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Vegetation on the northern Arabian Shield and adjacent sand seas

by

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ABSTRACT

Vegetation forms a scanty but diffuse, permanent shrub cover on the arid landscape of north-central Saudi Arabia. Floristically the area is dominated by the large transition zone between the Mediterranean and saharo-sindian regions. In general, vegetation types in north-central Saudi Arabia are dominated by Mediterranean flora except on the Arabian Shield peneplains, where the vegetation is typical of the saharo-sindian deserts. Vegetation distribution on the landscape correlates with six general landscape units; however, our information on floristic composition and seasonal changes is not complete enough to create phytosociological units.

In arid to extremely arid climate that prevails over the region, vegetation distribution is primarily dependent on the amount of soil moisture available to plants. Topography and sediment texture and thickness are the factors that control moisture availability: plant density is greatest in wadis (stream channels), depressions, and dunes where runoff collects and is partly protected from evaporation by medium- to coarse-grained sediments; and plant density is minimal on extensive bedrock plains that are overlain by a thin desert pavement.

Rocky, high relief areas support shrub and tree vegetation with tufted grasses and herbs; Rhus tripartita and Cymbopogon are common. Surrounding sandy pediments are covered by chenopods; primarily Anabasis and Hammada, along with Fagonia, Astragalus and many herbs. Wadis in the mountains support Acacia, Ochradenus, Artemisia, and Ballota, and wadis on the pediments support both Acacia and Lycium.

Rhanterium, Fagonia and Astragalus are the dominant shrubs of the extensive serir plains of the Arabian Shield. Anabasis and Hammada are common on sandy plains, and the large, sandy wadis on the Arabian Shield support an Acacia-Panicum vegetation. Along the margins of playas located on the plains, the density of Rhanterium increases and Artemisia is present.

The sand seas support a diffuse plant cover of shrubs and tufted grasses; both the number of species and plant density are greater on dunes than on the bedrock plains. Cyperaceae, Artemisia monosperma, Calligonum comosum, Stipagrostis drarii and Cyperus conglomeratus are the most common plants. Ahab florals are common at the foot of dunes following rainstorms. Plantago, Monosonia, Stipagrostis plumosa, Moltkiopsis, and Filago are among the common herbs. A sparse cover of Helianthus and Fagonia is found on lake beds and duricrusts that are sometimes present in the interdunal depressions.

INTRODUCTION and ACKNOWLEDGMENTS

This report is a description of the vegetation of north-central Saudi Arabia and is part of a series of studies on the modern and Quaternary environments of western Saudi Arabia. Pluvial deposits of Pleistocene and Holocene age have been recognized in the sand seas on the Arabian Peninsula (McClure, 1976; Whitney and others, 1983) and on the vast peneplains of central and western Saudi Arabia (Al-Sayari and Zötl, 1978; Whitney, 1983). In order to compare Pleistocene and Holocene environments with the present environment, it is essential to understand the modern vegetation distribution and its relationship to the present climate.

The flora of Saudi Arabia has been compiled by Blatter (1919-1936), Schwarz (1936), and Migahid (1978); however, most of our present knowledge of the vegetation of Saudi Arabia is based on the pioneering work of Vesey-Fitzgerald (1955, 1957a, 1957b), Popov (1965), and Zohary (1973). Recent publications have appeared on the vegetation of Kuwait and Qatar, two countries at the eastern edge of the Arabian Peninsula (Halwagy, and others, 1982; Batanouny, 1981), and on the vegetation of the Jeddah-Mecca region on the Red Sea coast (Batanouny, 1979). Large regions on the Arabian Peninsula, however, have not been botanically described in any great detail.

Our study area covered the northern part of the Arabian Shield, an exposed complex of Precambrian igneous and metamorphic rocks, and part of the large belt of Phanerozoic formations that overlap the northern and eastern edge of the shield. Three sand seas were also visited: An Nafud, Nafud As Sirr, and Nafud Urayk (fig 1). The altitude of the plains in the Jebel Shamar region is about 1000 m, and the relative height of the mountains and escarpments varies from 100 to 600 m for the mountains and from 50 to 300 m for the escarpments.

The present study was conducted in November and December of 1981, and is the first description of modern vegetation types and their distribution in north-central Saudi Arabia. A vehicle traverse was made from the Hail area to the town of Buraydah, and then west to the basalt plateaus at the west edge of the Arabian Shield near Medina. Vehicle side trips were made on the plains south of Hail, along Wadi Rimah, and to Nafud As Sirr. Helicopter traverses were made into Nafud Urayk and An Nafud sand seas, and into Jabal Aja. These traverses crossed several distinct physiographic environments; thus, we describe the vegetation as it is distributed on six different landscape units: inselbergs and escarpments, pediments, peneplains, playas, large and small wadis (ephemeral stream channels), and sand seas. Modern pollen was collected during the vehicle traverses and will be reported in a separate paper with the results of our paleoenvironmental investigation.

We are grateful to R. Jackson, Chief of Mission, U. S. Geological Survey in Jeddah for support of this study and to Professor H. Scholz, Berlin, for identification of the Gramineae. K. Weppler, Würzburg, kindly drafted most of the figures. Laboratory support and facilities were provided by the Geographical Institute at the University of Würzburg. This manuscript has benefited from the careful reviews of H. T. Shacklette and R. M. Turner, both of the U.S. Geological Survey.

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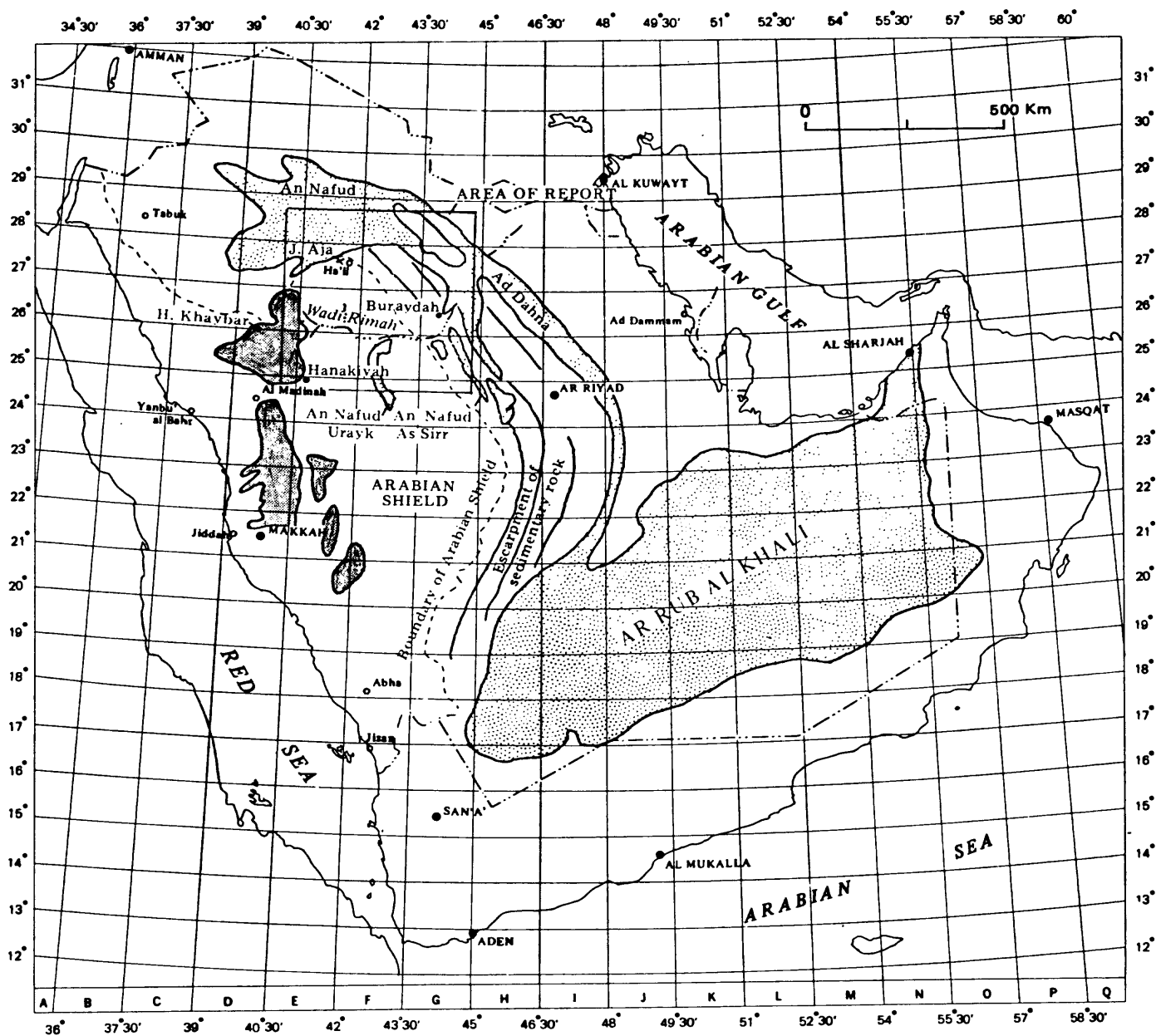


Figure 1: Simplified physiographic map of Saudi Arabia showing location of study area and places mentioned in text. Dotted areas are sand seas and shaded areas are basalt plateaus.

work agreement between the U.S. Geological Survey and the Saudi Arabian Ministry of Petroleum and Mineral Resources.

CLIMATE

North-central Saudi Arabia is presently arid to extremely arid. Extremely arid regions are climatically defined as receiving less than 100 mm precipitation a year (Walter, 1973). From the climate diagrams (Walter, 1964, 1973) in fig. 2, a clear difference is seen between the balanced, oceanic temperature regime of Jeddah, which is located on the Red Sea coast, and the greater temperature amplitudes in the continental region of Hail and Ar Riyad.

Mean annual temperatures vary across the study area from 24⁰ to 19⁰C. Average summer temperatures range from about 30⁰C in the An Nafud to 36⁰C in the Wadi Rimah region. Winter temperatures are also cooler in the north, ranging from 8⁰ to 12⁰C, and warmer on the Arabian Shield in the south, ranging from 12⁰ to 16⁰C (Bindagji, 1980). The coincidence of winter precipitation and cool temperatures are partly responsible for the effectiveness of the low rainfall in the study area, because potential evaporation at this time of year is at a minimum. Unfortunately, potential-evaporation data are not yet available for Saudi Arabia.

Annual rainfall ranges from slightly less than 50 mm in the An Nafud to slightly more than 100 mm in the cuesta region east of Buraydah and on the northern Arabian Shield (Whitney, 1983). The only meteorological station lying in the An Nafud (Jubbah) has averaged 41 mm a year for six years of record (Whitney and others, 1983). The region receives its precipitation primarily from winter cyclones that originate in the Mediterranean Sea and eastern Atlantic Ocean. Occasionally hail and snow fall during these winter storms. Cyclonic storms usually follow narrow paths across northern Arabia, normally releasing moisture in heavy rainstorms, and occasionally in hail or snowstorms. On rare occasions a summer storm from the south indicates that a minor influence from the summer monsoon will reach the study area. In characterizing the environment, we must stress that rainfall over the study area is very irregular, and that this irregular distribution of precipitation is characteristic of arid and extremely arid regions in the subtropical deserts.

The prevailing winds in the An Nafud sand sea are trades from the northwest; wind storms may occur at any time of year, but are most frequent in the spring. In Hail, the principal winds are from both the northeast and southwest, while farther to the east in Buraydah they are only from the northeast. The northerly winds (shamals) originate in the Tigris-Euphrates valley. The shifting of prevailing winds from westerlies to northeasterlies is partly responsible for the geometry and distribution of the sand seas on and around the Arabian Shield (Whitney and others, 1983).

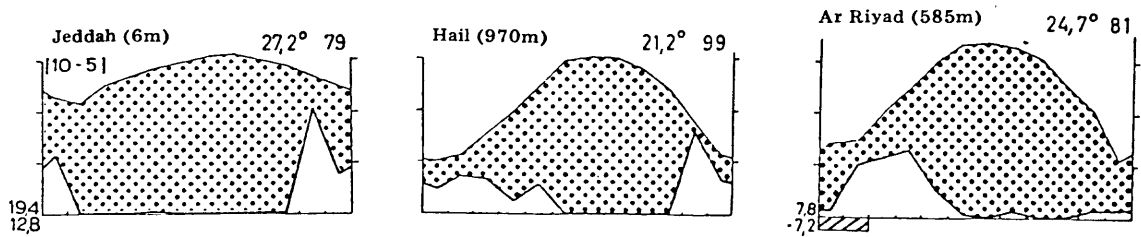


Figure 2: Climate diagrams of Jeddah, Hail and Ar Riyadh (after Walter and Lieth, 1960). The months (January-December) are on the abscissa; one division equals 10°C on the right ordinate or 20 mm of precipitation on the left ordinate. To the right of the station name are station altitude, mean annual temperature, and mean annual precipitation in mm. In the lower left corner, the upper number is the mean daily minimum of the coldest month and the lower number is the lowest temperature recorded. Months with diagonal shading have minimum temperatures below 0°C.

GEOLOGY OF THE LANDSCAPE UNITS

Our vegetation traverses crossed three physiographic provinces of north-central Saudi Arabia: peneplains of the Arabian Shield, low escarpments of the Phanerozoic formations, and sand seas. Within these provinces, six landscape units are distinguished to describe modern vegetation distribution: peneplains, pediments, inselbergs (isolated mountains) and escarpments, playas, wadis (ephemeral stream channels), and sand seas. However, variation in vegetation distribution occurs within some landscape units, and some borders between units can be difficult to define.

The landscape of north-central Arabia is dominated by the peneplains and inselbergs of the Arabian Shield. The Arabian Shield is an old continental landmass that is composed of Precambrian metamorphic and igneous rocks. Peneplanation of the landmass began during late Precambrian time, and continued until early Paleozoic time, when the surface was buried by Nubian-type sandstones. This surface was exhumed, reburied, and re-exhumed several times during Paleozoic, Mesozoic, and Tertiary times (Whitney, 1983). Repeated erosion of the surface, primarily under conditions of tropical weathering, created extensive low gradient plains, or peneplains (Blüdel, 1982). The surface gradient from the western edge of the study area to the village of Buraydah dips eastward at only about one meter per kilometer of distance.

There is normally very little soil overlying the extensive bedrock plains. Most surfaces are underlain by bedrock with a thin veneer of gravel or coarsely weathered residuum. Under present arid conditions, rock weathering is slow and fine-grained sediments are deflated by winds. Remnant fine-grained, alluvial deposits are found at constricted stretches along wadis and on alluvial fans in and adjacent to the inselbergs.

Most of the inselbergs on the Shield are remnants of granite plutons that intruded into the ancient landmass in late Precambrian time. Jabal Aja, situated between Hail and the An Nafud, is the largest inselberg in this area. The top of the mountain is about 500 m above the present erosion plain. Former weathering surfaces can be seen on the north side of the jebel, and narrow valleys that contain sandy alluvium have developed along faults and fractures in the mountain mass. Pediments are commonly found around the base of inselbergs and these rock-cut surfaces merge, sometimes imperceptibly, with the extensive peneplains. Pediments may have exposed bedrock surfaces, or may be overlain by alluvium derived from adjacent areas of high relief.

The eastern edge of the Arabian Shield is defined by a series of escarpments or cuerdas that are composed of Paleozoic to Mesozoic sandstones and limestones. These cuerdas generally have a 100-150 m high escarpment with a gentle back slope defined by the low dip of the formation. Pediments are found at the base of the escarpments and commonly terminate at topographic depressions that normally contain playas and dunes of the Ad Dahna sand sea. Playas are also found on the peneplains and in wadis where dunes have blocked former watercourses: for example, Pleistocene age dunes have filled Wadi Rimah east of Buraydah, which has resulted in the ponding of all surface runoff. A large playa has also formed on the north side of Jabal Aja because drainage off the jabal (Arabic word for mountain) is obstructed by the dunes of the An Nafud.

Most of the wadis on the peneplain are part of the Wadi Rimah drainage, which probably developed during the late Tertiary after the Arabian Shield was uplifted and tilted slightly east. Streams on the peneplain are incised only a few meters and tend to be filled with silty sand and local gravel lenses. Flood plains in many places merge with the general erosion surface. In contrast to wadis on the plains, mountain wadis are situated in narrow, confined valleys and receive more frequent local runoff. Deposits in mountain wadis vary from silts and sands to coarse boulders, and in some wadis all deposits have been flushed out, exposing bedrock in the channel.

The sand seas in Saudi Arabia are products of Quaternary episodes of increased eolian activity. The An Nafud is situated just north of the Arabian Shield and is composed chiefly of 60-120-m-high barchanoid and transverse dunes. In the central An Nafud, dunes are arranged in a linear pattern but they do not form true longitudinal dunes (seifs). At the eastern edge of the An Nafud, the influence of multiple winds has resulted in the formation of large star dunes (draa). Farther east northerly winds are dominant and the sands of the An Nafud have been blown south to form the longitudinal dunes of the Ad Dahna. Nafud Urayk is a small sand sea that lies completely on the Arabian Shield; it is confined by several inselbergs and by tributaries of Wadi Rimah.

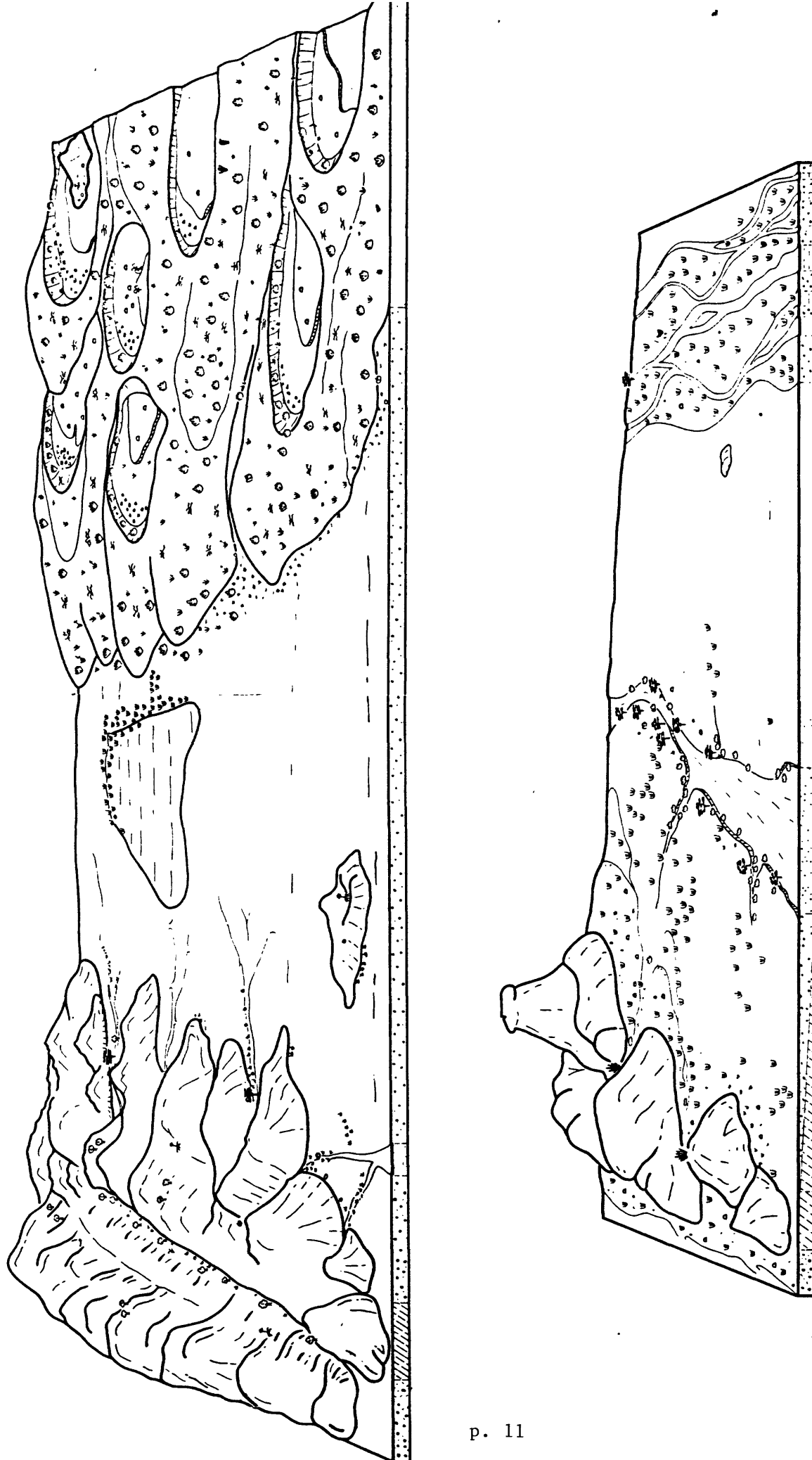
Interdunal depressions are common in all sand seas, and remnant lake beds are exposed in some of these depressions. The lakebeds were deposited during at least two different late Quaternary episodes of increased effective precipitation (Whitney, 1981). The older lake beds range in age from about 34,000 BP to 24,000 BP and are overlain by the large, principal dunes; the younger lakebeds are middle Holocene in age and are found in the present interdunal depressions (Whitney and others, 1983).

VEGETATION TYPES AND DISTRIBUTION

Past descriptions of the vegetation in the An Nafud and adjacent areas are conflicting. Nineteenth Century travellers Blunt (1881) and Euting (1896) described excellent pasturage with large and numerous bushes in the An Nafud; whereas Zohary (1973) described the region as part of the Mediterranean to sahara-arabian steppe, and Barth (1983) described the same area as a vegetationless core desert. These conflicting descriptions point out the difficulty in characterizing treeless vegetation in semiarid and arid environments. Originally, a steppe environment referred to the formation of herbaceous plants and sod grasses (Zohary, 1973); however, steppe is now widely used to describe all kinds of treeless environments. Thus, the term is too general to be applied in arid environments.

Definitions of what is called desert and semidesert are numerous. Although these definitions are based on various meteorological and ecological criteria, we need a practical definition to be able to compare vegetation in different regions. For this paper, then, we distinguish between semideserts and deserts on the basis of vegetation cover as described by Monod (1954) and Walter (1964); semideserts exhibit a permanent diffuse vegetation on the landscape that is dependent on annual rainfall, whereas permanent vegetation

Figure 3: Schematic illustrations of the relationship between different landscape-vegetation units: (A) the Jabal Shamar-An Nafud area; (B) Typical inselbergs, pediments and plains on the Arabian Shield.



in a true desert is restricted to wadis and depressions, where collected runoff is stored or ground water is available to root systems.

Zohary (1973) also distinguished between permanent and diffuse desert vegetation in the Middle East by referring to the former as a "true desert" and to the latter as a "rain desert". By definition, Zohary's steppe vegetation is found in the "rain desert", and desert vegetation is found in the "true desert". We prefer the terms desert and semidesert because these terms are widely used in the North African deserts, and because of the potential confusion over the definition of steppe vegetation.

The study area has, for the most part, a sparse but diffuse permanent vegetation. Thus, it is part of the large belt of semideserts that are situated south of the Mediterranean Sea and are influenced by both Mediterranean flora and climate. On the peneplains in the southern part of the study area, an enrichment of perennial and annual vegetation occurs along both large and small wadis. Vegetation types are typical of the saharo-sindian deserts: Acacia-Panicum; the shrub vegetation of Chenopodiaceae (Anabasis/Hammada); and the Artemisia-Calligonum communities of the dunes.

The principal vegetation types and their distribution are described in association with different landscape units where they occur. It is too early to construct phytosociological units because information at the present time on the seasonal changes of species composition within each landscape unit is insufficient. Our traverses took place only during the winter season and were not extensive enough to describe the complete vegetation of the region. Because the study area is mostly covered by scanty and diffuse permanent vegetation, the vegetation-landscape units are defined by the perennials. Only a few of the many different achab floras (short-term rain floras) were in bloom during our field collections, and these herbs are mentioned only where they were found.

In order to present an accurate description of the vegetation of north-central Saudi Arabia, vegetation records for each site are given in Table 1 in the standard phytosociological presentation. Table 2 lists the location of the plant collection sites, and an annotated list of collected plants is given in the Appendix. Numbers given in parentheses at the end of vegetation descriptions in the text refer to plant records at individual sites on Table 1.

Typical relationships between the different landscape-vegetation units are schematically illustrated in figure 3a and 3b. The northern edge of the Arabian Shield and An Nafud sand sea are represented on figure 3a and typical inselbergs, wadis, pediments, and peneplain on the shield are shown on figure 3b.

The mountains support a very open plant cover of scattered Rhus tripartita trees, shrubs, and small tufted grasses (Cymbopogon sp.), Centaurea, and Rumex vesicarius. In areas where fine-grained sediments have been deposited, or behind manmade barrages (fig. 4), there is a dense cover of grass and herb vegetation consisting of Calendula, Stipagrostis, Plantago, Launea, Rumex and others. The vegetation of the mountains is heavily overgrazed, as is vegetation in most other environments in the Kingdom.



Figure 4: Jabal Aja (about 30 km northwest of Hail) at about 1200 m altitude showing a small man-made barrage and field. Rhus tripartita, Cymbopogon are found on the rocks, and a dense grass cover is on the fine-grained sediment behind the barrage.

On the lower slopes of the mountains, on rock talus, and in the upper reaches of mountain wadis that contain gravels and boulders, shrubs are the dominant vegetation, especially Ochradenus baccatus, Astragalus sp., Anabasis Zilla, Helianthemum, and Fagonia, together with a few small acacias like A. gerrardii and A. tortilis. Common herbs found in this environmental niche are Stipagrostis plumosa, Scrophularia, Erodium and Heliotropium (31, 33-35. Numbers refer to collection sites on Table 1).

Vegetation on the large pediments adjacent to the mountains is dominated by the shrub Anabasis, especially on surfaces (serir) that are overlain by a thin cover of coarse sand and gravel (fig. 5). Anabasis is commonly found with Zilla, Astragalus, Blepharis, and some Rhanterium. Common herbs on the pediments are Trigonella, Cynodon, Launaea, and Linaria. This vegetation is very sparse, but still diffuse, and there is some vegetation enrichment along small drainage lines (27, 28).

Where there are small incised wadis, groups of Lycium shawii are typically distributed on slopes and small terraces (fig. 6), whereas Anabasis and Rhanterium still dominate on the plain (28). Groups of acacias (A. tortilis and A. gerrardii) are commonly found at the junction of smaller wadis in association with an understory composed of Lycium, Zilla, Astragalus together with Launaea, Medicago, and Aristida adscensionis (fig. 7). In the actual channel (thalweg), vegetation is sometimes absent because of frequent water erosion (29).

At the eastern edge of the Harrat Khaybar (a basalt plateau), the larger wadis support a vegetation that is similar to the Saharan Acacia-Panicum community. Acacia tortilis and A. ehrenbergiana, Aerva javanica, Panicum turgidum, Zilla spinosa and Rhazya stricta are the most common elements on the coarse sediments in the wadis. Fagonia and Cymbopogon are also common (38) and large stands of the doum-palm, Hyphaene thebaica, are present in the larger wadis. The vegetation on and adjacent to the basalt harrat at first gave us the impression that this region was a transition zone between the Mediterranean-influenced semideserts and the tropically influenced deserts; however, diffuse, sparse vegetation is present on all basalt slopes and surfaces. Vegetation traverses are needed south across the Arabian Shield to document whether or not a true botanical desert, similar to the central Sahara, exists in Saudi Arabia.

The wide plains that compose the Arabian Shield peneplain commonly exhibit few permanent vegetation types, except where surface runoff has collected in playas and in the few large wadis that traverse the peneplain. The wide plains on the Arabian Shield are the areas of least moisture availability in northern Saudi Arabia and do approach a true desert in areas where permanent vegetation is very sparse and vegetation is enriched only in depressions and stream channels. Rhanterium is the dominant shrub on serir plains that have a surface layer of gravel and semiconsolidated silt and sand (schaumboden); in fact, Vesey-Fitzgerald (1957b) referred to these plains as a "Rhanterium steppe". Astragalus and Fagonia are also common on these arid, gravelly plains (24). Some areas on the plains are overlain by unconsolidated sandy deposits and the vegetation on these surfaces is similar to that found on sandy deposits in wadis; Anabasis communities are dominant together with Hammada and some Salsola. Fagonia, Zilla and a few geophytes such as Asphodelus are additional elements (25).



Figure 5: Inselberg with pediments about 30 km southwest of Hail;
sparse Anabasis shrub vegetation.



Figure 6: Inselberg group about 30 km southwest of Hail; small wadi in the lower pediment with Lycium-Anabasis shrubs.



Figure 7: Wadi about 30km southwest of Hail supports Acacia gerardii-A.tortilis, Lycium shawii, Anabasis articulata.

On the extensive, flat plains, Anabasis vegetation is clearly limited in distribution to sand-and-gravel-filled wadis (fig. 8), flood plains, and low alluvial terraces. Commonly found with Anabasis are Fagonia sp. and a few annuals like Stipagrostis plumosa or geophytes such as Asphodelus tenuifolius.

In northern Saudi Arabia the richest floral environment is that of the sand seas. This observation is in direct contrast to that of Vesey-Fitzgerald, who wrote that "the greater part of the sand seas is permanently bare..." (1957, p. 781). Both the dunes (fig. 9) and interdune areas (fig. 10) contain a wide variety of vegetation types. In the An Nafud the lower dune slopes are mantled by a relatively dense and rich shrub and herb cover. The perennials are dominated by Anabasis, Artemisia monosperma, and Stipagrostis drarii. Frequently found are achab florals composed of Monsonia, Plantago, Astenatherum, Stipagrostis plumosa, Moltkiopsis, and Filago. Achab florals are common at the edge of the dunes, where moisture seeps from the dunes, and in the interdune depressions, where seepage and runoff collects from the dunes (2, 7 10). After a winter rainstorm, the achab flora forms an impressive green carpet on the lower dunes and interdunes, and the Bedu (nomads) waste little time bringing their flocks to rain-replenished regions.

The lower and middle parts of the dune slopes support a diffuse perennial vegetation of tufted grasses such as Stipagrostis drarii, and Cyperaceae such as Cyperus conglomeratus; and shrubs such as Calligonum comosum, Artemisia monosperma and a few Anabasis. In areas of moister sand, many geophytes and annuals are found, along with Monsonia, Moltkiopsis, Stipagrostis plumosa, Astenatherum, Filago, Centaurea, Asphodelus, and Allium. Eremobium and Neurada are also common (2, 3, 10, 11, 12, 14, 15).

The upper parts of the dunes have a similar cover of Artemisia, Cyperus conglomeratus, Stipagrostis drarii, and Calligonum comosum; however, only a few annuals like Stipagrostis plumosa are present. This type of diffuse vegetation is very common for all dune areas (fig. 9), and is evidence that the dunes are stabilized; that is, the dunes are not active in the present climate.

Ephedra alata is found on the dunes, but is relatively rare. We could not find individual plants of this species farther south than about 70 km northwest of Hail.

The interdune depressions have different shrub vegetation from the surrounding dunes. Helianthemum lippii and Rhanterium epapposum are found on calcareous lake deposits and duricrusts, but usually in sparse distribution. Fagonia arabica, Eremobium sp., and different Plantagos are commonly found in sandy interdune areas. In the center of some depressions, small runoff channels have incised the substrate, and commonly support Lycium and Astragalus spinosus together with Fagonia. Around the edge of interdune playas, Anabasis forms a belt of vegetation at the margin of fine-grained deposits of calcareous or gypsiferous silt.

In some of the larger depressions we visited, trees and shrubs of Haloxylon persicum were present on calcareous crusts that were underlain by older eolian sand, and also on the dune slopes. At one interdune depression in the Nafud Urayk, there is a relatively dense cover of Haloxylon shrubs on the lower part of the dunes, whereas the bottom of the depression was settled



Figure 8: Typical large shallow wadi on the peneplain, about 20 km southwest of Hail.

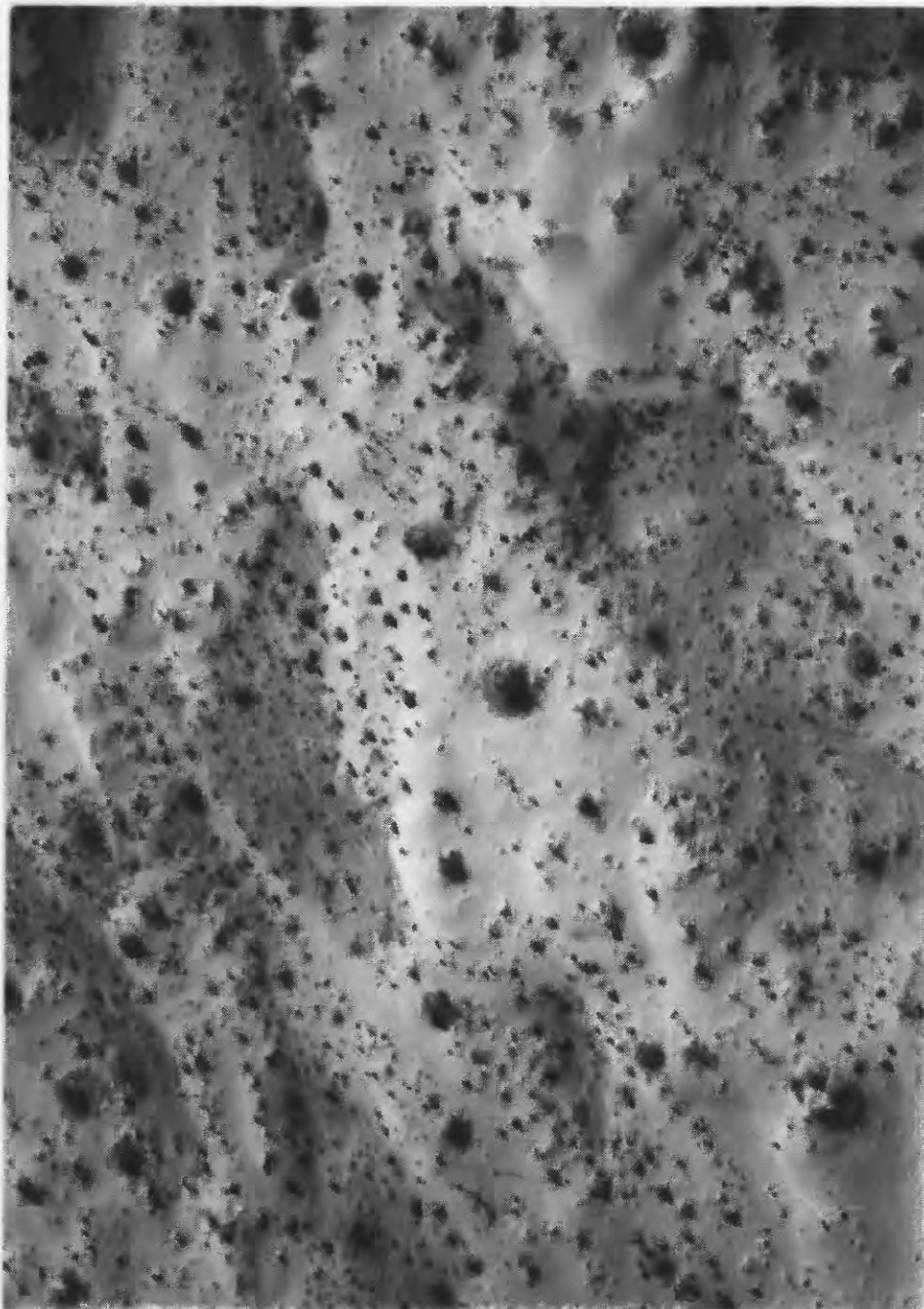


Figure 9: Diffuse permanent vegetation on the dunes of the southern An Nafud, located about 50 km northwest of Hail; a vertical view of the Calligonum-Artemisia-Stipagrostis-Cyperus vegetation.



Figure 10: Dune depression located about 70 km northwest of Hail; Haloxylon persicum on the ground. Artemisia, Calligonum, Stipagrostis and Cyperus on the dune slope.

by a thick cover of Anabasis articulata and Hammada sp. Occasionally found at the base of large dunes were large Tamarix aphylla trees (fig. 11) that indicate the dunes store a significant amount of shallow ground water (9, 13, 16, 17, 22).

Bedrock outcrops are sometimes exposed in interdune depressions. Common plants found in the rock fractures are Forsskalaea, Gypsophila, Pennisetum orientale, Rumex and Heliotropium. This vegetation is related to that in the mountains on the Arabian Shield (30).

Playas are similar to interdune depressions because both are water- and sediment-collecting basins. Surrounding a playa located between Jabal Shammar and the An Nafud (fig. 3A and fig. 12) is a different shrub vegetation than that found in the dunes; the two shrubs are Artemisia herba-alba and Rhanterium epapposum, and are found with Trigonella, Eremobium, Neurada and Plantago. This shrub community is more characteristic of the large plains that are overlain by thin, coarse-grained deposits of alluvium or residuum.

DISCUSSION

Clearly defined floristic and phytosociological units for the permanent vegetation, as they are defined by Zohary (1973) for the Arabian Peninsula, were not observed on the landscape of north-central Saudi Arabia. In our opinion it is too early to create such phytosociological units in a semidesert region of large transition zones, because local environmental factors such as topography, aspect, sediment type, and local moisture conditions are the dominant influence on vegetation distribution. Furthermore, our knowledge and understanding of the total vegetation distribution, types, and floristic composition are still minimal for this region. Our traverses across plains and sand seas indicate that within a system of permanent diffuse vegetation, changes occur in vegetation types and vegetation density, which are caused primarily by changes in sediment type and available moisture. Diffuse vegetation was found throughout the study area, including the hot, dry basalt plateaus. Thus, north-central Saudi Arabia is botanically a semidesert; the transition to a true desert with permanent vegetation limited to wadis and depressions does not occur in this region.

Table 1 indicates both wide interaction and similarities in the floristic composition of the landscape-vegetation units. Four groups are visible from the table: sand sea vegetation, which includes lakebed and achab floras; the gravel(sérir) and sandy plains; inselbergs; and the pediment slopes and wadis. The floristic elements show that this region is a botanical transition zone between Mediterranean-influenced areas and tropical-influenced areas. See the appendix for descriptions of the individual plants.



Figure 11: Dune depression in the Nafud Urayk. Anabasis shrub on the bottom, Tamarix aphylla trees; relatively dense Haloxylon shrub on the dune slope along with Cyperus, Artemisia, and Calligonum.



Figure 12: Playa and southern margin of the An Nafud dunes located about 40 km northwest of Hail. Anabasis articulata is on the playa surface.

SUMMARY

Permanent and diffuse shrub vegetation forms a botanical semidesert in north-central Saudi Arabia, even though the climate is arid to extremely arid. Vegetation types and distribution are primarily dependent on the topography and the kinds of surficial deposits that control the amount of moisture available to the biosphere. The combination of landforms and sediment types creates six general landscape units that compose the physiography of this region. Vegetation types and density on each landscape unit also vary to some degree with variations in moisture availability; preferred ecological niches with increased vegetation densities and floristic composition are commonly topographic lows or depressions where surface runoff has drained and is partly protected from evaporation due to sediment thickness.

Mountains, inselbergs, and cuestas support shrub and tree vegetation with tufted grasses and different herbs; Rhus tripartita and Cymbopogon are common. Some of the mountain wadis at lower altitudes that contain boulders and gravels support a tree and shrub vegetation of Acacia, Ochradenus, Artemisia, and Ballota, as well as a great variety of herbs.

The surrounding pediments and plains are covered by chenopods, primarily Anabasis and Hammada, together with Fagonia, Astragalus and different herbs. In small runnels and wadis Lycium shrubs and groups of Acacia are common.

The large, flat plains of fine-grained weathering material have a notable vegetation; Rhanterium, along with Fagonia and Astragalus, is dominant on the serir plains, while Anabasis and Hammada are found on sandy surfaces and sand-filled wadis. Large sandy wadis support an Acacia-Panicum vegetation, and in the southwest part of the study area Aerva and Rhazya are also present. Along the margins of the few playa located on the plains, the density of Rhanterium increases and Artemesia is also present.

The sand seas support a diffuse plant cover of shrubs and tufted grasses that contains a greater species variety and plant density than found on the plains: Artemisia monosperma, Calligonum comosum, Stipagrostis drarii and Cyperus conglomeratus are the most common elements. Achab floras are common at the foot of the dunes immediately following rainstorms: Plantago, Monsonia, Stipagrostis plumosa, Moltkiopsis, and Filago are among the most common herbs. A sparse cover of Helianthemum and Fagonia shrubs is found on lake beds and duricrusts that are sometimes present in the interdunal depressions.

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APPENDIX

List of collected plants

Plant families are alphabetically arranged. The sites where the plant was identified are given by the same location numbers as used in tables 1 and 2. Below the plant locations is a short description of the environment of the plant, followed by the vernacular names of the plant (Blatter, 1929; Batanouny, 1981) and its known distribution. Remarks on local plant use (eg. popular medicine) are from Zohary (1966), Blatter (1936), and Batanouny (1981).

Pteridophyta

Polypodiaceae

Cheilanthes catanensis (Consent) H. P. Fuchs

33.

Found on fine-grained deposits in rock fractures.

Distribution: Southern Mediterranean to Irano-Turanian.

Gymnospermae

Ephedraceae

Ephedra alata Decne

11, 12, 30.

Characteristic of sandy environments with Calligonum and Artemisia monosperma; however, is rare in southern An Nafud. Ephedra may be at the southern margin of its area.

Distribution: Macaronesian to Iranian.

Extract of branches is used in eye diseases.

Angiospermae

Dicotyledonae

Acanthaceae

Blepharis ciliaris (L.) B. L. Burtt

27, 31, 34.

In small gravelly wadis and among rocks.

Vernacular name: shawk ul-dab.

Distribution: Saharo-Arabian to Soudanian.

Aizoaceae

Aizoon canariense L.

12, 21.

Often part of the achab florae on coarse sands.

Vernacular name: carat, gafnah/chafna.

Distribution: Saharo-Arabian-Soudanian.

Gisekia pharnakoides L.

6.

Part of achab florals on fine sand; often found on irrigated fields.

Distribution: tropical.

Amaranthaceae

Aerva javanica (Burm.) Spreng.

38.

Characteristic shrub in the Acacia-Panicum communities on coarse-grained sediments, including bouldery gravel.

It has a comparable niche in tropical wadi vegetation as Zilla spinosa has in the north.

Vernacular names: tirf, ra, yeruk, jarra, ra, fiw.

Distribution: palaeotropical.

Aerva is used in popular medicine as an analgeticum and is also filling for bolsters.

Anacardiaceae

Rhus tripartita (Urcia) Grande

Characteristic part of the mountain vegetation; found in rock fractures and boulder-filled wadis of Jabal Aja.

Distribution: Saharo-Arabian to Irano-Turanian.

The bark is used for tanning and dyeing.

Apocynaceae

Rhazya stricta Decne

38.

Characteristic shrub in the Acacia-Panicum vegetation in large wadis on coarse sand.

Vernacular name: hermel.

Distribution: Arabian to Irano-Turanian.

Asclepiadaceae

Gomphocarpus cf. fruticosus (L.) Ait.

28, 11.

Found on small field on Jebel Aja.

Vernacular name: arjel.

Distribution: Mediterranean to Saharo-Sindian.

Boraginaceae

cf. Gastrocotyle sp.

7, 26, 27.

Heliotropium sp.

5, 7, 16, 22, 26, 27, 30.

Common part of the achab floras.

Heliotropium bacciferum Forssk.

6, 7, 20, 31, 32.

Common in the achab floras at the base of dunes and in shallow wadis.

Vernacular name: hahhfa.

Distribution: Saharo-Arabian to Sudanian.

Moltkiopsis ciliata (Forssk.) Johnst.

2, 3, 13, 20, 27, 32.

Found on fine sand.

Vernacular name: jureibi, halameh.

Distribution: Saharo-Arabian, Mediterranean, and Sudanian.

Trichodesma sp.

8, 33.

Capparidaceae

cf. Cleome sp.

32.

Caryophyllaceae

Gypsophila arabica Bahoudah

15, 30

In rock fractures or in relatively moist areas on coarse sand; common at the base of dunes.

Distribution: Irano-Turanian.

cf. Loeflingia sp.

7.

Rare part of achab floras on coarse sand.

Paronychia sp.

3, 7.

Part of achab floras on dunes and in sandy wadis.

Vernacular name: rimt, hammada.

Collected for fuel and used as a detergent.

Polycarpaea repens (Forssk) Asch. & Schweinf.

6, 13, 16, 31, 32.

Common annual on sandy substratum as part of the achab floras at the foot of dunes or in wadis with sandy places.

Distribution: Saharo-Arabian/Soudanian.

Silene sp.

31.

On coarse wadis sediments between rocks.

CHENOPODIACEAE

Anabasis articulata (Forsk) Moq.

1, 23, 25, 26.

Typical and common on coarse sediments in wadis and depressions.
Often together with Hammada, sometimes difficult to distinguish.

Vernacular name: remeh.

Distribution: Saharo-Arabian to Irano-Turanian.

Pasturage for goats and camels; used as detergent and for fuel.

Anabasis cf. setifera

26, 27

On coarse sediments together with A. articulata. Rare.

Vernacular name: Sharan.

Distribution: East Saharo-Arabian to Irano-Turanian.

Bassia muricata (L.) Murr.

20.

Shrub on coarse sediments.

Vernacular name: layyah, romlie, aeraejan

Distribution: Saharo-Arabian to Irano-Turanian.

Cornulaca aucheri Moq.

27.

Found on fine wind blown sands and less frequently on coarse sediments.

Vernacular name: thallag.

Distribution: Saharao-Sindian.

Haloxylon persicum Bge.

13, 19.

Often in dune depressions and on dunes.

Distribution: Saharo-Arabian to Irano-Turanian.

Haloxylon is heavily browsed.

Hammada sp.

32, 35

Hammada is noted by Zohary (1973) as a typical part of the Chenopodiaceae shrub vegetation on coarse material. In this area it may be common, but without flowers or fruits it is difficult to distinguish from Anabasis.

Vernacular name: rimt.

Distribution:

Used as fuel, browsed by camels. Used as detergent like Anabasis.

Salsola baryosma (Roem et Schult.) Dandy

9, 25, 32.

Common on different surficial deposits such as wadi gravels, silt, clay, and saline sediments.

Vernacular name: gaghraf, hamdh, kharit, shnan.

Distribution: Saharo-Sindian to Sudanian.

Cistaceae

Helianthemum sp.

3, 10.

Helianthemum lippii (L.) Pers.

8, 10, 14, 16.

Characteristic shrub on coarse sand and on duricrusts in the dune depressions.

Vernacular name: ragroug.
Distribution: Saharo-Arabian.

Helianthemum sancti-antonii (Schw.)

10.

Relatively rare; found in the same environments as H. lippii.

Distribution: Saharo-Arabian.

Compositae

Anvillea garcinii (Burm. f.) DC

3, 28, 11.

Common shrub on rocks and coarse sand.

Distribution: Saharo-Arabian.

Artemisia monosperma L.

6, 13.

Characteristic shrub in dunes with Calligonum, Stipagrostis drarri, and Cyperus conglomeratus.

Vernacular name: adeh, lallel, adah.

Distribution: Saharo-Arabian.

Artemisia herba-alba Asso (A. inculta Del.)

18, 28.

Unlike Artemisia monosperma, A. herba alba is common on coarse sand.

Vernacular name: ghorera, ghii, ghureirah.

Distribution: Saharan to Irano-Turanian.

Used as a remedy for toothaches.

Asteriscus pygmaeus (DC.) Coss. et Dur.

2, 6.

Part of the achab floras on fine grained sediments.

Vernacular name: nuqud.

Distribution: Saharo-Arabian.

Atractylis cf. carduus (Forssk.) Christens.

6, 7, 8, 17, 18.

Common on the moister areas on dune slopes with Artemisia and Calligonum.

Vernacular name: aheish, khosheruf.

Distribution: Saharo-Arabian to Mediterranean.

Atractylis prolifer Boiss.

8, 28, 11.

Jebel Aja ca. 30 km nw Hail ca. 1200 m in a small field.

Distribution: Saharo-Arabian.

Calendula arvensis L.

7, 30.

Characteristic annual in the achab floras and on cultivated lands.

Vernacular name: hanwa.

Distribution: Mediterranean to Arabian.

Centaurea sp.

12, 28, 11.

Found among rocks on Jebel Aja.

Centaurea pallescens Del.

5, 13, 13, 16.

Common on coarse sediments in small depressions and on lower dune slopes.
Distribution: East Saharo-Arabian.

cf. Conyza sp.

16, 34.

Filago argentea

6, 7.

Common part of the achab floras on fine-grained sediments.

Vernacular name: kattain.

Distribution: Saharo-Arabian.

Ifloga spicata (Forssk.) Sch. Bip.

3, 6, 26.

Common in achab floras in dune depressions and on lower dune slopes.

Vernacular name: kureshat-et-jndai, moscht, hasad.

Distribution: Mediterranean, Saharo-Arabian.

Heavily browsed by grazing animals.

Lapsana sp.

6, 7.

Launaea sp.

6, 7, 8, 26, 32.

Common annual in the achab floras on fine-grained sediments.

Pulicaria sp.

16.

Pulicaria desertorum DC.

34, 35.

In small wadis on coarse sediments.

Vernacular name: damsis, rara, Desdes, munis, neschusch, chaa, rabur, rabbul.

Distribution: Saharo-Arabian to Soudanian.

Pulicaria crispa (Forssk.) Oliver (Francoeuris crispa (Forssk.) Cass.)

28, 11.

Among the rocks on Jebel Aja.

Vernacular name: desdes, dehed, qutqat, sabut, rara tajar, kanuf, afrakh, dithdathm karwan.

Distribution: Saharo-Arabian.

Rhanterium epapposum Oliv.

17, 18, 30.

Rhanterium is a common shrub on coarse sediments. Common on lower dune slopes.

Vernacular name: arfaj.

Distribution: Arabian to Irano-Turanian.

Heavily browsed by goats.

Convolvulaceae
Convolvulus sp.
3, 20.

Convolvulus lanatus Vahl.
31, 32, 35.
Characteristic shrub in small wadis on coarse sediments.
Vernacular name: relkama, saejad, rehanah, barheimeh, brehema.
Distribution: Saharo-Arabian.
Heavily browsed by camel and sheep.

Convolvulus spicatus Peter
6, 13, 16.
Part of the sparse shrub vegetation found with Helianthemum on coarse sand or calcareous crusts in dune depressions.
Distribution: Saharo-Arabian.

Cruciferae
Eremobium diffusum (Decne) Botsch.
3, 6, 15, 32.
Very characteristic part of the achab florae on fine grained sediments in wadis and on dunes.
Vernacular name: tarbeh.
Distribution: Saharo-Arabian.
Good pasturage.

Farsetia sp.
32.

Farsetia aegyptia Turra
31.
Found in wadis with coarse sediments.
Vernacular name: garbun, djarba, garba, hajfal, gjerba.
Distribution: Saharo-Arabian to Soudanian.
Farsetia is heavily browsed by camels.

Lobularia sp.
28, 11.
Found on a high surface and on a small field behind a manmade barrage at Jebel Aja.

Morettia sp.
7.

Morettia canescens Boiss.
21, 32, 28, 11.
Found on a high surface (ca 1200m) on Jebel Aja.
Grass vegetation behind a small barrage.
A characteristic annual in the achab florae on coarse sediments and in wadis.
Vernacular name: gherera.
Distribution: Saharo-Sindian.

Torularia torulosa (Desf.) O. E. Schulz

32.

Found on coarse sand in wadis and associated with Acacia-Panicum vegetation.

Distribution: Saharo-Arabian to Irano-Turanian.

Cucurbitaceae

Colocynthis vulgaris Schrad. (Citrullus colocynthis (L.) Schrad.)

5, 20.

Common perennial on coarse sediments.

Vernacular name: handhal, hondel.

Distribution: Mediterranean-Saharo-Sindian.

Commonly used as purgative.

Euphorbiaceae

Euphorbia peplis L.

28, 31, 32.

Common annual on coarse sand in wadis.

Vernacular name: malaqah, wuneidahsabun-gheit, om-el-beene.

Distribution: cosmopolitan.

Geraniaceae

Erodium sp.

2, 8, 16, 28.

Erodium bryoniaefolium Boiss.

28, 11.

Small field behind a barrage on Jebel Aja.

Vernacular name: dehanin, murghit.

Distribution Saharo-Arabian, East Sudanian.

Erodium deserti

8.

Part of the achab floras on fine sand.

Distribution: Saharo-Arabian.

Erodium glaucophyllum (L.) Aiton

2, 7.

Part of the achab floras on fine grained sediment.

Vernacular name fummaejr, kabsjie, kabshiyah, kakul, tummeir, lidan-el-, hamal, moherad mahammi.

Distribution: Mediterranean to Saharo-Arabian.

Geranium cf. molle L.

2.

Found in wadis.

Distribution: Euro-Siberian to Mediterranean.

Monsonia nivea (Decne) Decne ex Webb.

3, 4, 5, 12, 13, 16, 30.

Common plant of the achab floras on fine-grained sediments

Vernacular name: yahaq.

Distribution: Saharo-Arabian to Sudanian.

Labiatae

cf. Marrubium sp.

28, 11.

Found on rocks on Jebel Aja .

Teucrium polium L.

34, 28, 11.

Found among rocks on Jebel Aja

Commonly found with Ochradenus and Acacia in rocky environments and on gravel.

Vernacular name: jaad, ya'ad.

Distribution: Mediterranean to W-Irano-Turanian.

Used in popular medicine as an infusion for lowering body temperatures during fever.

Micromeria sp.

31.

Molluginaceae

Glinus cf. lotoides L.

18.

Part of short-lived florals on coarse sand.

Distribution: Mediterranean to Irano-Turanian, tropical Africa.

Leguminosae

Acacia gerrardii Beuth.

2, 12.

In a small wadi ca. 25 km sw of Hail on gravel and coarse sand.

Common in wadis together with A. tortilis. in the northern part of the peninsula.

Distribution: Sudano-Arabian.

Acacia tortilis (Forssk.) Hayne

34.

Most common tree of the wadi vegetation on coarse sand together; found together with Panicum turgidum.

Vernacular name. talh, seyyal.

Distribution: Saharo-Sindian to Sudanian.

Astragalus cf. sieberi DC

32.

Part of the Acacia-Panicum vegetation found in coarse sandy wadis.

Vernacular names: sab-al-aross, qudad, asabi-el-arus, khansar-el-arus.

Distribution: Saharo-Arabian.

Astragalus spinosus (Forssk.) Musch.

8, 31.

On coarse sediments in small runnels or wadis.

Vernacular name: kidad thimrah.

Distribution: Arabian.

Lotus sp.

5, 7, 32, 37.

Medicago sp.
26, 27.

Vicia sp.
28, 11.
Small field behind a barrage on Jebel Aja.

Trigonella stellata Forssk.
8.
In achab floras on coarse sand
Vernacular name: gargas, serakrak, hendakuk, odur. elch addan. ethreni.
Distribution: Mediterranean.

Plantaginaceae
Plantago sp.
6, 8.

Plantago albicans L.
5, 7, 12, 15, 20.
Common in the dune vegetation with Artemisia monosperma and Calligonum.
Vernacular name: khana er-en-najeh.
Distribution: Mediterranean to Indian.

Plantago ciliata Desf.
8, 16, 18.
On coarse sediment in dune depressions and along playas margins.
Vernacular name: quraitah, drehemi.
Distribution: Mediterranean to NW Indian.

Plantago cylindrica Forssk.
10.
Found in the achab floras at the base of dunes.
Vernacular name: herchemi, umm lubbeideh, barkheimy.
Distribution: Saharo-Arabian.

Plantago indica L.
30, 33.
On fine grained sediment in rock fractures.
Distribution: Euro-Siberian, Mediterranean to Irano-Turanian.

Plantago notata Log.
7.
Occasionally found in the achab floras.
Distribution: Saharo-Arabian to Irano-Turanian.

Plantago ovata Forssk.
2.
Occasionally found in the achab floras.
Vernacular name: jeneimeh, kibash, lugmet-en-naaeh.
Distribution: Mediterranean to Indian.

Plumbaginaceae

Limonium thouini (Viv.) Ktze.

29, 11.

Found on a small field on Jebel Aja.

Distribution: Mediterranean to Iranian.

Polygonaceae

Calligonum comosum L'Herit

5, 6, 27.

One of the most common shrubs at dune sites.

Vernacular name: Artes, Rosak, Risu, Arta.

Distribution: Saharo-Arabian to Irano-Turanian.

The preferred pastureage of goats and camels. Used as a sand binder because of its extensive root system.

Rumex Vesicarius L.

2,3.

Often found in achab florals or in moist, rocky environments.

Vernacular name: Hammar.

Distribution: Mediterranean-Sudanian.

Primulaceae

Anagallis arvensis L.

28, 11.

Common in fields and on cultivated land.

Vernacular name: ein al-quitt.

Distribution: cosmopolitan.

Resedaceae

Ochradenus baccatus Del.

31.

Characteristic shrub in wadis with coarse sediments. Comparable niche to Randonia africana in the northern Sahara.

Vernacular name: gord, gurzi, wuebeh, blika, gurdi, qurdah, gurrsi.

Distribution: Arabian.

The shrub is browsed and the fruits are edible.

Rhamnaceae

Ziziphus spina-christi (L.) Willd.

5, 12.

Found on a sabkha about 50km east of Unayzah.

Vernacular name: ardj, ardji, orredj, aelbm sidr, olb, dom.

Distribution: Saharo-Arabian to Irano-Turanian.

Used in sacrifices. Infusions of the bark are used in washing the dead.

Rosaceae (Neuradaceae)

Neurada procumbens L.

2, 5, 7, 12, 31.

Very common annual on windblown sand and on small dunes in wadis.

Vernacular name: shadan, sadann.

Distribution: Saharo-Arabian.

Rubiaceae

Galium sp.

28, 11.

Found on small field on Jebel Aja.

Scrophulariaceae

Linaria aegyptiaca (L.) Dum.

27, 31.

Found in rocky or gravelly wadis.

Vernacular name: cigaha, dahamer, duwainet-el-fei, ushb-el-dib, dureishek, mujemineh, rihah, jawin.

Distribution: East Saharo-Arabian.

Orobancha sp.

12, 28, 11.

Found on a high surface on Jebel Aja.

Scrophularia cf. deserti Del.

26, 5, 12.

Found among rocks and on wadi gravels and coarse sand.

Vernacular name: monaseb, glyele, zeret, zeiteh.

Distribution: Saharo-Arabian.

Solanaceae

Hyoscyamus muticus L.

6, 20.

Found in the Artemisia and Calligonum communities at the base of dunes.

Vernacular name: schedjeret-es-sakran, sekran, semenr-el-fan, datora, saikaran, sakaran, sekkoran

Distribution: Saharo-Sindian.

Lycium shawii Roem. et Schult.

22, 27, 28.

Common in small wadis and depressions on coarse sediments.

Vernacular name: schirbit, ausai, sahanum.

Distribution: East Saharo-Arabian; East Sudanian.

Tamaricaceae

Tamarix aphylla (L.) Karst

20.

Found in dune depressions and wadis where there is shallow groundwater.

Vernacular name: atl, bthel.

Distribution: Saharo-Arabian to Soudanian.

Used in reforestation.

Tamarix cf. passerinoides Del. ex Desv.

5, 12.

Found at the edge of a sabkha about 50km east of Unayzah.

Common in saline environments.

Distribution: East Saharo-Arabian; East Sudanian.

Umbelliferae

cf. Pituranthos sp.

31.

Commonly found with Ochradenus and Astragalus in wadis on coarse sediments.

Urticaceae

Forsskalaea tenacissima L.

30.

Found on fine-grained deposits at moist sites.

Vernacular name: Leseke, Lessike, Lussaq, Hamshed.

Distribution: Saharo-Arabian to Soudanian.

The bark is used for fibres.

Zygophyllaceae

Fagonia arabica L.

10, 12, 31, 32, 34.

Common on coarse sand on the lower dune slopes and in wadis.

Vernacular name: naffel, orrae, schoki, bebut, aqul-el-hazel, gemdeh, had, schueikah, shaukan.

Distribution: East Saharan-Arabian.

Fagonia bruguieri DC.

7.

Common on dune slopes and in sandy wadis.

Vernacular name: jambah, shacha'ah.

Distribution: Saharo-Arabian.

Fagonia glutinosa Del.

6, 7, 18.

Common on windblown sand. Recognized by the viscid sand-holding glands.

Vernacular name: hamdah, attany, shika'ah, medahin, hallane.

Distribution: Saharo-Arabian.

Fagonia olivieri DC.

22, 23, 32.

Common in dune vegetation on the lower part of the dunes and on sandy terraces. Heavy browsed by animals.

Distribution: Saharo-Arabian.

Tribulus terrestris L.

6, 7, 32.

Common on fine grained sediments and in ruderal environments.

Distribution: cosmopolitan.

Fruits are used as detergents, astringents, purgatives, diuretics..

Zygophyllum simplex L.

31, 12.

Found on rocks and gravel.

Vernacular name: jarmal, qurmah, adhir, gormon.

Distribution: Saharo-Sindian, Sudanian.

Monocotylendoneae

Cyperaceae

Cyperus conglomeratus Rottb.

3, 4.

One of the most characteristic plants on the dunes together with Calligonum comosum, Artemisia monosperma, and Stipagrostis drarii.

Distribution: tropical.

Scirpus cf. holoschoenus L.

28, 11.

Found on small field on Jebel Aja.

Vernacular name: deess.

Distribution: cosmopolitan.

Gramineae

Aristida adscensionis L.

8, 28.

Found on coarse-grained sediments.

Distribution: cosmopolitan.

Astenatherum forsskalii (Vahl) Nevski

3.

Common on fine sand.

Vernacular name: chagaret-el ghemet.

Distribution: Saharo-Arabian.

cf. Avena sp.

28, 11.

Found on small field on Jebel Aja.

Cymbopogon cf. schoenanthus

Jebel Aja between the rocks ca. 1200 m.

Cynodon dactylon (L.) Pers.

20, 22, 32.

Common in wadis and on disturbed ground.

Vernacular name: nikil, neieel, okbell.

Distribution: cosmopolitan.

Hyparrhenia hirta (L.) Stapf

33, 28, 11.

Common among rocks and on gravel.

Distribution: tropical.

Pennisetum orientale Rich.

30.

On fine-grained sediments in rock fractures.

Vernacular name: haussefe, nassje, nessje, sabote, hagheni.

Distribution: Saharo-Sindian.

Polypogon monspeliensis (L.) Desf.

28, 11.

Found on small field on Jebel Aja; moist sand, cultivated land.

Distribution: Mediterranean.

Schismus barbatus (L.) Thell

2, 3, 7, 20.

Common annual in the achab floras in dune depressions on coarse sand.

Distribution: Arabian.

Stipa capensis Thunb.

6, 23.

Common in wadis and dune depressions on coarse sand.

Distribution: Mediterranean, Arabian, Iranian, South African.

Stipagrostis sp.

3, 5.

Stipagrostis drarii (V. Täckholm) de Winter

4, 12.

Most characteristic perennial on dunes with Calligonum comosum, Artemisia monosperma, and Cyperus conglomeratus.

Distribution: Arabian.

Stipagrostis obtusa (Del.) Nees

2, 3, 7.

Common part in the achab floras on the lower dune slopes.

Vernacular name: nassi.

Distribution: Arabian.

Stipagrostis plumosa (L.) Munro ex Anders.

3, 5, 7, 13, 32.

Most common element in the achab floras.

Vernacular name: nassi.

Distribution: Mediterranean, Saharo-Arabian to Iranian.

Good pasturage.

Liliaceae

Allium sp.

13, 16.

Asphodelus tenuifolius Cav.

6, 7, 20, 21, 32.

Common geophyte on fine grained sediments.

Distribution: Saharo-Sindian to Irano-Turanian.

Explanation of Table 1

sociability

- 1 single stem, shoot
- 2 very small groups or tussocks
- 3 small groups or small plots
- 4 small colonies or larger plots
- 5 large herds

abundance (cover)

- r 1 individual/cover is very sporadic
- + 2 -5 individuals cover < 5%
- 1 6-50 individuals cover < 5%
- 2 > 50 individuals cover > 5%
- or unlimited individuals cover 5-25%
- 2a unlimited individuals cover 5-15%
- 2b unlimited individuals cover 16-25%
- 2m > 50 individuals cover < 5%
- 3 unlimited individuals cover 26-50%
- 4 unlimited individuals cover 51-75%
- 5 unlimited individuals cover 76-100%

surface material

- fs fine sand
- ms medium sand
- cs coarse sand
- calc crust calcareous crust
- loam loamy soil
- serir desert pavement underlain by a silt layer
- gravel gravelly soil

- cm height of plant in centimeters

Table 2. Plant collection localities

1.	27°40'N	41°18'E	Playa north of Jebel Aja, south edge of the An Nafud
2.	27°40'N	41°18'E	Southern margin of An Nafud, north of Jebel Aja. Base of dunes.
3.	27°40'N	41°18'E	Southern margin of An Nafud. Middle slope of dunes.
4.	27°40'N	41°18'E	Southern margin of the An Nafud. Top of dunes.
5.	27°42'N	41°16'E	Southern margin of An Nafud. Interdune depression about 40 km north of Hail.
6.	27°43'N	41°16'E	Southern margin of An Nafud. Interdune depression about 40 km north of Hail.
7.	27°51'N	41°20'E	Southern part of An Nafud. Achab flora on interdune depression.
8.	27°51'N	41°20'E	Southern part of An Nafud. Interdune depression. Base of dunes.
9.	27°51'N	41°20'E	Southern part of An Nafud. Interdune depression. Lake beds.
10.	27°54'N	41°19'E	Southern part of the An Nafud. Lower dune slope on interdune depression.
11.	28°01'N	41°09'E	Southern part of the An Nafud. Interdune depression. Lower dune slope.
12.	28°06'N	41°22'E	Southern part of the An Nafud dunes. Lower dune slope.
13.	28°27'N	41°13'E	South central An Nafud. Calcareous crust on interdune depression.
14.	28°29'N	41°14'E	South central Nafud. Dune depression. Lower dune slope.
15.	28°23'N	42°21'E	Southeastern An Nafud. Interdune depression; middle dune slope.
16.	28°23'N	42°21'E	Southeastern An Nafud. Interdune depression.
17.	28°23'N	42°21'E	Southeastern An Nafud. Interdune depression. Lower dune slope.

18.	28°34'N	42°28'E	Central part of the An Nafud. Playa margin 200 km northeast of Hail.
19.	25°36'N	42°40'E	Nafud Urayk. Interdune depression. Lower dune slope.
20.	25°36'N	42°40'E	Nafud Urayk. Interdune depression. Base of the dunes.
21.	25°36'N	42°40'E	Nafud Urayk. Interdune depression.
22.	25°31'N	42°36'E	Nafud Urayk. Interdune depression.
23.	26°11'N	44°21'E	Northern Nafud Asir. Dunes near the Unayzah highway.
24.	26°48'N	43°36'E	Semidesert plain near Buraydah.
25.	26°04'N	43°36'E	Semidesert plain 60 km east of Batra. Disturbed surface near road.
26.	27°17'N	41°41'E	Inselberg about 30 km southwest of Hail. Upper pediment slope.
27.	27°17'N	41°41'E	Inselberg. Upper pediment slope and small wadis.
28.	27°17'N	41°41'E	Plain between inselbergs. Lower pediment slope with small wadis.
29.	27°17'N	41°41'E	Plain between inselbergs. Main wadi containing coarse sand.
30.	27°19'N	41°16'E	Southern An Nafud. Dune depression with a small rock outcrop.
31.	27°19'N	41°44'E	Wadi in inselberg.
32.	25°06'N	42°42'E	Southern Nafud Urayk. Wadi stream bed.
33.	25°49'N	43°05'E	Jebel Asmar. Fractures in rock slope.
34.	25°48'N	43°05'E	Jebel Asmar. Wadi stream bed at base of mountain.
35.	25°48'N	43°01'E	Jebel Asmar. Stream bed in upper reaches of wadi.
36.	25°42'N	43°13'E	Wadi Rimah. High floodplain.
37.	25°42'N	43°13'E	Wadi Rimah. Main channel.
38.	24°54'N	40°36'E	Large wadi near Hanikyah.