THE TAIF ESCARPMENT, SAUDI ARABIA:
A STUDY FOR NATURE CONSERVATION AND RECREATIONAL DEVELOPMENT

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ABSTRACT The mountain escarpment between Makkah (Mecca) and Taif in Saudi Arabia is wooded, scenic, and relatively undisturbed. Two species of juniper, Palaearctic and Afrotropical, overlap there for thirty kilometers. Extensive development is proposed for the region. In 1991 the National Commission for Wildlife Conservation and Development sponsored a university student-staff study of an area of 600 km². This paper gives the results of their survey with recommendations for protection of the natural vegetation, the establishment of a nature reserve with related recreational facilities, and for sustainable development.

RESUME L'escarpement de Taif, Arabie Séoudite: Une étude de conservation de la nature et du développement touristique. L'escarpement montagnard situé entre Makkah et Taif en Arabie Séoudite est boisé, pittoresque et relativement intact. Deux espèces de genévriers, palaearctique et afrotropical, s'y chevauchent sur trente kilomètres. Un développement touristique extensif est envisagé pour la région. En 1991, la commission nationale pour la conservation de la faune et le développement touristique a patronné une étude menée par des étudiants et du personnel universitaire, et portant sur une zone de 600 km². Cet article présente les résultats de cette étude avec les recommandations visant à la protection de la végétation naturelle, l'établissement d'une réserve naturelle avec des facilités de récréation, et à une agriculture viable.


INTRODUCTION

Between Makkah (Mecca) and Taif in the Sarawat mountains of the southern Hejaz, the wooded escarpment from al-Hada to al-Shafa (Figure 1) is the catchment for one third of Taif's water supply. It is also an area of outstanding scenery. In addition, it is ecologically unique—one of the only places in the Kingdom of Saudi Arabia where a range of Palaearctic flora co-exists with Afrotropical plants. Two species of juniper with distributions as far afield as France and Malawi overlap in an area which forms the northern limit of 1,000 km of a narrow belt of fairly continuous woodland. This contains many African species and of most of Arabia's endemic mountain animals and birds. Endangered succulent plants grow there. It is also on one of the main migratory flyways between Eurasia and Africa. Apart from the two main villages, and the effects of overgrazing, it has remained relatively unchanged for nearly twenty years, since a ban on development imposed in 1972.

In 1990 the ban on development was lifted. The Ministry of Municipal and Rural Affairs published a plan for the area and for the expansion of the villages; it recommended tourist roads and facilities, a second highway up the scarp bisecting a new national recreation area just below, and increased local services. The Gulf Crisis postponed immediate development, but large flocks of goats and sheep at once moved into the area.

In order to guide the development of the scarp and its wooded catchment, the National Commission for Wildlife Conservation and Development (N.C.W.C.D.) asked the Department of Landscape Architecture in the Faculty of Engineering, King Abdulaziz University, Jeddah, to make a student study (Department of Landscape Architecture, 1991), here summarized. The intent was to define a potential protected area for the woodlands, including recommendations for its development and related recreational facilities.

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Figure 1. Location of the Taif Escarpment study area.
Figure 2. The main physiographic zones.
FIGURE 2a. The high mountains south of al-Hada.

FIGURE 2b. The plateau highlands from the scarp.

NATURAL FACTORS

TOPOGRAPHY
The study area lies in the Sarawat mountains between five and 25 km west of Taif, between the main roads to al-Hada 19 km to the northwest, and al-Shafa, 25 km southwest of Taif. It covers about 600 km² but excludes the two main villages. For the purpose of analysis the area was divided into six main physiographic zones, shown in Figure 2; four of these are illustrated in the photographs (Figures 2 a-e).

1. Mountains above 2,200 m: rocky woodland with some terraced rainfed valley farms and many abandoned hillside terraces. The escarpment edge is largely composed of resistant pink granites. It is 1,900 m high at al-Hada, 2,300 m at al-Shafa, and 2,661 m at Jabal Sha'ar, the highest mountain in Arabia north of the Asir and its westernmost point. From here to south of al-Shafa the scarp crests in a line of southwest-facing mountains between 2,400 and 2,600 m high. Parallel to this, and six and ten km northeast are two shorter granite ranges, Jabal al-Amud and Jabal Barad (Figure 2 a).

2. Plateau highland and valleys, above 1,800 m: the dipslope starts in a narrow belt of upland basins in the granite. It is characterized by small cultivated valleys and lightly wooded ridges with much visual...
charm. Both al-Hada and al-Shafa lie on small plateaus of farmland on the escarpment edge. Beyond them towards Taif is a wide band of smoothly weathered black schist hills, barren and overgrazed, divided by wide sand-floored valleys (Figures 2b and 2e).

3. Escarpment slope: a steep rocky face rising 1,000 m at al-Hada and 1,500 m at Jabal Sha’ar, with rugged outlying peaks. The scarp is of striking visual quality, with sheer cliffs, pinnacles, gullies, and extensive views over Wadi Nu’man and the foothills towards Makkah (Figure 2c).

4. Foothills: barren overgrazed rocky hills between valleys with many boulders and some peaks up to 2,000 m (Figure 2d).

5. Foothill wadi bottoms: wide, sandy, flat-floored valleys at an elevation of 600–900 m in the study area; some irrigated farmland in Wadi Nu’man; all badly overgrazed.

6. Eastern plateau wadis: similar wide sand-bottomed wadis at 1,600–1,900 m with some irrigated farmland; also badly overgrazed.

Climate

The local climate is warm in summer and relatively cool in winter with an average annual rainfall of 170–250 mm at al-Hada, and 250–300 mm near al-Shafa which is always warmer, wetter, and more humid than Taif (Ministry of Agriculture, 1990). Winds blow from the west and southwest for 70% of the time (Min. of Agric., 1985 a). It is often cloudy and humid in winter and rainy in spring and autumn. The precipitation is due to:
a) the convection of humid air carried in from the Red Sea by the prevailing westerly winds, and northern winter cyclones. This is channeled up-wadi from the southwest and condenses on and above the mountain scarp in clouds and orographic rain.

b) the effect of the furthest reaches of the summer monsoon rains from the south (Konig, 1986).

c) the effects of the vegetation which are as follows:
   i) the rough, wooded terrain with low reflectivity, high heat absorption, and high evapotranspiration creates local cooling and convective turbulence which induces rainfall over the woodland.
   ii) condensation on the foliage in contact with clouds which is greatest in winter when the humidity is highest. In similar juniper woodland in Djibouti it was observed that 40% of annual precipitation came from condensation on trees (Blot, no date). When these were felled, annual rainfall decreased by up to 60% (200–300 mm). In Dhofar, water yield from fog has been observed to be up to 25 times that from direct rainfall (Stanley-Price, 1990).

The highest land (above 2,200 m) is the wettest and its north and west slopes are cooler and damper than the south and east, favoring tree growth and agriculture. This condensation zone maintains a thin cloud-contact woodland approximately 200 m in front of, and between 0.5 and 1.5 km behind, the scarp edge, except on the high mountains where it is 2.5–3.0 km wide. Within this zone precipitation from condensation may equal that from rainfall. There is a noticeable rainshadow northeast of the highest peaks and each of the shorter ranges parallel to them, Jabal al-Amud and Jabal Barad (Figure 3).

The edge of a subhumid zone can be traced at the limit of juniper growth, where the annual rainfall plus condensation may drop by 50% to 200–250 mm. This zone is 4 km wide at al-Hada and averages 3 km wide to the south, narrowing in rainshadow areas. It is 6–12 km behind the mountain and al-Shafa situated in a gap in the surrounding peaks which seems to attract and channel clouds. Down the scarp edge its influence is seen to about 1,400 m on north-facing slopes where increased temperatures and evaporation inhibit juniper growth.

**GEOLOGY**

The Sarawat escarpment is part of the uplifted mountain system associated with the Red Sea Rift. Near Taif the escarpment, slope, and foothills are formed mainly of a resistant coarse pink granite, mixed with grey diorite, granodiorite, gabbro, and gneiss. The scarp falls sharply towards the west in sheer cliffs, pinnacles, and steep rocky gullies. This belt of rocky granite mountains is wide near al-Shafa but narrows towards al-Hada to a line of sharp crags of fine-grained red granite. The many fault lines are inactive (Smith, 1980).

On the gentler dip slope between the scarp and Taif the predominant rocks are of various dark-colored schists: amphibolite, chlorite, and others. These are less resistant to erosion than the granites and have weathered into smoother barren hills. The flat wadi bottoms are covered with alluvial deposits, with boulders high up and sand lower down. Raised old river terraces are visible in Wadi Nu'man.

**HYDROLOGY**

Most of the relatively high precipitation on the crest runs off eastward via Wadi Wij and Wadi Liyyah, and west through Wadi Nu'man and Wadi al-Shara and other headwaters of Wadi Lamlam (Figure 3).

Historically, wells in Wadi Nu'man supplied water to Makkah and wells in the Wadi Wij to Taif. The Akramah reservoir at al-Waht, constructed to control floods and recharge ground water, is full after rain but is bare mud in summer. Its waters come mainly from the headwaters.
FIGURE 3. The meso-climate of the area.
of Wadi Makhadhat which rise in the well-vegetated mountains between Jabal Shaa‘ar and al-Shafa. They rise at al-Ayn in Makhadhat under Jabal Barad, 8 km up-wadi from al-Waht with which it is connected by an under­ground gallery whose stone inspection chambers lie in the wadi bed. This source was bought by King Faisal in 1963 from the Thagif Quraish tribe for public use at a cost of SR (Saudi Riyal) 8 million. It supplies a great number of public standpipes in western Taif. Many wells also exist in the fertile cloud gap area east of al-Shafa, in the watershed of Wadi Liyyah.

Taif with al-Hada takes about one third of its water from the aquifer underlying Wadi Wijj, one third from Wadi Turabah, 150 km south, and the remaining third from the new Shoaiiba desalination plant on the coast (Ministry of Municipal and Rural Affairs, 1990). However, the water from all three sources is not enough for Taif today. When the desalinated water was diverted before the Hajj pilgrimage in 1991, the price of tanked water in Taif rose seven-fold. Drought also occurred from 1987 to 1990. It is important therefore to preserve the effective­ness of the upper Wadi Wijj catchment area by maintain­ing its dense vegetation, permeable soil cover, and the terraces which retain runoff.

Water depths observed in wells vary with season from 3–4 m near the escarp to 30–45 m near al-Waht and in Wadi Nu‘man (Jammam, 1978). The water quality is high (in Wadi Nu‘man that coming from the west is more pure). There are annual floods in Wadi Wijj, contained by the Akramah dam. However, percolation through the underlying fractured and jointed rock is good, and its aquifer recharge rates are high (Ghurm, 1980). Flash floods elsewhere sweep the valleys every two-to-three years, sometimes destroying valley terraces in the mountains. Such floods have been aggravated by the loss of soil which results from overgrazing. The situation will deteriorate further if abandoned upland terraces are allowed to collapse, since this will reduce the infiltration of water and accelerate erosion.

### VEGETATION

Ecologically the study area is unique. The 40 km of humid highland scarp from north of al-Hada to al-Shafa is the northernmost limit in Arabia of many Afrotropical montane plants with their accompanying endemic animal species. It also forms the southern limit for several relict northern plants (Khoja et al., 1990). The dominant vegetation on the humid edge is Juniperus phoenicia and J. procera woodland with a Euryops arabica shrub layer; in other drier zones it is very sparse acacia scrub or wadi woodland, predominantly Acacia tragensis. In most areas (especially in Wadi Sinh and Wadi Nu‘man) the dominant influence is drastic overgrazing by sheep and goats, so that the only plants that remain to hold the soil are poisonous or unpalatable to stock. The worst weed is the Mexican prickly poppy Argemone ochroleuca which is begin­ning to replace every other herb on the wadi bottoms and is invading disturbed ground everywhere (Figure 4). However, if the native vegetation were allowed to recover it would crowd out the poppy within three-to-four years.

Within the study area, the research team found only two himas\(^1\) (traditional conservation areas), one quite small, and the other a small hoyra (family owned hima). As there are now no legal tribal rights to land, it is difficult to prevent outsiders from overgrazing local lands. Nevertheless, the flora as listed by the botanist, Sheila Collenette, contains 370 species (18% of the country’s total): 245 plus 35 grasses on the upper levels and 200 plus 27 grasses on the lower levels, 75 species being common to both (Collenette, 1991). The vegetation on the escarp slopes is lowland in species type up to about

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1. Arabic plural: ahmias
Figure 4. Vegetation. The juniper woodland diagram is based on Asmode, 1989. Note: plant taxonomists have recently renamed *Juniperus excelsa* and in the text it is referred to as *J. procera*.
1,000 m, and predominantly of highland type above 1,700 m. Included in the plant list are seven species listed by the N.C.W.C.D. as endangered, needing protection from plant collectors and herdsmen. These are all succulents growing on cliff faces (aloes) or amongst granite rocks on the dry edge of the sub-humid zone (tree euphorbias, carallumas, and huernias). If protected, plants in this area could serve as a natural seed-bank for the surrounding countryside. However at present much of this variety is of small numbers of tiny plants. The overall impression is of vegetation impoverished by overgrazing except in the denser juniper woodlands. However, designation as a reserve would offer little protection unless fences were erected.

Trees associated with the juniper are Acacia orixens on the escarpment, at its northern limit, and on scarp slopes sparse Pistacia falcata, Olea europaea spp. africana, and Tarchonanthus camphoratus, also at their northern limit. The dominant larger shrubs are Euryops arabica with Lavandula dentata, Pistacia pichulata, Rumex nosuos, Otostegia fruticosa, and, in drier areas, Dodonea angustifolia, Azura persica, and Lavandula pubescens. Where ungrazed, the woodlands host several endemic plant species and have always been used for the production of honey. This wide variety of ecosystems so near to major cities is an excellent scientific, educational, and recreational resource which should be carefully maintained.

Juniper Woodland

The lip of the escarpment is a narrow wooded zone some 1.5 to 4.0 km wide at, and south of, al-Hada, and from 5.0 to 7.0 km wide in the mountains northwest of al-Shafa. Here, orographic rainfall is intensified by the effects of woodland and supplemented by condensation from clouds in contact with trees. Owing to the ban on development over the past twenty years the wood is still relatively intact. In view of their contribution to the water supply of both Taif and Makkah, and their closeness to these cities, their preservation should be a first priority.

This woodland is unique because for 30 km two similar species of juniper overlap: Juniperus phoenicea (orixens), a Mediterranean tree whose southernmost individuals have been found on J. Sha'ar, and Juniperus procera, formerly excelsa, ('orixens), an East African species whose northernmost individuals in Arabia occur just north of al-Hada (Figure 4, inset). It is also the northern limit of the almost continuous belt of mountain woodland and Afrotropical species which extends from the Yemen. These trees are vital in ameliorating climate, reducing storm flow and erosion, and recharging the aquifers of the region. Even without rain each tree contributes condensation by stem flow and drip: the taller the tree the greater the amount of condensation. It also protects and enriches a porous soil beneath by its canopy and litter. Any reduction of the woodland, therefore, would mean loss of this available water.

Condensation Zone

In this cloud-contact or condensation zone there is quite dense woodland especially on the north and west-facing valley slopes above 2,300 m. It forms a shaded humid microclimate and a humus-rich topsoil; if ungrazed, seedlings can generate and a varied flora can grow. This is of mostly northern species, some of them rare. According to a recent study by J.-F. Asmode of the National Wildlife Research Centre, trees just north of Jabal Daka near al-Shafa average 3–4 m high at 3,500–5,700 per hectare, the density decreasing with steepness of slope. But this occurs in only a few of the least disturbed most humid areas (Asmode', 1989).

Trees near al-Hada in cut-over grazed woodland are only a third as dense. Where this is so, evaporation, the diurnal temperature range at the soil surface, and soil erosion increase while the shrub layer, litter, soil porosity, and infiltration decrease. Maintaining a tree density of above 1,000 plants per hectare is essential if the woodland is to remain cool and damp enough for seedlings to be established (Asmode', 1989).

Sub-Humid Zone

Behind and below the condensation belt is a sub-humid zone of overgrazed open woodland above about 2,600 m, and on the scarp face above 1,700 m, with dry soil and little shrub cover where the annual rainfall plus condensation may drop to 200–250 mm. Many of the trees are old, averaging 2–4 m high, and are not regenerating. In the rainshadow of the southwest mountain range this open woodland often extends to the edge of the escarpment. Beyond this to the east, especially on the granite which are more favorable to growth than schists, are scattered, often scrubby, junipers to the edge of the zone which lies 12 km from the scarp edge. This probably represents the furthest extent of a woodland now retreating due to overcutting, overgrazing, and thus desiccation. Down the scarp face open woodland persists to about 1,700 m on north-facing and west-facing slopes. The limit of the northern junipers has been mapped as 1,400 m on north-facing slopes and 1,900 m on south-facing slopes; they barely exist on the southwest face of the scarp.

Juniper Species

Juniperus phoenicea has a bluish-green, short, spiky foliage and red-brown berries. It is usually less tall than Juniperus procera, and is found in drier areas and thus further north and lower down slope. It predominates at al-Hada (70% of the total woodland) and in Wadi Ghadirain (94%), becoming evenly mixed with J. procera west of al-Sinh (Asmode', 1989). The similar J. procera has a more feathery yellow-green foliage and blue berries. It is dominant in the thick woodland north of al-Shafa and survives in moist valleys north of al-Hada. Both species are threatened by overgrazing, felling, and construction. Their distribution is mapped in Figure 4, based on information from the National Wildlife Research Centre (Asmode', 1989).

Both junipers are very slow growing, with a 1-cm increase in trunk diameter in six years, and are unsuited
for commercial exploitation. However, 40% have been lopped for fuel and charcoal in the south and up to 100% north of al-Hada (Asmode', 1989). Although this is prohibited it still occurs and a small truck load can be sold for SR 500. Trees may be far older than they appear: a specimen 2 m high may be 100 years old; some may be over 500 years old. The tallest trees usually stand on terrace and field edges; one, over 10 m high, stands on farmland at Qawah. These trees were sometimes lopped to give a straight trunk suitable for use in construction. About one fifth of the old trees have dead heads, due possibly to severe drought some 130 years ago (Child and Grainger, 1990).

### WILDLIFE

**ANIMALS**

Owing to the large human populations nearby and to overgrazing, there are almost no large wild animals in the study area, except for baboons. These occur in the foothills and on scarp slopes near water. They supplement their mainly fruit diet from garbage and many therefore live near settlements. The most evident troop, of some 250 members (in 1991), ranges over about 30 km² from al-Hada to a highway maintenance camp, 9 km downslope; it winters on the warmer foothill wadi slopes.

There are many smaller animal species but they are mainly nocturnal and so are less seen. In former times there were leopard, mountain gazelle, and nubian ibex in the area. The latter could well be re-introduced in protected rocky wadis on the scarp face, if goats competing for the same food were excluded and if it were possible to prevent hunting. Caracal are reported from Jabal Kabkab, 15 km west of al-Hada; they occur with ibex and even leopard near Jabal Judah, 20 km southeast of al-Shafa. The major species are listed in Table 1.

Animals observed by J. and P. Gasperetti and others from 1978 to 1983 on the Makkah bypass included honey badger, wildcat, and Ethiopian hedgehog, Egyptian jerboa, gerbils, and sheath-tailed bat (Gasperetti, 1989). These animals may therefore be present in the foothills and foothill wadi sections of the study area.

### BIRDS

The birdlife is quite rich. Sightings by staff of the National Wildlife Research Centre near Taif include the endangered lammergeier and nine of the 11 species endemic to the country, including the Yemen thrust and the Yemen linnet, here at the northern limit of their distribution; also seen are the amethyst starling and grey hornbill. In all, 60 species of birds were seen by the research team, a number which might well be doubled by expert observers during the migration seasons.

In the woodland, birds such as the Yemen thrust, little rock thrush in summer, and blue rock thrush and song thrush in winter are important in the digestive scarification and dispersal of juniper seeds which germinate if voided in the shade of an adult juniper. On the scarp

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**Table 1**

Animal species seen or reported at higher levels of the Taif Escarpment

<table>
<thead>
<tr>
<th>Common name</th>
<th>Latin name</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nubian ibex</td>
<td>Capra ibex nubiana</td>
<td>very uncommon</td>
</tr>
<tr>
<td>Hamadryas baboon*</td>
<td>Papio hamadryas</td>
<td>a growing population</td>
</tr>
<tr>
<td>Arabian wolf*</td>
<td>Canis lupus arabs</td>
<td>uncommon</td>
</tr>
<tr>
<td>Caracal lynx</td>
<td>Caracal caracal schmitzi</td>
<td>very uncommon</td>
</tr>
<tr>
<td>Striped hyaena*</td>
<td>Hyaena hyaena</td>
<td>uncommon</td>
</tr>
<tr>
<td>Arabian red fox*</td>
<td>Vulpes vulpes arubica</td>
<td>common, raids garbage</td>
</tr>
<tr>
<td>Honey badger</td>
<td>Mellivora capensis</td>
<td>uncommon</td>
</tr>
<tr>
<td>Whiptailed mongoose</td>
<td>Ichneumia albicauda albicauda</td>
<td>uncommon</td>
</tr>
<tr>
<td>African genet</td>
<td>Genetta felina graniti</td>
<td>common in woods</td>
</tr>
<tr>
<td>Wild cat</td>
<td>Felis silvestris irixtami</td>
<td>uncommon</td>
</tr>
<tr>
<td>Porcupine</td>
<td>Hystric indica</td>
<td>common on old terraces</td>
</tr>
<tr>
<td>Brandt’s hedgehog</td>
<td>Paramechinus hypomelas</td>
<td>at northern limit</td>
</tr>
<tr>
<td>Rock hyrax</td>
<td>Procavia capensis</td>
<td>hunted for sport</td>
</tr>
<tr>
<td>King jird</td>
<td>Meriones rex</td>
<td></td>
</tr>
</tbody>
</table>

Snakes
- 5 species are listed including the cobra, *Naja haje arabica* (Gasperetti, 1988)

Lizards
- Several species including *Agama yemenensis*

Amphibians
- 3 species (Balletto et al., 1985), including a tree frog, *Hyla savignyi* at its northern limit
there are several colonies of griffon vultures, several pairs of Barbary falcons, and one nesting pair of lammergeier, all that remains of seven pairs recorded in 1975. A pair of black eagles was recently seen on the slopes between 1,500–1,700 m (Asmode', 1991, pers. comm.).

In foothill wadis fruiting fig trees attract Bruce's green pigeon, Arabian woodpeckers, and Tristram's grackle. Shining sunbirds, amongst others, migrate from the foothill wadis to the scarp 1,000–1,500 m above in mid-summer when the yellow aloe is in bloom. The area also lies on a major flyway and large flocks of steppe eagles, honey buzzards, and black kites can be seen especially near al-Hada in spring and fall, roosting at night on the escarpment.

Wildlife Habitats

The areas most likely to contain concentrations of wildlife are those most remote from human disturbance. Most animals will be found on the undisturbed scarp slopes and in the unfarmed dense to medium-dense woodland and abandoned terraces. The wadi bottoms, populated valleys, roadsides, and villages are the least likely areas to harbor wild animals. The main exception to this is the al-Hada escarpment road where the baboons are commensal with humans, and there are sources of water and food from crops and garbage near settlements.

SOCIAL FACTORS

Traditional Land Use and Change

The landscape is relatively undisturbed for a scenic area so near to Makkah and Taif. It is skirted by excellent roads and electricity supply, except along the scarp, but apart from a road from the al-Shafa highway to al-Hait, rough tracks are the only way to enter. This factor and the ban on development have preserved its remoteness. However, the scarp-top roads proposed by the Ministry of Municipal and Rural Affairs (MOMRA) may change this (see Figure 5).

Three tribes presently occupy the lands between al-Hada and al-Shafa:

a) The Thagif Quraish, from south of al-Hada to Makhadhat Quraish; a closed track across Jabal Barad emphasizes the boundary with the Hidail to the south; they are herders and farmers.

b) The Hidail, from Jabal Barad to Jabal Daka (principal sub-tribe, Talhi) and all the land below the scarp, who farm in the mountains but are mainly herdsmen.

c) The Bani Sufyan, southeast of Jabal Daka from Okailah to beyond al-Shafa in the headwaters of Wadi Liyyah, who are mainly farmers.

In this area between the two villages traditional soil conservation and water harvesting in the high mountain wadis were well adapted to terraced rainfed crops. Further from the scarp, highland farms were both rainfed and irrigated; low wadi farms were irrigated from wells and from occasional flash floods. But drought, inaccessibility, the small size of most farms, and the attractions of government work elsewhere, have encouraged out-migration. Some tribal lands are held in common, notably himas (traditional conservation areas), but much is held by individual families.

It was considered shameful to sell these lands out of the tribe to whom any profits should rightly belong. But permanent changes followed from the abolition of tribal rights in 1932, and from national prosperity. This brought alternative employment in the cities, and encouraged overgrazing through the subsidizing of headage, water, and feed for flocks. Lands at al-Hada (held by the Nimur and Twarig) have been urbanized and their value inflated by recent development and speculation. Al-Shafa was well farmed 25 years ago, but the younger people have moved to Taif and it has become a picnic ground, many of its terrace fields being overrun by cars. Nevertheless, the authority of tribal sheikhs and customs backed by the Office of Bedouin Affairs is still recognized.

Quraishi Lands

In the Quraishi lands which are the driest on the plateau level, wadis Ghadirain and Dhahiyya are fairly intensively farmed for vegetables, fruits, and roses; wadis Sinh and Makhadhat are less intensively farmed but are intensively grazed. Some 80% of the tribesmen have government employment in the towns, and the laborers are all foreigners, mostly from Egypt, the Sudan, and Pakistan. Upland terraces on hillsides and in high valleys built for subsistence farming are mostly abandoned and beginning to collapse. Wadis and hillsides are badly overgrazed although a 15 km² hill-top hima remains between Wadi Ghadirain and Wadi Dhihiyya to pasture cattle which are still used for plowing small fields. There is a small family-owned honey hajira (private hima) on Jabal Qosah south of Wadi Dhihiyya.

Hidaili Lands

The Hidaili farmlands occur in the much terraced humid high mountains and in the wadis below the scarp. On the plateau there is a sub-tribal honey hima at Makhadhat Quraish. Some roses are grown and tiny wheat fields are still cropped, but many of the terraces are abandoned. The Hidaili also graze flocks both on the plateau and in the dry foothills and wadis below it, traditionally crossing the scarp at al-Misraq, north of al-Haït. This pattern of tribal lands, stretching from the relatively temperate plateau to the hot, dry foothills, reflects the advantages of the semi-transhumant life-style formerly practiced by tribes all along the escarpments (Al-Oshban, 1987). Following this regime, summer flocks were moved up, and winter flocks moved down to the 1,400-1,800 m level to avoid the different seasonal stresses. The pressure of overgrazing is greatest in the
Figure 5. Land use: roads, farmland, himas, and tribes.
wadis, owing to the tracks by which water, fodder, and animals can be easily brought in, and it extends up hillsides at least 300 m. Flocks from Wadi Dhim were seen at 1,700 m on the west face of Jabal Sha'ar. Some conservation is enforced; among the Talhys the fine for illegal tree cutting is officially $S R 10,000 but cutting continues.

Sufyani Lands

The Bani Sufyan farmlands east and southeast of al-Shafa in the lee of the rain-fed mountains are in strong contrast. They have many wells, are fertile between outcrops of rock, and densely settled, with a tradition of small individual himas and strong tribal conservatism. They demonstrate that there is always less grazing where the main land use is farming. Physically their country resembles the mountains north of al-Shafa but is under less threat from development and, apart from al-Shafa which has already changed, should not be forced to change.

Farm Terraces

These farmlands comprise:

a) banked wadi-bottom fields and larger terraced valleys, often recently enlarged or reinforced through government subsidy;

b) upland valley terraces both used and abandoned, especially if less accessible;

c) derelict hillside terraces.

The wadi bottom fields depend on wells and occasional flash floods, diverted by 2-2.5-m high, unsightly bulldozed banks as in Wadi Dhamiya and Wadi Nu'man. Mountain basins like Qawah and larger valley terraces depend mainly on wells although even in Wadi Ghadirain water is trucked to higher levels. Where access and water supply are good and alluvial soils remain, these areas thrive, and supply vegetables, fruit, and roses to Ta'if and Makkah.

The upland terraces depend equally on wells and rainfall, occasionally being scoured by floods. They are most productive just behind the edge of the scarp. However, even there, following four recent years of drought, many seem to be abandoned, especially the less accessible fields towards Jabal Sha'ar. This occurs even when terraces have been recently rebuilt and consolidated by bulldozer (causing erosion) to allow the use of tractors. At Rowaidhat hillside have been scaped and re-terraced for larger scale farming, causing extensive disturbance. In summer it also needs more water than is available without transport from wells in the wadi below. This invasion of a scenic area exemplifies a local land-use conflict.

Grazing

The increase in flocks of sheep and goats, assured by headage and feed subsidies and free water was assessed. The plateau and lands beneath the scarp are the most affected by grazing and locals claim that there are some 40,000 sheep on Quraishi and Hidaili lands. The flat wadi bottoms and hill sides extending up as far as 500 m, are all seriously overgrazed, especially within 5 km of wells. Free range meat is highly valued and many sheep are sold each year, but not to cull flocks to the carrying capacity of the land as in former times. Overgrazed land includes foothill slopes even 500 m above the wadi floors, plus the unfarmed juniper woodland and dry plateau hill tops. Lands grazed but not overgrazed are found on the top half of the scarp plus 1-2 km behind the scarp edge. Except for the wadi floors, there where there is scattered farmland, encroachment by flocks there is more controlled. A few areas are less grazed, all near al-Shafa, including the north slope of the royal palace. The honey hima on Jabal Juwahal is also assumed to be ungrazed (Figure 5).

Except where steep and inaccessible, most of the area is so overgrazed that honey production, once widespread and lucrative, is no longer so worthwhile. On the wadi floors, young acacia trees are eaten down to mis-shaped stumps and where the ground is not bare, the inedible prickly poppy has become dominant. In the Wadi Ma'an tree euphorbias (of a yet unnamed sub-species) have been cut and bled for fodder. Regeneration of the juniper woodland is being prevented by grazing. If a road is built along the edge of the scarp and it becomes developed, overgrazing will occur. However, sound range management, if practiced, might increase the productivity of the land and reduce soil erosion.

Himas

A hima is a traditional conservation area to restrict the overgrazing of rangeland, an institution that predates Islam. Two himas and one hojjra (individually owned reserve) were found in the study area:

1. Hima Quraisih (15 km²) lies on the hill tops between Wadi Ghadirain and Wadi Dhamiya. The grazing is for cattle only which are still used to plow small fields. It is controlled by four local sheikhs. In the past 5% of any trespassing sheep were confiscated but this is now illegal and protection is difficult. A larger buffer area might help. The hima is used for honey to some extent at Mahadd on the east side. This hill could be a site for a model rangeland.

2. The hojjra on Jabal Qosah (1 km²) is in a sheltered east-facing valley just south of Wadi Dhamiya. The grazing is for cattle only which are still used to plow small fields. It is controlled by four local sheikhs. In the past 5% of any trespassing sheep were confiscated but this is now illegal and protection is difficult. A larger buffer area might help. The hima is used for honey to some extent at Mahadd on the east side. This hill could be a site for a model rangeland.

3. Hima Jabal Juwahal (1 km²) is in the sheltered east-facing valley of Wadi Makhadhat. In a nook at the foot of a green hillside is a group of 75-80 stone honey houses, old and new. Each can take 14 log-hives, but less than 200 hives now seem to be in use. It is kept by a beekeeper on behalf of the tribe and its governing sheikhs.

These three areas are on the boundary between the sub-humid and semi-arid zones where succulent plants occur more frequently and the last junipers are found, about 4-7 km from the scarp. Himas seem little respected in the Quraishi lands but somewhat more by the Talhy branch of the Hidaili tribe on the plateau. Beneath the scarp there seem to be no himas, although one for olive tree firewood used to exist on the scarp slope below al-Shafa. The well-farmed Sufyan lands east of al-Shafa are said to have many small individual hojjras and at least two larger cattle himas.
Honey Production

The honey of Taif is highly valued, especially for medicinal uses, selling for S R 400-600/ kg. It should, therefore, be developed as a local renewable resource. In 1985 a government survey recorded 860 hives in the al-Hada area and 1,150 hives near al-Shafa, 95% being traditional in type (Ministry of Agriculture, 1984). However, traditional production is declining while a market has developed for large-scale producers who use syrups as much as nectars to produce a honey of commercial quality.

The main sources are mountain shrubs and some tree flowers: \textit{Lavandula dentata} gives the best white summer honey which comes also from \textit{Ostegia fruticosa}, \textit{Pulicaria undulata}, and \textit{Blepharis ciliaris}. A reddish spring honey comes from \textit{Psidium punctulata} which is held to have medicinal value. Winter honey is made from \textit{Acacia asak} and \textit{Ziziphus spina-christi} from the lower slopes and the Tihamah coastal plain where the hives are moved in winter. The dominant shrub \textit{Euryops arabica} is a source of beeswax.

The hives are 1.5 m X 30 cm hollow tree logs, that can be opened at the back end, laid 5–7 in a row either in a stone honey-house or under a weighted quilt in the open. Domestic hives may be anywhere near flowers but are often high on the mountain or concealed away from thieves as each log-hive may cost S R 2,500–3,000. One hive can produce from 7–15 kg of honey which is removed every 2–3 months, and two swarms a year. The comb is eaten. Swarms are attracted to a queen bee caged in straw fixed to a wooden cross tree.

Commercial producers may have 200–400 logs which are moved to follow flowers in bloom to avoid disease. They use syrup which is considered an adulteration. Some domestic hives are sited just below the scarp, as high as 2,400 m, where bees may forage but this is too cold, wet, and windy for large-scale production. The two honey \textit{himas} are at about 1,900 m in well-sheltered valleys on the east side of mountains along the edge of the semiarid zone, in locations where lack of water originally meant there was no competition from grazing. This interzone, about 4–7 km from the scarp, may be the optimal area for larger scale bee-keeping.

The main problems facing honey production are overgrazing, drought, and disease. Flocks are subsidized much more heavily than honey bees and eat most of the available flowers. Drought from 1988 to 1990 intensified this problem. The threats include an Australian parasite, ants which eat and blacken the wax, disease from Egyptian bees imported in the 1950s, which decimated the hives and are now wild, and pesticide sprays.

Rose Growing

The field crop for which the area of Taif is famous is the pink scented damask rose (\textit{Rosa damascena trigintipetala}). The market for attar exists in Makkah, amongst pilgrims, the rich, and the royal family, and a crop is often bought before it is planted. There is a tradition of expertise, two distilleries in Taif, and local conditions which make it quite profitable to grow roses. A small 10-gram phial of attar may take 10–15,000 blooms and cost S R 5–4,000 (about $1,000). To cut out the middlemen some growers also distil using a three-condensate process which also yields rose water. The roses need a well-watered, well-drained, slightly acid, and well-fertilized soil. The bushes are often planted round the edges of fields to benefit from the irrigation of the crop in the center. They are harvested in the early morning before the essential oils have evaporated, during one month in spring, by itinerant experts. Later blooms are taken for conserves and pot-pourri.

Planning and Development

Modern and Proposed Land Uses

Modern developments in the area are of five main types:

1. Subsidized agricultural improvements: These include chicken farms and wells, with field and terrace enlargement by bulldozer for mechanized farming. Rainfed agriculture is replaced by irrigated fields in all the major wadi bottoms, many minor valleys, and some hill sides, often resulting in soil erosion. Irrigated wadi-floor farms have developed as rainfed terraces were abandoned.

2. Road improvements: There is a new track from al-Shafa down the scarp but it is very steep and prone to landslips.

3. Institutions such as the military stations and hospital at al-Hada.

4. Tourist facilities such as the al-Hada Sheraton Hotel (refuge of the Kuwaiti government during the Gulf Crisis), the shops and amusement facilities at al-Shafa.

5. Private estates (many royal) and summer homes. Since 1972, except for limited personal use, development by local people, has been forbidden, even the topping of their own trees. The discontent that resulted led to an official study and subsequent report (Ministry of Municipal and Rural Affairs, 1990) which detailed a plan to regulate development which would follow the construction of new roads. By 1991, 17 sub-divisions had already been approved for al-Hada.

The plan, for which initial funding has been granted, proposes a road along the top of the escarpment, two roads connecting the scarp with Taif via Wadi Dhahiyya and Wadi Sinh, and a new highway up Wadi Nu'm'an, and the scarp north of Jabal Sha'ar. This road will bisect a national park proposed for the steep headwaters of Wadi Nu'm'an to be crossed later by a cable car. Nine tourist viewpoints along the scarp are suggested and a tourist village at al-Waht as well as social services, electricity, and the enlargement of al-Hada and al-Shafa.
Suitability Analysis for Land Uses

After detailed mapping of the natural and social factors, outline maps were analyzed by the research team using appropriate criteria for the suitability of each area for:

a) protection of the dominant vegetation as a basis for the establishment of a nature reserve;
b) limited recreational and tourist development compatible with the protection of natural resources;
c) sustainable agriculture.

The criteria used to define suitability for protection were: the density, ecological health, and diversity of woodland; effectiveness as a water catchment area; degree of vulnerability to existing uses; rarity of plant species; scenic quality; potential ibex habitat; and value for environmental education.

Using the outline maps and superimposing them on each other it was determined that where 60% of the critical factors coincided on the maps, a zone of primary protection was recommended. This included:

a) dense to medium-dense juniper woodland with abandoned terraces;
b) the escarpment slope with outlying peaks above 1,400 m (potential ibex habitat);
c) populations of rare and endangered plants on the plateau (tree euphorbias, aloes, carallumas, and huernias).

A zone of secondary protection was recommended for those areas where an equally high quality natural environment is intermixed with existing terraced farms and grazing. This covers:

- a) dense to medium-dense woodland surrounding farmed terraces;
- b) open woodland along the escarpment edge;
- c) Hima Jabal Juwwah.

The N.C.W.C.D. definition of a *hima* is a nature reserve, graded according to its degree of protection. The core zone would therefore comprise a Special Nature Hima: (a) and (b) above, and a Biological Hima: (c), with a Natural Hima in the secondary protection zone where existing uses make it more difficult to protect the area from degradation.

A zone of tertiary protection was recommended comprising areas where 25% of the superimposed criteria coincided. This zone includes:

a) the plateau up to the limit of sparse juniper woodland, including Hima Quraish and Hajjra al-Qosah;
b) the foothills and lower scarp slopes above the wadi floors between the mouth of Wadi Rahjan, the head of Wadi Dhim, and the headwaters of Wadi al-Shara, below al-Shafa. This area was recommended as a Resource Use *hima* or buffer zone between protected and unregulated land.

Suitability for tourism and recreation was also mapped in three classes. The main criteria were location outside the primary protection zones and accessibility to roads and services.

In addition, suitability for agricultural use was mapped in three classes based on the evidence of existing farmland.

The Master Plan

The area is one of relatively undisturbed habitat, close to major centers of population that partly depend on it for water supply, and which was opened to development in 1990 by decree. The integrity of its natural resources should be protected and a plan complementary to that made by the Ministry of Municipal and Rural Affairs should be drawn up to guide the development and sustained management of a national nature reserve and recreation area. The recommended Master Plan is shown in Figure 6.

The Local Interests

The local people most concerned are:

a) the Quraish, Hidail, and Bani Sufyan tribes who all wish to benefit from better services and facilities, farm improvements, and regulated development, but fear the disruption of their tribal lands by outsiders; they should be involved in both planning and benefits as well as compensated for loss of lands;
b) the local emirates who wish to promote tourism with its attendant benefits to the area, through the roads, facilities, and a national recreation area proposed by the Ministry of Municipal and Rural Affairs;
c) the local Ministry of Agriculture and Water who wish to conserve the valuable aquifer recharge areas and also to encourage viable local agriculture;
d) the N.C.W.C.D. who are concerned about protection of juniper forests and abandoned terraces of the catchment headwaters, endangered plants, the regionally outstanding landscape, and the promotion of sustainable activities to support this policy;
e) the people of nearby cities and elsewhere, both those wanting to build vacation homes and others who will want to use whatever new roads and recreation facilities are built.

The Primary Management Objectives

a) preservation of juniper woodlands together with associated natural plant and animal communities through a management program for the regeneration and expansion of the forest in potentially suitable habitats;
b) protection of the Wadi Wijj water catchment woodland and aquifer recharge areas, and of abandoned terraces retaining soil and water by the prevention of overgrazing, logging, development, erosion, and pollution;
c) protection of wildlife and potential wildlife habitats, especially ibex habitats for a supervised reintroduction of this species;
Figure 6. The study masterplan.
The Secondary Management Objectives

a) protection of vulnerable outstanding scenery and indigenous flora and fauna along the escarpment and in the highlands to maintain the essential basis for sustainable tourism and recreation, and for scientific research and education;

b) promotion by subsidy of manual repair and reforestation with juniper of abandoned terraces and hillsides; establishment of a tree nursery and research farm to experiment with, and propagate juniper and sweet olive trees to encourage their planting in suitable areas to benefit the local economy;

c) promotion of sustainable traditional farming (rose culture, bee-keeping, market gardening), and related rural industries (rose attar and rose water production) compatible with conservation, through the government agricultural extension service subsidies and the provision of irrigation water;

d) promotion of sustainable grazing practices by the establishment and maintenance of a range management program that regulates grazing in resource use areas to ensure long-term production of protein by free range local sheep. This could start with the removal of subsidies on feed, and the setting aside of a model rangeland to demonstrate rotational grazing;

e) provision and maintenance of outdoor recreation facilities and services which meet internationally accepted standards;

f) protection by controls, and restriction of development to long-term residents only, and to activities necessary to the protected areas, limiting the profit from these developments to local people in return for their commitment to conservation;

g) support of the Ministry of Municipal and Rural Affairs plans to concentrate urban and tourist developments within the al-Hada, al-Shafa, and al-Wahat areas.

The Nature Reserve and Visitor Center
The Reserve will need an administrative and educational center, which could be accompanied by wildlife displays, and nature trails, a tree nursery, and research farm. There could be holiday chalets, a model area of managed rangeland, and traditional farm, and perhaps an ibex release site. These facilities could be dispersed or grouped, either in the north near Al-Al Hada, in the center west of Taif, or in the south near al-Shafa.

For the purpose of illustrating the concept and providing a basis for student designs, a Visitors' Center was projected at the north end of the proposed protected area, near to the main points of entry from Taif, Makkah, and Jeddah. This is at Qadirim, south of the military reserve at al-Hada and Jabal Habalah, where the lip of the scarp can be reached.

The Visitors' Center would be part of a group of facilities that interpret or teach local ecology and conservation. The wildlife exhibit proposed is a fenced display including the low rocky peak above the Center, and an adjacent small hill, for ibex and idmi gazelle, each in its own habitat, needing no separating fence. The tree nursery and research farm in an adjacent wooded valley would produce both species of juniper. Experimentation with crops such as sweet olives, long-flowering roses, and bee-keeping could also be included. For example, hybrids of the European olive with small native sweet olive could be of future economic importance.

A farm demonstrating traditional terraced agriculture, especially rose growing, could be established nearby in Wadi Ghadirain, and small rental holiday chalets designed using local materials could be built nearby, perhaps at al-Iifar, 5 km south, and in other suitable sites. Managed rangeland and sustainable grazing can be demonstrated in an area bordering the semi-arid zone, for instance on Jabel Him a or Quraish. It could be divided into four units along topographic boundaries and grazed on a four-year cycle.

Management Recommendations
For the maintenance of the Nature Reserve a management structure was proposed of administrator; botanist and/or zoologist at a Visitors' Center in charge of research education and outreach programs; a nursery farm manager; a chief warden plus four field wardens, one each for highlands, plateau, escarpment slope, and foothills; a maintenance engineer and an office manager. All would be assisted by staff and as far as possible all personnel should be recruited from the local people. This would take advantage of local pride and knowledge, and be seen to be economically benefiting the population most impacted, rather than outsiders.

SUMMARY OF MAJOR RECOMMENDATIONS
The study recommended that the following areas should be designated according to the categories used by the N.C.W.C.D. (Figure 6).

Special Nature Himas: Strict Protection
This is the dense to medium-dense juniper woodland with abandoned terraces, plus the escarpment slope above 1,400 m.
- The core juniper woodland catchment area must be strictly protected; old terraces should be repaired and reforested with juniper.
• The upper escarpment above 1,400 m should be set aside as an ibex preserve.
• Prohibit hunting, shooting, grazing, tree-cutting, visitors without permit, and new road building; but schedule regular visits guided by rangers.
• Build a rangers headquarters and appoint a Chief Warden and rangers for each main zone of the area.

BIOLOGICAL HIMAS: Strict Protection
These are the populations of rare and endangered succulent plants (tree euphorbias, aloes, carallumas, huernias)
• These plants should be fenced where possible and strictly protected; prohibit grazing.

NATURAL HIMAS: Strict Protection with Conservation for Agriculture.
This is the dense to medium-dense juniper woodland surrounding farmed terraces, the open woodland along the escarpment edge, and Hima Jabal Juwwah
• The core juniper woodland catchment area must be strictly protected and rehabilitated, and the escarpment protected from development for 1,000 m behind the edge.
• Extension and large-scale development within the agricultural enclaves should be prohibited; compensation should be offered for any lands or rights taken, and benefits conferred, in return for local commitment to conservation.
• Prohibit hunting, shooting, grazing, tree-cutting, new roads, tracks, and all private engineering works and buildings within enclaves, if licensed.
• Preserve good examples of traditional terrace agriculture and old houses for their heritage and tourist value.
• Build a visitors’ interpretative center with an adjacent wildlife display for ibex and mountain gazelle as the headquarters of a public outreach program in conservation.
• Establish a tree nursery to research new crops and promote juniper reforestation.
• Appoint managers for the Center and the farm, both with appropriate staff.

RESOURCE USE HIMAS: Conservation
This is the plateau up to the limit of sparse juniper woodland plus Hima Quraish and Hojjra al-Qosah; also the lower scarp slopes and foothills between the mouth of Wadi Rahjan, the head of Wadi Dhim, and the headwaters of Wadi al-Shara, below al-Shafa.
• On the plateau subsidize and encourage traditional terrace agriculture, especially rose farming and beekeeping. Permit only regulated development.
• Prohibit unlicensed woodcutting and hunting.
• Discontinue feed subsidies to flocks, re-allocating subsidies for sustainable crops; permit grazing only within agreed limits for family use; establish a model rangeland to demonstrate rotational grazing practices.
• Regulate the development of recreational facilities: chalets, viewpoints, nature trails, camping and picnic grounds. Limit the profit from these activities to local long-term residents in return for their commitment to conservation.
• Mitigate the scars of engineering works by use of hydro-seeding, planting, and stone rip-rap where appropriate.

DEVELOPMENT AREAS:
These are the villages of al-Hada, al-Shafa, al-Waht and Qawah.
• Support the M.O.M.R.A plans to concentrate urbanization and most large-scale tourist development within these areas but with less emphasis on Qawah which is undeveloped.

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