
Carnivora	
Wolf	Canis lupus arabs
Red Fox*	Vulpes vulpes
Rüppell's Fox	Vulpes rueppelli
Blanford's Fox	Vulpes cana
Honey Badger or Ratel	Mellivora capensis
White-tailed Mongoose	Ichneumia albicauda
Striped Hyaena	Hyaena hyaena
Gordon's Wildcat	Felis silvestris gordoni
Sand Cat	Felis margarita
Caracal	Caracal caracal
Arabian Leopard	Panthera pardus nimr
Artidactyla	
Arabian Tahr	Hemitragus jayakari
Nubian Ibex	Capra ibex nubiana
Wild Goat	Capra aegagrus
Arabian Oryx	Oryx leucoryx
Mountain Gazelle	Gazella gazella cora
Sand Gazelle	Gazella subgutturosa marica
Lagomorpha	
Cape Hare	Lepus capensis
Rodentia	
Indian Porcupine	Hystrix indica
Lesser Jerboa	Jaculus jaculus
Egyptian Spiny Mouse	Acomys cahirinus
Wagner's Gerbil	Gerbillus dasyurus
Baluchistan Gerbil	Gerbillus nanus
Cheesman's gerbil	Gerbillus cheesmani
Sundevall's Jird	Meriones crassus
Arabian Jird	Meriones arimalius

Species in Bold are classified as extinct in the wild

Table 4-3: Introduced and domesticated terrestrial mammals of UAE

Common Name	Scientific Name
House shrew	*Suncus murinus*
Indian Grey Mongoose	*Herpestes edwardsi*
Domestic Dog	*Canis familiaris*
Feral Cat	*Felis cattus*
Rock Hyrax	*Procavia capensis*
Domestic Goat	*Capra aegagrus hircus*
Donkey	*Equus asinus*
Camel	*Camelus dromedaries*
Black Rat	*Rattus rattus*
Brown Rat	*Rattus norveggicus*
House Mouse	Mus musculus

From the remaining 41 species, 11 species have been introduced in UAE under recent geological times, either accidentally or as domesticated animals, and can be found in the wild.

IUCN (World Conservation Union; http://www.iucn.org) Red List Categories: LC: least concern, NT: near threatened, VU: vulnerable, CR: critically endangered (IUCN 2003). **Species in bold are listed in the 2004 IUCN Red List of Threatened Species in the World** (IUCN 2004; http://www.redlist.org). Species highlighted in bold are considered as species of conservation concern and included in the proposed National Red Data List of mammalian species of Abu Dhabi (Drew *et al.*, 2004; Drew & Tourenq, 2005). Species indicated with * are considered to be pest or invasive species (http://www.issg.org) and their presence is indicative of the rate and extent of urbanization within this area.

A Species List

Included below is a list of species that occur in neighbouring countries and for which the evidence of their presence in the Emirate has to be determined. 'Native Species' are distinguished from 'Introduced and Domesticated Species' that are closely linked to human settlement and expansion in the Arabian Peninsula from several millennia ago (*e.g.* goats and dogs bones from 7000 BC were found in Palestine, Qumsiyeh, 1996) to recent times (*e.g.* settlements in Arabian Gulf islands for oil exploitation).

Native Species

Order Insectivora - insectivores

Ethiopian Hedgehog (*Hemiechinus aethiopicus*): The species has a wide range through the Arabian Peninsula, except the central sands of the Rub al Khali (Harrison & Bates, 1991). Found even in extensive sandy areas, the Ethiopian Hedgehog is said to be the most widespread hedgehog species of the Abu Dhabi Emirate (Duckworth, 1996; Böer *et al.*, 1999; Drew *et al.*, 2003a; Drew *et al.*, 2004). It is classified as Least Concern in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-10: Desert Hedgehog (*Paraechinus aethipicus*)

Brandt's Hedgehog (*Hemiechinus hypomelas*): Due to its nocturnal habits and discretion, this species is said to be scarcer than the Ethiopian Hedgehog with a patchy distribution through the mountains of the Arabian Peninsula (Asir, Akhdar, Hajar, Musandam; Harrison & Bates, 1991). In Abu Dhabi Emirate, the species is restricted to the rocky areas of Jebel Hafit and Al Ain (Duckworth, 1996). Whereas it is said common in Jebel Hafit (reported in Drew & Drew, 2004), it was not recorded during intensive surveys in 1998 and 2002 (Stuart & Stuart, 1998; Drew & Al Dhaheri, 2003). Therefore, due to its restricted distribution in Abu Dhabi Emirate and the absence of recent observations, it is classified as Critically Endangered in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-11: Brandt's Hedgehog (*Paraechinus hypomelus*)

Savi's Pygmy Shrew (*Suncus etruscus*): This species is recorded along the Arabian Peninsula coasts (Harrison & Bates, 1991), and particularly in Bahrain, but the only record from UAE is from Sharjah (Peter Phelan *pers. comm.*). There is suitable habitat within the Emirate of Abu Dhabi for this species and there is one unconfirmed sighting of a southern grey shrike feeding on one shrew from Al Wathba fodder fields near Abu Dhabi Island in spring 2004 (Steve James & Chris Drew, *pers. obs.*). This species is classified is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Order Chiroptera - bats

Egyptian Fruit Bat (*Rousettus aegyptiacus*): This species has a wide distribution in rocky areas of the Arabian Peninsula (Asir, Dhofar, Jebel Akhdar, Hajar, Musandam; Harrison & Bates, 1991). The Egyptian Fruit Bat has been recorded in Jebel Hafit (Stuart & Stuart, 1998; Drew & Al Dhaheri, 2003). Individuals can be seen in Al Ain gardens and orchards when mangoes are ripening. Suitable roosting caverns are said to be restricted to the Ras al Khaimah region and this species can roam widely in search of food (Duckworth, 1996). However, a dead individual was found in a wadi of Jebel Hafit (Drew & Drew, 2004). Further investigations are then needed to identify the distribution and status of this secretive species in the Abu Dhabi Emirate. It is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-12: Fruit Bat (*Rousettus aegyptiacus*)

Muscat Mouse-tailed Bat (*Rhinopoma muscatellum*): In the Arabian Peninsula, this species is said to have a limited distribution in the Jebel Akhdar and Hajar mountains (Harrison & Bates, 1991). This species seems to be the most common bat found in Jebel Hafit where it breeds and roosts (Duckworth, 1996; Stuart & Stuart, 1998; Drew & Al Dhaheri, 2003; Drew & Drew, 2004; Barcelo & Drew, 2005). However as for other species of bats, Abu Dhabi Emirate does not have much available habitat for bats with the exception of Al Ain and some outcrops in the desert or the coast. Jebel Hafit may well be the only location in the Emirate of Abu Dhabi that provides suitable roosting habitat for the Muscat mouse-tailed bat. For this reason, it is classified as Vulnerable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-13: Muscat Mouse-tailed bat (*Rhinopoma muscatellum*)

Naked Bellied Tomb Bat (*Taphozous nudiventris*): This species was found in some rocky areas of the Arabian Peninsula (Asir, Dhofar, Jebel Akhdar, Hajar) and along the Tiger and Euphrates rivers (Harrison & Bates, 1991). The Naked Bellied Tomb Bat was recorded only in Al Ain and on Das Island (Duckworth, 1996; Stuart & Stuart, 1998). More surveys are needed to identify the distribution and status of this species in the Abu Dhabi Emirate. It is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Trident Leaf-nosed Bat (*Asellia tridens*): The species has a wide range through the Arabian Peninsula, except the central deserts of the interior (Harrison & Bates, 1991). In the Abu Dhabi Emirate, the Trident Leaf-nosed Bat was recorded in Al Ain only (Duckworth, 1996; Stuart & Stuart, 1998). More surveys are needed to identify the distribution and status of this species in the Abu Dhabi Emirate. It is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Persian Leaf-nosed Bat (*Triaenops persicus*): In the Arabian Peninsula, this species was found in Aden, the Jebel Akhdar and the Hajar mountains only (Harrison & Bates, 1991). In the Abu Dhabi Emirate, the Persian Leaf-nosed Bat was recorded in Al Ain only (Duckworth, 1996;

Stuart & Stuart, 1998). More surveys are needed to identify the distribution and status of this species in the Abu Dhabi Emirate. It is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Sind Serotine Bat (*Eptesicus nasutus*): The species has a wide patchy range through the Arabian Peninsula (Harrison & Bates, 1991). The Sind Serotine Bat has been found in only two localities in the Abu Dhabi Emirate: Ruwais and Ras Ghanada (Duckworth, 1996). More investigations are needed to identify the distribution and status of this species in the Abu Dhabi Emirate. It is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Kuhl's Pipistrelle (*Pipistrellus kuhlii*): The species has a wide patchy range through the Arabian Peninsula, except the central Rub al Khali (Harrison & Bates, 1991). The Kuhl's Pipistrelle was reported only in Al Ain, Jebel Hafit and some coastal areas of the Abu Dhabi Emirate (Duckworth, 1996; Stuart & Stuart, 1998; Drew & Al Dhaheri, 2003, ERWDA unpublished). Since it is said to be the most common bat around human settlements and gardens in the Gulf Region (Harrison, 1981), more surveys are needed to identify the distribution and status in other towns and farmlands of the Abu Dhabi Emirate. It is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Hemprich's Long-eared Bat (*Otonycteris hemprichii*): The species has a wide patchy range through the Arabian Peninsula, except the central Rub al Khali (Harrison & Bates, 1991). The Hemprich's Long-eared Bat is cited by Hornby (1996) and Cunningham (2004), despite no data being provided on the occurrence of this species in the Emirate of Abu Dhabi. Further surveying is needed to identify the distribution and status of this species in the Emirate. It is therefore classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Order Carnivora – carnivores

Wolf (*Canis lupus arabs*): The species has a wide range through the Arabian Peninsula, except the central sands of the Rub al Khali and Iraq (Harrison & Bates, 1991). The Arabian Wolf is considered to have gone extinct from Jebel Hafit in the 1970's (Duckworth, 1996; Stuart & Stuart, 1998). However, even as recently as 2004 there have been unconfirmed reports of sightings on Sweihan area and elsewhere north of Al Ain. These sightings, if correct, are almost certainly individuals on exploratory trips from Oman and there is no evidence to suggest that there is a breeding population living within the Emirate of Abu Dhabi. Consequently the species is assessed as being Regionally Extinct in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-14: Arabian or Grey Wolf (Canis lupus)

Red Fox (*Vulpes vulpes*): Native to Europe, Asia, Africa, and boreal regions of North America, European red foxes have been introduced into Australia and temperate regions of North America. They are now the most widely distributed carnivore in the world and have negative impacts on many native species, including smaller canids and ground nesting birds in North America, and many small and medium-sized rodent and marsupial species in Australia. The Red Fox is classified as one of the 100 World's Worst Invasive Alien Species by the IUCN (http://www.issg.org). The red fox is considered to have expanded its range into the interior of the Emirate where, were it not for agricultural plantations, afforested areas, or domestic livestock farms, the species would otherwise be unable to survive. Despite human persecution, the species does not meet any of the criteria for critically endangered, endangered, vulnerable or near threatened and consequently is assessed as being Least Concern in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Rüppell's Fox (*Vulpes rueppelli*): Rüppell's foxes live throughout the Emirate of Abu Dhabi, typically where there is aeolianite outcrops or interdunal depressions providing suitable denning habitat. It is thought that there has been a decline in the overall population size over the last 10 years. The reasons for this are not clear, although drought, overgrazing, and competition with other predators (for example red foxes and feral cats) are considered to be the most likely causes. Local reports indicate that the Rüppell's fox may suffer indirectly from foxes' persecution (poisoning, trapping). The species meets the criteria for being Endangered

in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005) because it is estimated that the population has or will decline by 50 % within a 10 year period based on direct observation, a decline in area of occupancy and habitat quality as well as suffering the effects of competition from other predators.

Figure 4-15: Blanford's Fox (*Vulpes cana*)

Blanford's Fox (*Vulpes cana***):** Due to its nocturnal habits and discretion, this species may be more common through the mountains of the Arabian Peninsula (Sinai, Asir, Dhofar, Hajar) where it has a very patchy distribution (Harrison & Bates, 1991). Within the Emirate of Abu Dhabi, the only suitable habitat for Blanfords fox is Jebel Hafit where it was recorded for the first time in UAE in 1995 (Stuart & Stuart, 1998). On the Jebel Hafit, Blanford's Fox seems relatively common, probably being the most encountered carnivore. Nevertheless, the population size is estimated to be less than 50 mature individuals and the available habitat is being reduced by development taking place along the lower reaches of the mountain. As the Rüppell's Fox, this species may suffer indirectly from foxes' persecution (poisoning, trapping). Due to the low population size, the restricted range, the declining habitat size due to tourism development and the competition with Red Fox, the taxon is assessed as being Critically Endangered in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Honey Badger or Ratel (*Mellivora capensis***):** The species has a wide range through the Arabian Peninsula, except central sands of the Rub al Khali (Harrison & Bates, 1991). Until recent times, it was not entirely clear whether or not honey badgers existed in UAE; however, there have been three recent records of tracks between Liwa and Umm az-Zamul, and in the Baynoonah area in the early 90's (Osborne, 1992; MacKinlay & MacDonald, 1992) and one individual was observed and photographed in Ruwais region (Aspinall, *pers. com*.). The species is therefore classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

White-tailed Mongoose (*Ichneumia albicauda***):** With a wide distribution in Africa, this species is found in rocky areas of the Arabian Peninsula (Asir, Dhofar, Jebel Akhdar, Hajar, Musandam; Harison & Bates, 1991). The White-tailed Mongoose was reported in Al Ain and the northern emirates (Gasparetti *et al.*, 1985; Gross, 1987; Jongbloed *et al.*, 2001) and sightings of unidentified mongooses on Abu Dhabi Island have been reported (Duckworth, 1996). However, since there may be several species introduced to UAE and that there are no confirmed records of this species occurring within the Emirate of Abu Dhabi, it is classified as Not Applicable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Striped Hyena (*Hyaena hyaena***):** The species has a wide range from North Africa to Nepal. In the Arabian Peninsula they can be found in all kind of habitats except the great sand deserts of the Rub al Khali (Harrison & Bates, 1991). Striped hyenas were recorded on Jebel Hafit by Thesiger in 1949 and more recently in the 1980's on the Al Ain-Dubai road, in Bani Yas and Liwa (Duckworth, 1996). Two confirmed records occurred within the last 6 years one from Sweihan and the other from near the Shah oil field, south of the Liwa crescent (Drew, unpublished data). These infrequent sightings almost certainly are of vagrant individuals and there is no evidence to suggest that there is a breeding population within the Emirate of Abu Dhabi. A security fence along the entire length of the terrestrial International border prevents any further nomadic movement between UAE and its neighbours (Saudi Arabia, Oman) where this species subsists. The taxon therefore meets the criteria for being Regionally Extinct in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-16: Striped Hyena (*Hyaena hyaena*)

Gordon's Wildcat (*Felis silvestris gordoni*): Individuals were caught in the 1970's and 1980's at Al Ain Zoo (Duckworth, 1996). However, feral cats might exhibit behavioural and phenotypic patterns similar to this species and only genetic studies can separate the two species. Due to their similarities with domestic cats, Gordon's Wildcat may benefit from a traditional religious respect because of their association with the Prophet Mohammed, and are less likely to be persecuted (Dragesco-Joffé, 1993). However this species is threatened by genetic pollution and introduction of disease such as feline immunodeficiency lentivirus, leukaemia, etc.) by feral cats (Nowell & Jackson, 1996; Ostrowski *et al.*, 2003). The Gordon's Wildcat may suffer indirectly from foxes' persecution (poisoning, trapping). Further research including survey work and genetics studies (to quantify the extent of crossbreeding with feral cats) is required to facilitate an assessment of the status of this species. The species is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Sand Cat (*Felis margarita*): The species is present in Abu Dhabi Emirate but due to its secretive and nocturnal habits, it is seldom observed. Intensive surveys and trapping by ERWDA in favourable habitats since 2002 have not revealed any confirmed records. There have been only 4 authenticated records of this species within the last 10 years: one individual was recorded in the Sweihan area five years ago (Cunningham, 2002), one individual was found for sale in a pet shop in 2002, having been caught south of Al Ain (Drew, unpublished data), one individual was seen again in the Sweihan area in autumn 2004 (Eichaker, *pers. com.*) and one observed and pictured in the Baynoonah area of Western Abu Dhabi in 2005 (Judas, unpublished data).

Figure 4-17: Sand Cat (*Felis margarita*)

Due to their similarities with domestic cats, sand cats may benefit from a traditional religious respect because of their association with the Prophet Mohammed, and are less likely to be persecuted (Dragesco-Joffé, 1993). However this species may suffer from competition by feral cats (causing both a reduction in area of occupancy as well as the introduction of disease such as feline immunodeficiency lentivirus, leukaemia, *etc*.) that benefited from expansion of human settlements in the desert (Nowell & Jackson, 1996; Bunaian *et al.*, 1998; Ostrowski *et al.*, 2003). With its avoidance of human vicinity, it is not known if the Sand Cat suffers indirectly from foxes' persecution (poisoning, trapping). With an estimated population size of less than 250 mature individuals within the Emirate of Abu Dhabi, the species is assessed as Endangered in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Caracal (*Felis caracal schmitzi*): The species inhabits mountains of the Arabian Peninsula (Asir, Dhofar, Musandam, Jebel Akhdar and Hajar; Harison & Bates, 1991). Recently, a caracal lynx was captured alive by locals in Ras al Khaima in 2003 (Gulf News, 12/01/03). In the Abu Dhabi Emirate, this species was observed far from its usual mountainous habitat: one specimen was recorded near Sweihan in the 1960's, one was found dead in the 1980's along the road from Al Ain to Dubai and one was sighted in the oil field of Bu Hasa (Duckworth, 1996; (www.uaeinteract.com/nature/natu_ems/en13asp). It is classified as Critically Endangered in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005) because it is estimated that there are less than 50 mature individuals within the Emirate of Abu Dhabi, and it is still the object of human persecution across the Arabian Peninsula by shepherds claiming losses of domestic stocks.

Arabian Leopard (*Panthera pardus nimr*): The Arabian Leopard is a discrete inhabitant of mountains of the Arabian Peninsula (Asir, Dhofar, Musandam, Jebel Akhdar and Hajar; Harrison & Bates, 1991). Within the Emirate of Abu Dhabi, there is insufficient mountain habitat and prey species to support a large carnivore such as the Arabian leopard. The species was recorded on Jebel Hafit in the past (Thesiger, 1949) and the last proof of the species presence in the area comes from an individual that was shot and wounded there in 1976 (Hellyer, 1993 *in* Duckworth, 1996). The Arabian Leopard is then classified as Regionally Extinct for the Abu Dhabi Emirate in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Order Artiodactyla - even toed ungulates

Arabian Tahr (*Hemitragus jayakari***):** It is estimated that there less than 20 individuals of this species on the UAE part of Jebel Hafit (Drew & Drew, 2004). Due to the fragmentation of the plain by fenced roads and the international border, exchanges between the population of tahr of Jebel Hafit and the main Hajar mountain range in Oman and the Northern Emirates might no longer be possible. Consequently the sub-population on Jebel Hafit should be considered as an 'island population'. Further research is required to identify population size, structure, resource availability and whether or not there is movement between Jebel Hafit and the main Hajar mountain range. It meets the criteria of Critically Endangered in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Nubian Ibex (*Capra nubiana)***:** The species inhabits the mountains of the Arabian Peninsula (Asir, Dhofar, Hadramut, Jebel Akhdar, Hajar, Musandam; Harrison & Bates, 1991). There is no evidence that this species occurred in the wild in the UAE despite petroglyphs found in the mountains depicting long horned animals that might be either Ibex or Tahr (Cunningham, 2004). The species is not considered to have existed (in the wild) in Abu Dhabi and is classified as Not Applicable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Wild Goat (*Capra aegagrus***):** Found in mountains of Kurdistan, here is only one single record of the wild goat having occurred (in recent times) in UAE (Masafi/Manama area; Harrison, 1968). There are no records at all that the animal existed on Jebel Hafit or elsewhere in Oman. The species is not considered to have existed (in the wild) in Abu Dhabi and is classified as Not Applicable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Arabian Oryx (*Oryx leucoryx***):** Once widespread in all the Arabian Peninsula, this species went extinct in the wild in the early 70's (Henderson, 1974). Since, reintroduction programmes have been initiated in Oman Saudi Arabia and Jordan (Harrison & Bates, 1991). There have been anecdotal reports of 'ad hoc' reintroduction programmes in the south and east of the UAE. According to a questionnaire survey, there are >3,400 animals in private collections of UAE, about 90% of them in Abu Dhabi (EPAA, 2003). There are no truly free-ranging oryx in UAE and consequently the species is classified as Regionally Extinct in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

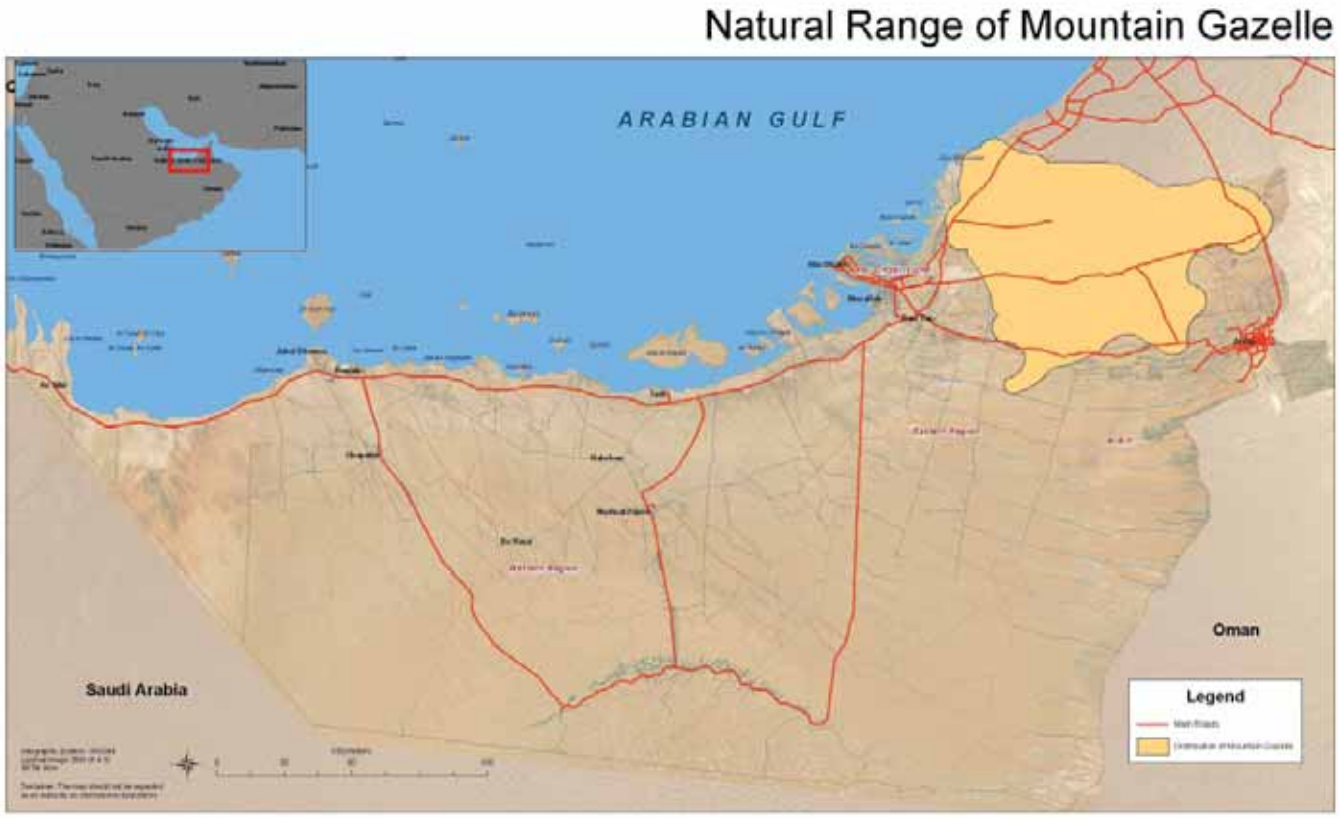
Figure 4-18: Arabian Oryx (*Oryx leucoryx*)

Mountain Gazelle (*Gazella gazella cora***):** This species is confined to the north east and coastal strip of the Emirate of Abu Dhabi, especially in the Jebel Ali area (EPAA, 2003). Captive herds are held in many private collections and forest plantations (around 5,500) and gazelles of mixed origins are known to have escaped or been released into various places. Consequently, there is concern that the gene pool within the wild population may have become polluted following releases of Dorcas gazelle (*Gazella dorcas)* and other non indigenous species (EPAA, 2003). Unlike the sand gazelle population, which lives within a largely unpopulated area, mountain gazelles exist within areas where there is continued anthropogenic impact and infrastructure development. Consequently available habitat is decreasing rapidly and it is thought that this would result in a population decline. Based on extent of occurrence, habitat fragmentation and a declining population size of less than 2500 individuals the taxon is classified as Endangered in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-19: Mountain Gazelle (*Gazella gazella cora*)

Sand Gazelle (*Gazella subgutturosa marica***):** The species is commonly found in the south east of the Emirate of Abu Dhabi. A large number, possibly 15,000, occurs on Sir Bani Yas Island but these were not included in the overall total as they probably have mixed origins and cannot be considered as free-ranging. Captive herds are held in many private collections and forest plantations (EPAA, 2003). The wild population is estimated to be between 500 - 1000 (EPAA, 2003; ERWDA, unpublished). The gazelles forage on natural desert vegetation as well as within open forests, particularly close to and north of Hameem (Khannur, Sbaittan, Bu Sahhan Haleeb and Bu Sahhan forests) as well as Qasaweerah and Khor bin Atee forests in the Eastern region (ERWDA, unpublished). Fragmentation of the habitat by fenced roads is considered a major threat rendering sub-populations susceptible to stochastic threats. Based on population size and fragmentation of the habitat, the species is assessed as being Vulnerable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-20: Sand Gazelle (*Gazella sugutturosa marica*)



Map 2: Natural Range of Mountain Gazelle (Source: EAD Wildlife Survey, 2007)

Map 3: Natural Range of Sand Gazelle (Source: EAD Wildlife Survey, 2007)

Order Lagomorpha - rabbits, hares and picas

Cape Hare (*Lepus capensis*): The species is found throughout all the landforms in the Emirate the Abu Dhabi from the coastal shores to the dunes of the Empty Quarter (Drew, 2000; Drew, 2004). It was also introduced on some islands of the Arabian Gulf, such as Al Yasat and Abu al Abyadh (Duckworth, 1996). Releases of individuals imported from southern and Central Asia, have been implicated in deaths of native hares due to the introduction of disease (suspected to be rabbit haemorrhagic disease) (Drew, 2004). The species is classified as Least Concern in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Order Rodentia - rodents

Indian porcupine (*Hystrix indica*): Only one reference indicates its presence in the western part of the Abu Dhabi Emirate (Gasperetti, 1967). Since, no mention of this species in the Emirate and the whole UAE has been reported since (Cunningham, 2004), this species is not considered to exist in the wild in Abu Dhabi Emirate and is classified as Not Applicable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-21: Cape Hare (*Lepus capensis*)

Lesser Jerboa (*Jaculus jaculus***):** This species occurs mostly in interdunal plains of sandy areas of the whole Abu Dhabi Emirate (Duckworth, 1996; B?er *et al.*, 1999; Drew *et al.*, 2003a; Drew *et al.*, 2004; Drew *et al.*, 2005a; Drew *et al.*, 2005b). Lesser jerboas may be under-represented as the tracks they leave on gravel plains are difficult to spot and identify (Drew *et al.*, 2005a). Further surveys are needed to identify the distribution of this secretive species in the Emirate of Abu Dhabi. It is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-22: Lesser Jerboa (*Jaculus jaculus*)

Egyptian Spiny Mouse (*Acomys cahirinus***):** This species is restricted to Jebel Hafit (Duckworth, 1996; Drew & Drew, 2004). It is also likely to be an 'island species' as the distance from Jebel Hafit to the nearest mountains is almost certainly greater than the home range or normal dispersal distances of the species. Developments taking place on Jebel Hafit have led to the occurrence of feral cats across the entire Jebel as recorded by camera trapping (ERWDA unpublished data) and consequently the species is expected to decline in numbers. The species is considered to be endangered in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Wagner's Gerbil (*Gerbillus dasyurus***):** This species is restricted to Jebel Hafit (Duckworth, 1996; Drew & Drew, 2004). Developments taking place on Jebel Hafit have led to the occurrence of feral cats across the entire Jebel as recorded by camera trapping (ERWDA unpublished data) and consequently the species is expected to decline in numbers. The species is considered to be endangered in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Baluchistan Gerbil (*Gerbillus nanus***):** This species is rarer than the Cheesman's Gerbil and known from only few locations in the Al Ain and Abu Dhabi area of the Emirate (Duckworth, 1996; Drew *et al.*, 2004; Tourenq *et al.*, 2005). It is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Figure 4-23: Cheesman's gerbil (*Gerbillus cheesmani*)

Cheesman's Gerbil (*Gerbillus cheesmani***):** It is said to be the most abundant mammal of the Abu Dhabi Emirate (Duckworth, 1996). This species is commonly found in sandy and gravel parts of the whole Abu Dhabi Emirate, except islands of the Arabian Gulf (Böer *et al.*, 1999; Javed *et al.*, 2004). The species is classified as Least Concern in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Sundevall's Jird (*Meriones crassus***):** The species was found in Al Ain, Baynoonah area and Umm az-Zamul (Duckworth, 1996; Drew *et al.*, 2003a; Drew *et al.*, 2004; Drew *et al.*, 2005). However, further surveys are needed to identify the distribution of this secretive species in the Abu Dhabi Emirate. It is classified as Data Deficient in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Arabian Jird (*Meriones arimalius***):** Identified previously as the Libyan jird (*Meriones lybicus arimalius*), this species has been found only in some areas of the eastern part of the Emirate in Sweihan, Umm az-Zamul, Al Khatam areas (Duckworth, 1996; Böer *et al.*, 1999; Drew *et al.*, 2003a; Drew *et al.*, 2004; Drew *et al.*, 2005a). However, recent and ongoing studies indicate that the species found in UAE is more likely to be the Arabian Jird (Breeding Center for Endangered Arabian Wildlife, *pers comm.*) which occurs in

Oman and Saudi Arabia and is classified as Endangered (IUCN, 2004). It is classified as Endangered in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Introduced and Domesticated Species
Order Insectivora - insectivores

House Shrew (*Suncus murinus***):** The native range of this species stretches across southern Asia from Afghanistan to the Malay Archipelago and southern Japan. It has since been introduced into northern and eastern Africa, as well as much of the Middle East (Ruedi *et al.*, 1996). This commensal species is present in ports throughout the Arabian Peninsula but to date, has still not been yet recorded in the UAE (Harrison & Bates, 1991; Duckworth, 1996; Cunningham, 2004). Note that this commensal and adaptable shrew is a rapid coloniser and a growing ecological threat, classified as one of the 100 World's Worst Invasive Alien Species by the IUCN (http://www.issg.org), predating on or competing with many plant and animal species.

Order Carnivora - carnivores

Dog (*Canis familiaris***):** Dog ancestors have been befriended around 12,000 years ago in the Arabic Peninsula (Davis & Valla, 1978). As Egyptians 3,000 years ago, dogs (particularly saluki) were still used some decades ago by UAE bedus to hunt gazelles. In many parts of the world, uncontrolled domestic dogs and packs of feral dogs may have an impact on native wildlife and thus are qualified as invasive species by the IUCN (http://www.issg.org). Dogs can range through a wide variety of habitats, whether open country or thick forest, natural or disturbed habitats. In UAE, they can be seen near human settlements and agricultural lands. The species is classified as Not Applicable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Feral Cat (*Felis cattus***):** This commensal and adaptable species is a rapid coloniser and a growing ecological threat, classified as one of the 100 World's Worst Invasive Alien Species by the IUCN (http://www.issg.org), causing or contributing to the extinction of many species of wildlife. This species is common in towns, where there is an abundance of food and water resources. It was introduced as a pet on islands of the Arabian Gulf, such as Zirku and Arzanah, where it constitutes a threat to seabird species of conservation concern (Javed *et al.*, 2004). Feral cats have benefited from expansion of human settlements and forest plantations in the desert and can be observed deeply in into the most remote areas of the Abu Dhabi Emirate. The species is classified as Not Applicable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Order Hyracoidea - hyraxes

Cape/Rock Hyrax (*Procavia capensis***):** This species was first recorded in the Jebel Hafit area where it is supposed to be escaped from captivity (Cunningham, 1999). Although individuals are regularly observed (ERDWA unpublished), the population seems to be declining maybe due to the harsh environment or predation (Cunningham, 2004). It is classified as Not Applicable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Order Artiodactyla - even toed ungulates

Camel (*Camelus dromedaries***):** Until the use of motorized vehicles, the camel was the desert dweller's primary source of transport, shade, milk, meat, wool and hides of the Arabian Peninsula, particularly in sandy areas where its broad, flat, leathery pads on the feet prevent it from sinking into the sand. Domestication of wild camels probably occurred about 4000 years ago in the Arabian Peninsula (Qumsiyeh 1996). Herds of domestic camels can be observed in all UAE. When not controlled they can have negative impact on the native flora, through overgrazing.

Feral/Domestic Goat (*Capra aegagrus hircus***):** Goats easily become feral and can also spread disease to native animals. Goats were often introduced to Pacific islands for their milk or released as potential food for people marooned by shipwrecks. Classified as one of the 100 World's Worst Invasive Alien Species by the IUCN and recognised as "the single most destructive herbivore" introduced to the islands of the world (http://www.issg.org), goats are particularly destructive to island ecosystems. The introduction of goats to islands worldwide has resulted in widespread primary and secondary impacts via overgrazing, often leading to ecosystem degradation and biodiversity loss. Escaped individuals can be regularly seen in the Jebel Hafit area. The species is classified as Not Applicable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Indian Grey Mongoose (*Herpestes edwardsi***):** The species ranges from Iranian Gulf coast to Sri Lanka, with the closest population occurring in Bahrain and Saudi Arabia coastal areas (Harison & Bates, 1991). Omnivorous feeding on human refuses and plantations, the Indian Grey Mongoose benefited from the urbanization of the coastal areas. With

some sightings of unidentified mongooses in Abu Dhabi Island (Duckworth, 1996), the possible occurrence of several introduced mongoose species to UAE and no confirmed records of this species within the Emirate of Abu Dhabi, the Indian Grey Mongoose was classified as Not Applicable in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

Feral donkey (*Equus asinus*): Until the use of motorized vehicles, the donkey along with the camel was the commonest beast of burden in the Arabian Peninsula, particularly in rocky and mountainous areas. Although wild asses (*Equus hemionus onager*) are still found in Iran and, until the last century, in Syria (Qumsiyeh, 1996; Tatin *et al.*, 2004), the domestication probably occurred about 6,000 years ago in Northern Africa, particularly Egypt, and involved the species still observed in the wild in north-eastern Africa: the African Wild Ass (*Equus africanus*) (Qumsiyeh, 1996; Beja-Pereira *et al.*, 2004). Motorized transport replaced donkeys that were released in the wild and feral individuals can be observed in northern Oman-UAE mountainous areas. In its invasive range, feral donkey have deleterious and potentially irreversible impacts on native flora and fauna, soils, and water quality, and thus are qualified as invasive species by the IUCN (http://www.issg.org), especially in Saudi Arabia and Yemen.

Order Perissodactyla odd-toed ungulates

Order Rodentia - rodents

Black Rat (*Rattus rattus*): This introduced species is common in towns, around major settlements and agricultural areas of the Arabian Peninsula (Harrison & Bates, 1991) and the Abu Dhabi Emirate, where itwas introduced by the early 2nd Millennium BC (Cunningham, 2004). The species is classified as Least Concern in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).This commensal and adaptable species is a rapid coloniser and a growing ecological threat, classified as one of the 100 World's Worst Invasive Alien Species by the IUCN (http://www.issg.org), causing or contributing to the extinction of many species of wildlife.

Brown Rat (*Rattus norvegicus*): With a world wide commensal range, this species is commonly found in towns of the Arabian Peninsula (Harrison & Bates 1991) and the Abu Dhabi Emirate. Its presence is reported also on islands of the Arabian Gulf, such as Zirku, where it constitutes a threat to seabird species of conservation concern (Javed *et al.*, 2004). The species is classified as Least Concern in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005). The brown rat is globally widespread and costs primary industry hundreds of millions of dollars per year. It has caused/contributed to the extinction/range reduction of native mammals, birds, reptiles and invertebrates through predation and competition. This commensal and adaptable species is thus a rapid coloniser and a growing ecological threat and classified as an invasive species by the IUCN (http://www.issg.org).

House Mouse (*Mus musculus*): This commensal and adaptable species is a rapid coloniser and a growing ecological threat and classified as one of the 100 World's Worst Invasive Alien Species by the IUCN (http://www.issg.org). They do considerable damage by destroying crops and consuming and/or contaminating food supplies intended for human consumption. They have also been implicated in the extinction of indigenous species in ecosystems they have invaded and colonised which are outside their natural range. The house mouse is found as a commensal species in towns and settlements throughout the Emirate of Abu Dhabi. As human settlements expand into previously unsettled areas, new habitat is 'created' for house mice. Consequently the population is thought to be expanding its geographic range and increasing in absolute numbers. This species is found also on islands of the Arabian Gulf, such as Zirku and Arzanah, where it constitutes a threat to seabird species of conservation concern (Drew *et al.*, 2003b; Javed *et al.*, 2004). The species is classified as Least Concern in the proposed Red Data List of mammalian species of Abu Dhabi (Drew & Tourenq, 2005).

4.2.1.2 Birds

Birds are one of the most recognisable elements of biodiversity. Found in a wide range of habitat types, from extreme cold arctic to harsh and inhospitable deserts to window sills in the midst of crowded urban jungles, they are more commonly associated with humans than any other group. Additionally birds are also most numerous and they contribute significantly to higher vertebrate biodiversity. Birds constitute nearly 81% of overall higher vertebrate biodiversity (reptiles, birds and mammals) in the Abu Dhabi Emirate.

Over the last few years substantial amount of information on birds of the United Arab Emirates has been collected. Ongoing monitoring and surveys undertaken by the Environmental Agency - Abu Dhabi (formerly ERWDA)

and also by members of various natural history groups in the country has added to the existing knowledge on the status and distribution of birds. To date, 416 species of birds have been recorded from the Abu Dhabi Emirate alone. This is approximately 96% of all the birds recorded in the United Arab Emirates. The relatively high number of species recorded from the Emirate is because of diversity of habitats from extensive coastline, to mud flats, mountains and inland wetlands.

The Abu Dhabi Emirate in particular is extremely important for bird conservation; not only because of the total number of bird species but also due to the presence of regionally and globally important breeding colonies of seabirds. The presence of the important island seabird breeding colonies and also due to the presence of wintering houbara bustard Chlamydotis macqueenii, significant conservation measures have been taken to protect the avifauna of the Emirate.

Of the total 29 avian orders present in the world, birds belonging to 20 orders are found in the Emirate. Avifauna of the country is represented by 61 families which is 67% of the total bird families in the Middle East and 32% of the world. The 416 species in the Emirate is 51% of all birds seen in the Middle East and is about 4% of the total global avifauna. Among land birds, passerines (*Passeriformes*) are the most abundant with 181 species. Waders and other shorebirds (*Charadriiformes*) are represented by 87 while 38 species of falcons, harriers and eagles (*Falconiformes*) are found in the Emirate. Families that are represented by more temperate climate/forest dwelling species, for example Paridae (*tits*), Sittidae (*nuthatches*) and Certhiidae (*tree creepers*), are absent from UAE because of the absence of suitable habitat and climatic conditions.

Species such as Egyptian Goose (*Alopochen aegyptiacus*), Ring-necked Parakeet (*Psittacula krameri*), Alexandrine Parakeet (*Psittacula alexandri*), White-cheeked Bulbul (*Pycnonotus leucogenys*) and Red-vented Bulbul (*Pycnonotus cafer*), originally introduced to the UAE now occur as regular breeding species and are considered naturalized. Similarly three species of Mynah, the Pied Mynah (*Sturnus contra*), Bank Mynah (*Acridotheres ginginianus*) and the fast spreading Common Mynah (*Acridotheres tristis*) are also naturalized.

There are several species of birds which occur because they have escaped or been released from captivity. Some of them such as Streaked Weaver (*Ploceus manyar*), Red-whiskered Bulbul (*Pycnonotus jocosus*) and Red Munia (*Amandava amandava*) to mention a few have bred in recent times. However, population of these species is currently not self sustaining and not regarded as naturalized.

A. Breeding birds of the Emirate

At present a significant proportion of the total bird species breed in the UAE. This includes both resident and migrant breeders. Although most of the species breed during summer (May-August), species such as Osprey (*Pandion haliaetus*),Socotra Cormorant (*Phalacrocorax nigrogularis*), Red-billed Tropicbird (*Phaethon aethereus*) and Brown-necked Raven(*Corvus ruficollis*) breed during winter (November-April)months.

Although non-breeding migrants constitute bulk of the entire avifauna, nearly 22% of the all the bird species found in the Emirate also breed here. A significant proportion of breeding birds are migrant breeders, highlighting the importance of the Emirate for migratory birds.

About 65% of all the bird species found in the Emirate are land birds. The remaining 35% are water birds. Of the 271 land birds 18% are resident while 82% are migratory. Nearly 32% of all land birds occur as common (more abundant) while about 44% of them are uncommon (*e.g.* Sykes Warbler *Hippolais rama*). Nearly 22% of the species are scarce or occur irregularly or erratically.

B. Bird habitats

In the UAE, seven broad habitat types are recognized, all of which are also found in the Emirate. This also includes green areas containing artificial plantations, gardens, parks, and inland wetlands. The following sections give an account of 271 land birds associated with different habitat types in the Emirate of Abu Dhabi. Proportions of land birds with associated habitats is based on known habitats for species, however certain species use a mix of habitat types and thus percentage values of birds using each habitat should be considered as a relative value to other habitat types rather than absolute.

Plantations and other green areas have increased in size and extant over the last few years. Such areas provide more feeding, resting and breeding opportunities to both resident and migratory avifauna. Thus it is not surprising that a good proportion of Emirate's avifauna is accounted for by these habitat types. Plantations, gardens, parks, and roadside green verges account for 36% of the total land birds in the Emirate. Large flocks of Collared Dove (*Streptopelia decaocto*) can be seen around these

green areas, which have possibly proliferated with the expansion of plantations and cultivations. Other examples of birds using these habitats are Bimaculated Lark (*Melanocorypha bimaculata*), Indian Roller (*Coracias benghalensis*)and European Roller (*Coracias garrulus*), Little Green Bee-eater and European Bee-Eater (*Merops apiaster*) and the Graceful Prinia (*Prinia gracilis*).

Birds found in the mountains, rocky habitats and wadis represent nearly 16% of the total avifauna. Typical representatives of this habitat are the Hume's Wheatear, a common resident breeder of the area. The Rock Thrush (*Monticola saxatalis*), Hume's Lesser Whitethroat (*Sylvia althaea*) and the Pale Rock Sparrow (*Carposiza brachydactyla*) are also seen regularly associated with this habitat type. Other species such as White-capped Bunting (*Emberiza stewarrt*i) and Ortolan Bunting (*Emberiza hortulana*) occur both in the mountains and wadis and also in the Acacia savannah habitat. Similarly, the Sand Partridge (*Ammoperdx heyi*) and the Lappet-faced Vulture (*Torgos tracheliotus*) occur as breeding birds in this habitat type.

Acacia savannah or Acacia plains occur in a narrow strip running parallel to the mountains. About 28% of birds are some what typical of Acacia savannah. Species such as Sparrowhawk (*Accipiter nisus*) and Steppe Buzzard (*Buteo buteo vulpinus*) both occurring as passage and winter migrants are good examples of species found in this habitat. Several species of birds seen in *Acacia* savannah also occur in other habitats *i.e. species which occur in plantations and in Acacia tortilis* dominated wadis associated with mountains (Short-toed Lark (*Calendrella brachydactyla*) and Woodpigeon (*Columba palumbus*)).

The desert species constitute about 5% of the total land birds found in the Emirate. Despite the fact, that desert occupies the largest area of any habitat type; they have impoverished avifauna. There are only 8 species which can be classified as typical desert species. Hoopoe Lark (*Alaemon alaudipes*) is one of the best examples of a true desert species. Another 6 species of birds categorised as desert are found associated with Acacia plains and wadis. There are species which occur in inland wetlands, at the edge of water, *i.e.* Bluethroat (*Luscinia svecica*), Reed warblers (*Acrocephalus spp.*), and they constitute about 13% of the total land birds.

Important and Threatened Bird Species

Several species found in the Emirate are regarded as important or priority species (species which are rare, threatened (globally or nationally) and have a restricted breeding range. A little over 19% of all the terrestrial species found in the Emirate are important or of conservation priority. No bird species are reported to be extinct in the wild in the UAE in recent times (Bird Life International, 2000; World Conservation Monitoring Centre,1992). However, Hellyer (1992), mentions that the Arabian Ostrich (*Struthio camelus syriacus*) once occurred in the country.

Of the 15 species listed as 'Globally Threatened' by the Bird Life International in the UAE, 4 are water birds and rest are terrestrial species. Of the 11 terrestrial birds, only Saker Falcon (*Falco cherrug*) is listed as Endangered (EN) while species such as Houbara (*Chlamdydotis macqueeni)*, Imperial Eagle (*Aquila heliaca*), Greater Spotted Eagle (*Aquilaclanga*), Lesser Kestrel and Lappet Faced Vulture are listed as vulnerable (VU). The remaining 5 species are listed as near-threatened (NT), which includes Pallid Harrier (*Circus macrourus*), European Roller and Cinereous Bunting (*Emberiza cineracea*) (CITES Appendix I).

Of the 11 globally threatened birds, only the Lappet-faced Vulture is a resident breeder. The remaining 10 species occur either as winter migrants, passage migrants or vagrants (CITES Appendix I). Unfortunately, there are no recent reports of confirmed breeding of this species on Jebel Hafit. With fewer sightings in recent years and an estimated 1-2 breeding pairs, the Lappet-faced Vulture is rare in the UAE.

Several species of land birds found in the Emirate are important as they have restricted distribution *i.e.* restricted-range (RR) species (species with breeding distribution restricted to c.50000 km^2). The Sand Partridge, Striated Scops Owl (*Otus brucei*); Yellow-vented Bulbul (*Pycnonotus xanthopygos*); the mountain dwelling Hume's Wheatear (*Oenanthe alboniger*) and the sympatric Hooded Wheatear (*Oenanthe monacha*) fall under this category. The Arabian Babbler (*Turdoides squamiceps*), found commonly in Acacia savannah and forestry plantations is also a restricted-range species with a small world range (Hornby & Aspinall, 1996).

Sooty falcon, a migrant breeder found on few near shore and offshore islands of the Emirate, is listed as regionally threatened. The Egyptian Vulture (*Neophron percnopterus*) also occurs as a resident breeding species in the Jebel Hafit Mountains of the Emirate. Barn Owl (*Tyto alba*), Desert Eagle

Owl (*Bubo ascalaphus*) and the Booted Warbler (*Hippolais caligata*) are also important species. Although Evans (1994) does not list them in one of the important species categories, Aspinall (1996) considers them as a priority species either due to being native or due to a declining population trend with less than 50 breeding pairs.

D. Threats to birds

The rapid rate of development in the United Arab Emirates following the discovery of oil has fast transformed the ecological landscape (Javed, unpublished). Unfortunately many of these development activities have directly or indirectly impacted the natural habitats and their species. Habitat loss, mainly due to developmental activities, remains the single biggest threat to birds. Due to the diversification of economy and record revenue from increased international oil prices, the UAE economy has grown impressively. The annual economic growth rate of around 5% is likely to be maintained (UAE Yearbook, 2005) and it is expected that development, particularly urban and industrial infrastructure will continue with the same pace, posing even greater challenges to bird and biodiversity conservation.

Given the prominence of breeding colonies on islands, the loss of breeding colonies as consequence of development is better documented for breeding seabirds such as Socotra Cormorant. Impacts of development are not so clearly established in the case of land birds because of non-colonial breeding habit of many land birds and also due to inadequate survey data.

Illegal trade and chances of exotic species escaping from captive collections and establishing themselves is another concern. The country's location in the middle of the east and west makes it an ideal entry and transit point for many species of birds. Accidental or intentional releases of species, nonnative to the country or the region, can have severe implications on the native avifauna of the country. Species such as Indian Mynah and Ring-necked Parakeet are good examples of this. These species have the potential to become a pest on crops and orchards (*i.e.* Ring-necked Parakeet), a nuisance at public places and gardens (Indian Mynah), or could be parasitic on the eggs and young ones (*i.e.* Indian House Crow). Additionally these species can bring diseases which can have far reaching consequences, both for wildlife and humans. Wild migratory birds and species which are illegally or legally traded between countries have been implicated in the recent outbreak of Avian Influenza in many countries. The Avian Influenza outbreak and its potential to become a pandemic have enormous economic, human health and conservation implications (Javed, 2005).

Private collection of many species of birds, both domesticated and wild species on the mainland and islands, is a serious concern. Often these birds are brought in the country without proper health check and screening. Bringing birds on the islands without health screening and quarantine poses serious health hazards to important breeding colonies of seabirds and also to significantly large and economically important collection of laying chickens and quails.

Shooting or hunting of birds, though prohibited by law, may be an occasional practice in some areas, particularly in those areas where captive stocks of ground dwelling birds are present. Avian predators such as eagles and falcons, including the important Sooty Falcon in particular, are likely to be vulnerable to such practices. A new hunting law is under preparation that will specify species under different hunting categories with quota and penalties for violation. This is expected to regulate and streamline the hunting activity in the Emirate.

Expansion of cultivation and forestry plantations in a desert ecosystem may not have significant implications in terms of loss of desert habitat, given the vast expanse and overall area under desert. It may even result in increase in the number of species. However, the new colonisers of such habitats are opportunistic, aggressive and invasive species with the potential to severely impact native desert species due to increased competition for feeding and nesting habitats. They also pose considerable risk of introducing new diseases and increased predation pressure on local avifauna. In the Emirate of Abu Dhabi, the area under forestry increased by nearly 60% (from 190,733 ha in to 305,243) during 2001-2003, whereas the area under agriculture increased by more than 100%, from 36,009 ha in 1996 to 75,449 ha by 2003 (ERWDA, Water Resources Statistics Bulletin, 2003). Not surprising the numbers of producing wells have gone up to 581,515 in 2002 from 47,444 in 2000 (Statistical Yearbook, 2002) to support increased demand for forestry and cultivation.

Table 4-2: Important Bird Areas in UAE

Site	Site Name	Criteria used to select site									
No.		1	2i	2ii	2iii	3	4	5i	5ii	6	0
1	Al Jazirah Khor		•								
2	Digdaga-Hamraniyah	•					•				
3	Siniyah Island		•				•				
4	Masafi-Tayibah Area						•	•			
5	Khor Al Beideh		•								
6	Ramth Lagoons						•	•		•	
7	Mushrif National Park						•	•		•	
8	Zabeel Pounds									•	
9	Khor Dubai		•	•						•	
10	Khor Kalba					•			•	•	
11	Qarn Nazwa						•		•		
12	Qaranayn Island		•				•		•		
13	Delma					•					
14	Ghaghah		•								
15	Islands off Sir Bani Yas		•				•				
16	Yasat Island		•				•				
17	Abu al Abyadh Island		•				•				
18	Um Amin		•				•				
19	Jebel Hafit					•	•				
20	Baynunah	•					•	•		•	

Source: Birdalife Middle East (www.birdlifemed.org)

E. Protection of Birds

By law, all birds are protected and no hunting is allowed. However, instances of selective shooting of some raptors and collection of eggs of some breeding seabirds are reported from a few islands. As per Article 1 of the Federal decree (Law No. 9) of 1983, 'hunting, gathering or destruction of eggs' of land and seabirds is banned with the exception of cormorants. Federal Law No. 24 and Federal Law No. 23 for environment and wildlife conservation further accords protection to birds. The Federal Law 24 of 1999 for the "Protection and development of environment" covers most aspects of the country's natural environment. Federal laws are implemented by the Federal Environmental Agency (FEA) with local authorities in each emirate as the competent authorities. Articles 63-68 (Chapter VI) of the Federal Law 24 make provisions for 'Natural Reserves', prohibits hunting, transportation or killing of birds and other animals, besides encouraging studies and monitoring, leading to establishment of reserves, protection and monitoring of the biodiversity.

Provisions for the protection of the country's marine environment are made in Federal Law No. 23 of 1999, regulating the exploitation, protection and development of marine biological resources, which indirectly protects land birds. Federal Law No. 11 of 2002 deals with the regulation and control of international trade in endangered species and is important law in checking illegal trade in birds. UAE is signatory to the Convention on International Trade in Endangered Species (CITES) and Federal Law 11 empowers the local authorities to enforce the law to regulate the trade and fulfill UAE's obligation as a signatory to CITES.

Protected Areas

Currently only two protected areas, the Al Wathba Wetland Reserve and the Morrawah Marine Protected area have been formally established through official decrees. Al Wathba , an inland wetland with an area of 4.9 km² was declared as protected area mainly to protect the breeding colony of the Greater Flamingo Phoenicopterus roseus, while the Morrawah Marine protected Areas (MMPA) covers 8 islands and intervening waters covering an area of 4255 km² and has been established to protect overall marine biodiversity including birds. Two more protected areas, the Jebel Hafit National Park with a proposed area of about 96 km² and Umm az-Zamul National Park with an area of more than 10000 km², have been proposed. Once declared, these two representative habitats will provide protection to important resident and migratory species of land birds such as Egyptian Vulture, Sand Partridge, Hoopoe Lark and the Golden Eagle (Aquila chrysaetos) and Eagle Owl.

Important Bird Areas (IBA's), sites of national and international importance for birds in the UAE, were identified by the Bird Life International (Evans 1994). Nearly 50% (9) of all the 20 IBA's are in Abu Dhabi Emirate. However, only two, Jebel Hafit and Baynounah, are inland sites while the remaining 7 are all islands. Given the rapid rate of development at coastal, island and other inland sites, it is practical to update the IBAs at regular intervals. Using the same criteria, as applied by the Bird Life International Javed and Khan (2003b), identified 5 new IBA's in the Abu Dhabi Emirate. Though IBA designation does not provide any legal protection to the sites, it never the less increases the importance of the site and remains an effective currency to secure protection of sites based on such global recognition. More research and surveys are needed on the land birds of the Emirate. A regular monitoring programme for some key wintering and breeding birds and important sites is needed. Additionally, bringing more areas of conservation importance under the protected area network will benefit both birds and other elements of emirates biodiversity.

4.2.1.3 Reptiles

Lizards, amphisbaenids and snakes are the main types of terrestrial reptiles in Abu Dhabi Emirate. As can be seen in **Figure 4-24,** the majority of species are lizards, followed by snakes and amphisbaenids. As per Hornby (1996), the order Snakes and Lizards (Order Squamata) consists of the following. There is also a new record of the Golden Skink (Mabuya aurata septemtaeniata) discovered on Jernain Island in 2004 (Soorae & Al Hemeiri, 2005).

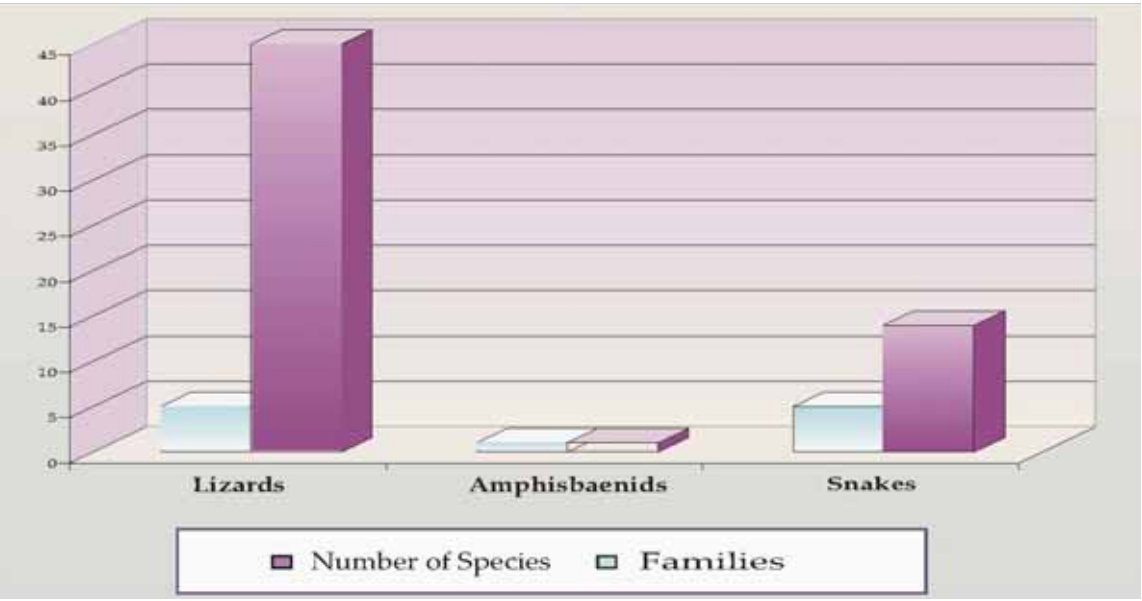


Figure 4-24: The Distribution of Lizard Amphisbaenids and Snake Families and Species

A. Lizards (Sub-order Sauria)

The lizards have usually slender bodies with typically 4 limbs which can be reduced or even absent. They are mainly small in size but some can be over six feet long. They are mostly oviparous but some are ovoviviparous. They feed mainly on insects and small invertebrates and some are even herbivorous.

Figure 4-25: Spiny-tailed Lizard (*Uromastyx aegyptius microlepis*)

Agamid lizards (Family Agamidae): These are usually strongly built lizards with large heads and heavily built tails. They usually feed on insects and some species are herbivorous. They utilize a variety of habitat types and also have special scales around the eyes which protect them from blowing sand which is an ideal desert species characteristic.

This Family is represented by 5 species. The main species of key concern in this group is the Spiny-tailed Lizard *(Uromastyx aegyptius microlepis)* as in **Figure 4-25.** This is a large terrestrial lizard that can grow to about 0.70 m in length and lives in burrows in colonies. The adults are mainly herbivorous but the young will include insects in their diet. This species is threatened with habitat destruction and over-grazing in their natural habitat.

Figure 4-26: Dune Sand Gecko (*Stenodactylus doriae*)

Geckos (Family Gekkonidae): Geckos are nocturnal climbing reptiles which feed on insect prey. They live on trees and frequent human habitation. They are also colonizers of new habitat and have been found on many of Abu Dhabi's islands where human habitation and or trees have been planted. This Family is represented by 19 species.

Lacertid lizards (Family Lacertidae): The Lacertid lizards are also known as the true lizards. They are capable of discarding their tails to distract predators whilst making their escape. They feed on small insects and other invertebrate prey. This Family is represented by 9 species.

Skinks (Family Scincidae): These are heavily built lizards usually with shiny scales and thickset tails. The head is also usually pointed as many of these species live underground and their eyes have transparent scales to protect them against soil particles and enable them to see at the same time. This is a transitional species from lizards to snakes. There is one new record of the Golden Skink (Mabuya aurata septemtaeniata) for the UAE from Jernain Island. This Family is represented by 6 species which includes a new record for the UAE.

Figure 4-27: Sand Skink (*Scincus mitrans*)

Varanid lizards (Family Varanidae): The Varanid lizards are large lizards which are carnivorous and in the UAE are represented by a single species the Desert Monitor Lizard (*Varanus griseus*). They are strongly built lizards with strong claws and carnivorous in their feeding habits. The single species in the UAE is the Desert Monitor Lizard (*Varanus griseus*) which occurs across a variety of habitats.

Figure 4-28: Desert Monitor (*Varanus griseus*)

B. Amphisbaenids (Sub-order Amphisbaenia)

The Sub-Order Short-head Worm Lizards (Family Trogonophidae) represents an intermediary group between the snakes and lizards. It is a limbless lizard with a blunt-head and very small eyes. It feeds on small invertebrates such as ants and termites and is usually found under surface litter and is well suited to a burrowing existence. This Family is represented by one species, the Zarudny's Worm Lizard (Diplometopon arudnyi) **(Figure 4-29).**

Figure 4-29: Zarudny's Worm Lizard (*Diplometopon zarudnyi*)

Snakes (Sub-order Serpentes): The snakes are the most highly evolved reptiles. They have long, cylindrical muscular bodies with a head, thorax and tail section. The body is covered by scales. Snakes can be broadly divided into non-poisonous (presence of teeth but lacking poison fangs), semi-poisonous (back-fanged), fixed front fanged (cobras, *etc.*) and moveable front-fanged (*e.g.* vipers).

Slender blind snakes (Family Leptotyphlopidae): These are small snakes that occur more often in gardens rather then in the open desert. They feed on small insects and termites. This Family is represented by one species the Hooked Thread Snake *(Leptotyphlops macrorhyncus*).

Blind snakes (Family Typhlopidae): These are species that occur more in gardens and can be easily transported in garden soil and potted plants. This Family is represented by one species the Flowerpot Snake (*Rhamphotyphlops braminus*).

Boas and pythons (Family Boidae): This species belongs to the Family Boidae and is a non-poisonous snake which has a unique habit of burrowing beneath the surface of the sand. It is represented by one species the Sand Boa (*Eryx jayakari*).

Figure 4-30: Jayakar's Sand Boa (*Eryx jayakari*)

Colubrid snakes (Family Colubridae): This Family alone consists of three-quarters of the genera of snakes in the world. They utilize a wide variety of habitats and most of them are harmless as they are non-poisonous. This Family is represented by seven species.

Figure 4-31: Arabian Horned Viper (*Cerastes gasperettii*)

Vipers (Family Viperidae): These are some of the most dangerous species of snakes as they possess haemotoxic venom which starts internal digestion to enable the snake to easily digest its prey. It also has some highly adapted species suited for desert habitats which can travel over loose sand by side-winding and also burrow into sand to lie in wait for their prey. This Family is represented by four species.

Figure 4-32: Short-nosed Sand lizard (*mesalina brevirostris*)

Figure 4-33: Scholari Sand Racer (*Psammophis schokari*)

4.2.2 Invertebrates

Invertebrate animals are the largest group of faunal elements, both in number of species and number of individuals. Insects dominate the faunas of all the continents and are the major components of the earth's biodiversity. The exact number of species present is unknown but there are thought to be at least 4,000 to 5,000 different species living within the United Arab Emirates. Surveys and studies provided only a basic taxonomic knowledge on the invertebrate fauna of U.A.E. But more complete view of the invertebrate fauna of U.A.E requires further collection with much greater taxonomic input.

Insects and other Arthropod diversity of terrestrial habitats of UAE can be classified as follows:

4.2.2.1 Phylum Arthropoda

The arthropod fauna of U.A.E is partly studied taxonomically. But the recent surveys and studies revealed the presence of a diverse Arthropod community living within terrestrial habitats of the U.A.E. Comparatively diverse plant community in the U.A.E supports a rich invertebrate fauna dominated by insects in several different orders. Tentative number of species recorded is 1,500+ species of insects; spider species form 9 Families of Aranea, 1 species of Camel spider and 19 species of Scorpions, 3 species of ticks and 3 species of mites, 2 species of Scolopendra and 2 species of Isopoda. See **Table 4.5** for the list of other arthropod group diversity in the UAE.

A Class Insecta

Insects are the largest group within the phylum Arthropoda, and it is better studied than the other groups of the phylum. Out of 31 insect orders of the world, U.A.E insect fauna comprises 22 insect orders. Some insect orders are dominant, representing large number of species (Coleoptera, Diptera, Lepidoptera and Hymenoptera); Others have a moderate number of species (Orthoptera, Heteroptera, Homoptera, Neuroptera, Odonata, Mantodea, and Blattaria). Apart from these insect orders several small, less abundant but well-known groups are represented by few species (Collembola, Thysanura, Ephemeroptera, Phasmatodea, Dermaptera, Embioptera, Isoptera, Phthiraptera, and Thysanoptera, Strepsipeta).

sp. and Dinothrombium are the three species so far known. The tropical mites of the genus Dinothrombium have a worldwide distribution and they live as parasites on mammals, birds, reptiles and insects during their larval stages. Some members of the family are known to transmit diseases in animals. The two spotted spider mite (*Tetranychus utricae*) has been identified as a serious pest in green houses and number of vegetable crops such as tomatoes and cucumber.

Table 4-3: Recognized Insecta taxa and its occurrence in UAE

Order	Common Name	Families	*Species*
Thysanura	Bristletails/Firebrats	1	*3*
Diplura	Two-tailed Bristles	None	*0*
Protura	Proturans	None	*0*
Collembola	Springtails		*0*
Ephemeroptera	Mayflies	1	*2*
Odonata	Dragonflies/Damselflies	6	*24*
Plecoptera	Stoneflies	None	*0*
Grylloblattodea	Ice- Crawlers	None	*0*
Orthoptera	Crickets/Grasshoppers	8	*78*
Phasmatodea	Stick and Leaf Insects	1	*1*
Dermaptera	Earwigs	2	*2*
Embioptera	Web-spinners	1	*3*
Blattaria	Cockroaches	3	*7*
Mantodea	Mantids	3	*15*
Isoptera	Termites	3	*4*
Zoraptera	Zorapterans	None	*0*
Psocoptera	Booklice	1	*1*
Phthiraptera	Lice	2	*3*
Heteroptera	True Bugs	15	*50>*
Homoptera	Aphids/Cicadas	18	*50>*
Thysanoptera	Thrips	2	*7*
Neuroptera	Lacewings/Antlions	7	*60>*
Mecoptera	Scorpion flies	None	*0*
Trichoptera	Caddis flies	None	*0*
Lepidoptera	Butterflies/Moths	30	*360>*
Diptera	True flies	31	*150>*
Siphonaptera	Fleas	1	*2*
Hymenoptera	Ants/Bees/Wasps	20	*400>*
Coleoptera	Beetles	37	*300>*
Strepsiptera	Heel-walkers or GladiatorsTwisted Wing Parasites	1	
Mantophasma-todea	*Heel-walkers or Gladiators*	None	*0*

Order Araneae (Spiders) Table 4.6 shows the occurrence of the number of insect orders, families and its species diversity in the UAE.

Thysanura - (Silverfish and Bristletails): Bristletails are extremely common in the sand desert and can survive extremely arid conditions. Also exist as household pests in the Emirate. However they are mostly represented from one family Lepistmatidae. Only three species have been identified so far.

Epheromeroptera - (Mayflies): Members of this order have an aquatic larval stage and as such this is a poorly represented group within desert ecosystems. In general mayflies have a low tolerance for pollution and for this reason they have been used in the world as indicator species. Representative specimens of only two species recorded.

Odonata - (Dragonflies and Damselflies): The order Odonata includes the suborders Zygoptera (damselflies) and Anisoptera (dragonflies). Al Wathba Wetland Reserve and the pools and wadis around Al Ain provide suitable breeding places for some of these insects (as they have an aquatic larval stage). Twenty-four species have been identified from 6 different families. Dragonflies are the largest flying insects in UAE, with the Emperor Dragonfly (*Anax imperator*) reaching 84mm in length. Many species are highly migratory and individuals of species such as *Hemianax ephippiger* and *Pantala flavescens* may be found in swarms in the desert, far from water. Studies required inorder to understand the population dynamics and ecology of any of the species present.

Orthoptera - (Crickets and Grasshoppers): The order Orthoptera is a wide spread large group of insects which includes the desert locust, which forms large swarms and can be a devastating agricultural pest. Based on distinct difference, the Orthoptera is subdivided into two suborders Ensifera (crickets) and Caelifera (grasshoppers). Eight families comprising 78 species recorded so far. The family Acrididae (grass hoppers) is well represented with large number of species. The Orthopterans form a vital component of the ecosystem providing a major food resource for small mammals, small birds, reptiles and arachnids.

Phasmatodea - (Stick Insects): This is another poorly represented group of insects in Abu Dhabi. Only 1 species has been collected so far, although there are almost certainly at least several more species that have not yet been collected. Stick insects are unlikely to be numerous within the desert ecosystem, as they are typically associated with dense vegetation.

Dermaptera - (Earwigs): This is small, primitive order of Dermaptera representing only very few species. Two species from two families, Labuduridae and Spongiphoridae have been identified, suggestive of the presence of low diversity (locally) within the order. Most of them are nocturnal, and hide during the day among debris or in dark spaces. They are scavengers on plant and animal matter, or prey on small insects.

Blattaria - (Cockroaches): Cockroaches are nocturnal scavenger insects, feeding on dead organic matter such as plant matter. Some cockroach species here live in wild and are of no economic importance. But there are a few species that thrive in and around human habitations. Four species from 3 families have been identified. The most common pest cockroaches in the Emirate are the smaller German cockroach *Blatella germanica* and the American Cockroach *periplanata americana.* They destroy food and contaminate it with their smelly excreta.

Mantodea - (Mantises): The mantids are so called 'praying mantids' separated from cockroaches by their strongly-spined raptorial front legs. These tropical carnivorous insects usually camouflage well with their surroundings and feed on a variety of other insects. The best known Eremian species is the ground mantis *Eremiaphila gene.* Nine species from 3 families have been identified.

Isoptera - (Termites or White Ants): 4 representative species from this order have been collected so far. The species is known as the common Sand Termite, belonging to the genus *Psammotermes.* Members of this order are social insects living in organized communities composed of mature males and females and sterile (female) workers and soldiers. They are serious pests in some parts of the world due to the damage that they cause by feeding on the cellulose of wood.

Psocoptera - (Book lice): Book lice are small insects with soft bodies, chewing mouth parts, and relatively long and thread like antennae. Psocids are often called book lice or bark lice because to the casual observer they look like lice species. The common indoor book lice species Liposcelis sp. is recorded and is always seen inside the cupboards where there is moisture and fungus growth. The occurrence of Psocids in UAE noticed during spring and summer seasons.

Phthiraptera - (Lice): Lice belong to order Phthiraptera, and are the only truly parasitic group amongst the exopterygote insects. As permanent ectoparasites of most birds and mammals they exhibit a remarkable level of host specificity which is unparalleled in most other metazoan parasites. Specifications in the diet of lice underpin their major taxonomic divisions and they can be broadly separated into those that feed on skin debris, feathers and fur (Mallophaga - chewing lice), and those that have specialized in blood feeding (Anoplura - sucking lice). Anoplura feeding solely on blood and are the vectors to a number of blood borne diseases. Two species of sucking lice from two different families recorded.

Thysanoptera (Thrips): Thrips are tiny insects usually brown, black with slender bodies with two pairs of fringed wings. Commonly found in flowers. Many species are plant sap or pollen feeders and can be serious pests of agricultural crops; but others are beneficial predators, preying on mites, small insects or serve a useful purpose in pollinating flowers. Seven species have been recorded so far from the Emirate.

Heteroptera - (True Bugs): Heteroptera comprises diverse group of insects. The vegetated dunes and woody herbaceous plants provide ideal habitats for Heteroptera. The bodies of these insects are generally flattened and the wings are folded flat over the body at rest. Many of the species have “stink glands” located near the hind legs. These glands secrete pungent chemicals which the insects use as a defense mechanism. The Squash Bug produces a particularly strong smelling secretion and is commonly found in Ghaf trees *(Prosopis cineraria)*. The major families include Pentatomidae (stink bugs), Lygaeidae (seed bugs), Miridae (leaf bugs), and Cydnidae (burrower bugs). Many of these families are phytophagous bugs possibly seen associated with specific species of plants. The Heteroptera are particularly diverse and include household pests such as the Bed Bug *(Cimex lectularius)* and several species of agricultural pests. Heteroptera is represented by fifteen families and fifty or more species.

Homoptera - (Cicadas, Plant hoppers and Aphids): The desert vegetation provides ideal habitat for Homoptera, which along with the Heteroptera form the major phytophagous group of insects in Abu Dhabi. It represents 51 species within the 18 families. Of which the leafhopper family, Cicadellidae is the most widely distributed. The order includes Cicadas, large singing bugs, seen in Acacia and Ghaf trees of deserts of the Abu Dhabi. A number of Aphid species are also noticed as pest species of vegetables.

Neuroptera - (Ant lions and Lacewings): The desert of Abu Dhabi Emirate has a rich fauna of ant lions and lacewings. Seven families, which include many taxa found in arid habitats, comprising 70 species have been so far identified from the Emirate. Most members are economically beneficial as they predate many soft bodied pest insects (aphids, scale insects) and help to control destructive insects. The majority of the species belong to the family Myrmeleontidae (ant lions).

Coleoptera - (Beetles): This is one of the largest orders in the animal kingdom representing large proportion of the insect species so far known. The deserts of Abu Dhabi have a rich fauna of beetles and a total 300 species within 37 families have been so far recorded. The majority of the identified species belong to the detritivorous Tenebrionid Family (Darkling beetles) and the ground beetle family Carabidae. Several other important families include Scarabaeidae (scarab beetles) Elateridae (click beetles), Curculionidae (weevils), and Meloidae (Blister beetles), Histeridae (histerids), Buperstidae (jewel beetles), Dermestidae (skin beetles) *etc.*

Diptera - (True Flies): Diptera is one of the largest orders of the insects, and this group of ubiquitous organisms is well represented through out the various habitats of the UAE. Important families of this order include Musidae (houseflies), Calliphoridae (bottle flies), Sarchophagidae (flesh flies), Syrphidae (hover flies), Asilidae (Robber Flies) and Tabanidae (Horseflies). Many fly species belonging to the family Culicidae (mosquitoes) and Ceratopogonidae (biting midges) have been recorded as carriers of harmful diseases or as vectors of germs. About 150 species have been recorded so far but this group needs more taxonomic identification, even to place many forms in the right family.

Strepsiptera (Stylopids or Twisted wing parasites): This small order comprises highly modified tiny insect parasites which are quite common, but they are usually overlooked due to their small size. Their frequent hosts are plant hoppers and various bees and wasps. Recorded on the Emirate, but not yet identified. Studies say that attack by Stylopids causes sterility in hosts, especially in female, and the parasite may play some specialized part in the natural regulation of the host population.

Lepidoptera - (Butterflies and Moths): Lepidoptera that have been collected reveal the presence of an extremely wide-ranging fauna of common moths and butterflies. 360 species in thirty families have been identified. The important holdings for this order include the Family Noctuidae (Owlet Moths), Geometridae (Earth-measure moth), Sphingidae

(Hawk moths), and Pyraliidae (Pyralid moths). Most caterpillars are herbivorous and some are identified as important pest species of agricultural crops. Beautiful forms can be found among the Sub order Rhopalocera and majority of the species belong to the forms which are commonly called moths (Heterocera). Studies initiated to understand the pest species of moths in the Emirates.

Hymenoptera - (Bees, Wasps and Ants): The Hymenoptera constitute an extensive group of highly specialized insects with diverse habitat requirements. This order is economically important, either through pollinating and therefore assisting in the reproduction of plants, or through the parasitic forms which help maintain the natural balance within the ecological web. Representation of this order is particularly strong for Crabronidae (digger wasp), Sphecidae (Digger Wasps), Bradynobaenidae (Parasitic Wasps), Brconidae (braconid wasps), Ichneumonidae (ichneumons), Tiphiidae (flower wasps), Bethylidae (solitary wasp), Apidae (bees) and Formicidae (Ants). Four hundred species from 20 families are represented so far. However, this well represented order of the insects in the Emirate needs more studies.

See CITES Appendix I for a complete list of insects recorded in the UAE.

B Class Arachnida

Order Acarina (Ticks and Mites): Ticks are the only members of the order Acarina which feed only on blood of vertebrates. There are two major groups of ticks; hard ticks soft ticks based on the two families Ixodidae and Argasidae. Ixodid ticks have a plate or scutum on their dorsal surface. Soft or Argasid ticks lack a scutum. The camel tick species Hyalomma dromedarii is commonly found throughout livestock pens and beneath shade trees frequented by camels and goats. And also another hard tick species *Rhipicephalus (rhipicephalus) sanguineus* reported as an external parasite associated with wildlife in the United Arab Emirates (Cunningham & Kevin, 2000). R. r. *sanguineus* are known to be vectors of serious disease in animals and humans, and it is, therefore, imperative to be aware of the risks involved when handing wildlife (Reeve, 1994). The Argasids are called so-called soft ticks, common in poultry houses and may injure or even kill chickens and may attack humans. So far only one fowl tick species *Ornithodorus* sp. has been recorded from wild birds in the Emirate. But more studies needed to know the exact number of species present here and its medical and veterinary importance.

Three species of mites have been reported; they are two spotted spider mite and red velvet mites belonging to the families Tetranychidae and Trombiculidae and Trombidiidae. *Tetranychus utricae, Trombiculus*

Spiders are free living, solitary and predatory invertebrates feeding mainly on insects and other arthropods. There are many interesting species of spiders in the Emirate but they have been comparatively little studied and it can be assumed that the group is much more diverse than is known from the available data. However, it is not studied to species level. Species from 9 major families have been recorded including the famous red back spider family Theridiidae.

Order Pseudoscorpionida (Pseudoscorpions or false scorpions): They are group of small arachnids that look like tiny scorpions but lack the scorpion's long tail and sting. The occurrences of these Arachnids in gravel plains and under rocks are recorded in the Emirates (Gillett & Gillett, 2005) but needs more study for the species level identification.

Order Chelicerata: (Scorpiones): Scorpiones are nocturnal predators of insects and spiders. Nineteen species are recorded including many active hunters of the family Buthidae. The many Scorpiones of the family Buthidae produce venoms which cause intense pain and more or less dangerous systematic effects. The species *Androctonus crassicauda* that belongs to the family Buthidae (buthids or fat tailed scorpions) is a world wide species often recorded in the desert of Abu Dhabi Emirate. The other families recorded from the Emirate include Chactidae (fat claw scorpions), Diplocentridae (spiny sting scorpions) and Scorpionidae (largeclaw scorpion).

Order Soilfugae (Camel Spider or Windscorpion): Camel spiders are adapted to live in the desert and can be found in areas where there is little vegetation. This carnivorous solifuges have nocturnal habit and are not true spiders and their jaws or chelicerae lack venom. But their bite reported painful with a possibility of a secondary bacterial infection. They possess two rows of 'paddles' to detect the presence of enemy or prey by vibration on the ground. Reports say that they have been cited as one of the world-wide biological indicators of desert as they prefer dry desolate areas and avoid fertile places. Species *Galeodes arabas* Koch (Tigar and Osborne, 1997) has been recoded from Sabkha and deserts of the Emirate. But there is likely more species of Camel spiders occur in UAE. Identification of Solifugidae and its medical importance in U.A.E. is needed.

Table 4-4: List of other Arthropod groups recorded in UAE

Subphylum& Order	Family	Genus and Species	*Common Name*
	Ixodidae	*Hyalomma dromedarrii, Koch,* 1844	*Camel tick*
		*Rhipicephalus sanguineus Latreille,*1806	*Hare tick*
Chelicerata: Acari	Argasidae	*Ornithodorus* sp.	*Fowl tick*
	Trombidiidae	*Dinothrombium sp.*	*Harvest mite*
	Tetranychidae	*Tetranychus utricae*	*Spider mite*
	Trombiculidae	*Trombiculus sp.*	*Velvet Mite*
		Androctonus crassicauda (Olivier, 1807)	*Scorpion*
		Apistobuthus pterygocercus Finnegan, 1932	*Scorpion*
		Buthacus leptochelys (H. & E., 1929)	*Scorpion*
		Buthacus yotvatensis nigroaculeatus Levy et. al, 1973	*Scorpion*
		Buthotus jayakari Vachon, 1949 b	*Scorpion*
		Compsobuthus maindroni (Kraepelin, 1901)	*Scorpion*
		Compsobuthus arabicus Lévy et al, 1973	*Scorpion*
Chelicerata: Scorpiones	Buthidae	*Hottentota jayakari (Pocock, 1895)*	*Scorpion*
		Odontobuthus sp.	*Scorpion*
		Orthochirus innesi Simon, 19010	*Scorpion*
		Parabuthus leiosoma leiosoma (Ehrenberg, 1828)	*Scorpion*
		Vachoniolus globimanus Lévy et al, 1973	*Scorpion*
		Vachoniolus minipectinibus Vachon, 1974	*Spider mite*
			Scorpion
	Chactidae	*Euscorpious sp.*	*Scorpion*
	Diplocentridae	*Heteronebo sp.*	*Scorpion*
		Nebo omanensis, Francke, 1980	*Scorpion*
		Nebo sp.	*Scorpion*
	Scorpionidae	*Hemiscorpius arabicus (Pocock, 1899)*	*Scorpion*
		Pandinus sp.	*Scorpion*
		Scorpio sp.	*Scorpion*

C Class Crustacea

Order Isopoda - (Pill bugs and woodlice): Isopods are common inhabitants of nearly all environments, and they are unusual among the Crustacea for their ubiquity. The terrestrial forms are known by unusual names like 'pill bugs' or 'salters' and they are by far the most successful group of crustaceans that invades land. Many forms are nocturnal in habit, live under leaf litter and other damp habitats and avoid hot and light intensive places to reduce loss of water by evaporation. However in the terrestrial fauna of Emirate, they are mostly represented from two families- Porcellionidae and Tylidae (Barbara and Osborne 1997).

D Class Myriapoda

Order - Scolopendromorpha (Centipedes): The centipedes are common in mountains, farms, and suburban gardens. These active fast moving invertebrate predators are less common in the desert habitats. They are nocturnal, spending their day in damp, dark places under stones and crevices. Two centipede species have been recorded so far from the Emirate (*Scolopendra mirabilis* (Porat, 1876) and S. *valida* (Lewis & Galagher, 1993). But as in most groups, there are also still undescribed forms exist here. All centipedes are poisonous, but little is known about the effects of the poison of different species (Wranik, 2003).

Table 4.6 :contd List of other Arthropod groups recorded in UAE

Chelicerata: Araneae	Scelionidae		*Crab spiders*
	Salticidae		*Jumping spider*
	Clubionidae		*Sac spiders*
	Thomisidae		*Small crab spider*
	Pholcidae		*Daddy Long Legs Spiders*
	Oonopidae		*Spider*
	Gnaphosidae		*Mouse spiders*
	Theridiidae	*Latrodectus sp.*	*Red back spider*
		Latrodectus hasselti	*Australian red back spider*
	Lycosidae		*Wolf spider*
Chelicerata: Pseudoscorpionida	Solifugidae	*Galeodes arabs Koch.*	*Camel spider*
Crustacea: Isopoda	Porcellionidae		*Wood louse*
	Tylidae	*Tylos maindroni Giordani Soika*	*Wood louse*
Chilopoda	Scolopendridae	*Scolopendra valida (Lewis & Galagher, 1993)*	*Centipede*
		Scolopendra mirabilis (Porat, 1876)	*Centipede*

4.2.2.2 Phylum Nematoda

Nematodes are widely known as “round worms”. Most members of the phylum are parasites in plants and animals. But some are free-living forms, inhabiting soil and water. Nematode parasite which causes the disease Serratospiculiasis in falcon has been identified from the Middle East (Samour *et al.*, 2001). *Serratospiculum seurati* is transmitted in captivity by ingestion of infected beetles.

4.2.2.3 Phylum Annelida

Annelids are popularly known as “segmented or ringed worms”, and they are found worldwide in different habitats of the environments like moist soils in our city parks and yards. Annelida split into three major classes; Polycheta, Oligochaeta (earth worms) and Hirudinea (leeches). Little information is available about this subterraneous groups. Recently collected few specimens of Oligochaeta that belong to the order Opisthopora but identification to the species level require considerable expertise.

4.2.2.4 Phylum Mollusca

A survey of UAE land molluscs has recorded a total of seven native species and six introduced species. All of the native species are land snails found primarily or exclusively in mountain and perimontane environments. *Zootecus insularis* and *Pupoides coenopictus* are widespread throughout the mountain areas of the UAE but are also common in other suitable environments (Feulner and Stephen, 2003). Some terrestrial mollusc species have been introduced into mesic habitats through extensive public and private landscaping and agricultural activities using imported pants, soil and fertilizer. The most common among these are the cosmopolitan *Alopeas gracilis*, the slug *Laevicauis* ate, and the Florida snail *Polygyra cereolus.* The latter two species are present in pest proportions in some lawn and garden environments.

Table 4-5: List of other invertebrate animals recorded in UAE

Phylum	Class & Order	Family	*Scientific Name*
		Veronicellidae	*Laevicalius alte (Férussac 1821)*
		Succineidae	*Calcisuccinea luteola floridana (Gould 1848)*
		Pupillidae	*Pupoides coenopictus (Hutton, 1834) G Gibbulinopsis signata (Mousson, 1873)*
		Chondrinidae	*Granaria persica (Gittenberger, 1973)*
Mollusca	Gastropoda: Pulmonata	Subulinidae	*Zootecus insularis (Ehrenberg, 1831) Allopeas gracilis (Hutton, 1834)*
		Buliminidae	*Mordania omanensis (E.A.Smith, 1894) Pseudonapaeus jousseaumei (E.A.Smith 1894)*
		Polygyridae	*Polygyra cereolus (Megerle Von Mühlfeldt, 1816)*
		Ariophantidae	*Macrochlamys indica (Godwin Austen, 1883)*
		Hygromiidae	*Xeropicta mesopotamica (Mousson, 1874)*
Annelida	Oligocheta		
Protozoa			*None*
Platy helminthes			*None*
Nematoda	Secernentea : Spirurida	Diplotriaenidae	*Serratospiculum seurati*
Echinodermata			*None*

4.2.2.5 Arthropods other than Insects

Spider: Among the Arachnids, spiders of the genus *Latrodectus* (of the comb-footed family Theridiidae) are medically significant. A close relative of the American Black widow, red back spider of the genus *Latrodectus* have been repeatedly noticed and collected from different places of the UAE recently. Initial steps have taken to understand the species seen in UAE and its venom potency. However, one species *Latrodectus hasselti* recorded from Dubai few years ago.

Ticks: *Hyalomma dromedarrii* (camel tick) of the family Ixodidae (hard tick) has been reported from the Emirate as medically significant. This species might be problem for those people visiting the UAE's deserts and spend extended periods away from luxury of showers and a change of clothes but have not given rise to human disease. In animals and humans, viral disease Crimean-Congo Hemorrhagic Fever (CCHF) is transmitted through the bite of many different species of hard ticks (Schwarz *et al.*, 1997).

Scorpions: Like other groups of venomous arthropods, only a small fraction of the existing species is known to have venom potent enough to endanger humans. Almost all poisonous scorpions are found in the family Buthidae which cause intense pain and more or less dangerous systematic effects. In the Middle East, species *Androctonus crassicauda* is the largest local species with potent venom and the species *Buthacus vachoniolus nigroaculeatus* is also recorded for its venom.

Centipedes: Centipedes are in the class Chilopoda. The two tropical species found in the Emirate have poison claws behind the mouthparts, which can deliver a painful sting. Many bite cases have been reported from the Emirate but no further studies on the venom toxicity of scorpions and centipedes carried out.

Table 4-6: List of Venomous Arthropods Recognized in the UAE

Order	Family	Scientific Name	Common Name
Hymenoptera (Ants, Bees & Wasps	Formicidae	*Pachycondyla sennaarensis*	*Samsum Ant*
		Solenopsis geminata	Tropical Fire Ant
	Vespidae	*Polistes watti*	Paper wasp
		Vespa orientalis	Oriental wasp
Araneida (Spiders)	Theridiidae	*Latrodectus spp.*	*Widow spiders*
Scorpionida (Scorpions)	Buthidae	*Androctonus crassicauda*	*Scorpion*
		Buthacus yotvatensis nigroaculeatus	*Scorpion*
		Vachoniolus minipectinibus	*Scorpion*
		Parabuthus liosoma	*Scorpion*
		Compsobuthus arabicus	*Scorpion*
Scolopendromorpha (Centipedes)	Scolopendridae	*Scolopendra valida*	*Scorpion*
		Scolopendra mirabilis	*Scorpion*

Table 4-7: List of Arthropods that are recognized as blood-sucking pests

Order	Family	Scientific Name	Common Name
Class: Insecta (Insects)			
Diptera (True Flies)	Culicidae	*Culex quinquefasciatus*	*Common House mosquito*
		Ochlerotatus caspius	*Yellow fewer mosquito*
		Anopheles spp.	*Malaria mosquito*
	Ceratopogonidae	*Leptoconops spp.*	*Biting midges*
		Culicodes spp.	*Biting midges*
	Psychodidae	*Phlebotomus spp.*	*Sand flies*
	Simulidae	*Simulium (Whihelmia) buttikeri*	*Black fly*
Heteroptera (True bugs)	Cimicidae	*Cimex lectularius*	*Human Bed Bug*
		Cimex hemipterus	*Tropical Bed Bug*
	Reduviidae	*Reduvius spp.*	*Assassin Bugs*
Siphonoptera (Fleas)	Pulicidae	*Ctenocephalides felis*	*Cat flea*
Phthiraptera (Lice)	Pediculidae	*Pediculus h. capitis*	*Head louse*
	Pthiridae	*Pthirus pubis*	*Pubic louse or Crab louse*
Class: Arachnida: Acarina (Ticks and Mites)			
Acarina (Mites &Ticks)	*Ixodidae*	*Hyalomma dromedarii*	*Camel tick*

Figure 4-34: Yellow Scorpion (*Apistobuthus pterygocercus*)

Figure 4-35: Pupal case & adult (*Strebolte siva*)

Figure 4-36: Arabian Paper Wasp (*Polistes watti*)

Figure 4-37: Azure Skimmer (*Orthetrum taeniolatum*)

Figure 4-38: Black Fat Tail Scorpion (*Androctonus crassicauda*)

Figure 4-39: Yellow Fat Tail Scorpion (*Buthacus yotvatesis nigroaculeatus*)

Figure 4-40: Blue Spotted Arab (*Colotis phisadia*)

Figure 4-41: Bottle fly (*Lucilia sp*.)

Figure 4-42: Camel Spider (*Galeodes sp*.)

Figure 4-43: Common House mosquito (*Culex* sp.)

Figure 4-44: Domino Beetle (*Anthia duodecimguttata*)

Figure 4-45: Flesh Fly (*Sarcophagus* sp.)

Figure 4-46: Giant Sand Swimmer (*Erodius octocostatus*)

Figure 4-47: Hare Tick (*Rhipicephalus* sp.)

Figure 4-48: Hover fly (*Eupeodes* sp.)

Figure 4-49: Oleander Hawk moth (*Daphnis nerii*)

Figure 4-50: Oriental Wasp (*Vespa orientalis*)

Figure 4-51: Praying Mantis (*Iris pitcher*)

Figure 4-52: Female Red Back Spider (*Latrodectus* sp.)

Figure 4-53: Red Velvet Mite (*Dinothrombium* sp.)

Figure 4-54: Samsum Ant (*Pachycondyla sennaarensis*)

Figure 4-55: Sulphurous Jewel Beetle (*Julodis euphratica*)

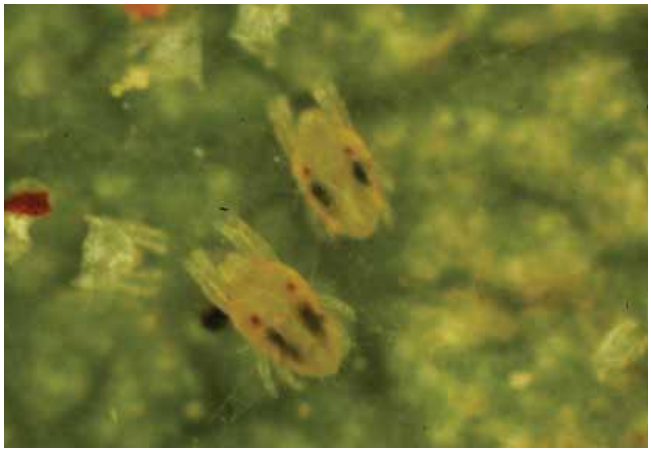


Figure 4-56: Two Spotted Spider Mite (*Tetranychus utricae*)

Figure 4-57: Yellow Fever Mosquito (*Ochlerotatus* sp.)

5 TRADITIONAL AND ECONOMIC VALUES


Photo by HABITAT

5.1 Traditional/Historic Uses

5.1.1 Ethnobotany

Plants are a source of powerful therapeutic drugs. A world leader in finding botanical solutions to human health problems, our natural environment has long been involved in the search for plant-based remedies for disease.

The practices of traditional medicine are based on hundreds of years of belief and observations, which predate the development and spread of modern medicine. Our ancestors started to learn from nature by tasting and using what was available. It is well known that old civilizations have flourished through the area and used its natural plants for various daily needs, such as food, shelter, and medicine.

Traditionally, the uses of plants have been inherited by successive generations, and thus some of the plants became well known for their uses especially by practitioners.

During the past decades, traditional systems of medicine have become a topic of global importance. Current estimates suggest that in many developing countries, a large proportion of the population rely heavily on traditional practitioners and medicinal plants to meet primary health care needs. Although modern medicine may be available, herbal medicines (Phytomedicines) have often maintained popularity for historical and cultural reasons. Concurrently, many people in developed countries have begun to turn to alternative or complementary therapies, including medicinal plants.

Like many other countries in the region the United Arab Emirates is comprised of two different societies; one rural and the other urban. Both of them depend upon the rich traditional heritage. The use of medicinal plants is widely practiced by the inhabitants of the nomads and the little villages and towns as a result of the long relationship between the people of the and their surrounding environment where they use to depend on much higher than nowadays, a local knowledge of the native plants has been developed along with its medicinal benefits and properties.

Few plant species that provide medicinal herbs have been scientifically evaluated for their possible medical application. Safety and efficacy data are available for even fewer plants, their extracts and active ingredients and the preparations containing them. Furthermore, and like most countries, the medicinal plants market is poorly regulated.

As a result of the long relationship between the people of the United Arab Emirates and their surrounding environment a local knowledge of the native plants has been developed along with its medicinal benefits and properties.

Ninety nine plant species of native plants (total about 400 in Abu Dhabi) are considered medicinal local plants that are being used traditionally by the people for the past thousands of years. This figure is relatively high and represents about 25% of the total flora of the state. Medicinal plants, as a part of the native flora of the country, suffer from different threats that are causing a decline in their number and population. This is mainly due to the effect of the change of land use, overgrazing, over harvesting, tree and shrub cutting and urbanization.

Also, the loss of traditional knowledge regarding medicinal plants is considered to be a major issue. Traditional healers, whether being men or women, are reducing in number and new generations are no longer interested in inheriting this traditional knowledge.

Thus, and from being of high value, all plants are to be preserved by taking the action of establishing a network of protected areas where plants are preserved "*in-situ*" in their natural habitats. Also, it has been decided to carry out sufficient research into the medicinal plants of the United Arab Emirates by establishing in 1996 a separate body for this purpose named the "Zayed Complex for Herbal Research and Traditional Medicine" (ZCHRTM) that encompasses different units of clinical, research and a manufacturing.

Table 5-1: Species of Native Plants in High Demand

Common name	Scientific Name	Uses
Desert squash (Figure 5.1)	*Citrullus colocynthis*	Used to cure diabetes.
Sodom apple (Figure 5.2)	*Calotropis procera*	Used to heal rheumatism. Dried bitter sap used to fill aching hollow teeth.
Harmal (Figure 5.3)	*Rhazya stricta*	Used in small quantities to settle gastric upsets. Smoke from the leaves used to treat epilepsy.
Teucrium	*Teucrium stocksianum*	Used for combating fevers.
Aloe	*Aloe vera*	The sap of the leaves used to treat skin diseases and rheumatism. Used to treat burns.
Arabian caralluma	*Caralluma arabica*	Used to treat high blood pressure. Used for curing liver ailments.
Heliotrope	*Heliotropium bacciferum*	The plant used as treatment for snake bite.
Rose of Jericho	*Anastatica hierochuntica*	Smoke of burning stem used to treat cold. Solution of dried plant eases pain in labour and childbirth.
Toothbrush tree (Figure 5.4)	*Salvadora persica*	Roots (miswaak) are chewed to clean teeth and treat gum disease. Crushed, dried and powdered leaves applied to heal sore joints and scorpion stings.Friuts used against cough.
Henbane	*Hyoscyamus muticus*	Used as sedative to treat insanity, epilepsy, insomnia and toothache. Used to relieve pain in snake and scorpion bite
Christ thorn (Figure 5.5)	*Ziziphus spinachristi*	Leaves used to heal broken bones.

Figure 5-1: Desert Squash (*Citrullus colocynthis*)

Figure 5-2: Harmal (*Rhazya stricta*)

Figure 5-2: Harmal (*Rhazya stricta*)

Figure 5-4: Christ Thorn (*Ziziphus spina-christi*)

5.1.2 Falconry

Arab Falconry is an age old traditional practice and still remains extremely popular. Despite the wealth, modern development and changing lifestyle, falconry remains as deep rooted as ever and is an important annual event for many Arabs. Roots of Arab life lie deep in the deserts, nomadic life style of camel herds and people in tents (Upton, 2001). Keeping pace with changing times, the Arab Falconry has also changed. Though, the fast and all terrain four-wheelers have replaced camels and tools like Global Positioning Systems (GPS) are used for navigation, the falconry camps still retain the bonhomie, joy, togetherness and frankness among the camp members.

Although many see falconry as an activity which significantly impacts both the prey and its main quarry the houbara bustard (*Chlamyodtis macqueenii*), there are different dimension to this activity. Falconry, particularly in the United Arab Emirates and probably in many other gulf countries is seen as an activity of royalties, and rich elites of the society. It is because of the involvement of such people there have been lot of interest in protecting falconry as a sport and tradition with emphasis on conserving both the falcons and their prey. Significant research and funding inputs because of interests in falconry has led to very interesting information on the falcons and their main prey and in terms has led to in situ and ex situ conservation initiatives. Setting up of NARC, establishment of ERWDA and its evolution into Environment Agency Abu Dhabi (EAD) can be attributed to interest in falconry, especially among rulers.

Extensive research work carried out by EAD on Asian falcons, particularly Saker, has made startling revelations. Catastrophic decline in Saker populations is due to habitat loss and fragmentation, impoverishment of already depleted and isolated pockets of distributions or trapping during the nesting period. The Saker Falcon became extinct in many European countries by 2000 (**Figure 5.7**). In recent times, the most dramatic losses have been observed in populations in Kazakhstan. Current harvest levels of Saker Falcons are considered unsustainable (Fox, et. al., 2002), and unless these levels are reduced, Saker will continue to decline. Falcon registration and Falcon Passport Scheme initiated by UAE are steps to control and regulate the trade, besides providing useful data on falcon demography. At present, 75 to 80% of all the birds in the UAE are registered. Saker constitutes about 41% of all the registered falcons. An estimated 10,000 wild caught Saker falcons **(see figure 5-5)** are trapped and sold to the Middle

Countries	Saker Numbers
Saudi Arabia	4000-5000
Qatar	1000
Bahrain	1000
Kuwait	1000
United Arab Emirates	500-1000
Total	7500-9000
10% mortality factor	8250-9900

Source: Fox et al., 2003 (figures are based on latest estimates wherever possible)

Figure 5-5: Number of wild caught Saker Falcons

East on an annual basis (Fox *et al.*, 2002). Unfortunately of the 1294 Saker falcons used in UAE, only 8% are captive and rest are wild caught birds. Reversing such trends and a ban on Saker Falcon use for few years may be essential to conserve Saker Falcon on a long-term basis. Similarly, a check on illegal import of houbara bustard is required to keep alive the tradition of Arab falconry.

The availability of all terrain vehicles and use of accurate navigational and communication devices such as GPS, mobile and satellite phones have virtually allowed unhindered access to remotest areas of desert in search of houbara bustard and other prey species such as Stone Curlew (*Burhinus oedicnemus*) and Desert Hare (*Lepus capensis*). A Global conservation Strategy for the Conservation of Falcons and houbara bustard published by ERWDA (ERWDA, 2000), identified global management of wild populations of houbara bustard, both in its wintering areas in (Pakistan and Arabian Peninsula) and its breeding areas in Kazakhstan and China.

Scientists from EAD's NARC have continued to implement the actions identified under the Strategy both in the breeding and wintering areas. Extensive data on population, movement and migration patterns of houbara bustard have been collected over the last 10 years. Monitoring of houbara bustard in Kazakhstan has revealed a dramatic decline in houbara bustard populations (Tourenq *et al.*, 2004). Kazakhstan remains one of the most important breeding areas for houbara bustard (Gubin, 1992; Goriup, 1997). Houbara bustard decline through out its range is attributed to poaching pressure, excessive hunting, general deterioration in their habitat (Collar, 1980; Combreau *et al.*, 2001) and decreased breeding success due to predator pressure (Combreau, *et al.*, 1999b, 2001).

Captive breeding of houbara bustard at NARC's state of the art breeding facilities and development of expertise and breeding skills over the years have led to significant increase in the breeding success. Continued research and monitoring of houbara bustard populations are essential elements of houbara conservation. A mix of in-situ and *ex-situ* conservation efforts complemented with increased education and awareness among falconers about the status of both the prey and its quarry is vital to maintain the tradition of Arabian Falconry, at least at sustainable levels.

Recent outbreaks of Avian Influenza in many parts of Asia, Middle East and Europe, particularly in the breeding areas of China and Kazakhstan highlight the need to practice the falconry with extreme caution. Falcons can contract infection on hunting trips and in the process pose a sever risk of infecting other falcons, owners, trainers and even bringing the disease to the country of origin after a hunting trip. The example of five falcons in Saudi Arabia, infected with the Highly Pathogenic Avian Influenza Virus (HPAI) leading to culling of 37 falcons at a facility is a good example of this. As each falcon is very expensive, loss of even a single bird is a significant loss to the owner, not only monetary but the bonding that the owner develops. However, other than these losses, the risks of spreading the disease among humans and poultry are enormous and much bigger human health and economic concerns at national level which can have implications at regional and global scales.

Given the hazards of infectious disease and general decline in populations of houbara bustards and falcons used in falconry, it is critically important that falconry is practiced with these realities in mind. Wisdom has been an integral part of Arab falconry. Modern day falconers have to show the same wisdom as well as acquire knowledge and understanding accrued through decades of scientific research to keep alive the tradition of Arab Falconry for years to come.

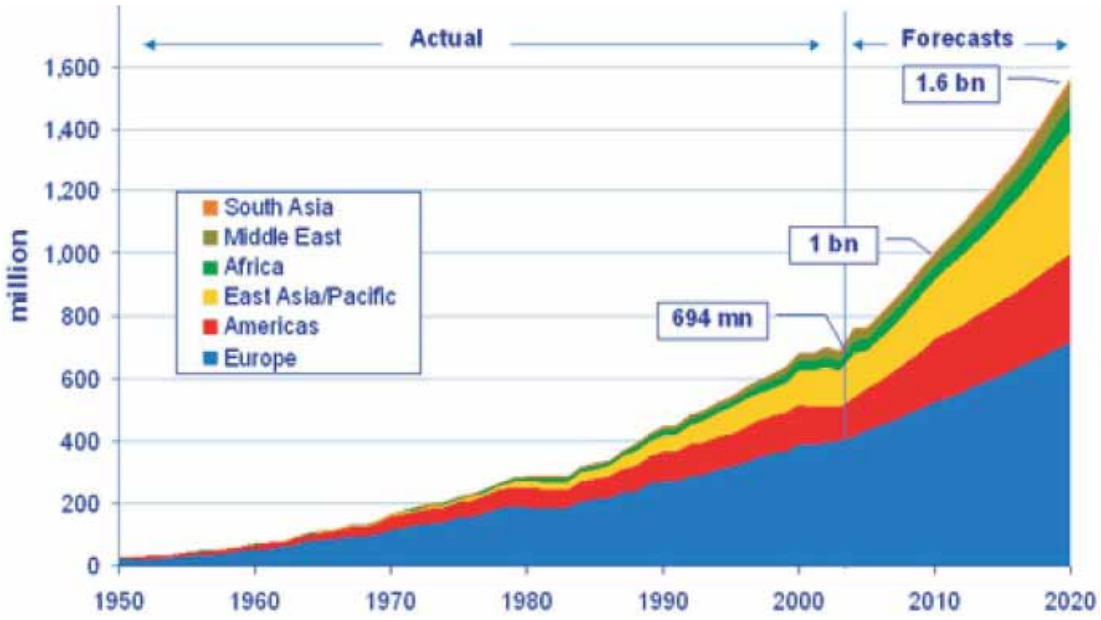


Figure 5-6: World Tourism Organization 2020 Vision *Source: World Tourism Organization* (www.world-tourism.org)

5.2 Current Economic uses

5.2.1 Recreation

Tourism is one of the world's largest and fastest growing sectors. A total of 760 million international arrivals were estimated in 2004 with an increase of 10% over 2003 (WTO, 2005). In the year 2010, the World Tourism Organization estimates total international arrivals to reach to 1 billion, while in 2020 this figure will increase to reach 1.6 billion arrivals as **Figure 5-6** indicates.

According to the WTO, North Africa and the Middle East lead the way in terms of growth as they did in 2005 with an estimated increase of around 11% each during the first four months of 2006. The UAE reported growth of 7%. According to Abu Dhabi Tourism Authority number of visitors is estimated to reach up to 3 million visitor by 2015 in compare to 830,000 in 2003 (http://www.abudhabichamber.ae).

In the mean time the global trend towards nature based tourism as an alternative or complementary to the traditional tourism is increasing rapidly. According to the World Resources Institute nature-based tourism arrivals reached up to 760 million during 2004 spending a total of US$ 622 million in compare to US$ 330.4 million, 416 million in 1988 and 1994 respectively. Diversity of species, unique habitats and landscape are key attraction elements for this type of visitors. In UAE generally Tourism activities are mainly restricted into business activities and shopping. There are some initiatives that UAE is highly considering in developing and promoting certain nature-based tourism projects and these include Al Maha Resort in Dubai, Sir Bani Yas Island which a master plan has been developed by the Abu Dhabi Tourism Authority to promote the Island as a wildlife tourism destination, and Al Wathba Wetland Reserve that is managed by the Environment Agency where an ecotourism master plan is under preparation which will be targeting birdwatchers, schools and daily visitors.

5.2.2 Economic botany

Human beings have always had vital interest in plants of all kinds. Plants and plant products are used in almost every aspect of daily life. Plants provide food, shelter, clothing, flavours, beverages, drugs, medicines and decoration. Plants that can be utilized either directly or indirectly for the benefit of mankind are called Economic plants. In UAE, many indigenous plants are traditionally used as herbal medicines, dyes, perfumes, as building material for houses and for the production of traditional household implements. In the present day, usages of plants are lessening for the modern day values. Even then plants are still utilized, as medicines, to make utilitarian objects, perfumes and dyes.

The use of native plants for medicinal purpose goes back to pre-Islamic civilization. The use of plants and plant products had been established as incense, perfumes and dyes and food since ancient days in UAE as in any other part of the world. Some plants had been used as traditional medicines from the ancient era and are still used in modern medicine as well. All the plants have their own importance in maintaining the nature and ecosystem.

Plants of Medicinal Value

Medicinal plants have extremely important role in the future use and economy of the country. Herbal medicines are very commonly used for digestive problems and treatment of cold and coughs. Powdered seeds of *Rhazya stricta* are used in small quantities to settle gastric upsets. Fevers and headaches are commonly treated by applying paste from the leaves of *Lawsonia inermis* and *Aloe vera.* One of the popular uses of herbal medicine is in childbirth and pre and post natal care. Solutions of dried plant of *Anastatica hierochuntica* are drunk by women in labour to ease childbirth. Plants are also used for various skin infections, bite and stings, and for alleviating muscular pain. *Heliotropium bacciferum* and *Hyoscyamus muticus* are used against snake and scorpion bites. Species of Caralluma, Caralluma flava and *Caralluma arabica* have high medicinal value. They are used against high blood pressure and to cure liver ailments.

Plants used for grazing and fodder

One of the most important uses of plants in the Arabian Peninsula is for livestock fodder. In UAE, *Panicum turgidum* is regarded as one of the most important grazing indigenous species. It is a perennial grass that has high tolerance to draught conditions, a good level of nutritive value, and is regarded as one of the most relevant species for sand dune fixation. Due to its adaptation to dry conditions, *Panicum* has been considered as an important grazing species for future domestication and forage production in the country. *Cenchrus ciliaris* is another important grazing plant which has high resistance to drought and high nutritive value. Perennial grass species of *Bromus, Cenchrus*, *Cynodon, Lasiurus* and *Stipagrostis* are also grazed and cut for fodder. Other plants lopped for fodders include *Acacia tortils* and *Prosopis cineraria.* A species of *Medicago* (Afalfa) is a fodder plant that is cultivated traditionally.

Ornamental plants

Eremobium aegyptiacum, Silene villosa, *Tribulus terrestris* are ornamental plants found in sand dunes. Limonuim axillaire is an ornamental plant of coastal areas. Most of the ornamental plants have nectar value.

Food plants

Since the early days of human activity the wild plants were the main and only source of food. Some of the wild edible plants are the fruits or the seeds of the trees such as *Ziziphus spinachristi,* leaves and fleshy parts of the herbs such as *Calligonum comosum, Rumex vesicarius, Helianthemum lippi etc.*

Cultivated crops of economic importance include T*riticum vulgare,* species of *Citrus, Mangifera indica, Terminalia catapa etc.*

Date palm, *Phoenix dactylifera* has varied uses. Its wood is used as a building material, and the leaves are very useful for making several handicrafts like fans, ropes, sticks, mat etc. The fruit is not only sweet and delicious but is one of the best known nutritious diet plants. Dates are reputed for great medicinal value. Because of the beauty and elegance, date palm gardens are an exquisite sight.

Leaves of *Juncus rigidus* are also used as building material, used for making mats. *Salvadora persica* is an important tree, where its twigs and roots are often used as tooth brush. The wood extract is reported to contain lots of salts and resins which are responsible for cleaning and shining of teeth. The berries of *Salvadora persica* are edible.

Lawsonia inermis, henna is a traditional important plant, whose flower has been used an important article of cosmetics. The flowers of henna have a cooling effect and are also very good stimulant. The extract from the leaves is used as dye.

Avicennia marina, the native mangrove species has high environment and economic value as it provides habitat for fish and crustacean, as well as breeding habitat for number of bird species. It reduces the erosion of the coast and it considers being a source of food for camels and goats. Native trees like *Acacia tortilis* and *Prosopis cineraria* are widely used for afforestation projects, hedges and wind breaks.

Figure 5-7: Grazing Camels

Sand dune fixatives

Some plants are able to grow under the desert dry conditions can fix and prevent the sand movement. Haloxylon persicum, Calligonum comosum, *Haloxylon salicornicum* and *Panicum turgidum are examples*. *Sporobolus ioclados* and *Juncus rigidus are coastal sand dune stabilizers.*

Grazing

Grazing is the process whereby animals consume plants to acquire energy and nutrients to be used for growth and maintenance. It is an ecological process in that the energy captured and stored by primary producers is consumed by primary consumers. Grazing management is the process whereby grazing and browsing animals are manipulated so as to accomplish a desired result.

Figure 5-8: Overgrazing

Grazing and Overgrazing

Managed or controlled grazing is good for the environment. Grazing in a planned and scientific manner has been found to be beneficial for the land. Uncontrolled grazing, often referred to as overgrazing is due to the lack of management Overgrazing can lead to loss of habitat, loss of vegetation and soil erosion which ultimately leads to the destruction and degradation of natural plant community. This can be prevented or controlled by regulation and better grazing management systems. Research has shown that light or moderate grazing is usually more beneficial than no grazing.

Economic benefits associated with livestock grazing

Historically, forages have been the major source of nutrients for livestock. More than 80 per cent of the country is currently utilized as rangeland. Native grasslands and improved pastures still contribute the majority of nutrients for cattle in many parts of the world. Improved grazing management offers one of the greatest opportunities for making livestock farming more profitable by lowering production costs.

The deserts of the region have always supported a race of herdsmen. For the sake of survival, the Bedouin have had to be acquainted with the names of the plant, their growth season and phonological aspects and their palatability or toxicity. Nomadic pastoralism enables the Bedouin to dominate vast areas and traverse hundreds of miles with their flocks to reach the verdant patches occurring at various periods of the year at various sites.

This helps them to spread knowledge, culture and maintain relationship between the tribes. There has been a gradual shift from nomadic to sedentary forms of pastoralism over the past decades in the country, with an ever-increasing demand on the available natural resources.

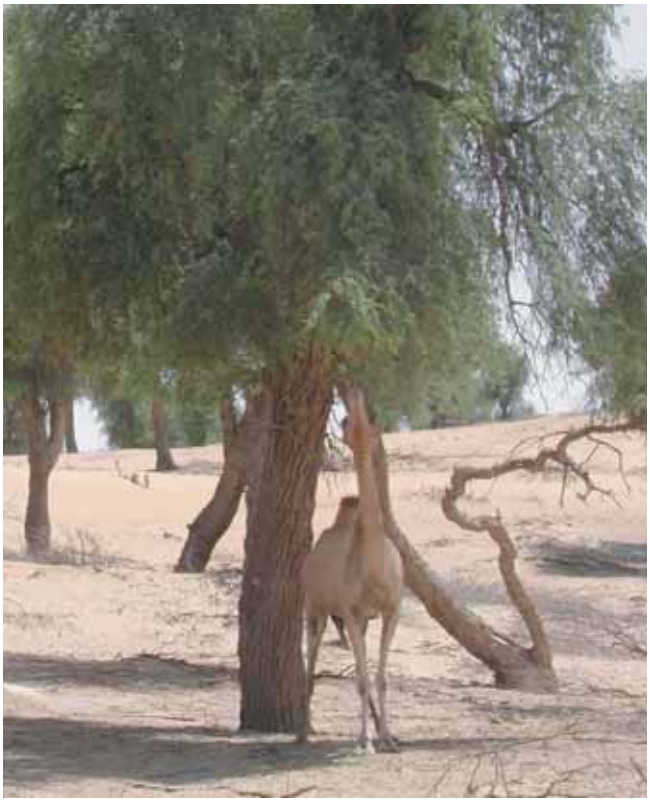


Figure 5-9: The characteristic shape to the Ghaf tree is due to grazing by camels

Situation in Abu Dhabi

All national and international research indicates that within the whole emirate of Abu Dhabi, natural habitats suffer highly from extensive overgrazing. Habitats are degraded and palatable species are being lost as sand is covering vast areas of the country.

Along with that, still the number of livestock and especially camels are increasing where more pressure is to be within the different natural habitats of the emirate. This situation leads to the increase in the demand on the planted forages, mainly Rhodes Grass and Alfalfa, whether imported or locally cultivated..

With knowing the effect of this ever-increasing numbers of different livestock on the different natural habitats of the emirate, still it plays a significant role in its economy.

The following table shows the increase of the number of livestock in the United Arab Emirates for a period of 5 years (1998-2002)

Type	1998	1999	2000	2001	2002
Sheep	436,710	467,281	494,917	524,510	553,614
Goats	1,128,182	1,207,155	1,278,547	1,354,993	1,430,176
Cows	84,753	90,686	96,050	101,793	107,444
Camels	193,877	207,446	219,713	232,848	245,766
Total	*18,435,22*	*1,972,568*	*2,089,227*	*2,214,144*	*2,337,000*

Table 5-2: Comparison of Numbers of Livestock in Abu Dhabi and Numbers in Other Emirates

Figure 5-10: Livestock Numbers in UAE, 1998 - 2002

The following table and chart show the percentage of the total number of livestock in the emirate of Abu Dhabi comparing to the all other emirates.

	Abu Dhabi	Other Emirates	Percentage
Sheep	115,692	437,922	20.9%
Goat	312,240	1,117,936	21.8%
Cow	14,624	92,820	13.6%
Camel	158,421	87,345	64.5%

Table 5-3: Number of livestock in UAE 1999-2002

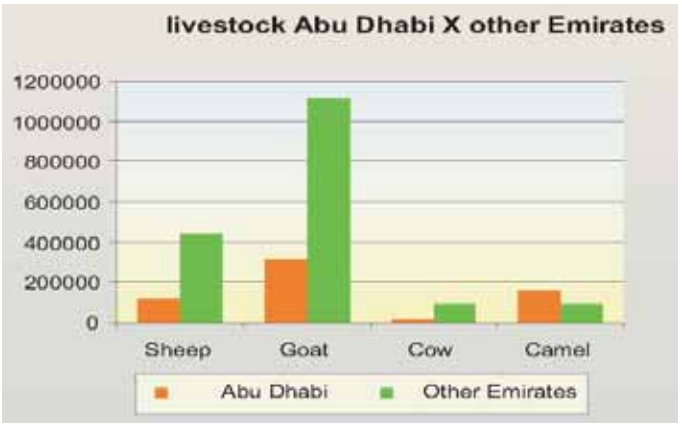


Figure 5-11: Livestock Numbers in UAE, 1998 - 2002

With a total number of 2,337,000 animals in the whole country, Abu Dhabi alone contains some 600,977 animals, representing about 26% of that total. Abu Dhabi has 64.5% of UAE's camels, but less than 50% of all other livestock types. **Table 5.4** and **Figure 5-12** show the contribution Abu Dhabi makes to the national totals for meat and milk production.

Item	Abu Dhabi	Total UAE	Abu Dhabi percentage
Milk Production	35,071	92,288	38.0%
Milk Value	115,444	331,661	34.8%
Meat Production	11,957	27,780	43.0%
Meat Value	167,056	461,190	36.2%

Table 5-4: Meat and Milk Production in Abu Dhabi and the UAE

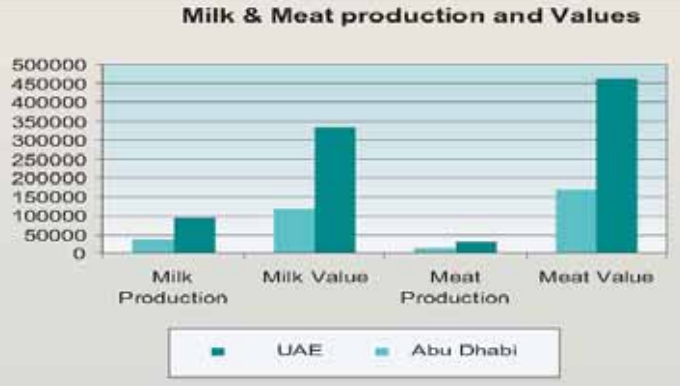


Figure 5-12: Meat and Milk Production in Abu Dhabi and the UAE

Abu Dhabi produces about 38% of the total UAE production of milk and about 43% of the total UAE production of meat which is considered to be very high according to the highly degraded rangeland in the emirate.

5.2.3 Invertebrates of Medical Importance

About 75% of the world's animal species are arthropods and few have medical importance. It is difficult to deal with the full impact of arthropods and other invertebrates on human health and welfare. However, these organisms have the capacity to inflict injury, disease, discomfort, or distress that can be a direct cause of illness, pain, and suffering through bites and stings, infested wounds, or allergic reactions. Medically important Arthropods can be grouped in different categories according to their mode of attack on man and animals. Their bite produce at times a certain amount of unpleasant after effects (mosquitoes, fleas, ticks, lice, bedbugs etc); they produce a kind of diseased condition by their presence either on the skin or in the body; they produce dermatitis by their irritating effects; (as in spider- lick dermatitis, and conjunctivitis and dermatitis caused by caterpillar hairs); those which produce symptoms of local and general toxemia due to the introduction of a venomous glandular secretion (sting by centipede, spider, scorpion, wasp, etc.); those which carry disease germs mechanically (house flies, tabanid flies, blood-sucking flies). Finally that they act as vectors in which the development of the pathogenic organisms always takes place: *e.g.*: mosquitoes and plasmodial parasites, avian and mammalian; mosquitoes and filarial parasites, sand flies and leishmania etc .

In the U.A.E. few preliminary studies have been carried out to understand the arthropods and other invertebrates which are medically important to man and animals (Balfour, 2003). The most important group of venomous arthropods that have come across so far has been discussed in this section of the report. The medically important group of Arthropods that occur in the U.A.E. is recognized from the insect orders like Diptera, Hemiptera, Hymenoptera and the members from the Class Arachnida. Toxicologically, there is far more diversity in spider venom than in the venoms of Hymenoptera and scorpions, so the identification and studies on spiders need more emphasis.

5.2.4 Insects of Medical Importance

A. Diptera:

The Order, which possess a number of species are of great medical importance as carriers of harmful diseases or as vector of germs transmitted while feeding. But there are many other species that are beneficial to agriculture as pollinators, and predatory or parasitic in controlling the insect pest population and as scavengers, maintains the balance of nature. Many species of medically important Diptera have been recorded from the emirates so far but requires considerable expertise work. They belong to the families of Musidae (house flies) Sarchophagidae (flesh flies), Tabanidae (horse flies), Culicidae (mosquitoes), Calliphoridae (bottle flies) Psychodidae (sand flies), Simulidae (black flies) and Ceratopogonidae (biting midges). The predaceous midges are common inhabitants of lakes and ponds and semi aquatic situations. Many cases of fly bites have been reported from camp workers in different parts of the Emirate. More collection and studies required to understand the diversity of biting flies in the UAE. Many species of the family Musidae and Sarchophagidae have been recorded from different parts of the UAE. Flies can disturb people and diminish their enjoyment of their surroundings. In UAE, these species have the status of a nuisance. Studies have shown that *M. domestica* can carry pathogenic microorganisms both on its body surface and in its alimentary tract.

Mosquitoes are also familiar pests to everyone. In UAE, about 25 species of mosquito occur some of which readily bite people. Of these, some medically important species like *Culex quinquefasciatus, Ochlerotatus (Aedes* sp.), *Anopheles stephensi and Anopheles culicifacies* have been recorded. But we need more studies on vector species of mosquitoes that are unlikely to be completely eliminated and inevitably a small number of travelers entering the country will be carrying parasites in their blood stream.

The smallest flies that bite people in the Emirate are the tiny females of certain members of the Family Ceratopogonidae (biting midges). No significant vectors of human disease are included in this family, although the genus *Culicoides* includes important vectors of animal diseases. Generally local night flying Culicoides are not a problem to people but can be threat to race horses. The representative of the biting midge of the genus *Leptoconops* has been considered important of their biting nuisance. The presence of large numbers of these insects is a threat to laborers working outdoors.

Phlebotomine sand flies of the genus *Phlebotomus* are a serious public health pest which transmit Leishmania major from wild desert rodents to people causing "oriental sore" (cutaneous leishmaniasis). Sand flies have been reported from northern emirates but needs more studies on the vector biology and reservoir host biology to determine the particular pest species. The family Simuliidae (black flies) has many species of importance to health. Simuliids feed on the blood of humans cattle, horses, sheep, goats, poultry other livestock and wild mammals and birds. Simuliids are severe biting pests that cause stress, fever, nausea and allergic dermatitis. Occurrences of black fly species *Simulium (Whihelmia) buttikeri* have been reported from the Emirates (Crosskey *et al.*, 1994).

B. Hymenoptera

Several species of ants and wasps have been recorded from UAE as venomous group. This includes the most dangerous ant species Pachychondyla sennaarensis that occurs around the human settlements throughout the Emirate. Problems with its stings and venom hypersensitivity occur throughout the UAE. The literature shows the infestation of Tropical Fire Ants recorded from the Emirate some years ago. Their stings are painful and infested areas cannot be fully utilized by people for recreation. However, with the efforts of Pest Control Section this alien ant species has been eliminated from the Emirate to a certain extent. Unchecked, the infestation of Tropical Fire Ants would presumably eventually spread to occupy almost all irrigated areas and have profound impact upon the flora and fauna of the man made habitats of UAE.

Among the wasps, the species Vespa orientalis (oriental wasp) and the members of the Genus Polistes are the medically important ones. Generally in the Emirate Polistes (paper wasp) do not become aggressive unless there is direct tampering with the nest. Therefore, we should always treat nest with caution, particularly when they are located on or close to buildings. The wasp species V. orientalis is a highly venomous insect because of the histamine content in the toxin. Histamine is responsible for the immediate pain and swelling at the site of sting. Fortunately, in the Emirate this species is less common than the Polistes wasps.

Phthiraptera

Lice are highly characteristic ectoparasites of mammals and birds. Usually host specific, thus the information on the host and the site of infestation of the lice on that host is an important aid to identification. The head louse species *Pediculus capitis* has been found infesting schoolchildren and it does not transmit any pathogen. The human pubic louse or crab louse *Phthirus pubis* has been recoded from the Emirate. It infests pubic hair some times may infest armpits or beard and infestation can be intense.

C. Hemiptera

Bed bugs are not regarded as significant vectors of human diseases. The bed bug species *Cimex lectularius* and *Cimex hemipterus* of the family Cimicidae have been recorded from the UAE. Even though the bites are painless, they can cause secondary infection in sensitive people and deprive people of sleep. Some members of the Family Reduviidae (assassin bugs) are thought to be poisonous but require more collection and studies on the particular group.

D. Coleoptera

The blister beetles, family Meloidae, have defensive secretions which cause skin blistering (vesication). *Mylabris bipuntata* is common in the region. The rove beetles, family Staphylinade, have blistering and irritant effects if crushed. This is a very large family of many small beetles most of which are characterized by having wing cases (elytra) shorter than the abdomen. Few Carabids (ground beetles) have spectacular mechanism for ejecting their defensive secretions. *Pheropsophus africana* (bombardier beetle) is recorded from the UAE. Some members of the families of Chrysomelidae (leaf beetles), Dermestidae (hide & carpet beetles) and Tenebrionidae (darkling beetles) are found in the region and probably do have poisonous members (Gillet, 1994)

6 MAJOR ECOLOGICAL ISSUES

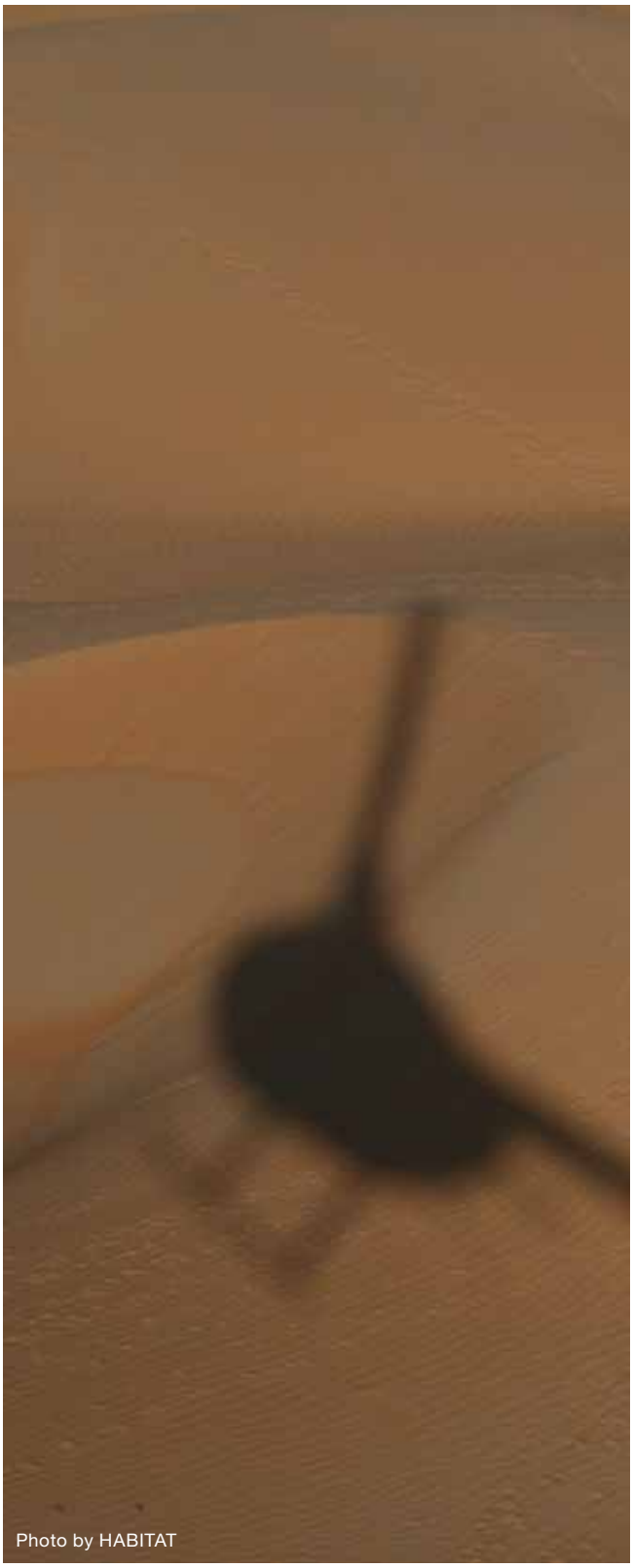


Photo by HABITAT

The single most important ecological issue for Abu Dhabi's terrestrial environment is degradation and loss of natural habit. As described in the preceding chapters, Abu Dhabi has a remarkable number and variety of plant and animal species, but these biological resources are extremely fragile, and in the last few decades, many habitats and species have come under severe threat, primarily due to the rapid rate at which the emirate has developed, and continues to develop. Surviving in the harsh natural environment is challenging enough for the emirate's plants and animals, but by far the most serious threats to the viability and sustainability of the region's terrestrial flora and fauna are man-made.

This section describes the major causes of habitat loss, degradation and fragmentation in Abu Dhabi. It also discusses weaknesses in the institutional and legislative framework within which current efforts to conserve wildlife and vegetation communities are operating. These include inadequate enforcement of environmental laws and regulations, planning and coordination procedures that fail to keep up with the rapid pace of development, and a shortage of quality information about environmental assets and the threats to them.

6.1 Habitat Loss, Degradation, and Fragmentation

Of all Abu Dhabi's diverse natural habitats, those of the coasts and islands face the greatest pressures from both natural and man-made threats. Infrastructure development to house the emirate's rapidly growing population and to cater to the needs of the increasing number of tourists are the major threats. Development for tourism and recreation is also threatening habitats in and around Jebel Hafit, which is unique in being Abu Dhabi's only mountainous area. Other types of habitat that are being damaged and destroyed by tourism and recreation activities are those associated with sand dunes, popular sites for potentially damaging off-road activities such as camping and dune bashing.

Habitat degradation and destruction are almost inevitably accompanied by threats to individual plant and animal species. The risk is that habitats are degraded to such an extent that they no longer provide the means of support to specific species. Examples of species that have become extinct in the wild in Abu Dhabi include the Arabian leopard, the Arabian wolf and the striped hyena (Drew & Tourenq, 2005). The Arabian Oryx met a similar fate, but it is now being reintroduced in selected areas as part of EAD's captive breeding program. As the population continues to grow, and natural resources exploitation and infrastructure development struggle to keep pace with it, more and more

species come under threat. Among those at greatest risk at present is the Arabian Tahr, which is endemic to the UAE and Oman, and in Abu Dhabi is only found on Jebel Hafit. According to the IUCN Red List, the Striped Hyena, Sand Gazelle and Sand Cat are 'near threatened'; the Sind Serotine Bat, Blandford's Fox, and Mountain Gazelle are 'vulnerable'; and the Arabian Tahr, Nubian Ibex, Arabian Oryx and Arabian Jird are 'endangered'. Animals are killed for different reasons; it's either because people fear them or because of the damage they might cause for agricultural farms or hunted for food, skin, horns and trophies. Superstitions and legends are associated with carnivores for instance such as the striped hyena, wolf, mongoose and other animals make people hate and fear these animals. However, most of the animals are disliked creatures and people tend to eradicate them by direct killing or poisoning. Eradication of animals by poisoning is a serious issue because it might affect non targeted species. Poisoning of the red fox for instance might target also the sand fox which is a threatened species. However, the impact of this issue is probably decreasing nowadays because of the new environmental laws which strictly prohibit killing and poisoning of wildlife (EAD, 2004).

The causes of habitat degradation are both natural and man-made and include urban and agricultural development, deforestation, over-grazing of livestock, illegal hunting and depletion of water resources. The following presents a brief description of major ecological threats of both kinds.

Figure 6-1: Red Fox poison in Jebel Hafit

6.1.1 Harsh Climatic Conditions

Harsh climatic conditions are a major environmental issue due to the negative consequences of drought and high temperatures on plants and animals. Low levels of rain fall make it very difficult for vegetation cover to regenerate, a problem that is exacerbated by over-grazing of camels. Loss of vegetation cover generally leads to a decline in the variety and numbers of the animals that use this vegetation for food, shelter and breeding. In the long term, changes in temperatures, humidity, wind patterns and rainfall associated with global warming are almost certain to have a major impact on habitat and species viability. Inevitable rises in sea level will also affect the natural environment, most notably in coastal and island habitats, but the impact in this case is likely to be most severe in built-up areas of the emirate's major settlements.

The continuous decrease in habitats quality and quantity is probably the major ecological issue which had resulted in significant impacts on wild species and populations. The primary causes of the increasingly rapid rate at which habitat and species are being lost or degraded include: a rapid rate of population growth; rapid development of urban and agricultural infrastructure; over-grazing by increasingly large livestock herds; facilities and activities associated with tourism and recreation; pollution of air, land and water resources; and depletion of water resources. These causes are discussed in the following sections.

6.1.2 Population Growth

Between 1995 and 2005, the population of the UAE grew by some 26% from 2.41 million in 1995 to 3.77 million in 2004. During this 10-year period, growth has averaged 7.9% annually. The population of Abu Dhabi Emirate grew from 942,463 to 1,292,119 during the same period, and approximately 50% of this total lives in Abu Dhabi City. The Ministry of Planning anticipates that Abu Dhabi City's population will surge to 1.35 million in 2020 (see the sector paper on Population, Development and Economy).

Emirate	1995 Census	2005 Census	%Growth 1995 - 2005	Proportion of UAE Growth, 1995 - 2005
Abu Dhabi	942,463	1,292,119	37.1%	25.7%
Dubai	689,420	1,200,309	74.1%	37.6%
Sharjah	402,792	724,859	80.0%	23.7%
Ajman	121,491	189,849	56.3%	5.0%
Umm Al-Quwain	35,361	45,756	29.4%	0.8%
Ras Al-Khaimah	143,334	197,571	37.8%	4.0%
Fujairah	76,180	118,617	55.7%	3.1%
Total	**2,411,041**	**3,769,080***	**56.3%**	**100.0%**

Table 6-1: UAE Population and Growth

Sources: UAE Ministry of Planning (1995 and 2001 estimate) and TEDAD (http://www.tedad.ae/english/index.html), official website of the UAE 2005 census *This number does not include 335,615 that are not counted in the census.

6.1.3 Land Development

There are three major threats to Abu Dhabi's natural animal and plant communities that come under the general heading of land development. Those threats come from urbanization, industrial development and the expansion of transportation networks.

Urbanization - The rapid and drastic increase in the population has significant implications for natural habitats and the environment. This significant increase in population requires a rapid and parallel development of infrastructure such as roads, houses and markets, to meet increasing demand. Large areas of the coastal zone have been completely replaced by towers and big investment projects. In addition, because of the high demand for these types of developments, new coastal areas have been created by reclaiming land from the sea. Abu Dhabi city, for instance, occupies a relatively small island, but the continuous increase in population there requires the building of more houses, shops, schools, hospitals, roads, parking areas and so on.

Urbanization has also extended to remote areas. New towns and villages have been built in the recent time. A huge network of roads has been also constructed to serve these towns and villages. Oil industry at the same time has expanded the extent of urbanization to many areas all around the country. Urbanization ad associated practices has resulted in fragmentation of natural habitats and in certain parts complete loss of the habitat.

Intensified Industrial Development - The rapid population growth is usually associated with industrial and economic development to meet its increasing demand. Big investment projects and industries have been developed during the past few years. On the other hand, oil industry is a major development in UAE for the last few decades. Major consequences on the environment include degradation fragmentation of natural habitats and resources disturbance, and pollution (for detailed more information refer to Waste Management and Pollution Sector Paper).

Transportation

Air Transportation - This impressive pace of development has been facilitated by considerable expenditure on airport expansion, as well as the launching of a number of new airlines. In 2003, five new airlines were licensed, including Etihad Airways, the Abu Dhabi based airline which is intent on becoming a leading world airline in the shortest possible time-frame. In addition, recent significant aircraft purchases by Etihad Airways have further underlined the challenge that they pose to the established world aviation hierarchy.

General Civil Aviation Authority (GCAA) management has developed a strategic plan for 2004-2013 based on the following parameters:

- New and expanding UAE flag carriers and operators will see fleet size expansion of the civil aircraft registry from 109 aircraft in 2003 to 210 aircraft by 2013, an increase of 93 per cent.
- The international airport is becoming leading hub airports connecting east and west. Local initiatives to diversity the economy, including expansion of tourism, trade and the IT industry, will accelerate this trend.

Air traffic will increase to an estimated by a conservative 4.4 per cent annual growth rate factor.

- Capital growth expenditure by the GCAA for the planning period will be an estimated Dh134 million to ensure that infrastructure and equipment needs remain capable of responding to all expansion forecasts.

Abu Dhabi International Airport - Abu Dhabi International Airport experienced 28 per cent growth in passenger traffic in the first quarter of 2004. The airport expects to handle more than 5 million passengers in 2004, up from 4.3 million in 2003. With Gulf Traveller, Gulf Air's new service, and Etihad Airways, the new national carrier of the UAE, operating from Abu Dhabi, escalating growth is predicted. At present 50 airlines operate from Abu Dhabi, but this is expected to increase in the near future.

Situated 35 kilometres east of Abu Dhabi City, the airport is well equipped with comfortable lounges, a large duty-free area, a hotel and even an adjoining golf course. The airport's Dh1.5 billion three-year expansion is scheduled for completion by 2006. The facelift, which will effectively double passenger capacity, includes a new 4-kilometre runway, 18 new aircraft stands, a 4000-square-metre transit area, the region's first rapid transit shuttle, and an extensive new duty free shop overlooking the departure halls. Some modifications to the original plan are being made to accommodate the specific needs of Etihad Airways.

Abu Dhabi Cargo Village - Abu Dhabi Cargo Village, which opened in April 2003, specializes in cargo, storage and re-export operations. The new facility, destined to become one of the biggest cargo hubs in the region, is custom-designed for easy access to bonded warehouses and offices to facilitate cargo airlines, freight forwarders, courier companies, re-exporters, clearing agencies and others. The new facility intends to become one of the biggest cargo hubs in the region.

Al Ain International Airport - Abu Dhabi's second international airport is located on a 600hectare site, 23 kilometres from Al Ain City, an important agricultural and educational area which is in the process of exploiting its huge tourism potential. Although the airport only commenced operations in 1994, ten airlines, including Gulf Air, are operating out of Al Ain. Plans are already under way to spend Dh75.23 million (US$20.5 million) on doubling the size of the departure lounge and check-in area, and building a VIP lounge, office facilities, dedicated cargo terminal, bonded warehouse and a high-tech in-flight catering facility.

Marine Transportation - Local ports export oil, raw materials and finished goods worldwide, import goods and raw materials for local industry and consumers, as well as channeling the country's re-export and redistribution trade to other economies around the Gulf, East Africa and the Indian subcontinent. In addition, the UAE ranks among the top five locations in the world for ship supplies and bunkering and is gaining a strong reputation for its ship-repair facilities.

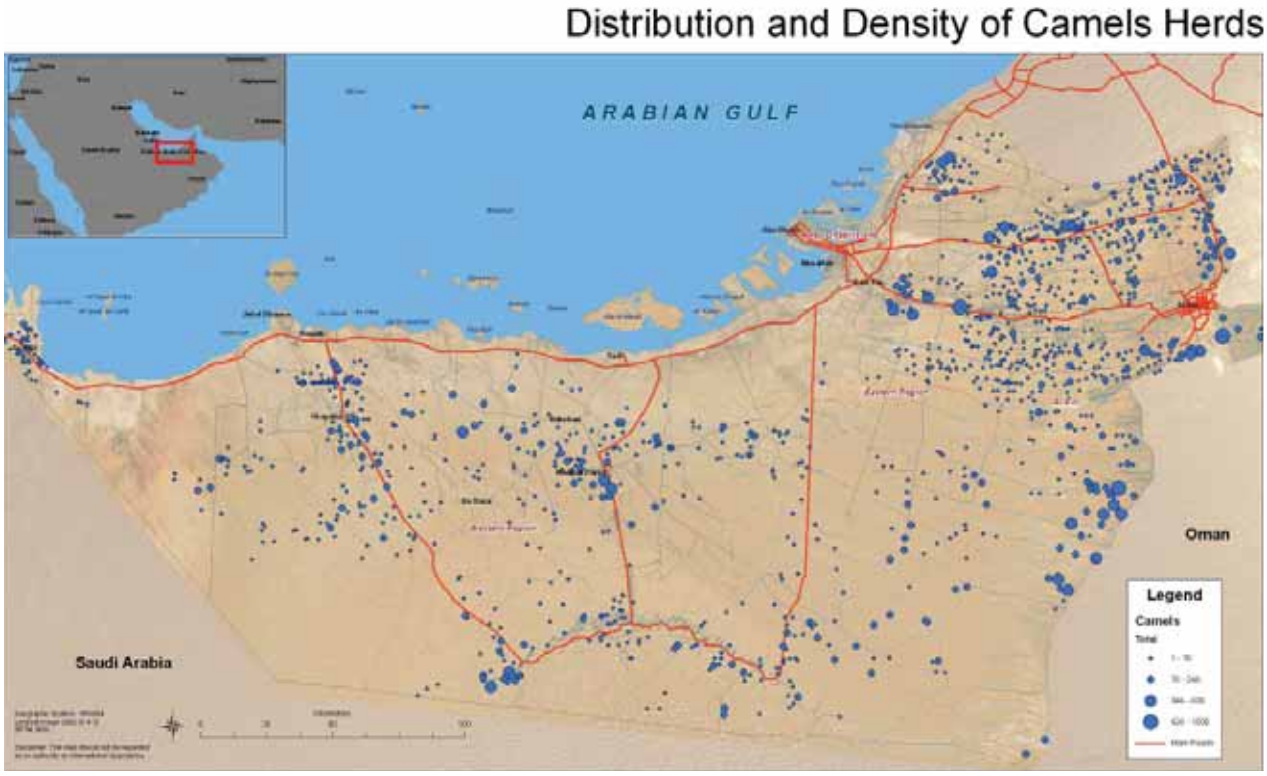
The total volume of Abu Dhabi's foreign trade by sea is more than double its volume by air and land combined. The marine terminals of Jebel Dhanna/Ruwais, Umm al-Nar, Das Island, Zirku and Mubarraz islands handle the vast bulk of the UAE's significant crude oil and gas exports. Mina (Port) Zayed in Abu Dhabi City is the emirate's main general cargo port.

Established in 1972, Mina Zayed's facilities occupy a total area of 510 hectares, including 41 hectares dedicated to container terminals that can handle around 15,000 TEUS (20-foot-equivalent-units). Within the port's boundaries are over a million square metres of paved storage yard, over 100,000 square metres of climatically controlled storage sheds and ample cold storage. There are 21 berths for handling general cargo, including bulk cargo, roll on – roll off, project cargo, and reefer cargo and petroleum products. The port has 17 general cargo berths with a total quay length of 3380 metres and a quayside depth varying from 9 metres to 15 metres.

Expansion plans at Mina Zayed envisage the development of the port in two phases over a period of 15 years, ending in 2013. The first phase, to be completed by 2006, includes rebuilding the docks, constructing a new 650-metre long container depot that will virtually double the port's container handling capacity, and increasing the depth of the access channel from 13 metres to 16 metres. The second stage involves construction of four new docks, a fully computerized quality control system and new fuel storage facilities.

6.1.4 Over-Grazing

One of the most serious threats to the natural desert environment has been the catastrophic over-grazing that has ensued as a direct consequence of the wealth generated from the oil sector. Now that local herdsmen are no longer reliant on the natural desert vegetation as their sole source of livestock fodder, and water is freely available, they have been able to increase their livestock holdings substantially by importing supplementary fodder. Whereas in the past pastoral nomadism was the main form of animal husbandry, and the stocking density was strictly dictated by the natural carrying capacity of the land, nowadays large herds remain in relatively small areas for extended periods, denuding the natural vegetation in the process. As a result, many palatable species have declined dramatically (*e.g.* Rhanterium epapposum), and in some cases have been replaced by ones that are toxic to livestock, such as Calotropis procera and Rhazya stricta. The effects of over-grazing have been accentuated over the past years by the paucity of rainfall, giving the vegetation little opportunity to hold its ground, let alone recover. The destruction of the natural vegetation cover and the degradation of soil resources are key features of 'desertification', a controversial term that is often misused. An important consequence of these degradation processes is the loss of biodiversity, both flora and fauna, leading to a simplification of the ecosystem in general.



Map 4: Distribution and Density of Camel Herds

Map 5: Distribution and Density of Goat Herds

6.1.5 Tourism and Recreation

Direct use of natural resources, both renewable and non-renewable, in the provision of tourist facilities is one of the most significant direct impacts of tourism in a given area. Land use for accommodation and infrastructure provision, the choice of the site, the use of building materials are all essential factors. Deforestation and intensified or unsustainable use of land also cause erosion and loss of biodiversity. Direct impact on the species composition and on wildlife can be caused by incorrect behaviour and unregulated tourism activities (*e.g.* off-road driving, plant-picking, hunting, shooting, fishing, scuba diving). Moreover, tourists and tourist transportation can increase the risk of introducing alien species and the manner and frequency of human presence can cause disturbance to the behaviour of animals. Construction activities related to tourism can cause enormous alteration to wildlife habitats and ecosystems.

According to the WTO, North Africa and the Middle East lead the way in terms of growth as they did in 2005 with an estimated increase of around 11% each during the first four months of 2006. The UAE reported growth of 7%. According to Abu Dhabi Tourism Authority number of visitors is estimated to reach up to 3 million visitors by 2015 in compare to 830,000 in 2003. In order to meet this target the serious plans were developed add 20,000 more hotel rooms in the next 10 years to cope with demand and growth in tourism from the present 7,500 rooms (http://www.abudhabichamber.ae).

Off-road driving and disturbance to wilderness areas - After the introduction of 4 wheel drive vehicles, access to remote areas became easier. Uncontrolled off-road driving has severe impacts on wildlife and natural habitats. In addition to the direct killing of plants and small animals and the destruction of burrows, uncontrolled off-road driving has disturbed areas which large mammals and other animals used to consider safe, causing them to desert their native breeding grounds and territories.

6.1.6 Pollution

Pollution is one of the biggest global environmental issues. The amount of solid waste, gas and liquid materials produced every year is increasing significantly parallel to the increasing population and the extensive industrial and economic development. Beside the direct effect of pollutants on species, the accumulative deposit of pollutants in the environment is causing a significant decline in the quality of the natural terrestrial and marine habitats (for detailed more information refer to Waste Management and Pollution Sector Paper).

6.1.7 Water Resources Extraction

The Emirate of Abu Dhabi has an arid climate with less than 100 mm/yr average rainfall, a very high evaporation rate (2-3 m/yr), a low groundwater recharge rate (<4 % of total annual water used) and no reliable, perennial surface water resources and yet one of the highest per capita water use in the world. Furthermore, it is a downstream water user and shares trans-boundary water resources along common borders with Saudi Arabia and the Sultanate of Oman, 350 km and 280 km in length respectively.

Historically, sustainable use of water resources was achieved by developing groundwater obtained from shallow hand dug wells, the traditional *falaj* system and rainfall harvesting methods. Over the last three decades, however, rapid economic development, coupled with sharp population increases and the development of a large agricultural sector, substantially supported by government subsidies, has lead to large increases in water demands. A reduction in the groundwater table has caused numerous shallow wells to go dry and the almost total cessation of natural groundwater flow within the aflaj systems. This has meant an increasing reliance on unconventional water resources, such as desalination and re-use of treated wastewater, and also the development of alternative conventional water supply measures, such as recharge dams, storage dams, recharge wells, interception of groundwater losses and water transfers from other Emirates. With water use now being twenty six times larger than the total annual renewable water resources of the Emirate, there is an urgent requirement to implement Integrated Water Resources Management in order to achieve sustainable development within the water sector.

In Abu Dhabi emirate, water is obtained from the following 2 sources:

- Traditional or conventional sources: rainfall, springs, wadis, sabkhas, lakes, ponds and groundwater.
- Non-Traditional or unconventional sources: desalinated water and treated wastewater

Groundwater occurs in the Emirate as either consolidated or unconsolidated surficial deposit aquifers or as bedrock / structural aquifers and contributes 79% to the total water demand, followed by desalinated water (17%) and treated wastewater (4%). It is estimated that there is still 640 km^3 groundwater resources available, but less than 3% is fresh and, based on current abstraction rates, both fresh and brackish reserves will be depleted within 50 years.

Numerous well fields abstract groundwater of various qualities and in some areas massive over-abstraction has resulted in alarming groundwater declines and a severe deterioration in groundwater quality. The water policy in the Emirate has been largely based on supply, rather than demand management, through the construction of numerous, expensive desalination plants and domestic well fields. This policy has led to the current high levels of per capita water consumption in the Emirate (350 l/c/d), which is more than double that of developed, European countries which have much greater water resources availability.

Irrigation in the agriculture, forestry and amenity plantation sectors accounts for a massive 82% of the total Emirate water use, the remainder is taken up with domestic and industrial consumption, both of which is supplied in bulk by the Abu Dhabi Water and Electricity Authority (ADWEA).

Domestic well fields in the western region have now closed due to water quality concerns, leaving 16 producing well fields in the eastern region which only contribute 4% to the total domestic demand. Around 25,000 citizen farms consume 1949 Mm^3/yr of mostly brackish groundwater and many wells are currently going dry. Miss-use and over-use of fertilizer application has also caused significant, widespread Nitrate pollution in groundwater, although there appears to be no evidence of pesticide residues from a recently completed Emirate groundwater sampling project. The 305,243 ha of irrigated forestry use 607 Mm^3/yr of largely brackish and sometimes saline quality groundwater which causes many operational problems for irrigating the 63 million trees.

Generally, operational difficulties, due to poor groundwater quality and resources depletion, are commonplace in the municipal, agriculture and forestry sectors and in the latter two, sound water resources management practices have not generally been followed.

In the past, lack of regulation and control on the development of water resources has been largely responsible for the current poor water situation, and since no single authority had the mandate for water resources management, water resources development has been largely ad hoc and unplanned, and duplication of efforts has lead to wasted resources. Recent changes in assigned responsibility for the various aspects of water resources development and management in the Emirate has now created the opportunity for improved Integrated, Water Resources Management and the outlook is much brighter.

In 2005, the newly formed Environment Agency - Abu Dhabi (EAD) was assigned total responsibility for groundwater management and during 2005 and 2006, the new and enlarged water resources department have commenced projects which focus on the following activities, all of which are essential to effective IWRM:

- Protection, conservation and monitoring of water sources;
- Planning, policy-making and regulation of water use;
- Managing data and information about water;
- Exploring for and assessing sources of groundwater;
- Building capacity and developing institutions;
- Fostering and engaging in local, regional and international cooperation and collaboration;
- Managing strategic emergency water resources.

As a major step towards controlling groundwater development, a water well drilling Law was established in March, 2006 and the well permitting policy is managed by EAD. In late 2005, EAD also established a groundwater monitoring network and in April, 2006, work will commence on the development of a comprehensive water resources database for the Emirate.

6.2 Introduction of Alien and Invasive Species

In UAE many species have been introduced to the country though shipments, luggage and illegal trading of wildlife. Some plant species which tolerates high temperatures and salinity have been also introduced to the country for forestry plantations and landscaping of cities. Several alien species were also introduced to the country as private collections including European and African species. The competition on food and space between native and introduced species might cause severe consequences on the natural wildlife and environment of UAE. The Rock Hayrex was escaped from private collections into Jebal Hafit area by private owners (Cunningham, 1999).

Common Myna believed to have been introduced in the UAE more than three decades ago, the Common Myna, also known as the Indian Myna has slowly spread, from 10 sites in 1995 to nearly 30 sites in 2006. Some areas such as eastern Corniche in Abu Dhabi and Ras Al Khor in Dubai have high concentration of these birds. Besides their nuisance value from roosting colonies and other harmful effects as an invasive species, Common Myna poses a potential human health hazard, especially after the recent outbreaks of Highly Pathogenic Avian Influenza (HPAI) (Javed *et al.*, 2006).

The Common Myna is also listed by IUCN as one of the100 most invasive species in the world. A bird of the Indian subcontinent, it has spread into some of the remotest areas of the world. Common Mynas are able to establish and expand in any new area because of their broad climatic and habitat tolerances combined with their commensal, omnivore and aggressive habits. They have been introduced to new areas intentionally, often for their role as biological control agents as was done in Australia to control garden pests. Once fully established common mynas are difficult to eradicate and only sustained control measures can keep their numbers under control.

The Ring-necked Parakeet is a common resident bird of the UAE. Once present mostly in the coastal urban areas around Abu Dhabi, Sharjah and Dubai, it is now expanding its range in areas more inland. They roost in gardens and parks in the cities, often mixed with Alexandrine Parakeet. Communal roosts in Dubai and Abu Dhabi may account for thousands of birds and their population estimated to be around 1,500-2,000 pairs (Aspinall, 1996) in 1996 may have grown much bigger since then. Parakeets are well known pests of orchards and crops in India and Pakistan and cause considerable damage to fruits and cereals. The extensive date orchards in the UAE may be potentially vulnerable to attacks from ring-necked parakeet, especially as their population continues to grown with expansion of green areas and date orchards. Parakeet is well known for its destructive feeding habit, destroying much more than what it actually eats. Being cavity nesters, availability of big trees for nesting may be a limiting factor in large-scale increase in the parakeet numbers.

Invasive plant species have probably greatly expanded their populations in the far-east of the Emirate, and especially in the northern Emirates where rainfall is highest. The main problematic species there is *Prosopis juliflora* (mesquite), which is able to reproduce rapidly and occupy large areas of disturbed ground and some wadis. Less of a problem are species such as Calotropis procera ('ushar'), a large, extremely fast-growing shrub that is toxic to small trees.

6.3 Legislative and Institutional

6.3.1 Environmental Legislation and Enforcement

The laws of the UAE and Abu Dhabi that currently address environmental protection concerns are considered inadequate. Only a few articles concern habitat and species protection, enforcement is weak, and penalties for breaking conservation laws are inadequate. Recently, new laws that deal directly with environmental issues such as hunting and grazing have been declared by the government. Effective implementation of these laws will be key to the conservation of Abu Dhabi's natural environment and species. EAD is in the process of developing new strategies and organizational structures for strengthening the enforcement of the new laws (see Policy and Regulations Sector Paper).

6.3.2 Planning, Coordination, and Follow Up

Land use/Land tenure - Before 1960, the only settlements were small towns and villages. Oil resources have enabled massive modernization. Towns have been transformed from mud-walled communities into commercial capitals integrated in the global economy. Because of the small population and harsh desert interior, 80 percent of the population lives in the coastal capital cities, leading social scientists to describe them as city-states.

Urbanization has been characterized by unparalleled growth. Abu Dhabi is one of the most modern cities in the world. Cities have been heavily influenced by the global city type. Dominant urban features include skyscrapers in the commercial city centers, multistory residential buildings, large shopping malls, wide boulevards, an extensive network of highways, and sprawling new suburbs.

The cities have a multiethnic composition, with segregated housing areas for nationals and the immigrants. Housing is subdivided further according to class, social power, ethnicity, and nationality.

To create a balance between their global and local aspects, municipalities have adopted policies projecting Arab-Islamic architectural design, particularly arched windows, gates, and decorative stucco. Recently, more urban settings have exhibited decorative designs with local themes related to the national heritage. Preservation of the urban heritage also is seen in the renovation of old forts, palaces, souqs (marketplaces), and mosques. Date palm trees, symbols of the local culture, have been planted extensively along city roadsides.

Infrastructure Development - Infrastructure development in Abu Dhabi has been phenomenal in view of the relatively brief period since the country's establishment. Modern cities have risen like phoenixes from the barren desert, connected by a vast network of first-class roads and linked to the outside world by modern airports and ports. Houses, schools, hospitals, shopping centers, telecommunications, electricity and water, luxury hotels and recreational facilities have all been provided for the people in a remarkably short space of time. As the country enters the third millennium a process of consolidation is taking place, with the private sector taking more of an active role in infrastructure development.

Until recently, land ownership in Abu Dhabi was extremely restricted. Abu Dhabi's new property law regulating the right to own and transfer real estate for citizens and expatriates will revolutionize the real estate industry paving way to a new economic order. Abu Dhabi's gradual but decisive step in opening its property market started with Sheikh Khalifa Bin Zayed Al Nahayan allowing nationals to buy and sell properties in early March this year; 2005. The new property law, which allows expatriates to invest on long-term surface ownership of 99 years, will take the property market by storm. On 29th August 2005, His Highness General Sheikh Mohammad Bin Zayed Al Nahayan issued Decision 22 for 2005 specifying the Al Raha Beach and Al Reem Island developments as Investment areas.

The property law established a sound legal basis for the development, sale, leasing and mortgaging of property in Abu Dhabi. The law grants differing rights of land ownership to UAE nationals, GCC citizens and other expatriates. UAE nationals or companies wholly owned by UAE nationals can now own land anywhere within the Emirate of Abu Dhabi. GCC citizens can own land in designated Investment Areas and lesser rights in land throughout Abu Dhabi. Other expatriates can acquire a Musataha right (form of leasehold) of up to 50 years - renewable within the Investment Areas - which will be designated by the Executive Council according to a research study by the National Investors.

Abu Dhabi's new law will now likely be further impetus for other Emirates and even other Gulf Countries to liberalize their property ownership legislation. It is expected that Abu Dhabi will issue additional property laws before year-end, which are expected to regulate the rights and obligations of developers, financing banks, owners, and expatriates in the Investment Areas.

The Abu Dhabi regulatory changes come after the Government declared its new long term vision for the Emirate in late in 2004, with the intent of diversifying the revenue streams away from oil, developing the infrastructure and industry, and promoting the city as a premium tourist destination.

Ad hoc Development - Abu Dhabi has witnessed unparallel vertical and horizontal growth to the extent that the 1990-2010 master development plans are in the final phases of completion 5 years ahead of the proposed timeframe. This rapid acceleration is due to profits gained in the oil sector, population and immigration boom and the eagerness of decision makers to excel Abu Dhabi into leading position at all levels in the international arena.

On the flip side of the coin, the continued development without a framework plan has created void and chaos as well as pressurizing environmental resources as permits being given for medium size to major size developments without actually appreciating how this fits within the overall plan for the emirate. One clear example is the coastal developments on the western region where parcels of lands were allocated and permits given to dredge private channels into these parcels, apparently without appreciating the environmental stress of the marine and coastal resource, only to be halted later on after clear signs of misuse and ill planning has emerged.

Currently, Abu Dhabi Economic and Planning Department is spearheading formulation of an interim development master plan that extends the current one into the year 2020 taking into consideration the impressive rate of development and the more impressive outlook for the emirate in light of the mega projects starting to become Abu Dhabi reality at warp speed. This master plan is being contributed to by all concerned enviro-socio-economic institution in the emirate through a steering committee setup to do so.

6.3.3 Shortage of Environmental Information

Environmental research and monitoring has recently started in this region of the world. The data and information currently available is not enough to thoroughly understand environmental processes and issues. Precise and comprehensive data on species diversity and richness, habitats and ecosystems would help for better planning and developing action plans for the protection of the environment. Comprehensive, accurate environmental baseline data would also help promote environmentally

sensitive approaches to infrastructure development, especially in the areas of strategy and policy formulation and implementation planning. Ongoing research and monitoring programmes at EAD are primarily seeking to provide this baseline information and build up the environmental data base of UAE.

Upon the creation of the federation of the seven Emirates namely: Abu Dhabi, Dubai, Sharjah, Ajman, Umm Al Quwain, Ras Al Khaimah and Fujairah the UAE was established and declared as a state in December 2nd, 1971. National mandates and responsibilities were given to the federal agencies and authorities while local government institutions were given the mandate on the local (Emirate) level. Some overlap in the responsibilities of federal and local government institutions may occur in particular those relating to Environment protection and Wildlife Conservation. Some international, national and local NGOs are involved in the conservation process within UAE. For more details and information see Policies and Regulations Sector Paper.

7 ECOLOGICAL MANAGEMENT AND CONSERVATION

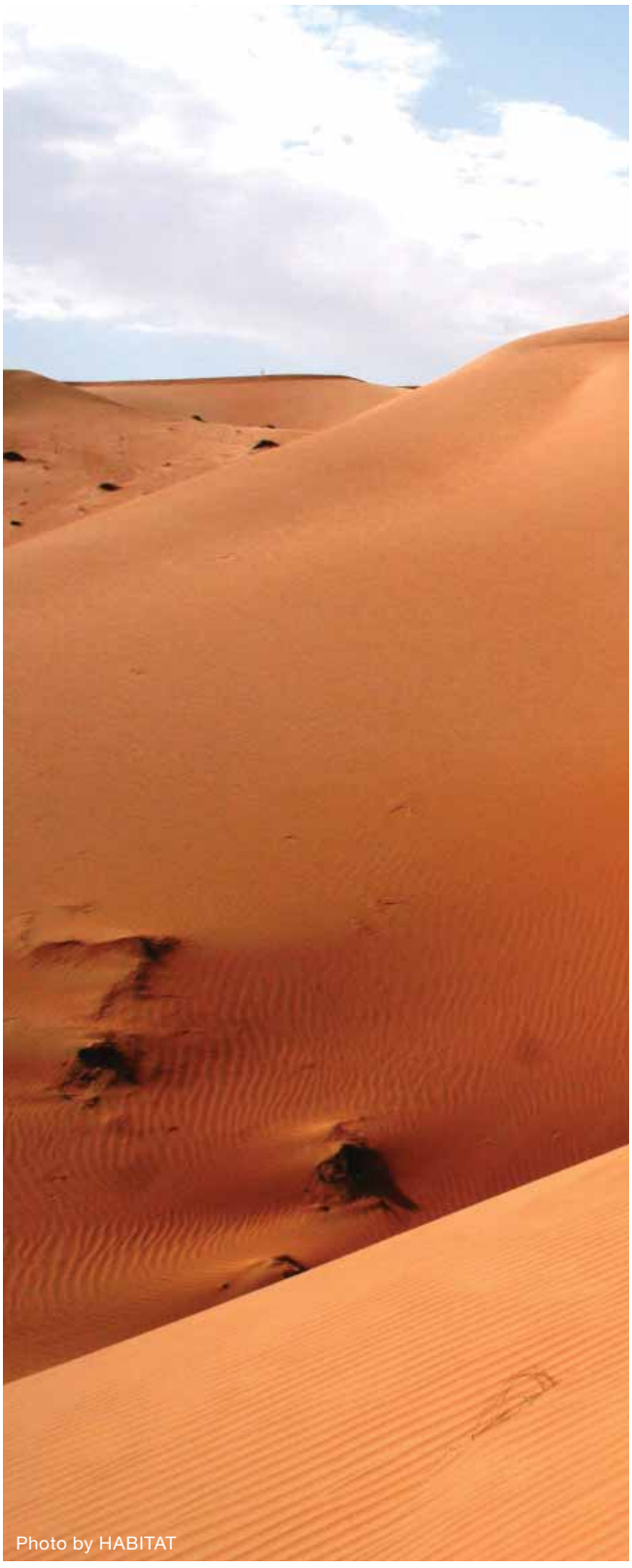


Photo by HABITAT

7.1 Legislation and Institutions

7.1.1 Institutional Structure

A. Federal Government Organizations

The Federal Environmental Agency (FEA) was established by Federal Law No. (7) of 1993. This Law was amended twice, (by Federal Law No. (30) of 2001 and Federal Law No. (20) of 2004). FEA was established as an independent entity with financial and administrative independence and annexed to the Cabinet of Ministers in UAE.

The objectives for establishing the Agency are:

- To protect and develop the Environment within UAE;
- To determine the necessary plans and policies to safeguard it from damaging activities, particularly those affecting human health, agricultural crops, wildlife, marine life, other natural resources and atmosphere;
- To implement such plans and policies; to take all suitable measures and actions to prevent deterioration of the environment;
- To combat environmental pollution of all kinds, and to minimize effects of pollution for the welfare of the present and future generations.

FEA has also prepared the UAE National Environmental Strategy and National Environmental Action, in cooperation with all concerned parties in UAE.

B. The Environment Agency - Abu Dhabi:

The Environment Agency-Abu Dhabi was established by Abu Dhabi Emirate Local Law No. (4) of 1996 as amended by the Local Law issued in January 1997.

In June 2005 and as per Abu Dhabi Emirate Local Law No. (16), EAD was restructured giving it more authority in all environmental efforts. As per the same Law the name of the Agency was changed to become the Environment Agency-Abu Dhabi (EAD).

These responsibilities are mandated by items 1-26 of Article No. (3) of the Local Law and are summarized as follows:

- Protection and conservation of the quality and natural balance of the environment and consolidation of environmental awareness and principles of pollution control.

- Control of all forms of pollution and avoidance of any immediate or long-term harmful effects resulting from economic, agricultural, industrial development or other programmes aiming at improving life standards.
- Development of natural resources and conservation of biological diversity and the exploitation of such resources with consideration of present and future generations.
- Protection of society, human health and health of other living creatures from activities and acts which are environmental harmful or impede authorized use of environmental setting.

EAD consists of five major Centres/Departments for implementing EAD responsibilities and achieving EAD objectives, these are:

- Environmental Protection Division (EPD);
- Terrestrial Environment Research Center (TERC);
- Marine Environment Research Center (MERC);
- Environmental Education and Awareness Division (EAAD);
- National Avian Research Center (NARC).

7.1.2 Federal Laws

Federal and local environmental legislations and regulations were developed and issued to meet the needs of UAE in general and Abu Dhabi Emirate in specific.

A. Federal Law No (24) of 1999 concerning the Protection and Development of the Environment:

This law was issued on 17th October 1999 and it entered into force in February 2000. This law aims to achieve the following goals:

- Protection and conservation of the quality and natural balance of the environment;
- Control of all forms of pollution and avoidance of any immediate or long-term harmful effects resulting from economic, agricultural, industrial, development or other programmes aiming at improving life standards and co-ordination between the agency, competent authorities and parties concerned with the protection of the environment and conservation of the quality, balance and consolidation of environmental awareness and principles of pollution control;
- Development of natural resources and conservation of biological diversity in the region of the state and the exploitation of such resources with consideration of present and future generations;
- Protection of society, human health and the health of other living creatures from activities and acts, which are environmentally harmful or impede authorized use of the environmental setting;
- Protection of the State environment from the harmful effects of activities undertaken outside the region of the State;
- Compliance with international and regional conventions ratified or approved by the UAE regarding environmental protection, control of pollution and conservation of natural resources.

This Law contains 101 Articles divided into 9 Chapters:

Chapter 1-Development and the Environment: this chapter deals with the standards, specifications, principles and regulations for the assessment of environmental impact of development projects taking into consideration aspects of protection of the environment in development plans, environmental monitoring networks and emergency plans.

Chapter 2-Protection of Water Environment: this chapter specifies the standards and regulations in accordance with regional and international conventions for the Protection of the marine environment regardless of source (chemical, oil, wastes, etc) from marine means or establishments near the coastline, it also deals with the protection of drinking water and ground water.

Chapter 3-Soil Protection: this chapter deals with land-utilization and development of the desert environment as well as the conservation of agricultural areas and the protection of soil from pollution resulting from the use of pesticides, fertilizers, etc.

Chapter 4-Protection of Air from Pollution: this chapter deals with the standards, regulations and permissible levels necessary for the protection of air from pollution from different sources, in addition to environmental standards, occupational health and noise.

Chapter 5-Handling of Hazardous Substances, Hazardous Wastes and Medical Wastes: this chapter deals with the standards, specifications, principles and regulations for Handling or using of hazardous substances, hazardous wastes and medical wastes in accordance with regional and international conventions, such as the prohibition of importation of hazardous wastes to the country or its final disposal in any form in the environment.

Chapter 6-Natural Reserves: this chapter deals with natural reserves in the country and the specifications for the boundaries of such areas as well as the Competent Authorities responsible for its protection and development. In addition, it also specifies the prohibited acts which may lead to damage or deterioration of such areas.

Chapter 7-Liability and Compensation for Environmental Damages: this chapter specifies the judicial control powers for the inspection of establishments and other places to verify their compliance with the application of the provisions of this Law and resolutions issued for its enforcement, the costs of treatment or removal of such damages and any compensation incurred as a result.

Chapter 8-Penalties: this chapter sets the penalties for punishment of individuals or establishments upon violation of the provisions of this law.

Chapter 9-Final Provisions: this chapter deals with different subjects concerning licenses for establishments and activities, the fees required for the activities and procedures and licenses granted under the provisions of this Law. In addition to the incentives awarded to organizations, agencies, establishments and individuals undertaking jobs or projects for the protection and development of the environment in the State and the period required for the establishments existing at the date of operation of this Law to amend their status according to its provisions.

In Abu Dhabi Emirate the Environment Agency-Abu Dhabi (EAD) is the Competent Authority responsible for implementation of this law.

B. Federal Law No. (11) of 2002 concerning Regulation and Control of International Trade in Endangered Species of Wild Fauna and Flora (CITES)

CITES is the Convention on International Trade in Endangered Species of Wild Fauna and Flora, which is an international agreement between Governments to ensure that international trade in specimens of wild animals and plants does not threaten their survival. The CITES Convention covers international trade across borders and gives varying degrees of protection to over 30,000 species of animals and plants and their derivatives such as fur coats, caviar, oils, barks, etc. The CITES functions as an international agreement to which States (countries) adhere voluntarily. Once these States have agreed to the Convention they are referred to as Parties and there are currently 169 Parties. Species under CITES are listed under three main Appendices namely:

- **CITES Appendix I -** These are species that are threatened with extinction and CITES generally prohibits commercial international trade in these species. Trade may only be allowed under exceptional cases *e.g.* for scientific research.

- **CITES Appendix II -** These species are not necessarily threatened with extinction but increased and unchecked trade can result in the species facing extinction.

- **CITES Appendix III -** These are species included at the request of a Party that already regulates trade in the species and that needs the cooperation of other countries to prevent unsustainable or illegal exploitation.

7.1.3 United Arab Emirates and CITES

The UAE (United Arab Emirates) is the 104th Party to the CITES Convention with its Accession to the Convention on 8th February 1990 and going into force on 9 May 1990. The CITES Convention in the UAE is managed at a Federal level. To properly implement CITES a Party must designate a Management Authority and a Scientific Authority which must be independent from each other. At a Management Authority level there are two main authorities in the UAE namely:

Management Authority - The Management Authorities are responsible for the reviewing of requests, issuance and/or reject CITES Permits and Falcon Passports. This authority also cooperates with agencies both inside and outside the country to facilitate implementation of the Convention. The management Authority is also responsible for sending Annual Reports to the CITES Secretariat and participating in the Conference of Parties held every 2 years. The two Management Authorities in the UAE represent the Emirate of Abu Dhabi and Dubai and the Northern Emirates, The Abu Dhabi Management Authority is the Federal Environment Agency (FEA) based in Abu Dhabi. The Management Authority for Dubai and the Northern Emirates is the Ministry of Agriculture & Fisheries (MAF) based in Dubai.

Scientific Authority - The Scientific Authority provides scientific advice and non-detriment findings to the Management Authority about the export of species listed in CITES Appendix I and II and import from CITES Appendix I. This authority also provides scientific advice for live animal handling facilities for CITES Appendix I

animals. This authority also monitors trade in general and gives opinions and advice to the Management Authority on the placement of confiscated species and their derivatives. This authority is also responsible for handling tasks designated by the Management Authority. The designated scientific Authority in the UAE is the Environmental Agency-Abu Dhabi.

CITES Permits

When a CITES listed species moves across an international border both a CITES export (country of origin) and an import permit (country of destination) have to be issued. This allows the movement of specimens from country A to B. If the specimen then moves from country B to C then country B has to issue an re-export permit and country C an import permit. To facilitate this complex procedure the UAE has introduced Federal level software that is linked between the two Management Authorities, one Scientific Authority and to MAF offices in international airports such as Abu Dhabi and Dubai. This software also allows the issuance of permits and the stored information is being used to generate Annual Reports for the CITES Secretariat and provide data on trade trends for scientific analysis.

Falcon Passports

Falconry is a traditional sport in the UAE which has been practiced for many generations. It is common for falconers to travel to countries within the region to practice their sport. As all falcon species are listed in CITES Appendix II and some in CITES Appendix I this necessitates the issuance of CITES permits every time a falconer travels across international boundaries with his falcon(s). To overcome the need for extensive paperwork every time a person travels across an international border, the UAE has developed the Falcon Passport to replace CITES permits for frequent cross-border travel. The UAE has registered and issued passports for over 9,000 falcons. This has also enabled the falcons to be officially registered into a national database and passports are issued for a period of three years which can be further renewed. The falcon passport has owner details and falcon information (species, sex, origin of bird, CITES Appendix, ring number, PIT number, issuing authority, *etc*.). There are some Parties that currently do not accept the falcon passport as a travel document and for such cases regular CITES Permits are issued.

Trade in CITES listed Species

The legal trade in CITES listed species in the UAE is mainly focused on:

- Mammals - This comprises mainly large carnivores (lion and leopard live and trophies) and large herbivore (antelope and gazelles) species.
- Birds - This comprises mainly of falcons, parrot species and small ornamental birds for the pet trade.
- Reptiles - This consists of mainly boas and pythons for the pet trade and crocodilian skins for the expensive watch straps.
- Products and derivatives - This consists mainly of caviar from sturgeon species and agarwood which is used in the perfume industry.

This Law includes 40 Articles and covers the following issues:

- Scope of application: applies to all specimens of the species listed in the Appendices that are part of the International Convention of Trade in Endangered Species of Wild Fauna and Flora.
- General provisions: Import, transit and trans-shipment, export, re-export, and introduction from the sea of any specimen of the species listed in the Appendices should be in accordance with the provisions of this Law.
- Responsibilities of the Management Authorities, which include revision of applications for granting permits and certificates, communication with the secretariat of the convention and other parties on scientific, administrative and enforcement issues, maintain records of international trade and preparation of annual reports.
- Responsibilities of the Scientific Authority, which include giving, advise to the Management Authorities on issues related to trade in certain species, protection of species and on the disposal of confiscated or apprehended specimens.
- International trade documents required upon issuance of a permit or certificate.
- Exceptions in trade with some species.
- Trade with non-parties to the convention.
- Penalties for trading without permits.

7.1.4 Local Laws

The most important Environmental Local Laws implemented in Abu Dhabi Emirate are:

- Local Law No. (5) of 1970 concerning Regulating Hunting of Birds and Animals as amended by Local Law No.(1) of 1978.
- Local Law No. (4) of 1989 concerning the Establishment of the National Avian Research Center (NARC).
- Local Law No. (13) of 2005 concerning Regulating of Grazing in Abu Dhabi Emirate.
- Local Law No. (16) of 2005 concerning the re-organization of the Environment Agency of Abu Dhabi.
- Local Law No. (21) of 2005 for Waste Management in Abu Dhabi Emirate.
- Local Law No. (22) of 2005 concerning Animal Hunting in Abu Dhabi Emirate.
- The UAE is also party to a variety of international conventions that relate to the coastal and marine environment as follows:
- Convention on International Trade in Endangered Species of Fauna and Flora (CITES) - signed and ratified in 1990.
- Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment - signed in 1978 and ratified in 1980.
- Convention on the Control of the Transboundary Movement of Hazardous Wastes and their Disposal (Basel Convention) - signed in 1989.
- Convention on Biological Diversity - signed in 1992.
- United Nations Framework Convention on Climate Change (UNFCC) - signed and ratified 1995.
- Convention on the Conservation of Wildlife and Wildlife Habitats in the Gulf Region 2001.

7.1.5 Strategies and Action Plans

Several national, regional, and international environmental strategies and action plans have been developed some of these include:

UAE National Environment Strategy and Action Plan: This strategy was published in September 2000. The preparation of the strategy was funded by the Federal Environment Agency with the financial and technical support of the UNDP. 57 participants from more than 40 governmental and nongovernmental organizations in the UAE set up the objectives of the 10 sectors of the strategy. The plans and priority projects of the marine sector of the UAE national strategy included: (1) Survey of marine biodiversity (2) Conservation of endangered species (3) Public awareness and environmental education (4) Protection of marine water quality (5) EIA legislation (6) Sustainable commercial fishing and (7) Marine Pollution.

Environmental Strategy-Abu Dhabi: In coordination with all relevant environmental sectors, the EAD developed an Environmental Strategy for the years 2000-2004 and 2003-2007. Detailed work plans within these strategies address the six strategic goals of the agency namely: (1) Environmental regulatory system (2) Environmental monitoring system (3) A management regime for fisheries (4) A management regime for water resources (5) A regime for the management and restoration of wildlife (6) A society with increased environmental education and awareness. Now days a new strategy and action plan is in its final stage for the years of 2007-2011.

Global Strategy for the Conservation of Falcons and Houbara: This global strategy was developed and published in 2000. The main purpose of this strategy is to encourage regional and international efforts to conserve the Falcons and the Houbara Bustard and to ensure their sustainability.

7.2 Species Conservation

7.2.1 Captive Breeding and Reintroduction

Captive breeding (Ex situ Conservation) is a term used to maintain a species in captivity in zoos, aquaria, and botanic gardens. It is the only hope for the survival of some species where the threat to their existence in the wild is now extreme or if natural habitat is no longer suitable or to support its existence. This conservation method, however, serves many other purposes such as allowing more control over breeding in order to avoid inbreeding, increased reproductive rate, providing educational and public awareness programmes and providing materials for basic and applied research.

However, reintroduction is "*an attempt to establish a species in an area which was once part of its historical range, but which it has been extirpated or become extinct*." (IUCN 1998). The principal aim of any reintroduction programme should be to establish a viable, free-ranging population in the wild of a species, subspecies or race, which has become globally extinct, or extirpated, in the wild. Species should be reintroduced within its natural habitat and range and should require minimal long-term management.

Within UAE in general and Abu Dhabi in specific several initiatives were taken that played an important role to the conservation efforts of both native and non native species. Some of these initiatives are summarised in the following:

A. Arabian Oryx Reintroduction Programme

The Arabian Oryx is a stocky, pure white antelope, weighing around 100 kg, with prominent dark blue-black face markings and two, long straight horns about 75-90 cm long. Its colour and horns have certainly contributed to the myth of the unicorn.

Formerly, the Arabian Oryx existed throughout the Arabian Peninsula and the Middle East, it was hunted to extinction in the wild in 1972. Fortunately, animals held in zoos and private collections were assembled to form a "World Herd" and the progeny have since been used to reintroduce Oryx back into the wild in a number of countries, including Oman, Saudi Arabia, Jordan, Syria and United Arab Emirates.

More than 3,500 individual Arabian Oryx are estimated with the UAE in which 90% (3,150) are found within the Abu Dhabi Emirate. Today, the Environment Agency-Abu Dhabi is working on a reintroduction programme for the Arabian Oryx in the desert of Abu Dhabi. Three main release sites were identified and preparations have been accomplished in Um Ez Zommoul Release site that pre-release facilities were constructed and 30 animals were selected and transferred from Al Ain Zoo in Abu Dhabi to the pre-release facilities. Work is under progress regarding other sites. In February 2007, under the patronage of H.H. Sheikh Mohammad Bin Zayed Al Nahyan, Crown Prince of Abu Dhabi 98 animals were released into the wild. Figure 36 shows the range of released Arabian oryx.

B. Houbara Bustarad Reintroduction Programme

The Houbara Bustard Chlamydotis undulata is a striking bird resembling a turkey in shape. The Houbara Bustard is at its most magnificent during the courtship display. It has a long neck and tail, narrow wings, and long black and white feathers drooping over the neck. The head is small with a short, black and white crest and large eyes. Males are slightly larger and have ornate bristles on the head and neck. The body is brown with wavy, black barring on the back and white on the underside. Juveniles resemble adult females. The houbara bustard classified as Vulnerable (VU A2bcd + 3bcd) on the IUCN Red List 2004 and is listed on Appendix I of CITES. There are three subspecies bustard: *Chlamydotis undulata macqueenii* is found in the deserts of Russia and the Middle East, *C. u. undulata* is found in North Africa and *C. u. fuertaventurae* is found in the eastern Canary Islands. They differ slightly in their size and colouration, but are not consistent in their migratory tendencies.

Map 6: Range of released Arabian Oryx

Figure 7-1: Houbara Bustard (*Chlamydotis undulate macqueenii*)

The traditional practice of hunting for houbara bustards by Middle Eastern falconers has reduced populations significantly, mainly on the wintering grounds. This over-hunting has been compounded by habitat loss and degradation.

Figure 7-2: Breeding Houbara Bustard

In Abu Dhabi, the Environment Agency (EAD) has been promoting bustards, falcons, and bird conservation ever since 1989. It has also been reconciling the traditions of Arab falconry with a sustainable use of resources throughout the bustards' and falcons' range. The Asiatic Houbara Bustard, *Chlamydotis macqueenii*, is the traditional quarry of Arab falconers. Hunting with falcons is a revered pursuit and a test of men, falcons and quarry in the harsh desert environment. EAD set the Global Strategy for the Conservation of Falcons and Houbara, which has been proposing the implementation of a series of conservation measures to preserve the

Seasons	2003	2004	2005
Females			
Number	67	60%-72%	209
Number and % of layers	27 (40%)	59 (43%)	110 (53%)
Number and % of New layers	13 (19%)	32 (23%)	53 (25%)
Males			
Total	72	127	204
Number and % of males displaying	62 (86%)	111 (87%)	180 (88%)
Number and % of donors	33 (46%)	54 (43%)	110 (54%)
Number and % of new donors	21 (29%)	25 (20%)	54 (26%)
Number of donors producing usable sperm	16 (22%)	31 (24%)	72 (35%)
Eggs and chicks			
Number of eggs laid	223	409	796
Number of eggs incubated	202	378	708
Number of fertile eggs (% fertility)	169 (84%)	273 (72%)	588 (83%)
Number of chickes	121	223	447
Number of chickes/Laying Female	4.48	3.78	4.06
Apparent hatchability-Real hatchability	60%-72%	59%-81%	63%-76%

Table 7-1: Houbara Captive Breeding Programme Performance, 2003-2005
Source: EAD Annual Report 2005

remaining wild houbara populations in their ecological, migratory, physiological, and genetic diversity and integrity. The strategy calls for a substantial reduction in the hunting and poaching pressure on wild birds. However, the Houbara is today threatened by detrimental factors including excessive hunting and habitat loss.

The National Avian Research Center (NARC) which is a highly specialized centre for the breeding and reintroduction of Houbara bustard at EAD has contributed significantly to the bustard conservation efforts through various initiatives on the national, regional and international levels.

C. Captive-Breeding Programme

In 2005, the flock was comprised of 209 females and 204 males, a total of 796 eggs were laid by 110 females. Out 0f 796 eggs laid, 708 eggs were incubated and 83% (588) eggs were found to be fertile. Total number of chicks hatched is 447 in compared to 223 in 2004. Table 7.1 shows the breeding performance for the years 2003-2005.

D Release Programme

During 2004 a total of 74 Houbara were released into the wild. 5 of the released birds were equipped and monitored using GPS satellite transmitters whilst the other 69 were monitored using VHF transmitters. **Table 7.2** shows a summary of released Houbara that were bred in captivity.

E Al Ain Zoo

One of the major roles of the modern zoo is to protect and secure endangered species and ecosystems. To achieve this goal many Zoos contribute to conservation programmes by being part of global conservation actions and promote this activity through the public visiting these zoological institutions.

Zoos have a primary role as recreation centres, displaying animals in modern habitat exhibits, while educating the public on endangered species and the threats to their continued survival in the wild. In various ways this is achieved through an enjoyable recreational experience. The opportunity exists therefore to engage the public with conservation programmes that are part of the fabric of the zoo.

Zoos are in a unique position to inform the public of their various conservation programmes and to provide the opportunity for ongoing support.

Al Ain Zoo is the largest zoo in the UAE and has a strong history of providing a sanctuary to wildlife and breeding many threatened and endangered species particularly from the Arabian peninsular.

The recent change in its governance from the Municipality of Abu Dhabi to its own public institution has provided the opportunity for a new direction and vision for conservation effects. Work has started on a change in infrastructure and priorities of management to establish Al Ain Zoo as a primary conservation centre in the UAE, meeting all international zoo standards.

Zoos can make significant contributions to conservation in various ways, through direct and indirect action. Captive breeding of both native and exotic species can form a valuable, genetically sound reservoir population as insurance against catastrophic decline of wild populations.

Reintroduction to secure wild sites becomes a valuable tool that can be used by zoos for direct in-situ conservation. Education also plays a significant role in providing the 'conservation message' to visiting public, school students, Universities and conservation agencies. Al Ain Zoo is actively promoting the various ways it contributes to conservation activities now and for the future.

Group release	1	2	3	4	5	6	7
Date of release	Jan-04	Feb-04	Feb-05	May-05	Oct-05	Dec-05	Dec-06
Number released	3	2	15	10	27	7	15
Number surviving as of Dec. 2005	0	1	12	9	19	6	14
			+ 1 missing		+ 4 missing		
% dead (Number dead)	100% (3)	50% (1)	14% (2)	10% (1)	14% (4)	17% (4)	7% (1)

Table 7-2: Releases of Captive-Bred Houbara in UAE, 2004 – 2006

Source: EAD Annual Report 2005

Areas of conservation activity that Al Ain Zoo in now engaged with include:

Work with local institutions to improve knowledge and expertise in conservation efforts: Al Ain Zoo has established good working relation ships with Sharjah Wildlife Park, Dubai Zoo and Zoos around the world for not only the exchange of animals for captive management programmes but also exchange of knowledge and expertise. The role of Zoos in conservation and specific conservation actions are important aspects of the Al Ain Zoo conservation philosophy much of which can be learnt from the global zoo community.

Conducting and supporting conservation programmes on the international stage: Al Ain Zoo is now member of the World Association of Zoos and Aquariums (WAZA) and through a network of Zoos around the world will contribute to zoo based conservation programmes (ex-situ). It is also a member of the Conservation Breeding Specialist Group (CBSG). This organization is dedicated to saving threatened species by increasing the effectiveness of conservation efforts worldwide. CBSG is recognized for its innovation and application of scientifically, collaborative processes that brings people and knowledge together to make positive conservation changes.

Engaging with government conservation agencies: Al Ain Zoo is managed through the Abu Dhabi Environment Agency and its resources. A strong partnership in conservation has been developed which provides the zoo with expertise, knowledge and resources to implement conservation actions.

A recent programme involves the transfer of captive bred Arabian Oryx to a site in the UAE for eventual release. This in-situ wildlife programme involved a close, working partnership with the Environment Agency to facilitate a clear conservation goal. Other conservation programmes in the future will involve further release of animals, engagement with the CITES authorities and the IUCN Reintroduction Specialist Group.

Capture Breeding Programmes: As part of future redevelopment plans the Al Ain Zoo will establish a Wildlife Breeding and Conservation Centre which will facilitate endangered species breeding programmes under specific and scientific methods. Computerized animal record systems will enable species management programmes to be linked with zoos world wide enabling exchange of animals for captive populations to be maintained in a healthy genetically secure environment. These facilities will allow for improved animal transfers and isolation for reintroduction programmes.

It is also the intention to open the Wildlife Breeding and Conservation Centre to invited public groups for a specialist 'behind the scenes' tours.

Funds collected for this experience will be redirected to support conservation programmes within the Zoo. Al Ain Zoo's contribution to conservation is a major objective and the new management structures established now will facilitate this primary goal well into the future.

7.3 Habitat Conservation

7.3.1 Terrestrial Protected Areas

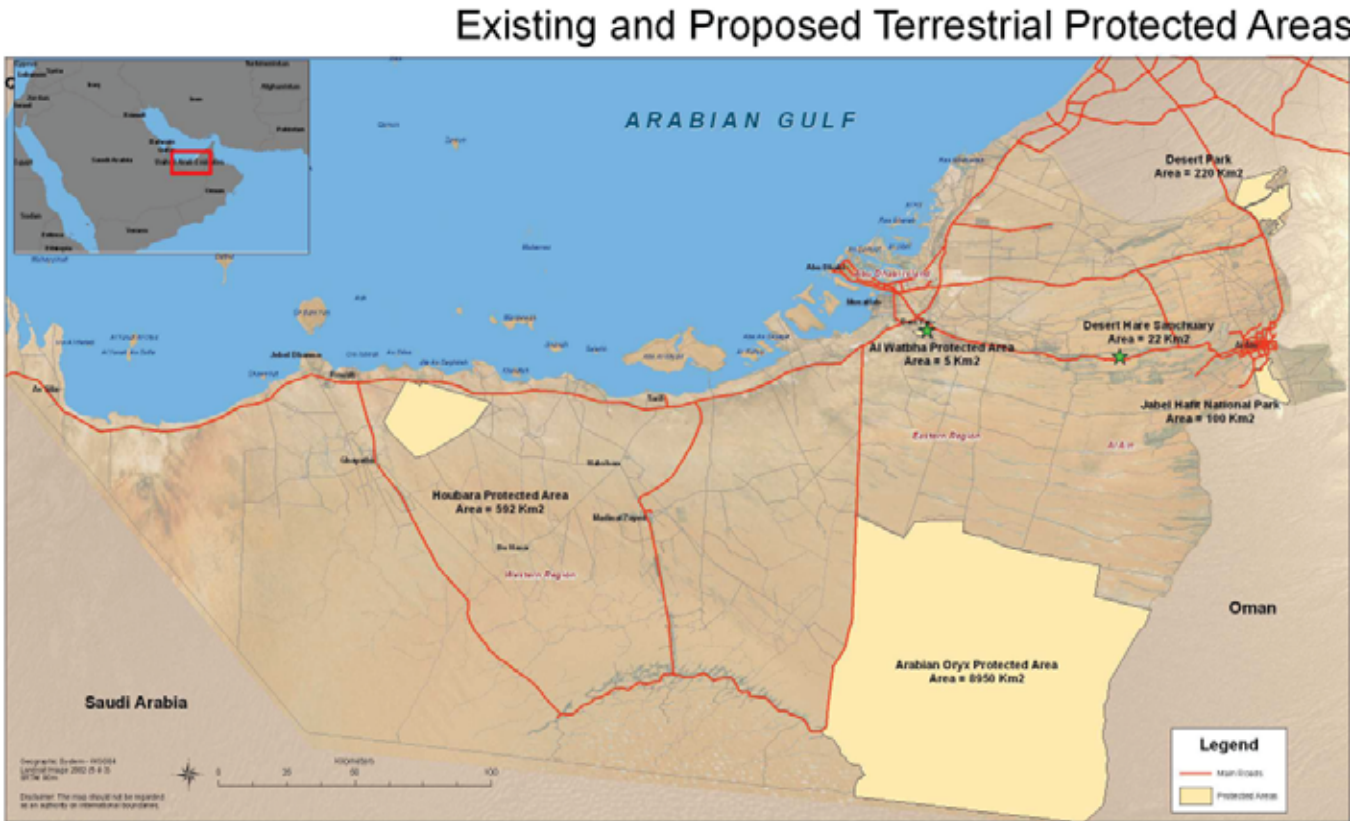
Although viable populations of some species can be maintained ex-situ either under cultivation, or in captivity, such methods are much less effective than in-situ conservation, and they are extremely costly. In-situ conservation "conservation of species in their natural habitats" is the most appropriate way of conserving biodiversity. In-situ conservation measures involve designating areas as protected sites. Protection may be offered at different various levels, from complete protection and restriction of access, through various levels of permitted human use.

Protected areas were a major interest in the UAE that in late 1970s and early 80s large areas were fenced and protected against hunting and grazing. Different animal and plant species were introduced into those areas for different purposes such as recreation, breeding, and in some occasions hunting.

By issuing the Federal Law No (24) 1999 for the Protection and Development of Environment; the concept and approach of establishing and managing protected areas have been changed that they are clearly defined. Fifteen protected areas are already established in the UAE covering a total area of 4888 km^2 representing 5.9 of the country's terrestrial land. These areas are distributed as following: Six terrestrial protected areas, eight marine protected areas and one is classified as mixed. Table 7.3 lists protected areas in the UAE.

Abu Dhabi Emirate has 5 legally established protected areas (3 marine and 2 terrestrial) covering approximately 4,740 km^2. Four terrestrial protected areas are proposed to be declared and established covering more than

9,000 km² and these are the Arabian Oryx Protected Area (8,950 km²), Jebel Hafit National Park (100 km²), Houbara Protected Area (592 km²) and Desert Park Area (220 km²). Combined these 4 new protected areas cover more than 12% of Abu Dhabi Emirate. Figure ??? shows existing and proposed terrestrial protected areas in Abu Dhabi.



Map 7: Existing and Proposed Terrestrial Protected Areas

#	Name of PA	Size/km²	Type	Date of Declaration	Location
1	Morawah Marine Protected Area	4255	Marine	2003	Abu Dhabi
2	Al Yasat Marine Protected Area	482	Marine	2005	Abu Dhabi
3	Bu El Sayaeef	280	Marine	2007	Abu Dhabi
4	Al Wathba Wetland Reserve	5	Wetland	1998	Abu Dhabi
5	Arabian oryx Protected Area	8950	Terrestrial	2007	Abu Dhabi
6	Jebel Hafit National Park	100	Terrestrial	Proposed	Abu Dhabi
7	Ras Al Khor	6.2	Marine	Declared	Dubai
8	Al Maha Reserve	250	Terrestrial	2001	Dubai
9	Hatta Protected Area		Terrestrial	Declared	Dubai
10	Al khawaneej		Terrestrial	Declared	Dubai
11	Nad Al Shiba		Terrestrial	Declared	Dubai
12	Musharaf		Terrestrial	Declared	Dubai
13	Al Aweir		Terrestrial	Declared	Dubai
14	Jebal Ali Wildlife Reserve		Marine	Declared	Dubai
15	Sir Bu Nair	13.242	Marine	2000	Sharjah
16	Khor Kalba	5	Marine	Proposed	Sharjah
17	Seih El Masmoot	2	Terrestrial	Proposed	Sharjah
18	Al Senieah	90	Marine	Proposed	U, Al Qewain
19	Al Akaab Island		Marine	Proposed	U, Al Qewain
20	Al Hala			Proposed	U, Al Qewain
21	Al Dhab			Proposed	U, Al Qewain
22	Al Yosvah			Proposed	U, Al Qewain
23	Al Harmalah			Proposed	U, Al Qewain
24	Hatem			Proposed	U, Al Qewain
25	Al Zarayeh			Proposed	U, Al Qewain
26	Al Kubreih		Terrestrial	Proposed	U, Al Qewain
27	Al Ghola	0.08	Terrestrial	Proposed	U, Al Qewain
28	Dedna		Marine	1995	Fujaira
29	Al Aqah	0.71	Marine	1995	Fujaira
30	Ras Debah	1.36	Marine	1995	Fujaira
31	Al Badiah	0.57	Marine	1995	Fujaira
32	Zakkat		Terrestrial	1995	Fujaira
33	Al Ghob		Terrestrial	Proposed	Fujaira
34	Al Hafiah			Proposed	Fujaira
35	Ahforah			Proposed	Fujaira
36	Ras Al Khaimah	6	Marine	Proposed	Ras Al Khaimah
37	Khor Al Rims	4	Marine	Proposed	Ras Al Khaimah
38	Al Hamra Island	5	Mixed	Proposed	Ras Al Khaimah
39	desert protected area		Terrestrial	Proposed	Ras Al Khaimah
40	Roos El Jibal	250	Terrestrial	Proposed	Ras Al Khaimah
Total Area		14706.162			

Table 7-3: Protected Areas in UAE (FEA, 2003), EAD 2006 Annual Report

7.4 Environmental Research and Monitoring

Research and monitoring is a very helpful tool in the management of natural resources. It provide the baseline information required to develop integrated management plans, polices, legislations and actions. Baseline data is also used to monitor changes through time, in other words it helps testing the efficiency of actions taken and ultimately decide weather efforts are going on the right track or not. Monitoring is very important because it enables planners and management to take actions, modify and improve plans properly and on the right time to achieve goals and operational objectives effectively.

The Environment Agency - ABU DHABI (EAD) has established the Terrestrial Environment Research Center which is intended and through well qualified team to conduct research and monitoring programmes on the natural environment of Abu Dhabi. Research programmes carried out cover various aspects of the environment including, natural habitats and ecosystems, plants diversity, distribution and ecology, forests, rangelands, animals diversity, distribution and ecology, birds diversity, status and migration, invertebrate fauna, soil cover, and water resources. Information gathered through different research fields with the help of the geographical information technologies (GIS) are used to build up the ecological profile of the emirate including biotic and physical components of its terrestrial environment.

The Marine Environment Research Center has several programmes and projects devoted to study the marine life including fisheries, sea turtles, corral reefs, Dugongs and other forms of marine life.

Environmental research programmes are also aiming to address threats and impacts on natural habitats and species. One major role of the research and monitoring programmes is also to address threatened species and predict future changes. This is a very essential role that this type of applied research programmes has to play because its results and recommendations will form the basis and guidance for developing scientific sound management planning and take actions on a solid background.

Moreover, research and monitoring helps the governmental agencies identifying priorities and direct efforts, funding, resources, and attention to the right place at the right time. This is a very crucial role especially with increasing and accelerating environmental issues which makes the need for proper and well designed conservation plans essential to ensure the maximum benefit and outputs of conservations initiatives.

Environmental research plays a major role in the development and effective implementation of legislations and conventions at booth national and international levels. The convention on international trade of endangered fauna and flora (CITES) for instance is an international convention dedicated in organizing wildlife trading of endangered species. Wildlife research and monitoring is responsible here for identifying endangered species and monitor any changes on their conservation status. The effective implementation of this convention at the national level requires good knowledge of species included in the convention appendices and which of these species occur in the country.

Results of research and monitoring are also used to guide the formation of environmental laws and regulations. Hunting law is for example defining penalties for illegal hunting of wild species prohibited for hunting due to their small populations. To define which species can be hunted and numbers of individuals that can be hunted each season, a census research programmes carried out to estimate the population density of certain species. Research also helps putting species in categories and groups according to their conservation status which consequently define penalties for each group.

Recently, the EAD conducted a full census for desert antelopes with focus on three different species, Arabian oryx, Sand gazelle and Mountain gazelles within the Emirate of Abu Dhabi. As a result of these studies, population, age structure, sex ratio were defined and clear distribution maps were produced for the three different species. This will enable the EAD to manage the wildlife programmes in more efficient way. See **Maps 2, 3, and 6** for desert antelope distribution.

7.4.1 Environmental Education and Public Awareness

Environmental awareness and education is a key tool promoting environment protection biodiversity conservation through raising people understating and appreciation for the environment. EAD is adopting several awareness programmes targeting different groups of community. The fundamental goal for the awareness and education activities is to improve the knowledge about the environment and its component which will ultimately increase the appreciation for its role and hopefully help conserving it.

Several Environmental programmes were developed and running by EAD targeting various sectors such as students, women, fishermen, trainers and the general public. Some of these programmes are described below.

Enviro-Spellathon

This programme was conceived by the World Wildlife Fund for Nature/Emirates Wildlife Society in coordination with the Ministry of Education in UAE. The main objectives of this programme are:

- Promote environmental awareness to students through a sustained educational programme.
- Cut across a whole spectrum of the student population in a structured way.
- Implement a programme that grows with the child and develops according to his/her level.
- Instill sound environment behavior/ethics in the growing youth of the UAE.

This programme was initiated in 2004 starting with 172 schools including 45,000 students. During the 2004-2005 total numbers of schools reached to 247 including 73,000 students as **Figures 7.3 and 7.4** show.

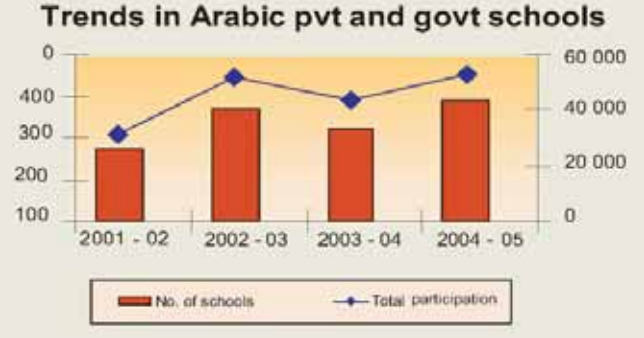


Figure 7-3: Trends in Arabic Private and Government Schools

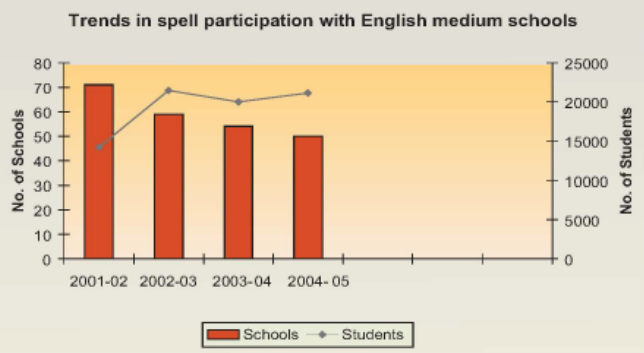


Figure 7-3: Trends in Arabic Private and Government Schools

Students and schools benefited from this programme through increased:

- language skills, comprehension and vocabulary skills;
- awareness and understanding of the UAE's environment;
- awareness about the need to conserve resources and develop sound environmental behaviour;
- knowledge about environmental issues.

Education Programmes for the Education Sector

This programme began in 1998 with the introduction of the 'Nature Bus' to give the desert and the marine experience to Primary and Middle school students in private schools. The first batch of senior students was whisked away on a field trip to the desert in the same year. Today, the programme reaches out to schools and colleges with interactive classroom modules and workshops on various themes covering more than 10,000 students annually. More than 2,500 students are given a hands-on experience through field trips to different ecological habitats in the Emirate. These programmes are systematically structured to support the curriculum already taught in schools and targets students as well as teachers through training programmes.

Knowledge on the environment currently being disseminated in schools is theoretical and exam-oriented so there is little scope or infrastructure for promoting theme-specific programmes. The focused awareness programme was designed and structured to complement the school curriculum and help students translate the awareness gained into action. The field trips organized use the ecological and systems approach and help students rediscover their link with nature and. In higher educational establishments, there is a need to orient the youth to think "green", regardless of whichever field they take up in the future, as the decision-makers of tomorrow. And the main objectives for this programme are:

- Raise environmental awareness among students at all levels.
- Adopt an interactive approach to environmental education dissemination.
- Update and upgrade the knowledge of teachers on current environmental issues and capacity build to diffuse that knowledge in their classrooms.
- Instill sound environmental behaviour and attitude among students.
- The main benefits that students and teachers can get are:
- Increased awareness among the student population.
- Increased motivational level among the teacher coordinators by enhancing their skills, thus creating a multiplier effect.
- Promotion for the sustainable use of resources through various programmes.
- Help to translate the information and knowledge gained to environmental actions.

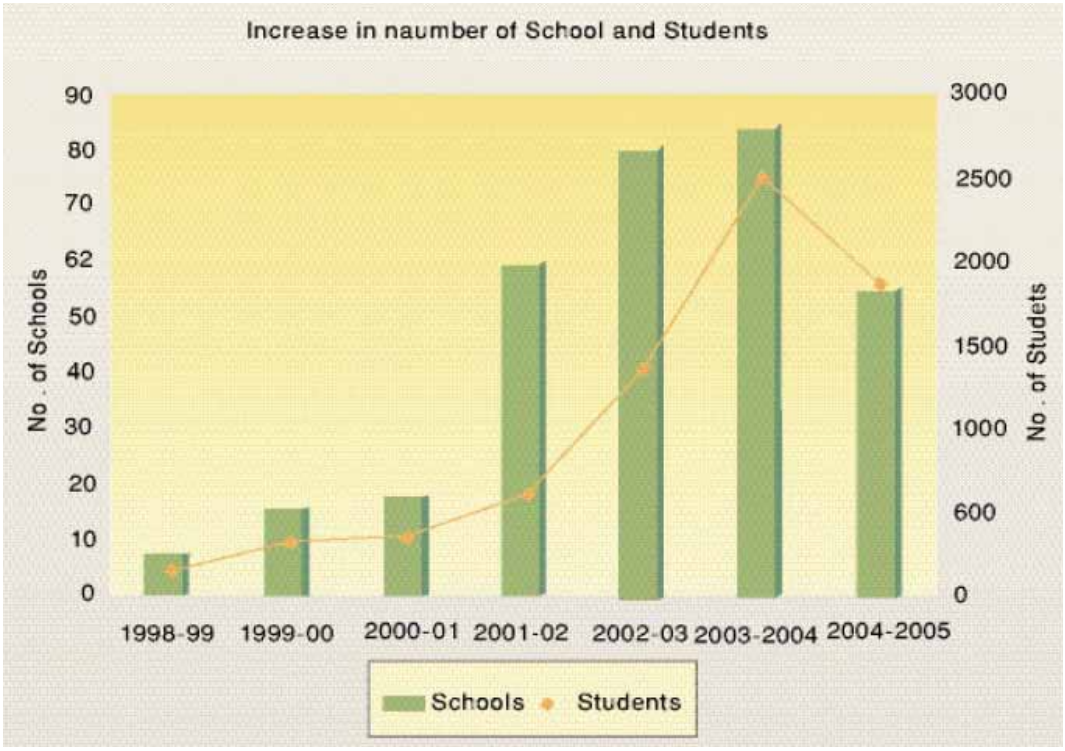


Figure 7-4: Trends in English Medium Private Schools

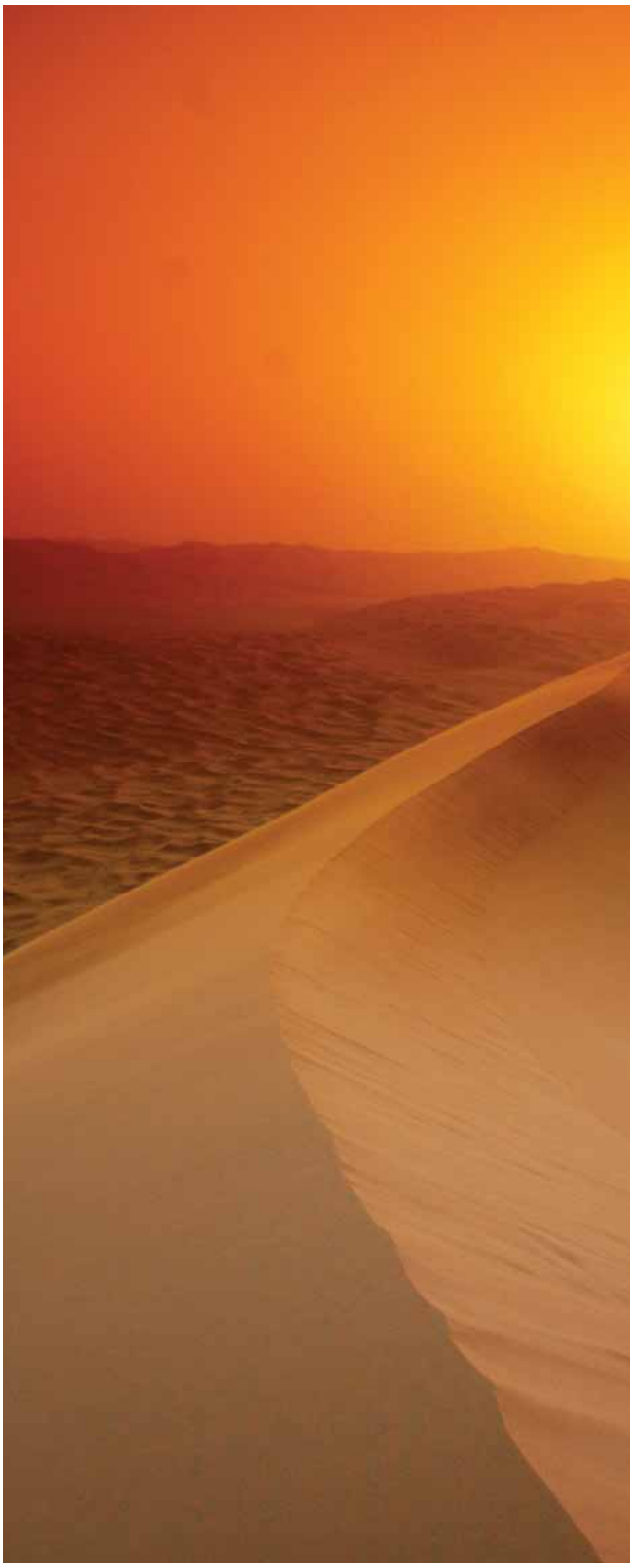
Informal Education Programmes for other Community Sectors

This is a non-formal awareness programme began with a need to promote a participatory and motivational approach towards environmental awareness. These programmes enhance a sense of ownership towards environmental conservation and protection issues amongst the different target audience besides inculcating sound environmental behaviour with all those involved. Non-formal awareness programme is popular and supports the formal structured awareness towards environmental education and awareness. These programmes are action- oriented and are also able to target a large number of people at the same time.

This programme started in 2001 with focus on environmental competitions. Each year, these competitions involve more and more students and schools. Their efforts are then displayed in a grand exhibition for the public to view. EAD Agency has also constituted environmental awards for identifying excellence amongst schools, teachers and students with regards to their contribution towards environmental awareness and protection efforts. Clean ups and campaigns to commemorate environmental days with students, the public and other target audiences with appropriate activities have also been carried out regularly. Nature/Green clubs have been established in a quite a few schools where it has been the Agency's strategy to ensure that all schools and colleges in the Emirate have one. Other programmes that EAD is working on are:

- Assessment of Current State of Environmental Awareness, Behaviour & Trends
- 'Greening' the School Curriculum
- Regional Flagship Project on Water Awareness
- Awareness Programme for Fishermen
- Awareness Programme on Pesticides and Water
- Environmental Education through the Enviro-Spellathon programme
- Al Dhabi Quarterly Publication
- Promoting the Agency's Conservation Programmes and Goals
- Organizing the Environment Conference Series
- Organizing and Participating in Public Exhibitions, Workshops and Seminars
- Scholarships and Internships for UAE Nationals

8 OUTLOOK



To ensure the rapid economical developments have minimal impact on the environment and biodiversity conservation there was an urgent need to establish an environmental governance body within the Emirate of Abu Dhabi which responded through a range of environmental management and conservation initiatives such as; issuing new laws and regulations, development of environmental strategies and action plans, establishment of protected areas, environmental research and monitoring programmes and promoting of environmental education and public awareness there is still a great need to ensure that such developments and practices are environmentally sustainable especially with the new government approach towards a sustainable developed Abu Dhabi.

With such high level commitments coming from the highest decision making levels in the Emirate towards sustainable development, the future of terrestrial biodiversity is very clear and positive that there is a need to create a balance among the economical, cultural and environmental needs and requirements. In order to meet this vision the following should be highly considered as top priorities.

8.1 Legislation

- There is a need to review all federal and local laws and legislations related to environment and biodiversity conservation. The review will include identifying main gaps and a list of management recommendations.
- Some of the existing laws and legislations lack enforcement including hunting and grazing laws. So there is an urgent need to establish clear mechanisms and tools on how to enforce the implementation of such legislations or related ones.
- Strong coordination is needed between local institutions from one side and between local and federal institutions from the other side.
- Environmental bylaws are the hand that is needed to ensure law enforcement, so there is a need develop bylaws related to federal laws. For example, protected area by laws it has been proposed since more than 3 years and up to this date it has not yet been issued which organizes the work of establishing and managing protected areas at both federal and local levels.
- Laws and legislations should be developed to regulate internal local wildlife trade and wildlife movement between emirates.

8.2 Land Use Planning

Planning is a vital tool for biodiversity conservation. Land use planning is the way we use our land space which can have major impacts on environment and biodiversity. Such impacts can be direct, such as the destruction of natural habitats and landscapes, or indirect, such as increasing the amount of traffic can lead into air pollution and greenhouse gases The Emirate of Abu Dhabi lacks for a land use plan that regulates assists all present and future human activities and practices within the Emirate. It was till recently when the process starts moving through developing an Integrated Coastal Zone Management for the Emirate of Abu Dhabi which is still in its embryonic stages. More information on the Integrated Coastal Zone Management Plan can be found on Coastal and Marine Natural Resources Sector Paper.

8.3 Institutional Frame Work

A comprehensive review of the existing institutional framework is required. Implicit in this is the need to identify overlaps in mandates and areas of duplication and new responsibilities according to the EAD new establishment Law (Local Law No. 16).

Institutional Capacity Building programme is a must at this stage where the agency is moving towards national and regional levels. Strategic Planning Cycle is a must for the agency where work is evaluated, monitored and planned for the coming years. Clear operational SMART objectives should be adopted with clear action plans and reasonable and realistic budgets should be prepared by all departments and sections. Clear institutional structure based on functions and strategies should be adopted at the same time the structure should be flexible to adapt with minor changes.

8.4 Strategic Action Plans

Biodiversity is all living things; it includes all species of plants and animals, their habitats and the complex ecosystems that sustain them. Biodiversity supports life itself and regulates the environment; it provides human kind with free services such as our food and medicines, and the raw materials for many other goods that we take for granted such as clothing, paper products, and the furniture in our homes. Plants also help to clean pollutants from our air, regulate the temperature and provide the oxygen we breathe. A rich diversity of life around us also provides us with a quality of recreational, relaxation and spiritual well being.

The United Arab Emirates signed up to the Biodiversity Convention at the Earth Summit in Rio de Janeiro in 1992 which requires all state members to prepare and implement their National Biodiversity Action Plan. Such Plans should be prepared at the national level in coordination with the local environmental authorities and other to help ensure that the national objectives are translated into effective action at a local level and to take into account, local biodiversity issues.

The Biodiversity Action Plan should sets out the overall strategy for biodiversity action plan for priority habitats and species and key objectives. It should also:

- describe Abu Dhabi's biodiversity;
- identify habitats and species of priority concern;
- explain how detailed action plans will be prepared for priority habitats and species;
- review important issues that affect biodiversity in Abu Dhabi;
- promote a strategy for managing information and data;
- set out actions to increase aware ness of biodiversity and involvement in its conservation; and
- explain the role of individual partners in the biodiversity programme and how the programme will be coordinated in the future.

Tourism development is becoming a major income generating tool in Abu Dhabi. With more than 1.2 million visitor to Abu Dhabi by the end of 2005 and with expected figures to reach up to 2.6 million visitors by the year 2012; tourism strategic plans and polices should be developed taking into consideration all environmental and cultural issues. Tourism should take another curve and adopt sustainable tourism principles to fit with the Abu Dhabi Government's goal of a sustainable Developed Abu Dhabi. This requires all sectors to work together to achieve that vision. The Sustainable Tourism Strategy is a very important planning tool which sets tourism development objectives at the same time ensuring environmental and cultural parametres and needs are well respected and appreciated.

8.5 Ecological research and assessment

A comprehensive review and assessment should be conducted regarding the existing research programme within the EAD. A research study should be adopted with clear research priorities and standard methodologies. The review should include the possibility of developing a partnership programme with the academic and research sectors at all levels with more emphasis roles to the national and local universities. Research data and information should be available for public which will strengthen the role of the agency at all levels. Annual financial allocations should be approved for ecological research and monitoring.

8.6 Communication and collaboration

Biodiversity conservation requires high level of communication and collaboration among wide range of national, regional and international organizations. In the year 2000 the EAD started a participation process to include major stakeholders and developing first Abu Dhabi Environment Strategy. The participation process was very limited with no commitment from various organizations to lead any certain programmes. Both, federal and local Biodiversity Conservation Committees representing all stake holders and local community representatives are needed to start the process of developing both national and local Biodiversity Action Plans

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