# SAUDI ARABIAN FLORA AND ITS APPLICATION IN LANDSCAPE DESIGN PROJECTS

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In the name of God, Most Gracious, Most Merciful

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## ABSTRACT

This practical thesis aims to reform the use of plant material in landscape architecture projects in the Najd or Central Region of Saudi Arabia. Many aspects of landscape architecture in Najd attempt to emulate western concepts. Neglect or unawareness of the values of Arabic society is one of the main reasons for the failure of the landscape programme. This factor of traditional culture is particularly sensitive in Najd which is the birthplace of Whabism, one of the strictest applications of Islam. This implies special conditions that made outdoor design sensitive and complicated, unable to tolerate western forms.

Western urban patterns in planning, such as wide streets, neighbourhood parks and their detailed components of artifacts and plant materials, all shattered the character of traditional landscape architecture in the region. Although indigenous landscape elements in Najd evolved as a result of socio-environmental factors, many consultants do not differentiate between Persian, Islamic, and Najdi gardens.

The inventory of available plant species indicates that most are imported from tropical and subtropical countries. These species require stripping of soil from wadi Hanifah for potting, and for top soiling planting projects, a process destructive to the rich wadi habitat. Such a process is necessary when using imported plant material while native ones can adapt to the existing sandy and saline soil. The devastation of the wadi ecosystem, the saline water table and the high cost of maintaining those plants, represents serious short and long term economic, ecological and technical implications. These implications all point to the scale of these negative consequences of using imported plant material. Also, climatic data, points to the suitability and adaptability of native flora and its significance in avoiding further damage to eco-environment. Use of imported plants in arid Najd and creating a man-made micro climate to suit them, is a waste of resources, especially the water budget in Saudi Arabia. The thesis proves that these plants consume large amounts of water, require high levels of maintenance, are unsuitable to Najdi environment, introduce new pests and diseases, require special microclimatic conditions, rich soil and prove unsuccessful in their functions.

All the previous factors combine to acknowledge the failure of many tropical gardens in the arid land of Najd. The answer lies in Najd itself which is wealthy in flora adapted to its local conditions. The potential for their use in Saudi Arabian landscape projects is vast. Individually they will substitute for the imported nursury stock, while the available communities represent a ready-made and complete landscape element which would be valuable for Najdi parks.

The general question, the comparative advantages of native over imported plants is

conclusively answered in the thesis. Though the native plants are diverse, attractive and available, they were tested practically aiming at, firstly to test the individual species, the "target species method", and secondly to test the whole community "target community method". Three test sites were allocated in the Diplomatic Quarter to test the selected target species and communities. The tests were conducted extensively over five years and intensively over three years, during which the author monitored closely a large number of species and communities and arrived at an encouraging set of results and findings.

The conclusion of the thesis consists of two parts. Firstly, the successful species which is included in a Flora, and the successful target communities which use selected target communities as a landscape design tool. These are aimed specifically at landscape designers. Secondly, the author recommends how to utilize both methods in a typical Najdi urban park, and how to encourage their successful use.

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# INTRODUCTION AND PROBLEM DEFINITION

## 1) INTRODUCTION AND PROBLEM DEFINITION

### A. PREAMBLE:

Through out history all cities have been changed according to some new sense of what is appropriate. Islam once dominated Mediterranean Europe but now western values are claiming the Islamic strongholds in the Middle East. In a world increasingly standardized and diminished by convenience and technology the west has created an image and the trappings of success readily accessable to countries willing and wealthy enough to accept and develope them.

The migration of technology to and the frenetic pace of construction in the Middle East have caused enormous problems,

> *"Western models for buildings, some of doubtful origin, were used without thinking although it is only fair to say that this was not just a conspiracy by outside professionals overriding local wishes, but just as often a response to meet local wishes to produce progressive buildings that were noticeably up-to-date and by implication western in flavour".*[1]

The problem folds into the two distinct but associated areas of technical and social design; traditional, religious and social values have been ignored. The following statement sums up this approach to local considerations.

> *"It has been suggested by some western specialists that the most appropriate response to the desert environment is not to adapt to it, but to create totally artificial environment for each settlement in domed cities".*[2]

As a result, the most significant features of the reconstruction are the large and incongruous glass buildings isolated within an open disintegrated urban fabric, replacing mud buildings, narrow streets and compact communities (Fig 1).

Many landscape projects are associated with this urban expansion, in the form of open spaces, routeways and urban places. Unfortunately, these have had damaging consequences on both the natural resources and the ecology of the region. The excessive use of imported plant material in landscaping the arid regions has been destructive to the local environment, water budget and indigenous landscape character; especially in places characterized by arid environment, scarcity of water, as well as special traditions,

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[1] J W Thorpe, *The Emerging Aesthetic - Accident or Design*, Landscape Research 13 (2) 1988.

[2] Buckminster Fuller, *Futuristic vision of moon city.* Discuused and mentioned by Kelly, Kathlen. *"Landscaping the Saudi Arabian Desert"* The delancey press, Philadelphia, Pennsylvania, U.S.A 1976.p29.

planting soil, high salinity level in both the soil and ground water, high maintenance costs and most important the loss of authentic and indigenous landscape elements from those regions once known for their unique architecture and indigenous landscape character.

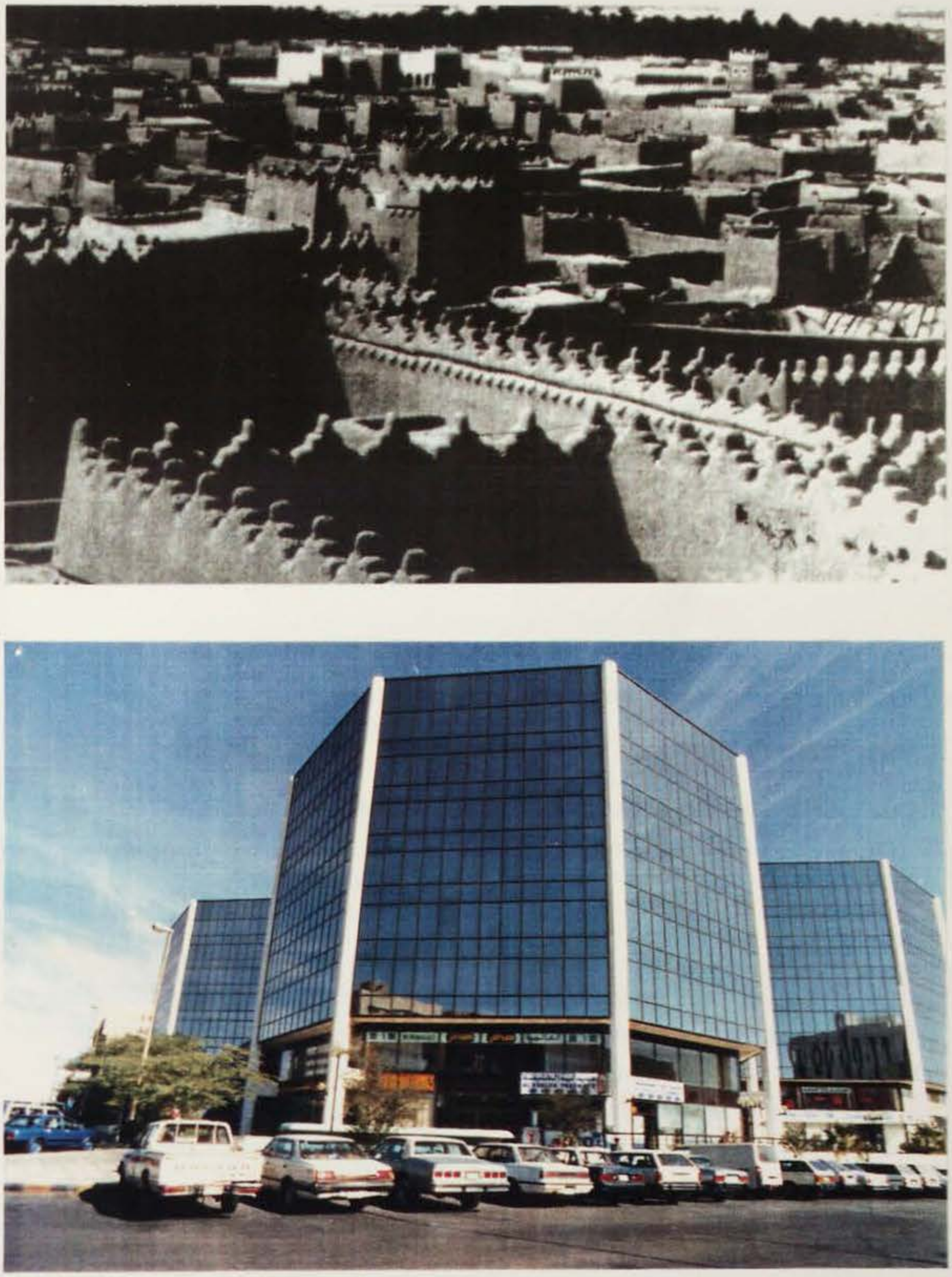

**Fig 1: The glass curtain wall buildings in a disintegrated urban fabric, replacing the mud traditional buildings and compacted urban mass.**

Traditionally, the native inhabitants evolved an understanding of the dynamics and balance of their arid ecosystem. The extreme heat was countered by natural low-technology solutions; by special clothing, court yards, compacted urban pattern, thick mud walls and narrow streets protected by dense palm groves. The modern response ignored the local constraints and requires complicated air conditioning life-support systems in buildings and cars. Such man made microclimatic controls ruined the adaptation ability of the local inhabitants and undermined the traditional method of adapting to the arid land. This disturbance to the understanding of the local environment, was a direct consequence of rapid and intensive urbanization all over the Middle East, as a result of different factors: wars, western-aided development plans or oil wealth which has given an extra boost to urbanization all over the region. Also Seamus Filor has written about this critical phase of development:

> *"Development has brought the pioneer, not in covered wagons or trading glass beads, but bearing gifts of high technology and the human expertise with which to implement it. For the native population, this meeting of two very different cultures has brought an erratic new life style, exposing them to the attributes and goods of materialistic, profit based society offering them a seemingly easier existence in the expanding cities and industrial areas. Certainly in Saudi Arabia the nomadic Bedouin seem to adjust from caravan to Mercedes truck, from Arab stallion to yellow taxi cab or Toyota pick-up. There is a constant background noise of traffic, squealing breaks and tooting horns, as values of desert based freedom are replayed in the restrictive grid iron pattern of city streets"* [3]

As a result of this development phase the identity, spirit and character of arid zones was lost. The loss affected town planning, architecture and landscaping which is the focal argument of this research. To summarize the reasons:

1. The urbanization and development took place rapidly and without native environmental designers or sympathetic foreign designers who intuitively respect and understand the components and the sensitivity of the arid system. (Westoby, 1972).[4]

2. Importing exotic water demanding plant material for "greening" (an alien concept) the cities, exhausted the valuable and limited water budget, caused native plant material to lose their unique dynamic response to local environmental factors, introduced new pests and diseases to the arid regions and ultimately did not successfully fulfil their primary landscape function, to provide an

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[3] Seamus W Filor, *"Landscape Architecture in Saudi Arabia"*, Landscape Research, 13 (2) 1988.

[4] Westoby, M. (1972). *Problems-oriented modelling: a conceptual framework.* presented at the Desert Biome Information Meeting, Tempe.

environment combatable with traditional Najdi values.

3. Most of the major projects and new towns were built and inhabited without prior consideration given to intelligently designing the outdoor spaces created which now became essential. Population was increasing rapidly, an imported work force and native migration into the towns created the need for parks and recreation spaces: these parks were planned and constructed quickly, avoiding the great intellectual challenge of arid ecosystems that contains diverse habitats characterized by indication of special complexities in their structure, succession and dynamics. This application of western methodology, and the imitation of landscape solutions from tropical and temperate regions have failed technically and culturally.

Designing for arid regions is a critical process governed by initially forceful factors: the physical characteristics of the arid land, its environmental behaviour and the static components of its ecosystem. Secondly the culture and traditions of the existing inhabitants and the likely professional problems that might influence landscaping process and quality.

> *"Any attempt to understand the potentials for planning resource use in the arid lands must first understand the nature of aridity itself. What are the basic characteristics of the arid climates, what are the constraints they impose upon life forms, how permanent are these characteristics and what is their relevance to other aspects of the arid environment?."* [5]

As Heathcote, mentions, the arid land is special and special consideration should be carefully given before, during and after any planning process. Torrential rain may be followed by prodigious dust, And intolerable heat is often followed by extreme cold.

By standard definitions any region which receives less than 300 mm annual precipitation is a desert. Thus most of central Saudi Arabia is classified as desert. But contrary to the common belief that this is just an "arid empty land", it contains a rich diversity of habitats that are far from static. It should be obvious that an effort to understand the nature of the arid Najd is needed in order to assess the suitability of particular design methodologies for the region, and select the most appropriate.

### B. THE ARID LAND

Arid land dominates the Middle East and must be understood before any new man made activity is considered within the area. Fifty years ago climatic and physical factors were

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[5] Heathcote, R. L, *The Arid Lands: Their Use and Abuse*. First ed. New York: Longman, 1983. p.24.

the strongest influences on settlement design and the surrounding landscaping. Arid land should be understood as a simple yet complex and sensitive ecosystem. One must observe the dynamic behavior and the interaction of its components.

The primary limiting resource is moisture. This determines the life pattern of the living ecosystem ( human, vegetation and animals ). However, the arid land in this region is characterized by its diverse ecosystem, especially among plants and animal population and their response and use to the available resources.

The objective of this section is twofold: to review briefly what species are native to arid regions and describe their plant to plant interaction; and to disscuss the ecological problems encountered by imported species, and how they interact with indigenous species.

1. Plants that are native to arid regions are adapted to water and heat stress, salinity, lack of nutrients and indigenous insects, pests or diseases. It is not simply a question of a landscape architect using such species directly in landscape projects, since the indigenous plants available in local nurseries are propagated from only a single variety and under ideal conditions, such as modified micro-climate, rich soil and irrigation. This means that other varieties with their unique adaptation to particular environments are essentially lost and with them considerable landscape opportunities that might have employed their special adaptive characteristics. Kelly, 1976 [6]

2. Plants which are indigenous to such areas tend to be distributed regularly, rather than randomly or clumped; the tendency for plants to be regularly distributed is accentuated as available moisture declines; the entire zone is occupied by the underground root system. This dispersed character gives an unattractive appearance to a garden planted solely with native species.

3. Spatial variations in arid vegetation are closely associated with the different landform patterns. The assemblage of plants in depressions and wadis is different from that on the top of hills, and common species on sand dunes will not be the same as those in depressions. Through their influence on micro-climatic and edaphic characters, landform controls moisture availability, salinity and soil stability in the macro ecosystems of the whole sector. Given the general availability of seeds, moisture availability is primarily responsible for the actual distribution of species. Therefore, a separation and classification into wadi species,

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[6] K. Kelly. *Landscaping The Saudi Arabian Desert*, First ed, Philadelphia, U.S, Delancey Press, 1976.

ridge species and plateau species, is essential (Salama, 1987),[7] to ensure that species adapted to the moisture characteristics of each landform are specified.

4. Imported plant materials are less resistant to pests than indigenous plant material. The large number of exogenous, especially horticultural, plant species now being imported to these Regions are bringing with them new pests to which local species may not be immune. In Arriyadh city, (the capital of the Kingdom Of Saudi Arabia) Nerium oleander was infected by a new virus in 1987 and consequently large numbers of plants had to be replaced.

5. The wind and heat set up conditions which force plants to transpire more water than they would normally in order to cool the plant. Temperatures near the ground are higher than above the ground, so plants tend to absorb both direct radiation and atmospheric heat which forces them to transpire more water. These conditions encourage excessive use of water ( in non-native species ). Whereas native species are especially adapted to conserve water: studies show that native plant material requires only initial irrigation water which usually equals the annual minimal amount of rain fall.

6. Non-native species requires expensive imported soil which holds water and requires complicated drainage and irrigation systems. Moreover, some species require special micro-climate control and fertilizers.

7. Most western designers use dense ground cover as found in temperate designs, which needs many plants/$m^2$. This approach to planting design in the arid context will result in losses of large numbers of plants used, due to competition for moisture and nutrients.

8. Some native species change their habits in response to irrigation. These changes comprise form, color, spread, growth rate, and foliage. Thus, the authentic native appearance of an arid landscape disappears, if irrigated native species are used. Natural rainfall should be calculated and irrigation levels, in case of drought, should not exceed this.

9. As native species produce seeds which maintain their drought adaptability through the summer period; it is recommended that seeding operation should take place during the late summer with minimal storage period. Seeding native species in the winter after long storage periods is alien to the nature of such seeds, and

[7] M.Salama. *Availability and use of plant material in urban parks in central Saudi Arabia* M.Phil. diss., Edinburgh University, 1987.

may decrease their adaptability.

The current design and use of plant material does not satisfy the social needs of the local population, especially privacy. This should be provided by alcoved areas defined relative to spacial design and regularly monitored public response; the planting should also emphasize the ecology of species to reduce competition between plants and increase natural succession.

The plant material used now in landscaping is obtained through commercial dealers who import plant material from Pakistan, India, USA and Holland. The available species are ordered by the consultants using plant lists from text books for tropical species native to the countries from which the suppliers obtain their material. These species are not native to an arid zone in the middle east which results in major ecological, visual, environmental and technical problems. In addition, their continual use demands western methodology and design theories that sadly ignore the local culture.

There have also been changes in the social and cultural character of the region, the result of technical innovations, demographies and urban alterations, native-foreign conflicts, and the introduction of cars to the typical close-grained arid settlements. The compacted urban fabric, the unity in style and the hierarchy of open spaces were lost and this is a problem throughout the region. Most of the native people feel disassociated from the new environment. The damaging outcome is particularly obvious in Najd, where Islamic heritage and lifestyle are deeply rooted, and the culture and traditions are decisive to any outdoor design. These local traditions were neglected as the forces for change accelerated.

The changes were so many and came so quickly that little which is old and familiar is left. In a society adapted to arid environment, the relationship between culture and outdoor design is very important. Landscape design, especially in outdoor design, where activities are visible, should reflect traditional needs, values, motifs and influences, especially as Islamic traditions are sensitive to the nature and orientation of outdoor activity.

Religion is the main core of all design factors. Privacy, especially for women and individual family groups, is paramount to Muslims. The use of plant material in outdoor design should aim to provide this by visual separation. Until now, being largely based on foreign criteria alien to Islamic culture, the new parks and public open spaces have failed to satisfy these traditional needs.

These western design criteria are based on mistaken assumptions and are not socially or environmentally suitable: firstly, open grass land which exposes the users of the park to each other, where privacy is destroyed as a result of the absence of shrub barriers. Secondly the extrovert design approach to urban parks in cities. Thirdly, open pedestrian walkways through parks, which affects the privacy of park users. They also introduced the use of large surfaces of water in a hot, dusty, windy region, which will result in salt lakes and very high maintenance. Their appearance is totally unnatural. Finally these policies aim to create artificial tropical landscape units by creating all the microclimatic conditions necessary to achieve and sustain the illusion. This requires a constant import of un-renewable or valuable resources, such as irrigation water, moisture retaining peat, nutrient rich wadi soil, and imported plant material.

What is needed is the systematic identification of suitable and tested native species which do not require these add-on costs of irrigation, imported soil and high maintenance and could equally well be used to satisfy public needs. However, any introduction of highly sensitive plant material to a particular ecosystem requires strict management.

In fact, the deterioration of current landscape projects is largely due to the poor management of the greening process and can be summarized as follows. Firstly, the specification of non-indigenous species was not coordinated with the available nursery stock, resulting in a change in plants actually supplied to a contract, dictated by the available species; this usually happens when work is already on site. As a result the consultant has to make a change order covering the available species, which results in additions to budget, and changes to drawings and bills of quantities. Secondly, the lack of a published comprehensive inventory of indigenous species of plants which are available for use and qualified for public parks. Thirdly, parks which are recently planted are subject to grazing during the night by local animals.

Apart from the basic poor design choice of plants, the recent parks also suffer from ill-coordinated supply, short falls in budget and minimal after-care.

## C. CONCLUSION:

The detrimental effect of westernization on the urban environment of Saudi Arabia has been established. Landscape projects have suffered particularly badly. Tropical gardens are still favoured by both the designers and the client. These abuse the main principles of arid land ecosystems. The microclimatic conditions created for them are exhausting many precious resources.

Even the native inhabitants have lost their unique understanding of their ecosystem. Hence, they have changed native clothing, abandoned naturally airconditioned houses built around court yards, and the townscape has become comparable to any western city.

In the heart of Arabia, and inside what was traditionally a dense urban context, the sense of space is now agoraphobic.

The use of high technology, sophisticated irrigation systems and imported soil have aided the immigration of exotic tropical and subtropical species of plant material, even to Najd which is governed by the severe and extreme environmental conditions of an arid land.

Despite the use of expensive technology to create specific microclimatic conditions, these current landscape attempts generally fail. This is illustrated by the constant loss of imported species and the replanting process. In addition, planting non-native species has resulted in an excessive and speedy consumption of part of the precious and limited Najdi water budget. Meanwhile the surrounding Najdi habitats prosper with plant material that contain a hidden wealth of tough, durable and attractive species. These do not require any additional water or imported soil.

In addition to these technical problems, many social implications began to emerge as the imported species did not satisfy the social needs, such as privacy within the community, and the Islamic values and motifs. That applies to most of the country and was most obvious in the central region due to its special traditions, culture and strict application of Islamic laws after the rise of the Wahabi movement in Najd. [8]

For these reasons, the central region with an especially strong Islamic culture, was selected for close observation by the author to gain an understanding of its ecosystem, the traditions of the local inhabitants and the growth pattern of native plant material, as an essential step in the process of creating a relevant vernacular design policy.

Research into the plant resources of Najd and the significance of its wild habitats will point to the hidden wealth of the region. The research aims are as follows. Firstly, it will point to the actual resources in Najd. Secondly it will assess the vegetation material that might replace imported species and, monitor selected species in trial planting projects to test their capability. Thirdly, it will present a preliminary flora of native plants suitable for use in landscape projects in Najd.

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[8] Hopwood. D, *The arabian peninsula. Society and politics*. 1972. p54.

## 2) THE CENTRAL REGION AND THE SIGNIFICANCE OF ITS WILD HABITATS.

### A. INTRODUCTION:

Saudi Arabia is one of the largest Arab nations of the middle east. It is 1,500 km from North to South and 1,000 km from East to West. Al-Jazirah which is the ancient name of Saudi Arabia slopes gently from the Hijaz Hills on the West coast of the Red sea to the Gulf on the East. In Asir, the South West region, the hills reach up to 2 km in height, where the climate is cold-temperate. But towards the Central Region, the climate is extremely arid.

Saudi Arabia consists of five regions; the Central, Eastern, Western, Northern, and the Southern or Empty Quarter (Fig 3). All regions maintain the same social and religious traditions. They vary, generally in ecological habitat from the subtropical to the arid . To investigate the factors influencing landscape design in arid regions, the Central Region of S.A. has been chosen as the case study. Essentially a raised plateau, it is defined by the Twaiqi mountain range, the curved spine of the Arabian peninsula, extending from the Nafud desert in the north down to the Empty Quarter in the south. To the west, the mountains slope to a flat plateau with extensive isolated pinnacles, cliffs and narrow gorges on either side. To the east the Twaiqi slope down gradually with many finger-like shuaibs, or gullies, eroded into the limestone plateau. (Fig 2).

The Central Region generally has an extensive wadi system that is rich in flora and contains a diverse range of habitats. The most important and longest wadi in the Central Region is Wadi Hanifah which passes adjacent to Arriyadh city. It rise to the east, high in the Tuwaiq range, about 100 km northwest of Arriyadh. The wadi contains many farms which cultivate, fruit trees and herbs. (Fig 4).

The study will concentrate on the Arriyadh region, as this contains the range of habitats common to the Central Region (Najd).

### B. NAJD, THE HEART OF ARABIA:

The desert habitat of Najd contains a wide variety of land forms. Its Wadis, Escarpments, Ridges, Plateaus and Oasis are associated with the geomorphological and metreological structure of the region. These landforms maintain their characteristic microclimatic and edaphical conditions, which are the two factors affecting the habit and the growth rate of plants in arid conditions.

The soil type is the result of the weathering of the existing geological surface. Variations in this will effect water retention, soil quality and drainage characteristics. Therefore the identification of soil and surface geology for a particular site will point to the appropriate selection of a plant or plant community. This was an important factor in the design assessment mentioned by R & M Adams:

> *"Each rock type should therefore be analyzed to assess how both the climate has changed its form on the surface, and how its detailed characteristics will eventually affect plant colonization potential"* [9]

This statement points to the importance of soil investigation in determining the species required for a certain type of soil. The classification of Najdi soil and its associate species in the region should be an integral part of any design methodology.

The soil pattern determines the water habit of the soil which consequently defines the structure of the plant selection; where the dominant soil is fragmented rocky components eroded from a nearby escarpment this will lead to a minimal resistance to water penetration into the lower layer of the soil. The degree of permeability and the depth of the top soil or the presence of an impermeable layer will determine the species and the methodological design approach. In a permeable, loose and deep soil the designer should approach species selection by examining root patterns and the plants capability of responding to water beyond the extent of their roots. A soil with high amounts of clay and silt will form an impermeable glazed surface, preventing the water from entering the soil and so evaporating. The structure of the soil should be balanced and modified to suit the selected species or alternately (as this research argues) the chosen species should match the existing soil whether it be permeable, impermeable, saline or contains other chemical substances.

As a result of the soil structure some native species are able to use the microenvironment i.e the presence of debris covering the soil surface will eventually form a shaded lee side where the seed can nest and establish. It was found that the temperature difference in such lee sides could be 6° less than the surface temperature, while under the rock the moisture could be retained forming establishment conditions for most surface root species which are the dominant species in the region.

The distribution of a plant community is determined by the depth of the top soil and its ability to hold and retain moisture. Distributed according to weathering pattern and the topography in the region, most of the higher quality soils are found in the wadis and shuaibs known as alluvial fans: all the soil used in the current landscape projects come from those shuaibs and wadi beds. In Najd those wadis and shuaibs contain a valuable habitat, now being destroyed by this soil removal, largely to supply the requirements of

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[9] Robert & Marina Adams, Alan & Ann Willens, *Dry lands Man And Plants*, First Ed. London: The Architectural Press Ltd, 1978. p26.

imported species as mentioned earlier.

The soil of the plateau, and steppes into which these wadies are cut, consists of varying grades of sands and gravels. Their texture and water retention depends on their degree of coarseness and compaction. Five broad types have been classified (see table 1). These types are sandy, compacted stony, loamy, stony and compact coarse sand.

**Fig 2: Wadi Hanifah and the intensive ancient Palmland in the lowland and the extensive Shuaib vegetation which leads to the plateau vegetation.**

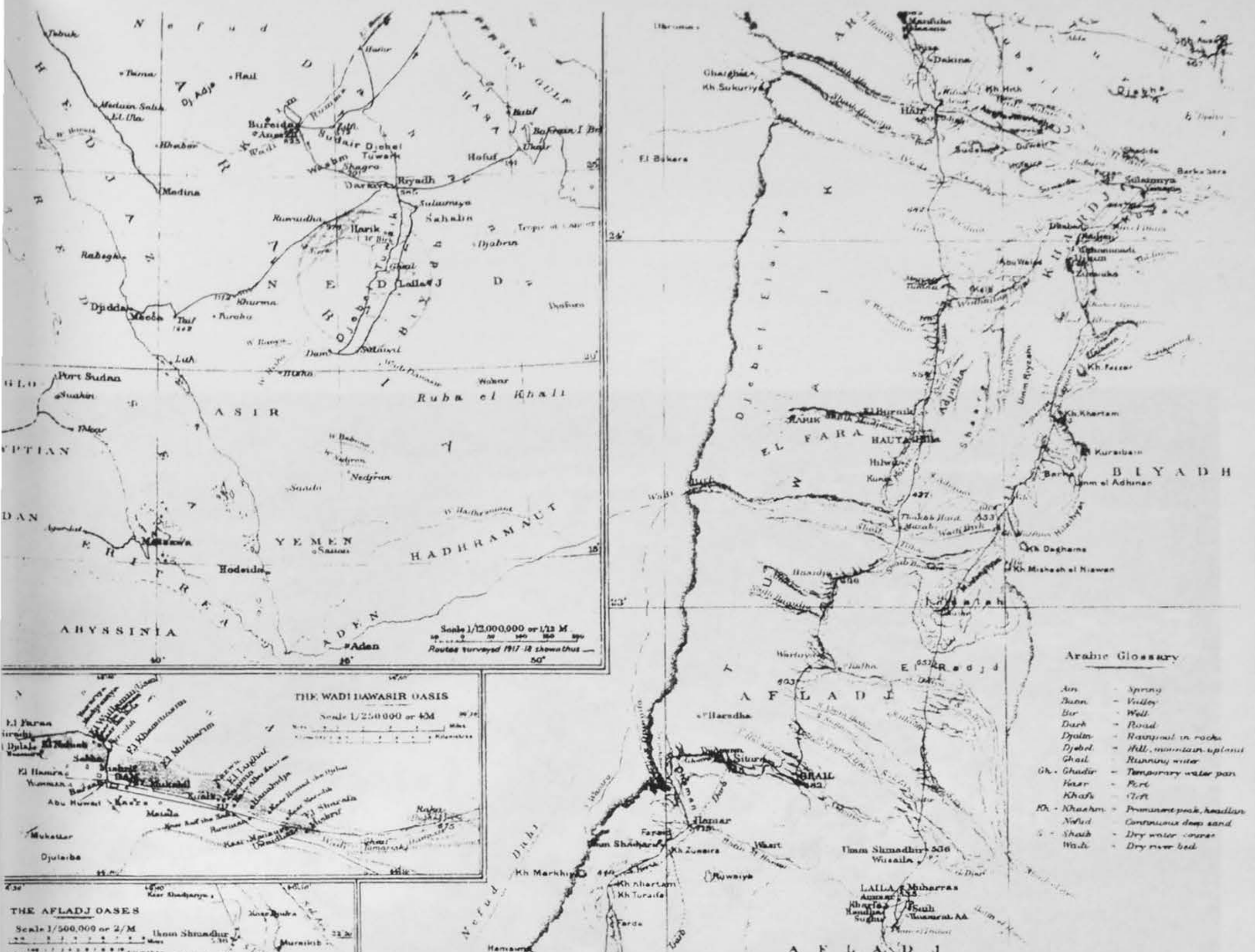


**Fig 3: National context of Saudi Arabia and its regions (top left). The rest of the map points to Najdi region in the centre where the study will concentrate upon.**

Fig 4: The central region aerial view.

## C. DISTRIBUTION OF NATIVE FLORA IN THE CENTRAL REGION

### 1. INTRODUCTION TO LANDSCAPE ARCHITECTURE, PLANT COMMUNITIES AND LAND USE PATTERN IN THE CENTRAL REGION

The main categories of land use in the Central Region are: Urban land use, semi urban, grazing areas and date palm lands which might be considered as agriculture land.[10] The ancient landscape elements in the region are based on oaises or depressions in the desert land where the water table is near to the surface and hence a range of plant material can be found. The depression is usually the dominant factor in the desert vegetation clasification. Most of the vegetation stands are found in depressions. In fact wadis can be considered as a depression into which shuaibs discharge.

Although K.Talib is not a landscape architect he argued that:

> "*A formal tradition of landscape architecture does not exist in Saudi Arabia. There are no significant examples of formal landscaping available for understanding the past methods*".[11]

His argument is not absolutely valid. There are many formal landscape units clearly illustrated in the fabric of Najdi settlements. The man made landscape appears in the traditional court planting, the descending penetration of the surrounding palm groves in to the urban context. Beyond the palm groves there are apparently limitless and diverse arid landscape models, from Acacia woodlands and open shrublands to sand dunes.

The urban land use pattern for the Central Region is controlled and defined by the wadi pattern and the consequent presence of water bodies particularly underground water. The presence of palm trees and acacia species is a sign of underground water; around these depressions in the desert the urban settlements occur. The semi urban settlements which characterise the region are largely the result of different factors such as ancient caravansaries, ancient farms and most importantly a market or Souk. Many residential and commercial communities in the vicinity of Arriyadh like Al Kharj, began as a Souk for dates and other important crops.

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[10] Rural land use areas mainly for arable agriculture crops such as wheat, are located in Al-ahsaa, well outside the study area.

[11] Kaizer Talib. *Shelter in Saudi Arabia.* First ed. London: Academy Editions/st. 1984. p.32.

Most palm lands are located in wadis and shuaibs.[12] Palm trees are planted in groups using a grid and a canal - basin system of irrigation. The basin system is microclimatically suitable for cultivating vegetables and other crops which require filtered sun and a cooler temperature.

## 2. CLASSIFICATION OF NATIVE SPECIES ACCORDING TO THE ENVIRONMENTAL FACTORS IN NAJD

### 2.1 GENERAL VEGETATION FEATURES IN THE REGION

In the Central Region besides the environmental factors, such as the climatic, topographical, geological and edaphic factors, the vegetational structure in the area has been highly influenced by selective grazing activities of sheep, goat and camels. The variety of plant communities are effected by these factors to a different degree.

This part of the study includes a typical plant community found in the Central Region (Najd). In Najd, apart from the wadis, the dominant feature is the steppe formation, which belongs mainly to forms of chamaephyte and hemicryptophyte. Those plants are in a continuous struggle for the available water around the root zone; this results in the absence of closed vegetation cover especially in areas with an average precipitation of less than 200 mm.

After the winter rain the gaps between the vegetation groups are usually filled by annuals which avoid the harsh environmental conditions by germinating only after rain fall and by completing their life cycle within one or two months. Their presence is linked to the moisture content of the upper soils. This will vary depending on the structure of each soil type. The five common soils and their associated plant species, are shown in Table 1.

This vegetation will be found in the spring time on undisturbed and shady wadi banks. If not disturbed by grazing and trampling a beautiful and attractive green cover can occur in the upper part of the shuaib.

A dense vegetation cover consisting of different annual species will occur all around Najd especially in the spring on a sandy wadi bank in the shade of acacia trees.

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[12] The finest dates in the world are cultivated in the central region, especially in Al-ahsa province.

* Sandy soil which is the dominant soil in the region will contain the following species of annuals:

Anthemis melamyzodina ssp.
Deserti astragalus gyzensis
Cutandia memphitica
Eremobuim lineare
Horwoodia dickronia
Launaea spp.
Matthiola longipetala.
Picris damascena.
Plantago cylindrica.

As for the compacted stony areas:

Aristida adscensionis.
Asterisus pygmaus.
Anastatica hierochuntica.

For loamy soils which are found in depressions:

Diplotoxis acris.
Enneapogon desvauxii.
Forsetia burtonae.
Gymnarrhena micrantha.
Plantago ciliata.
Pteranthus dichotomus.
Savignya parviflora.
Sclerocephalus arabicus.

Stony sandy habitat:

Anisosciadium lanatum.
Medicago laciniata.

Compact coarse sands:

Blepharis ciliaru.
Neurada procumbends.

Table 1: Associated plant species with different soil type. The species were obtained from R.D.A. Maintenance Division and for identification see " Flora of Saudi Arabia " by Migahid.

## 2.2 PHYTO-ECOGEMORPHOLOGICAL SYSTEMS IN NAJD

The Central Region contains a special phyto-ecogeomorphological system. Especially in an area with a uniform macroclimate, the vegetation structure is effected by land forms. According to the study which was done by the R.D.A. consultants.

> *"The subdivision of the higher syntax of desert vegetation according to the type of desert and according to the landform systems clearly reflects this close correlation. Through their effects on the environment including the integration of factors such as soil, insulation, air water radiation, temperature, wind and humidity, these*

*landforms influence the distribution and growth of plants".* [13]

The Central Region contains the following phyto-ecogeomorphological systems: cliffs, steep ridges and rocky outcrops, gravelly plains, gravelly hills, sandy formations, wadis, shuaibs. These features are now described as an introduction to Central Region geomorphology.

* Cliffs, steep ridges and rocky outcrops:

The vegetation of the rocky outcrops, the escarpment and the steep talus areas is generally very sparse. This is mainly due to the character of the substratum which is loose, unstable and contains very little fine material suitable for rooting and holding available moisture.

* Rocky and gravelly plains and hills:-

These areas are characterized by the solid desert pavement. The larger stones and coarse gravel particles are frequently mixed with gravel particles creating an unsuitable habitat as the rain water cannot penetrate into the upper soil layer, running instead into the depressions where a linear runnel vegetation occurs. The plains themselves are usually un-vegetated, but where the pavement is covered by a thin sand layer one finds traces of vegetation, mainly the annual dwarf shrub Rhanterum epappasum.

* Sand formation

A layer of surface sand will enable the rain water to dampen the sand particles ,which will maintain enough moisture for vegetation growth. Different plant communities colonize such surfaces. Where gravel is overlain by a thin, partially cemented sand layer, the Stipagrostis plumora community will dominate the area. On even sheets of frequently coarse sands or gravelly sands an even vegetation cover will appear. The dominant species in the surface sand are Panicum turgidum, Lasinrus scindicus and Lycium shawii shrubs which indicate the course of the water beneath the sand (fig 5). On mobile sand many of these species are absent and the vegetation generally consists of specially adapted Psammophilous species such as Stipagrostic drarii and Artemisia monosperma.

* Runnels, wadis, shuaibs, depressions

These areas are characterized by dense vegetation especially in wadis and shuaibs. Besides direct precipitation, the plant community receives large amounts of additional run off water from the surrounding areas.

The beginning of a runnel is frequently and generally characterized by linear strips of annuals ( Fagonia bruguieri and Slipagrostis raddiana ). The Cymboyzogon community

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[13] Arriyadh Development Authority, *Ecological Survey (task 9)*. Volume 1, (Arriyadh, S.A. August, 1985). p 26.

is found on stony terrain and the Chrysopogon plumulosus community is found in stony runnels.

* In wadis

The channel is more sandy than the upper slopes where the following communities usually are found:

Lasiurus scindicus, Hyparrhenia hirta, Hammada salicornica , Rhanterum epappasum communities where the sandy soil becomes deeper the above species disappear in the Pennisetum division community.The main channels of the large wadi systems are characterized by stands of acacia trees. At the end of the wadi the soil is mainly clay and the following species are found:-

Francoeria crispa, Hamada salicornica, Ziziphus nummularia, Lasinrus scindicus, Anvillea garcini, Heliotropium ramosissimum, Anastatica hierochuntica, Fagonia glutinosa and numerous weed species. Single Acacia ehrenbergiana specimens can occur. [14]

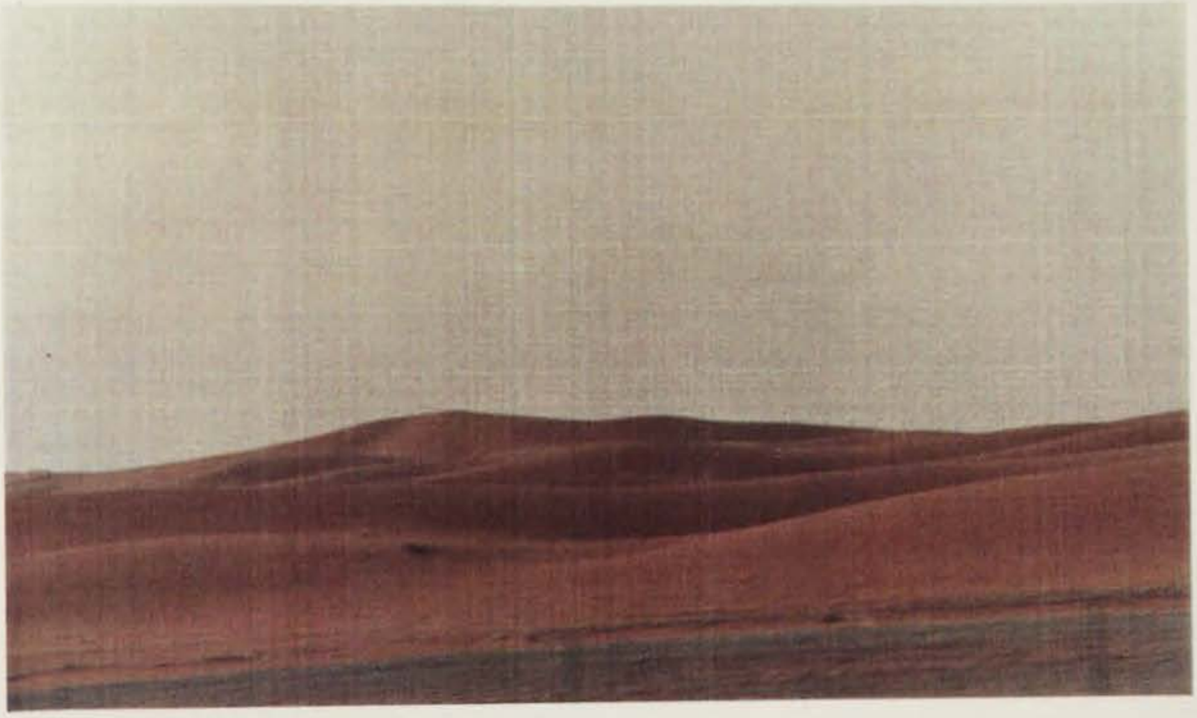

**Fig 5: Deep sand in the Central Region.**

## 2.3 CONCLUSIONS:

The rich, sensitive and wealthy ecosystem of Najd is ultimately classified according to Environmental factors. There is a clear link between plant communities and topography, with due consideration to soil condition and characteristics. The wadi ecosystem is the

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[14] ( Species were obtained from A.D.A., Flora of Saudi Arabia by Migahid, Flowers of Saudi Arabia by Shiella Collenette).

richest and most diverse of all, the vegetation decreasing in diversity upwards towards the escarpment.

Classification is valuable for the testing process that later will consider using soil patterns and associated communities as landscape design tools. For example, a park might contain a rocky feature planted with the vegetation community appropriate to that geological feature. Therefore, the study of the plant community in Najd will not only list the budget of its plant communities but will point to the associated communities and their relationship. This is very important in the determination of the available and suitable plant community for further study and to know the dominant and associated species that might be successful in landscape use.

## 3. PLANT COMMUNITIES IN NAJD:

The plant communities of Najd are diverse and often associated with other species. Here the author will list the communities found in a typical Najdi habitat. The borders between these plant communities are usually clearly defined by physical factors such as the shape of the wadi,shuaib, the soil structure and local geology. The following are the commonly found plant communities in Najd which are usually classified according to these factors:

* Woodland community (very open stand of trees)

This is usually found in open areas, is known as thorn woodlands and is built up of different acacias. They usually grow in the open and in the wide wadis. Zohary 1973 [15]

The following species of acacia are found and listed:-

* Acacia arabica
* Acacia gerrardii
* Acacia ehrenhergiana
* Acacia tortitis
* Acacia raddiana
* Acacia farnesiana

For particular edaphical and climatical reasons the Acacia gerrardii is here a real tree with a distinct stem, rather than the more characteristic shrubby form.

* Shrubland community

The distribution of shrubland in the Central Region is usually linked to the more moist areas which receive additional water such as wadis and depressions. The most common species are :-

Ziziphus nummularia
Lycium shawii

The associated species are

* Althaea ludwigii
* Anastatica hierochuntica
* Asphodelus temfolius
* Cassia italica
* Cenchrus ciliaris
* Chrozophora obliqua
* Citrulluys colocynthis
* Francoeria crispa

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[15] Zohary, Michael. *Geobotanical Foundations of the middle east.* Gustav Fischer Verlag. Stuttgart, Germany. 1973.

* Heliotropium ramorissimum
* Malva parviflora
* Lasiurus scindicus
* Plantago amplexicaulis
* Prosopis fracta
* Psoralea plicata
* Tragus racemorus
* Trigonlla stellata
* Zilla spinosa

The Ziziphus nummularia community generally covers reasonably rich soil.

* Dwarf shrub community:-

In the Central Region Dwarf shrub formations are the dominant and physiognomically most important vegetation type of the vegetated plain areas with a clayey, sandy, and sandy gravelly substratum. They cover the majority of the vegetated areas of Najd and they can be listed as follows:

- Hammada Salicornica community
- Rhanterium epposum community
- Fracoeria crispa
- Artemisia monosperma community
- Salsola baryorma
- Aellenia sulrophylla
- Anabasis setifera community
- Atriplex leucaclada

* Grasslands

Plants of different grass species form the main vegetation feature of the wadis and depressions. The grassland communities on stabilized dunes, on shallow sand sheets and on desert pavements are physiognomically of minor importance and the main broad communities only will be mentioned as follows:

Panicum turrgidum community

"open grassland, characteristic vegetation unit of deep sands and widespread in the middle east and in northern Africa" (C.F. Knapp, 1968; Kassas & Elabiyad 1962 - 1963); Giacomini et al., 1979 and others).

* Other grass communities:
    - Pennisetium division community
    - Lasiurus scindicus community
    - Stipagrostis plumosa community
    - Cymbopogon commutatus community
    - Chrysopogon plumulosus community
    - Hyparrhenia hirta community

- Oropetium africanum - O. capense community

* Other plant communities which could not be classified found in:
  - Rock desert
  - Gravel desert
  - Clayey depressions
  - Heavily disturbed areas

These are the main plant communities in the Central Region. Fig 6 & 7, shows the distribution of plant communities in typical vegetation stands in Najd.

Those communities will be fully described in chapter 4 in order to decide upon the target species that will be a tested to assess their suitability and durability for landscape use.

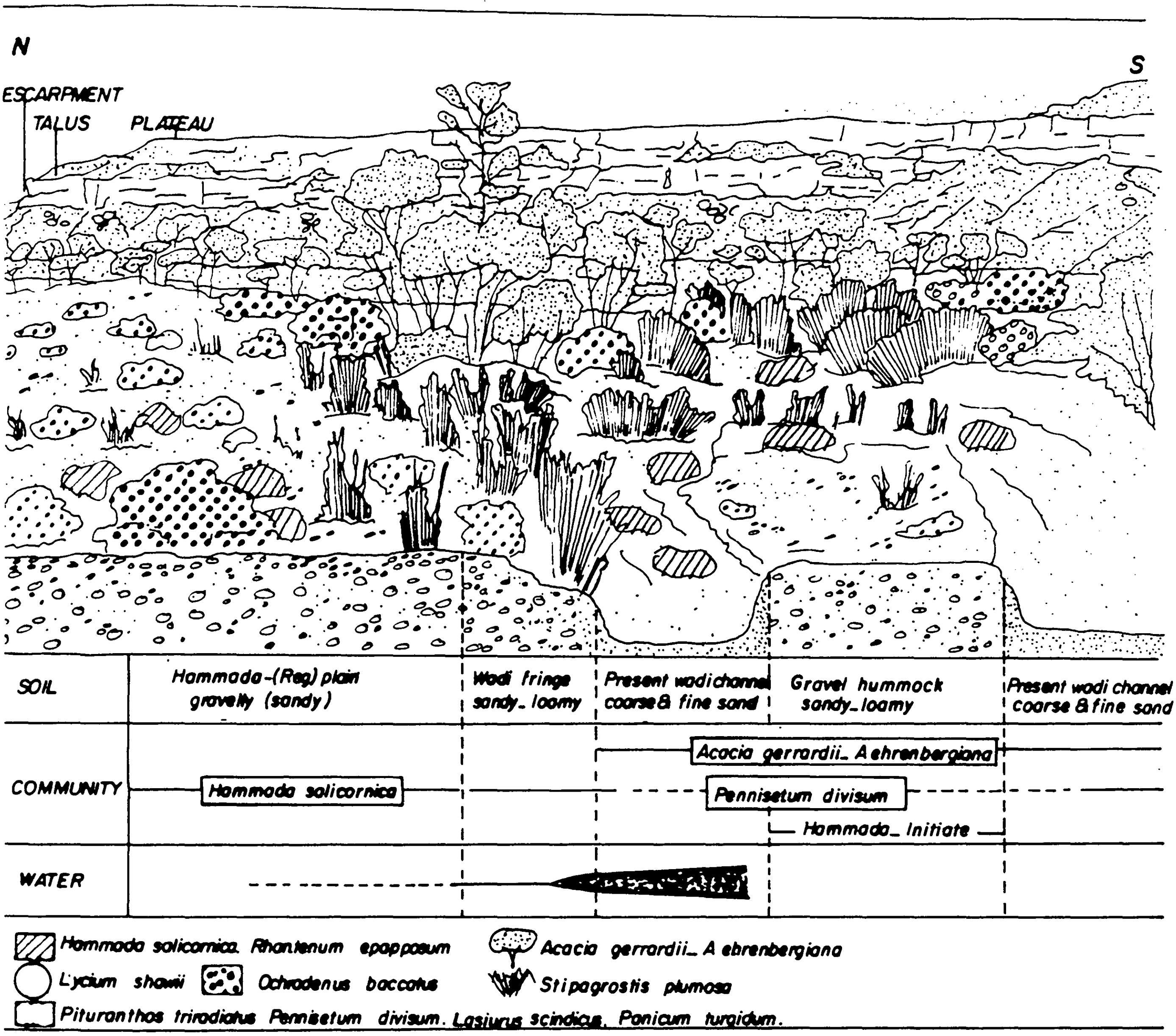


**Fig 6: Distribution of plant material in the Central Region. source A.D.A.**

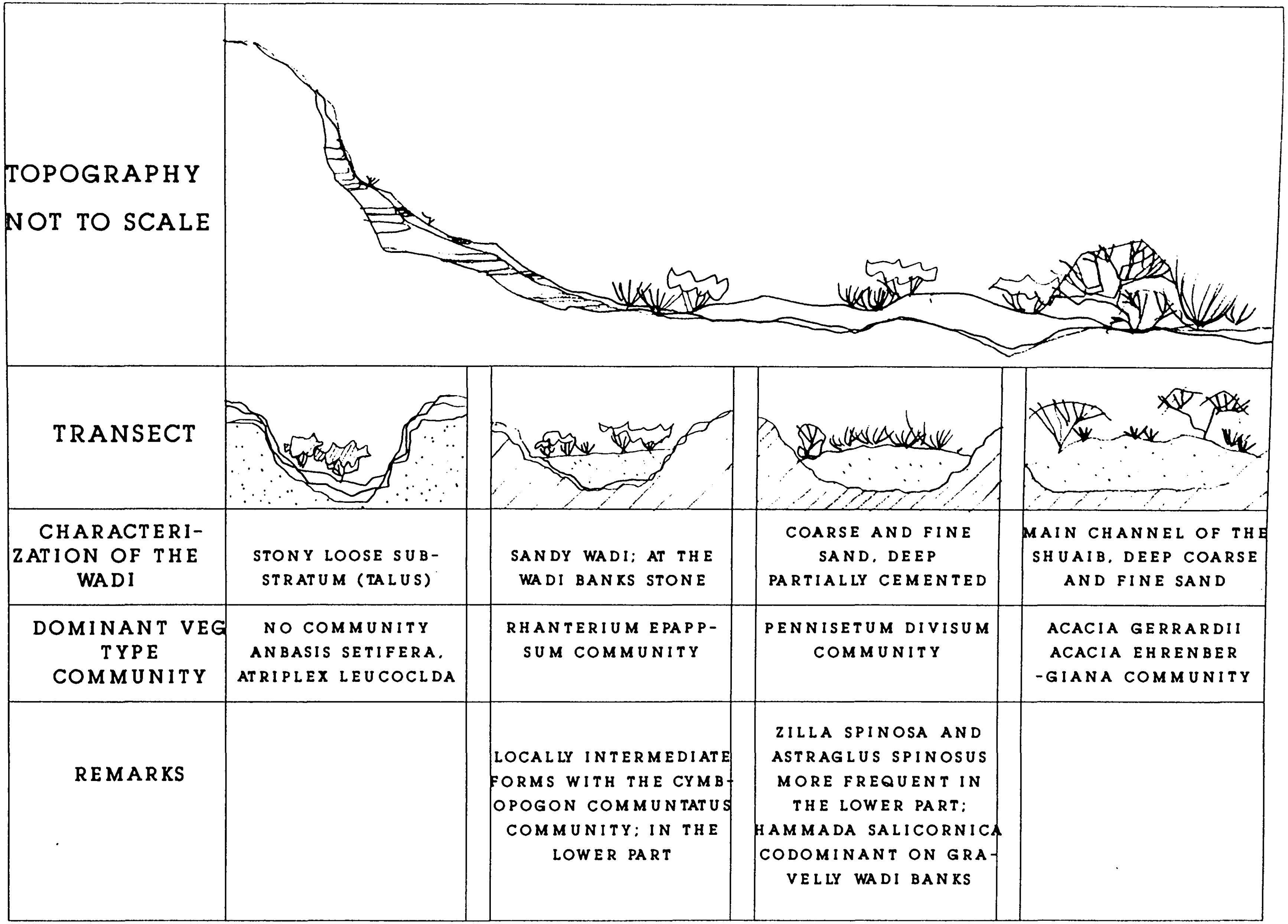


**Fig 7: Classification of native plant material according to topography.**

## D. NATIVE FLORA, ECONOMIES, AND THE STRUCTURE OF URBAN AND SEMI URBAN SETTLEMENT IN THE DESERT.

Najd is characterized by the clear and strong relationship between plant communities and the location of residential settlements. The distribution of a certain grass or dwarf shrub will attract a group of Bedouin for grazing. This may result in the establishment of a settlement which develops into an urban community. In fact Arriyadh itself is strongly linked to the history of indigenous flora: the city was a region of palm land which created a thriving market for date products such as dry dates (for storage), compacted dates, palm oil, sugar and building material. This acted as an important economic factor which attracted more people leading to the establishment of Arriyadh city. In Arabic Arriyadh means a group of parks: this points to the traditional importance of green areas.

The structure of Arriyadh city, (the core of this study), divides mainly according to vegetation pattern and vegetative topographical features. The city is bordered by Wadi Hanifah which acts as the green belt for the city. This wadi is rich in palm trees and other important species. In the city itself the palm trees controlled the urban spaces in the past, defining the structure of the city. The factors of this control will be described in Chapter 6.

## E. CONCLUSION

The Central Region is generally arid but its wadis, runnels, shuaibs and depressions are rich in diverse species which are perfectly adapted to a hostile environment. The local people traditionally used and maintained this rich habitat and moulded their daily living pattern closely to these species. By successfully exploiting the indigenous species, they became economically independent. For example they used the palm canopy to provide suitable soil and microclimatic conditions for cultivation of crops which require a cooler climate.

Although very diverse the indigenous species are classified according to a clear, phyto-ecogeomorphological structure: this provides a sound basis from which to introduce these species into urban spaces.

Bedouin and local farmers appreciate the native plant material and it has had a great influence on their movement, occupation and settlement locations. Traditionally there was a close relationship between the patterns of native species, such as the palm tree, and the existence of a local urban community. In addition the urban pattern influenced the distribution of native species and usually resulted in defining its structure, such as the palm groves that used to surround and protect the compact urban mass.

Contemporary urban designers have created an unidentifiable and confused open space pattern where plant material could be used. A study into the urbanization process and its transformation of the urban fabric can indicate the extent of its effect on landscape architecture. This forms the content of the next chapter.

# CHAPTER 2
# URBANIZATION EFFECT

## 1) HISTORY OF URBANIZATION AND LANDSCAPING IN CENTRAL SAUDI ARABIA (NAJD)

The first chapter introduced the region; its social ecological and geological characteristics and points to the wealth of its ecological habitats.

This chapter will introduce the problems which occurred during urbanization, emphasize the cause of the loss of landscape identity and character, identify traditional urban and landscape character and their surrounding social environment. The chapter will also investigate the potential landscape projects in the case study area.

Both chapters will form the first part of the hypothesis that the central region is far from an idle arid area. It is rich in native vegetation, unique urban character, traditional use of plants and great potential for landscape projects. It will also points to the loss of its traditional urban and landscape character as an important part of the hypothesis.

### A. URBANIZATION AND TRANSFORMATION, CAUSE AND EFFECT.

As a result of oil wealth, the growth of urbanization in the kingdom was rapid and intensive. In 1970 urbanization stormed the Saudi Arabian towns of Arriyadh, Makkah, Jeddah and Madinah. The government gave full support for unlimited urban growth, by guaranteeing and providing infrastructure, utilities, housing and other important services. This intensive urbanization will continue, especially in Najd, as a consequence of the population and urban growth. Urban expansion during the last 15 years was so fast that the master plan of the Central Region capital Arriyadh has undergone four or even five distinct changes. Four distinct patterns of development can be identified:

* **The old town** (Fig 8), a compact environmental pattern which represents and respects the Saudi arabian culture, traditions, heritage and lifestyle. Those factors are clearly registered in the urban fabric, the architecture and the character of open space. Even the distribution of planting in the city blends well with the urban pattern.

* **The centre of the town**, which was clearly planned according to the concept of the contemporary Egyptian School of Planning (1965-68). The old urban pattern was distorted without a transitional zone between the compact and rich old pattern and the substandard extensive new pattern. The centre was planned and built without keeping in mind the Saudi Arabian heritage, lifestyle, culture and even environment. This also applies to the open spaces and planting; the native trees were replaced by subtropical plants imported from Egypt, South Asia, Australia and U.S.A. Even the palm trees were replaced by another species (Washingtonia spp) which was used as a specimen in the streets and squares. There is a feeling of travelling from old Najd to Cairo in ten paces.

The only plant material is found in the street islands and roundabouts.

**Fig 8: Arriyadh (the old town).**

* **The edge of the centre**, which consists of a number of neighbourhoods with low density population was planned by the Greek town planner Doxiadis 1976 [16]. A checker board system influences the character of these neighbourhoods. This resulted in spaces consisting of roads defining housing blocks, further subdivided into house sites which are defined by walls without any external windows. The planting elements are omitted resulting in a hot, dry and arid neighbourhood. This area is called locally "the town of fences".

* **The edge of the city** - this is the phase where the city expanded more rapidly than the planning process. As a result, the only factor effecting the urban and landscape pattern is profit, which was the ambition of private investors. These bought large pieces of land and subdivided it using surveyors,which resulted in the following:-

- Isolated settlements within the city.
- Destitute master plan.
- Deficiency of parks or designed open spaces.
- Motor ways inside the city to link the isolated settlements.
- Major change in the infrastructure.
- Destruction of some shuaibs and associated wild life.

The four previous patterns apply equally to the major cities in the region. The greatest

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[16] Ministry of municipal and rural affairs, Deputy ministry of town planning, *Riyadh Action Master plans*, Technical report No. 8, Scet International / Sedes, 1982.

loss is the ancient urban and landscape pattern which was rich, compacted, traditional and environmental. It is sensible to briefly study this ancient urban landscape pattern, to see if the design principles have applications in to-day's cities.

## B. THE ANCIENT LANDSCAPE PATTERN

In the Central Region, most of the ancient towns were demolished and replaced by substandard modern architecture and a western style urban fabric. There are a few ancient towns preserved by the Saudi authorities still remaining in the region.

The landscape pattern in the ancient towns of the Central Region is characterized by the following:

1. Compact urban fabric creating a close-grained open space pattern.

2. The pattern reflects the traditions and religious way of life i.e. no segregation between community levels; the poor live in harmony with the rich, large houses intermingle with small reflecting the cohesion of the community structure. This effect of Islamic life style resulted in a hierarchy of open spaces, as the variety of house sizes sharing walls resulted in contained active and passive open spaces defined sometimes by mud walls or by groups of palm trees (fig 9). The edge of the ancient towns are surrounded by palm trees and reflect the same factors effecting both urban communities and plant community; the palm land contains both large and small farms according to the wealth of each farmer but retain a natural character. Also the urban fabric tends to blend peacefully into the palm community. Moving outward the palm trees will blend into other native species. In brief, in traditional settlements there appears to be a strong relation between the pattern of open space and the pattern of native species.

3. The character of native species such as <u>Phoenix dactylifera</u> permits the use of this species in small spaces.

4. The distribution of native settlements are linked with both water and certain native species such as <u>Ziziphus spina christi</u> and <u>Phoenix dactylifera.</u>

5. In ancient cities roads are defined by the mud wall of the houses. The width of the roads ,which are principally for pedestrians, vary from 2-6 meters (secondary) or 6-12 m (primary). The height of the buildings are usually 8m, which adds a special value to the sense and the quality of the landscape space. The spaces were designed in proportion with the height of the walls to achieve maximum shade and to modify the microclimate (Fig 10).

6. Native species are usually found in the courtyards ,which dominate the urban patterns.

7. The compaction of urban pattern resulted in intensely shaded areas which focus the planting into common and collective open spaces in a hierarchial system from palm land into small courtyards.

8. Grapes flourish in the surrounding oasis of towns which influence even the decoration of urban details (Fig 11).

9. Landscape pattern in traditional settlements is characterized by the following features:

* Canal and basin irrigation (Fig 12)

* Geometrical distribution of plants

* Compacted palm canopy to provide maximum shade areas to create microclimatic conditions for cultivating other important crops and also to provide desirable places for recreation activities, as the temperature difference under the canopy could be up to 7oc cooler.

* The water well usually acts as an active area in the park as people tend to gather around this for recreation activities.

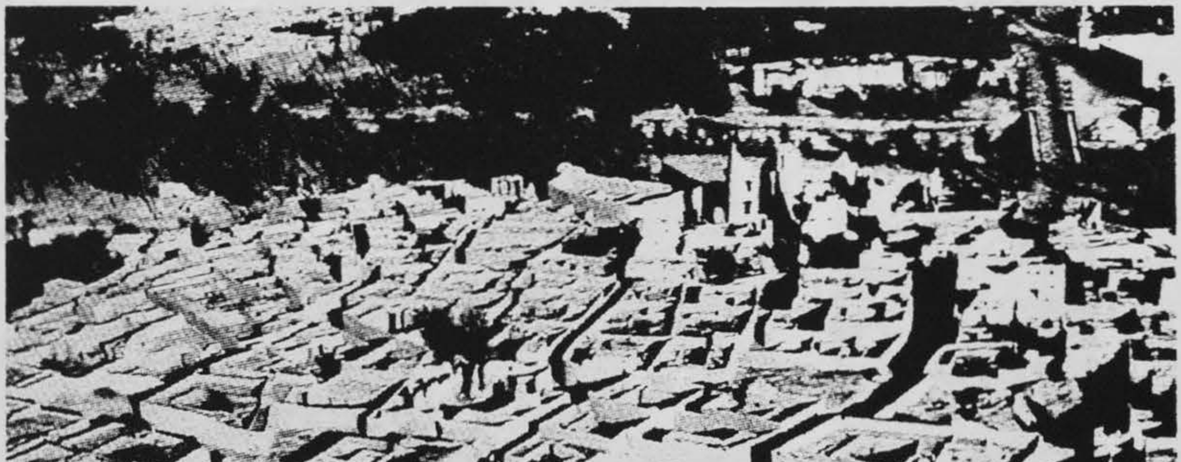


**Fig 9: Palm trees and space definition. The fig shows how the palm trees were used to define the urban space along the edge of the town. source K.Talib.**

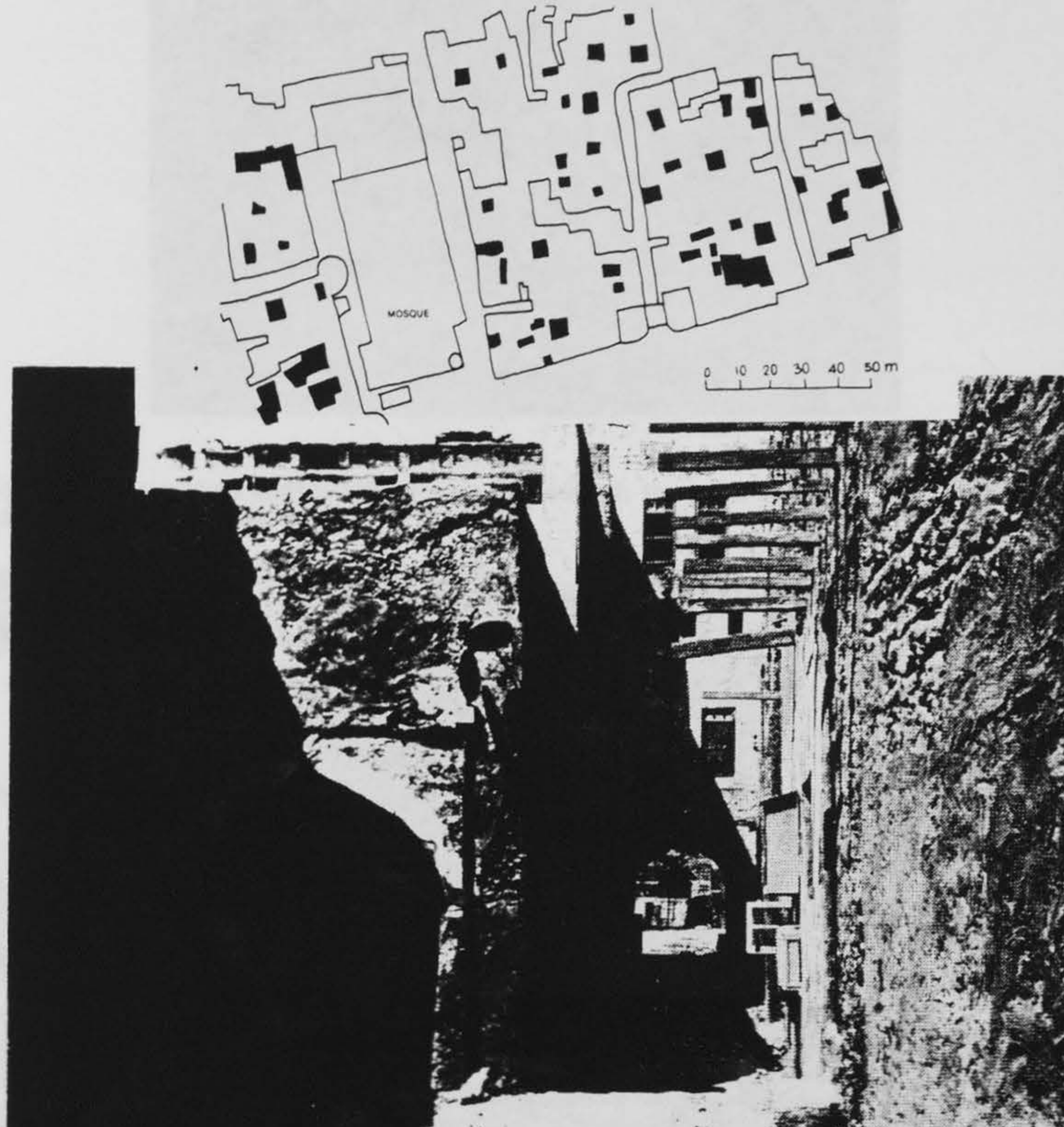



**Fig 10: Narrow pedestrian roads in ancient towns. As an ancient solution to minimize exposure and glare. The pattern of those streets usually was planned perpendicular to the wind direction to minimize their dehydrating effect.**

Fig 11: There was an appreciation of plant material, that was used as a decoration for this wooden door from Adiraiyah.

Fig 12: Canal and basin irrigation method. The traditional success of using slope and soil to create an intelligent irrigation pattern for cropping the rich soil beneath the palm canopy

## C. ARRIYADH MASTER PLAN

This section will introduce potential landscape sites in which native flora could be used, and the landscape structure of the area where most of the proposed target species will be tested.

### 1. HISTORY AND SETTING:

The growth of Arriyadh closely parallels the rise to prominence of Saudi Arabia. The chain of small settlements situated along the wadi Hanifah, (Fig 13 below) formed Arriyadh, which gained importance due to its location and the rise of the Al-Saud tribe. Specific reference to Arriyadh was made in the early 18th century by the Arab historian of the Najd Othman ibin bishr.

Old Arriyadh city (old village) is clearly the core around which the city expanded. The old city was rectangular in plan and measured 1125m from N to S and 750m from E to W. The perimeter walls were surrounded by palm trees all around the town. The rapid growth of the city began after King Abdul Aziz unified the Arabian peninsula in the 1930's. The growth radiated from the core. Fig 14.

The large gardens surrounding the town with names such as AL Wusaita, Al-Shamsiyah, Al-Hantah, Al-Badia and Al-Faryan were over taken by urbanization and now only give names to new districts.

Arriyadh is almost exactly in the centre of the Kingdom at 24o 42' latitude and 46o44' longitude. It is situated at the confluence of three major Wadis. The city is generally flat. To the West, Wadi Hanifah runs in a North-West / South/East direction, with many smaller shuaibs. Although dry most of the year this wadi may suddenly fill after rainstorms.

### 2. OPEN SPACE PLAN:

The Open Space plan was described by the Arriyadh master plan (1986) as follows: a hierarchy of recreational and open space facilities, and existing green areas in Arriyadh Metropolitan area would be reinforced and organized into a unified park system (fig 15). Major projects consists of:

- The Dirab Park which is 30 km south of the city along the old Jeddah Road. This park will focus on the Najd agricultural resources.
- The camel race park, located east of the new airport. This park, which exists as a camel race track would be reorganized around active outdoor activities and include the camel track.

- The Jabal Tuwaiq recreation park (located outside the city) will cover an area of 4,000 hectares approximately.
- The Amaniyah and Jubailah wadis North-West of Arriyadh.

The revised master plan also proposes to transform the Wadi Hanifah into a metropolitan park system wherever favourable soil conditions and water availability permits. The whole wadi will act as a "Green Belt". It is already completed in the Southern agriculture land. This area would be used for recreation, agriculture, and as a buffer zone to protect the city against the desert. The lack of large parks will be remedied by creating a city park system which will be designed, built and managed by the municipality of Arriyadh.

As described earlier the Open Space Plan failed to respect the Saudi Arabian heritage and life style (see the comparison between (Fig 16 and fig 17).

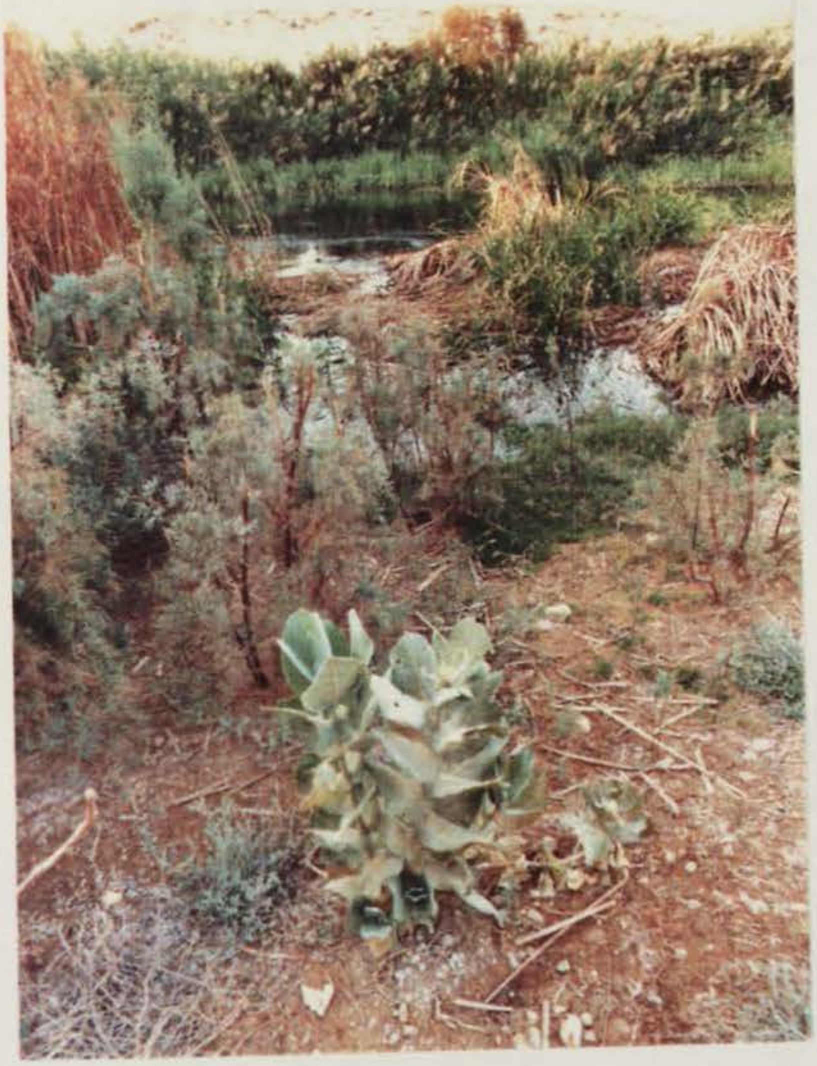


**Fig 13: The end of Wadi Hanifah south Arriyadh.**

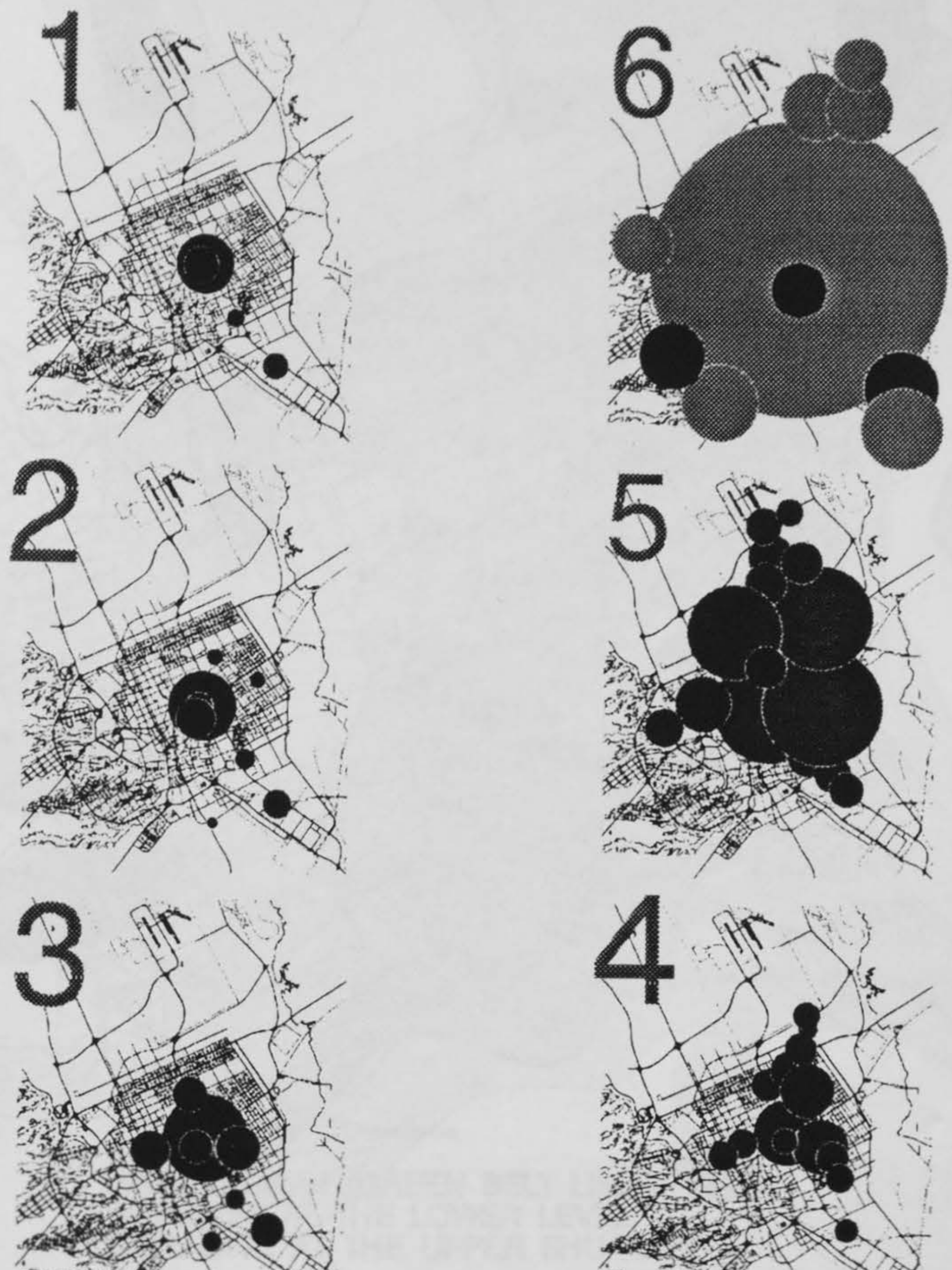



Fig 14: The growth of Arriyadh city. source master plan. (Update from Riyadh Action master plans). 1=1940, 2=1950, 3=1960, 4=1970, 5=1980, 6=1990.

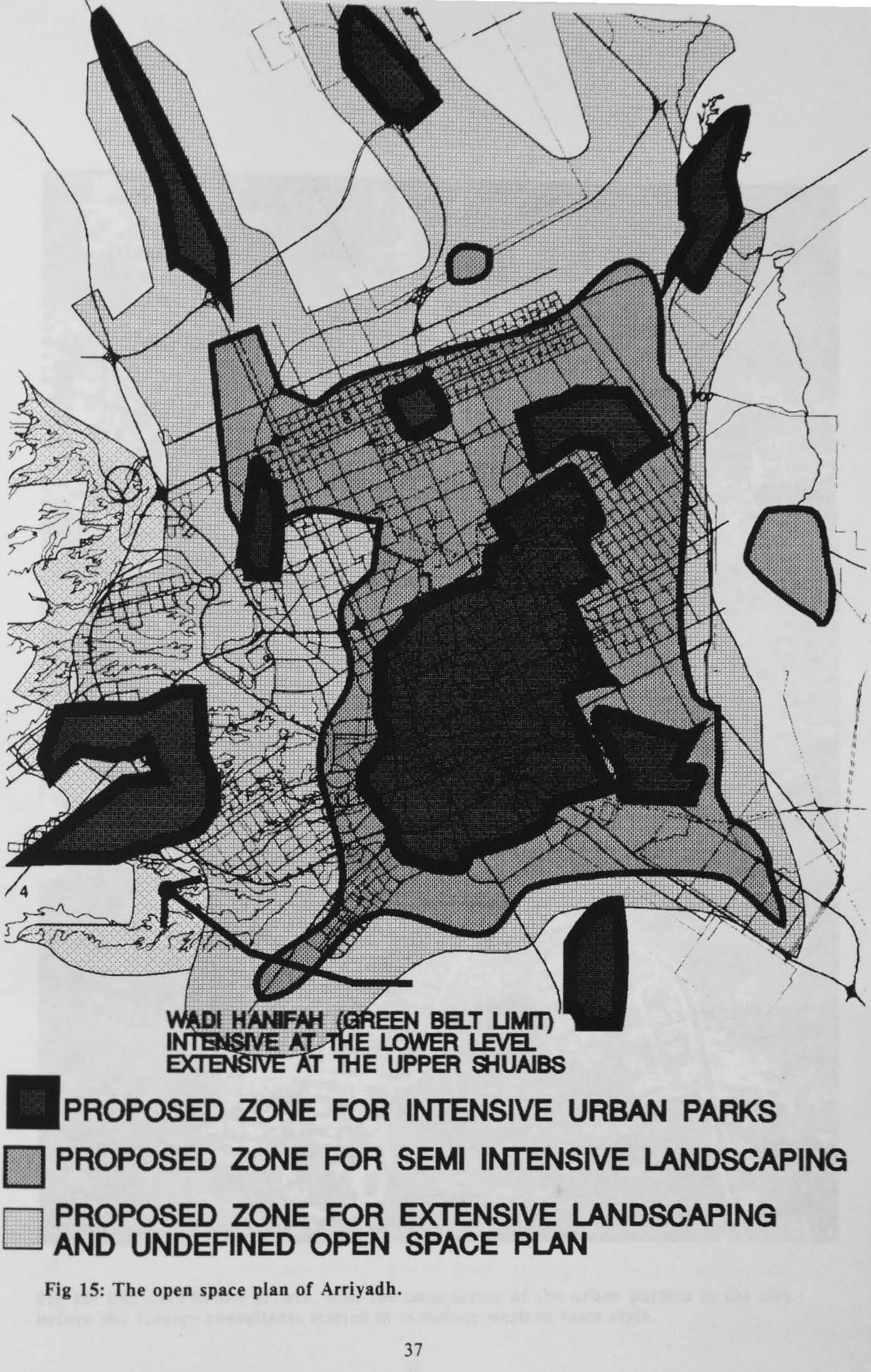
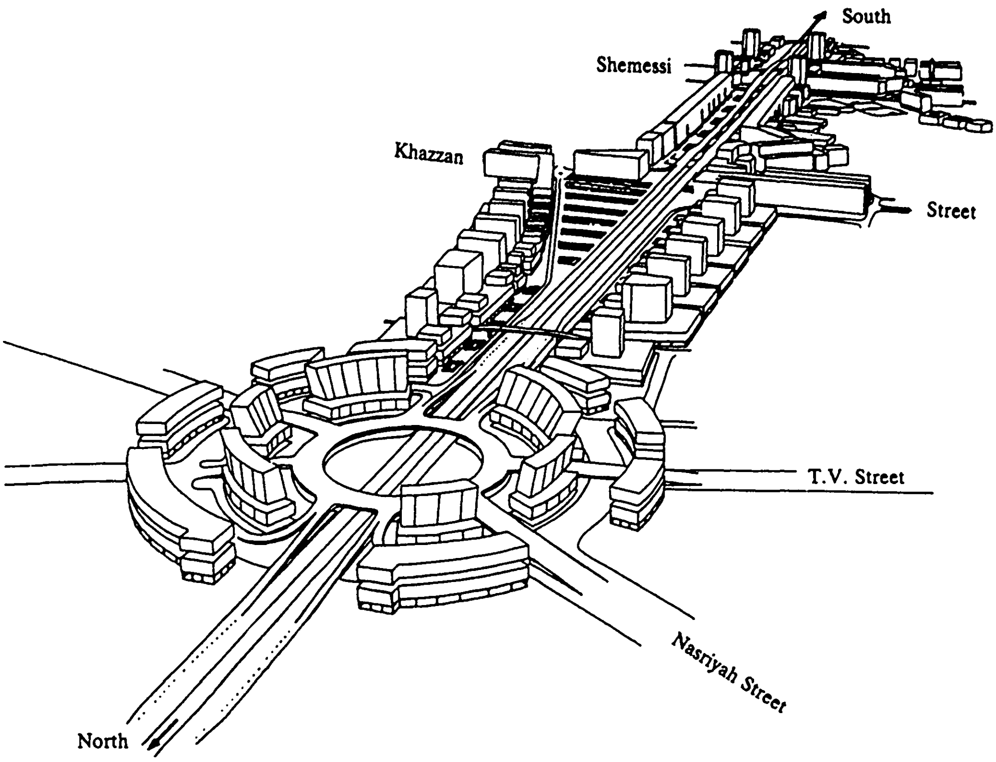



Fig 15: The open space plan of Arriyadh.

Fig 16: Old najd before growth, note the compaction of the urban pattern in the city before the foreign consultants started to introduce western town style.



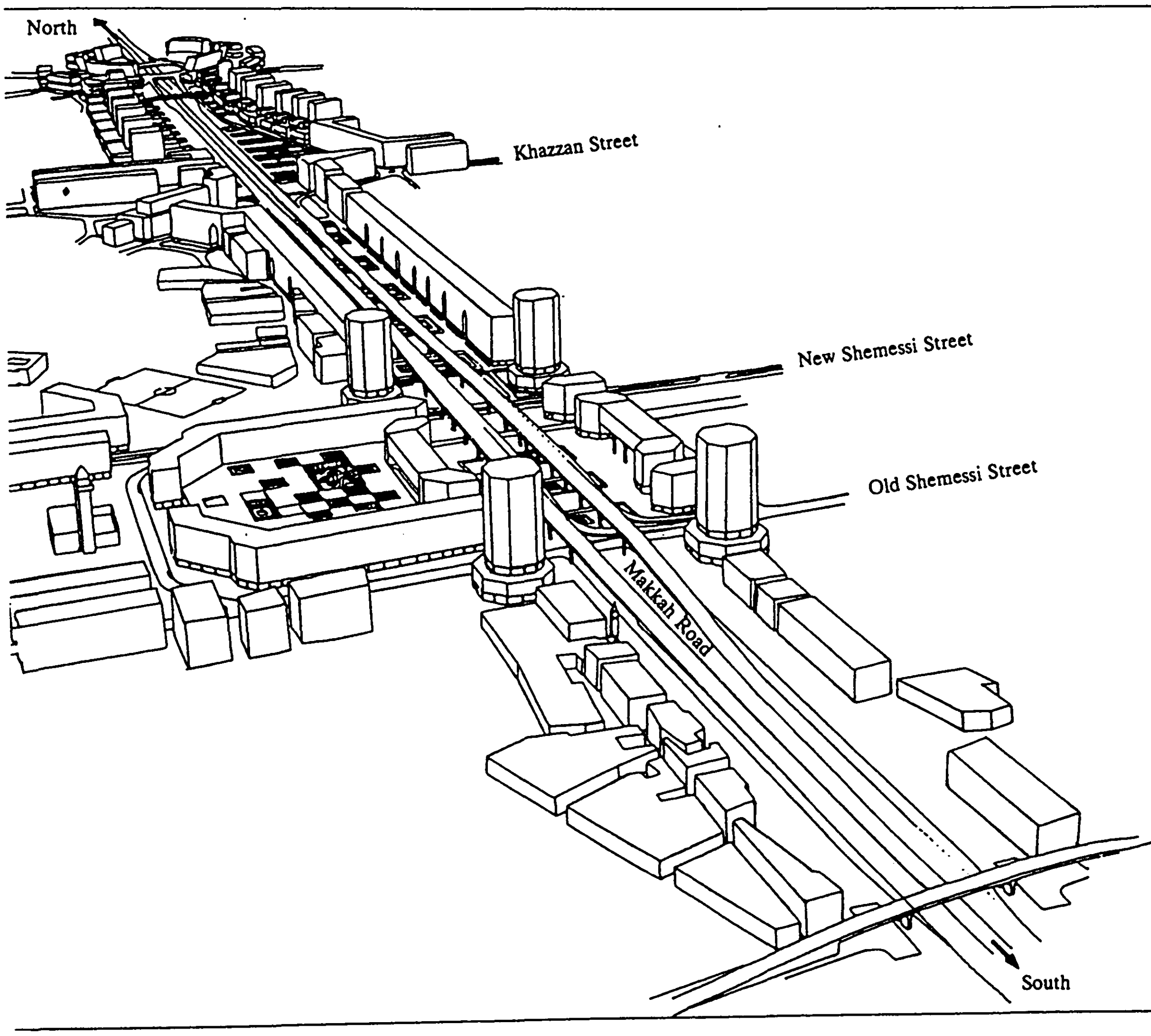




**Fig 17 :- Arriyadh as proposed by the master plan , note the western style and the destruction of the old urban fabric.**

## 2) LANDSCAPE CHARACTER

### A. THE CHARACTER OF TRADITIONAL LANDSCAPE (CASE STUDY AL-DIRAIEYAH).

In contrast to the destruction to the historic buildings in Arriyadh, the small rural settlement of Al-Diraieyah has suffered clearly through loss of population. To day it is being restored by the Department of Archaeology. The old urban structure is worth discussing as an example of traditional urban form in Najd.

Al-Diraieyah is a small town situated a few miles North-West of Arriyadh city. The traditional distribution of courtyards, semi open spaces and open spaces has a cellular structure which indicates that they are part of a social organism. The streets vary in width. In narrow streets the scarcity of planting is obvious, while in semi open spaces traces of plant material are often present. The influence of environmental factors on the city layout is demonstrated by the hierarchial distribution of the semi sheltered open space, the compact urban grain, the solid external building facades and the introverted court housing layout. Plant material is used in association with an introverted and environmentally evolved courtyard building pattern. The court houses and other building form provides spaces protected from the hostile environment and suitable for all outdoor functions. This is illustrated in Fig 18 and described by Talib, K:

> *"This development is shielded from the harsh elements of the environment by the thick growth of palm trees around it. The narrow streets and courtyards are the only open space in such 'mud lumps'. In such a densely built development, the sand-storms cannot enter the narrow streets or the courtyards. The densely built structures sharing as many as three walls shade each other throughout the day".* [17]

The courtyard (Fig 19) should be considered as an important landscape element: it acts as an active element in the house planting areas. There are certain species used in planting the courtyards. Traditionally the palm tree was favoured by the locals for its useful dates and long life. Under the palm tree the locals tend to use vines and citrus trees or sometimes Ficus pseudo-sycamrus, which is called the holy tree. All though subtropical species were found to thrive under such conditions, they were rarely used.

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[17] Kaizer Talib, *Shelter in Saudi Arabia*, First ed. London: Academy Editions/st. 1984. p.48.

Fig 18: The use of palm masses to shield urban settlement.

Fig 19: Shows the court yard which was used as a landscape element for creating microclimatic conditions inside the house.

Tamarix aphylla was used as the main source of wood in the town. The native people used to plant them as wind protection, and wood for general use. Capparis spinosa, associated with dry mud walls, proved a successful species for these compact urban landscapes (Fig 20).

**Fig 20: Capparis spinosa and building material: the use of mud walls and compacted gravel walkways over the sandy soil, formed an excellent environment for this species and reinforced the association between native species and indigenous urban settlement. They are usually found naturally in depressions, damp areas and between housing blocks.**

The structure of the Central Region's urban settlements dictates the use of plant material mainly in the following four areas - courtyard areas, semi open spaces, intensively and extensively used open space.

### B. LANDSCAPE AND SOCIAL LIFE:

The distribution of landscape elements from palm land to urban landscape is controlled by the social pattern. The wealth of a family is counted by the number of palm trees they own, which encourages the people to cultivate more palm trees.[18] Again there is no segregation between rich and poor farmers, no right of way or water control i.e. each farmer will share the water in case of drought, in a way typical of Islamic society. Since their main occupation is grazing, the wild desert plants directly effect the Bedouin community; one such is "*Barseem*", a species of grass germinating under the palm canopy, which was used as the main source for animal food. This classified and affected the distribution of those who bred sheep not camels and explains the relationship between native trees and the Bedouin. The location of palm lands will attract the Bedouin to oasis areas in the desert. For this reason some farmers will cultivate this grass attractive to Najdi sheep.

Native species were an important element in controlling the key factors effecting social life. For example the successful location of palm trees will eventually form an oasis leading to the formation of microclimatic and edaphic conditions under the palm canopy where farming activity can establish. In fact 25 years ago the social pattern in Saudi Arabia was dependent on such interdependence of habitat, agriculture and settlement.

## C. CONCLUSION

The values which characterize the urban landscape in the Central Region were largely lost as a result of the following:

* The speed of urban growth.
* Lack of open space plan.
* Lack of information about native flora and its values.
* Foreign consultants failure to understand the Saudi Arabian heritage and lifestyle which resulted in the loss of landscape character for the Central Region cities.
* The pattern in old towns which was rich, compacted and blended well with the rest of the urban fabric, was lost and replaced by a grid of wide streets and disintegrated urban mass. Which resulted in the disappearance of open space hierarchy, unity and proper usage of plant material.

The Central Region (Najd) which has one of the harshest, most limiting environments in Saudi Arabia requires the landscape designer carefully to consider all the local environmental factors.

The new and expanding towns were developed according to the western style of architecture and planning regulations (Fig 21). The Western open space regulations such as a certain setback for each housing unit from the streets and neighbours resulted in disintegrated urban fabric which created gaps in the urban context permitting more sun into the open spaces. This is contrary to the form of the old towns which were compacted and characterized by a clear landscape pattern suitable to the environment.

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[18] A. Albrahime, local senior citizen, interview by the author, 12 July 1988, Arriyadh.

The mistakes of the recent past lie in the unthinking application of inappropriate, "progressive" techniques. The old town represents an evolutionary answer to the environmental needs of the area: many landscape design principles emerge from close examination of these old towns. It is important that contemporary designers understand these principles and strive to incorporate them into the planning and development of towns in Saudi Arabia.

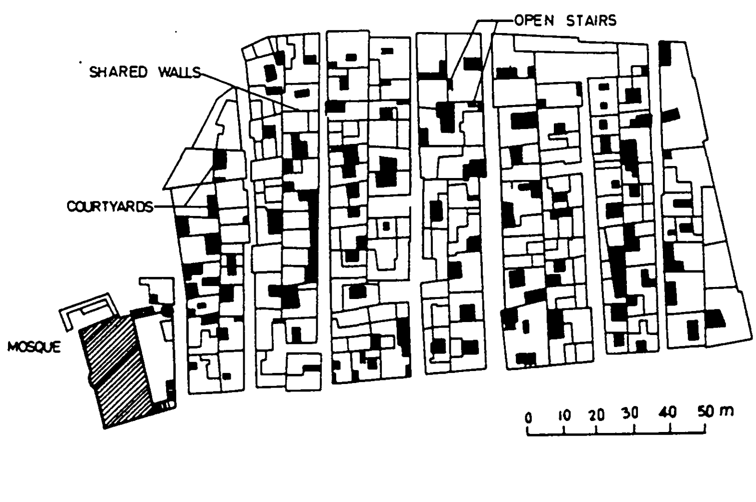


**Fig 21: The introduction of semi western style in the new Najdi towns albatha. Note the checker board system and the start of linear planning method.**

## 3) POTENTIAL LANDSCAPE WORK

### A. FIFTH DEVELOPMENT PLAN AND LANDSCAPING.

The Central Region covers 23% of the total area of the Kingdom with a population of approximately 3,000,000. It includes the Emirates of Arriyadh, Qassim, Afif and Al-Khaeirah. The region is considered by the government to be an area in which priority should be given to development as it contains the capital, the centre of trading industry and the government. The development plan (1974) aimed to create a "green city" and incorporate the immediate surrounding region in planning for major recreational facilities, as the existing small recreational facilities failed to serve the daily needs of the region. It also considered improving the marketing and distribution system for plant material and provide financial incentives and credit subsidies for any project linked to landscaping. The total budget of approximately five billion SR (£800 million) was approved in order to construct parks and extensive landscape areas around Arriyadh such as Wadi Hanifah. The plan is characterized by a distinct continuity with the previous development plan. The landscape department in the municipality of Arriyadh is responsible for the majority of the intensive landscaping in Arriyadh city: the department employs local landscape architects who supervise appointed consultants and contractors.

### 1. THE POTENTIAL AND FUTURE OF LANDSCAPE ARCHITECTURE IN THE REGION

There is unlimited demand for the use of plant material in landscape architecture.

> *"The program in Saudi Arabia would have to be characterized as ambitious beyond belief even if the climate were more temperate and less arid"* [19]

During the last ten years the Saudi Arabian government provided this programme with full support. The first landscape department in the municipality of Arriyadh was opened in 1978. It was treated generously by the council of ministers who approved a large budget for their use: from 1979 until now a large number of parks and have been completed. Table 2 shows the landscape work completed and proposed since 1971 by the municipality of Arriyadh; this excludes street planting, which has not yet been measured.

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[19] Kelly, Kathlen, *Landscaping the Saudi Arabian Desert*, The Delancey Press, Philadelphia, Pennsylvania, U.S.A 1976.

| | |
|---|---|
| Regional parks under tendering | 1,000,000 $m^2$ |
| District parks constructed, | 243,397 $m^2$ |
| Children's play areas | 312,840 $m^2$ |
| **Proposed Regional and Nature parks** | |
| Arriyadh wadi park | 40 $km^2$ |
| Arriyadh nature park | 20 $km^2$ approx. |
| District park (Arriyadh and Central Region towns) 6,000,000-8,000,000$m^2$ | |

**Table 2: Potential parks for introducing native species. source annual report and "*Civilized face of Arriyadh*" Vol. 7, Municipality of Arriyadh.**

The second landscape authority in the Central Region is Arriyadh Development Authority (A.D.A.), the main agent commissioning important planning and construction projects. They are the government agent responsible for constructing the Diplomatic quarter. The following landscape work (Table 3), was constructed by A.D.A. during the last five years:

| | | |
|---|---|---|
| * | Intensive landscape | 536,644 m2 |
| * | Extensive landscape | 336,616 m2 |
| * | Public parks | 144,000 m2 |

Much of this extensive landscape program made use of native species.
**Table 3: Landscape work carried out by the A.D.A.**

Now the A.D.A. has been appointed by the government to study the whole development of wadi Hanifah, which extends from North to South for 100 km in length and 2 km in width (Fig 13). Such an enormous project requires a well thought out strategic study. This project is a perfect opportunity for using native flora especially when the essential information is obtainable.

Other potential recreational sites commissioned for parks in the region are situated around Arriyadh city and thought likely to be approved soon by the Saudi authorities. However, the figures are not known yet as the municipalities are studying the feasible sites around each city. It is likely that imported flora will be used in most of these projects if research into use of native species is not available by then. Such information would act as a guide and education to landscape architects and introduce indigenous flora to landscape projects in the region. From data given by the municipality of Arriyadh and A.D.A, and the probable existence of other potential sites in the region, this appears to be a most suitable time for introducing native flora as an alternative to largely unsuccessful imported flora. The implications of using imported plant material are described later.

The landscape department was awarded a "special interest" from the council of ministers and the correspondingly large budget which was mentioned earlier. They started to implement a landscape policy to create a green city: to design and construct parks on selected vacant land, and within every housing area. The following principles were the ultimate goals for the department: [20]

1. Encourage universities to establish landscape architecture departments.
2. Interest free credit over long periods for private nurseries.
3. The best use of water resources, especially depletable resources.
4. Protection of the environment from pollution associated with landscape activities.
5. Establish a central nursery to supply plant material.

Those policies are only theoretical: after the building of some parks they discovered that the cost of construction and maintenance was prohibitively high and the use of imported plant material, imported soil, and expensive irrigation systems created a continuous costly maintenance requirement.

## 2. POTENTIAL PARKS IN THE MASTER PLAN IN WHICH NATIVE FLORA COULD BE USED:

The existing master plan contains a number of sites approved by the government for landscape recreational projects. In 1987 Al Arriyadh Development Authority was appointed by the Saudi Arabian government to study the potential of extensively landscaping and managing Wadi Hanifah. This project will be the largest landscape project ever in the Middle East; apart from the projects mentioned in the open space plan, there is a huge area approved by the municipality inside the city, a total of some 3000 hectares.

## B. CONCLUSION

The speed of urbanization and the absence of native designers, resulted in the birth of non-vernacular settlements that belong to any where, but not Najd. In addition, most of the rich traditional urban pattern was demolished and replaced by disintegrated urban fabric and non indigenous architecture. These have left the towns with open spaces similar in scale and character to any in western towns.

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[20] The head of the landscape department Y. Alnaiem, interview by the author, 27 December 1987, Municipalty of Arriyadh, Arriyadh. (4 Parks in Arriyadh, M. Salama, Project architect).

The ancient landscape pattern became lost, and the its definitive elements were engulfed by the casual urban expansion. The traditional landscape techniques and the unique irrigation systems were neglected and replaced by advanced costly systems. In brief, the identity of Najdi landscape architecture that usually demonstrates a hierarchy of court yard planting to palm land to desert communities, was eroded.

Arriyadh city and Al-Derayiah, are representative of settlement throughout the whole of the central region. Their study showed the following:

1. The Central Region enjoys a rich history which inherits the spirit of Islam, affecting the fabric of the urban and landscape community.
2. The open spaces in old towns were traditional, environmental and most suitable to this region.
3. Contemporary open space plans failed to satisfy the Saudi Arabian heritage and lifestyle. Moreover, the environmental factors were not considered during design stages.
4. The Central Region's native species are diverse and clearly classified according to geomorphology. The initial impression shows that a further analysis of certain communities is important and essential in order to establish sources of native species.
5. The imported landscape consultants were unaware of the local values, traditions and influences.
6. There is a great potential for landscape projects in which native species could be used. The lack of tested data and general information about these species is holding back their general use.
7. This study is important for the region and should result in introducing native species to the landscape profession with consequent enormous short and long-term benefits for all involved in future landscape projects. Consequently it will help in the elimination of many eco-environmental problems

Especially now, during the fifth phase of the current development plan, the chance is greater to rehabilitate and establish vernacular landscaping using native flora. The administrative experience of the A.D.A has shows that the successful application of native species in landscape architecture can be achieved in urban landscape. Yet there are two main issues to be discussed in order to validate the hypothesis of using native species: firstly the implication of the continual use of imported species and their abuse of arid land's ecosystem. Secondly, does the Najdi wealth of plant material contain a suitable range of species for use in landscape architecture ?.

# CHAPTER 3
# IMPLICATIONS AND NEEDS

## 1) IMPLICATION OF EXISTING LANDSCAPE PROCESS, IT'S KEY FACTORS AND THE NEED TO INTRODUCE NATIVE FLORA.

### A. INTRODUCTION:

This chapter aims to introduce the main factors which affect the existing landscape profession in Najd and discusses the main reasons for the poor quality of existing landscape projects. The factors extracted and the lessons learnt may serve as a guide to develop the proposed indigenous landscape process and to avoid the failures which have occurred during the current landscape phase. These were largely due to the use of foreign consultants and imported plant material.

This chapter will also introduce the implications for such an approach to landscaping the Najdi by discussing some of the religious, socio-behavioral, traditional, professional, environmental, ecological and technical factors. After the discussion of such factors, perhaps the arguments for introducing native species will seem more valid.

### B. KEY FACTORS AND THEIR IMPLICATIONS ON THE EXISTING LANDSCAPE PROCESS.

#### 1. SOCIO BEHAVIORAL ,TRADITIONAL AND RELIGION.

#### SAUDI ARABIA

Saudi Arabia as mentioned before is special in its religion ,culture and traditions. The socio religious factors are the key to the public success of any project. The special religious values which Saudi Arabia enjoys results from it being the homeland area of God's messengers, from Abraham to Mohammed. The inhabitants of the Arabic semi island were described (by God) in the holy koran as tough and strong. The choice of this land to be the birthplace of Islam is reflected in the special values, motifs and lifestyle which Saudi Arabia enjoys to this day. [21]

More recently, these unique values were maintained by King Abdul Aziz. Through clever application of religious and tribal symbolism and organization, he was able to manipulate the traditional tribal structures of Saudi Arabia so that they supported not the independent tribal units but loyalty to the al Saud Family.

However the social revolution and changes accompanying the exploitation and development of the oil industry brought to the country ideas and influences totally

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[21] The holy Quraan.

foreign to its traditions. As mentioned previously, that wealth attracted a large population of foreign workers with their mixed culture and alien life styles.

During this period Saudi Arabia was swamped by Western and Eastern culture. However, the Kingdom managed to preserve both its own social and political identity and the country's cultural heritage, by the strict government policy which limits and diverts these alien influences.

Hence a major Foreign-native conflict emerged between native and foreign cultures. The foreigners maintained their alien culture while the Saudi maintained their tribal one. This local lifestyle was not however, considered during the planning of the city. This was planned and constructed by foreigners who did not absorb and appreciate local social and religious factors.

Within Saudi Arabia itself every region differs in the influence of social, traditional and religious factors. In Najd these factors and values are especially important. Wahabism is an Islamic reform movement which evolved in the heart of Saudi Arabia. This movement rehabilitated the strict application of Islam, a return to the original principles of Islam and a denial of all innovations contrary to the practice of the prophet Mohammed and the early generation of dedicated muslims. Participants in the movement were described by Hopwood, D as:

> *"They hold that their movement is al-dawah ila al tauhid (the call to the doctrine of the Oneness of God), a return to the original principles of Islam and a repudiation of all innovations contrary to the practices of the prophet Muhammed and the early generations of pious muslims."*[22]

The movement concentrated within the Najdi community, aiming to implement the strict, literal Islamic way of life. [23] The strong rule King Abdulaziz Al-Saud brought to the Wahabi land, as described by Philby, complemented Wahabism and added further character to the strict way of life that ruled then, and has existed since then. Ref, Philby, J.B.[24]

The movement resulted in a community that is special in its social structure and in the relationship between its components. The unique social fabric is characterized by strict separation between male and female contact in all outdoor activities. The purity of this particular community has been desecrated by the work of imported architects, planners

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[22] Hopwood, D, *The arabian peninsula, Society and politics*, London: George Allen and Unwin Ltd, First Ed, 1972. p54

[23] Dr. Abdullah mohammed Alajlan. *The movement of renovation and rehabilitation in Najd*, Arab Bureau of education for the gulf states.

[24] Philby, J.B, *Arabia of The Wahabis*, First Ed, Vol I&II, London: Constable & Co Ltd, 1928.

and landscape architects. One can say that their failure to understand the spirit of Wahabism and its social implication was the most important reason behind the failure of new housing, parks, recreation areas and public facilities throughout Najd. [25]

## ISLAM, SAUDI ARABIA AND DESIGN

Islam, the religion, is the single most important factor in Saudi Arabian culture. Religious considerations dominate nearly all activities and policies of both the government and the people. In addition, Saudi territory contains two of the three holiest sites in Islam; Makkah and Madinah. It serves as both the custodian of Islam's holist places and the administrator of its most sacred rites. Islam was born from Arabic spiritual thoughts and social patterns. Therefore, Saudi Arabia is more intimately bound to the faith than any other Islamic nation on the Earth.

The government at present applies the most strict and fair form of Islamic practice. This factor, combined with their fundamental Wahabism implementation, has created a special local character in the pattern of social activities both indoors and out. The muddle of most contemporary outdoor design is recognised to be a direct consequence of the neglect by designers of both factors.

Understanding Islam in the Najd, the heart of Arabia, is essential. It is necessary to absorb these two basic concepts of Arab society before attempting to accommodate any new physical development. Firstly, the strong relation between the Arabs and Islam, secondly the total integration of the secular and religious domain in Islam. This applies all over the Arab nations, but more critically in Saudi Arabia where Islam was born.

The Islamic way of life has been compared to a society that acts as one wall in which every stone has its function in supporting the rest of the wall. On this M. Berger has said:

> *"The special conditions under which Islam arose has left another legacy to the arab world: a religion that recognized no separate spars for "chuch" and "state" but unified religious doctrine, morality, and legality into one inclusive system of the Islamic community. This community (the ummah) was at once a religious brotherhood, a political association, and a social order. Religious law, the shariah, regulated all aspects of social life. The holy book, the Koran, dealt with all life, not merely an identifiable domain called religious or spiritual."* [26]

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[25] Richard F. Nyrop, Beryl Lieff Benderly, Laraine Newhouse Carter, Darrel R. Eglin, Robert A. Kirchner, 1976. *Saudi Arabia, A Country Study.* The American University, Third Ed.

[26] Berger, M, *The arab world today*, First ed, London: Weidenfeld & Nicolson, 1962. p.30.

Islam is a paradox that penetrates all aspects of social life. The Islamic way of life is derived from the koran and sunnah which organize all of life is activities from clothing, sports, rules of sexual relationship and successfully raising children. These rules of organization were established in A.D 622, and have evolved little since then. Scholars have used them as implied planning regulations and a strict set rules to define the use and planning open space.

Traditionally Islam is a family-society orientated religion, where each individual should respect and satisfy the need of his family, neighbours and community. This applies both indoors and outdoors as demonstrated by the layout of any Islamic town. In old Arriyadh for example, the master plan reflects all the previously mentioned factors by firstly satisfying the privacy of the open space users, secondly the orientation of the introverted houses (which applies also to the open space), and thirdly by linking the community through a net work of shared walls, pedestrian paths and mosques.

One may question the relevance of influential factors such as Islamic social rules, and Wahabism to landscape architecture. These factors are in fact fundamental influences on a whole range of outdoor activities, where the landscape elements are an essential component. Understanding such influences will generate a suitable environment for a successful vernacular domain. Native flora is a key element within these traditional spaces. Islam encourages the use of native plant materials in all the elements of the urban settlements (Fig 22). The description of paradise in the holy koran is always a combination of trees and water. [27]

[27] Reference The holy Koran and Sahih Al-bokhari 520 A.D.

Fig 22: The use of native plant material in a typical Islamic city. The urban context is compact and each cluster allocated to a certain family to maximize privacy. The presence of plant material was confined to court yards and to the urban fringe, defined by the masses of palm groves.

This integration between human, urban and vegetation communities illustrated in the oasis city, are in fact fundamental design factors underlying planning of the Islamic city. Such ideas however have not been respected by foreign consultants employed in the region. For example the Islamic garden in Hofuf, a central region city. This is located in the old citadel inside this oasis city, and one of the few historic structures still preserved in Saudi Arabia. The foreign consultant appointed to design this Islamic garden produced a design consisting of a mixture of contemporary Western and post modern elements; with an identity alien to either an Islamic park or even a middle eastern or Egyptian one. Fig 23 shows a plan for this park and illustrates how it rejects the context and grain of the surrounding urban area.

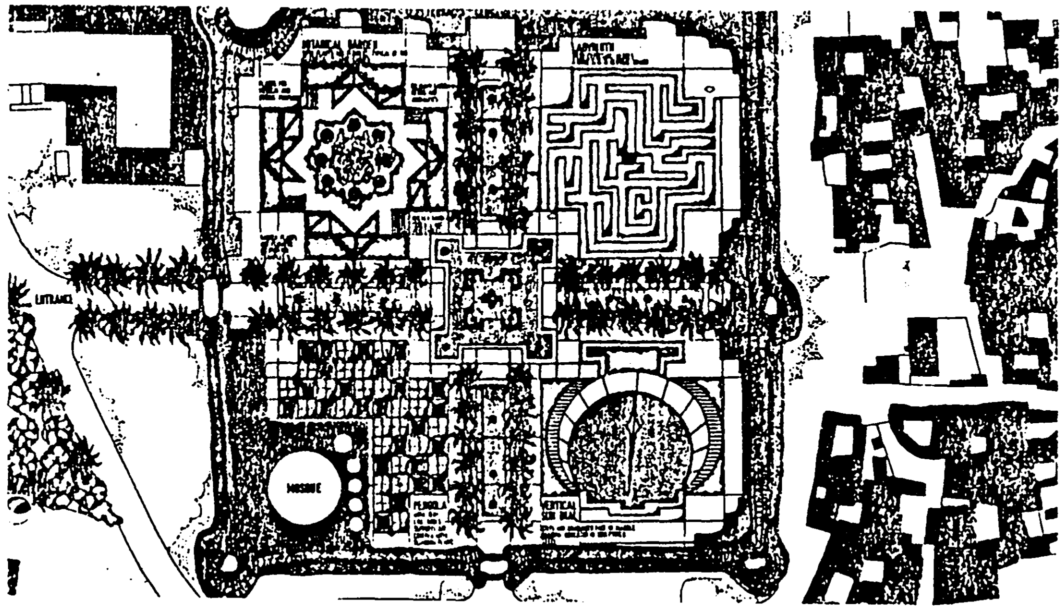


**Fig 23: The Islamic garden, Hofuf, and the surrounding old city of Hofuf which is one of the few of Saudi Arabia's historic structures still preserved. Note the distorted landscape concept inside the old citadel. The figure shows clearly the surrounding compacted indigenous pattern and the completely alien garden, hidden behind the citadel walls. Source:** Bodeker, R & Scharabi, M. *"Stadt- und Ferizeitparks in Saudi Arabien"*. Garten Und Landschaft, 8, 1976.

Here, the foreign designer has clearly missed most of the important aspects of native landscape character, which is clearly interpreted in the layout. This quotation from the designer would appear to acknowledge that:

> *"It was from the first day of our work a special concern to provide this historic structure with new substance. In the inner area of the citadel, about 1 ha in size, we thought to represent the classic Islamic garden"* [28]

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[28] Bodeker, R & Scharabi, M. *"Stadt- und Ferizeitparks in Saudi Arabien"*. Garten Und Landschaft. 8, 1976.

The quotation points to a usual misunderstanding by the foreign consultant of the difference between an Islamic garden and traditional Najdi landscape. Adding a new or alien substance to a valuable and distinctive historical structure is something intolerable. In a place which is special in its lifestyle and deep Islamic believes, such an alien interpretation of open space design deserves to be unsuccessful. Traditionally there was no precedent of geometric based planting with a central feature. In fact such a layout is contrary to the local values of family and privacy. The geometric plan, reinforced by the planting, focuses attention into a central space. This axial layout gives no recognition to the need for privacy and seclusion, values rooted deeply in the local culture.

## TRADITIONS AND SOCIAL RELATIONS

Social life is still family centred; no other institution of comparable strength exists. Family loyalty dominates all aspects of life. The Najdi household consists of Kinsmen, and among the tribes each family ties into a coherent tribal structure. The individual's loyalty is ultimately to his family which overrules most other obligations. Family unity finds expression in part in the absolutely strict and guarded privacy surrounding family life.

Sexual segregation is an essential ingredient of Saudi social life and is enforced by law both indoor and outdoor. The typical Saudi house still contains distinct men's and women's areas. There are two reception areas, two dining rooms and entrances. The same applies outdoors where the veiled women are highly protected and many public places are strictly men free zones, such as some gardens and souks[29]. Women may not drive cars, attend mixed classes or unveil outdoor. Mixed social events are rare except among foreigners and highly sophisticated Saudis. However, women are highly protected and respected within the society. In Najd this sexual segregation is an ancient tradition. Even before Islam, Najd was known for these special traditions.

The extreme privacy, especially when women and families are involved, is strict and should be valued. Separation between male and female, families and bachelors is therefore an essential, indispensable ingredient in the success of any landscape project. Visual and physical privacy should be achieved for each family group. For example, in public parks the use of shrubs, landform and natural building materials, can be used to achieve this desired privacy. This requirement, however is more vital in urban parks rather than in rural ones. Fig 24 shows the lack of visual privacy in exposed sitting areas in the Diplomatic Quarter. This clearly shows how unveiled families would be exposed to passers by. This has largely contributed to the poor use of the space.

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[29] Shopping centres or malls.

**Fig 24: Exposed sitting areas in the D.Q.** [30]

Pilot studies and interviews by the author, to some selected families showed that the majority supported the theory that privacy will impose itself in a nature park or in the desert, which is used by the native population to escape the urban parks, now occupied by foreign families, who are not effected by the lack of privacy.

Some twenty years ago, the traditional use of parks in Najd was different. Then they were used only by families for camping, using tents. The use of such parks was limited to camping and traditional activities such as horse racing and desert trailing. Nature and natural process was then more respected by the Saudi than by the foreign families. Most of the waste material left behind was biodegradable and buried. The use of palm land canopy as a cool microclimate zone for the local people to spend their vacations was naturally acceptable to the native people and welcomed by the palms owners (the farmers). The structure of the old Najdi cities allowed integration between the urban mass and the palm community, as a direct reflection of socio Islamic factors. The mosque, farm and the housing settlement were located according to the topographical distribution of native palm land. The Arriyadh urban community developed around the existing palm lands. The translation of Arriyadh means gardens.

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[30] These areas are referred to as nature parks in K.S.A. This term will be used throughout the text.

The zoning of these ancient parks allowed the separation between age groups, which is very essential in outdoor activities. There is great difficulty satisfying all age groups, as the requirement for each are different. Sports facilities are requirements for males age 10-30 (essential in district parks), visual and physical privacy for families, and simple play equipment and sand boxes for ages 3-10. The recent parks, which were designed by foreign designers, miss these essential social needs.

> *"Due to the intensive urbanization in the country as a whole, the number of foreign workers is equal to, if not more than, native residents. Those workers brought with them their culture and traditions which are Western oriented. This resulted in a big conflict between native and foreign use of parks. You will find that the parks which contain foreign families are empty of native families. Moreover, the park which satisfies native needs will be an enclosed design (introverted solution), which won't satisfy foreign workers".* [31]

Such integration between the foreign and local community, can result in the loss of native values, motifs and life style. Although this stage is still some time away , measures to prevent such conflict are already under way.

In fact both the religious and socio traditional factors are clearly important as highly sensitive and instrumental design factors. The two, along with environmental and ecological factors are very influential on the landscape process in Najd. Simply, imported flora, and alien western urban design concepts are not the ideal habitat for the unique social life in Najd.

## 2. PROFESSIONAL FACTORS

Much important research has been done worldwide on the nature of desert ecology. Most of this work has studied existing habitats, and the impact on these of changing land uses. The particular relationship between urban expansion on these fr agile environments have been at best empirically recorded.[32]

Sources of the detrimental effects of these secondary level impacts on the countryside around Najd settlements have already been mentioned. This section will discuss the specific factors arising from landscape projects which have the most obvious detrimental effects on the existing habitats. Choice and establishment of plant material, response to real user needs, and the attitudes of the construction team are each clear examples of such factors.

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[31] M.Salama *Availability and use of plant material in urban parks in central Saudi Arabia* M.Phil. diss., Edinburgh University, 1987. p.50-51.

[32] Adams, Robert, "*Dry Lands*". The Architectural Press, London, 1978, (DLA-1).

## 2.1 NURSERIES AND AVAILABLE PLANT MATERIAL IN NAJD.

One of the factors any landscape architect working in the Central Region of Saudi Arabia must consider, is the availability of plant material. Therefore, an intensive questionnaire was carried out in the summer of 1987 in order to obtain a record of the plant material available in the market and their country of origin.[33] The main emphasis was to record newly introduced species and their source, how they were specified and by whom and also to find out if any native species were in general landscape use. (Table 4 shows the species available in the nurseries).

Most of the plant species used in the Central region were still imported from abroad (Fig 25). The importing system for such plant material is very easy and insufficiently controlled. The release of such material is not subject to adequate examination for pests and diseases, which consequently are now spreading around the Kingdom.

The species surveyed in Table 4 are not the only plants which are available to landscape architects, for use in their parks and open spaces. They can also consider any tropical, subtropical or even other arid species, which are generally available to local nurseries by direct importation. The lack of a comprehensive indigenous flora to guide choice of suitable species, forces the designers to use general textbooks for regional flora when specifying plants. Thus exotic species are regularly included in the contract documents and the contractors then have to supply those species through imports. Most of the species found in the nurseries are still imported from tropical and subtropical countries such as north Africa and south Asia, as a result of continuous demand for such species from foreign consultants.

> *"In 1984 a foreign consultant specified a Mexican fan palm costing 30,000 US$ (£18,000). But during importing process the plant was exposed to undesirable conditions, which resulted in the loss of the plant".* [34]

This is not an isolated example. It shows the importance of having available a comprehensive indigenous flora, which covers and tests the most suitable native species for both propagation and use in landscape design.

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[33] This questionnaire was a modified version of the one in the M. Salama M.Phil 1986-87, see Appendix I.

[34] A.D.A. Landscape Architect, interview by the author, june 1987, Arriyadh, S.A.

| | |
|---|---|
| **TREES** | |
| ACACIA CYANOPHYLLA | FICUS BENGALENSIS |
| ACACIA FARNESIANA | FICUS NITIDA |
| ALBIZZIA LEBBEK | FICUS RELIGIOSA |
| AZADIRACHTA INDICA | MELALEUCA LEUCADENDRON |
| BRACHYCHITON POPULNEUS | MELALEUCA VIRIDIFLORA |
| CAESALPINA FERREA | MELIA AZEDARACH |
| CALLISTEMON VIMINALIS | PARKINSONIA ACULEATA |
| CASUARINA SPP. | PELTOPHORUM PTEROCARPUM |
| CAMAEROPS HUMILIS | PITHECELOBIUM DULCE |
| DELONIX REGIA | PLUMERIA OBTUSIFOLIA |
| DELONIX ELATA | PROSOPIS JULIFLORA |
| ERYTHRINA CAFFRA | SCHINUS MOLLE |
| EUCALYPTUS CAMADULENSIS | SCHINUS TEREBINTHIFOLIUS |
| EUCALYPTUS WOODWARDII | ZIZIPHUS SPINACHRISTI |
| | ZIZIPHUS JUJUBA |
| **PALMS** | |
| PHOENIX DACTYLIFERA | |
| WASHINGTONIA FILIFERA | |
| WASHINGTONIA ROBUSTA | |
| **SHRUBS** | |
| ATRIPLEX SPP. | HIBISCUS ROSA-SINENSIS |
| CAESALPINA GILLESI | LANTANA CAMARA |
| CAESALPINA PULCHERRIMA | NERIUM OLEANDER |
| CALLISTEMON VAR. | ROSA SPP |
| CARISSA GRANDIFLORA | ROSMARINUS OFFICINALIS |
| CASSIA NEMOPHYLLA | TECOMA STANS |
| CLERODENDRON INERME | TEVETIA NERIFLORIA |
| CYCAS REVOLUTA | ZIZIPHUS NUMULARIA |
| DODONEA VISCOSA | |
| **GROUND COVER** | |
| ARABIS CAUCASIA | LANTANA MONTEVIDENSIS |
| ASPARAGUS SPRENGERI | LIPPIA NODIFLORA |
| CARISSA GRANDIFLORA | LOCHNERA ROSEA |
| DROSANTHEMUM HISPIDUM | PORTULACA GRANDIFLORA |
| GAZANIA LEUCOLEANA | SANTOLINA CHAMAECYPARISSUS |
| LAMPRANTHUS SPP. | SENECIO CINERARIA |
| **CLIMBERS** | |
| ANTIGONON LEPTOPUS | JASMINUM OFFICINATIS |
| BIGNONIA IGNEA | JASMINUM POLYANTHEM |
| BOUGANVILLEA SPP. | PLUMBAGO AVRICULATA |
| IPOMOEA PES-CAPRAE | QUISQUALIS INDICA |
| **ANNUALS** | |
| ALLYSSUKM MARTINA | KOCHIA SPP. |
| AMARANTHUS | PETUNIA HYBRIDA |
| CANNA INDICA | VERBENA SPP. |
| CHRYSANTHEMUM CORONARIUM | ZINNIA SPP. |
| **SUCCULENTS, CACTI** | |
| AGAVE SPP. | OPUNTIA SPP. |
| ALOE SPP. | SANSERIERA SPP. |
| EUPHORBIA SPP. | YUCCA SPP. |
| **GRASSES** | |
| ARURDO DONAX | |
| CORTEDARIA SELLOWINANA | |

**Table 4 : Available species in Arriyadh nurseries.**
The above species were obtained from the nursery questionnaire.) Source, M. Salama.

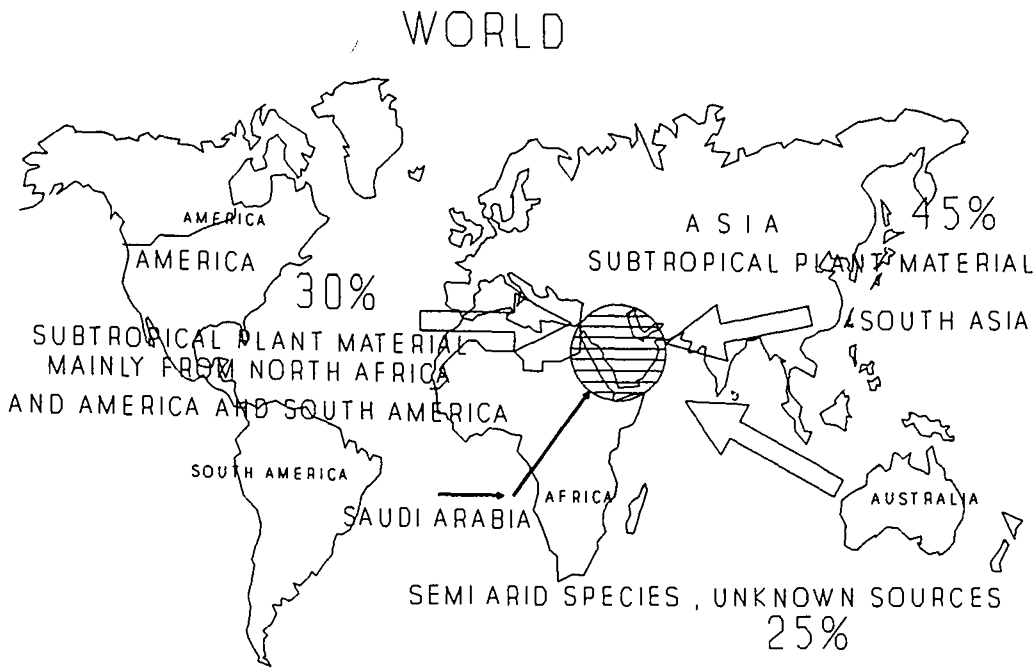


**Fig 25: The source of imported plant material to Saudi Arabia. Importation through direct individuals and government agents. Source (field survey).**

Commercial nurseries supplying plant material in the Najd are located along Wadi Hanifah under the long established canopy of the palm groves. The original rich soil is removed for potting soil or as top soil supply for other planting projects. This man-made erosion has caused aridity in parts of the wadi. This problem has been brought to light as part of this research. The effect of nurseries on the wadi habitats is destructive and should be stopped. The questionnaire to some of the nursery owners showed that the time for stripping all the top soil could be as little as five years. The nursery then transfers to another farm to strip its top soil. On a simple calculation, such a process could eliminate the long established wadi soil by the year 2000; especially when the market price for one cubic metre of wadi soil is 700 Sr (£110). Thus the continual specification by consultants of use of wet wadi soil as part of the top soil mixture due to its rich soil fauna, is destructive to the wadi ecosystem. Certain dry wadi soil near the urban developments could be manipulated instead. [35]

Stripping wadi soil is a practice destructive to its rich habitat and the traditional palm groves, while the use of this rich soil to create living conditions for imported plant

[35] K. Klein, A.D.A, Interview by the author, July 1988, Audio recording.

species is extremely costly. Both processes should be avoided by ending the destructive cycle arising from imported species and their establishment requirements. More suitable methods are discussed later, which use native desert soil patterns for propagating selected native species. These can be propagated even in arid sites. This shows the importance of making consultants and nurseries aware of the benefits of Native species.

Nurseries play a key role in the presence of imported plant material and their consequences. Limiting their plant sources by specifying native material will help to minimize the destructive effect of soil stripping and other negative results.

## 2.2 THE USERS OF OPEN SPACES

The demands for both urban and rural open spaces is increasing. The users needs should be considered as an important influence upon landscape design especially in Central Saudi Arabia for reasons referred to earlier under social and traditional factors. These factors dictate a special way of life and different use of open spaces. In Najd separation between male and female is essential in any public area. However, in recently developed public open spaces this requirement has not been met.

The previously discussed foreign-native conflict centres on user identity and need. Native needs were engulfed by a progression of faulty beautification programmes that aimed mistakenly to satisfy foreign criteria. After the first rapid urban development, macro landscape plans committed the municipalities to a construction programme. During this phase a series of parks emerged each with broadly similar layout and landscape elements.

These parks were designed and constructed more to suit a Western lifestyle. This is displayed clearly by their design concept, their planting composition, and also the choice both of imported plant species and building materials. These Westernized parks, therefore, are used solely by foreign workers and their families, leaving the native people house bound.

Modifying these existing parks to suit the local needs would require the entire modification of their conceptual structure and details; i.e a redesign and reconstruction is the logical approach. The prime requirements for native users are: firstly complete visual and physical separation between families and bachelors. Secondly, Saudi Arabian people have inherited a respect for nature from their recent past as farmers and bedouin.[36] The use of open space should be oriented to their traditional way of life by creating

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[36] Philby, J.B. "*The Heart Of Arabia*" Vol I & II. 1922. See also, Philby, J.B. "*Arabian Days*" an autobiography. 1948. and Philby, J.B, *Arabia of The Wahabis*, First Ed, Vol I&II, London: Constable & Co Ltd, 1928.

areas which are more like natural camping sites, buffered from each other by native plants, rocks and sand formation as described by Salama. M:

> *"A brief study for ancient parks in Riyadh will introduce the character of the ancient landscape units and their main landscape elements. The existing mean of traditional parks in Saudi Arabian life is found in two ways. The first potential open space for Riyadh residents is simply the desert, where some depression in the desert is colonized by some desert species, where the depression modifies the macro-climate to be suitable for outdoor activity. The (asr period) 3:20-7:00 P.M. is the time for active use of those depressions (sports, etc.) and then all the night is for other passive activities. The main users for these places are families (mainly big groups of relatives) who use their cars to form a lee area where they start a fire and barbecue. Playing cards, walking, hunting and talking are the main activities at night when the temperature decreases to the minimum. In order to maintain the privacy for each family, a radius of 50m area should be for one family. Some families use tents, especially for the week end. The second potential, traditional and recreational open space for Riyadh residents is the surrounding farm land which is mainly palm groves creating under their canopy a modified desired micro-climate. The record of the difference between the macro-climate and the micro-climate under the canopy could reach up to 7 °c. The typical farm is used primarily for growing dates and the rest of the year for grasses and minor crops.".*[37]

The questionnaire to the local people, established the fact that a 50 M radius circle is required for each family in order to maintain separation and privacy. Separation between age groups is also essential. Alcoved areas are also desired by the native people only if they were sensibly oriented. Some attempts by consultants to create sitting alcoves have been interpreted by locals as cave-like, oriented and exposed to the footpath. (Fig 26 illustrates a design by one of the foreign consultants). As most Saudi families have their own garden facilities inside their screened villa yards, the contemporary neighbourhood park is not appropriate to Saudi society. The logical approach to urban planting is the introduction of native landscape elements that are visually favourable to native residents. That is supported by the quotation following, where the presence of active parks within a residential area could conflict with the requirement of privacy.

The fatal effect of this failure to understanding the social factors, especially in such a sensitive society, are shown in another conflict between different user groups leading to the discarded, unused parks around the capital as found by M. Salama:

> *"There is conflict between the users of urban parks and the adjacent villas where the occupiers consider their privacy is in danger from those users. This requires heavily planted edges which kill the quality of open space visually and physically, e.g., "Alrabwah" park. Due to the level of this park above the adjacent villas, the Municipality of Riyadh had to control the users in order to satisfy the residents,*

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[37] M.Salama. *Availability and use of plant material in urban parks in central Saudi Arabia* M.Phil. diss., Edinburgh University, 1987, p.57.

*and dense planting along the edges was added to the design.".*[38]

This is a major consideration that the designer should be aware of. Any violation of the privacy of the neighbouring residential areas could easily result in a public inquiry, that would impose a high fence, total screening or sometimes reorganization of the whole park.

**Fig 26: Alcoved seating area in the Diplomatic Quarter (the stone cell) foreign consultant's answer to privacy.**

Flowering plants attract vandals and should be reduced to the minimum, especially shrubs and ground cover which are more easily approached. There is also a demand from some users to plant decorative plants within urban parks. This generally means planting imported species which as mentioned above, may cause problems. This research however will also consider the use of native species as a decorative design element which will challenge and replace the imported species.

[38] M.Salama. *Availability and use of plant material in urban parks in central Saudi Arabia* M.Phil. diss., Edinburgh University, 1987, p.50.

## 2.3 THE CLIENT, THE CONSULTANT AND THE CONTRACTOR

### 2.3.1 INTRODUCTION

In Saudi Arabia the special relationship between the client, the consultant and the contractor in Najd (Fig 27) is a critical influence upon the landscape process. The absence of legislation to govern the relationship between the three, awards the client immense power. As a result, the landscape profession in the region has failed to achieve any work of genuine landscape quality. The following hypothesis points to the cause and the negative effect of such lack of effective legalisation for the contract.

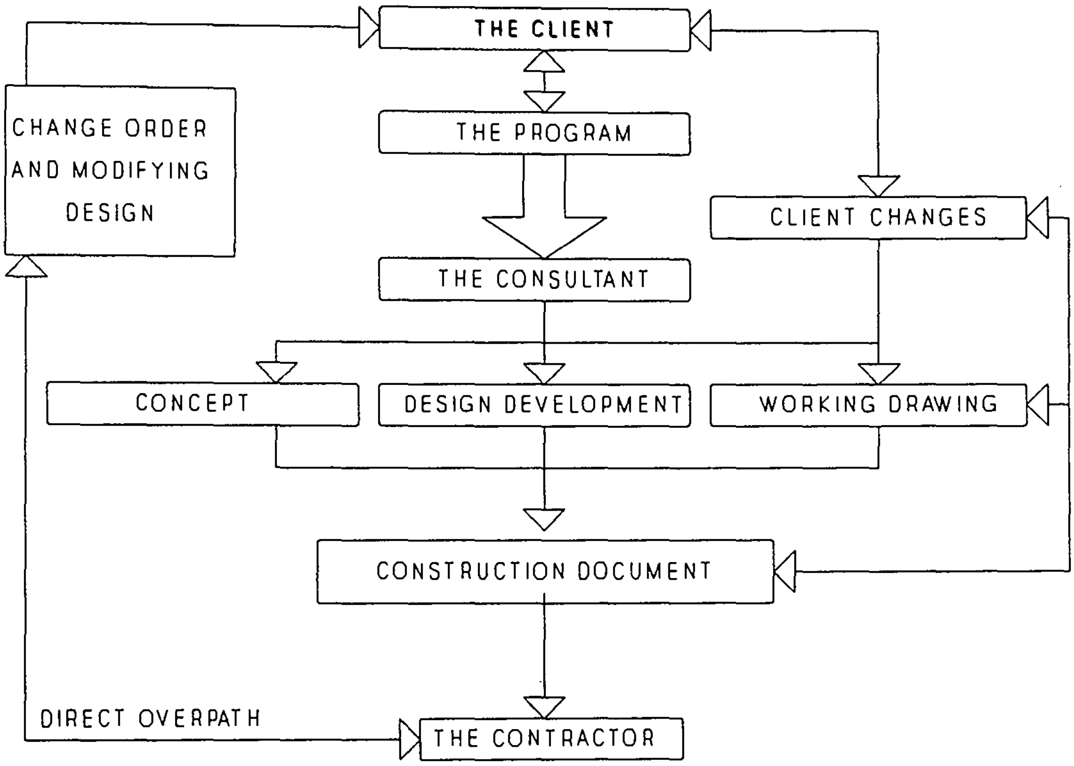


**Fig 27: The process of a typical landscape project showing how the client can influence all stages, even during construction documentation; also how the contractor can side step the consultant in changing orders, materials and modifying design.**

Discussion of the important key factors in this relationship, will establish their cause and effect and suggest suitable legislation to govern such a process in future and to establish suitable administrative conditions. This part will firstly describe and introduce each element, secondly the implications of such a process and finally define the key factors which will insure an improved model.

### 2.3.2 THE CLIENT

In the Kingdom of Saudi arabia the client is probably the key person in the whole landscape process. The landscape consultant's client can be a government agent, another consultant, or a contractor to a private developer. The hierarchy of different clients reflects the importance of this factor and its effect on the whole landscape process. The diagram below (Fig 28) shows the typical hierarchy of landscape client in Arriyadh:

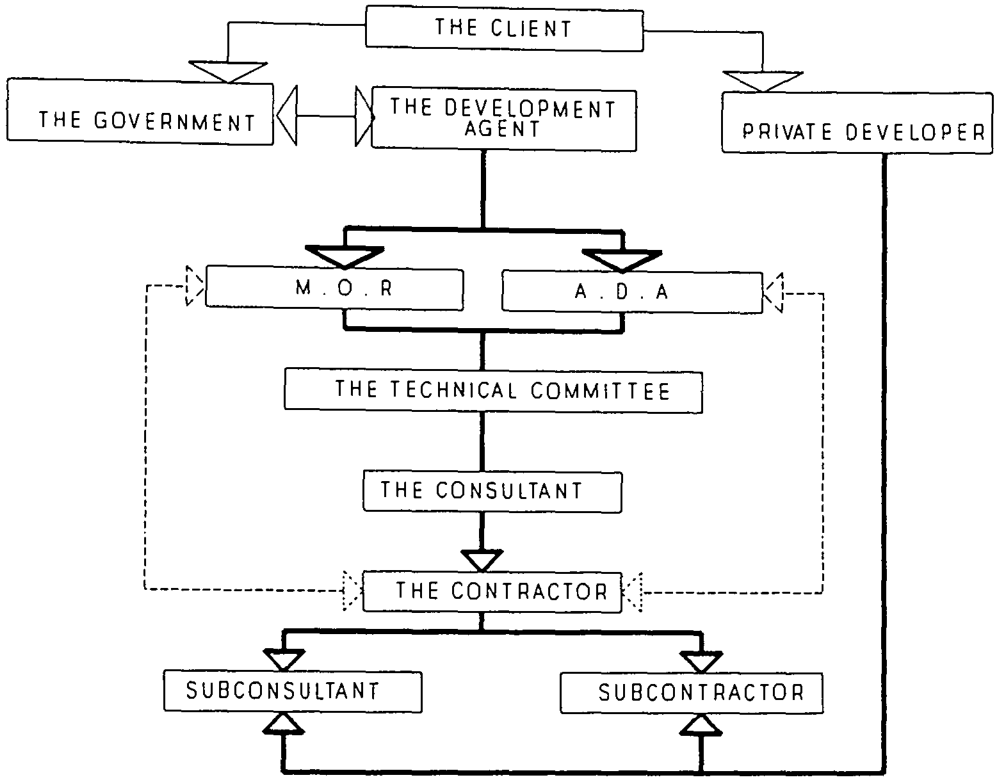


**Fig 28: Hierarchy of parties involved in landscape process. (M . O . R) Municipality of Arriyadh. (A . D . A) Al-Riyadh development authority. The diagram illustrates the minimal authority given to the consultant.**

To establish the practical problems which might confront the use of native plant material in Najd, the design and construction process of a typical landscape project through the different Saudi Arabian channels will be illustrated. The landscape projects with most potential for introducing native species are most likely to be government ones.

A typical landscape project is initiated when the government appoints one of it s agents, either M.O.R or A.D.A. [39] to carry out such a project. The selected agent will form a technical committee which writes the brief and invites selected landscape consultants

[39] Refer to chapter 1 for definition.

(preferably a maximum of five) to tender in a priced design competition. On the basis of these limited competitions, a consultant is selected for appointment. Thirdly, the consultant will carry out the design, staged as concept, design development and construction documents to tendering stage. Usually at this point the technical committee start to critically assess the design and may demand amendments.

The extent of interference will vary according to the technical committee's policy. This might even be linked to the experience of individual members. For example in M.O.R the landscape technical committee usually consists of architects and engineers. Such a technical committee will formulate the brief and direct the design in a more architectural manner, with an emphasis on park structure and privacy. In Alaishah park, for instance, the brief was written by this technical committee, and contains more architectural elements than landscape ones. This park, which covers an area of 3,000 $m^2$ contains the following architectural elements: gate house, concrete shade areas (rather than shade trees,) mosque, toilets and cafeteria, concrete fountain, concrete boundary wall and concrete paving. The area of the park left over was subsequently planted by a local gardener. The total cost of the park was 200,000 Sr (£40,000). The cost of plant material, soil, irrigation was 30,000 Sr (£5,000), the remaining sum (88% of the contract sum) was spent on these architectural elements (Fig 29). This proportion of construction elements to planting also applies to several other neighbourhood parks in Arriyadh.

**Fig 29: Alaishah park emphasises architectural elements.**

This example of Alaishah park represents the typical outcome when the technical committee consists of architects and engineers. When it contains a member who is an agriculture engineer, it is likely that he will impose certain species of plants which are available in the municipality nursery and force the consultant to use these. According to interviews with many consultants, some contractors have approached the technical committee during construction and succeeded in changing both the selection and composition of the species chosen and specified by the landscape consultant. Within the M.O.R, there is a deliberate policy to avoid appointing the same consultant for the design and the supervision construction stages. For example, Figure 30 & 31 illustrates such a policy, where major changes to the original design by the consultant "Omrania" took place, authorized by another architecture consultant, "Alturath", who was appointed to supervise construction.

These changes took place for several reasons: firstly, the progression of construction events is controlled at the critical site supervision stage, where the two consultants may disagree on details and concepts. The original intention of the consultant in this case was to imitate the old canal irrigation system by providing exposed channels feeding the existing palm groves by basin irrigation. By handing the project to another consultant for supervision, the design was altered by eliminating the distinctive channel system and replacing it by simpler, easier to construct open grass land as illustrated in Figure 31. Secondly, the client often approves the use of certain products which can drastically alter the design concept or detail, as in the case of Sultanah park. The park was originally designed to acknowledge and preserve an existing old well. But the supervision consultant suggested a fountain instead and managed to gain the client's approval. As a result, a historic feature was demolished and transformed into a ceramic and steel fountain.[40] Such examples are usual among most government projects handed to committees where none of the members are landscape architects.

In the Middle East, recent landscape architecture projects have been confined only to large scale and turnkey projects. The open space design has been tacked onto the end of the project, almost as an after thought. Education of client, whether government or private developer, in respect of landscape design is minimal, and there is a common lack of differentiation between a landscape architect and an agriculture engineer. However, there is one exceptional government agent that has managed to achieve a sensible landscape policy. This is the A.D.A, inside the Diplomatic Quarter (D.Q).

The A.D.A is another government agent, formed in 1979 by his royal highness prince Salman bin Abdul-Azzizs the governor of Arriyadh city. It is directed by Dr. M

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[40] Refer to Salama. M. 1987, case study.

Al-Seikh and follows the same process as M.O.R except that the technical committee is selected carefully, according to the character of each project. They employ highly qualified architects, landscape architects, planners and engineers. For a landscape project, the technical committee will be headed by a landscape architect, the consultant will be a landscape one , the project will be supervised by the designer, and the contractor should be experienced in landscape work. In fact during construction the project will be supervised by the technical committee, the consultant and the D.Q maintenance department. Such proliferation of supervision often results in problems . The contractor must satisfy the technical committee , educate the maintenance staff and comply with the consultants requirement. Sometimes the contractor will approach the director general personally to resolve conflicts. As a result, changes in design during construction are inevitable.

Fig (30) top, (31) above: The original design before and after construction. Such changes during the contract can directly affect the establishment of a serious indigenous landscape program.

This can sometimes even change the whole image and function of a design as reported by Salama. M, [41] where design concept, hardscape material, irrigation system, soil and even species were altered. So, some form of legislation is needed to govern and correct the process of landscape projects. The use of native flora especially in Najd, will need to be very carefully specified and the recommended method for planting them must be strictly followed. However, this can only be achieved by convincing all the parties involved in the contract of the importance of native species, especially the client, who chooses both the consultant and the contractor. This choice is usually based on the cost but also on their flexibility to the clients change orders. The client till now has the power to cancel the agreement with either or both parties if his orders are not carried out. This needs to be governed by strong legislation, giving control to the approved consultant during all stages of the contract. The duty of the landscape designer is to use these powers in a convincing way. Also it is important that strict monitoring and classification of the performance of landscape consultants and contractors is methodically and regularly carried out.

41 M.Salama. *Availability and use of plant material in urban parks in central Saudi Arabia* . M.Phil. diss., Edinburgh University, 1987. Case study of both Alrabwah park (page 42) and for Sultanah park (page 81-89).

### 2.3.3 THE CONSULTANT

Although native landscape consultants are obviously more aware of their environment and their social needs, they are scarce in Saudi Arabia, and the majority of landscape consultants are foreign. There is one school of landscape architecture in Saudi Arabia at Jeddah which supplies the market with specialized Saudi landscape consultants. Their first students graduated in 1982. Many, however, continue in higher education, or enter the government service as bureaucrats. For a non-Saudi to secure a landscape job, it is legally essential to be sponsored by a Saudi consultant. This has resulted in the majority of Saudi consultants acting superficially as an officially appointed consultant, while most of the work is done either outside the Kingdom or by the foreign partner. Moreover, these local sponsors are usually civil engineers or architects. Consequently they are likely to demand the introduction of elements compatible with their disciplines, such as a high percentage of built up areas within a park.

The local traditions, heritage and lifestyle are usually neglected by these foreign consultants as mentioned in Chapter 1. The source of reference for consultants during plant selection are imported textbooks. The most common one is *Tropica Colour Plants* by A.F. Graf. The name reflects why most of the surveyed flora in the Najdi commercial plant nurseries come from tropical countries. Nursery owners tend to import their species of plant material as a result of consultants using such books when preparing their planting specifications and schedules. The loss of many plants after establishment, the high initial cost of plant material, the costly irrigation system required to sustain them, pests and diseases are the direct result of such imported landscape criteria and ideologies. The implications of these imports is costly and damaging to both indigenous landscape architecture and resources.

Some of the more aware foreign consultants began to use some common native species. But they generally used them in a Western manner, as a dense, compact ground cover (Fig 32). Ecologically this acts against the habit and distribution of such native species, when most of them have an extensive surface root system. Using them in such a compact way, will result in the loss of their character and eventually the plant. As a result salinity will increase and root behaviour will change. For example, in the extensive landscape zone within the D.Q one can find a species that adapted to such conditions by increasing the transpiration of water by enlarging the size of their leaves.

Foreign designers have contributed directly to the introduction of strange policies, elements, factors and concepts which often are not suited to the national, physical or social environment of Arriyadh. Some of these are:

1. Open areas which expose the users visually to each other, where privacy is

destroyed as a result of the absence of visual barriers such as alcoved shrubs (Fig 33).

**Fig 32: The consultant used <u>Artemisia halimus</u> as a compact hedge, (Western concept and alienating the ecological growth of the specie's root system).**

**Fig 33: Foreign policies (Sultanah park). [42], the absence of shrub layer exposes the families to the walk ways ,which resulted in the absence of Saudi families.**

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[42] M.Salama. . *Availability and use of plant material in urban parks in central Saudi Arabia.* M.Phil. diss., Edinburgh University, 1987.

2. Street seating areas which are typical in Western cities are introduced to Saudi Arabian towns. These seating areas are not used due to the high temperature and reasons of social behavioral and traditions (Fig 34).

**Fig 34: Foreign ideas such as visually exposed seating areas, are a common failure to satisfy public need.**

3. The majority of hardscape elements specified are imported and usually of a synthetic material and artificial appearance and alien to the context.

4. Driven by their financial aims, the consultants always seek to satisfy the client as a priority, for instance by specifying annuals and expensive decorative plants to imitate a park design seen in the west. These decorative plants are short lived and require high quality maintenance, rich soil with special additives and costly irrigation systems.

5. Previous attempts to use native species by foreign consultants failed to comply with the nature of native plant material. The chosen species were used, stored and planted as imported plants. Native palm trees used by a foreign consultant in Arriyadh plazas were unsuccessful as reported by K.Klein of A.D.A 1987. The loss of 40 plants of Phoenix dactlyfera and the failure of the Central walkway "spine" to

as a pedestrian collector, was the direct result of the foreign consultant being ignorant of the habit of native species, native people, climate and the Islamic culture and traditions. In practice the consultant used the palm trees, which are a surface root species, in a contained planting area covered with a steel grill. He also heavily pruned side branches (Fig 35). This resulted in two main problems. Firstly; planting surface rooting species in a restrictive concrete box, destroys the root system, denies water and nutrient supplies to the tree, and results in the eventual loss of the majority. Secondly, side branches act as shields protecting the species from pests and disease, this heavy pruning made them increasingly susceptible to these factors.

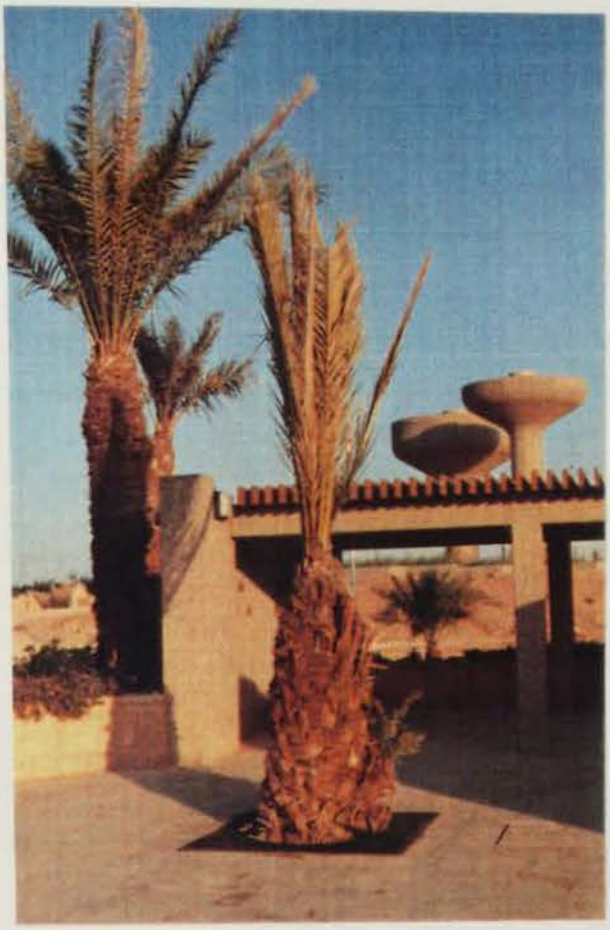

**Fig 35: Shows how the consultant planted palm trees in a contained concrete box covered with steel (right) grill while heavily pruning side branches (left).**

6. Many species in the D.Q required continual physical support after they were pruned to give the appearance of Western shade trees. The consultant specified a large shrub and required the pruning and training of the tree to fulfil the role of shade tree (Fig 36).

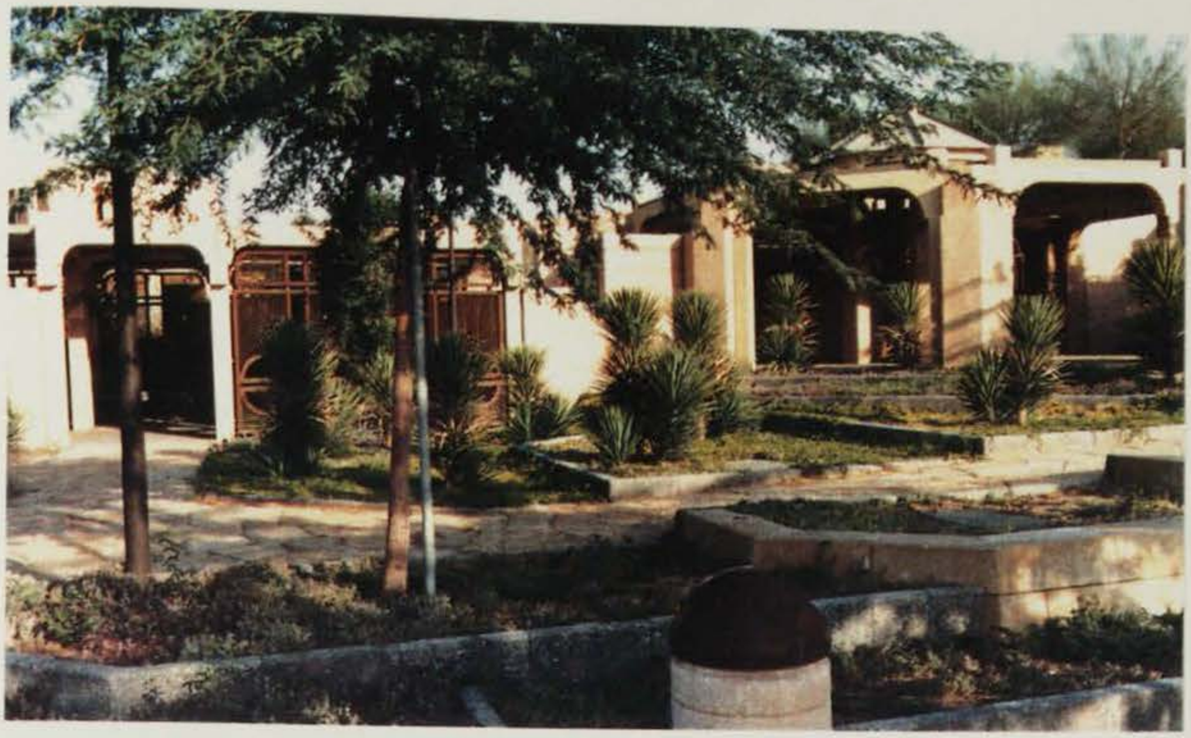

**Fig 36: Heavily pruning to convert form. By foreign consultants.**

7. Introducing large open bodies of water (Fig 37) in Saudi Arabian parks is a strange element contrary to sensible environmental design policies. Constructing such elements in the middle of the Najdi desert where water is scarce will only result in serious problems such as accumulation of salt on the edges and the lower surface of the pool blocking the pipe work, strainers and skimmers. To resolve these problems, the system must be fitted with a reverse osmosis system. Statistics show that a total of 6700 water bodies including swimming pools were built in Arriyadh up to 1987. 48% of these have subsequently been converted to planting areas, which reflects the failure of such imported elements. The humid saline atmosphere tends to corrode metals and stain other materials. Also air borne sand and dust is saline, and therefore corrosive. Such characteristics of the typical Najdi environment were ignored when introducing such imported elements by the consultant. In addition to cost, metal outdoor also causes heat absorption problems. Thus metal seats and play equipment are uncomfortable to use for large period of the day.

8. The logical approach to design in the Najdi environment is to make the maximum use of shade. Despite that, most of the contemporary Najdi parks are strongly oriented to maximum exposure. Also the majority of these parks do not consider the undesirable effect of the shamal storms. For example, most of the construction elements contain or are designed to contain voids and cavities, inside which sand and dust will soon accumulate and give a neglected, poor appearance to the feature.

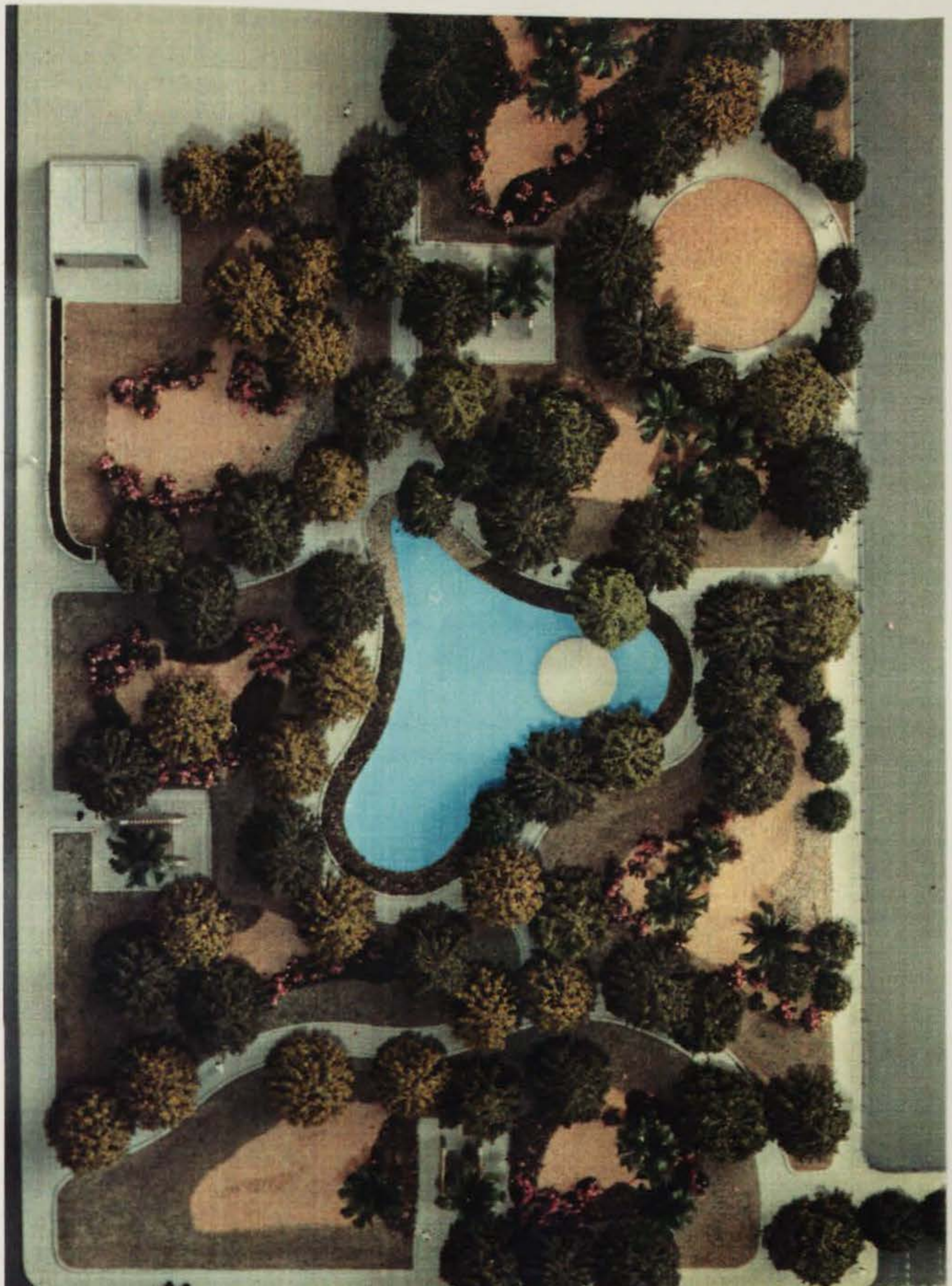

Fig 37: large water bodies in sulimaniah park.

9. Although the extreme temperature variations (both diurnal and annual) require expansion and construction joints for all hardscape elements, heat retaining materials such as metal and concrete are widely used in landscape projects.In addition, these material can result in severe burns to children upon contact with skin.

It is crucial, that consultants in Najd should design in the context of Islamic principles and the traditional lifestyle, which grew out of a respect for the desert ecosystem. The designer should understand the implication of landscaping in a desert community whether it is a garden, a district park or a nature park. An assessment should be made of all proposed advanced technologies, which are supposedly superior to traditional methods, to judge whether their application in Najd is sensible. A combination of new and traditional methods are often of advantage to the design. Such assessment should govern the decisions of the design team which will be organized and appointed according to the brief's requirement. They must also ensure the sensible use of local resources.

Judgment on the suitability of the design for the Najdi environment should not be governed by how lush looking the parks are , but on how well the designer has understood the key factors mentioned in this chapter and how he has used the Najdi environmental factors to the project's advantage.

The landscape consultant should design in Najd while keeping in mind how it's people, plants, animals and even urban settlements, are adapted to the harsh conditions and lack of water. Such design should be oriented to respect the habits of native species, Saudi Arabian heritage and lifestyle. Also to avoid sun and heat and most importantly to preserve the Saudi Arabian identity.

This information, which was obtained from the questionnaire to consultants shows that their role is very sensitive and effective on the landscape architecture profession in Najd. The introduction of design guidelines is needed in order to insure a successful introduction of native species in the Central region.

### 2.3.4 THE CONTRACTOR

Specialized and qualified landscape contractors in Najd are rare, and so difficult to find. Consequently, the majority of landscape work is carried out by building contractors. This has resulted in an emphasis on built elements such as pavement and concrete artifacts. Planting is usually carried out by an agricultural foreman. A Landscape architect is usually not employed during construction, due to the high cost of landscape supervisors. An intensive survey targeted at selected landscape consultants revealed that even if a landscape architect is resident on the site, most landscape decisions are approved by the project manager or even the company director who is usually neither an architect nor a landscape architect but a self educated local sponsor or a business man.

The contractor's sponsor can intervene in landscape decisions at any time during the contract period, even changing plant material if cheaper substitutes are found locally, disregarding the species role and function. In fact in al Sulimaniah park a palm tree was replaced by a lighting fixture as shown in Fig 38. From personal experience practising as a qualified architect (1980 - 1985), the contractors used to control change orders for building materials and even details of design layout by their direct personal relationship with the client.

Another problem effecting landscape work in Najd is the conflict between English and Arabic. The consultants use English language in contract documents with Latin names in planting lists, while most of the plant material held in nurseries are classified under their common Arabic names. 95% of the work force are Arabic speakers. This results in major problems in translating and changing the specification, which often results in technical faults. Recently the Saudi Arabian government has introduced new legislation to control contractors and sub-contractors. To summarize this legalization, all documents should be issued by the consultants in both the Arabic and English language, and material should comply with the Saudi General Organization for Specifications And Measurements.

**Fig 38: Lighting fixture replaced palm tree inside the shade structure.**

### 2.3.5 CONCLUSION

The progress of any landscape project in Saudi Arabia is critically affected by three parties: the client, the consultant and the contractor. Each party at present is contributing something to the poor quality of completed landscape projects. The client has power over all parties. Till now this was used to the detriment of the process and to alter many of the design features. Changes required by the client usually disrupt the project's schedule, and lead to late completion.

Consultants are strangers to the local environment and customs. Their initial response to that is to change the local customs and modify the environment as an approach to designing. Clouston. B, describes such a "logical" option for the designer.

> '*Complete modification of the soil within areas to be planted, traditionally solved by replacing with an imported mix of Wadi soil, sand and organic material. The principal is simply to choose plants which thrive by watering; plant in a soil mix which ensures sharp drainage; supply plant nutrients and a sufficient amount of organic material to retain mixture and give a cool rooting medium*'. Clouston, B. page 17. [43]

That forms the usual approach by a foreign consultant; imported soil, plants that require watering and drainage. Now much of the Najdi ecology and landscape are suffering as a result. He also mentions that;

> '*Climate is a matter beyond our control. Soil we can modify; water we can supply; plants we can grow, and these in turn modify local climate. But there is nothing we can do about macro climate of the area but accept it.*' Clouston, B. page 20. [44]

He accepts macro climate as the only factor beyond his powers modification. As a result, many ecological crises exist now: shallow and saline water table, disappearance of wadi habitats and implications of pests and diseases brought in by imported plant material. The freedom given to the consultant to specify imported building or planting material has undoubtedly contributed greatly to the failure of the current landscape programme.

The shortage of qualified landscape contractors and the absence of laws to clearly define the relation between the client, the consultant and the contractor may delay and deceive any genuine attempt to indigenously landscape the Najdi desert.

This examination of the present professional procedures and their implications for the existing and prospective landscape design process, strongly argues the need for further legislation to control the relationship between client, consultant, contractors and nurseries has been clarified. It is essential to establish a suitable professional framework,

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[43] Paper published in: Cochrane, T; Brown, Ali, J. "*Landscape Design for the Middle East*"6. RIBA Publication LTD, 1978.

[44] Paper published in: Cochrane, T; Brown, Ali, J. "*Landscape Design for the Middle East*"6. RIBA Publication LTD, 1978.

which can ensure that the use of native flora is properly handled. Firstly more control should be applied to the importing of new species. The stripping of wadi soil by the nurseries should be abandoned. The relationship between the client and the consultant should be directed more to the benefit of the design, and the technical committee must be formed with the emphasis on selecting members with landscape expertise. It should be a duty of the consultant to convince the client of the benefit of introducing native species. The consultant should design keeping in mind the Saudi Arabian environment, heritage, lifestyle, culture and Islamic traditions. Finally the contractor should comply with the consultant's orders, while a register and classification of landscape contractors is essential to encourage a general improvement in their number and their quality.

# 3. ENVIRONMENTAL FACTORS

## 3.1 INTRODUCTION

An important element in the argument for substituting imported flora is the natural environment of Najd. This will directly control the native species in their distribution, location and seasonal variation. It will also influence the types of plants associated with particular habitats, and their form, habit and reproduction methods. By studying such environmental factors, it becomes clear that native plant material, which has successfully adapted to the aridity of Najd, are generally the most suitable for landscaping projects in Najd. Thus by the same argument, imported species are less suitable. This section introduces the relevant environmental data, usually an essential consideration for the design analysis stage.

The prevailing climate in Najd is uniform. The average summer temperature is 47°C, but commonly exceeding 49°C. The extreme heat optimises shortly after sunrise and lasts till sunset, after which a cool night persists. In the winter, might temperature can drop to freezing level aided by the absence of humidity and cloud cover with high wind chill factor, resulting in a harsh cold atmosphere. The two extremes make the hypothesis for using native and long adapted plants more valid.

The rainfall is extremely low, average some 25 mm per annum. In addition, an entire year's rainfall may be the result of one or two torrential rainfalls, which often disappear through the soil, to be trapped above the impervious rock layer to form the valuable ground water supply. Using such precious water to irrigate imported flora and leach their soil of salts will only pollute and increase the salinity of the ground water, the gross water budget of the region.

Although the average yearly amount is as little as 25 mm, one might not experience rainfall for several years. In 1957 and 1958, the entire area was devastated as a result of severe drought. Many animals were lost, except camels, which owed their survival to their dependence on native hardy perennials as food source. These plants survived even such a drought. Despite the scarcity of water, much is still used to irrigate imported plant material and for soil leaching operations. This is only a waste and degradation of a precious resource and threatens the water sources in Najd and especially in Arriyadh where the majority of planting schemes are executed.

Arriyadh is taken as representing the general meteorological conditions in Najd. It is situated at 24° 39'N, 46° 22'E, at an elevation of 590 meters above sea level. It is located in the middle of Najd. The dominant weather character in Najd is hot and dry with mean temperatures of + 45°C and a short cold winter with night temperatures dropping as low as -7.2°C. Infrequent thunderstorms and cloudbursts occur in winter and spring. Central Saudi Arabia experiences very low precipitation. The climatic zone is semi desert to desert without deep winters, but with night frosts of less than one hour duration.

Table 5 shows microclimatic data for Wadi Hanifah, Arriyadh with a mean annual temperature of 24.8°C. The mean maximum is 32.2°C and the mean minimum 17.2°C. The mean relative humidity is 43% and the mean precipitation is 89mm. Rainfall occurs on an average of 11 days/annum, with a mean maximum for one day of 61mm. Prevailing winds are mostly from the north west and north in winter.

**Arriyadh station: 20 39' n/ 46 42' E 591 Meters above sea level; 25 Years mean recordings.**

| | J | F | M | A | M | J | J | A | S | O | N | D | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEAN TEMP.(C) | 14.4 | 15.9 | 20.6 | 24.7 | 30.0 | 33.6 | 33.6 | 32.8 | 30.6 | 25.3 | 20.9 | 15.3 | 24.8 |
| MEAN MAX TEMP.(C) | 21.1 | 22.8 | 27.8 | 31.7 | 37.8 | 41.7 | 41.7 | 41.7 | 38.9 | 34.4 | 28.9 | 21.1 | 32.2 |
| MEAN MIN TEMP.(C) | 7.8 | 8.9 | 13.3 | 17.8 | 22.2 | 25.0 | 25.6 | 23.9 | 22.2 | 16.1 | 12.8 | 9.4 | 17.2 |
| MAX. TEMP.(C) | 30.0 | 32.8 | 38.3 | 40.0 | 43.3 | 45.0 | 45.5 | 44.4 | 43.9 | 38.3 | 34.4 | 30.6 | 45.5 |
| MIN TEMP.(C) | -7.2 | -1.7 | 0.6 | 2.2 | 15.0 | 19.4 | 19.4 | 16.7 | 17.2 | 10.0 | 1.7 | 0.0 | -7.2 |
| MEAN RELATIVE HUMIDITY (%) | 57 | 50 | 51 | 49 | 41 | 39 | 26 | 27 | 33 | 36 | 47 | 64 | 43 |
| RAINFALL (MM). | 3 | 20 | 23 | 25 | 10 | 2 | 0 | 2 | 0 | 0 | 2 | 2 | 89 |
| RAINFALL 24HOUR (MM) | 5 | 58 | 61 | 51 | 18 | 2 | 0 | 2 | 0 | 0 | 2 | 2 | 61 |
| RAINY DAYS 1.0 MM. | 1 | 1 | 3 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 11 |
| EVAPOTRANSPIRATION POTENTIAL MM. | 17 | 2 | 60 | 111 | 185 | 204 | 210 | 197 | 169 | 116 | 55 | 21 | 1367 |

**Table 5: General microclimatic data. (Source A.D.A Meterological report). The potential Evapotranspiration is high and a major influence on plant material in the region.**

As most native plant material distribution is related to a combination of macroclimatic factors, the following brief data are essential criteria for successful indigenous landscape design.

## 3.2 MACROCLIMATIC FACTORS

The reasons for the aridity of the Saudi Arabian desert are particularly complex, since several systems of atmospheric circulation are involved. In the Central Region, precipitation typically occurs only during the winter months (October - March). The form and orientation of the Tuwayq escarpment, which lies west of Arriyadh extending in a north westerly direction, has an orographic (mountain rain) effect. This modifies local rainfall sufficiently to make this escarpment area the least arid in the region. Average annual rainfall ranges from less than 50 mm in the south of the Central Region, to over 150 mm along the northern Tuwayq escarpment. Most rainfall takes the form of sudden showers, which tend to be unpredictable. The average number of rainy days in a year does not exceed 11 in Najd. It was reported by the A.D.A that " rainfall in Najd is unreliable (extremely variable from one year to the next) and average figures tend to have little meaning. During the period analyzed, rainfall has ranged from more than 200 mm per annum to less than 20 mm per annum in Arriyadh" (A.D.A meteorological report). Even such data reflects the success of native species ,which thrive even under the stress of this variable annual rainfall.

The Kingdom is influenced by two different global air movement systems according to the season of the year. In winter the effect of cold air current from the eastern Mediterranean areas sometimes penetrates down the Arabian peninsula in the form of relatively moist northwesterly winds. During this season the Central Region receives all of its rainfall, while in summer, very hot and dry conditions prevail.

Wind directions are very variable, and maximum velocities tend to occur during spring and early summer; speeds of over 40 knots have been registered in Arriyadh. In Najd sand and dust storms are typical of this type of climate and terrain. They usually occur from March to May when hot and cold air masses converge in this zone, creating particularly unstable atmospheric conditions. The general macroclimatic data shown in Fig 39 covers the average mean recordings over a 25 year period for Arriyadh, Hail, and Jeddah. (Information obtained from A.D.A.

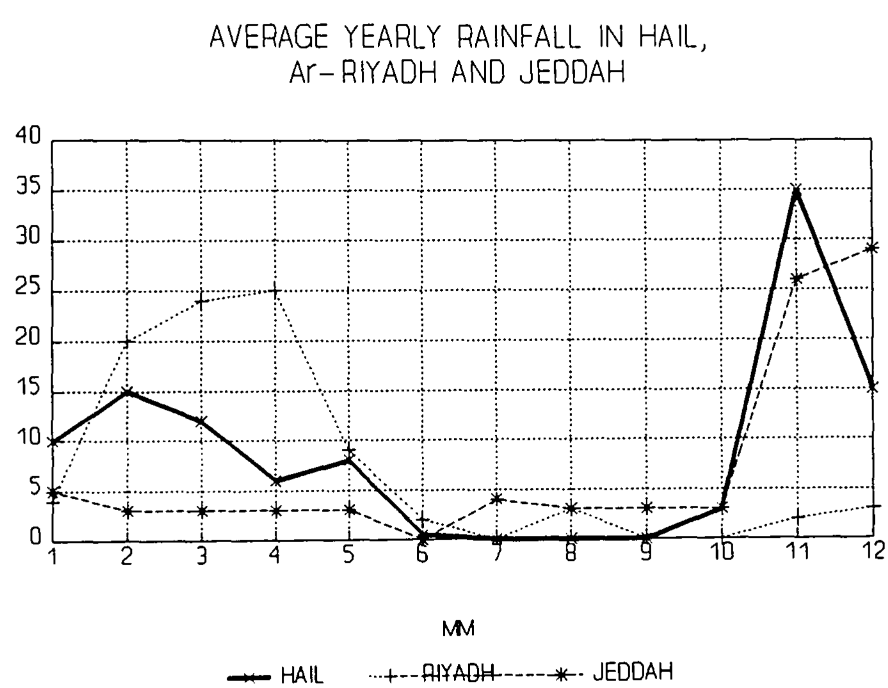


**Fig 39: The mean recording of average yearly rainfall in Hail, Arriyadh and Jeddah. The graph shows the minimal rainfall that Arriyadh receives during summer and even winter.**

Other factors contribute to the aridity of Najd: temperature, relative humidity, rainfall and evapotranspiration. These influences are of great importance to landscaping and to sustain the hypothesis of the thesis.

### 3.2.1 TEMPERATURE

The maximum temperatures in Arriyadh occur in July (45oC) and the minimum in January (-7.2oC), giving an overall variance of 52.2oC. Mean monthly temperatures are 14.4oC in January and 33.6o in July. The spring and autumn means are both approximately 26oC. The difference between summer and winter is wide enough to cause suffering for imported flora (Fig 40 below).

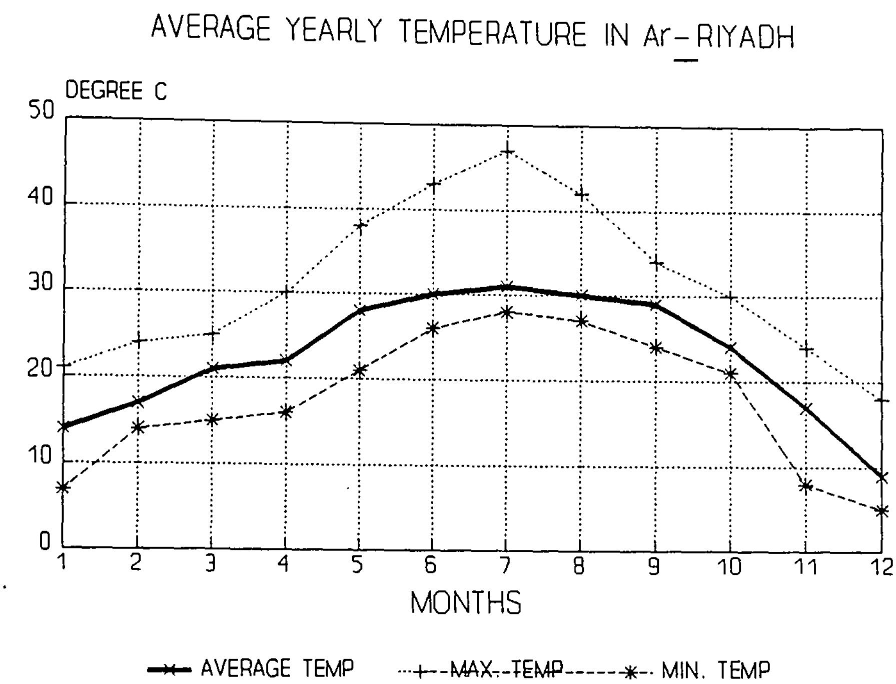


**Fig 40: Average and absolute temperature in Arriyadh.**

### 3.2.2 RELATIVE HUMIDITY

The relative humidity in Arriyadh, differs from those of Hail and Jeddah as these settlements are located near the coast. In Jeddah, the values are relatively constant at 60%, with Arriyadh being considerably lower during the summer period. Arriyadh's mean relative humidity is 43% due to relatively high values during the winter months. This factor of higher and constant relative humidity in Jeddah and Hail reflects the success of imported flora in those regions.

### 3.2.3 RAINFALL

Unlike other regions of Saudi Arabia, the Central Region is excessively dry, with

Arriyadh receiving significantly less precipitation than cities closer to the Red Sea and the Gulf. Such rainfall as occurs in Arriyadh (an average of 50 mm/annum), tends to fall in February, March and April, with a tendency to powerful storms, which often cause floods in the lower land. For this reason, most of the statistics given earlier show that Arriyadh is receiving a minimal amount of rain fall.

### 3.2.4 EVAPOTRANSPIRATION

Potential evapotranspiration in Arriyadh per month is given in Fig 41. The mean annual potential evapotranspiration is 1367 mm, although this accommodates significant seasonal variation, being high in the summer and low in the winter. These values are greatly affected by the influence of wind, vegetation and other factors which are not quantifiable, and the figure of 1367 mm per annum is considered to be unrealistically low. Such levels of evaporation will increase the water consumption by imported flora, which tend to transpire water to achieve cooling effects adding to the problem of salinity and underground water quality.

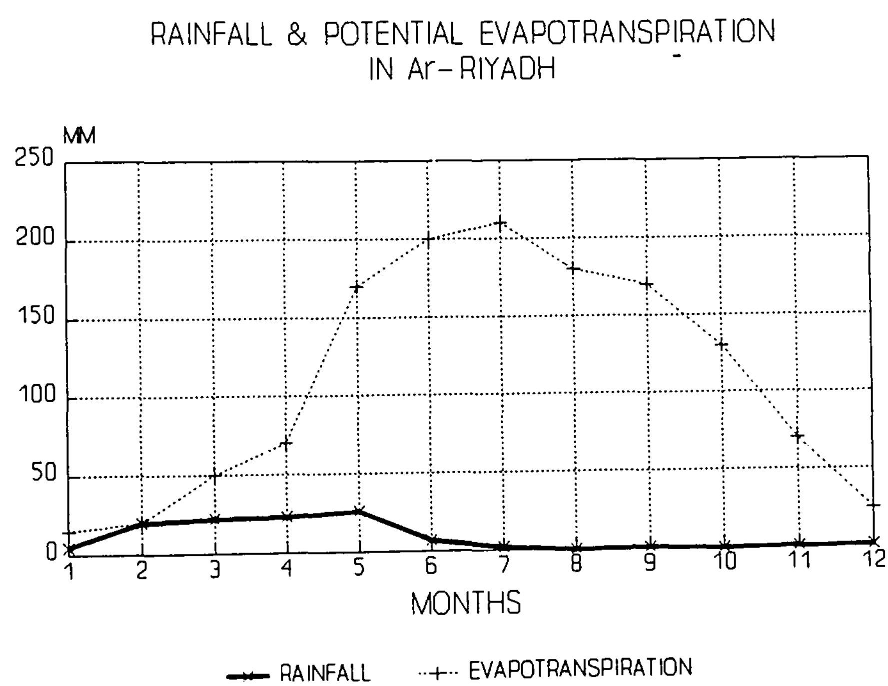


**Fig 41: potential evaporation in Arriyadh.**

Such meteorological factors introduce the two extremes, winter where heating in buildings is required and the extra dry summer. The native flora thrives in such conditions while imported ones suffer. This will support and add to the pressure for substituting imported species by native ones.

Local climatic changes in the urbanised parts of the Central region, which are caused by the rapid growth of the cities, result in increased demand for recreation facilities in locations where the natural climate can be enjoyed. Climatic data should be measured for each site and its vicinity, in order to assess the relevant ecologically suitable species for each site.

### 3.2.5 LANDSCAPING AND WATER BUDGET IN NAJD.

The task of calculating an estimated water budget for irrigating imported plant material used in landscaping in Najd is under process now by the Ministry of Agriculture and Water. The estimated daily amount of water used is 750,000,000 gallons of water in the summer while this amount will decrease in the winter by 65%. Water is scarce in the Kingdom. Such a quantity of water ,which is currently consumed by imported flora ,could largely be saved by using native species instead. The guaranteed reduction in water could reach up to a minimum of 75% in the summer and 95% in winter.

The only natural source of water in the Central region comes from the rain which is discharged to the underground impermeable layer. The rest is imported from a desalination plant on the gulf coast at Dammam . But as mentioned previously ,there is little rain in the Central region and the distribution is also uneven and much of it is evaporated. There are no perennial streams in the area, and the rare heavy showers are usually accompanied by considerable run-off especially on the impermeable slopes of the Tuwayq mountains. Records indicate that the rainfall decreases from north to south and from west to east as follows: 160 to 80 mm/annum from west to east in the northern part of the area; with average of 100 mm annually in the west of the region - 80 - 40/annum in the south, while the annual average is 110 to 85 mm over the whole area. Table 6 shows the precipitation data, which was recorded by the Ministry of Agriculture and Water for the Arriyadh area. Such data only supports the previous argument that water is scarce and too valuable to waste on imported flora while the country is rich in native species which do not require irrigation water (Table 7), except the equivalent of annual rain fall/year.

## TABLE 6 Arriyadh PRECIPITATION DATA 1976-1982

| | 1976 | | 1977 | | 1978 | | 1979 | | 1980 | | 1981 | | 1982 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MONTH | 24H | MONTH | 24H | MONTH | 24H | MONTH | 24H | MONTH | 24H | MONTH | 24H | MONTH | 24H |
| JANUARY | 5.3 | 3.3 | 12.8 | 6.0 | 2.5 | 1.5 | 2.6 | 1.6 | 12.6 | 11.4 | T | T | 0.5 | 0.5 |
| FEBRUARY | 21.7 | 11 | 2.1 | 2.1 | 6.4 | 2.3 | - | - | 38.9 | 20.6 | 1.7 | 1.5 | 16.7 | 7.6 |
| MARCH | 78.7 | 23.4 | 10.2 | 5.3 | - | - | T | T | 3.6 | 1.6 | 12.3 | 3.4 | 41.8 | 16.8 |
| APRIL | 124.3 | 37.5 | 23.3 | 12.9 | 6.3 | 3.4 | 2.2 | 1.5 | 1.4 | 1.0 | T | T | 19.4 | 4.8 |
| MAY | 8.9 | 6.8 | 8.1 | 5.5 | - | - | 14.9 | 12.8 | T | T | 7.3 | 5.8 | 3.4 | 2.4 |
| JUNE | - | - | - | - | - | - | T | T | - | - | - | - | - | - |
| JULY | T | T | - | - | - | - | - | - | 0.3 | 0.3 | - | - | - | - |
| AUGUST | - | - | 17.4 | 17.4 | - | - | - | - | - | - | - | - | - | - |
| SEPTEMBER | - | - | - | - | 4.2 | 3.4 | - | - | - | - | - | - | - | - |
| OCTOBER | T | T | 7.4 | 4.1 | - | - | 0.4 | 0.4 | - | - | - | - | 27.1 | 10.2 |
| NOVEMBER | 3.5 | 1.7 | - | - | 3.4 | 3.4 | - | - | 3.8 | 3.8 | T | T | 5.3 | 3.2 |
| DECEMBER | 15.3 | 7.4 | 3.5 | 3.5 | - | - | 14.4 | 6.0 | 3.1 | 1.2 | 0.5 | 0.5 | 15.7 | 5.2 |
| MONTHLY TOTAL | 257.7 | | 84.8 | | 22.8 | | 34.5 | | 63.7 | | 21.8 | | 129.9 | |

T=TRACES

**Table 6: Precipitation data.**

Table 7 below shows a comparison of water consumption between native and imported flora:

| DESCRIPTION | NATIVE | L/DAY | IMPORTED | L/DAY |
|---|---|---|---|---|
| TREES | ACACIA TORTILLAS | 5/L/D | DELONIX REGIA | 150 L/D |
| SHRUBS | OCHRADENUS BACCATUS | 2/L/D | LANTANA CAMARA | 40/L/D |
| GROUND COVER | CLEOME ARABICA | 20/L/M2/D | CARISSA GRANDIFLORA | 20/L/M2/D |
| GRASS | PANICUM TORGIDUM | 20/L/M2/D | ARURDO DONAX | 20/L/M2/D |

**Table 7: Comparison in water consumption between native species and imported ones.**

The information related to imported plant material was obtained from test sites for one month on Sulimaniah Park, (Ref. M.A. Shnkiti) municipality of Arriyadh. The information for native species was obtained by the maintenance department A.D.A.

during the rainy season only, as these plants can survive during the other seasons without any or little water consumption depending on their function. The tight water budget in Najd and the gap in water consumption between the two supports the argument for eliminating imported plants and substituting with native ones.

### 3.2.6 CONCLUSION:

Environmentally, the imported flora is unsuitable for use in landscaping the Najdi cities. By looking at each environmental factor, the argument is reinforced. Firstly the macroclimatic factors represent the extreme aridity of Najd in which only native species survive without irrigation. Importing plant material native to sub-tropical, humid conditions into the arid land of Najd, then creating microclimatic conditions to suit them has proved to be a waste of resources. Secondly the water budget in Saudi Arabia as a whole is restricted to a minimal and small amount of rain fall and desalinating plants located 500 miles away from Najd. Therefore it should not be wasted on imported flora, which consumes a vast and expensive amount of water. The use of native species instead will save this resource and suit the environment.

## 4. ECOLOGICAL IMPLICATIONS:

A great amount of research is required to ascertain the suitable environment for reestablishing native vegetation cover. The loss of unique native indigenous vegetation stands which are currently being replaced by buildings or grass areas, is a great tragedy as shown in Fig 42. Here the palm land was neglected to enable the use of the land as a building site. The palm land was established over a long period and contains a precious soil resource. Also Fig 43 displays the extent of the damage to the Wadi system in Najd where the ecological implications are devastating. An intensive questionnaire to selected landscape bodies was carried out during the summer of 1988. This was designed to obtain the key ecological factors which directly affect the prime goal of this study. The survey concentrated on professional observation by landscape architects within those bodies.

The ecology of extreme aridity, such as in Najd, is complex and interesting at the same time. The native plants of Najd are adapted to water and heat stress, high salinity levels, poor nutrient and soil condition, resistance to local pests and diseases and also the ecogemorphological conditions. If these species find their way in to the local nurseries, in order to be propagated for landscape use, they are propagated from only a single species and under ideal microclimatic conditions. These are humid and cool atmosphere, rich imported soil, and with an irrigation system. Such conditions are likely to cause the loss in the nursery stock of the unique characteristic of growing adaptation to local environmental factors inherent in the original stock plants.

The man made microclimate in which those species are propagated is destructive to their inbuilt adaptation to Najdi environment. It produces a new generation of weak plants that are sensitive to pests, diseases, soil conditions, heavy public use, meteorological factors and nutrient value. The propagation method used in the testing process included later is highly recommended for native plant material.

The regular distribution of natives according to available moisture tend to produce a special character appropriate for native landscape design. This feature should be used and reinforced to meet the local needs and taste. The entire humid zone around the plant will be occupied by its root zone. This is a character of flora native to arid zones. They usually fail to thrive in a compact design, as used by many foreign consultants. Therefore, the arid park should be designed according to arid ecological rules and diversity of humidity, in order to achieve maximum success. The most successful rule implemented till now is "natural succession". Ecologically the biotic characteristics inside native plant material interacts with the surrounding environment to sustain a degree of succession and growth. Although that growth is slow, it is eventually comparable in form and diversity to the imported plant material, which have heavy losses.

Imported plant material is not only less resistant to local pests and diseases but, the large numbers of exogenous, especially horticultural plant species now being imported to Najd are introducing new pests and diseases. The native plant material may not be immune to such pests and diseases, and so may be at long term risk. Lessons are to be learnt from the U.S.A where imported species have been decimated by local pests and viruses.

Species of imported plant material require the creation of a suitable microclimate before their successful introduction, i.e, irrigation, new soil, fertilizers, implementation of humidifiers and intensive sheltering. Apart from this being exorbitant, a man made microclimate will suit only a limited variety of species, due to the mixture of sources from which those species are brought. In 1984 in Alaishah park south Arriyadh, such ecological problems resulted in the loss of 75 native species of Phoenix dactylifera. The introduction of advanced and complicated irrigation systems such as "rain bird", resulted in a sharp and sudden increase in the level of humidity, and even water logging, which the plants which are long adapted to drought could not cope with. [45] At the same time some imported species thrived especially those of tropical origin.

The addition of chemicals and fertilizers to the soil in order to achieve suitable growing conditions for imported species, is a considerable cost factor. As the existing native species are adapted to poor soil conditions, drought and a certain level of salinity, these problems are avoided.

Even the adapted imported species, such as the ones from similar environments in Australia are suffering the same symptoms. The solution for such problems are complicated and can only be achieved by changing the soil character and composition to suit each imported species. [46]

Imported plant material is less resistant to local pests and diseases than indigenous ones. In 1987 it was announced by the Agriculture department that all species of Nerium oleander imported from India should be lifted from the nurseries as a result of a virus, which attacked all the existing plants. [47]

In Najd meteorological conditions tend to encourage an excessive use of water. This applies only to imported plant material, as native plant material are adapted to these

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[45] Reports acknowledging that started to emerge in 1985 by the municipality of Ar-Riyadh.

[46] Pers. com: municipality of Arriyadh; Omrania, 1988.

[47] Agriculture department, municipality of Ar-Riyadh, interview by the author, July 1988.

conditions by the following sophisticated botanical characteristics:

1. Fleshy leaves covered by thick waxy cuticles in which water is stored.
2. Sunken stomata to minimize water loss, and these few in numbers.
3. The native species are able to develop large photosynthetic areas which do not desiccate quickly.
4. Native plant material are adapted to control the stomatical opening.
5. Hairy leaves slow down movement of air.
6. Many are typical of xerophytic plants.
7. They also develop an extensive system of thin roots to acquire water.
8. Some native species of xerophytes roll their leaves to prevent water loss from a large surface area.

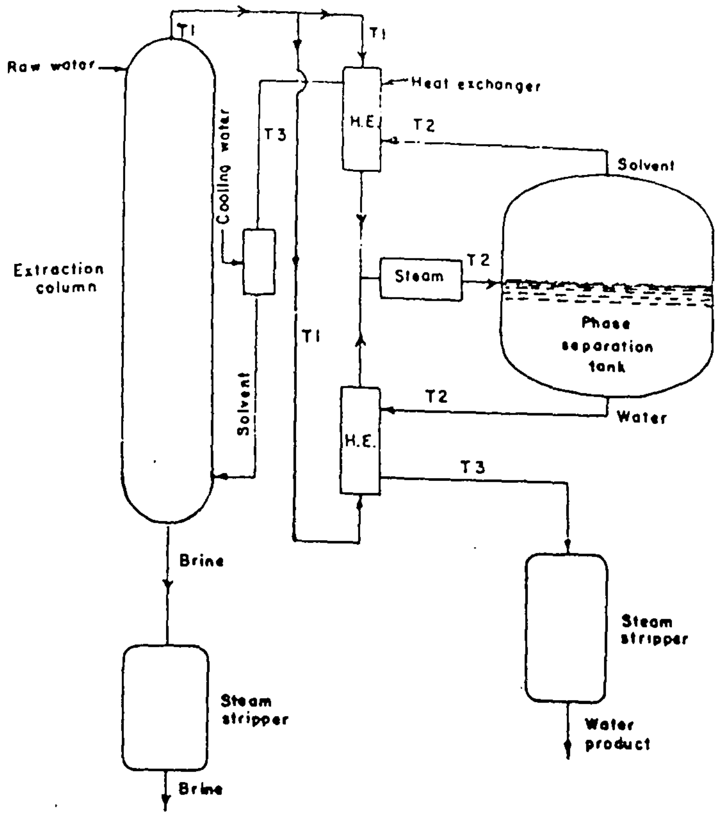
Such botanical data enables a great adaptability to local environment. Those botanical qualifications do not exist in most of the imported ones, especially those imported from north Africa, southeast Asia and south America. Some of the Australian species are successful, but they suffer from local pests and diseases. That explains why most of the foreign consultants tend to specify complicated irrigation systems to compensate for the lack of adaptation.

The saline ground water table in some areas strongly influences imported plant material. An imported soil is essential for such plant material to raise the root ball level above the saline water. The use of this plant material requires a capillary break between the saline ground water and the sweet irrigation water. This is achieved usually by a layer of subgrade drainage gravel with a separator of impermeable material and perforated agriculture drain tiles to divert saline ground water. However, where the local elevation is low and close to ground water, salt tolerant plants are particularly appropriate and only native species can fulfil that role.

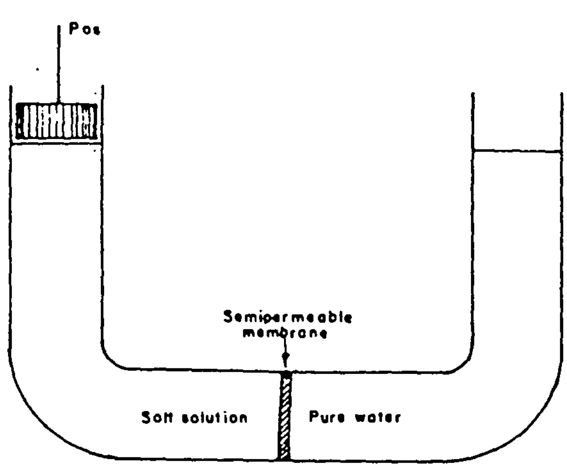
The use of imported species also requires the introduction of a reverse osmosis (R.O) system (Fig 44) which is very expensive initially. It also requires highly trained staff and a costly maintenance programme. In Sultanah park the installation of an R.O system cost the local authorities a sum of 120,000 S.R (£25,000), while the maintenance contract cost 50,000 S.R./anum (£10,000/anum). Also, the newly constructed irrigation systems do not always give the expected conditions without causing adverse effects on soils or ground water. Often these irrigation systems cause the spread of human, animal and plant diseases, also the spread of weeds as a result of both the rich soil and the continuously irrigated system (Fig 45).

Najdi soil ,especially on the plateau zone, is highly alkaline,and where imported species should be irrigated ,the salt,water and climate work together to introduce salt as an ever present problem for imported species. As with the case in Arriyadh parks irrigating highly saline soil with saline water in the presence of intense solar radiation causes the formation of a salt crust on the surface of the soil. This results in both evaporation and salt uptake by the imported plant material. This leads to the use of already saline water to leach the top soil, which does not eliminate the presence of the salt in the soil. This has resulted in: firstly, the loss of 45% of the total species that were planted in Arriyadh streets by the agriculture department of the Municipality of Arriyadh. (Fig 46). Secondly, the increase of salinity level to the under ground water reserves. Thirdly, a shallow and saline water table and continual maintenance to both soil and irrigation system. Some designers tend to avoid such technical problems associated with using plant material, by using constructed elements as in Fig 47.

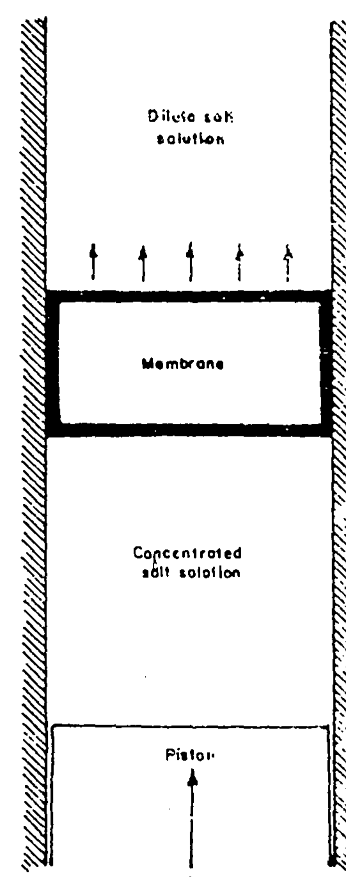
**Fig 42 & 43: The Damage to palm land (above) and Wadi Hanifah.**




Schematic of solvent extraction process for saline-water conversion. Cold salt-water and solvent flow countercurrent through extraction column. Steam heats wet solvent to effect water precipitation. Steam strippers recover traces of solvent. Components marked "H.E." are heat exchangers. T designates temperature. From Hood and Davison (1960).




Osmotic "equilibrium" across a semipermeable membrance (a membrane permeable to water but not to salt).




Submemrane reverse Osmotic

**Fig 44: R. O system.**

FIG 45: Irrigation system,imported soil encourages weeds to colonize the soil. Al-Rahmaniah park North Arriyadh.

FIG 46: Effect of salinity on Ficus nitida.

Fig 47: Some consultant tend to avoid such technical problems by constructing hardscape elements. Diplomatic quarter, Arriyadh.

## 5. TECHNICAL PROBLEMS

### 5.1 IRRIGATION AND SOIL

Irrigation was the main cause of diverse hydrologic impact on Najdi ecological elements. Shallow water table, surface salt accumulation increased drainage requirements, deterioration of underground water quality and salinity problems are contemporary side effects of irrigation. Many hydrological studies and surveys have established the nature and cause of problems and indicate their present and potential extent. The figure below (Fig 48) points to the extended damage to the Wadi systems in Najd caused by irrigation and drainage.

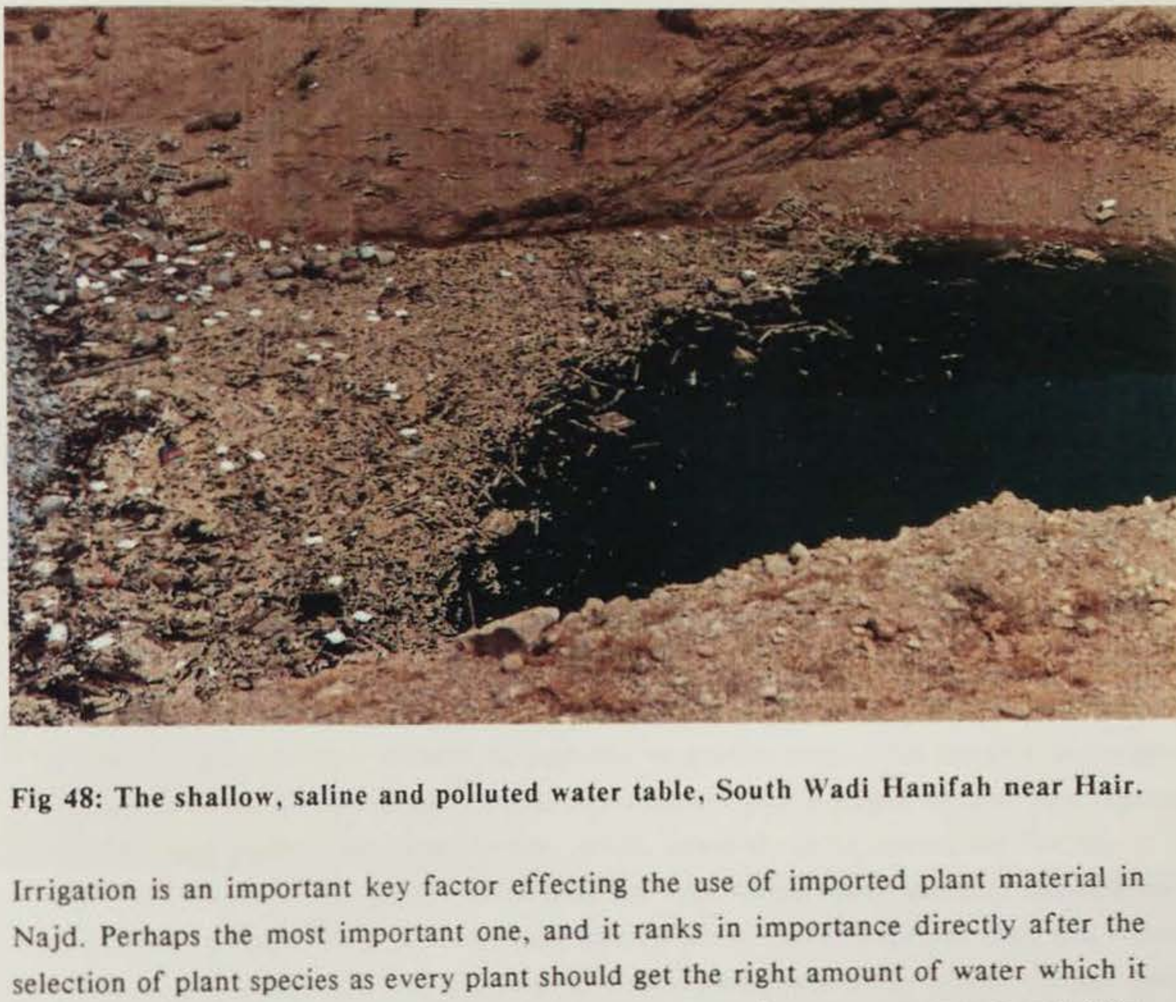


**Fig 48: The shallow, saline and polluted water table, South Wadi Hanifah near Hair.**

Irrigation is an important key factor effecting the use of imported plant material in Najd. Perhaps the most important one, and it ranks in importance directly after the selection of plant species as every plant should get the right amount of water which it requires to sustain growth. Until now, however, the precise amount recommended for each species is only approximate, and there is no reliable information on exactly how much water each species needs.

Some long adapted species planted in urban parks are normally irrigated by techniques which apply water to the surface of the soil. Accordingly, the plants will come to expect water from this direction and will not seek water by rooting down to the water table. As a result it is likely that the plant will die when watering stops.

Planting adapted species using underground water as the main source of watering will lead to the inevitable survival of the plants as reported by Turner, T.H.D: he stated that indigenous arid plants could be independent from irrigation shortly after establishment as in the case of Port Tawfik to the south of the Suez canal. The garden here was established long before the invention of modern irrigation techniques. The garden was irrigated by the traditional flood irrigation that initiated a water table. During the 1967 war, irrigation stopped for long time but large number of plants survived despite the low 30 MM average yearly rain fall. [48]

As for native species they will survive with only 100 mm of annual rain fall, but their mere survival is not the goal of this study. Irrigating native species regularly will result in a complicated change in their habit. They will be less resistant to wind and to environmental factors. The information described later will determine the amount of water which will still enable them to sustain a suitable adaptation to those factors and also achieve their role as a landscape plant. Without this information they cannot be successfully introduced to the urban or semi urban landscape context. Over irrigating natives will result in the introduction of pests and diseases. This will also result in the loss of growth characteristics of many native flora. For example, they tend to produce more leaves to increase evaporation of undesired water quantities.

One of the targets for this research is to determine how much water any individual plant must receive to achieve its goal as part of functional plant material in a landscaping project. As an interesting side issue it was discovered that certain species changed some of their habits in response to varied amount of water. For example, the colour intensity of the flowers in Vinca rosea can be altered by the control of water quantities (Fig 49).

This colour control is a potentially useful feature of native flora. They can produce an attractive colour in both flowers, foliage and vegetative parts. This forms a distinctive visual discovery that needs to be closely monitored since it might be used as a feature in landscape design. This characteristic needs, however, to be researched further. It is possible to see how the use of one species, but with varied water quantity and soil, can achieve a variety of heights, texture and colours out of that one species. But, this would probably only apply to the recommended species mentioned under colour control (See. Chapter 6, Flora). This method is only recommended for use in the private sector to aid their requirements to achieve a distinctive colour inside private gardens, and should be limited to a minimum due to the implication of using water in Najd and the characteristics of Najdi soil.

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[48] Cochrane, T; Brown, Ali, J. "*Landscape Design for the Middle East*"6. RIBA Publication LTD, 1978.

**FIG 49: Colour control by water quantity (VINCA ROSEA) . This plant was noticed by the author during the initial observation, to achieve a change in the colour hue when water quantity is increased or decreased.The white hue is largely present when plenty of irrigation water and rich soil is available. (location R.D.A Diplomatic Quarter Arriyadh).**

Najd has large areas of sandy soil, which have very low water -holding capacity. The efficiency of water is exceedingly low under the current irrigation methods. It is also very costly to improve existing soil to suit imported flora. There is however, an urgent need to develop parks for recreation use. [49]

Arriyadh and the adjacent rich wadi habitats are located in low-lying land. The use of irrigation water in Arriyadh and the development of high cost drainage and leaching systems in Najd have created a problem of salinity and water logging in this low land around. (Fig 50).

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[49] Worthington, E. Barton. *"Arid Land Irrigation in Developing Countries Environmental Problems and Effects".*

However, optimum water requirement, which is based on planting pattern, soil and climatic conditions are not yet established in the Najdi landscape process. The efficiency of water used is generally low, being less than 20 -30 %. in a modern irrigation system. The key factor, which can optimize the efficient use of plant material and irrigation water, lies in using native plant material,which require minimal irrigation and are adapted to Najdi environmental factors.

Water requirement, water application, the design and operating of an irrigation net work is a complex process and only necessary when using imported plant material. Poorly trained landscape technicians are also one of the main causes of the current misuse of water, irrigation failure and loss of many species in Najdi cities.

**Fig 50: Salinity and water logging problem in Wadi Hanifah.**

As mentioned earlier under macroclimatic condition, the climate is hot and arid with rain fall not exceeding 50 mm/ year and usually torrential in nature. Irrigation under such arid conditions generally leads to increased soil salinity and over consumption of the already small amount of ground water. This results in decreasing the quantity of the water resources and increasing salinity levels. Such irrigation problems could be greatly reduced by using indigenous species.

Alternating dry and wet seasons, low gradients with slopes less than 1m/1km, a highly saline underground water table and Najd being bedded into limestone rock, are the main causes of serious salinity problems in Najd. The upward capillary movement of water can influence evaporation and the quantity of irrigation water used must be sufficient to balance the loss due to transpiration and evaporation. Prior to irrigation, salt is distributed throughout the depth of the soil crust. With the introduction of irrigation, the redistribution of salt takes place, which results in the formation of a zone of accumulation. The zone moves up and down in accordance with the movement of water. If the irrigation water is applied in sufficient quantity, which is the case in Najd, to leach the salt down to a depth from which capillary movements cannot influence evaporation, then the zone of accumulation will remain harmlessly in the subsoil, below the root zone.

The most common and complicated irrigation system used in Najd is the American system called *RAIN BIRD* . The system is technologically advanced, but complicated,costly and effective only for an initial period of time. It has been proven that the system increases salinity levels, depends on costly water tanks, pipe work, control panels & nozzles, and results in the use of certain imported species which can grow under the system. Fig 51 demonstrates an example of this system in Araija park. The available water used for irrigation in such systems is salt laden ground water, which increases both water salinity and risk of system failure. The salt accumulates inside the nozzle, resulting in system blockage, which is reflected in the high cost of maintenance contracts.

The majority of native plants and irrigation systems are incompatible. The indigenous species are trained and adapted to drought conditions. Their root zone is extensive and a surface system which, in addition to its main function, also acts as a firm foundation to the plant, supporting it against the wind. They also create a nutrition zone around the plant preventing other species from colonizing this zone (Fig 52).

All such natural behaviour patterns are disturbed by introducing irrigation systems which provide a very easy and rich water source. Such input will only result in temporary success. The fast growth, the dramatic decrease in root ball zone and more flowers, will only result in weak species both structurally and genetically. The application of such imported irrigation systems in the municipality of Arriyadh resulted in the loss by wind blow of approx 3000 trees of <u>Prosopis juliflora</u>. [50] The continual irrigation changed the root structure from extensive and deep to very small, shallow and intensive. (Fig 53).

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[50] Municipality of Ar-Riyadh, maintenance department, interview by the author, July 1988.

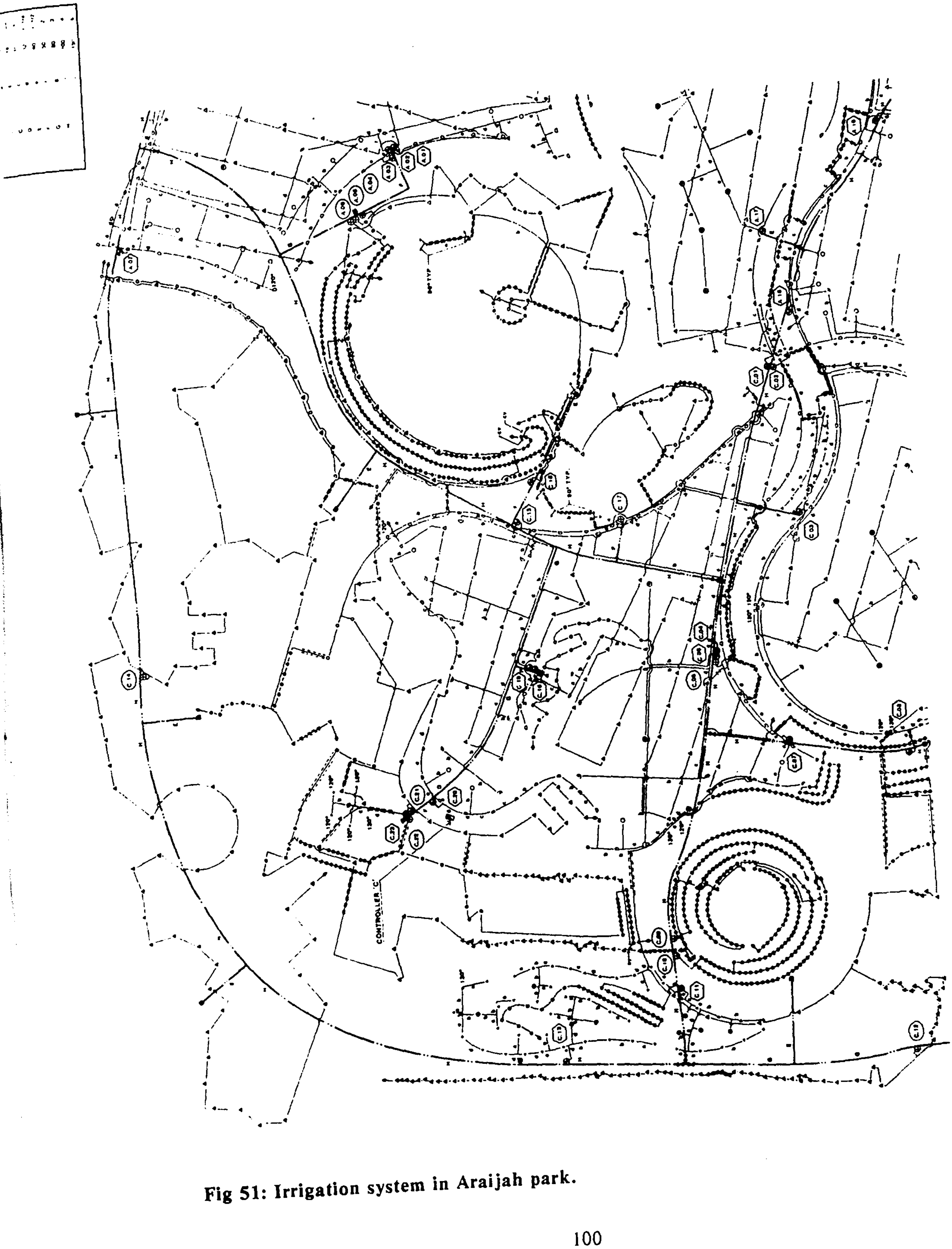

**Fig 51: Irrigation system in Araijah park.**

FIG 52: The nutrition zone controlling the distribution of native plant material in wadi hanifah and in R.D.A (ZYGOPHILLUM DECBENS RIGHT). (FARSETIA SPP LEFT).

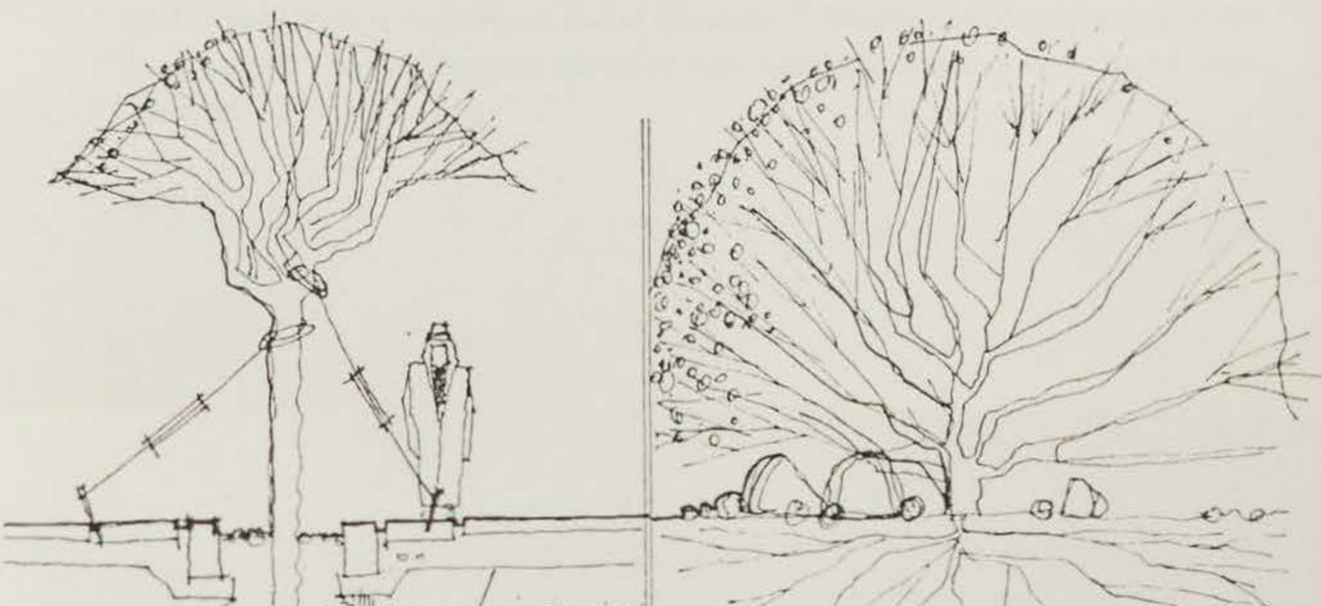


FIG 53: Shows a Prosopis juliflora in the wild habitat (right). And after training as an irrigated shade tree in the Centeral region cities (left).

Pop up irrigation systems used in irrigating grass areas, were designed primarily to achieve a green grass carpet. Such a landscape element is alien in the Saudi Arabian context. Many aspects of the system were oriented to acknowledge Western technology. For example, the pop up system was designed to suit the mowing machine, weeding material and even some Western social aspects. This system, when combined with Arriyadh underground saline water, results in salt accumulation inside the nozzles and system failure. The salinity levels also increase as a result. Cyndon dactylion, the common species used as the grass element in Arriyadh's parks, is not a salt tolerant species, which adds more salt to the existing soil. Such a process always requires changing the top soil every two years, eventual introduction of R.O system and boosting salinity level of the shallow water table. In brief, both grass as a Western green carpet and its irrigation system should be avoided.

There are some other systems in use from Western irrigation companies such as drip irrigation, which is an underground sub tubing, bubbler system and emitter (Fig 54). These are successful in crop production, but they are likely to fail in amenity use from salt accumulation if not carefully maintained.

All the previous factors show the following disadvantages: firstly, using saline Arriyadh water in complicated irrigation systems has serious technical and ecological implications. Secondly, the failure of many imported and native flora, as reported by the Municipality of Arriyadh leads to an immense loss of resources. [51] Thirdly, the dissatisfaction of the local people, who criticised the failure of both imported irrigation systems and plant material.

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[51] The Agriculture Department, Municipality of Ar-Riyadh. Interview by the author 1988.

**FIG 54: Drip irrigation around the palm tree. Note that the domain of the flexible pipes is too limited to match the root behaviour.**

## C. CONCLUSION

Many aspects of landscape architecture in Najd attempt to emulate a western context. Neglect or unawareness of the concept of Arabic society, is one of the main reason for the failure of the landscape programme, especially in the Central Region where this factor of traditional culture becomes very sensitive. The reason is that Najd is the birthplace of Wahabism, one of the strictest applications of Islam. This implies special conditions that made outdoor design sensitive and complicated. Indeed, that sensitivity would not tolerate emulation of western forms.

Western urban patterns in planning, such as wide streets, neighbourhood parks and their detailed components of artifacts and plant materials, all shattered the character of traditional landscape architecture in the region. Although indigenous landscape elements in Najd evolved as a result of socio-environmental factors, many consultants do not differentiate between Persian garden, Islamic garden and Najdi garden, as illustrated by the case in Hofuf. Moreover, the requirements of the native users of the open spaces was not considered by the majority of landscape consultants, resulting in a major functional failure by the current landscape profession to satisfy basic functional aspects. Satisfying the native users needs of more privacy might lead to success of future landscape projects.

Professional factors represent the main cause for such poor designs. The nurseries represent a vital component of the landscaping process, since they supply the plant material necessary for the greening process. However, the inventory of plant species indicates that most are imported from tropical and subtropical countries. These species require stripping of Wadi Hanifah's soil for potting, and for top soiling planting projects, which is a process destructive to the rich wadi habitat. Such a process is necessary when using imported plant material while native ones can adapt to the existing sandy and saline soil. The devastation of the Wadi ecosystem, the saline water table and the high cost of maintaining those plants, represents serious short and long term economic, ecological and technical implications.

In the absence of legalization to govern the relationship between the three main parties involved in the process; the client, the consultant and the contractor, has initiated conditions hostile to a successful landscape programme.

Ecological, environmental and technical implications, all point to the scale of the negative consequence of using imported plant material. Also, climatic data points to the suitability and adaptability of native flora and its significance in avoiding further damage to eco-environment. Climatic factors support and justify native plants as the only type suitable for macroclimatic factors, water budget and soil conditions. Use of plants in Najd from humid or subtropical countries and then creating a man-made micro climate to suit them, is a waste of resources. Moreover, the water budget in Saudi Arabia as a whole is restricted to a small amount of rain fall and desalinated water. This small and precious water recourse requires that it should be preserved and not be wasted on irrigating imported flora, which consume large amounts of water, require high levels of maintenance, are unsuitable to Najdi environment, introduce new pests and diseases, require special microclimatic conditions, rich soil and prove unsuccessful in their functions.

As the previous factors combine to acknowledge the failure of many tropical gardens in the arid land of Najd, perhaps now the argument for introducing native flora as substitutes for imported species is valid. Najd is wealthy in flora adapted to its local conditions. The next chapter will aim to assess the native species, appoint target species to be tested and introduces the vegetation communities in the region. Also the chapter will cover the possibility of using both target species and target communities as landscape design tools. This was achieved through maintaining actual test sites in Arriyadh Diplomatic Quarter.

# CHAPTER 4

# INTRODUCING AND TESTING THE NATIVE SPECIES.

## 1) INTRODUCING AND TESTING THE NATIVE SPECIES

### A. INTRODUCTION.

In recent years, during the contemporary expansion in landscape projects in Saudi Arabia, there has been an increasing demand for a comprehensive native flora, one that is especially oriented towards and useful for professional landscape designers. In Saudi Arabia, although botanical literature covers a long period of time there is little actual written material. What exists is poorly categorized. Although the earliest known mention of the local plants and vegetation dates from the time of *Abu Hanifah Al-Dinwari* who died about ad 895, there is a deficiency of botanical bibliography in the region, particularly that identifies the native species of plant material in the kingdom generally, and specifically in Najd. Consequently the majority of the plant material tested in this chapter was re-identified by Sheila Collenete. [52]

The arguments, developed earlier in Chapter 2, appear to justify the need for more appropriate flora to be used in landscaping projects in Najd. Such flora is already available in Najdi deserts.

This chapter will discuss specific indigenous plant material of Najd useful in the landscape design field, their historical use in the region, contemporary application in Arriyadh, with illustrations and comments on their character and ecological structure. The aim is to determine target species, test their usefulness as a landscape material, and classify them according to their original habitats. Thus it is hoped to set the foundation for introducing successful native species to the landscape field. Methods of seed collection, seeding and seed storage will also be studied to establish the technical criteria necessary for using such species. The target species were planted in selected test sites, which were monitored during a period of six years by the A.D.A Maintenance Department, and by the author during the last four years. This monitoring covers the habit, response, and behaviour of each target species.

There are three test sites. These were intentionally chosen for their different ecological factors in order to determine how successful these target species were, when planted in different conditions. It is hoped to determine how successful these native species are in landscape use, the relationship between water quantity and species behaviour, how to introduce wadi species into a sandy plateau habitat, habit changes during or without irrigation, comparison between native and imported species and colour control using water.

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[52] Collenette, Sheila, *An illustrated guide to the flowers of Saudi Arabia*, First ed, Meteorology and Environmental Protection Administration, Saudi Arabia; Flora Publication No. 1, London: Scorpion Publishing Ltd, 1985.

It was also hoped to be able to classify the successful species in to three categories; irrigated natives to be used in an urban context; species irrigated during establishment only, to be used in semi urban areas; and non irrigated, self establishing species which are suitable for extensive landscaping and shelter belts.

## B. NATIVE PLANT MATERIAL

### 1. HISTORICAL USE OF NATIVE PLANT MATERIAL

In the ancient Najdi towns ,the hot dry conditions dictated the evolution of the local landscape and open space character in urban zones. The narrow streets, the dead end pedestrian roads, the height of the buildings facade and the external palm envelope, are all aspects introduced to modify microclimatic conditions. In the semi urban zones, where population density decreased and the urban voids widened and dominated the urban fabric, one found that certain native plant communities had moved into and colonized these gaps, protecting and shielding the urban mass from the harsh macroclimatic conditions. These native plant communities were usually Phoenix dactlyfera planted in groves, which varied in size and direction according to the wealth of the owners, ground water availability, soil conditions and wind direction. These palm groves were planted by both manual seeding method and natural succession. They were planted in a hierarchy of density which varied from extensive planting near the edge, intensive in the middle, to extensive again near the desert (Fig 55, 56).

These blocks of planting could be classified as follows. Firstly, in the urban fringe the palms were extensively planted to act as a transition belt to define the urban growth, satisfy recreational needs and filter the sand storms common in Najd. Secondly, the middle intensive zone was mainly for cropping dates and using the modified microclimate under the palm canopy to cultivate different crops and for lengthy recreational use such as camping with cooking facilities, walking, hunting and sometimes horse riding out into the desert. The maximum camping period is usually one week. Thirdly, the external layer, which was exposed to the desert, absorbed the harsh macroclimate and acted as a transition zone to the desert communities. This transition zone would gradually integrate and overlap with the desert communities starting from Acacia arabica stands, Ziziphus numelaria shrub land, to open and sparse grass land.

The desert communities were used by the native people during the winter as short camping and amusement facilities ,while in the summer the recreation activities could be classified into two parts. Firstly during the morning, when hot conditions prevailed ,the native residents tended to utilise the naturally developed microclimatic conditions beneath the palms canopy. Secondly at night, when they migrated to the open stands of acacia trees in the desert especially during the moon nights ,which persist for a period of 14 days every Arabic month. The existing traditional and recreational activities usually covered camping, horse riding ,trailing and other sports facilities.

The native Najdi inhabitants manipulated indigenous vegetation through a variety of methods; particularly using them as a useful source for medical material. Historical records show ancient Arab physicians to have been pioneers of current medical achievements as recorded by "Ibn-Sainaa" on his tomb.[53]

Also the stands of indigenous vegetation ensured the existence of the native people by the supply of grazing material for their animals. They thereby developed an understanding of their environment tending to classify the habitats according to diversity, spacial hierarchy and land use. Ancient management methods were common in manipulating the desert resources. Grazing zones were regularly and closely monitored to maintain a germinating period for new plant material .

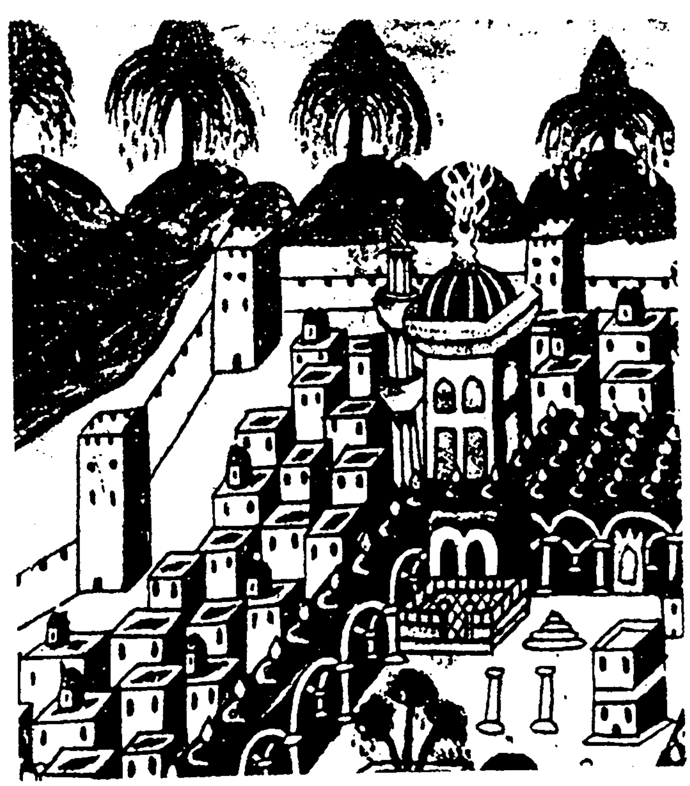

**Fig 55: Palm trees use to form a definition to the edge of the city. Example, from madinah as seen by early pilgrims. By courtesy les Editious Khayat. Source. Landscape design 2/83.**

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[53] Khalifah, Said, *Trees and shrubs in Kingdom of Saudi Arabia*, Firs Ed, Riyadh, 1980.

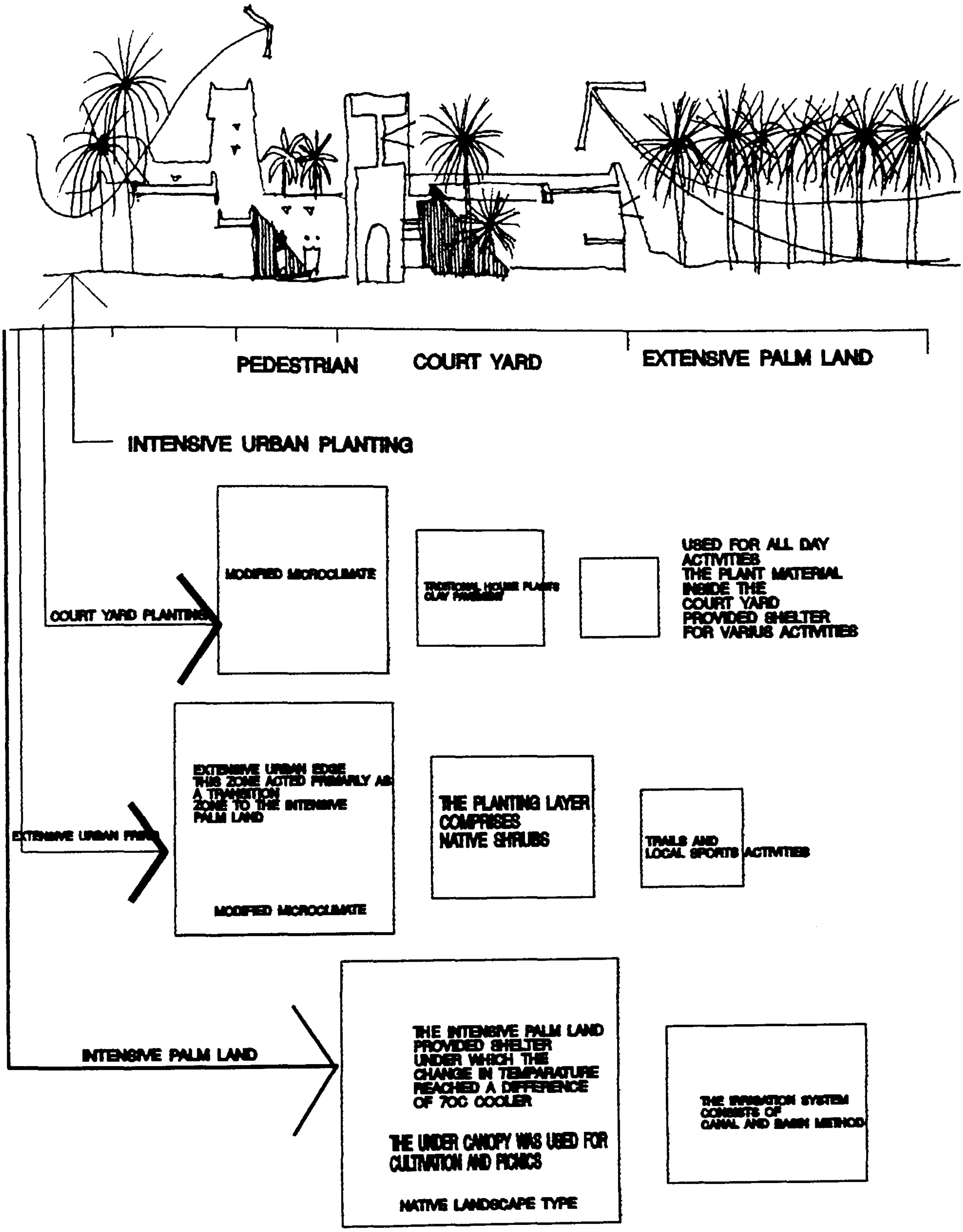


Fig 56: The hierarchy of plant masses in the ancient landscaping of Najd.

The Natives were known for their admiration of their native wild life; a questionnaire to some senior citizens showed their knowledge of the diverse breeds of animal ,birds and insects. It also revealed some awareness of the associated species of plants with certain animals.[54] Generally the traditional use of plant material in ancient Najd could be categorized as follows:

**Urban open spaces :** where the presence and manipulation of plant material in ancient plazas "miadien" or "sahaat" was interpreted through, firstly, planting masses of palm trees as a shaded pavilion under which trading activities would take place; secondly, in the primary roads the palm trees were planted to either direct the pedestrian movement, to emphasize a certain architectural element or to add to the sense of space (Fig 57).

**Fig 57: The use of palm trees to define pedestrian movement in ancient Najdi towns.**

54 Local bedouin of Wadi Hair, interview by the author, 1987.

Thirdly, inside the courtyards the palm canopy was used again to create microclimate conditions for formulating the court as the living room. In conjunction with the Arabian mashrabia the planting was used as a natural air-conditioning and cooling method (see Fig 58). The desired species used were layered as follows: from the top **Phoenix dactlyfera, Ziziphus spina christi, Nerium oleander, Vinca rosea**. A grass layer was not normal, natural succession usually occurred under the palm tree and new species would possibly germinate.

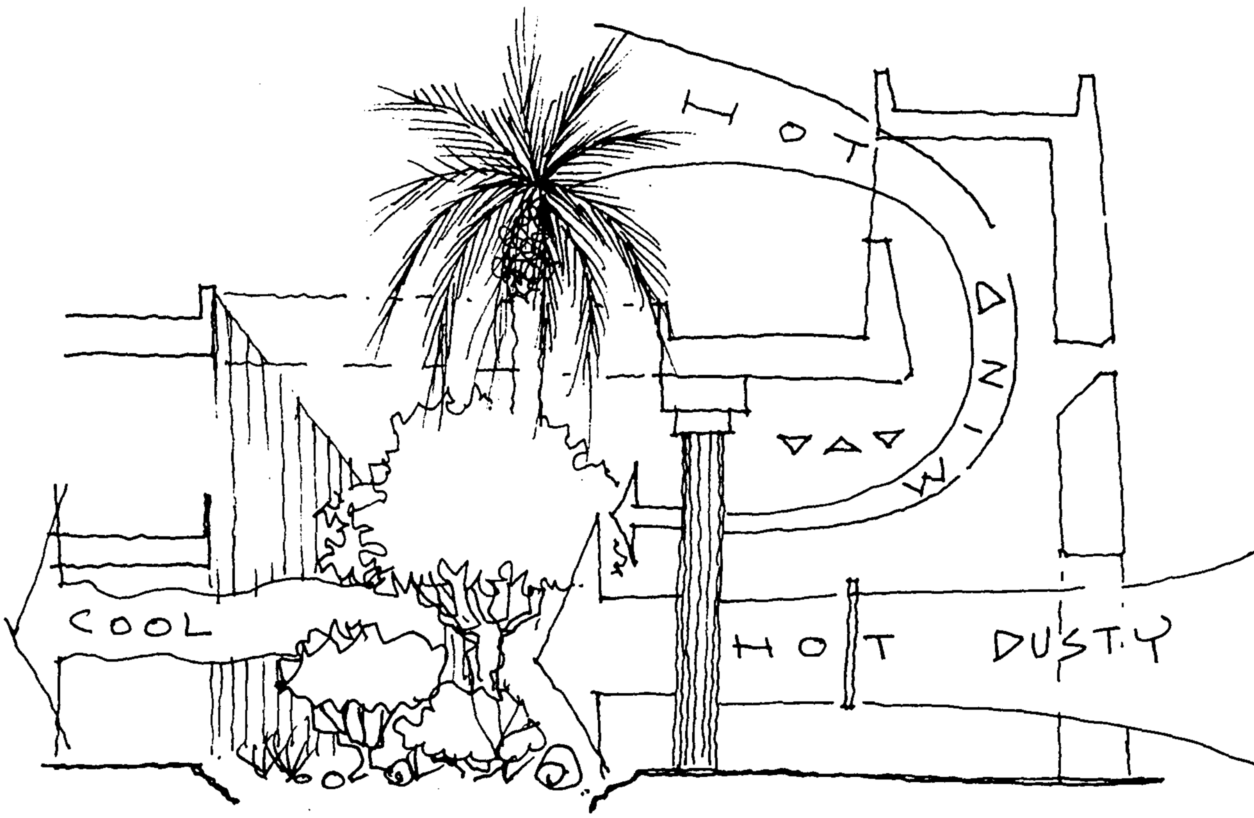


**Fig 58: The use of plant material as natural air-conditioning element in the ancient Najdi housing.**

Semi urban spaces : The application of indigenous plant material in the semi urban spaces was limited to a single species, Phoenix dactlyfera. However this added a distinctive character to the sense and feeling of these semi urban spaces. This policy added to the quality of the architecture by limiting the surface materials to mud and wood only. This factor, as well as the proportion, orientation and inspiration of the space all added to the quality of such open spaces. The mud walls of the buildings usually developed a language of succession with the arid plant material as they colonized the wall feeding on the relatively higher humidity coming from the court yards. see (Fig 59).

**Fig 59: The mud walls of the buildings usually develop a language of succession with the arid plant material.**

EXTENSIVE ZONES:

The extensive term in Najdi landscape indicated the edge of the city where the presence of plant material started to be more intensive and diverse than in the urban and semi urban zones. The palm mass would start to intensify and inhabit the rugged urban edge moving towards the desert passing through a staged succession, from semi intensive to intensive, to extensive again, overlapping with the desert species leading to the ultimate desert habitat.

1.2 CONCLUSION:

The indigenous plant material was used in Najdi urban and semi urban fabric in a clever way by following the pattern of the urban space, filling the appropriate gaps in it and defining the space. The limitation to one building material and a single species in the urban open space added a special character to the Najdi town, which was radically altered by the current urban design methodology and landscape strategy of diversity of imported plant material. This has resulted in the loss of this rich and magnificent traditional character. This single species inside the urban pattern could be modified carefully by developing some of the indigenous species found in the region. However some urban zones should maintain such traditional unity, which added flexibility to the use of the space.

The ancient urban context was classified into zones related to function and related to planting. Similarly today certain plant groupings may be more appropriate to one potential land use than others. For example a housing zone should be specially classified into indoor native species, semi indoor and courtyard species and outdoor species to match the nature of this function. A commercial zone will require different species, perhaps a single species policy, as used by the ancient inhabitants.

In brief, the ancient landscape elements are rich in both strategy and quality. The native plant material that was used to enhance the urban mass and environment acted as a shield, protecting and modifying the urban community while filling up the jagged urban edge, and implemented the theory of the oasis city.

## 2. THE MOVE TO NATIVE PLANT MATERIAL (CONTEMPORARY EXAMPLES).

### 2.1 THE MOVE

Currently there is great encouragement from the Saudi Arabian government to rehabilitate the spirit of traditional architecture and landscaping, as a result of their increased awareness of the value of national heritage, and the danger of losing this architectural and landscape identity. This adds to the pressure on foreign consultants to start the process of understanding and of considering Saudi Arabian design factors. However, early projects were not successful due to the lack of a comprehensive reference of indigenous flora. No literature or research recorded the performance of this flora when applied to landscape design under varied conditions, both urban and extensive.

### 2.2 CONTEMPORARY ATTEMPTS

The first attempt to use native Najdi flora in the public domain was carried out by the A.D.A in the Diplomatic Quarter. Although the social factors are different here, as the users are mainly foreign diplomats, the attempt was considered successful by the consultant. The author disagrees for the following reasons. Firstly, the native species were planted in a rich soil using mechanical methods for seed collection and seeding. This resulted in the loss of many valuable seeds, and only weed species colonized the rich imported soil. Later the consultant removed this stage and carried out the planting manually in the existing soil, but with three basic mistakes. Firstly, the method of seed collection, storage and planting were dubious, collecting was by means of mechanical vacuum systems, which destroyed many of the seeds, storage was inadequate and seeding was delayed so that much seed had lost the ability to germinate. Secondly the consultant injected the seeds with initial rich irrigation water combined with synthetic hormone, which further changed their adaptation structure. Thirdly the seeding was carried out during the winter, a process destructive to the species natural adaptation to the dry season.

## 3. THE CHARACTER OF THE NATIVE PLANT COMMUNITY, ITS FABRIC STRUCTURE AND PATTERN.

### 3.1 VEGETATION ANALYSIS METHOD

The relevant method in classifying vegetation is the physiognomic-ecological division of vegetation based on the different life forms of the indigenous species. This life form reflects the character of such species as related to their local environment and then represents the ecological equivalent of the different climatical zones.

This classification method was used as reference to divide the native vegetation of Najd into basic units. There are five different basic units or formation classes and several communities can be distinguished, as mentioned in chapter one.

Since native plant communities differ from location to location, it seems more useful for community classification to analyze several samples of vegetation stands from the same type of community, by estimating species quantities, rather than to analyze only one in greater quantitative detail.

Indigenous plant communities are conceived as types of vegetative material, recognized by their florostatic composition. Among the species that compose such florostatic composition of a plant community, some are more sensitive of a given special relationship than others. These are known in this method as the most effective indicators of an ecological relationship and referred to as the diagnostic species. These diagnostic species are used to organize communities into a hierarchial classification of the individual basic unit. The character and name of each plant community will be according to the dominant species. For example, the common shrub formation in the flat land and wadi beds in Najd is named as Hammada salicornica community, according to the dominant Hammada salicornica shrub. However, synsytematical and syndynamic relationships between these communities would be neglected as a result of classifying these communities according to the dominant species method only. For example the vegetation found in large sandy wadis is mainly dominated by the growth of tussock grass such as, Lasiurus scindicus, Panicum turgidum and Pennisetum divisum. In some locations, but at a higher elevation, Hammada salicornica can be found to dominate the vegetation community. All these species can dominate a certain sandy wadi section at the same time. Therefore applying this dominant method gives four communities, too refined a classification, and so it is not acceptable in this case. During the evaluation of samples from the wadi part of Wadi Hair (south Arriyadh) among the previous species only Pennisetum divisum turned out to be not only dominant but also typical for this type of Wadi habitat. However this species is sometimes present with low coverage value. Panicum turgidum is characteristic for deep Wadi sand. This species often dominates the vegetation communities in these wadis. It is also frequently the dominant perennial species in semi-stabilized sand dunes.

As a result of this problem the naming of the vegetation communities will be according to a species that was found to be a typical component of the vegetation community with high coverage value. As these communities will be the main guide to choosing and testing both target species and target communities, the other diagnostic species for sub-units will be listed.[55] For example the community might contain a number of associated species that are not dominant but they were found to be candidates for testing as an individual landscape tool (Fig 60). Therefore some of these will be listed and named as associated species for the pioneer dominant species of the target community.

**Fig 60: Example of Acacia gerrardii community. Note, the dominance of the tree layer.**

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[55] (for further reference to this method see Zohairy 1973, Frey / Robst, 1977).

## 3.2 INDIGENOUS PLANT COMMUNITIES

The main indigenous plant communities were mentioned briefly and listed in Chapter 1. Here some of the communities from which target species will be chosen are discussed. This detailed description will help to introduce the eco-geomorphololological factors effecting each individual community and also target the species. Also this will help in selecting the species that associate together in one community and how to begin to choose certain planting compositions for landscape projects using combinations of such species as found in their original community. They are discussed under four broad groupings: trees, shrubland, small shrubs and grassland.

### 3.2.1 THE LARGE TREE STANDS

The community of large trees usually occurs in the main channels of the major wadi system. These habitats frequently receive a large amount of additional water moisturizing the existing alluvial deposited soil. This rain water will be stored in the sedimentary rocky layers under the Wadi.

The dominant species in such areas are usually Acacia gerrardii with associated A.raddiana and A. tortilis. the associated shrubs are :
Lycium shawii , Ochradenus baccatus and Periploca aphylla. The dwarf shrub and herb layer of this community consists mainly of the Pennisetum divisum community which will be mentioned later in this chapter. Hammada salicornica becomes more frequent towards the wadi . Also a more frequent presence of Astragalus spinosa, Caltropis procera, Rhazya stricta and Zilla spinosa, and numerous weeds like Cyndon dactylion and Gisekia pharnaceoides. S.A, Chaudhary. [56]

Moreover in such deep alluvial soil, a pure Caltropis procera stand might occur. Vegetation dominated by this plant usually occurs on deep alluvial soils in areas where acacia has been thinned. Cutting of acacia trees is followed by soil erosion and invasion by Caltropis procera. Botanouny 1979.

### 3.2.2 SHRUBLAND

Similar to the large tree stands,distribution of shrublands in the central desert regions is mainly confined to areas which receive additional water from surrounding areas: Wadis and depressions. The most common shrubland in the region is the Ziziphus nummularia community.The scattered stands of Lycium shawii shrubs in small wadis do

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[56] Chaudhary, S.A. " *Acacia and other genera of mimosoideae in Saudi Arabia* ", National Herbarium, Regional Agriculture and water research centre, Arriyadh, 1982.

not form physiognomically dominant shrublands.They are therefore described with the grassland and dwarf shrub communities where they are frequent.The same applies to the stands of single shrubs like Ochradenus baccatus and Periploca aphylla in remote stony areas, usually found at the edge of the Wadi escarpment.

ZIZIPHUS NUMMULARIA COMMUNITY.

Such a community is found in depressions with deep and fine textured soils, a result of accumulation by water. After the winter rains,the stands of this community are under water for some time. The coverage of this community of shrubs reaches relatively high percentages.The undergrowth of the shrubs contains scattered grasses and dwarf shrubs which are typical components of the wadi communities as well as numerous weeds.The most common associates of Ziziphus nummularia are :Althaea ludwigii, Anastatica hierochuntica, Asphodelus tenuifolius, Cassia italica, Cenchrus ciliaris, Chrozophora obliqua, Citrullus colocynthis, Cynodon dactylion, Francoeria crispa, Heliotropium ramosissimum, Malva parviflora, Lasiurus scindicus, Plantago amplexicaulis, Prosopis farcta, Psoralea plicata, Tragus racemosus, Trigonella stellata, Zilla spinosa. Single Acacia trees and shrubs can occur as well.

### 3.2.3 DWARF SHRUB FORMATIONS

Dwarf shrub formations are the dominant and physiognomically most important vegetation type of plain areas with a clayey, sandy, and sandy-gravelly substratum. These usually occur in the central plateau area of the region. Consequently they encompass the majority of vegetated areas in Najd. There are several intermediate vegetation forms between these dwarf shrub formations and the grass units.

#### Hammada salicornica Community

Dwarf shrublands dominated by Hammada salicornica are the community which covers the largest part of such vegetated areas. This community usually occurs in sandy, gravelly and loamy soils, on almost flat sandy plains, where a shallow sand layer covers the compacted gravel areas. Stands are connected with alluvial land-forms with moderate salinity level. They are found to be very diverse in their ecological habitats.
According to the heterogeneity of the colonized habitats, the domain of the associated species in this community includes nearly all the associates of the other plant communities found in similar Najdi habitat. Main groups of the associates must be mentioned:

**- On sandy-gravelly ground:**
Atractylis carduus, Blepharis ciliaris, Ephedra alata, Lasiurus scindicus, Neurada procumbens, Polycarpaea repens, Rhanterium epapposum, Stipagrostis plumosa.

**-In accumulation areas:**

Anastatica hierochuntica, Anvillea garcini, Centaurea pseudosinaica, Fagonia glutinosa, Heliotropium ramosissimum, Lasiurus scindicus, Polycarpaea repens, Robbairea delileana and numerous other associates of the Francoeria crispa community.

**-On deep sands:**

Centropodia forsskalii, Moltkiopsis ciliata, Monsonia nivea, Panicum turgidum, Ephedra alata and Stipagrostis plumosa. In uniform Hammada salicornica stands the shrub Lycium shawii and the grasses Panicum turgidum, Pennisetum divisum and Lasiurus scindicus frequently indicate the course of small water channels. In depressions, single Acacia trees can occur.There also, Lasiurus scindicus can be co-dominant. Rhazya stricta is a frequent associate in all Hammada salicornica dwarf shrublands, which have been subject to intensive grazing by Najdi bedouin. "Sand annual species" colonize the sand mounds created around the Hammada salicornica dwarf shrubs, and they are absent in the surrounding area ( for example in a clay depression with mainly compact silty soil ).

**Rhanterium epapposum Community**

Together with the Hammada salicornica community the dwarf- shrublands dominated by Rhanterium epapposum are the most important dwarf-shrub communities of the typical vegetated plain areas with clayey, sandy and sandy-gravelly substratum. The typical habitats of the Rhanterium epapposum community in Najd, where windblown sand overlies limestone or gravel plains, and it is absent on high dynamic dunes, hard limestone, sandstone or pebbly plains. Even Rhanterium epapposum dwarf-shrublands occur in some parts Najd on the high gravel plains and on thin sheets of windblown sand. They also colonize, however, places where the limestone was only partially covered by sand. It is likely that these stands, physiognomically dominated by Hammada salicornica, represent heavily grazed stands of the Rhanterium epapposum community. [57]

Associated species of the Rhanterium epapposum community consist of: Atractylis carduus, Hammada salicornica, Lasiurus scindicus, Polycarpaea repens and Stipagrostis plumosa. This is similar to the associates of the Lasiurus scindicus, and the Hammada salicornica community. But in the stony habitats of the Rhanterium epapposum community, Fagonia bruguieri, Helianthemum lipii and Gymnocarpos decandrum are associates as well. The most frequent annual species in these Rhanterium epapposum stands are Anisosciadium lanatum and Medicago laciniata.

**Francoeria crispa community**

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[57] Riyadh Development Authority. "*Development of the Thumama Nature Park*". Hydrological Survey (Task 7B). Ecological Survey (Task 9), vol.1 & 2.

Such a community occurs in depressions with finely textured sediments. It is a characteristic feature of these habitats in the Arabian Peninsula (BATANOUNY, 1981, also VINCETT, 1977). If a good water supply is maintained for such a community, the coverage value by Francoeria crispa is very high, reaching up to 30 %. The associates comprise many species ,which are also common in other parts of the drainage systems like Anvillea garcini, Heliotropium ramosissimum, Lasiurus scindicus and Zilla spinosa, as well as species mainly confined to clay soils. Among them there are many weeds: Althaea ludwigii, Anastatica hierochutica, Chrozophora obliqua, Citrullus colocynthis, Cleome amblyocarpa, Euphorbia granulata, E. retusa, Fagonia glutinosa, Farsetia depressa, Gypsophila antari, Haplophyllum tuberculatum, Malva parviflora, Paronychia arabica, Polycarpaea repens, Pulicaria spec., Robbairea delileana. In some depressions Hammada salicornica is co-dominant, and are even more prominent than Francoeria crispa.

**Artemisia monosperma community**

A dwarf shrub community ,which is characterized by Artemisia monosperma is a typical vegetation unit of deep eolian sands in Najd. The Artemisia monosperma community must, like other sand, formations be included in the vegetation class of the Raetametea retami (Zohairy. 1962).

The units of this class are highly resistant to sand movement, based on several adaptations (concerning the adaptation mechanism of Artemisia monosperma cf. DANIN 1983).

Other characteristic species of the community are : Centropodia forsskalii, C. fragilis, Cyperus conglomeratus, Heliotropium digynum and Moltkiopsis ciliata. Cyperus conglomeratus, Moltkiopsis ciliata, Centropodia forsskalii as well as Artemesia monosperma. These are all among the species listed by ZOHARY (1962) as feature plants of the above mentioned Retametea retami ZOHARY (1962). Among the annual species occurring after the winter rains, Plantago cylindrica is the most frequent.

### 3.2.4 Grasslands

Grasslands, which are plant communities characterized by different grass species, form the main feature of the contracted runnel and wadi vegetation. Especially in the otherwise bare stone and gravel areas these ribbon like, grass rich vegetation units characterize the physiognomy of large areas of the desert system of Najd. The grassland communities on stabilized dunes, on shallow sand sheets and on desert pavement are physiognomically of small importance.

**Panicum turgidum Community**

Panicum turgidum occurs in deep sandy wadis and on stabilized dunes. Frequent associates of the Panicum turgidum community are (annual species included): Astragalus schimperi, Atractylis carduus, Centropodia forsskalii, Dipcadi erythraem, Ephedra alata, Hammada slicornica, Helianthemum spec. (ann.), Mathiola longipetala, Moltkiopsis ciliata, Monsonia nivea, Pancratium sickenbergeri, Plantago cylindrica, Polycarpaea repens and Stipagrostis plumosa.

**Pennisetum divisum Community**

This typical vegetation type of the large and medium sized sandy wadis and the wadi outlets or alluvial fans is associated with the Acacia gerrardii, A.ehrenbergiana community. This also colonizes loose and deep alluvial wadi sands and is strongly correlated with the area influenced by the Wadi floods. In most of these wadis, the flood channels themselves are free of perennial vegetation. The Pennisetum divisum community then forms a grass belt along the edge of the wadi channels. The most characteristic features of this community are the large tussock forming grasses Pennisetum divisum, Panicum turgidum and Lasiurus scindicus. The dwarf shrubs Pituranthos triradiatus and Hammada salicornica also sometimes reach a high coverage value in this community. Characteristic associates of this community include (typical annuals included): Blepharis ciliaris, Cakile arabica, Cenchrus ciliaris, Centaurea pseudosinaica ssp. pseudosinaica, Farsetia aegyptiaca, Heliotropium ramosissimum, Schismus barbatus, Scorzonera tortuosissima and Stipagrostis plumosa. In the springtime, many of the annuals preferring sandy soils can occur. These are mainly: Erembium lineare, Horwoodia dicksoniae, Picris damascene, Plantago cylindrica, Launaea capitata and Launaea mucronata. The shrub Lycium shawii occurs occasionally in some of the wadis with the Pennisetum divisum community. Astragalus spinosus, Rhazya stricta and Zilla spinosa are frequent associates of the Pennisetum divisum grasslands.

**Lasiurus scindicus Community**

A grassland community ,which is characterized by Lasiurus scindicus, is the typical vegetation unit of many small to medium sized sandy runnels and sandy depressions.

Associates of the Lasiurus scindicus in such runnels are mainly: Atractylis carduus, Hammada salicornica, Heliotropium ramosissimum, Panicum turgidum, Polycarpaea repens, Rhanterium epapposum, Schismus barbatus, Stipagrostis plumosa and Zilla spinosa. Lycium shawii can occur in runnels, where the water supply is sufficient. In the spring the transition zone between the perennial species can be colonized by numerous annuals strangers to this community.

### Stipagrostis plumosa Community

This is a grassland vegetation type that is characterized by a rather dense growth of Stipagrostis plumosa and found only in some of the central region plains. It usually colonizes a shallow sand layer covering the compacted sand and gravel areas. The associate annuals are: Atractylis carduus, Centaurea pseudosinaica ssp. pseudosinaica, Convolvulus spicatus, Centropodia forsskalii, Monsonia nivea, Moltkiopsis ciliata, Neurada procumbens, Plantago cylindrica, Polycarpaea repens. Scattered specimens of Ephedra alata, Panicum turgidum and Rhanterium epapposum can be observed as well. Ephedra alata becomes more frequent, where firm coarse-sandy substratum outcrops occur, with Panicum turgidum where the sands are deeper.

### Cymbopogon commutatus Community

The Cymbopogon commutatus community is the most frequent and typical plant community of the small runnels crossing stony desert pavement and gravel areas. It occurs in nearly all bio-ecological units where compacted and stony or gravelly soil is outcropping.
The associates of this community consist of: Anvillea garcini, Cenchrus ciliaris, Fagonia Bruguieri, Farsetia burtonae, Gymnocarpos decandrum, Helianthemum lippii, Heliotropium ramosissimum, Rhanterium epapposum (partially with high coverage values), Stipagrostis raddiana, Salvia aegyptiaca, Teucrium polium. Tricholaena teneriffae may be co-dominant in shady, remote places on steep slopes. Single Ochradenus baccatus and Lycium shawii specimens can occur where the water supply is good.

### Chrysopogon plumulosus Community

The grassland community characterized by Chrysopogon plumulosus, is the most typical vegetation unit of runnels and small wadis. Sometimes it is found in almost bare, stony runnels, where the plants colonize the wadis between the stones, in runnels, where the stony-gravelly ground is only partially covered by sand or other fine material and in little sandy-rocky wadis, where the wadis between the stones are filled with loose sands. The ecological conditions in the wadis between the rock plates, colonized by the grasses and dwarf shrubs, are similar to these in the runnels described before.

Associate species of the Chrysopogon plumulosus community are: Anvillea garcini, Cenchrus ciliaris, Chrysopogon plumulosus, Cymbopogon commutatus, Fagonia bruguieri, Farsetia burtonae, Gymnocarpos decandrum, Helianthemum lipii, Heliotropium ramosissimum, Rhanterium epapposum and Stipagrostis raddiana. Of these Chrysopogon plumulosus, Cymbopogon commutatus and Rhanterium epapposum reach high coverage values and each of these three species can be dominant in wadi zones with the Chrysopogon plumulosus community.

**Hyparrhenia hirta Community**

This runnel vegetation type is described by Zohary as like the Chrysopogon plumulosus community- mainly confined to the water courses. It is the typical community in medium sized wadis with an even and shallow sand layer covering sandstone and limestone blocks.

Common associates of this community are: Anvillea garcini, Cenchrus ciliaris, Chrysopogon plumulosus, Cymbopogon commutatus, Fagonia bruguieri, Farsetia aegyptiaca, Gymnocarpos decandrum, Rhanterium epapposum, Scorzonera tortuosissima and Teucrium polium. Since this community occurs on stony-sandy substratum in an area where firm stony ground prevails, annuals typical of stony ground as well as those preferring sandy soils can be found after the winter rains. Anisosciadium lanatum and Medicago laciniata are some of the most frequent species.

**Oropetium africanum . O. capense Community**

This community is the characteristic vegetation unit of parts of the desert pavement of the upper plateau region in Najd. The little tussocks of the dominant grass species Oropetium capense and Tripogon africanus rarely exceed 10 cm in height. A difference in the habitat of both species could not be found. They grow either in pure stands or both together. In the springtime they are frequently accompanied by a special set of annuals, typical of the stone desert: Anastatica hierochuntica, Aristida adscensionis, Asteriscus pygmaeus, Diplotaxis acris, Enneapogon desvauxii, Farsetia burtonae, Gymnarrhena micrantha, Plantago ciliata, Pteranthus dichotomus, Sclerocephalus arabicus and others. In the little depressions, small channels and other favourable places the growth of the Oropetium specimens and of the accompanying annuals becomes more dense. Here also single perennials can occur like Fagonia bruguieri, Helianthemum lipii, Stipagrostis obtusa, S. raddiana. This is a common feature, where runnels begin in the stone desert pavement. Further down these runnels, where the soil is more sandy, the Oropetium species are absent. This as result of coverage by sand.

## 4. CLASSIFICATION FOR NATIVE SPECIES ACCORDING TO NAJDI HABITATS

In Najd, the spatial variations in desert vegetation seem to be associated with landform patterns. As mentioned before the assemblage of plants in wadis will be different from that on the shuaibs, ridges or plateaus. Common species on sand dunes will not be the same as those in depressions. Accordingly target species will be classified by their associated landform types, each of these containing its own plant communities from which the target species will be acquired.

### 4.1 WADI ZONES

The Najdi wadi system is noted for its rich vegetation communities. This wadi system can be divided into two parts, firstly the palm land zone, which is mainly the middle section near the high underground water table (Fig 61). Secondly the wild wadi zone, which comprise the ridge, escarpment and the ridge habitat.

**Fig 61: Palm land zone dominated by the famous Phoenix dactlyfera.**

### 4.2 PALM LAND ZONE

Here the Phoenix dactlyfera is the dominant native species, usually maintained by the bedouin or farmers. The palm land under the canopy accommodates cultivated crops if owned and managed by farmers. With the increase in nursery use, however, the following species (Table 8 below) are found under the palm canopy, managed by bedouin that have abandoned grazing, mainly for resale as transplanted street trees or as seedlings:

| TREES | SHRUBS | GROUND COVER |
|---|---|---|
| Ficus pseudosycamorus | Abutilon pannosum | Vinca rosae |
| Ziziphus spina christi | Caltropis procera | Ipomea alba |
| Plueria acutifolia | Nerium oleander | Ipomea palmata |
| Prosopis juliflora | | Ipomea tricolor |
| Albizia lebbeck | | **SUCCULENTS, CACTI** |
| | | Agave ,Aloe, Opuntia, Sansevilra and Yucca sp. |

**Table 8: Common species found under palm tree canopy.**

### 4.3 WILD WADI ZONE

This zone comprises the surrounding geomorphological elements such as Shuaibs, ridges, escarpments and plains as shown below. Its habitats depend on the relative proximity of the underground water table to the water surface. Inside the wadi, the soil is mainly alluvial deposits coming progressively from the surrounding shuaibs. On ridges, the depth of soil and consequent plant presence depend upon the intensity of rain fall, and the position of the slope. Within these ridges are found the vertical depressions which form the shuaibs. In these, the run-off erodes material that becomes deposited as the water flow slows down. The gentler the slope the more deposits it carries. The upper part of the ridges, called escarpment, carries no soil, due to its steep slopes (Ayyad, M.A). For each geological feature there is an associated plant community or habitat which are classified in the following chart Fig 62, and illustrated in Fig 63.

## 5. CONCLUSION:

This section has been an essential introductions and acknowledgment of the wealth of Najdi habitats. These desert habitats each contain specific resident communities and their associated species. These communities were characterized by their sensitivity to each other and their adaptation to certain edaphical conditions. Their structure and pattern consists of a dominant species which will form a certain community characterized by its associated species. These communities in conjunction with their edaphical factors will form the ultimate key factor for introducing these native species to the domain of the landscape profession through new design methods that use these communities and their associated species directly as innovative elements in landscape design projects.

The associated species have formed the starting point for choosing and classifying target species which will be tested as potential substitutes for imported plant material. Also as a base for a new design methodology, which uses the communities as a landscape design tool, described above and tested later in this chapter.

The short introduction to the wadi zone and its habitats, aimed to alert the reader to the rich and diverse habitats that are the character of depressions in the flat desert. The palm land and the potential of using its under canopy for most landscape elements, is also a precious fact that could be implemented widely in Landscape project gardens.

Introducing desert plant communities and wadi habitats will reassure the diversity of Najdi ecosystem and the potential of its plants to be tested. for general landscape use.

| Vegetation Community / Ecological Habitat | Acacia gerrardi - Acacia ehrenbergiana community | Ziziphus nummularia community | Hammada salicornica community | Rhanterium epapposum community | Prancoria crispa community | Artemesia monosperma community | Panicum turgidum community | Pennisetum community | Lasiurus scindicus community | Stipugrostis plumosa community | Cymbopogon commutatus community | Hyparrhenia birta community | Oropetium africanum - O.caprice community | Rock desert | Gravel desert | Clayey depression | Destroyed area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wadi Habitat | ⊠ | ⊠ | ⊠ | ⊠ | ⊠ | ○ | ● | ◒ | | ◒ | ◒ | ○ | ● | | | | |
| Shuaib Habitat | ◒ | | ◒ | ● | | ◒ | ◒ | ◒ | ◒ | ◒ | ○ | ● | | ◒ | | | |
| Ridge Habitat | ○ | | ○ | ○ | | | | | | | ● | | | ⊠ | | | |
| Escarpment Habitat | | | | | | | | | | | ● | | | ⊠ | | | |
| Gravel Plains Habitat | | | ⊠ | ◒ | | | | | ◒ | | ⊠ | | ● | | ● | | |
| Plateau Habitat | ○ | | | ○ | | | | | | ● | | | | ● | ◒ | ⊠ | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

⊠ Typical units covering the majority of the area.
◒ Medium importance low coverage.
● Small area coverage.
○ Very low coverage.

**Fig 62: Classification and distribution of native plant communities according to typical Najdi habitats. The target species will cover the dominant species and its associates; source , Thumamah nature park Report.**

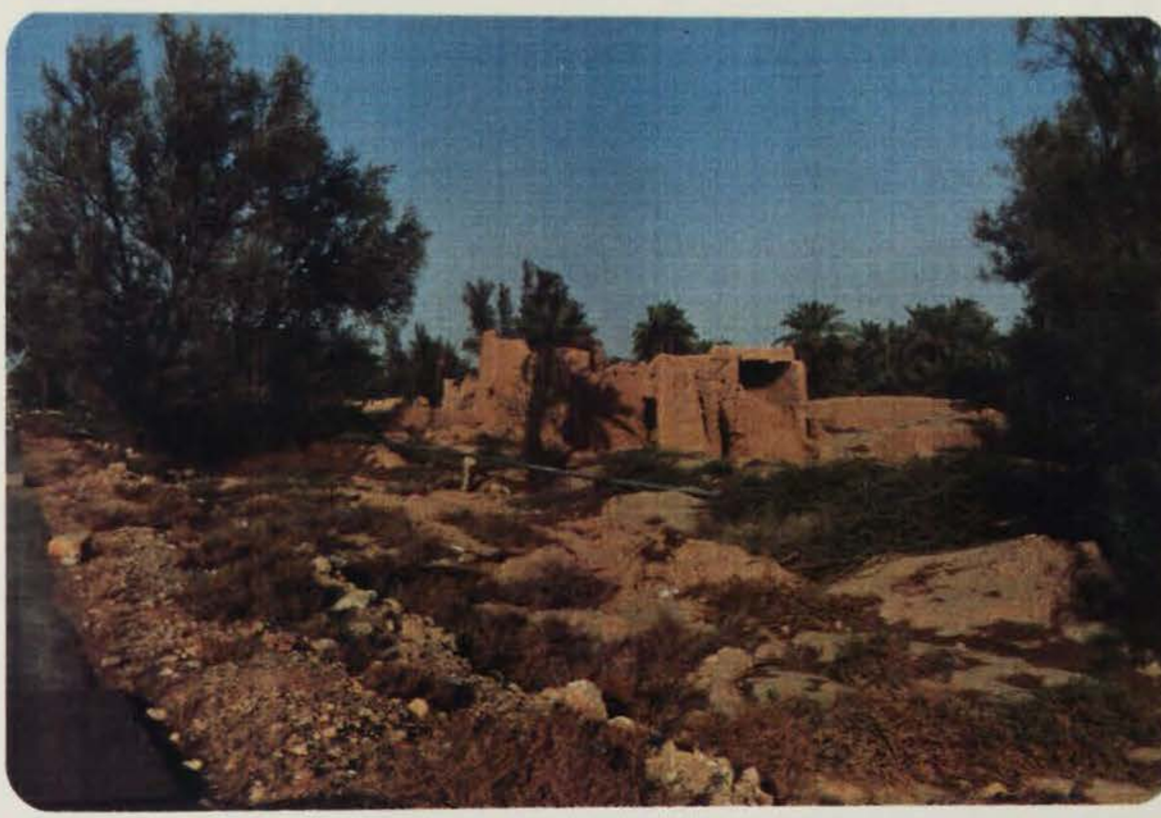

Fig 63 (both pictures): The diversity of palm lands and their associated activities and species.

## C. TESTING PROCESS

### 1. INTRODUCTION:

To test the appropriate native species the testing process will involve defining suitable plant material and then identifying their best growing conditions. The test will take two main channels. The first is testing individual species for use as a conventional nursery stock for urban parks. The second is testing the proposed method of employing a desert community as one landscape design element for use in extensive landscaping.

To follow is a description of the testing methodology for both. It includes detailed descriptions of the selection process from seed collection, storage through to the planting.

### 2. TESTING METHODOLOGY :

Testing native species under conditions similar to a landscape contract was done to assess the target approach method of selecting suitable species. This method can be divided into two sub-methods, target species and target communities (Fig 64). Firstly, the target species method selects certain species to be tested. These are determined by their form, habit, character, ease of propagation process and availability. These target species will be chosen disregarding their natural association with specific growing conditions. Rather the aim is to test for multi purpose species, useful in a range of projects and conditions. Each species will be monitored for form, texture, colour, habit and growth rate. The growth rate will be measured manually for both the root ball and the canopy diameter. By these measurements a comparison with imported species can be made, to reinforce the argument.

Secondly, the non selective method or target community approach which is mainly used to select one of the previous communities for a certain landscape unit where edaphical conditions match those of the selected community, named by the diagnostic species. This method is based on the identification of the target community, then lifting a thin layer of the surrounding top soil which contains a blend of native seeds, to be spread on the similar top soil of the target site (Fig 64). An industrial vacumn could be employed in the lifting process. However such a method is not recommended because of its destructive effect on the valuable seeds.

### 3. TARGET SPECIES METHOD

Selection of target species will be based on both their availability, ease of propagation, toughness, and endurance. The indigenous communities and their associated species will be chosen for their availability, ease of propagation, habit, form and edaphical conditions. The author aimed to avoid, by investigation means, species which can only be propagated by transplanting or cutting methods only. Species with disputed origin were also omitted.

Species included in the target species inventory were planted after propagation in the Diplomatic Quarter. The method is simply a monitoring process for the manually planted species. Each plant is monitored for growth, behaviour and response to predetermined conditions, which fully described in the test sites.

### 3.1 COMMERCIALLY AVAILABLE NATIVE PLANT MATERIAL

An intensive questionnaire was carried out targeted at nurseries and suppliers in order to discover the commercial availability of native plant material. The questionnaire revealed that supplies of many of these, are not directly available. Some however are but one must be careful when using such available species, since it is very difficult to be sure that it is true to name and type. Within an area, there can be several populations of the same species, each being adapted to their own local conditions. Most commercially available seed in Najd, of the same species targeted by this research, are of foreign origin. Even though they are the same species, they will probably not be suited to the Najdi desert conditions. Consequently, it was considered advisable for plant material to be collected manually from local natural stands, despite the many disadvantages. Seed or plants from commercial sources was not used in the test sites.

### 3.2 COLLECTION OF SEED:

Seeds were manually collected from natural stands of vegetation, mechanical harvesting of seed was not recommended due to its destructive effect. Manual collection in the target approach was from selected species. This requires the selected species to be recognised. Only ripe material must be collected. Manual collection is generally confined to the time when seed is still on the plants. Where there is a high density of fallen seed, gathering this can, however, give quick and easy collection.

Species differ in their collection times and for some the seeds are adapted to disperse widely from the plants and may be lost before collection begins. Therefore the timing of the target seed collection method is critical. The best time for collection of most perennial species will span between July and September, and sites need to be identified where collection will be more successful. After collection, the seed will either be sown or stored. For immediate sowing, which was recommended by the experts [58], seed cleaning was not necessary. Many species have a short period of viability, and storage time can be critical. The viability can be maintained by employing techniques like dry vacuum storage.

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[58] Recommended by B.B.W horticulture consultant.

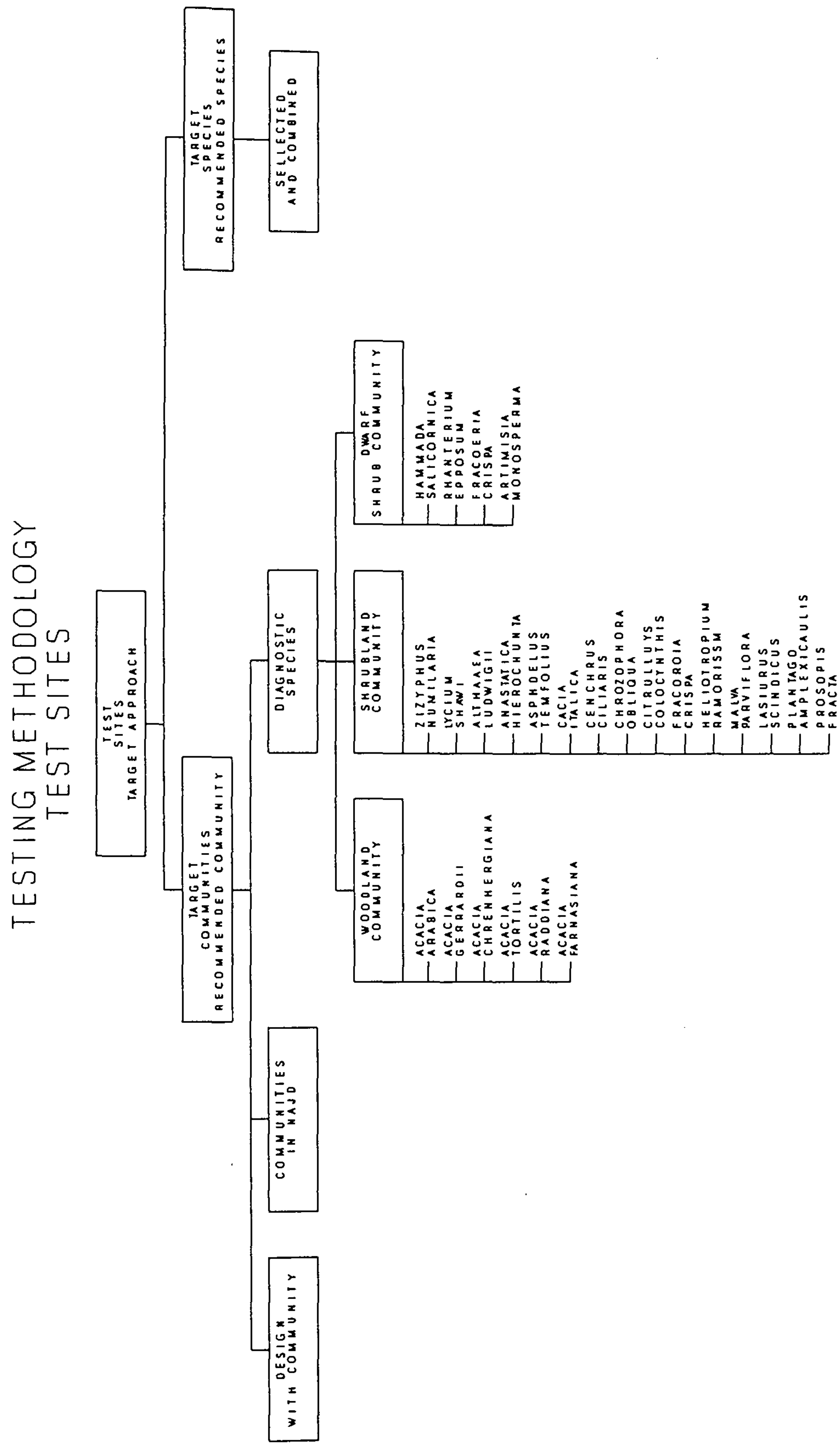


**Fig 64: Testing methodology and test sites.**

Also, the availability of seed from natural stands varies from year to year according to climatic conditions. Often in a particular year, local native seed can be scarce. Therefore earlier collection and appropriate storage method of such native species is recommended.

## 3.3 COLLECTING VEGETATIVE MATERIAL.

Collection was carried out from natural stands around Arriyadh, see appendix III and Fig 108, targeted at those species which were easy to propagate from vegetative materials; however this can be destructive. The collection of vegetative material was selective and used only for "target" species, as not all species can be propagated in this way. This operation requires skilled technicians in the collecting process, and preservation and preparation of the collected material. The period available for collection is less restricted than for seed collection, but there are optimal times for the collection of most species (especially for herbaceous perennial). It is likely that most woody species (trees and shrubs) can be propagated from shoot cuttings. Vegetative material was collected and returned safely and quickly to the Diplomatic Quarter nursery, where rooting-treatments were implemented. Root cuttings were not recommended for their destructive effect on natural habitats. Species (including some grasses) were propagated by division, as they grow from bulbs, rhizomes, and crowns. These plants need to be collected in their entirety, consequently, this very destructive process was limited. The collection of natural seedlings has been employed in some parts of the test sites. These were transplanted at a very early stage from the desert to the nursery for growing on. Each community and species was identified and tested for its suitability for each site. Material from only these target species was collected, and was made from several sites and plants to ensure different levels of adaptation to diverse ecogeomorphological conditions.

The ease of propagation was an important factor in the selection of the target species. Species which are difficult to establish from seed were eliminated and were propagated from vegetative material. Selection of target species was not made only on landscape, land use and environmental criteria. The availability and ease of propagation of plant material was also a major consideration.[59] The following criteria was also followed for collecting and selecting seeds that will be tested:

1. Sort storage time was a favourable selection criteria for the test.
2. Only seeds of approved, indigenous species were collected in the wild. They were tested by approved means to determine percentage of germination and to insure minimum purity of 95%.
4. Before using the seeds, they were subject to analysis of seed mixture, percentage of pure seeds and dates of collection.

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[59] The information based on a questionnaire to the A.D.A technical committee

## 3.4 TARGET SPECIES

The species of greatest landscape value are trees, shrubs and ground cover. Trees species will only be possible where initial irrigation is employed. The shrub species were emphasized as of greater importance for landscaping, especially if they are evergreen. The following Table 9 lists the target species that were selected for the test, and their propagation method.

| Species | Propagation method |
|---|---|
| **TREES:** | |
| Acacia tortilis | Cutting |
| Acacia albide | Cuttings |
| Acacia farnaziana | Cuttings |
| Acacia arabica | Seeds |
| Albizia lebbeck | Cuttings |
| Delonix elata | Seeds |
| Ficus pseudosycamorus | Cuttings |
| Prosopis cineraria | Cuttings |
| Prosopis juliflora | Seeds |
| Tamarix aphylla | Cuttings |
| Ziziphus jujuba | Cuttings |
| Ziziphus spina-christi | Cuttings |
| **SMALL TREES:** | |
| Acacaia canophylla | Seeds |
| Caltropis procera | Seeds |
| Ecalyptus camaldulensis | Cuttings |
| Ficus psedo-sycamrus | Cuttings |
| Ziziphus numilaria | Cuttings |
| Prosopis fracta | Cuttings |
| Acacia gerrardii | Seeds |
| **GROUND COVER:** | |
| Bassia erophoria | Transplanting |
| Diplotaxis acris | Cuttings |
| Hammada elegans | Cuttings |
| Heliotropium bacciferum | Cuttings |
| Ipomea sinensis | Cuttings |
| Ipomea pes-capri | Nursery stock |
| Silene arabica | Seeds |
| **CLIMBERS:** | |
| Anagallis aruensis | Cuttings |
| Cissus Guadrangularis | Seeds |
| Citrilus colocynthis | Seeds |
| Clitoria ternata | Cuttings |
| Cucumis prophetarum | Seeds |
| Ipomea palmata | Nursery stock |
| **SHRUBS:** | |
| Abutilon pannosum | Cuttings. |
| Atriplix halimus | Cuttings. |
| Capparis spinosus | Transplanting. |
| Capparis cartilsqunea | Transplanting. |
| Cassia italica | Cuttings. |
| Datura inoxa | Seeds. |
| Lycium babbarum | Seeds. |
| Noaea Mucronata | Cuttings. |
| Ochradinus baccatus | Seeds. |
| Periploca aphylla | Seeds. |
| Rhazia stricta | Seedlings, Cuttings. |
| Ricinus communis | Cuttings. |
| **SMALL SHRUBS:** | |
| Allenia subaphylla | Seeds. |
| Argemone mixicana | Seeds. |
| Artemisia judaicamonosperma | Cuttings. |
| Asparagus africanus | Cuttings. |
| Atriplex dimorphostegia | Cuttings. |
| Atriplix leucoclada | Cuttings. |
| Belepharis ciliaris | Leafe Cuttings. |
| Carrisa edulus | Cuttings. |
| Ficus salisifolia | Cuttings. |
| Hammada flegans | Seeds. |
| Heliotropium digynum | Seeds. |
| Lavandula dentata | Cuttings. |
| Peganum harmala | Seeds. |
| Penicum turgidium | Cuttings. |
| Psiadia arabica | Seeds. |
| Recinus communis | Seeds. |
| Salsola vermiculata | Seedlings. |
| Salsola pacitoi | Seedlings. |
| Tamarix amplexicaulis | Cuttings. |
| Tamarix arabica | Cuttings. |
| Zygophyllum coccineum | Seeds. |
| Zygophyllum album | Seeds. |
| **GRASS:** | |
| Aegilops kotschyi | Not known. |
| Alopecurus agrestis | Seeds. |
| Aristida obtusa | Seedlings. |
| Arundo donax | Seedlings. |
| Koeleria sinaica | ''. |
| Panicum turgidum | ''. |
| Pennisetum setacum | ''. |
| Phragmetus communis | ''. |
| Phragmetus Australi | ''. |
| Typha domingenis | ''. |

**Table 9: Target species selected for the test and the monitoring process.**

### 3.5 PIONEER SPECIES

The following species were used as a pioneer. These species are short lived and have the ability to establish rapidly in conditions which may not be ideal for most other species. The local annual leguminous species were used in this way in order to increase the nitrogen and organic matter in the soils, and to create microclimatic protection to the slow growing shrub species. In fact those species were found on the site and left as part of the intended succession. The following Table 10 lists those species:

Aegilops kotschyi an annual grass that might be used as pioneer species
Aristida obtusa perennial grass
Hippocrepis unisiliquosa
Lotus halophilus
Medicago laciniata
Panicum turgidum perennial grass
Pennisetum spp perennial grasses
Trigonella stellata

**Table 10: Pioneer species used as a preparation before the testing stage on the test site.** The above species were obtained by investigation means by the author.

### SPECIES TOLERANT TO SALINITY

Where salinity is too high for non-halophytes, halophytic species may be used. Most of the halophytes are evergreen shrubs and are useful landscape plants in the absence of other species. Their inclusion on non-saline soils needs to be carefully considered, as some have a tendency to accumulate salts on the soil surface, thereby giving rise to saline soils.

SALSOLA INERMIS: an annual that might be used as a pioneer species
SALSOLA VERMICULATA: shrub
SALSOLA PACITOI: shrub
NOAEA MUCRONATA: shrub
HALOGETON ALOPECUROIDES: shrub
ANABASIS ARTICULATIA: shrub

## 4. TARGET COMMUNITY METHOD USING BLANKET TECHNIQUE.

This method starts, firstly by geomorphological and edaphical analysis of the site of the landscape design project on which the target community will be established. Secondly by collecting a thin layer of soil from the natural community matching the proposed site conditions. Manual collection of seeds in this method was non selective. Seed material was collected from the whole community stand, a blanket approach. This soil is spread on the target site and left until the first rainfall to germinate (Fig 65). The method, which is explained in detail in the test, may prove appropriate to extensive landscaping and green belts around arid cities. The test aimed also to use this method in an attempt to arrest a small sand dune in the third test site.

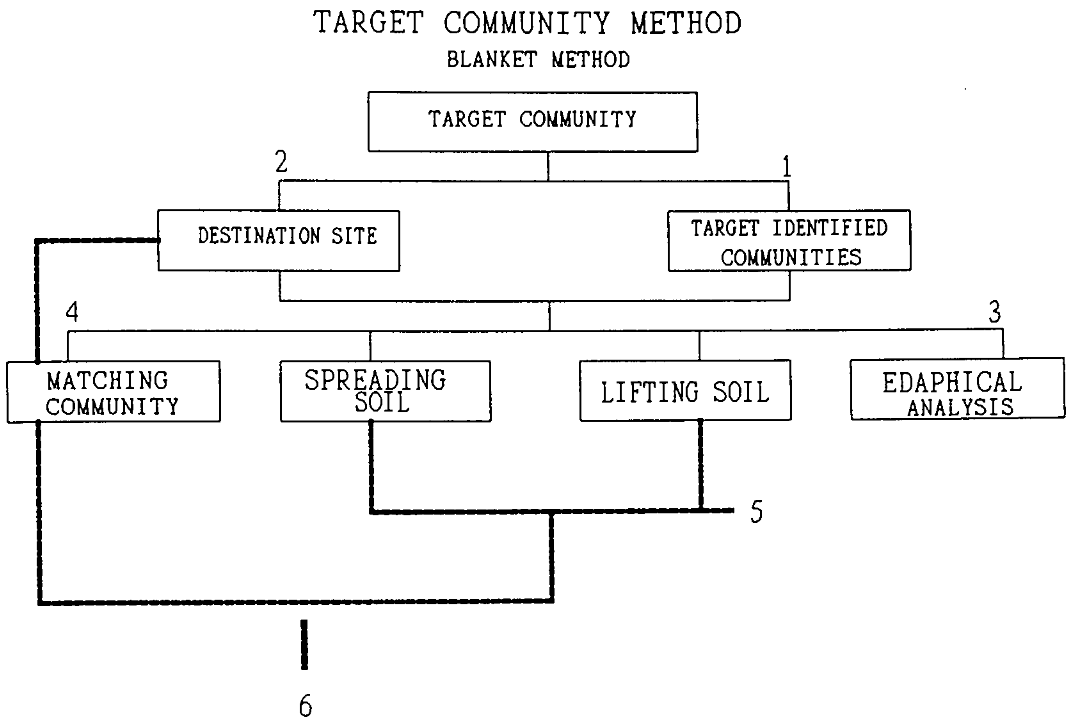


**Fig 65: The process of target communities method. (field survey).**

## 4.1 TARGET COMMUNITIES AND GEOMORPHOLOGICAL EDAPHICAL CONDITIONS.

Since this method uses the plant community as a design tool, consequently these should be classified according to Najdi topographical and edaphical conditions and characters. These are shown in Table 11. The structure of each individual community has already been discussed in detail in this chapter. Conventional formula of investigating the soil characteristics of the target site, will unveil the appropriate soil class. With the aid of the Table below the designer can chose the appropriate community to his site.

| CONDITION AND CHARACTER | COMMUNITY | |
|---|---|---|
| Little stony gravelly stony soil with cover of fine material. | only annuals no community runnels. Cymbopogon commutatus | G |
| Medium sized sandstones with deep loose sands in pockets between stones. | Chrysopogon plumulosus | G |
| Shallow sand layer over sand and limestones, stones outcropping. | Hyparrhenia hirta | G |
| Deep fine sands. | Pennisetum divisum | G |
| Sandy gravelly area. | Hammada salicornica | DS |
| Clayey soil. | Francoeuria crispa | DS |
| Stones covered by 30-50 cm sand. | Rhanterium epapposum. Lasiurus scindicus. | DS |
| Compacted mounded sheet. | Hammada salicornica alluvial with sand soil covered (Rhazya stricta and single Caltropis). | DS |
| Deep coarse and fine sand. | Acacia gerrardii. Acacia ehrenbergiana. | T T |

**Table 11: Classification of target community according to ecogeomorphology and edaphic conditions.**

The above information was used in the third test site to trace and identify the thriving communities in relation to the existing soil. The former Fig 62 shows those communities classified according to Najdi habitats.

## D. CONCLUSION:

The potential for the use of native plant material in Saudi Arabian landscape projects is vast. The species available to the landscape architects are generally still imported. If it was proved to be more suitable native plant material would be welcomed by the Saudi

Authorities. Chapter three disscussed the tremendous richness and diversity of the Najdi habitats while previous chapters showed the consequent advantages of native over an exotic flora in a maintained or un-maintained environment.

These habitats contains many individual species ideally suited for landscape use. Combined they form attractive communities characterised by distinct and various compositions and structures. Individually they will substitute for the imported nursury stock, combined they represent a ready-made and complete landscape element which would be valuable for Najdi parks.

The classifications of the Najdi habitats summarised the available species and their associated species; these could form the basis of a design founded on principles of plant communities rather than individuals as landscape elements.

The general question, the comparative advantages of native over imported plants has been conclusively answered. Though the native plants are diverse, attractive and available, they must be tested practically, this testing had two aims, firstly to test the individual species "target species method" and secondly to test the whole community "target community method". The definition of these terms and techniques was an essential prerequisite before the selection of the test sites.

The next chapter will look at the actual test sites having disscussed a methodology for both individual plants and communities. By varying the conditions and monitoring progress the most successful of each category will emerge for use in landscape design.

# CHAPTER 5

# TESTING NATIVE PLANT MATERIAL

## 1) TEST SITES DESCRIPTION

### A. INTRODUCTION AND OBJECTIVES:

Because of the quality of maintenance in Ar-Riyadh urban parks, the Diplomatic Quarter was selected for this test. Their parks receive a high standard of maintenance. The D.Q authorities approved access to sites for the purpose of testing and provided technical support from their maintenance department.

There are three test sites (Fig 66), allocated and selected by the author for the following reasons:

1. The A.D.A dedicated a zone within the extensive landscape area as a highly maintained and controlled area. Consequently, the test site located here should receive the maintenance and continual irrigation required to fulfil the goal of the test. It will guarantee the growing conditions that are essential to achieve high growth rates and good physical appearance for the target species set for the test. The objective in this site was to test native species for the commercial market especially the private sector. The species were chosen for both their physical and toughness characteristics. This irrigated site will establish a comparison with the same native species on un-irrigated areas.

2. Although the second test is located adjacent to the first, the authorities decided to gradually reduce the amount of irrigation water to zero. The aim is to assess of the ability of native flora to stand changes in growing conditions.

3. The third site was found to contain a soil pattern and species that comply with the target community method, and consequently was put under closer monitoring in order to validate that method.

All sites were monitored by the author each season over a three year period. Test sites one and two were observed for testing selected individual target species to appraise and identify the best growing conditions for these native species, in both extensive and intensive landscape applications. It is hoped this will lead to the dissemination of successful species into the general landscape design field. In these test sites, criteria was set upon which to judge the success of each species. Factors were selected for development projects such as trails and camp sites or as landscape elements, such as shading for cars and defining passage.

The third test site mainly develops the theory of using the target community or non selective method as a design tool. This site was monitored for the success of the community that was found in the soil lifted from the identified sites.

In this section each site and the factors affecting them will be discussed in detail. It is hoped that species or methods proved by the testing could then be included in a recommended flora that will act as the main reference for landscape architects wishing to implement any of the methods initiated here.

## B. THE FIRST AND SECOND TEST SITES

The first and the second tests are located between the urban fringe of the D.Q and Wadi Hanifah. This area is referred to by A.D.A as the extensive landscape. Both tests share the same site but under different man made conditions. Topographically, the site is flat, and limited by the Wadi Hanifah. Apart from a layer of 1 m thick compacted sand, the site has no top soil.

The first test was designed to assess the response of target species under full maintenance, persistent irrigation and rich soil conditions. The second test was devoted to monitoring the effect of water reduction till total stoppage on the same target species. The aim was to identify species most suited for uncontrolled planting schemes or schemes with initial irrigation only.

Both tests are divided into three zones according to their exposure to wind and temperature which is the most effectual factor at such scale. The first zone is the most exposed to these factors and the third is the least exposed and most enclosed. Such division will represent a mixture of likely microclimatic conditions in any park. These criteria together with other factors such as soil composition and irrigation will be recorded and monitored. The recommended species for each zone will consequently be linked to design criteria which match similar locations in a potential park (Fig 67).

Tests were conducted to manipulate the target species method discussed earlier. A record of the changeable factors affecting each zone was related to the growth rate of each individual species. Since the prime target of the testing process is to obtain a list of species suitable for landscape application, the test was carried out in a simple way aimed to extract the direct response of native plant material under diverse conditions.

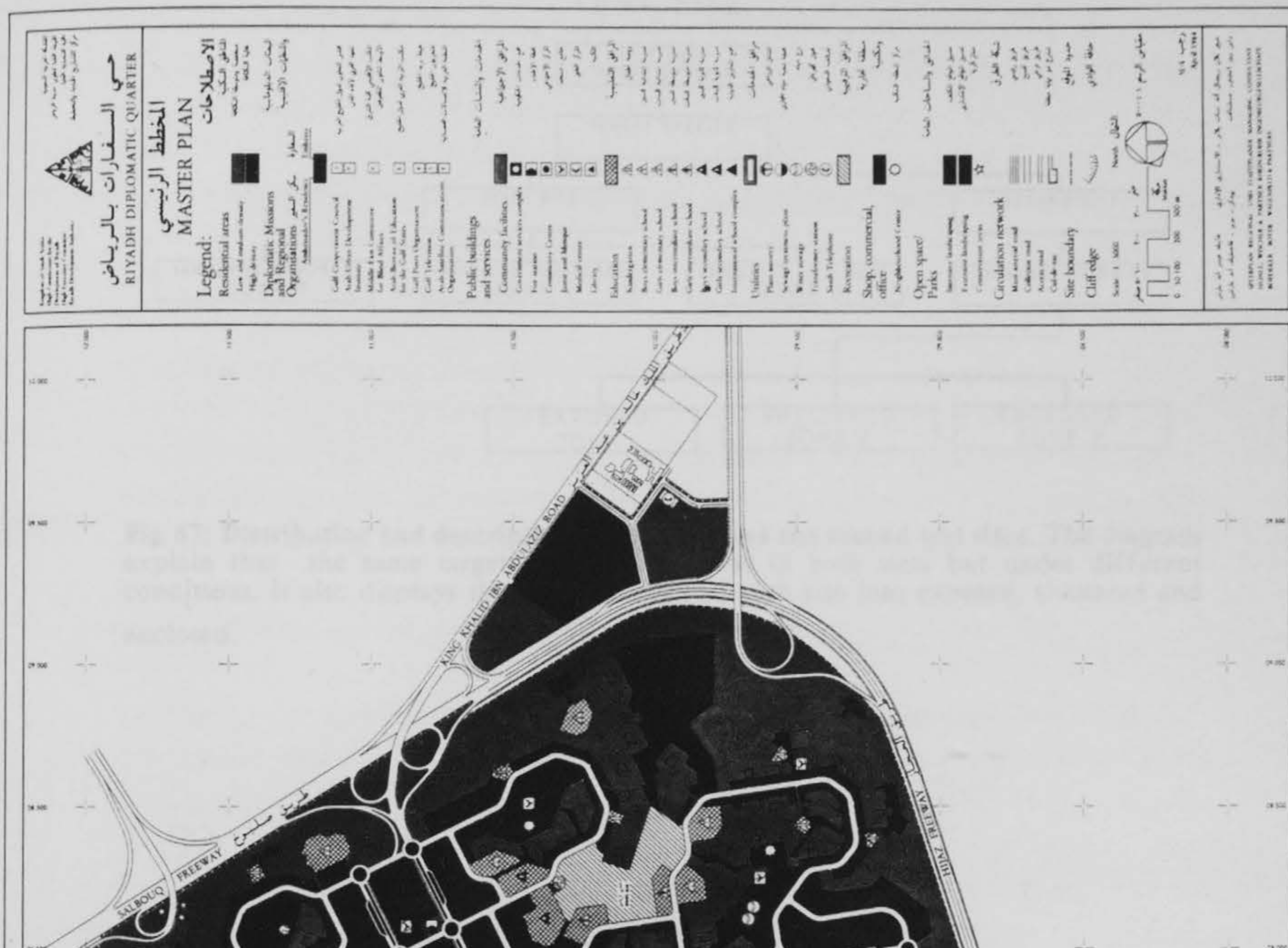


**Fig 66: Test sites in the Diplomatic Quarter Ar-riyadh.**

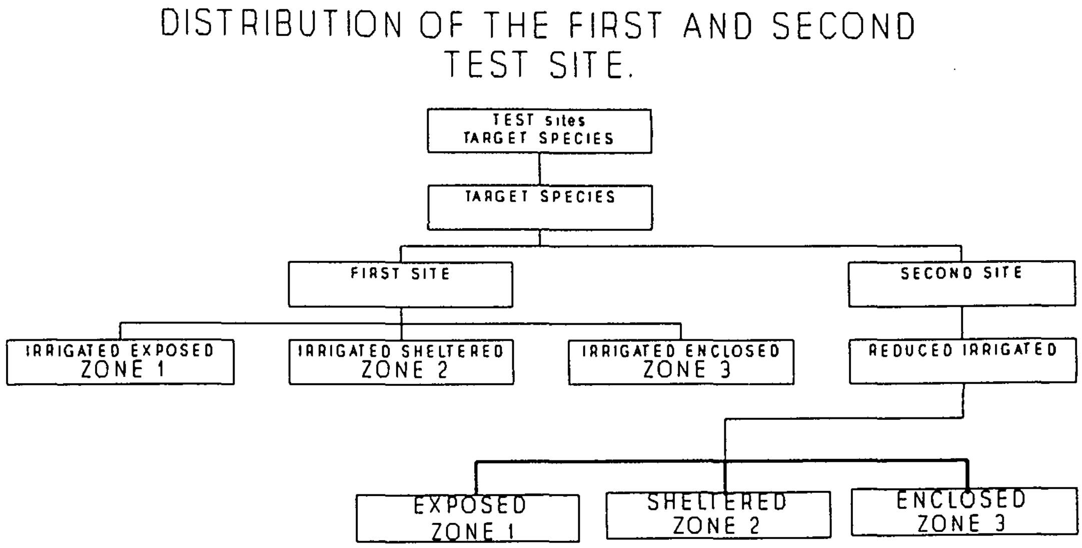


**Fig 67: Distribution and description of the first and the second test sites.** The diagram explain that the same target species were used in both tests but under different conditions. It also displays the categorization of each site into exposed, sheltered and enclosed.

## 1. THE FIRST TEST SITE, DESCRIPTION AND PROCESS

The construction of the site was completed in 1980 and in 1984 this test commenced. The site is located on the plateau looking towards the Diplomatic Club. (Fig 69) It was divided into three distinctive zones in order to test the response of the plants under a range of conditions. The three zones were broadly classified according to temperature measurements that show a drop of 2°C between each zone. The dehydrating effect of wind and relative humidity discussed previously were additional determining factors for selecting each zone.

This first test site is still irrigated regularly by stream irrigation with the same amount of water, 25 L / $m^2$ / 3 times per week. The site is part of the pedestrian net work along the Wadi Hanifah and extends from east of the International School to the western boundary of the adjacent Wadi Hanifah. The objective in this test site is to study the growth rate, the habit, behaviour, and how successful these native species are when given minimal irrigation using the available and relatively low quality water. Fig 68 shows a detailed part of the site.

Each of the native species has a typical form when growing in the wild. In the first test site, species were propagated and tested, using methods that aim to maintain as far as possible their natural form. Groups and associated species for each zone were selected to match as closely as possible their structure and distribution in wild habitats. The western style of compacted planting compositions were omitted from the test. [60]

Since the main goal of this test site is to supply the market with competent native plant material for intensive urban planting, only selected species were chosen for the test. Choice was according to their physical characteristics, i.e form, texture and colour. After planting, the habit for each species was monitored for four years and its seasonal behaviour was recorded by the author. The growth rate was also recorded over a period of six years by the author. Monitoring methodology was modest and could be outlined into eight stages, as follows:

1. Site analysis which includes: vegetation analysis, soil type, water analysis (quality, frequency and timing), species's date of propagation and source of seeds or vegetative material, analysis of the management method, macro and microclimatic analysis.
2. Inventory and identification of the suitable species. This stage's emphasis was

[60] Some parts of the D.Q's landscape implemented open grass areas and compacted ground cover as found in some western parks. See hypothesis, the client, the consultant and the contractor, (The consultant).

on the source of seeds, re-identification by a third party [61] to assure nativity to the central region.

3. Study of the propagation technique and investigation to the transitional period between the propagation stages till planting.
4. Planting method and layout.
5. Detailed study of irrigation, quantity, frequency, method and data collection..
6. Manual measurement for the canopy and root growth.
7. Analysis of data in relation to other imported species.
8. Analysis of data in relation to different growing conditions.

In the site analysis stage the eco-climatic and edaphic analysis is listed to establish the best conditions for each species. The first test site was intentionally divided into three zones. Each maintains a different set of microclimatic conditions, to achieve maximum assessment of such influential factors on the behaviour and response of target species. All three zones were sorted to:

1. Contain similar species under different conditions.
2. Each zone was again classified into compositions each containing a diversity of plants. (Fig 70 & 71).

In chapter 3 the meteorological analysis indicated the dehydrating effect of hot wind and high temperature. Therefore the zones were classified according to their compositions and noted microclimatic modifications. A record of temperature change around each species was taken during the summer peak in order to extract the best growing conditions.

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[61] Re-identification carried out in the Royal botanic garden mid 1988, by Collenette, Sheila, the author of *An illustrated guide to the flowers of Saudi Arabia*, First ed, Meteorology and Environmental Protection Administration, Saudi Arabia; Flora Publication No. 1, London: Scorpion Publishing Ltd, 1985.

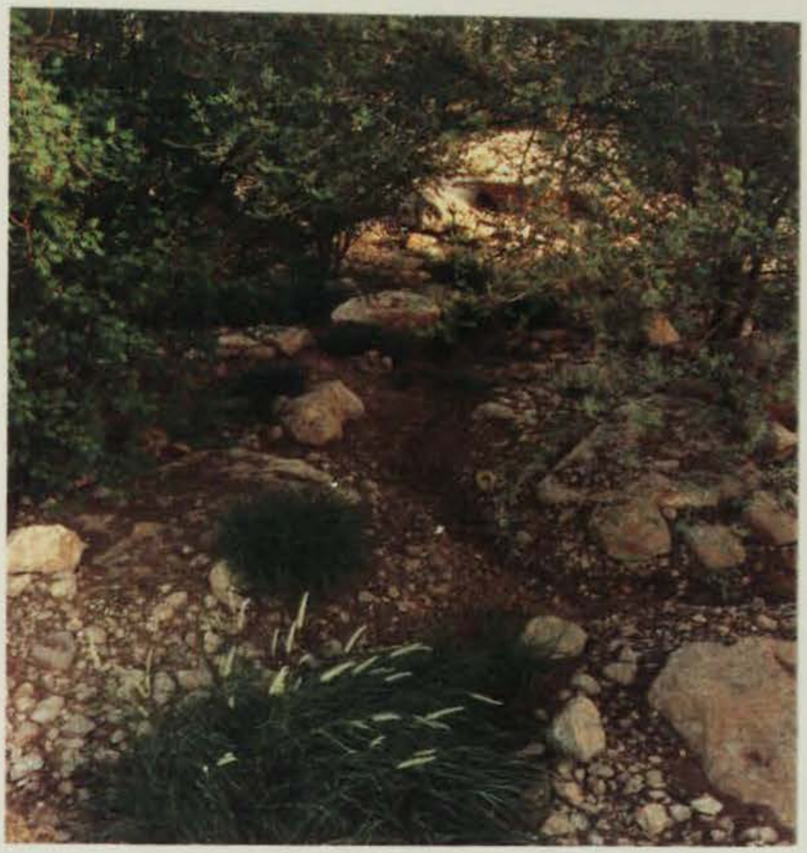

Fig 68: Shows part of the first test site and the stream irrigation colonized by manually planted Acacia farneziana and Farsetia spp.

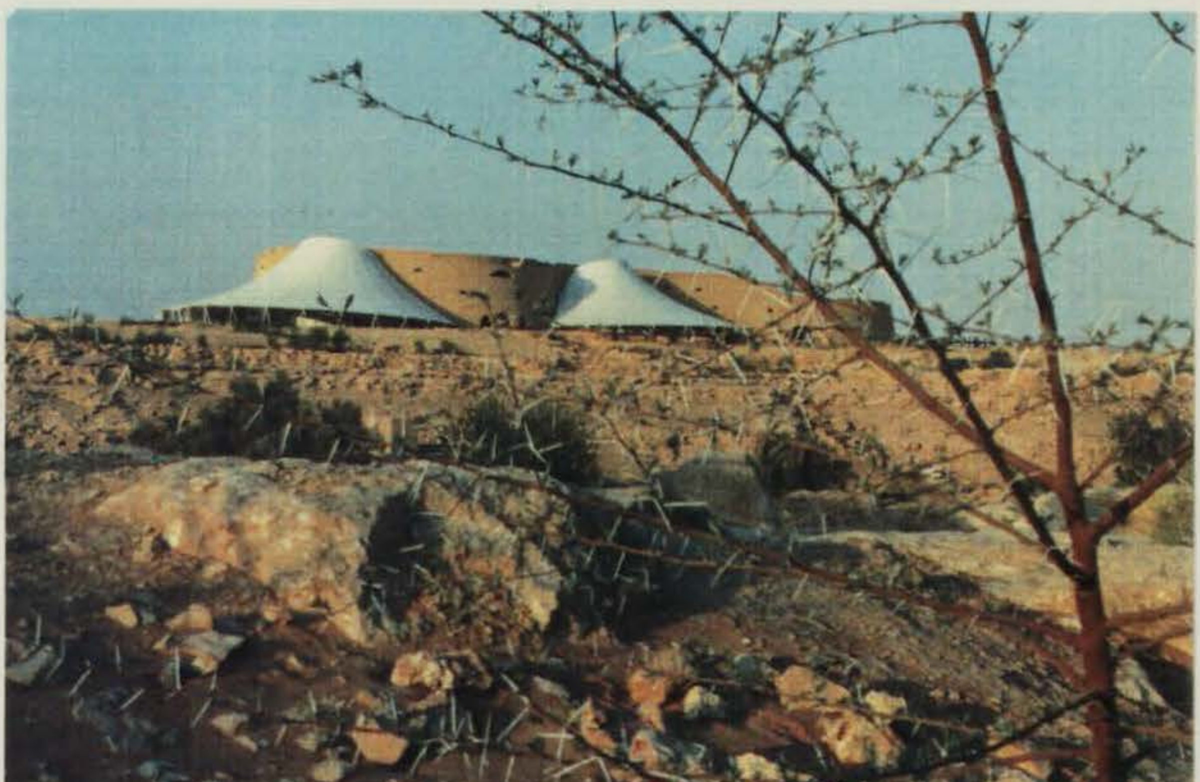

Fig 69: The test sites are situated on a plateau opposite the Diplomatic Club, Diplomatic quarter, Arriyadh, Najd.

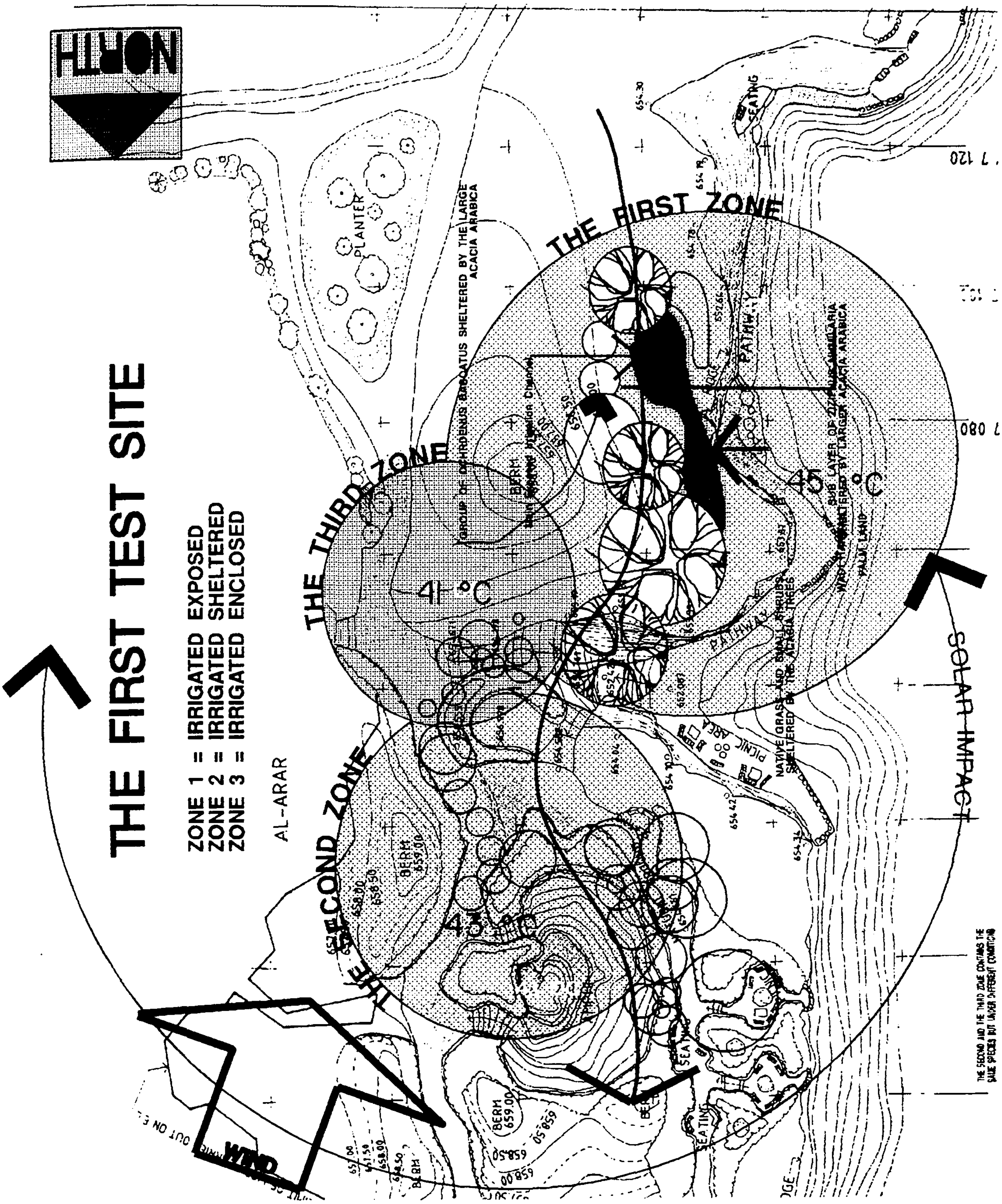


Fig 70: The three zones, analysis to the influential factors on the site and each zone.

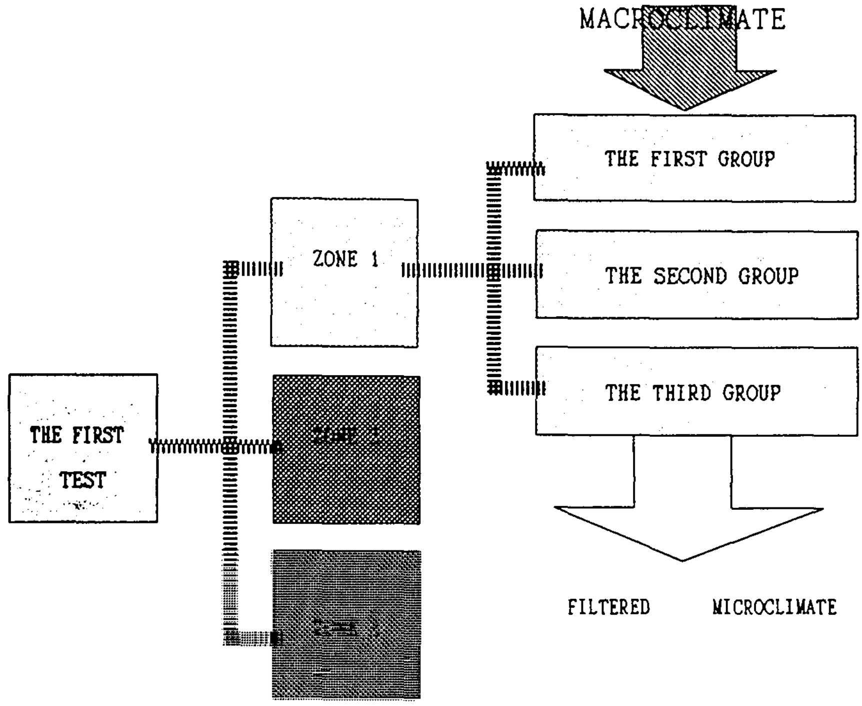


**Fig 71: Classification for the first test site and its zonation and compositions. The first zone was divided into three compositions that found to contain acceptable diversity of plants.**

The following target species were planted by the Authority using native seedlings propagated in their nursery under initial ideal conditions (described later) then moved gradually after rooting to conditions comparable to the native habitat of each species, i.e unsheltered and using the same soil characteristics. All the target species listed earlier,[62] were planted in the site but only the following species were monitored. This was due to complications in the propagation and growing conditions of the others. Table 12 lists those species:

**SPECIES PLANTED IN THE FIRST TEST SITE:**

**TREES:**

| | |
|---|---|
| Acacia tortillas | Cutting |
| Acacia albide | Cuttings |
| Acacia farnaziana | Cuttings |
| Acacia arabica | Seeds |
| Albizia lebbeck | Cuttings |
| Delonix elata | Seeds |
| Ficus pseudosycamorus | Cuttings |
| Prosopis cineraria | Cuttings |
| Prosopis juliflora | Seeds |
| Tamarix aphylla | Cuttings |
| Ziziphus jujuba | Cuttings |
| Ziziphus spina-christi | Cuttings |

**SMALL TREES:**

| | |
|---|---|
| Acacaia canophylla | Seeds |
| Caltropis procera | Seeds |
| Ecalyptus camaldulensis | Cuttings |
| Ficus psedo-sycamrus | Cuttings |
| Ziziphus numilaria | Cuttings |
| Prosopis fracta | Cuttings |
| Acacia gerrardii | Seeds |

**GROUND COVER:**

| | |
|---|---|
| Bassia erophoria | Transplanting |
| Diplotaxis acris | Cuttings |
| Hammada elegans | Cuttings |
| Heliotropium bacciferum | Cuttings |
| Ipomea sinensis | Cuttings |
| Ipomea pes-capri | Nursury stock |
| Silene arabica | Seeds |

**CLIMBERS:**

| | |
|---|---|
| Anagallis aruensis | Cuttings |
| Cissus Guadrangularis | Seeds |
| Citrilus colocynthis | Seeds |
| Clitoria ternata | Cuttings |
| Cucumis prophetarum | Seeds |
| Ipomea palmata | Nursury stock |

**SHRUBS:**

| | |
|---|---|
| Abutilon pannasum | Cuttings. |
| Atriplix halimus | Cuttings. |
| Capparis spinosus | Transplanting. |
| Capparis cartilsqunea | Transplanting. |
| Cassia italica | Cuttings. |
| Datura inoxa | Seeds. |
| Lycium babbarum | Seeds. |
| Ochradinus baccatus | Seeds. |
| Periploca aphylla | Seeds. |
| Rhazia stricta | Seedlings, Cuttings. |
| Ricinus communis | Cuttings. |

**SMALL SHRUBS:**

| | |
|---|---|
| Allenia subaphylla | Seeds. |
| Argemone mixicana | Seeds. |
| Artemisia judaicamonosperma | Cuttings. |
| Asparagus africanus | Cuttings. |
| Atriplex dimorphostegia | Cuttings. |
| Atriplix leucoclada | Cuttings. |
| Belepharis ciliaris | Leafe Cuttings. |
| Carrisa edulus | Cuttings. |
| Ficus salisifolia | Cuttings. |
| Hammada flegans | Seeds. |
| Heliotropium digynum | Seeds. |
| Lavandula dentata | Cuttings. |
| Peganum harmala | Seeds. |
| Penicum turgidium | Cuttings. |
| Psiadia arabica | Seeds. |
| Recinus communis | Seeds. |
| Tamarix amplexicaulis | Cuttings. |
| Tamarix arabica | Cuttings. |
| Zygophyllum coccineum | Seeds. |
| Zygophyllum album | Seeds. |

**GRASS:**

| | |
|---|---|
| Alopecurus agrestis | Seeds. |
| Arundo donax | Seedlings. |
| Koeleria sinaica | '' |
| Panicum turgidum | '' |
| Pennisetum setacum | '' |
| Phragmetus communis | '' |
| Phragmetus Australi | '' |
| Typha domingenis | '' |

Table 12: Species planted in the first site and included in the monitoring process.

[62] See Testing process, (target species).

Trees and shrubs were planted using container grown stock, size 15 gallon for trees, 5 gallon for shrubs. Small shrubs and ground cover containers varied from 1-3 gallons.

The above species were propagated using conventional methods. Trees were propagated from seeds and cuttings, grass was propagated from seedlings while shrubs, ground cover and climbers from cuttings. seedlings and seeds (Table 9). There was particular emphasis on the source of propagation material, to be sure it was:

1. True-to-name and type.
2. Free of disease and insect pests.
3. In the proper physical state.
4. cuttings, seeds and seedlings, were taken from species native to habitats similar to the target site.

Propagating native plant material, is a very laborious process and usually influenced by the kind of rooting medium used, not only in the percentage of cuttings rooted but in the quantity of root system formed and the consequent growing behaviour.

There were two options to aim for during the propagation process: the first to achieve a successful container grown stock using advanced technology for the project; while the other to propagate native vegetation in similar conditions to their native habitat. The latter was omitted because of the complicated process, the length of time required and or not being appropriate for the first test site since the propagated species will be growing under ideal man made conditions. Therefore it was decided to leave that propagation option for the third test site.

Cuttings and seeds for the anticipated test were collected as mentioned earlier.[63] Cuttings were typically 8 Cm long and of semi mature form. Seeds were prepared by grinding the outer shell while seedlings were transplanted to the propagation pots immediately. Rooting from cuttings took from 10-14 weeks and 16-24 weeks for seeds to germinate. The average success rate for cuttings was 49% and 23% from seeds. The low success of seeds propagation is due to the technique of preparing the seed's shell. Conventional seeding trays were not used in this test due to the habit of native species's root system.

Rooting medium consisted of wadi soil, Perlite with added peatmoss to increase water retention capacity and a small amount of vermiculite. They were automatically irrigated using an Intermittent Mist System (Fig 72) and sheltered primarily from direct sun light.

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[63] See chapter 4: Target species method; collection of seeds and collection of vegetative material.

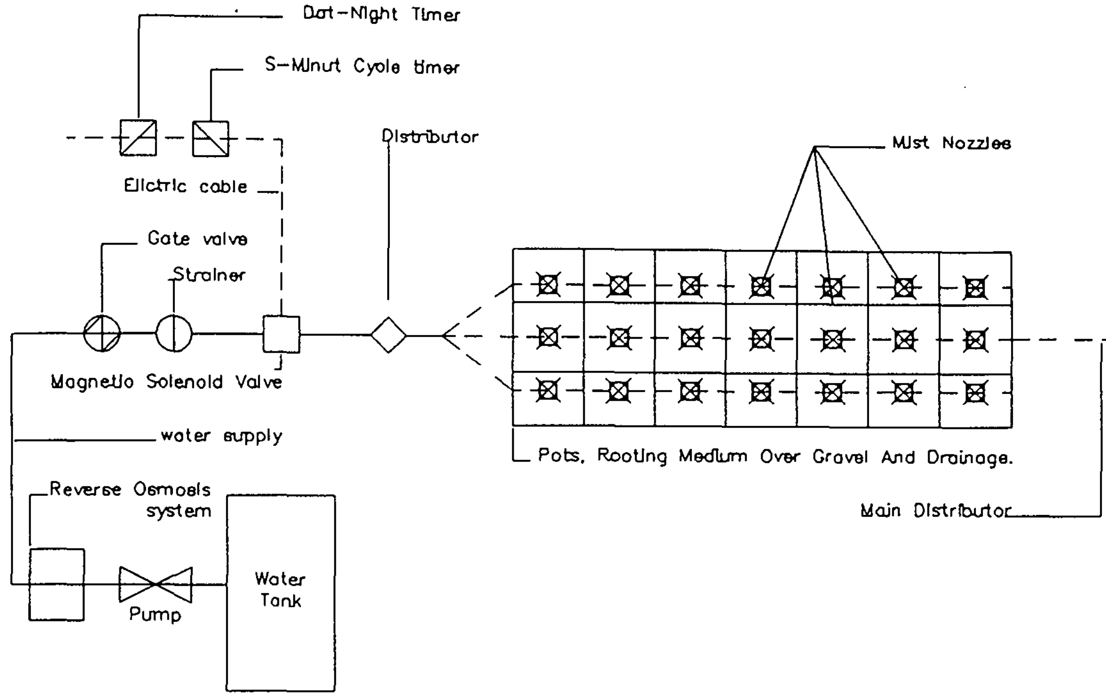


**Fig 72: Basic Mist Intermittent propagation layout similar to system used in the initial propagation of native species. Note the two timers: one turn the system on in the morning while the other off at 2300. The second timer is a short intervals timer to provide The intermittent mist cycle.** [64]

Although this system is initially suitable for leaf cuttings, it proved to be successful with other propagation methods especially vegetative cuttings. All plant material was grown in containers more than double the size required by imported species, to accommodate the root structure of most native plant material. During the propagation process, plants were transferred to different microclimatic domains to prepare them for transplanting to the site. That preparation was achieved through three stages: the initial sheltered misty zone, to semi sheltered with direct root irrigation by drip system and finally exposed site with irrigation reduction to the level to be on site. This helped in increasing the percentage of established plants in the target site. (Table 13)

| | CUTTINGS | SEEDS |
|---|---|---|
| TOTAL NUMBER | 500 | 1200 APPROX |
| ROOTED | 49% | 23% |
| ESTABLISHED | 83% | 38% |

**TABLE 13: Percentage of plants rooted and established. The percentage of the established plants are counted from the total number rooted.**

[64] (Source: Field observation, Hartmann and Kester).

Unconventionally, most of the plant loss occurred during the mist intermittent event. After the initial rooting, most plants responded to the reduction of ideal conditions as shown by the higher success rate.

Each target site was planted with the above selected target species on rich soil, and irrigated regularly by stream irrigation that distributed an estimated 25 litre/day/$m^3$ three times per week. The simple stream irrigation supplies the water to the lower soil level to comply with the habit of most native plants that are expected to root down to that level. Irrigation water is a mixture of treated effluent and potable water. The following Table 14 represents the Water analysis:

| | |
|---|---|
| 1. PH value | = 7.4 |
| 2. Total alkalinity | = 90 mg/letter. |
| 3. Total suspended solids | = 0.0'8 mg/letter. |
| 4. B.O.D | = 1.5 mg/letter. |
| 5. C.O.D | = 0 mg/letter. |
| 6. Turbidity | = < 1 mg/letter. |
| 7. Residual chlorine | = 0.15 mg/letter. |

**Table 14: Analysis of water used in the first test site.[65] The test shows that the water quality is not very high. The water Ph value is relatively high and also the alkalinity. That will only add to the tough conditions under which those species will be tested.**

> *"Salinity problem is regarded as arising when the concentration of sodium chloride, sodium carbonate, sodium sulphate or salt magnesium are present in excess".*[66]

Some of the above alkali salts are present in the water used in Arriyadh as in Table 14 above and Table 15 below which fully shows most of the water substances. According to Chapman, only sodium chloride has been studied sufficiently, and there is no evidence to suggest any departure from the earlier figure of 0.5% in the soil solution. From the above water analysis, alkalinity is present sufficiently to threaten the growth rate of any imported planting. However, it was acknowledged that plants can grow satisfactorily using irrigation water containing 1% NaCl, provided that the substrate has high permeability, e.g Sand.[67] That was the main reason for the high percentage of the sand in the soil used in the test.

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[65] Water analysis by Portals water projects (Saudi Arabia) limited. Sample of pedestrian networks "b" extensive landscaping.

[66] Chapman,V,J. "*The salinity problem in general, its importance, and distribution with special reference to natural halophytes*". Paper in "*plants In Saline Environment*" by Poljakoff-mayber and Gale,J. 1975, springer-Verlag Berlin Heildelberg New York. Page 7.

[67] Boyko, H. "*Salinity and Aridity: New approach to old problems*". The Hague, junk 1966.

| | | | |
|---|---|---|---|
| Electrical conductivity | (M.Mhos/cm) | = | 665 |
| Total Dissolved Solids | (Mg/L) | = | 480 |
| Aluminum | ,,, | = | 0.88 |
| Arsenic | ,,, | = | 0.006 |
| Beryllium | ,,, | = | 0.093 |
| Boron | ,,, | = | 0.50 |
| Cadmium | ,,, | = | 0.01 |
| Chlorides | ,,, | = | 90 |
| Chromium | ,,, | = | 0.016 |
| Cobalt | ,,, | = | <0.02 |
| Copper | ,,, | = | 0.045 |
| Cyanide | ,,, | = | 0.01 |
| Fluoride | ,,, | = | 1.61 |
| Iron | ,,, | = | 0.13 |
| Lead | ,,, | = | <0.02 |
| Lithium | ,,, | = | 0.022 |
| Manganese | ,,, | = | 0.085 |
| Mercury | ,,, | = | <0.01 |
| Molybdenum | ,,, | = | <0.01 |
| Nickel | ,,, | = | 0.13 |
| Nitrate - N | ,,, | = | 2.6 |
| Selenium | ,,, | = | <0.02 |
| Vanadium | ,,, | = | 0.03 |
| Zinc | ,,, | = | 3.6 |

**Table 15: Water analysis of the water used in the extensive landscaping.**

The soil used is locally available and not of a high quality as required by imported plant material (Fig 73 shows the mixture of soil used).

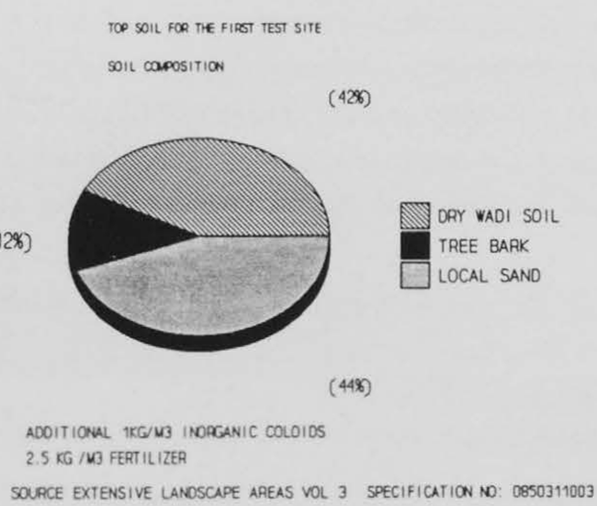


**Fig 73: Shows the mixture of top soil used in the first test site.[68] Soil was mixed on site with the existing top soil that primarily contains sand, and levelled to benefit from the stream irrigation.**

**[68] Although Wadi soil was used, it was extracted from a dry valley 70 Km south Ar-Riyadh.**

The mixture was recommended by the technical committee for the D.Q. Here this was employed as a measure for the behaviour of such target species when planted in a man made semi rich soil. Favourable results will qualify these species for use in the urban context. The wadi soil used had the same relative composition ,texture, and structure, free of roots, clods and stones larger than 25mm, and characterized by a sandy loamy soil. It was checked for any plant disease, organisms, pests or undesirable insects. The wadi soil used was chosen to meet the following requirements:

a. Salinity as measured by the saturation extract method not to exceed 2.0 millions per centimetre.

b. The sodium absorption ratio (SAR) to be no greater than 5.0.

c. The PH values to be between 5.5 and 7.5.

d. The boron concentration in saturation extract not to exceed 1.0ppm.

e. The silt, plus content, not to exceed 16 per cent by weight.

f. A minimum 90 per cent by weight to pass a 2mm round hole sieve.

g. The permeability rate not to be less than 13mm per hour when tested in accordance with ASTM D2434 or other approved methods.[69]

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**[69] This information was obtained from the A.D.A and was modified by M. Salama M.Phil 1986.**

## 1.1 THE FIRST ZONE

The first zone in test site one is located on the escarpment adjacent to the edge of Wadi Hanifah and exposed to the northerly wind with direct negatively pressured turbulence from the wadi, to the sun and macro environmental factors (Fig 74). The test will monitor some planting compositions under diverse conditions, to assess their potential use in landscape design projects.[70]

A planted and established part of the first site was selected as the first zone. It is exposed to the hot dusty shamal wind and other macroclimatic factors. This zone was designated to appraise growing conditions under full environmental exposure, maximum maintenance, maximum public use and rich soil with continuous watering. The zone is fully exposed to the unmodified and standard Najdi macroclimate and meteorological conditions as described in chapter three.

The zone was classified into three different plant compositions. Each incorporate potential design compositions which might be applied as a planting unit in arid projects.

The three main compositions that were monitored as a group and individuals are disscussed next. For all the three compositions, each plant was monitored by the following tests:

1. The change of rootball and canopy size was recorded by three main readings. The first reading was taken before planting, i.e the container size (1980) [71]; the second reading, two years after establishment at the beginning of the monitoring process 1984; the last reading took place at the end of 1988. The root growth between 1984 and 1988 was calculated as an average growth. Seasonal reading was avoided to minimize damage to plants.

2. The change in canopy size was recorded every March, June and October by the author.

3. The author recorded signs of succession, conflict and change within each composition.

4. The study of the three compositions aimed to extract species with

[70] The zone was selected carefully on the recommendation of the A.D.A landscape architect K. Klein to ensure maximum; exposure to harsh climate, heavy public use and high standard of maintenance.

[71] Information obtained from A.D.A's nursery records.

commercial viability and the fulfilment of different landscape need.

5. Due to lack of similar botanical or landscape data on such tested species, the author decided to include the result of the three tests combined in a simple Flora. This flora can act as a manual for landscape architects. If so used, native flora should start to appear in the inventories of local and international nurseries.

6. Plants sheltered by larger plants were considered to be growing under modified microclimate. That was considered as a growing factor and context, i.e in temperature difference under the larger trees, succession with their root structure and association with other species.

7. Salinity level was recorded before, during and after the test. Readings were taken during the analysis of soil samples taken before planting and at the end of the test. It was monitored in conjunction with growth and response of plants. The results were processed as a graph for ease of monitoring.

8. Growth rate for each species was compared with a similar category of imported species growing in the intensive part of the Diplomatic Quarter. This will validate the argument upon which the study is based.

## THE FIRST GROUP

The first group or composition, (Table 16) Contains species which qualify, upon success, as potential urban landscape plant material. Combined, they form an attractive landscape unit. The group contains a collection of species that were found to thrive together with minimal conflict.[72] Individually, it contains a street tree such as Ziziphus numilaria, ground cover; Ochradenus baccatus, Ipomea palmata, and grass. Fig 75 shows the group in its hierarchial composition. These species were monitored for orientation association, response to irrigation need, endurance of public use, growth rate for both root ball and canopy or spread, and how successful they appear as a design composition. Each successful species will replace similar imported species.

In brief, most of the individual species were thriving with steady growth rate. Although both Acacia arabica and Ziziphus numilaria prove not to thrive near each other, the composition, using one or the other, was visually and botanically successful as a unit.

The next part will introduce briefly the general behaviour and response of the group. Results of the successful individual species will be structured according to their

[72] Some plants were removed after establishment to enable the root growth of others.

potential category and use in landscape design in both the main conclusion of this chapter, chapter 6 and the Flora.

GROUP 1

| SPECIES | FACING NORTH | SHELTERED BY PLANTS | SOIL | TEMPERATURE | IRRIGATION | RESPONSE TO PUBLIC |
|---|---|---|---|---|---|---|
| ACACIA ARABICA | Y | - | A | 46°C | 25/L/D/M² | H |
| ZIZIPHUS NUMILARIA | Y | A.a | A | 45°C | ,, | ,, |
| ARTEMESIA HERB-ALBA | Y | Z.N | A | 44.5°C | ,, | ,, |
| OCHRADENUS BACCATUS | Y | - | A | 46°C | ,, | ,, |
| IPOMEA PALMATA | Y | A.A<br>Z.N | A | 43.5°C | ,, | ,, |
| PENNISETUM SPP | Y | A.A<br>O.B | A | 46°C | ,, | ,, |

**Table 16: Design factors for planting composition 1.** y=yes A.a=Acacia arabica Z.n=Ziziphus numilaria O.b= Ochraddonus baccatus T=tree S=shrub GC=ground cover G=grass. H=excellent a=soil type (wadi soil described earlier).

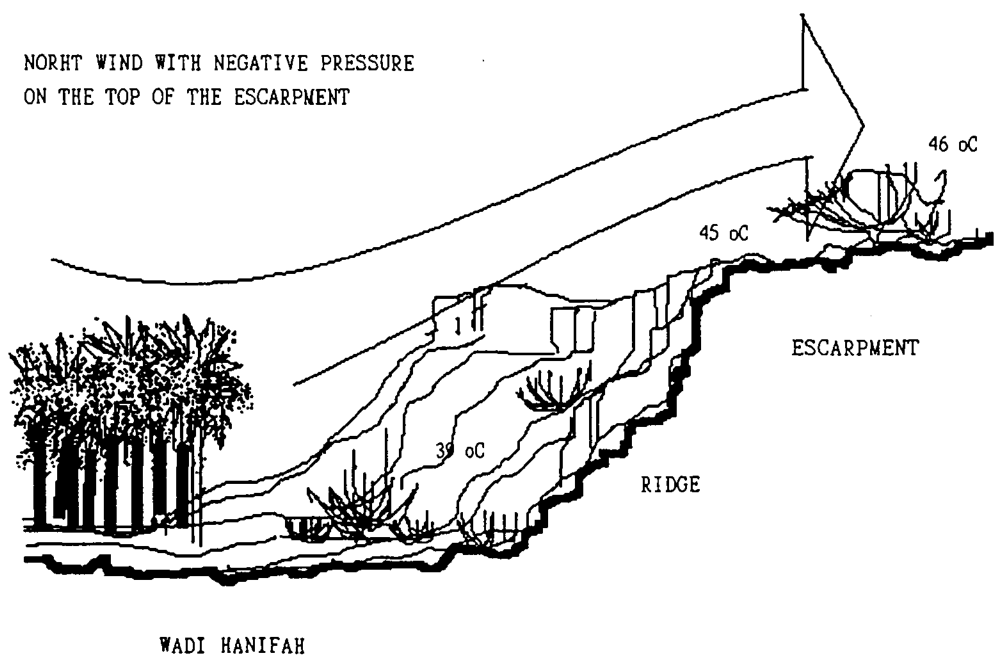


**Fig 74: Analysis of the first test zone which is located at the escarpment of Wadi Hanifah exposed to the environmental conditions as shown. The temperature shown was measured over the summer season.**[73]

[73] Field survey.

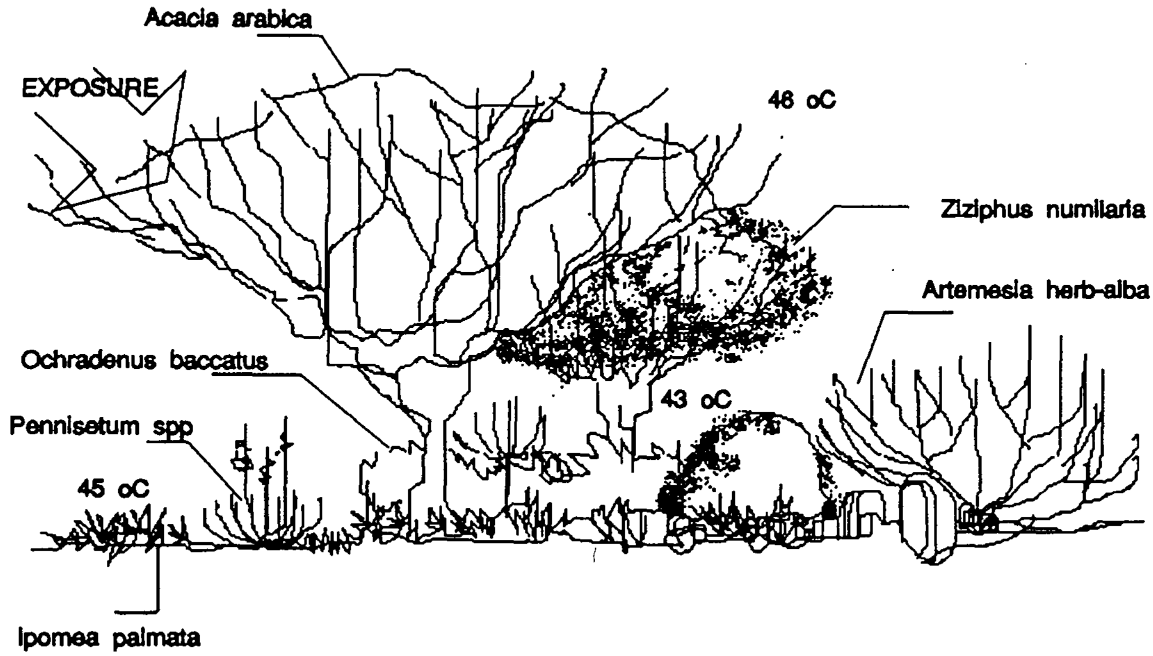


**Fig 75: The first planting composition. Table 16 shows the assessment factors for these group.**

## RESPONSE AND BEHAVIOUR:

Most native species are sensitive to alien species planted within their nutrition zone, as discussed earlier.[74] The selection of this composition was heavily based on that hypothesis. Growth rate and general physical aspects were the dominant evaluation factors for the success of a species. Aesthetic appearance and growth rate for canopy and roots were made by simple measurement, visual observation and questionnaire to landscape architects involved in the construction process. The following table 17 summarizes the group's initial performance.

| SPECIES | LOST SPECIES DURING THE INITIAL ESTABLISHMENT | SATISFACTORY GROWTH RATE | AESTHETICALLY SATISFACTORY | LANDSCAPE USE POTENTIAL |
|---|---|---|---|---|
| Acacia arabica | * | ** | * | ** |
| Ziziphus numilaria | - | *** | ** | *** |
| Artemesia herb-alba | - | **** | ** | *** |
| Ochradenus baccatus | - | *** | ** | *** |
| Ipomea palmata | - | *** | *** | **** |
| Pennesitum spp | * | * | ** | * |

Table 17: Brief report of the first group. Lost species during initial establishment: * indicates failure of more than 30% of total planted. The other criteria: number of stars indicate success.

[74] See: Chapter 3, **TECHNICAL PROBLEMS; IRRIGATION AND SOIL.**

## THE SECOND GROUP

The second group consists of a group of target natives sheltered by the first group from the most severe environmental factors. Interwoven with the first composition, the modified microclimate by the first composition reduced the temperature by 2°C, which enabled a broader selection of plants to be included. The second group tested comprised of the following species (Table 18):

| SPECIES | ORIENTATION BY PLANTS | SHELTERED | SOIL | TEMPERATURE | IRRIGATION | RESPONSE To PUBLIC |
|---|---|---|---|---|---|---|
| Acacia farnasiana T | nw | y A.a | a | 43 | 25/1 3/week/$m^2$ | h |
| Procopis juliflora T | nw | y A.a | a | 43.2 | '''' | h |
| Procipis cineraria | nw | n | a | 44.5 | '''' | h |
| Tamarix aphylla T | nw | n | a | 45 | '''' | h |
| Ziziphus Spina-christi T | nw | n | a | 46 | '''' | h |
| Abutilon Pannosum L.S | nw | n | a | 44.5 | '''' | h |
| Caltropis procera | n | n | a | 46 | '''' | h |
| Ficus pesudu-sycamorus L.S | ne | n | a | 45.5 | '''' | h |
| Salsola pacitoi S | nw | y O.b | a | 43.5 | '''' | h |
| Salsola Vermiculata S | nw | n | a | 44 | '''' | h |
| Nabasis arculatia S | nw | n | a | 45 | '''' | unexposed |
| Ficus salisifolia S | nw | n | a | 44 | '''' | direct trampling |
| Farseta spp | n | n | a | 45.5 | '''' | h |
| Datura inoxa G.C | n | F.s | a | 45 | '''' | h |
| Clitoria Ternata C | n | n | a | 45 | ''' | Minimal |
| Citrulls colocynthis | n | n | a | 44.5 | '''' | h |
| Pennissetum setacum | nw | A.f | a | 43 | '''' | h |

Table 18 : Design factors and species used in landscape design group 2.[75]

[75] Location and information based on field survey each plant was monitored individually.

The following abbreviation is used as a guide for tables:

SPECIES:

A.f= Acacia farnasiana, P.c= Prosopis cineraria, P.j= Prosopis juliflora, T.a=Tamarix aphylla , Z.s=Ziziphus spina-christi, A.p Abutilon pannosum, C.p=Caltropis procera, F.P=Ficus pesudosycamours, S.p=Salosa pacitoi, S.v=Salosa vermiculata, N.a=Nabasis articulatia, F.s=Ficus salisifolia, F,spp=Faresta spp, D.i=Datura inoxa, C.t=clitoria ternata, C.c=Citrullis colocynthis. H=Excellent

OTHERS:

T=tree, LS=large shrub, S=shrub, GC=ground cover, G=grass, n=north, nw=north west, a=soil type mainly wadi soil as mentioned earlier.

Fig 76 shows the existing composition of the second group and the factors that seem likely to effect its growth rate.

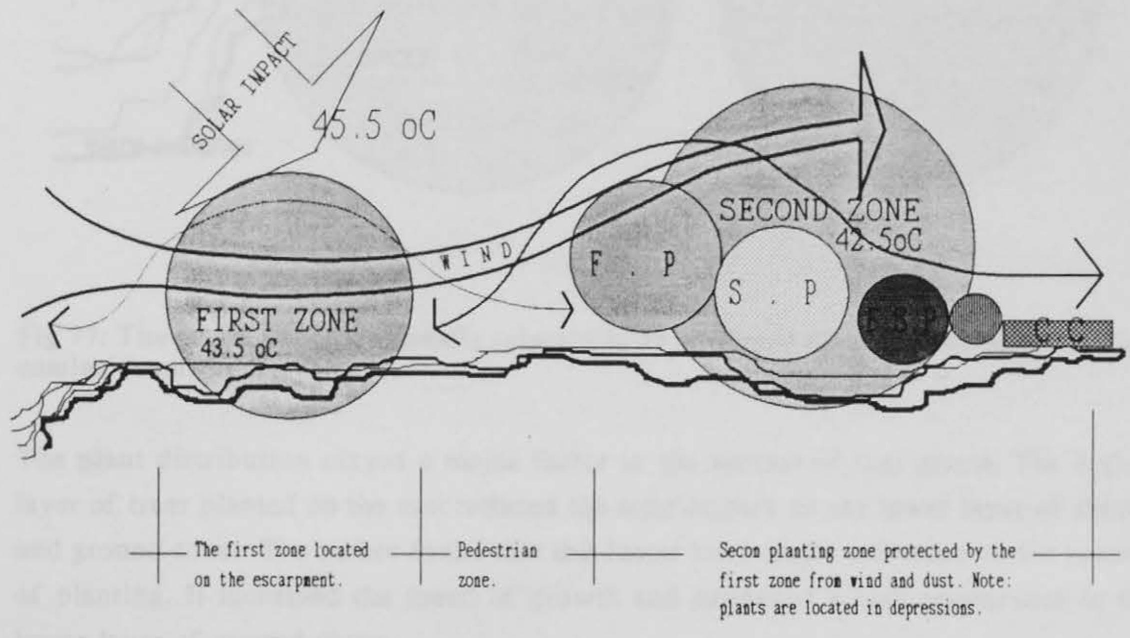


**Fig 76: Site analysis for the second zone demonstrating the distribution of plants and their design formation.**
P.j= Prosopis juliflora, T.a=Tamarix aphylla , Z.s=Ziziphus spina-christi, A.p Abutilon pannosum, C.p=Caltropis procera, F.P=Ficus pesudosycamours, S.p=Salosa pacitoi, S.v=Salosa vermiculata, N.a=Nabasis articulatia, F.s=Ficus salisifolia, F,spp=Faresta spp, D.i=Datura inoxa, C.t=clitoria ternata, C.c=Citrullis colocynthis.

The site is sheltered by the first group resulting in the modification of the existing microclimate through filtering the northerly winds. Soil composition is the same as test site one. Irrigation also is constantly controlled not to exceed 25/litre/day/$m^2$. This will emphasize the influence of other growing factors such as orientation, distribution, microclimatic effect and associated species.

The group was chosen intentionally to take benefit from being sheltered from the dehydrating wind by the first composition (Fig 77). The author found that water transpiration from the former group reduced microclimatic temperature and created cooler air. In turn, that affected the growth rate considerably.

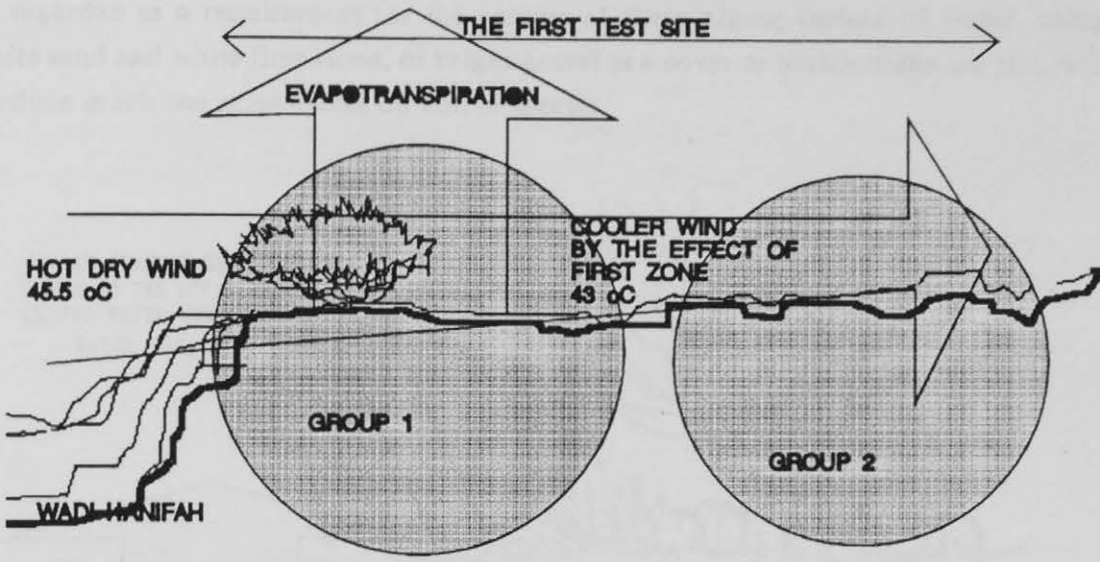


**Fig 77: The group was intentionally selected to be sheltered from the dehydrating wind coming from the north.**

The plant distribution played a major factor in the success of that group. The higher layer of trees planted on the east reduced the solar impact on the lower layer of shrubs and ground cover. The author found that this factor has a major influence on the success of planting. It increased the speed of growth and produced a lush appearance to the lower layer of ground cover.

A further factor, revealed by the author's analysis of the excavation of the site, helped in the quick establishment of the lower ground cover. The group was planted above an elongated and linear concave impervious formation of Ar-riyadh stone. This trapped the irrigation water initially for a short period before it was completely drained. The water cooled the 2.5 m thick top soil by capillary action and evaporation. The soil surface in this area which is usually extremely hot in mid summer, was found to be encouraging creeping plants such as Ipomea spp. This factor was a major reason to their authentic appearance and growth success (Fig 78). It also added to the success of all plants in this group. A comparison between this group and other groups, confirmed the validity of this factor. However, the salinity level in this particular area is marginally higher than other areas. Table 19 summarizes the result of that group. This table represents a brief report on the response of the group, which was considered to be a successful testing of native species as a whole. The group contained a diversity of species with complicated structures. The overall aesthetic appearance of the group was appropriate for use in public parks. Most of the species retained a satisfactory response to public abuse. The effect of drainage water that reduced the surface temperature of the top soil produced a lush appearance to the most apathetic native species. This temperature reduction can be regarded as a requirement for the success of these plants; instead of water, using white sand and white lime stone, or bright gravel as a cover or mulch to the top soil, will produce much the same effect on native species.

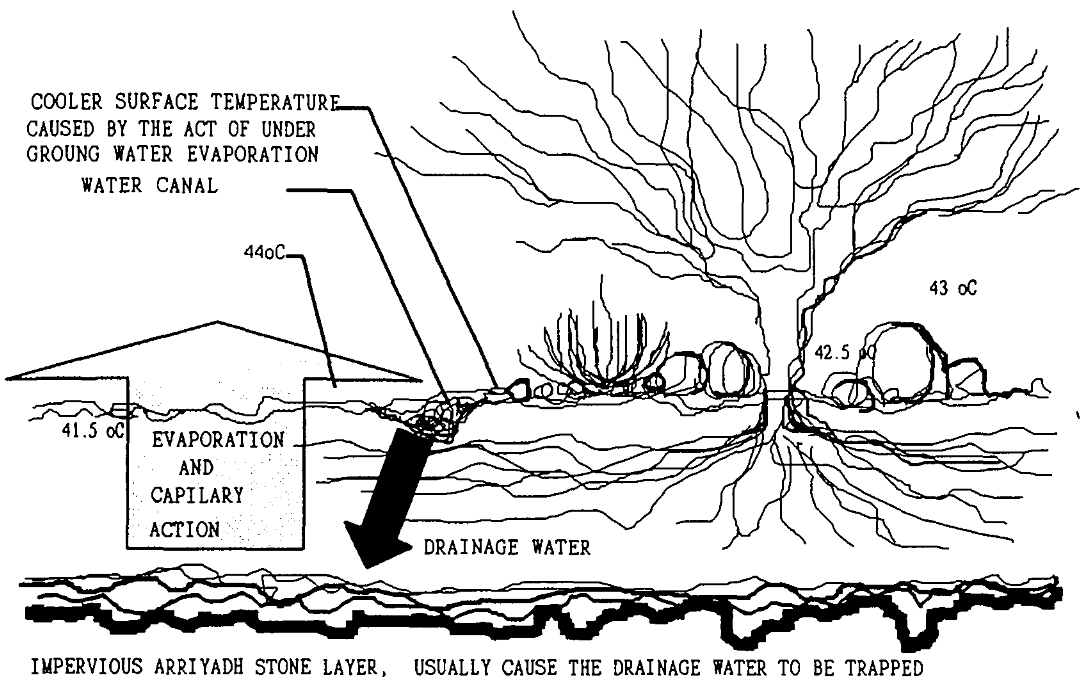


**Fig 78: Surface cooling action by evaporation in the second group.**

| SPECIES | FAILED SPECIES DURING THE INITIAL ESTABLISHMENT | SATISFACTORY GROWTH RATE | AESTHETICALLY SATISFACTORY | LANDSCAPE USE POTENTIAL |
|---|---|---|---|---|
| Acacia farnasiana | - | *** | ***** | ***** |
| Procopis juliflora | - | **** | ***** | ***** |
| Procopis cineraria | * | ** | ** | *** |
| Tamarix aphylla | - | **** | ***** | **** |
| Ziziphus Spina-christi | - | ***** | ***** | ***** |
| Abutilon Pannosum | - | *** | ** | *** |
| Caltropis procera | - | ***** | **** | ** |
| Ficus pesudu-sycamorus | - | *** | ***** | ***** |
| Salsola pacitoi | * | * | *** | *** |
| Salsola Vermiculata | * | * | * | * |
| Nabasis arculatia | - | ** | * | ** |
| Ficus salisifolia | - | **** | **** | ***** |
| Farseta spp | - | ** | ** | ** |
| Datura inoxa | - | ***** | ** | ** |
| Clitoria Ternata | - | ***** | ***** | ***** |
| Citrulls colocynthis | - | *** | *** | **** |
| Pennissetum setacum | - | ** | **** | *** |

**Table 19: Brief report of the second group. Failed species during initial establishment: * indicates failure of more than 30% of total planted. The other criteria: number of stars indicate success.**

## THE THIRD GROUP

Sheltered by the previous groups of plants, they were planted in an artificial depression, Fig 79. As a result they thrived in a microclimate 1.5 °C less than the previous group. Again, the water transpiration from the previous groups created more favourable conditions. As expected, the plants grew marginally faster with continual decrease in water consumption.[76] The effect was also apparent in a more intensive colour hue and a more spreading ground cover.

**Fig 79: The third group planted in an artificial depression.**

The illustration points to the depressed area in which the group was planted. Depressed areas in the wild habitats are usually found to be inhabited by native flora. Some plants were found to have higher successful growth rate in the lee side of rocks or even accumulated sand. Such a tendency could be employed as a useful technique in establishing native flora as a landscape tool. By conceiving depressed areas, with a water channel in their centre, a better chance of establishing planting is more probable. The following Table 20 reports the growing factors for this group.

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**[76] Calculating a water consumption comparison between the second and the first group, in such circumstances is usually impossible. Therefore, here it was calculated by the amount of drainage water dumped to the wadi. That was achieved by monitoring the drainage pipe outlet for both at the edge of Wadi Hanifah.**

| SPECIES | ORIENTATION BY PLANTS | SHELTERED | SOIL | TEMPERATURE | IRRIGATION | RESPONSE |
|---|---|---|---|---|---|---|
| Acacia farnasiana T | nw | n | a | 43 | 25/1 3/week/$m^2$ | Minimal access [77] |
| Caltropis procera | n | n | a | 42.5 | '''' | h |
| Abutilon Pannosum L.S | nw | y C.p | a | 42.5 | '''' | h |
| Aellenia subaphylla S | n | y A.h | a | 42 | '''' | h |
| Artemesia halimus S | n | n | a | 42 | '''' | exposed |
| Capparis spinose S | w | n | a | 42 | '''' | direct trampling |
| Ipomea pes-capri GC | n | y A.f, C.P, A.h | a | 41.5 | '''' | h |
| Pennissetum G setacum | nw | A.f | a | 43 | '''' | h |

**Table 20: Design factors and species used in landscape design group 2.** [78]

The following abbreviation is used as a guide for tables:

SPECIES: A.f= Acacia farnasiana, P.c= Prosopis cineraria, P.j= Prosopis juliflora, T.a=Tamarix aphylla , Z.s=Ziziphus spina-christi, A.p Abutilon pannosum, C.p=Caltropis procera, F.P=Ficus pesudosycamours, S.p=Salosa pacitoi, S.v=Salosa vermiculata, N.a=Nabasis articulatia, F.s=Ficus salisifolia, F,spp=Faresta spp, D.i=Datura inoxa, C.t=clitoria ternata, C.c=Citrullis colocynthis. OTHERS: T=tree, LS=large shrub, S=shrub, GC=ground cover, G=grass, n=north, nw=north west, a=soil type mainly wadi soil as mentioned earlier. H=Excellent

Most species responded successfully to their growing conditions. At the beginning of their establishment, they were growing slowly till the establishment of the other planting. After which, the growth rate was boosted. Table 21, reviews their reaction.

| SPECIES | LOST SPECIES DURING THE INITIAL ESTABLISHMENT | SATISFACTORY GROWTH RATE | AESTHETICALLY SATISFACTORY | LANDSCAPE USE POTENTIAL |
|---|---|---|---|---|
| Acacia farnasiana | - | *** | ***** | ***** |
| Caltropis procera | - | ***** | *** | **** |
| Abutilon pannosum | - | *** | ** | ** |
| Aellenia subaphylla | - | *** | ** | * |
| Capparis spinose | - | *** | *** | * |
| Ipomea pes-capri | - | ***** | ***** | ***** |
| Pennesetum setacum | - | ** | *** | *** |

**Table 21: Brief report of the third group's reaction. Lost species during initial establishment: * indicates failure of more than 30% of total planted. The other criteria: number of stars indicate success.**

[77] **Minimal access was due to Ipomea pes-capri covering the under canopy area. That restricted public approach.**

[78] **Location and information based on field survey, each plant was monitored individually.**

The above table reflects the high success rate of species in the first two years. Being sheltered, the group could represent a successful model for growing conditions in urban environments.

### 1.2 THE SECOND ZONE

The second zone was planted by the same species as in zone 1. It was noticed that the plants in this part were faster in their growth rate and root behaviour. Therefore a set of comparison factors were set up to assess the exact conditions which caused such growth rate. A reduction in temperature by 3.5 °C was recorded. This is due to the zone being sheltered by the first three planting groups, from the hot breeze coming from the north and the presence of a man made pond near by (Fig 80), which modified the temperature. The effect of such factors was clearly noticed, since the soil and the irrigation quantity remained the same.

**Fig 80: An artificial pond nearby the second zone reduced the temperature and increased humidity level.**

## a. FACTORS FOR ZONE 2

Fig 81 and Table 22 show the existing conditions and the possible factors that might effect the growth rate for these species.

| SPECIES | ORIENTATION BY PLANTS | SHELTERED | SOIL | TEMPERATURE | IRRIGATION | RESPONSE To PUBLIC |
|---|---|---|---|---|---|---|
| Acacia farnasiana T | nw | y A.a | a | 43 | 25/1 3/week/$m^2$ | h |
| Procopis juliflora T | nw | y A.a | a | 43.2 | ,,,, | h |
| Procipis cineraria | nw | n | a | 42.5 | ,,,, | h |
| Tamarix aphylla T | nw | n | a | 43 | '''' | h |
| Ziziphus Spina-christi T | nw | n | a | 42 | '''' | h |
| Abutilon Pannosum L.S | nw | n | a | 41.5 | '''' | h |
| Caltropis procera | n | n | a | 41 | ,,,, | h |
| Ficus pesudu-sycamorus L.S | ne | n | a | 42.5 | ,,,, | h |
| Salsola pacitoi S | nw | y O.b | a | 41.5 | ,,,, | h |
| Salsola Vermiculata S | nw | n | a | 41 | ,,,, | h |
| Nabasis arculatia S | nw | n | a | 41 | '''' | unexposed |
| Ficus salisifolia S | nw | n | a | 42 | '''' | direct trampling |
| Farseta spp | n | n | a | 41.5 | '''' | h |
| Datura inoxa G.C | n | F.s | a | 42 | '''' | h |
| Clitoria Ternata C | n | n | a | 43 | ''' | Minimal |
| Citrulls colocynthis | n | n | a | 43.5 | '''' | h |
| Pennissetum setacum | nw | A.f | a | 43 | '''' | h |

**TABLE 22: Species in the second zone and recorded growing factors.** [79]

The following abbreviation is used as a guide for tables:

SPECIES:

[79] Location and information based on field survey; each plant was monitored individually.

A.f= Acacia farnasiana, P.c= Prosopis cineraria, P.j= Prosopis juliflora, T.a=Tamarix aphylla , Z.s=Ziziphus spina-christi, A.p Abutilon pannosum, C.p=Caltropis procera, F.P=Ficus pesudosycamours, S.p=Salosa pacitoi, S.v=Salosa vermiculata, N.a=Nabasis articulatia, F.s=Ficus salisifolia, F,spp=Faresta spp, D.i=Datura inoxa, C.t=clitoria ternata, C.c=Citrullis colocynthis. H=Excellent

OTHERS:

T=tree, LS=large shrub, S=shrub, GC=ground cover, G=grass, n=north, nw=north west, a=soil type mainly wadi soil as mentioned earlier.

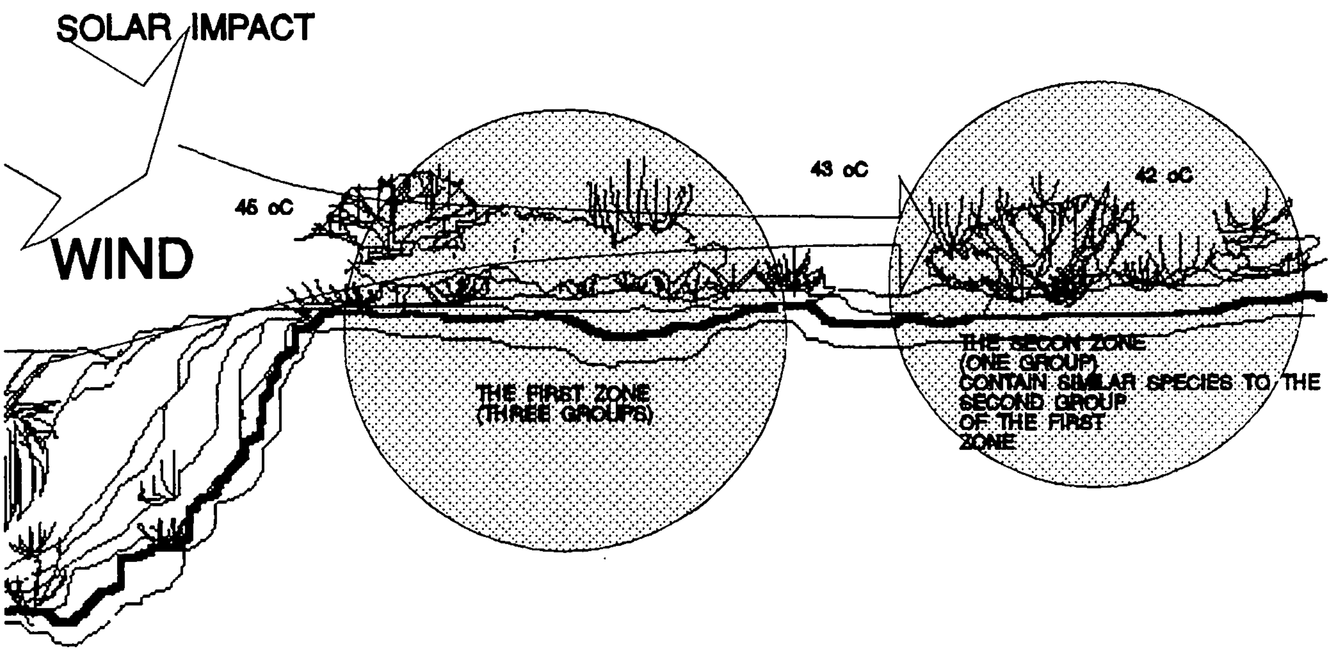
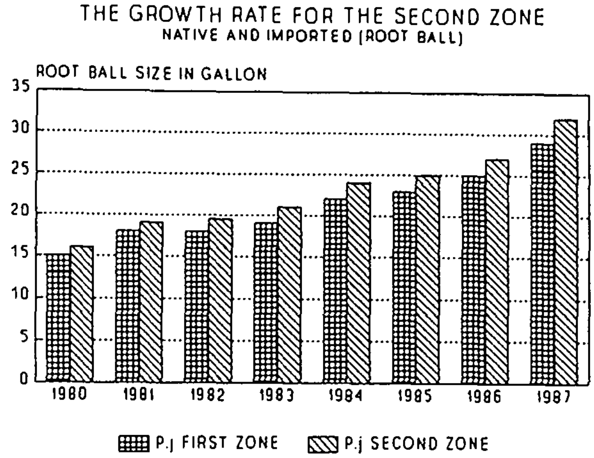



**Fig 81: The second zone. Diplomatic quarter. The fig indicates the zone being sheltered from macro factors boosting its growth status.**

It is vital to test how a native species responds to modifications and changes in microenvironment. Results of such test, can lead to the determination of optimum growth conditions for target species. Studying this zone will appraise how successful the same species was, when planted under the different conditions most likely to occur within an urban setting.

The graphs below (Fig 82) show a comparison between the two zones. Since they were planted with the same native species, the graphs clearly indicate faster growth of the same species under the second conditions.



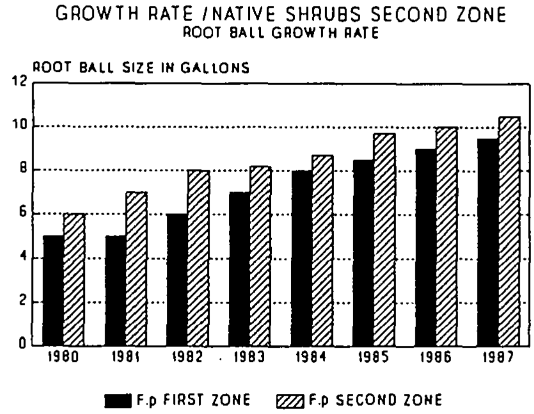




**Fig 82: A comparison between native species growth rate under different conditions which construct the growing factors in both the first and the second zone.** P.j= Prosopis juliflora, F.P=Ficus pesudosycamours.

Indication of sensitivity to modified microclimate, is strongly present in both graphs. Although in this example comparison was restricted to two species, the rest were found to achieve similar results. The conditions were similar to any open space within the urban context. A record of the microclimate of arable land inside Arriyadh showed similar temperature with similar relative humidity. Therefore these species can be recommended as a preferable potential substitute for imported species, using the same soil type A (a mixture of dry wadi soil mixed with local sand), the available low quality water, no additives to the soil or water system, and also the of use a simple irrigation system. They also maintain a greater tolerance to salinity. The proposed Flora will indicate the exact microclimatic conditions, the growth rate expected from these species and the seeding method for the test species. Table 23 below reports the initial result of this zone, which was much similar to the second group of the first zone.

| SPECIES | FAILED SPECIES DURING THE INITIAL ESTABLISHMENT | SATISFACTORY GROWTH RATE | AESTHETICALLY SATISFACTORY | LANDSCAPE USE POTENTIAL |
|---|---|---|---|---|
| Acacia farnasiana | - | *** | ***** | ***** |
| Procopis juliflora | - | **** | ***** | ***** |
| Procopis cineraria | - | ** | *** | *** |
| Tamarix aphylla | - | **** | ***** | **** |
| Ziziphus Spina-christi | - | ***** | ***** | ***** |
| Abutilon Pannosum | - | *** | *** | *** |
| Caltropis procera | - | ***** | **** | ** |
| Ficus pesudu-sycamorus | - | *** | ***** | ***** |
| Salsola pacitoi | - | ** | *** | *** |
| Salsola Vermiculata | - | ** | ** | * |
| Nabasis arculatia | - | ** | * | ** |
| Ficus salisifolia | - | **** | **** | ***** |
| Farseta spp | - | ** | ** | ** |
| Datura inoxa | - | ***** | ** | ** |
| Clitoria Ternata | - | ***** | ***** | ***** |
| Citrulls colocynthis | - | *** | *** | **** |
| Pennissetum setacum | - | ** | **** | *** |

**Table 23: Brief report of the first group. Failed species during initial establishment: * indicates failure of more than 30% of total planted. The other criteria: number of stars indicate success.**

## 1.3 THE THIRD ZONE

There was continuous shade over the third zone, which was planted with a similar range of species. The only difference in microclimatic factor was present in the lower temperature resulted from the shading and sheltering. A two degree decrease in temperature over the second zone was registered. Also the plant mass was sheltered by the International School's high boundary wall and there was no indication of wind movement. Soil conditions and irrigation status remained the same.

Initial impression, after six years, showed some indications that the plants suffered as a result of the deficiency of direct sunlight, which was confirmed by the growth test as shown in the graph below (Fig 83). Plants started to compete for the light especially the higher tree layer. Short ground covers were most affected. The graph indicates the deterioration in the growth rate for Acacia farnasiana in both the root ball and the canopy size. The colour also indicates the unsuitable microclimate in which these species are growing, a pale olive with yellowish cast on the edges instead of its normal dark olive green.

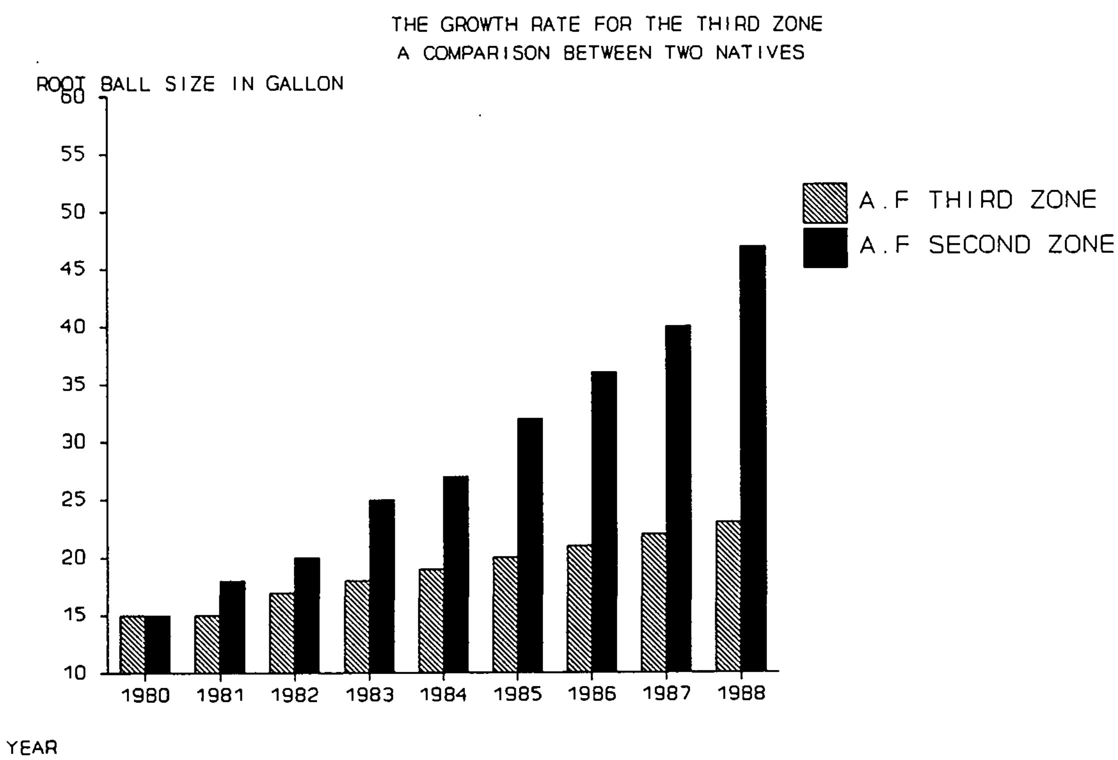



**Fig 83: A comparison between native species growth rate in both second and third zone.**

There are many explanations for such behaviour, according to the A.D.A maintenance department, *"The seeds that were collected in the summer, showing early suffering from existing conditions, while the slow growth only apply to species that were seeded during winter".* [80]

This clearly indicates that native seeds are adapted to the harsh Najdi environment, therefore it is recommended that seeding operation should take place during the summer season. This might explain the growth behaviour for the species incorporated in this zone. Nevertheless, some ground cover species recorded a superior growth rate under these shaded conditions, for example Ipomea pes-capri. The creeping species tolerated such problems by extending to the sunny spots.

It was clear here that some species lost their adaptation, due to their propagation period in the nursery which was estimated to be at least 12 months. Here they received a variety of special treatment under ideal conditions. That propagation weakens their natural adaptation characteristics which these unique species have inherited over many generations.

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[80] Said Nour, A.D.A maintenance department, interview by the author, (translation from arabic).

## 2. CONCLUSION, FIRST TEST SITE

The native plants tested possessed most of the required aesthetic and environmental features demanded of plant material used in Najd urban projects. Environmental tolerance is especially high. Their use should enhance the physical urban environment visually and microclimatically. The functional, behavioral, growth and aesthetic aspects are described in the proposed Flora. (See chapter 6, "The native flora").

In the urban context, the microclimate both above and below the soil surface will form better growing conditions than the actual test sites. Buildings create shadows and slow wind, reducing the aspect of drought stress which represents the main cause of death and reduction in vigour of amenity plants. The cause and effect of drought stress: exposure, shade, shelter, modified temperature and drought tolerance, were the qualifying criteria for each plant as presented in the test's tables.

The author chose compositions and species in order to set an example for the amenity landscape market, which is thriving and potentially healthy. The successful species can therefore be introduced directly to the market, while landscape architects can learn from the authentic criteria found within each composition and check their environmental suitability.

"Modern", "international" or "western" aesthetic and functional criteria do not apply to Najdi indigenous landscape design. Therefore, the issues discussed in the final chapter about the aesthetic requirement for massed, structure planting, and street planting, must be understood before using these plants, especially those tested here.

In all three zones, where the microclimatic conditions differed to a certain degree in their climatic factors, the selected native species for the test showed;

1. Most tested plants responded with great sensitivity to minimal microclimatic changes. Faster growth, more branches and darker leaves were the symptoms of temperature fall and occasional shadow.

2. In the second zone, where the conditions are similar to that of semi urban context or low density housing, plants achieved an excellent growth rate. Such success was achieved under peak temperature of 42°C and high salinity levels.

3. Although the first group were exposed to dehydrating macroclimatic conditions, they still achieved a satisfactory growth adequate for most extensive landscape use.

4. Within unsheltered groups, exposure to macroclimatic conditions, using saline

irrigation water and primitive drainage system, increased salinity level. However, most plants showed signs of thriving in higher salinity levels.

5. The test succeeded in its aims to recommend certain target species as a replacement for the unsuited imported species. Plants thrived in minimal irrigation water estimated at 1/4 of that required by imported plants, local soil and with minimal maintenance. They also gave results superior in physical appearance to those of imported ones.

It is particularly important to note that the soils used in the three zones are of low quality and available locally. Despite the initial success the following should be noted:

1. The propagation process used in this test is wasteful of the genetic potential of native species; only a few were retained. The retained characteristics was due to the gradual transition process that took place in the nursery.

2. Despite that, the short term success is high (78% survived) and sufficient to indicate a promising start for substituting imported species. In addition, the environmental suitability is not questioned as is the case with alien species.

3. The test showed the existence of a large number of species unknown to amenity landscape, most with potential, and some at least, that were worth testing.

4. Survival of tested plants alone was not adequate to qualify a plant to be used in public landscape projects. Therefore the test was located in a public park where most plants survived public abuse, soil compaction and continual rising salinity levels.

5. The author noted from reading the contractor's schedule that some species were seeded during the summer and achieved a satisfactory rate. Some of those such as <u>Acacia ongrup</u> and <u>Acacia cylopsis</u> despite their success, were omitted for doubt about origin or for their poisonous fruits.

The following part will introduce and compare some individual plant species as they progressed during the test. Selected species were discussed aiming to support certain aspects of the hypothesis. For example, salinity tolerance, water consumption and response to growing conditions.

### 3. INDIVIDUAL SPECIES AND TEST:

The following part will report and discuss in details, the habit of some selected species during the first test. [81] It is aimed to introduce the reader to the changes that are likely to occur if those species were under different growing conditions as found in the three groups in the first test site. As reported in the first test site, zone 1 was classified into the following three groups; first, second, and third group according to their degree of exposure to macroclimate and being most sheltered by the other group. Below is a data organised to acknowledge that:

1. Different category of native plants responds positively and sensitively to local macroclimatic, microclimatic and edaphical factors.
2. Native plants thrive, even when planted at the edge of an escarpment and exposed to the influence of direct desert macroclimate.
3. By sheltering a group of native species by other plants, will result in a dramatic increase in the physical characteristics of the plants in favour of landscape requirements.
4. Some species thrive with the increase in salinity level.

The first test includes three zones, zone 1 consists of three groups. Here the first and the second group will be disscussed in details while the last group's result will be disscussed briefly as it was comparable to the second group.

#### FIRST GROUP:

#### TREES:

1. Acacia arabica, was planted in the group at the same time as the other species. Pilot studies were made to assess the habit of the plant growing in the wild. These showed that species thrived in the natural habitats successfully with minimal watering. The author chose to test a group of the species growing away from the main stream irrigation with adequate space free of other plants for its sensitive root structure. The species showed slow but steady growth. With other plants, it showed minimal conflict with Ziziphus nummularia but failed to accept any ground cover or grass within its root zone. After the first three years there was some indication of acceptance of colonization from Ipomea palmata's roots. Fig 84 (both graphs) shows its growth rate and makes comparison with the imported Delonix regia, which is the most commonly used imported species.

The canopy graph points to the slow growth of Acacia arabica's canopy compared to Delonix regia. This is due to the initial growth pattern, where most of its early growth

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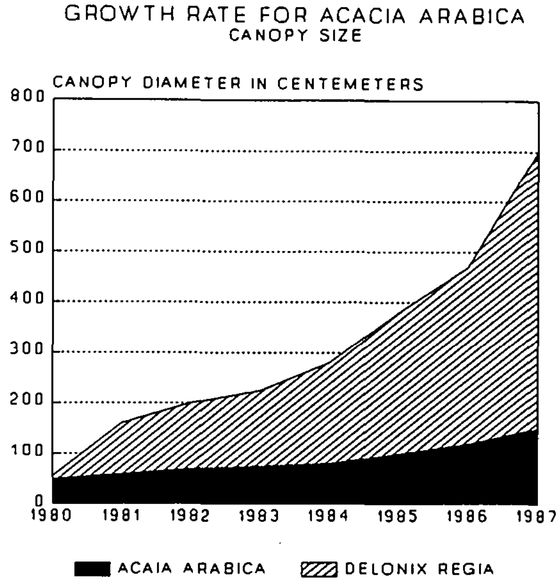
[81] The reason behind selecting the first test site, was that it matches the most likely growing conditions found in a typical Arriyadh urban park.

is, concentrated on the root system. This was due to two reasons: Firstly this is a habit of most native species and will apply to the rest of the plant material in this study. Secondly the irrigation system adapted to the test sites was designed to discharge the water direct to the underground water table to simulate for native plants the existing conditions in their native habitat. [82]



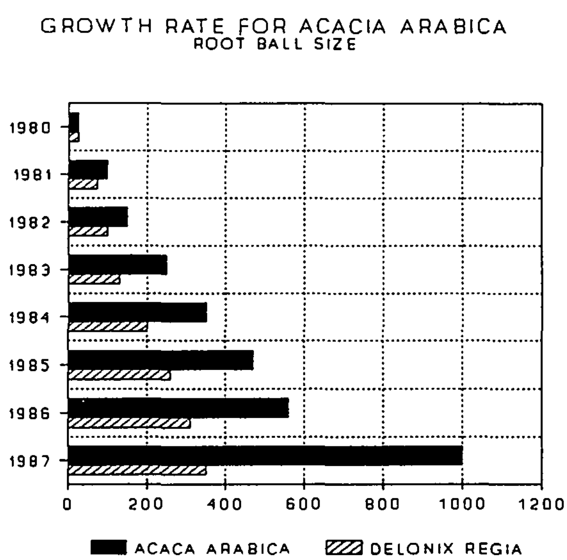




**Fig 84: The growth rate for root ball and canopy of Acacia arabica,and a comparison with Delonix regia.**

Despite the slow growth for Acacia arabica, it makes more prudent use of Najdi water

[82] Robert & Marina Adams, Alan & Aann Willens, *Dry lands Man And Plants*, First Ed. London: The architecture Press Ltd, 1978.

resources as in Fig 85 where the data below supports the hypothesis of native species being less water demanding after establishment. In contrast to Delonix regia it doesn't require additional doses of irrigation water during the growth process.

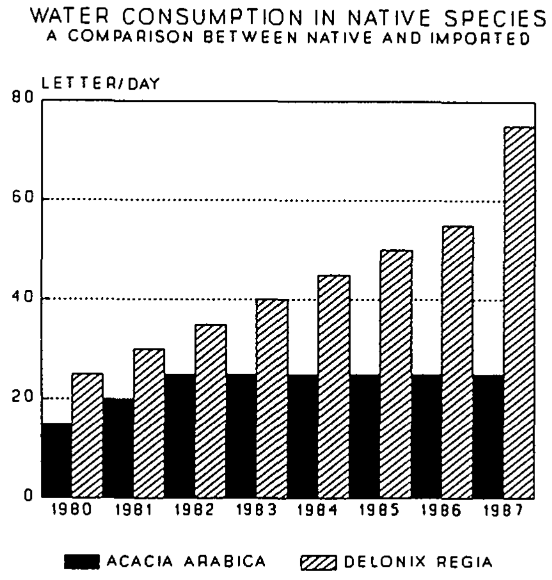
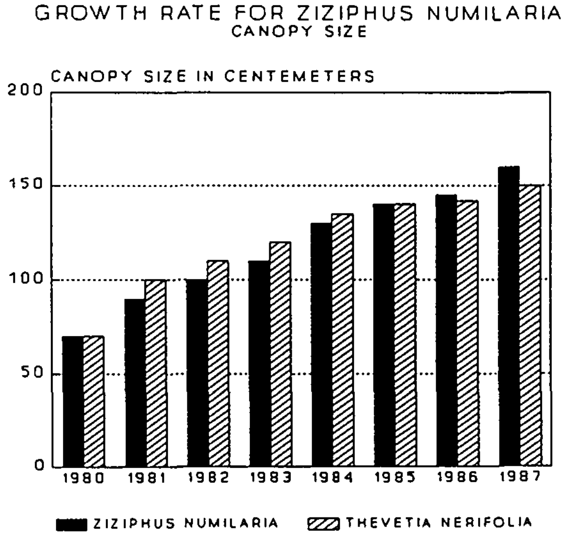



**Fig 85: A comparison in water consumption.**

2. Ziziphus Nummularia:

Since the species was screened by Acacia arabica, the recorded temperature under its canopy was less by 0.5°C. There was no explicit root conflict between the two as they were planted 4 metres apart. Fig 86 shows that the initial growth rate in both the canopy and the root ball is comparatively slow compared to an imported species such as Thevetia nerifolia but it also shows that Ziziphus nummularia is faster than Thevetia nerifolia after the first four years due to its adaptability to the local environment.

Simple analysis of both graphs shows that the root growth's pattern of Ziziphus nummularia was affected by the persistent supply of irrigation water. In nature, the species will root extensively for the initial growth period with minimal canopy growth. Under the test conditions, both the canopy and root growth was active with noticeable reduction in root diameter due to the presence of water. That made the species vulnerable to wind and consequently required support. Water consumption was also noticeably stable. In fact in this test the process of water consumption measurement could instead be called response to water supply. In general, there was not any demand for increased watering by most of the native species tested here. The imported ones however, needed increasing amount of water as they grew since they were unadapted to saline ground water (Fig 87). This shows that water consumption for Ziziphus nummularia is lower than for Thevetia nerifolia due to the first being adapted to drought and its ability to retain water. Ziziphus nummularia proved more adapted to water reduction than Thevetia nerifolia as it adapts itself to a constant amount of water while maintaining satisfactory growth. The planting of <u>Ziziphus nummularia</u> sheltered and shaded by <u>Acacia arabica</u> helped to reduce the water loss and achieved this success. The tree blends well with the planting composition. It is characterized by its rounded and broad leaves of an olive green colour, rare in such native species.



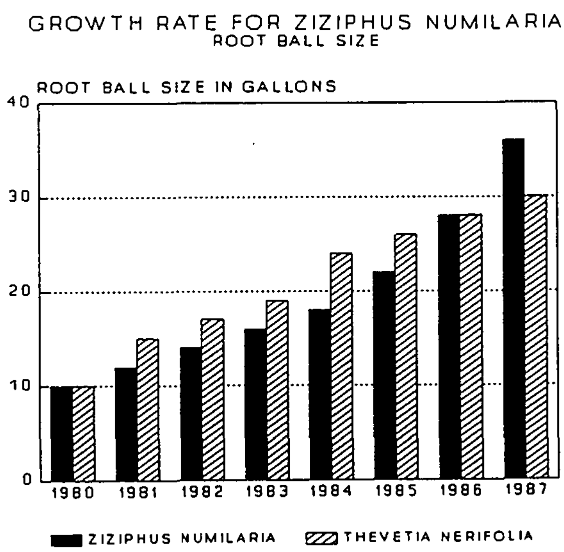




**Fig 86: The growth rate for <u>Ziziphus nummularia.</u>**

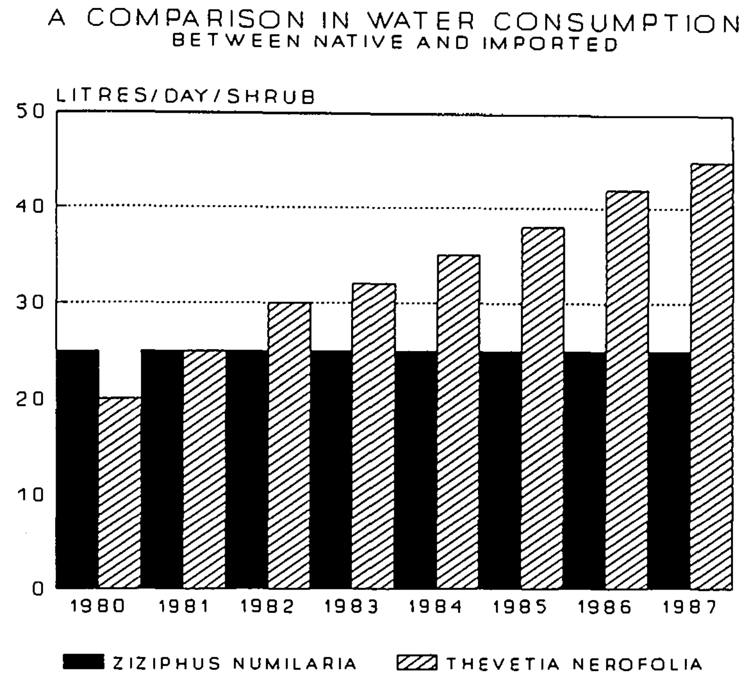
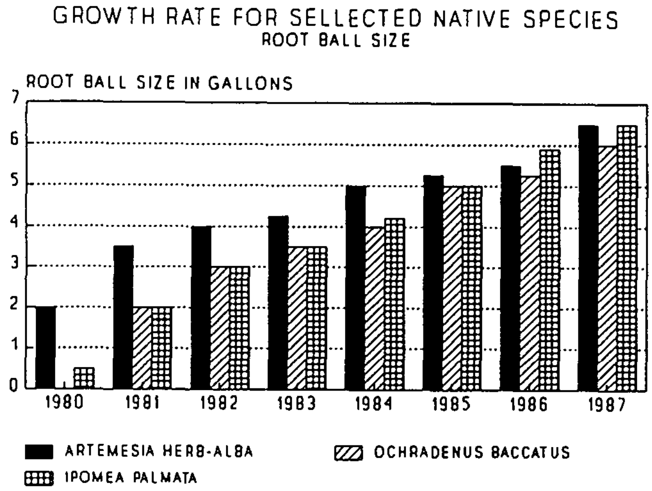



**Fig 87: A comparison in water consumption between <u>Ziziphus nummularia</u> and <u>Thevetia nerifolia</u>.** The water amount for <u>Ziziphus nummularia</u> applies during the summer season only, no watering is needed during a normal winter.

## SHRUBS AND GROUND COVER:

Three native shrub species, <u>Artemisia herb-alba</u>, <u>Ochradenus baccatus</u> and <u>Ipomea palmata</u> performed excellently, especially <u>Ochradinus baccatus</u> which was exposed to the direct environmental factors and not sheltered by any other species. The <u>Artemisia herb-alba</u> was successful as an individual plant but did not blend well with the composition due to its distinctive silver grey colour, which is rare in arid shrubs, It could be used as a specimen or ornamental, especially as it can respond positively to heavy pruning. The <u>Ipomea palmata</u> was especially flourishing in its growth rate as shown in Figure 88, and harmonizes satisfactorily with the rest of the composition especially with the <u>Ziziphus nummularia</u> and the gravel mulch material. It was noticed that it was sensitive to the river washed gravel ,which was spread over the top soil by the contractor, as this absorbed a great deal of heat in the summer season.



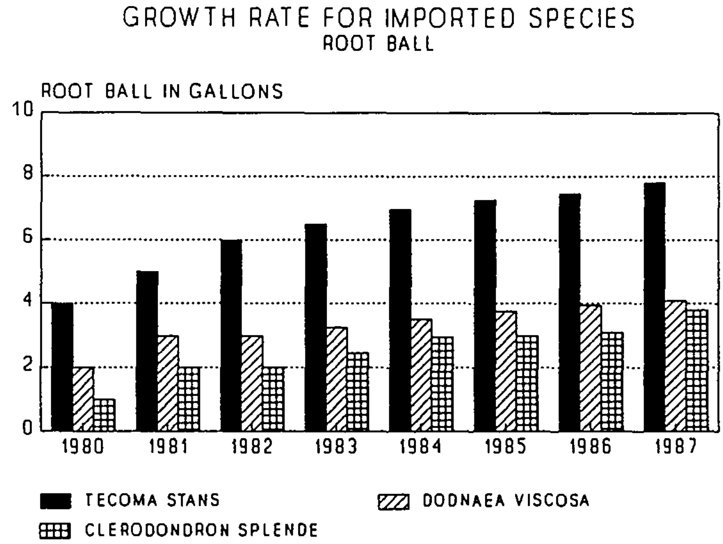




**Fig 88: A comparison between the growth rate of the root ball for <u>Artemisia herb-alba</u>, <u>Ochradenus baccatus</u>, <u>Ipomea palmata</u>, and <u>Tecoma stans</u>, <u>Dodonaea viscosa</u> and <u>Clerodondron splender.</u>**

Although the Native species were irrigated with lower quality and quantity of water (Fig 88, 89) they maintained a fast growth rate especially <u>Ochradenus baccatus</u> which maintained an excellent growth rate from seed compared to <u>Dodonaea viscosa</u> which was planted from 2 gallons seedlings([83]).

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[83] These imported species were planted in the eastern part of the Diplomatic Quarter at the same time. Information based on records during planting and a site measurement in the summer of 1987.

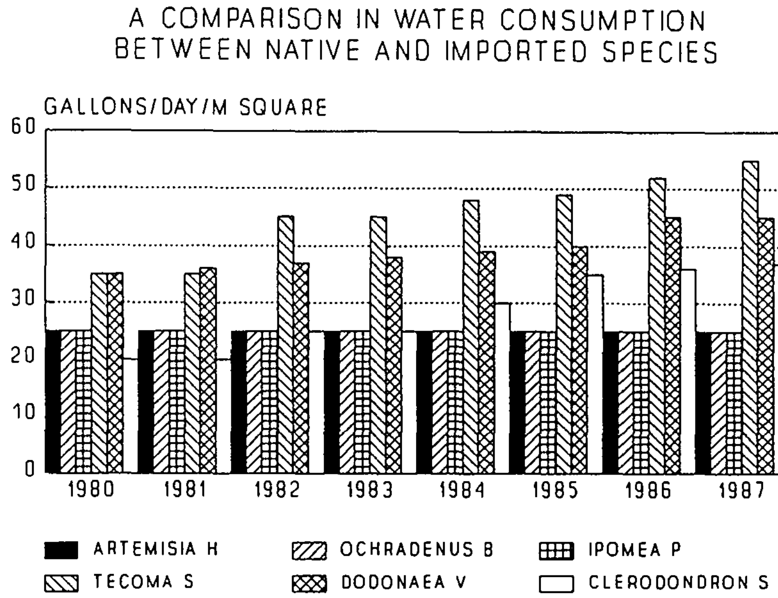


**Fig 89: A comparison in water consumption between native and imported species of composition 1.([84])**

To enable the use of each species from this composition to be utilised in the landscape field, a record of its botanical description along with the test result is essential due to the deficiency of such information. This is covered in the Flora, chapter 6.

[84] All the water consumption measurements were taken during the summer season only due to its critical effect on the plants.

## SECOND GROUP

## THE TREES

Although this group was sheltered by the first group it contains trees which are usually the highest plant layer. Exposure to direct sunlight increases the magnitude of water discharge adding to the salinity of the soil. Planting a layer of salt tolerant shrubs under selected trees will absorb the increasing salinity. The growth rate of such trees, a comparison of both water consumption and growth rate to imported species, and the salinity level was monitored from 1980 to 1988 (Fig 90 & 91). Fig 90 shows their growth rate, covering both the root and the canopy.

The root ball growth rate for the indigenous variety was greater compared to Ficus nitida, which was slow in its growth rate. Although it is imported, planted in a much richer soil, continually irrigation and given intensive care, its growth progress does not equal native species. Evaluating both graphs one find that Prosopis juliflora, Ziziphus spina-christi and Caltopris procera are the most successful in both their root and canopy growth rate. The sudden increase in the graph during 1985 was due to a torrential rain fall boosting their growth rate. They coped well with such unpredictable environmental behaviour, while Ficus nitida deteriorated as a result, especially when the rain fall was torrential in nature.

Despite Acacia farnesiana being slower in its root growth rate it is very attractive and blends well with the Najdi environment. It maintains a seductive image shooting directly from ground level with dark green small leafs and yellow flowers. Tamarix aphylla wasn't fast in its growth rate, nor attractive in its form. However, it can survive in rigorous growing conditions and was used traditionally to stop sand dunes. The previous Table 22 shows that it was exposed fully to the sun, and still claimed satisfactory growth. That qualified it to be used for a shelter belt and dune conservation projects. Prosopis cineraria maintains the same growing progress as Tamarix aphylla but maintained a more attractive form and colour, however it cannot compare as a shelter belt tree.

When the native species received a constant quantity of water, their growth rate was not affected, and they maintained a superior rate over the imported species. The second graph proves that due to their adaptability to salinity and their minimal water discharge the salinity level in the soil was lower and still acceptable. In contrast, imported species increased salinity level in their top soil and consequently consumed more water for the leaching technique needed to reduce salinity levels.[85]

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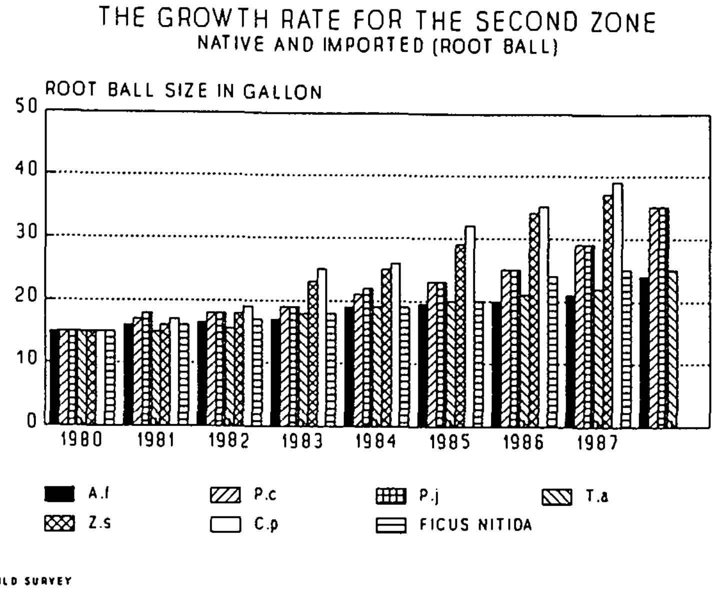
[85] Salinity data and information obtained from Omrania irrigation department and A.D.A maintenance department.



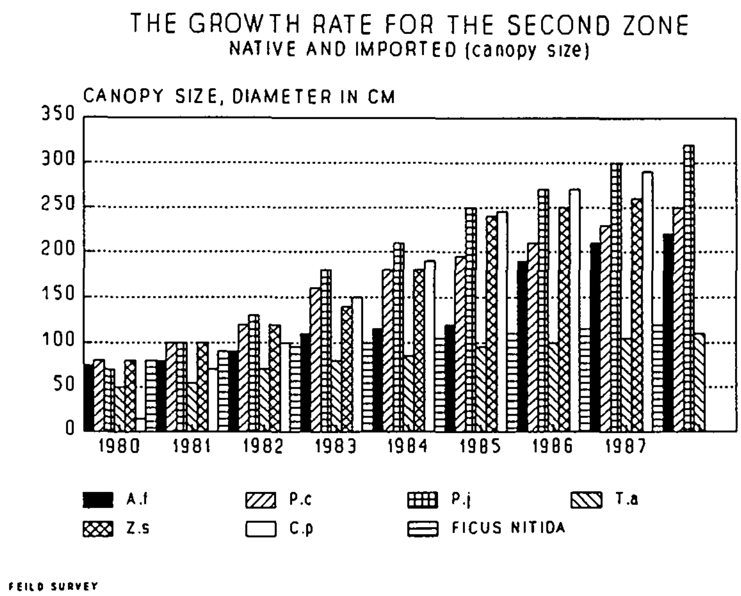
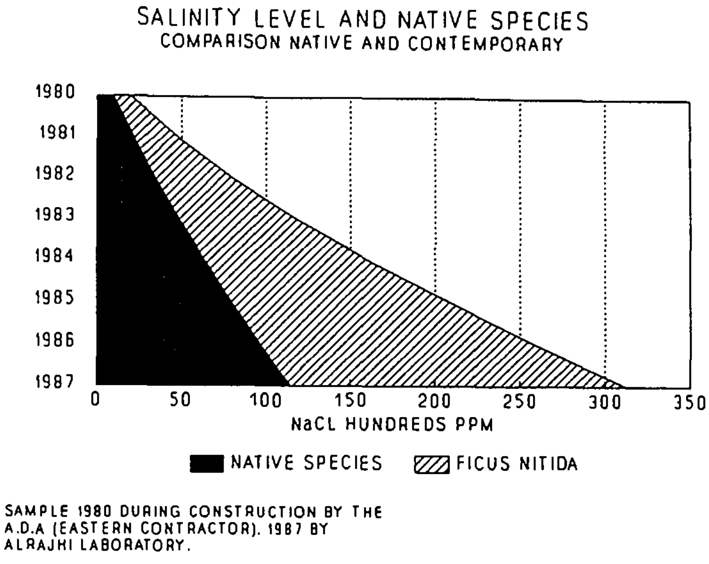




**Fig 90: The growth rate for native species. Noting that the above graph is for root and the lower one for the canopy growth rate.** [86]

LEGEND A.f= Acacia farnasiana, P.c= Prosopis cineraria, P.j= Prosopis juliflora, T.a=Tamarix aphylla , Z.s=Ziziphus spina-christi, C.p=Caltropis procera.

[86] field survey



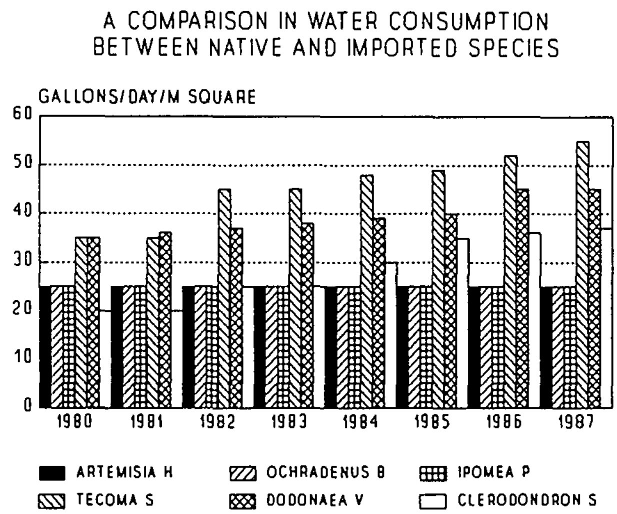




**Fig 91: Compares water consumption and salinity level between native and imported trees.**

## SHRUBS

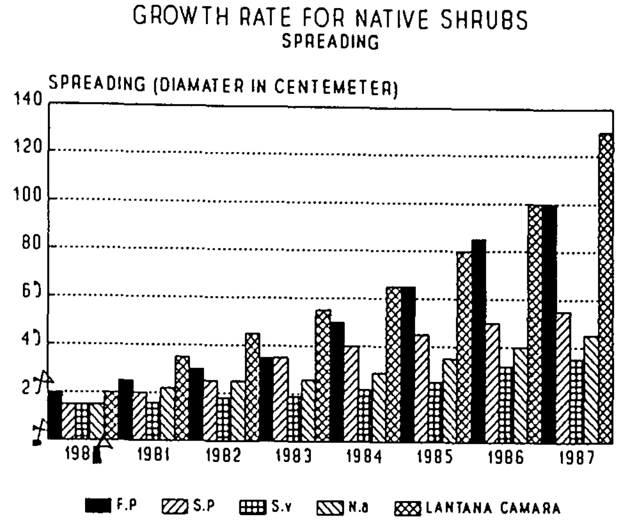
Shrubs are the ultimate design tools for the landscape architect in arid zones. They are essential to provide texture and space definition. The shrubs used in this group aimed to serve these functions in similar site conditions. Imported shrubs are exceptionally sensitive to irrigation and they need to be zoned and grouped in order to be irrigated at specific times with a variable water quantity. This test will demonstrate the ability of native species to be used in landscape design, without such complicated irrigation systems. The shrubs used here were planted in 1980 from seeds and seedlings (mentioned earlier). They were not subject to any man made aid, and still retained their original adaptation level.

Most of these shrubs (listed in Table 22) were sheltered by the larger trees and used as different design tools: specimen; as a group or as a compacted hedge. The latter form of use is not recommended as an appropriate landscape application in the Najdi environment. The compaction of native species of shrubs is usually against the root habit, requires the use of irrigation to achieve such compaction, increase water transpiration and is not characteristic of the natural distribution of shrubs in arid lands.

The shrubs were monitored for the last six years maintaining the factors discussed earlier. Most of the species were not sheltered by other plants and therefore the environmental factors had an optimum impact. The two prime and most prominent factors here are the fact that they were being irrigated during the summer with constant amount of water and the soil was local and of moderate quality. The maintenance level was minimal and limited only to weed control. An imported species was selected to compare native shrub growth rate against. The species chosen was Lantana Camara due to its planting time, available information and its reputation of being successful and widely used in the central region. An illustration of the most successful shrubs is included in the flora. These shrubs are qualified according to their growth rate and salinity tolerance.

Fig 92 shows the growth rate for both the selected native species and Lantana Camara. It is clear that the root ball statistics graph indicates that Ficus pesudosycamours and Salosa vermiculata are almost as fast as Lantana Camara in their growth rate. They not only grow fast under such conditions but they are more attractive. Considering the harsh conditions that the remaining species were exposed to, they would be classified as thriving and qualify as important landscape design material.

The spreading graph below shows that Lantana Camara, grew faster due to the amount and the quality of irrigation water it received and the rich soil conditions it requires. However, the native species diameter is satisfactory for landscape design use. In brief, Ficus pesudosycamours, Salosa pacitoi and Nabasis articulatia were acceptable in their growth rate for both root and spread.



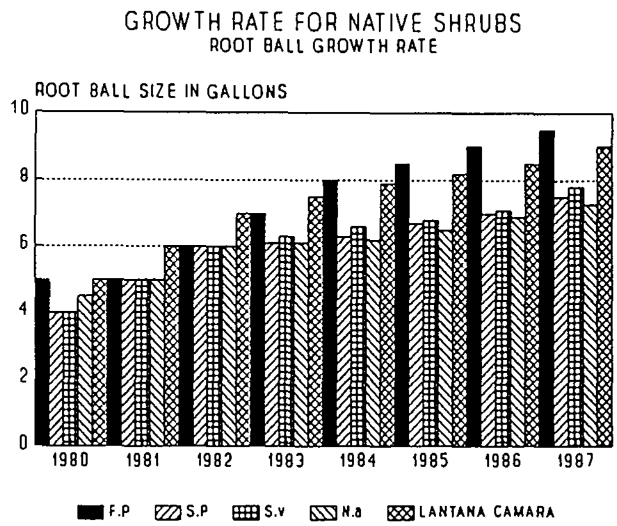




**Fig 92: Shows the growth rate for native shrubs, root ball and spreading. (The other physical factors will be mentioned in the data sheet later in this chapter).** F.P= Ficus pesudosycamours, S.p= Salosa pacitoi, S.v=Salosa vermiculata, N.a=Nabasis articulatia

During the test there was no record of any pests or diseases except for a weed colonization at the root zone. The occurrence of the nutrition[87] zone around the root zone of an arid species seemed to apply here only under harsh conditions.

Salinity causes stunting of most imported flora. In contrast native species, although able to thrive in non-saline substrate, usually grow better with the presence of salt. The graph in Fig 93 shows that salinity level in the soil beneath native species was less than that under Lantana Camara, although the latter was planted in salt free soil and fitted

[87] Nutrition zone is the zone above the root ball of a surface rooting plant which is native to arid area. That zone is usually uncolonisable by other plants.

with an R.O system for water desalination. Such success showed that native species are adapted to high salinity levels and they also reduce the salinity level in the soil. They were found to be thriving at higher salinity level. For example the Artemisia spp being grown in the A.D.A nursery in the absence of NaCL, registered a growth of 25 cm high in two years whilst at the optimal NaCL concentration level (120mM) it reached a height of 47 cm. Such growth rates were achieved under dry chamber conditions. [88]

Fig 93 shows that native species thrive with low relative humidity and high salinity.[89] The graph indicates that during high relative humidity the growth rate was not as satisfactory as low.

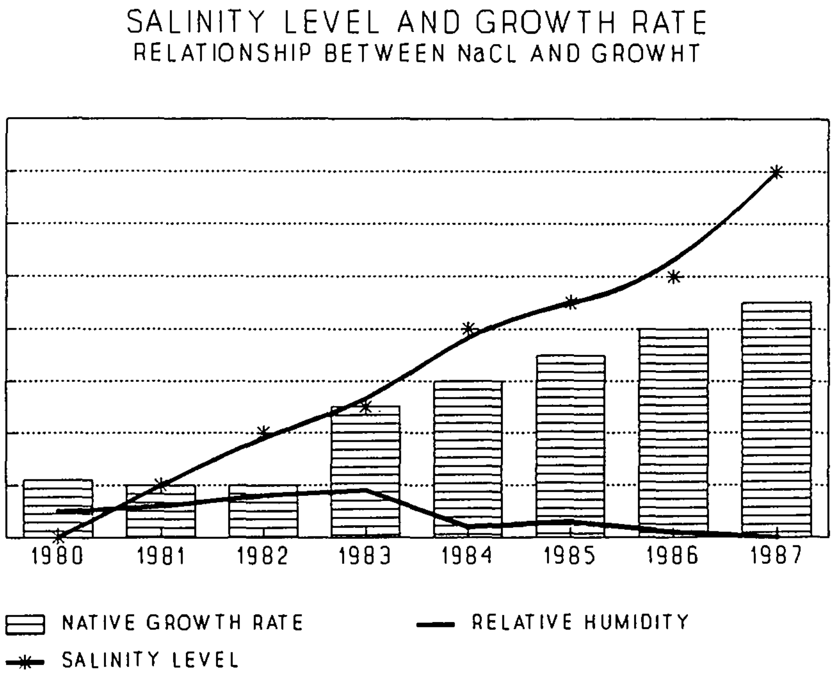



**Fig 93: Salinity level and growth rate and also registers the effect of both native and imported species on salinity level in the soil.**

It is clear that, as the imported species discharge more water to counterbalance the harsh climatic conditions, the salinity level has increased dramatically during the past six years; whereas under the occupation of native species the salinity level increase was minimal for the reasons mentioned before and because of their low level of water discharge.

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88 This method of testing growth rate under salinity was adapted by the A.D.A according to that by Shahamgold 1963. Paper in Pojakof, A. p 98.
Shahamgold, *interaction between gebberelin and NaCl in their effect on growth of Atriplex halimus.* M.Sc. Thesis (in Hebrew). The Hebrew University of Jerusalem (1963).

89 These readings were obtained from the Ministry of Atmospheric reports, A.D.A and recorded growth rate for some native species.

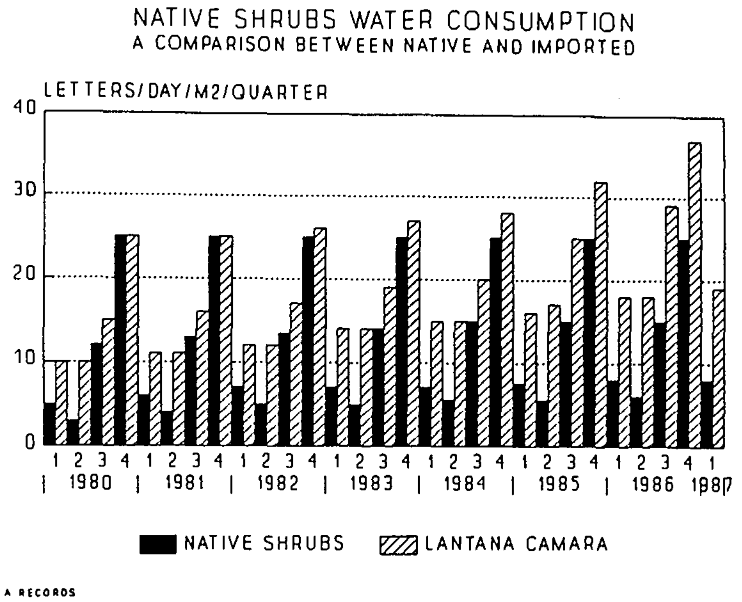


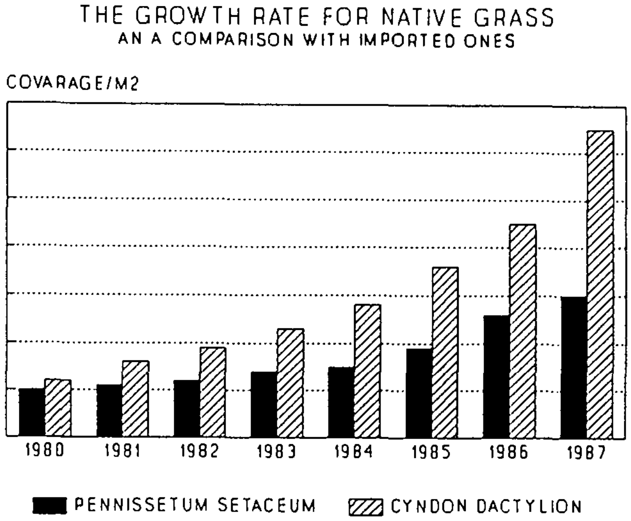

**Fig 94: Displays a comparison of water consumption between native and imported shrubs.**

The graph in Fig 94, which is divided into the four seasons, indicates that during the winter and autumn the irrigation for native species was minimal compared to <u>Lantana Camara</u> which required from the beginning a high amount of irrigation water. Native species did not register any response to water reduction which was carried out in the winter and autumn. Moreover, the natives were planted in a poorly drained soil with no record of any leaching operation.

The same growth rate for these native species applies to the other native shrubs planted that were governed by similar conditions. (For full comprehensive data see the testing data later in this chapter).

## (1) GRASS

Grass, as used in western gardens has proved to be in complete conflict with the Najdi ecoenvironmental factors as mentioned in Chapter two. Here, this test will assess the water consumption and growth rate for native grass against that of imported. Although this zone was receiving a constant water quantity, the grass was planted away from the stream irrigation to avoid the possibility of any blockage to the system. The grass was found to be receiving a minimal amount of water obtained from the neighbouring soil estimated at 3/litre/m$^2$/day in the summer. Despite such little water, the graph (Fig 95) shows that the coverage for such grass/m2/year from a single division compared satisfactorily to <u>Cyndon dactylion</u>, which was receiving an amount of irrigation water estimated at 25 litres/m$^2$ day for each m$^2$.



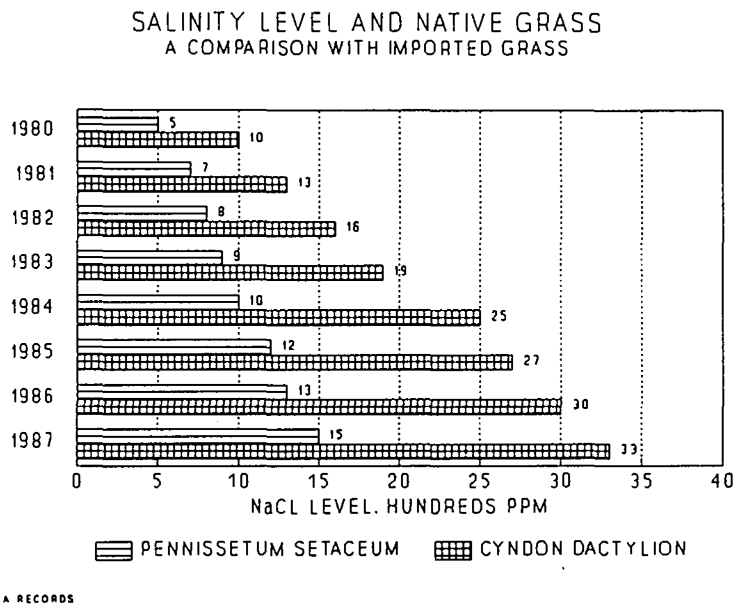




**Fig 95: Above: the growth rate for native grass, and a comparison with imported one. Below: the graph shows a study of the NaCL level in the soil after six years and without any leaching operation for both species of grass.**

Looking at the growth rate for both native and imported grass ,it is clear that the imported one was growing faster. This was due to; firstly the quality and amount of irrigation water it received and the high quality soil it required. Secondly, such grass require imported fertilizers, thereby requiring special treatment for the first three years in order to establish the grass. A comparison of cost /$m^2$ will clearly justify such growth rate. For example, a cost of a $m^2$ of native grass with a coverage ratio of 25%/$m^2$ costs 5 pounds a year, while the cost of Cyndon dactylion will costs 60 pounds a year with an increasing chance of failure.

This reinforces the theory of using native grass as found in nature, environmentally or as part of the planting composition (Fig 96), i.e without mowing or any modification to the natural form.

**Fig 96: Shows the first zone. Acacia farnasiana, Ziziphus spina-christi and Prosopis juliflora in the background with Caltropis procera and native grass in the foreground. Notice how the native grass is used as a mass of ground cover.**

## 4. THE SECOND TEST SITE

This test site is located in the D.Q adjacent to the first site (Fig 98). In 1984 the maintenance department decided to reduce watering to stoppage in this area.[90] There was no obvious reason behind such a decision other than possible infrastructure development which might take place in late 1989. The instruction to the maintenance personnel stated that irrigation must stop immediately and the plants should be cleared or left, to save maintenance cost for this area. After discussion the head of the landscape and planning department was persuaded to allow part of the site for the second test. This was used to observe the effect of water reduction on the native species behaviour and spatial variation. It was approved that water reduction should take place in coordination with the maintenance department, on conditioned that the test should be completed by the beginning of 1989.

On the author's suggestion as an alternative to sudden water stoppage, the maintenance department agreed to reduce the irrigation gradually according to a specific time table and maintain a schedule of irrigation reduction which is shown in Fig 97. The aim of this test was to firstly, determine the minimum water quantity for the survival of native species while maintaining a satisfactory growth rate; secondly to assess the change in form, habit, colour and growth rate of these species as a result of water reduction. Thirdly, discover which were the most successful species in the event of drought or water being inadequate. Also the test will monitor the new species introduced by succession to the site during the operation. The test points to the importance of further research into the colour control features which occur from using different quantities of irrigation water.

In 1980 selective native species were planted using the same target species approach, method and soil composition as in the first test site. As shown in the Fig 97 below, the water was reduced gradually from early 1984 to be completely stopped by the end of 1988.

Water reduction took place in 1986, ending in 1988, as shown in the graph. The gradual water reduction started towards the end of January 1987; to allow step-by-step preparation for such reduction, the quantity was increased as the summer season drew on to counterbalance the anticipated heat. In a continuous irrigation decline this trend was carried out till the irrigation flow was finally terminated in the winter of 1988.

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[90] Maintenance department. A.D.A.

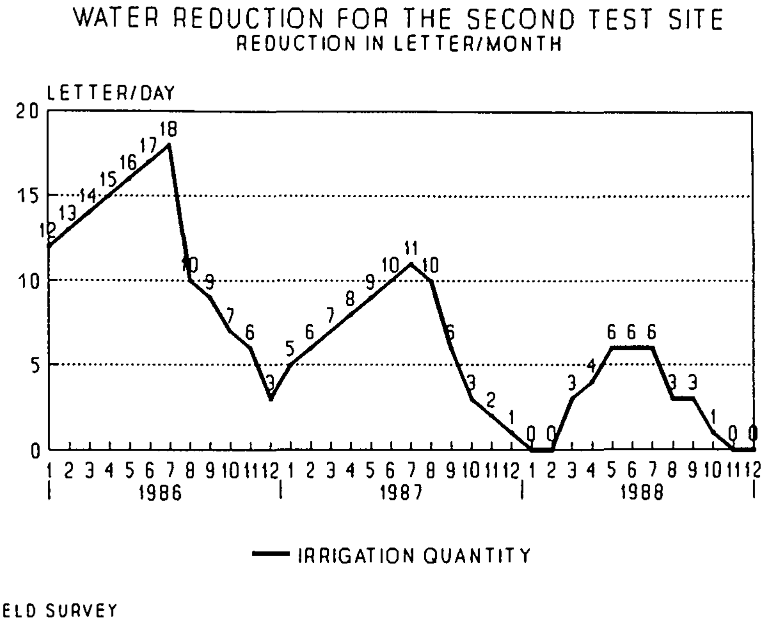


**Fig 97: The water reduction process and quantity.**

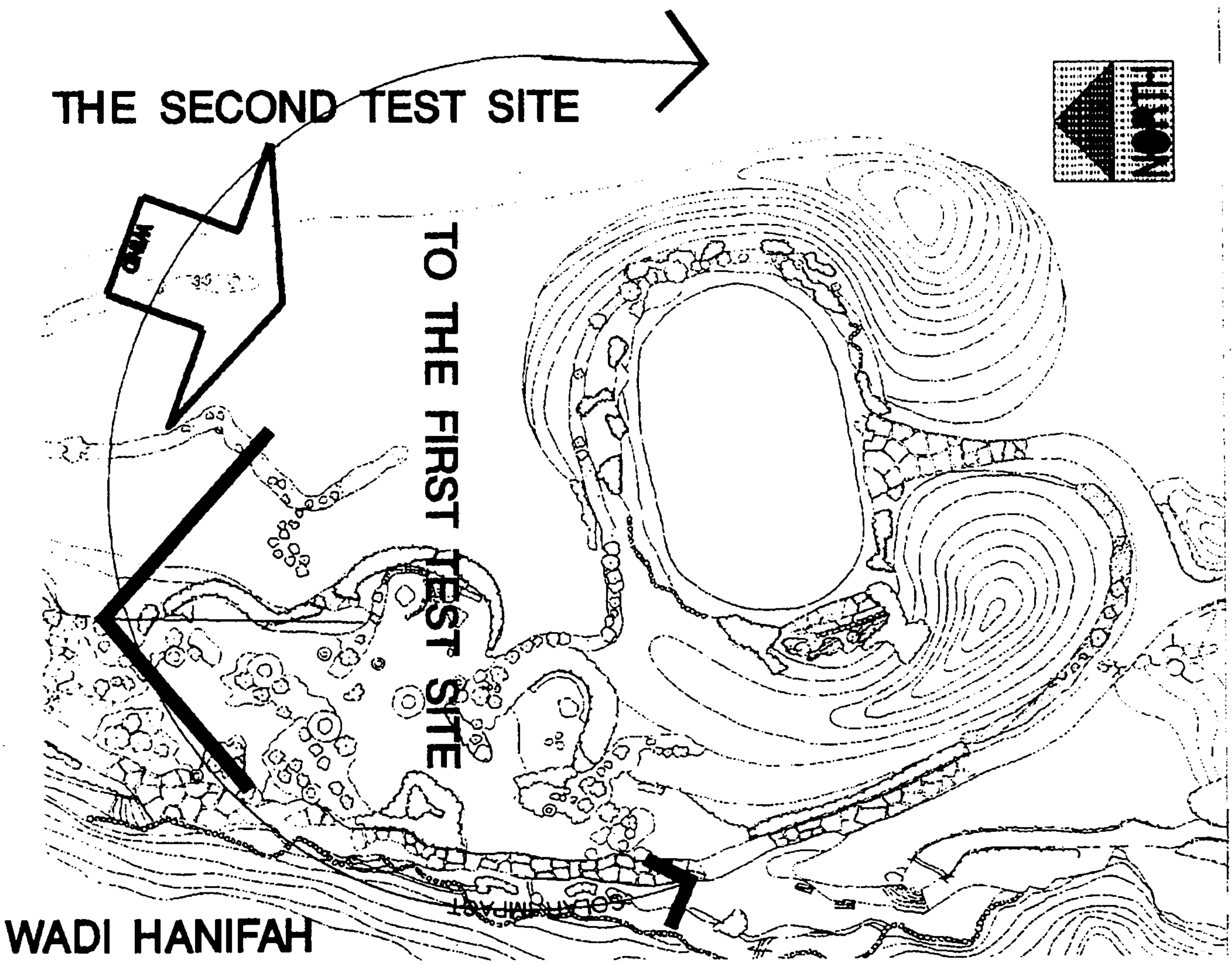


**Fig 98: The second test site. It was sheltered as shown by the first test site.**

## 4.1 THE EFFECT

Till the test commenced, all plants maintained the same growth rate as for the first test. During the first six months after the water reduction started there was no sign of change in behaviour except that, early in the summer of 1984 change in colour started to appear. Flower colour hue was brighter, and leaves started to react to the scarcity of water by reducing their size and their orientation, which presented the species in a dense, textured form. This colour change was noticed and monitored during the first two years of this operation as shown later in this study.

At the end of the 1987 summer season some species started to retreat, disappearing completely by the end of the 1988 summer season. The remaining species were considered as tolerant of an unpredictable drought. Fig 99 shows both the first test site and the second test site in late summer of 1988. The difference in growth rate was clear from the only remaining species and grass. Although there was a loss of some species more unique species started to germinate. These will be included as the secondary target species for the dry extensive landscape zones in Najdi cities.

Two major results could be extracted; the important colour shift theory, that is to employ the change in species colour as a design tool. Upon success of this theory, designers could start to use water quantity in association with the recommended species to control different hue of colour for the same species. Secondly, the surviving species two years after this test are clear nominees for extensive landscaping and areas vulnerable to drought. In addition during the progression of the test as the water stopped, succession occurred and new air borne species established.

**Fig 99: The second test site (left) and the first test site (right).**

## 4.2 COLOUR SHIFT FOR SELECTED SPECIES

This will focus on how certain species behave in response to a certain amount of water reduction. Management of water amount delivered to plants aims to introduce control over the plants colour hue and texture.

During this test, a manual portable irrigation scheme was designed to maintain the exact amount of water required by each individual species in order to maintain the desired degree of colour. The exact amount of water and its influence on colour change was summarised by graphs discussed later. The effect of such an operation on their strength and tolerance to wind effect was also monitored.

To control irrigation variation and frequency, a manual and portable irrigation scheme was commissioned to maintain the exact amount of water required to achieve certain colour hue. Once the desired colour and texture was achieved, the water quantity was frozen for one year.[91]

Visual observation on the site revealed that species showed a distinct colour shift represented by a change in leaf form and difference in texture. Subsequently, species that displayed such changes, were the target for maintaining the temporary irrigation quantity.

The following species listed in Table 24 were selected as candidates for target species to assemble the colour shift theory. They established a uniform colour during each irrigation phase. Each irrigation phase lasted for one year during which species that maintained a change colour hue were listed and recorded for further investigations. The author though that although such a feature might initiate a new design theory for arid lands, it requires special skills in research and technology to establish the genetic effect on the plant and long term effects. The theory was triggered by inadvertent observation of Vinca rosea. The author noticed the colour change between a number of plants from the same species and source, planted in several Ar-riyadh parks. Upon analysis, water quantity was the only different factor between those sites.

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[91] Due to the short duration of the test, a further research on its effect on strength and adaptability is recommended.

**TREES:**

<u>Acacia farnaziana</u>
<u>Acacia arabica</u>
<u>Albizia lebbeck</u>
<u>Prosopis cineraria</u>
<u>Prosopis juliflora</u>
<u>Tamarix aphylla</u>
<u>Ziziphus jujuba</u>
<u>Ziziphus spina-christi</u>

**SMALL TREES:**

<u>Acacia gerrardii</u>
<u>Caltropis procera</u>
<u>Prosopis fracta</u>
<u>Ziziphus numilaria</u>

**GROUND COVER:**
<u>Bassia erophoria</u>
<u>Diplotaxis acris</u>
<u>Hammada elegans</u>
<u>Heliotropium bacciferum</u>
<u>Ipomea sinensis</u>
<u>Ipomea pes-capri</u>
<u>Silene arabica</u>

**CLIMBERS:**

<u>Citrilus colocynthis</u>
<u>Clitoria ternata</u>
<u>Ipomea palmata</u>

**SHRUBS:**

<u>Abutilon pannosum</u>
<u>Atriplix halimus</u>
<u>Capparis cartilsqunea</u>
<u>Cassia italica</u>
<u>Cassia edulus</u>
<u>Datura inoxa</u>
<u>Ochradinus baccatus</u>

**SMALL SHRUBS:**

<u>Argemone mixicana</u>
<u>Asparagus africanus</u>
<u>Atriplix leucoclada</u>
<u>Belepharis ciliaris</u>
<u>Carrisa edulus</u>
<u>Ficus salisifolia</u>
<u>Hammada flegans</u>
<u>Hammada salicornica</u>
<u>Heliotropium digynum</u>
<u>Lavandula dentata</u>
<u>Peganum harmala</u>
<u>Tamarix amplexicaulis</u>

**GRASS:**

<u>Alopecurus agrestis</u>
<u>Arundo donax</u>
<u>Koeleria sinaica</u>
<u>Phragmetus Australi</u>
<u>Typha domingenis</u>

**Table 24: Species showed initial colour changes associated with water quantity.**

Table 24 lists the selected target species for the colour control method. Table 25 lists the amount of irrigation/ year/ plant and the determined water amount related to the desired colour and texture.

| SPECIES | IRRIGATION 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 |
|---|---|---|---|---|---|---|---|---|---|
| **TREES:** | | | | | | | | | |
| Acacia farnaziana | | ,, | ,, | ,, | 18 | 14 | 10 | 4 | 2 |
| Acacia arabica | ,, | ,, | ,, | ,, | 16 | 10 | 8 | 0 | 0 |
| Albizia lebbeck | ,, | ,, | ,, | ,, | 20 | 13 | 8 | 5 | 0 |
| Prosopis cineraria | | ,, | ,, | ,, | 20 | 15 | 10 | 5 | 0 |
| Prosopis juliflora | | ,, | ,, | ,, | 15 | 10 | 5 | 0 | 0 |
| Tamarix aphylla | ,, | ,, | ,, | ,, | 10 | 8 | 5 | 0 | 0 |
| Ziziphus jujuba | ,, | ,, | ,, | ,, | 20 | 15 | 10 | 5 | 0 |
| Ziziphus spina-christi | | ,, | ,, | ,, | 15 | 10 | 8 | 3 | 0 |
| **SMALL TREES:** | | | | | | | | | |
| Acacia gerrardii | ,, | ,, | ,, | ,, | 20 | 15 | 8 | 5 | 0 |
| Caltropis procera | | ,, | ,, | ,, | 10 | 5 | 2 | 0 | 0 |
| Prosopis fracta | ,, | ,, | ,, | ,, | 20 | 15 | 8 | 5 | 0 |
| Ziziphus numilaria | | ,, | ,, | ,, | 15 | 10 | 8 | 2 | 0 |
| **GROUND COVER:** | | | | | | | | | |
| Bassia erophoria | ,, | ,, | ,, | ,, | 10 | 5 | 3 | 0 | 0 |
| Diplotaxis acris | ,, | ,, | ,, | ,, | - | - | - | - | - |
| Hammada elegans | ,, | ,, | ,, | ,, | ,, | ,, | ,, | ,, | ,, |
| Heliotropium bacciferum | | ,, | ,, | ,, | ,, | ,, | ,, | ,, | ,, |
| Ipomea sinensis | ,, | ,, | ,, | ,, | 20 | 15 | 10 | 5 | 0 |
| Ipomea pes-capri | ,, | ,, | ,, | ,, | 20 | 15 | 10 | 5 | 0 |
| Silene arabica | ,, | ,, | ,, | ,, | ,, | ,, | ,, | ,, | ,, |
| **CLIMBERS:** | | | | | | | | | |
| Citrilus colocynthis | | ,, | ,, | ,, | 10 | 5 | 3 | 0 | 0 |
| Clitoria ternata | | ,, | ,, | ,, | 20 | 15 | 10 | 5 | 0 |
| Ipomea palmata | ,, | ,, | ,, | ,, | 20 | 15 | 10 | 5 | 0 |
| **SHRUBS:** | | | | | | | | | |
| Abutilon pannosum | | ,, | ,, | ,, | 15 | 10 | 5 | 3 | 0 |
| Atriplix halimus | ,, | ,, | ,, | ,, | ,, | ,, | ,, | ,, | ,, |
| Capparis cartilsqunea | | ,, | ,, | ,, | ,, | 10 | 8 | 5 | 0 |
| Cassia italica | ,, | ,, | ,, | ,, | 20 | 15 | 10 | 5 | 0 |
| Cassia edulus | ,, | ,, | ,, | ,, | ,, | ,, | ,, | ,, | ,, |
| Datura inoxa | ,, | ,, | ,, | ,, | 15 | 10 | 8 | 5 | 0 |
| Ochradinus baccatus | | ,, | ,, | ,, | 10 | 5 | 3 | 0 | 0 |
| **SMALL SHRUBS:** | | | | | | | | | |
| Argemone mixicana | | * | * | * | * | * | * | * | * |
| Asparagus africanus | | * | * | * | * | * | * | * | * |
| Atriplix leucoclada | | * | * | * | * | * | * | * | * |
| Belepharis ciliaris | | * | * | * | * | * | * | * | * |
| Carrisa edulus | * | * | * | * | * | * | * | * | * |
| Ficus salisifolia | | * | * | * | * | * | * | * | * |
| Hammada salicornica | | * | * | * | * | * | * | * | * |
| Heliotropium digynum | | * | * | * | * | * | * | * | * |
| Lavandula dentata | | * | * | * | * | * | * | * | * |
| Peganum harmala | * | * | * | * | * | * | * | * | * |
| Tamarix amplexicaulis | | * | * | * | * | * | * | * | * |
| **GRASS:** | | | | | | | | | |
| Alopecurus agrestis | | * | * | * | * | * | * | * | * |
| Arundo donax | * | * | * | * | * | * | * | * | * |
| Koeleria sinaica | * | * | * | * | * | * | * | * | * |
| Phragmetus Australi | | * | * | * | * | * | * | * | * |
| Typha domingenis | * | * | * | * | * | * | * | * | * |

**Table 25: Plants and irrigation amount. Each species's tolerance to water reduction was estimated by research into the individual species's history and characteristics. ,, & * (not calculated, 25l/week).**

### 4.3 COLOUR SHIFT, CONCLUSION:

### COLOUR SHIFT FEATURE:

Here are some selected examples of plants that were found sensitive to quantity of water by colour shift and the variety of colour hue which resulted:

Acacia arabica. Acacia farnasiana and Ziziphus numilaria, each reacted differently to the water reduction. Firstly Acacia arabica thrived on the experiment without change in colour or texture, due to its high adaptation magnitude to drought and different climatic changes. This proved and qualified the plant for urban, semi urban and extensive landscape projects. Acacia farnasiana displayed a distinctive change in colour as shown in Fig 100 below.

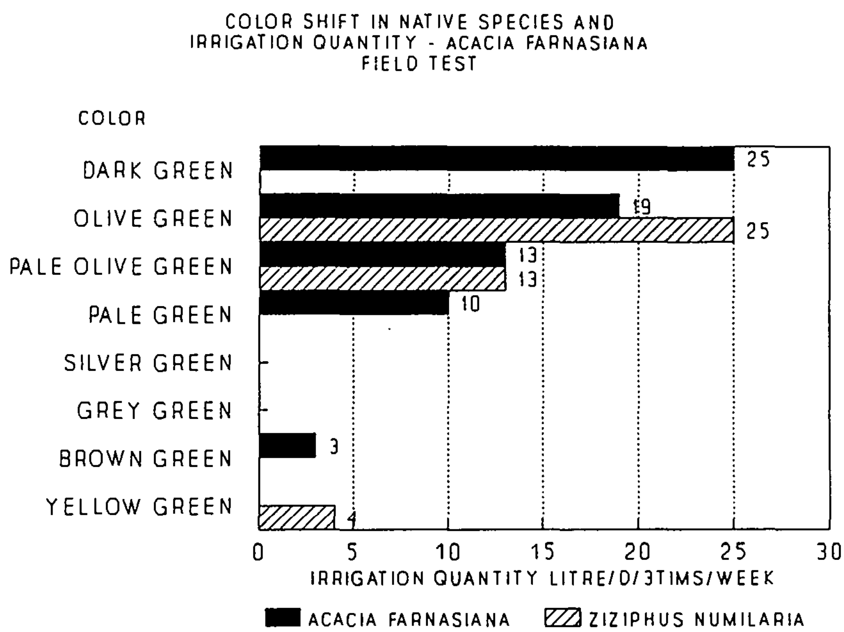
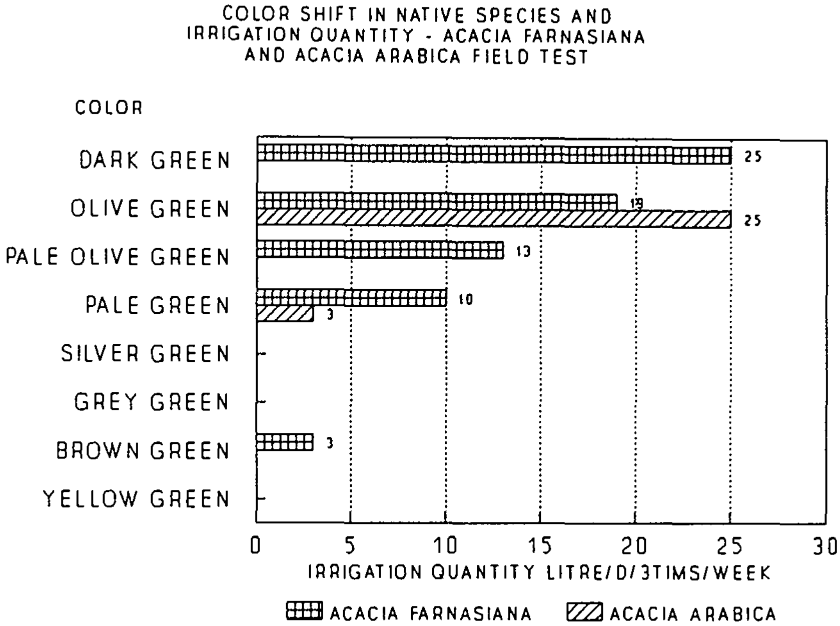


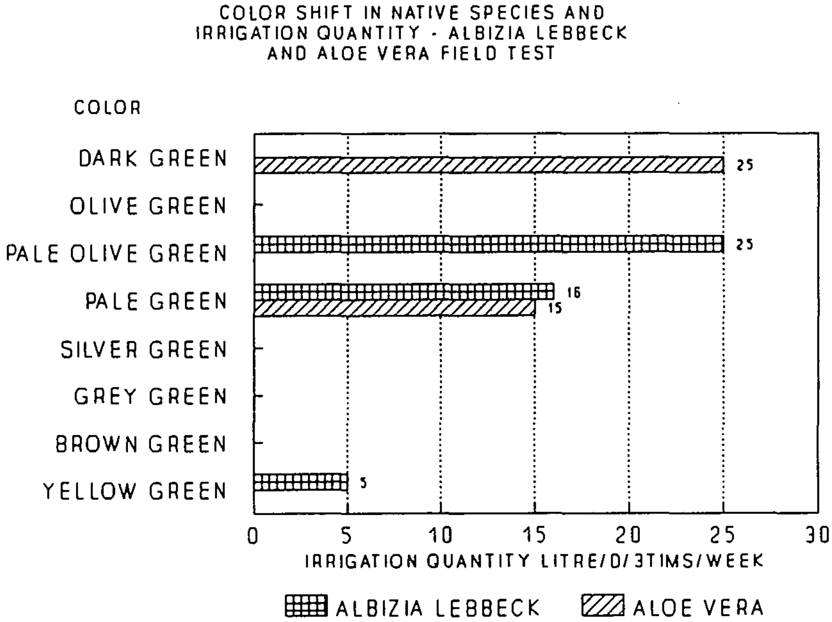

**Fig 100: Colour shift in both Ziziphus numilaria and Acacia farnasiana.**

Further research is needed for the assessment of how such species, like Acacia farnasiana will behave, when the last amount of irrigation water is fixed for three years. In this test site, each species was allocated a fixed irrigation quantity according to the colour desired and labelled in the test graph for a period of one year. This procedure was carried out for the remaining species in table 26, and will to be included in the conclusion of this testing method.

Below are some examples of selected species, their behaviour and change in colour. These examples aim to display the variation in colour associated with water reduction determining which species are to be the target for adjusting the quantity of irrigation water to achieve the desired colour.

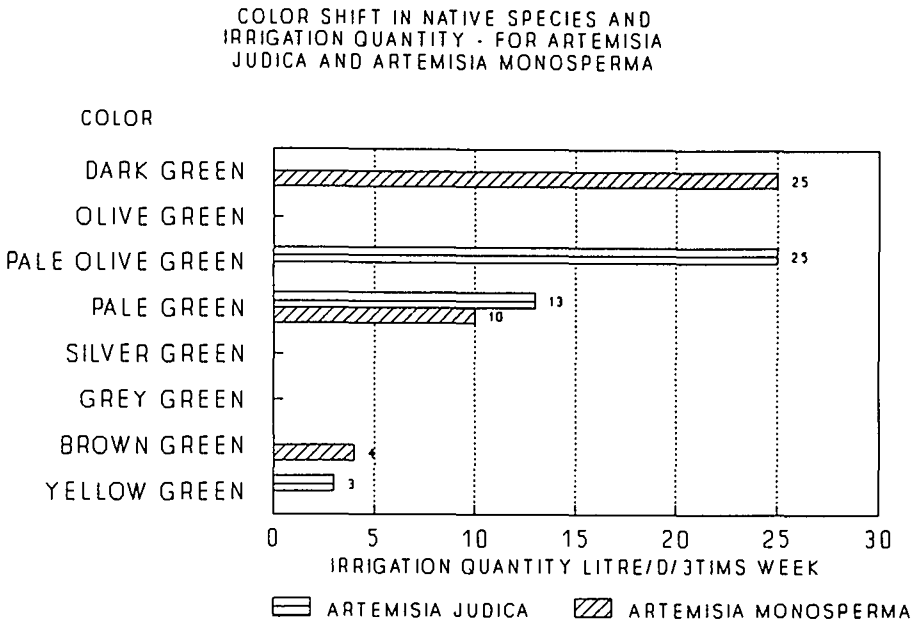



1. <u>Acacia arabica</u>. the graph above conclusively indicates minimal colour shift associated with the rather speedy water reduction. It also showed maximum adaptation to the cutback. <u>Acacia Farnasiana</u> reacted to each phase in water decline by change in colour hue which was noticed only in the summer. The top of its canopy, however maintained the original colour throughout the test.



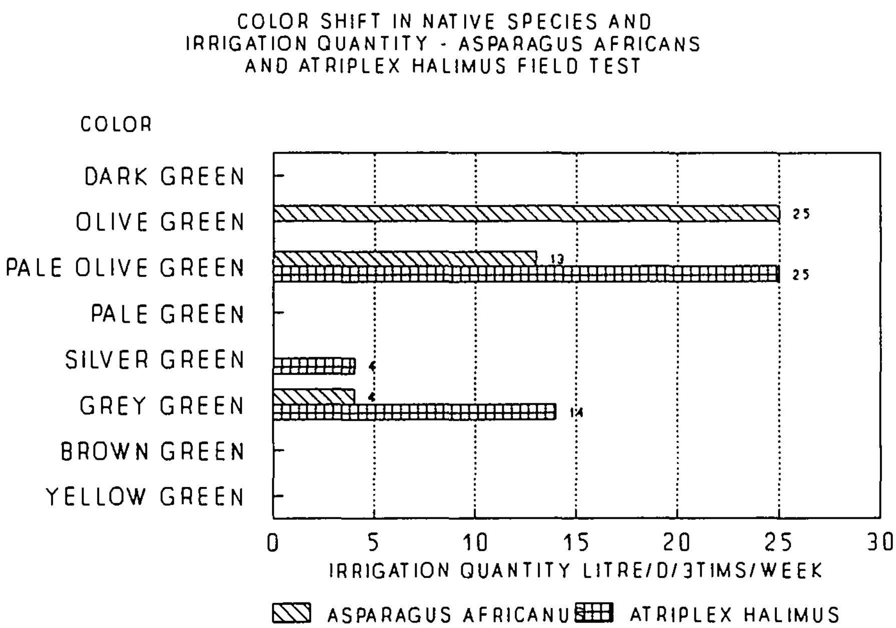

2. <u>Albizia lebbeck and Aloe vera:</u> Although <u>Albizia lebbeck</u> maintained a satisfactory growth rate, the achieved change in colour was not desirable, Its yellowish pale green was not as bright. As for <u>Aloe vera</u> the colour achieved was accompanied by a change

in form. The flower was more red than with the higher irrigation ratio. The water was frozen on 5/l/d 3/week.




3. Artemisia judaica and A. monosperma.

Both species maintained an attractive colour change throughout the test as shown in the graph below.




Atriplex halimus and Asparagus africans.

A distinctive change in the colour of both species was maintained especially in the Atriplex halimus with its silver grey colour when water quantity is decreasing.

## 5. CONCLUSION SECOND TEST SITE.

Two main conclusions could be drawn from the test. Firstly, there is little or no doubt that water amount has a definite influence on selected native plants colour and texture. However, the test should be carried out for at least ten years before it can be applied to general landscape use. Applying the test's result could be used as in fig 101. By planting an area with a single species, then dividing the surface into zones each irrigated with the appropriate water quantity, should produce the desired variation in colour hue. This theory proved to be most suited to ground cover.

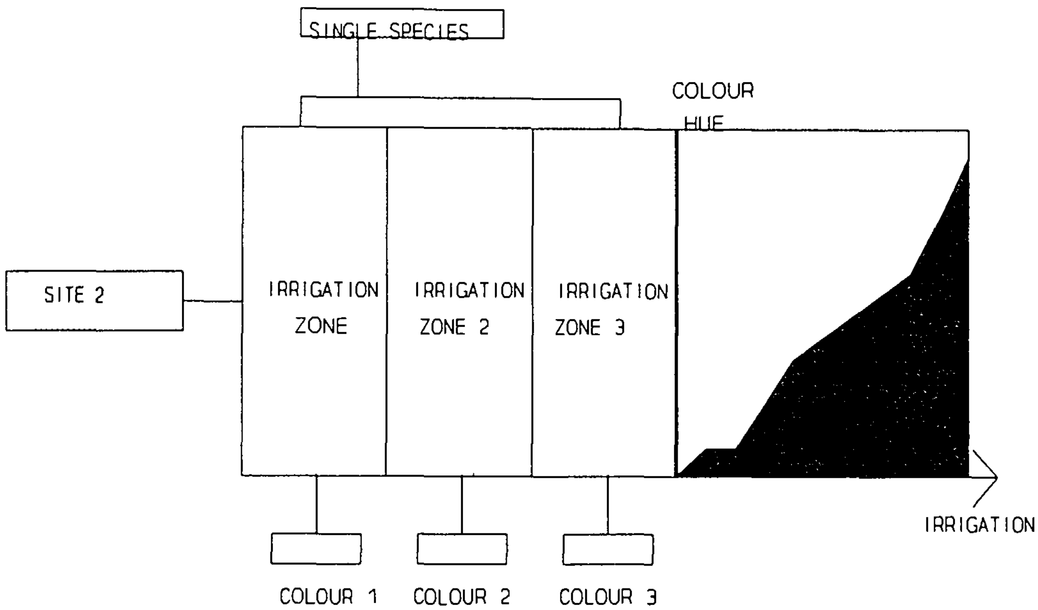



**Fig 101: Applying colour shift technique.**

Secondly, the test proved that plants which survived without irrigation are ideal species for amenity planting in Najd. Their response and characteristics makes them appropriate drought resistance species. They show significant tolerance to water decline and gradual increase in salinity level.

The plants remaining after water stoppage in 1988, and newly self-seeded communities are the key benefits from such a test.

**THE REMAINING SPECIES IN THE SITE 2 YEARS AFTER WATER STOPPAGE**

The following species (Table 26) still survived after two years of terminating the water supply. This indicates their tolerance of drought in arid landscape design and they are recommended for use in any type of landscape project which is likely to be exposed to a certain change in conditions or function.

| | |
|---|---|
| ACACIA ARABICA | Tree. |
| ALOE VERA | Succulent. |
| ARTEMISIA JUDAICA | Shrub. |
| ATRIPLEX HALIMUS | ... |
| CALOTROPIS PROCERA | Small tree. |
| CAPPARIS SPINOSA | Shrub. |
| CAPPARIS CARTILAGINEA | Shrub. |
| CUCUMIS PROPHETARUM | Climber. |
| DATURA INNOXIA | Small shrub. |
| FICUS SALICIFOLIA | Small shrub. |
| HAMMADA ELEGANS | Small herb. |
| PENNISETUM SETACEUM | Grass |
| RHAZYA STRICTA | Small shrub. |
| TAMARIX APHYLLA | Tree |
| ZIZIPHUS SPINA-CHRISTI | Tree. |

**Table 26: The remaining species two years after water stoppage.**

Although most of these species survived the unusual test some maintained their initial behaviour during the final irrigation course, especially Acacia arabica, Artemisia judaica, Atriplex halimus and Tamarix aphylla. The shrubs around their root zone failed to survive as a result of the nutrition zone theory, leaving the area with a landscape element characterized by a natural zonation and composition. The plants character and behaviour will be discussed later in the main Flora. Fig 102 shows these species at present, and how their form and colour is satisfactory. The yellow cast colour will develop to green in winter, (that applies to both the ground cover and the trees) without any additional irrigation.

**Fig 102: The second test site after water reduction.**

## NEWLY INTRODUCED SPECIES AS A RESULT OF WATER TERMINATION.

Four years of irrigation, the gradual change in microclimatic conditions for growing and decaying plants added to the soil a trace[92] of organic matter. This was colonized by air borne seeds, leading to the colonization of the site by a group of herbal flora. That was presented by a single Hammada salicornica community and its associated species which were not identified.

The main reason for not identifying such species was that their establishment causes are not controllable. Therefore their direct application, to landscape design, is not applicable and also they are generally considered as weeds.

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[92] According to recent soil test.

## C. THE THIRD TEST SITE

The site is located in an isolated part of the extensive landscape zone inside the D.Q. In this test the method of applying target community will be implemented for the first time in Najd. Such a revolutionary method may set a new standard in landscape design and establishment within Najd.

This test aims firstly to apply the target community method ,which was mentioned earlier, secondly to examine the growth rate for some target species when planted without irrigation or imported soil. Only the available soil existing on this site will be used. The species tested were selected from the associate species of the target community.

The site is currently controlled and managed by the maintenance department to prevent any grazing or irrigation activity (see letter, Appendix III). The site was classified into four main soil types, deep sand layer on a Riyadh stone bed; a bare rocky area; sandy gravely soil; and stony soil.

### 1. STRATEGY

In 1981 the site was allocated by the A.D.A, and the intention was to create a man made sand dune containing vegetation. The soil containing the seeds was collected during the summer of 1982 by the landscape department. It was transported to the site and spread on the existing top soil. There was no irrigation system fitted, the only source of water being the annual rain fall.

Wadi Hanifah, Khories and some other sites located along Mekkah Riyadh road, were the estimated source of seed. From these, a thin layer of the top soil was lifted, using the blanket method described in the testing methodology, and transferred to the test site by a simple manual operation. That layer was analyzed by the author using the records in the A.D.A files and a questionnaire to their landscape architects. The analysis revealed the exact location from which the soil was lifted. Site survey then followed, and thus detected the resident communities as listed below.

During this research it was found that by tracing the source of the collected soil which contained the seeds, the target community that this soil originally belonged to could be identified. The site was classified according to both the soil type and its resident plant community in order to obtain the key factors that affected the existing communities on the site.

It was noticed that successful communities were collected from a soil type similar to that of the test site. Each soil type was considered as a landscape unit to bear the relevant plant community as shown in Fig 103. A site survey for the surrounding Najdi desert was carried out to determine the matching target community to this site and its soil types. A site analysis for any future landscape project should also be used to distinguish its soil patterns and then choose the appropriate community from which to gather seed for that particular site.

## 2. COLLECTED PLANT COMMUNITIES

According to the field survey which was carried out during the summer of 1987 the collected soil was acquired from natural stands and found to contain the following communities shown in Table 27:

| * TREES | * SHRUBLAND COMMUNITY | * GRASSLANDS |
|---|---|---|
| Acacia gerrardii | Hammada Salicornica | Panicum turrgidum |
| Acacia raddiana | Rhanterium epposum | Pennisetum division |
| Ziziphus numilaria | Fracoeria crispa | Hyparrhenia hirta |
| Lycium shawii | Artemisia monosperma | Oropetium africanum - O. capense |
| | Salsola baryorma | |
| | Aellenia sulrophylla | |
| | Anabasis setifera | |
| | Chrypopogon plumulosus. | |
| | Cymbopogon comitatus. | |
| | Hyparrhenia hita | |

**Table 27: Detected plant communities in the third site.**

The collection, which was carried out by the landscape contractor, was not selective but targeted at any vegetation stands. Forming the sand dunes was the main target of the consultant. Target community method was applied by this research to the grown communities which established on the site, where they were identified later during this research.[93]

## 3. INITIAL SUCCESS

In 1987 there were distinct signs of flourishing patterns of certain plant communities colonizing the site. These started by seeds germinating on the site and continued by an increase in the number of plants on the site. Those plants clearly classify in to distinct communities, found to be related to the existing soil pattern of the site as shown in Fig 103. The thriving communities and their associate species proves that using a target community method could be successful as a landscape design tool, when the appropriate edaphical conditions, which suits each desired community are provided. This statement is supported by the fact that several communities originally seeded disappeared as a

[93] By the help of Sheila Collenette, Klaus Klein and Said Nour.

result of the absence of their optimum soil conditions. This factor is the key to applying this method. The process below summarises the target community method.

1. The local plant communities should be identified .

2. The particular ecogeomorphological, edaphical and climatical factors should be obtained.

3. A thin layer of the top soil under the selected community will be lifted using the blanket method after the seed production season.

4. The target site will be classified according to its soil pattern.

5. Each soil pattern will bear the relevant collected community soil which contains the seeds.

6. The spread soil will be left without any irrigation until the next rain season.

7. The result should be as shown in Fig 104.

Sites planted using this method may look idle for a long time. In fact, they are far from idle, as the monitoring process revealed[94]; their initial activity was primarily focused on their root growth. That phase should last for the first three to four years. Following this phase, a steady growth is then expected. Its speed is associated with other sub factors such as frequency and amount of rain fall, condition and level of underground water table.

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[94] The author selected two plants, Acacia Arabica and Ziziphus numilaria, to be uprooted for checking.

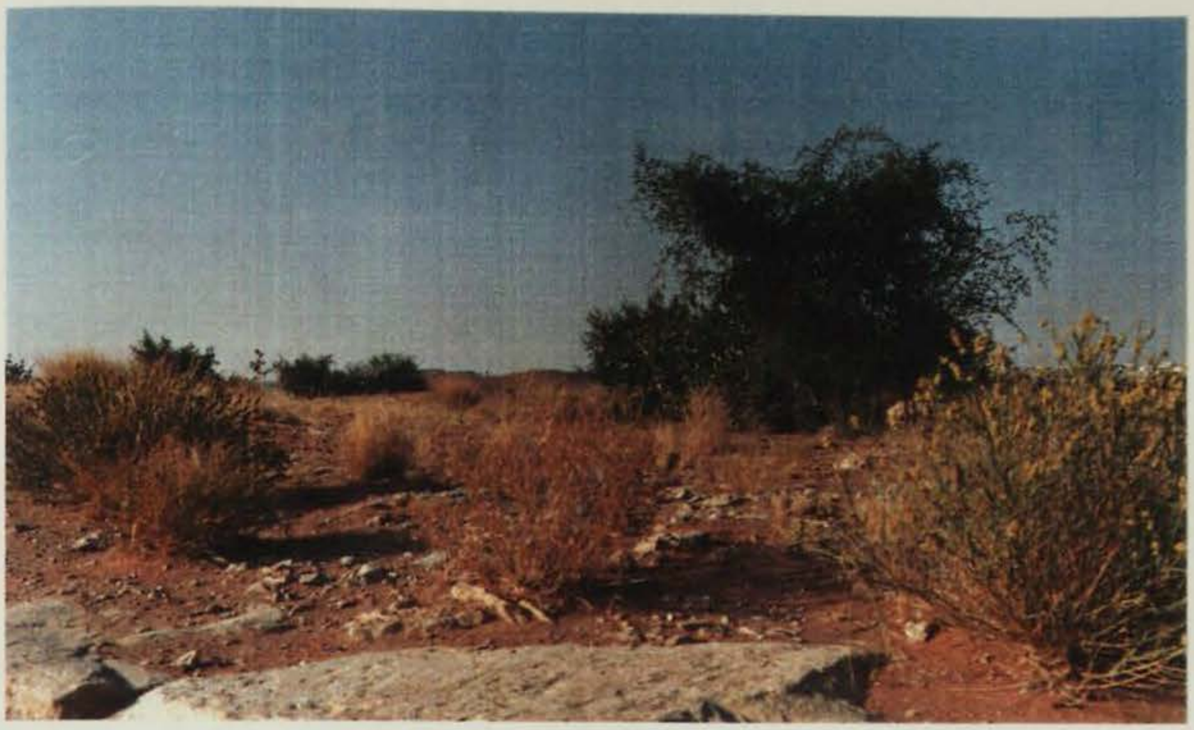


**Fig 104: the thriving community of Cymbopogon comitatus and Rhanterum epposum, after five years without irrigation or modified soil.**

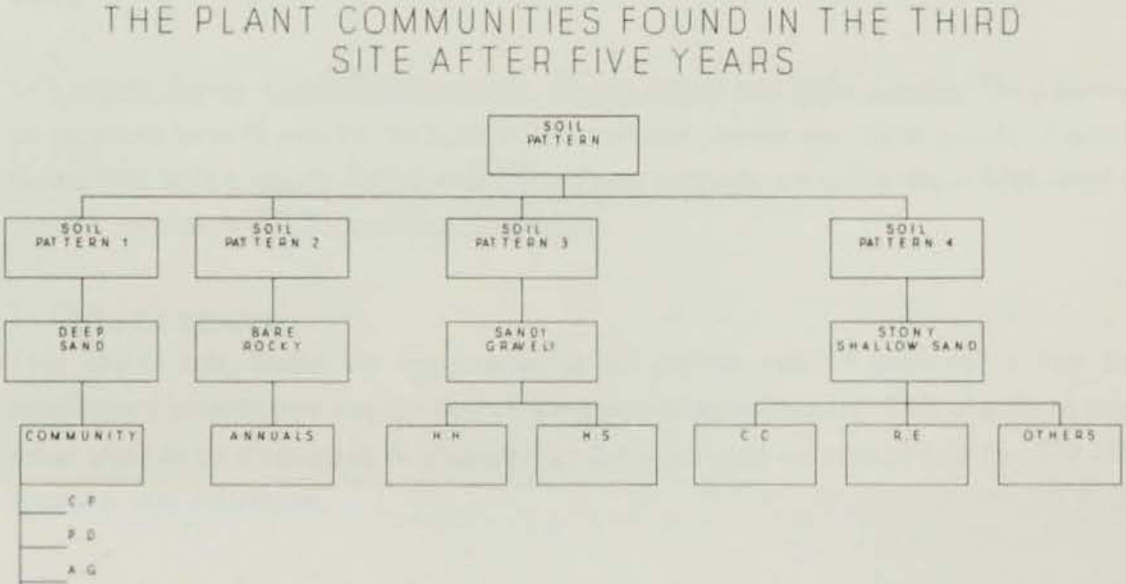



**Fig 103: The plant community found in the site after five years and its associate soil type.** C.P= Chrypopogon plumulosus, Z.n = Ziziphus nummularia P.D = pennisetum divisum, A.G= Acacia gerrardii, A.E = Acacia ehrenbergiana, H.h= Hyparrhenia hita, H.S= Hammada salicornica, C.C= Cymbopogon comitatus, R.E= Rhanterum epposum.

## 4. GROWTH RATE FOR THE ASSOCIATE SPECIES

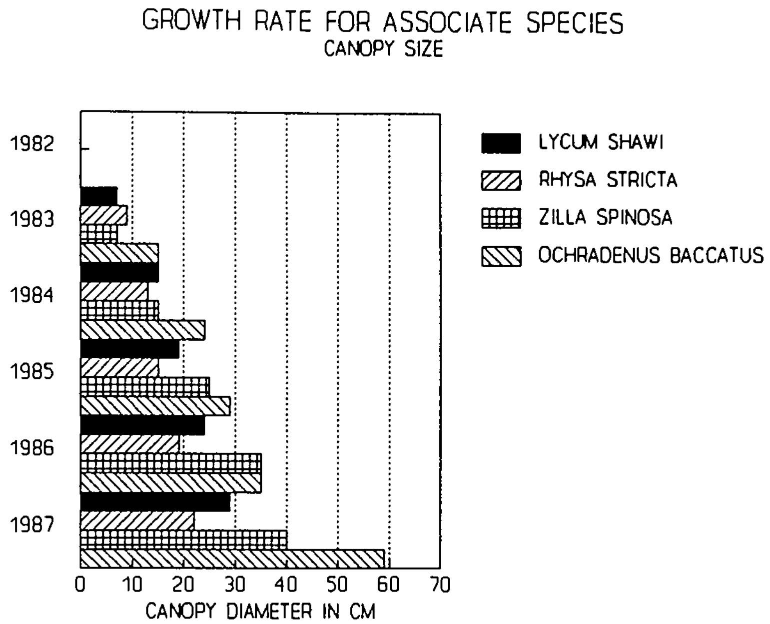
Apart from the success of establishing communities, there is a greater benefit to amenity landscape in their associated species. They form a ready successful blend of species. Their blend, form, structure and fabric can improve the landscape quality in Najd. However, it was found that not all the associate species included in a specific community are desirable, since some may contain poisonous substances or thorny branches. A selected number of associate species were monitored to assess their individual growth rate. The aim was to examine their ability to grow without initial irrigation or any modification to the existing soil.

Some of the successful associate species will not be included in the individual growth assessment due to their undesirable form and texture. In this test they were identified and monitored individually.

For example, the author monitored the associate species of Acacia gerrardii community which comprises: Lycium shawii , Ochradenus baccatus and Periploca aphylla. Pennisetum divisum , Caltropis procera, Rhazya stricta , Zilla spinosa, Cyndon dactylion and Gisekia pharnaceoides. Their progress was registered and recorded as the following graphs demonstrate. The rest will be included in the recommended species and Flora.

1- Lycium shawii, Ochradinus baccatus, Ryazia stricta and Zilla spinosa. They showed an excellent growth rate for both their root ball and canopy size. Both graphs (Fig 105) shows that both Lyceum shawii and Ochradinus baccatus are achieving a high level of growth considering their growing conditions.

2- Caltropis procera.
This native tree broke the expectation in its growth rate, it achieved a fast and satisfactory growth rate near to that of the same irrigated species. This applies to some other trees to be mentioned in chapter 5 as the concluded successful species. (Fig 106) supports that statement.



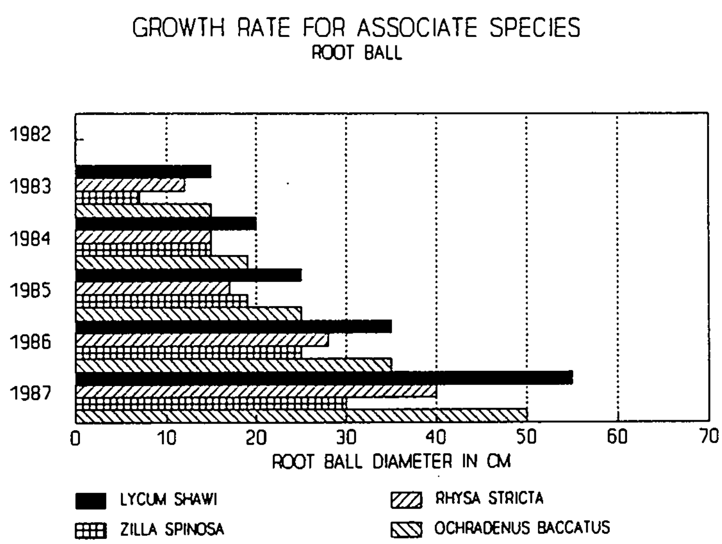




**Fig 105: Both graphs prove that the growth rate for the shrub layer is acceptable and adequate enough to fulfil any function as a landscape design tool.**

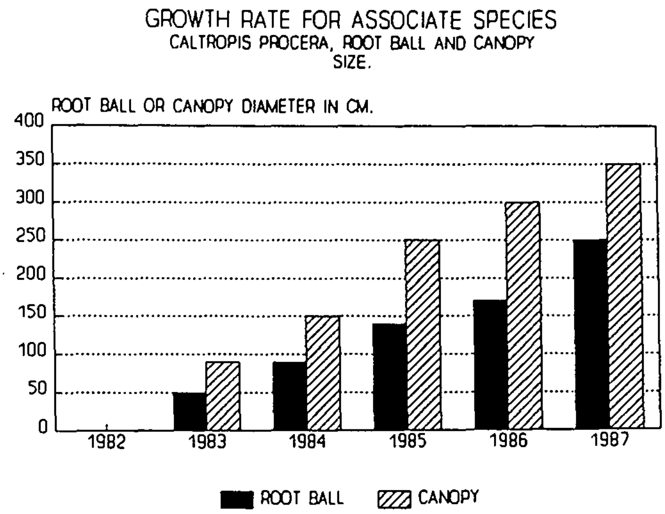



**Fig 106: The growth rate for Caltropis procera.**

## 5. CONCLUSION (THIRD TEST SITE):

Due to the established link between the plant community and the soil pattern, it is clear that their condition is related to similarity between edaphical conditions in their target site and original native habitat. In order to manipulate this fact, it is essential to classify the Najdi communities in relation to their native soil pattern. This could then be used as an assessment and design factor for the target site; in brief, the soil pattern might dictate the design layout. The disadvantage here is that this method will seem to acquire limited flexibility for small sites. However, an individual community usually maintains a distinct character; either a scattered Acacia stand with patches of ground cover, to diverse communities as in the Ziziphus numilaria community.

Associated species within successful communities have achieved satisfactory growth when considered as an individual. Each can be planted from seeds, directly on the appropriate site. The test covered in detail some associated species individually, and evaluated their ability to be planted from seeds with no man made modification to soil or using additional water to the actual amount of annual rain fall.

It may prove that some plants may flourish only as part of a plant community or as a stage of succession. In that case, seeds of woody perennial may be the sensible selection for planting individually. Another alternative is to plant the whole community, using the blanket method, till establishment, then removing the undesirable plants. That will be a pre-stage to landscape design, and a redesign to suit the remaining plants should then commence.

Each community should be planted or imported on to the appropriate soil type found in the target site. The coverage of the successful community will vary according to the existing soil conditions. For example a community belonging to a wet sandy soil will achieve a coverage of 90% in seven years, while another one belonging to a rocky soil will achieve only 30% in the same period.

Associate species achieved a satisfactory growth rate adequate enough to solve the problem of green belts around arid towns, as some indications showed that their presence stabilises moving sand dunes, as the case in the eastern part of the third test site (Fig 107 below).

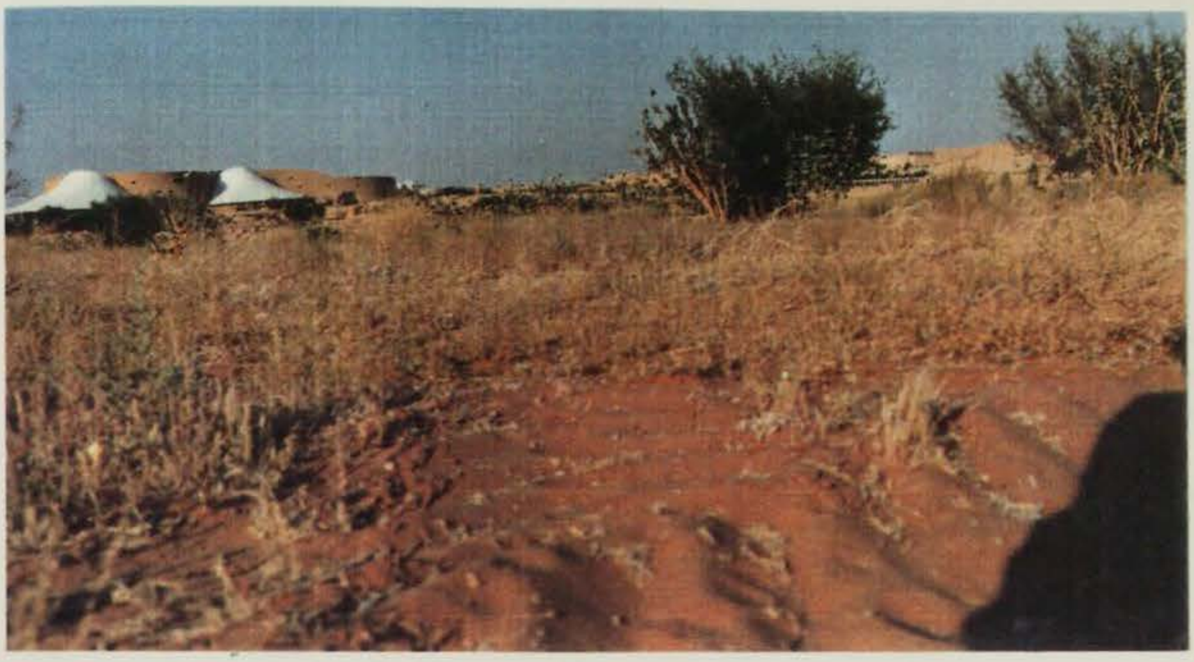


Fig 107: The presence of the grass community stopped and stabilised the creeping sand from the west.

# CHAPTER 6

# TESTING NATIVE SPECIES, CONCLUSION

## 1) TESTING NATIVE SPECIES, CONCLUSION

### A. INTRODUCTION

The nature of most landscape sites in Najd are hostile in their soil and environmental factors, which current imported amenity plants do not have the capacity to tolerate. The three tests were conducted on extremely hostile sites, located at the edge of the sand belt of Ar-riyadh and exposed to most factors expected to influence plant growth. The nature of the urban environment is far less hostile, due to slower winds and greater shade caused by buildings. This will insure further success to most native species which are qualified for amenity landscape.

Most of the plants discussed in test 1 & 2 are of a type suitable for urban locations and for diverse landscape functions; trees, shrubs, ground cover, climbers and grass.

In this chapter, the overall conclusion of testing native plants is first described. A brief report follows on the qualified species recommended as a result of the tests. Their detailed responses to the test conditions and a description of them, is provided in the form of a Flora. It is important to stress that this Flora has an important role to play in the process of introducing native flora to more general landscape use. The Flora will cover each species in the test, its ideal growing conditions, its response and behaviour. It is seen as a preliminary manual which can be used by designers, managers, contractors and clients when preparing contract documents for landscape projects in Najd.

### B. CONCLUSION TESTING NATIVE PLANT MATERIAL.

The argument for substituting imported species became clearly valid as a result of this test. Although native species were used for the first time, a satisfactory growth rate, form and general habit was achieved.

The richness of Najdi ecological habitats forms a viable source of indigenous plant material. Those ecological habitats supplied the test with its essential ingredient of target species and communities.

Applying both the target species and target community method was successful as shown in the graphs. There is a clear and concrete signal of their excellent growth rate under increased salinity levels and their sensitivity to water reduction. These two methods could now be used to introduce the selected native species to the landscape architecture design field.

The most successful species will be presented as a comprehensive Native flora to substitute for imported plant material. This flora will cover the recommended irrigated, non irrigated and community species which are suitable for urban parks, urban spaces, passive zones, extensive landscaping and green belts. It will also cover the water ratio and its affect on colour hue, seed collection method, seeding time, and initial maintenance if required.

Table 28 summarises and supports with measured data the previous hypothesis, which validates the use of native species as potential and sensible substitutions for imported species. The data given below was obtained from the community plan for Ar-riyadh, and the test sites.[95] Such data and the test result, which is to follow, will form the evidence and the foundation for the reformation of indigenous Saudi Landscape Architecture.

| Group | Unit | Native species in winter. | Native species in summer. | Imported species in winter. | Imported species in summer. |
|---|---|---|---|---|---|
| Grass. | $M^2$ | nil. | Average of 7/litre/ week. | Average of 25/litre/ week. | Average of 100/litre / week. |
| Shrubs. | $M^2$ | nil. | Average of 3/litre/ week. | Average of 35/litre/ week. | Average of 70/litre/ week. |
| Succulent and ground cover. | $M^2$ | nil. | nil. | Average of 40/litre/ week. | Average of 50/litre/ week. |
| Trees. | $M^2$ | nil | 15/litre/ week. *** | Average of 55/litre/ week. | Average of 150/litre / week. |

*** Most of the native trees rarely require watering during summer especially after establishment. Water is usually essential if a luxurious appearance was required.

**Table 28: A comparison between water requirement of Native and imported species (after the test sites).**

Generally, the three test sites fulfilled the qualifications of two principal landscape tools, the target species and community method. Successful species are those which, tested exclusively, were sufficiently diverse and adequate to fulfil most landscape design requirements. Most of the communities extracted from the third test site were flourishing and progressively adapting to public access.

[95] Update for M.Salama M.phil Table 14- Irrigation water requirement for Imported species.

Both methods were closely monitored especially for public response. A close investigation showed an increase in the regular presence of Saudi families especially in the extensive zones where no irrigated species and communities are located. Those areas were the target for extracting the most appropriate species or communities.

## 1. THE QUALIFIED SPECIES AND COMMUNITIES.

### 1.1 QUALIFIED TARGET SPECIES

Fifty successful species resulted from all test sites. These species are suitable for the range of site conditions described earlier. Although the initial success rate for the three test sites and the associated species within the target community method are higher than fifty, the author decided to omit most of the herbaceous species and to concentrate on the successful woody species that are of direct application within any Najdi urban or extensive park.

Tables 29, 30 and 31 summarise these successful species according to their type and height. Their detailed botanic characterization and test response are included later in this chapter as a comprehensive Flora that will comprise also their behaviour on the test sites during the past four years, their best growing conditions and their specific requirements for achieving most satisfactory growth. The test result is presented as a statistical analysis with graphs to cover their growth rate in conjunction with water quantity, temperature and other environmental factors affecting each species and site. The continually irrigated species, except during winter, are targeted at the intensive landscape areas, where lavish appearance to softscape is required.

The following Table 29 represents the successful species in the first test site.

| SPECIES | ADAPTATION TO WATER STRESS | | | | ADAPTATION TO TEMPERATURE STRESS | | | | ADAPTATION TO SALINITY | | | | ADAPTATION TO SOIL COMPACTION AND POOR NUTRIENTS | | | | TOUGHNESS AND ENDURANCE OF HEAVY PUBLIC USE | | | | TOLERANCE TO INSECTS, PESTS OR DISEASES | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D |
| TREES. | | | | | | | | | | | | | | | | | | | | | | | | |
| Acacia albida. | | ● | | | | ● | | | | ● | | | | | ● | | | ● | | | | ● | | |
| Acacia arabica. | ● | | | | ● | | | | ● | | | | | ● | | | | | ● | | | | ● | |
| Acacia seyal. | | | ● | | | ● | | | | ● | | | | ● | | | | | ● | | | ● | | |
| Albizia lebbeck. | | | | ● | | ● | | | | ● | | | | | ● | | | | ● | | | | | ● |
| Delonix elata. | | | ● | | | | ● | | | | ● | | | ● | | ● | | ● | | | | ● | | |
| Prosopis juliflora. | | ● | | | ● | | | | ● | | | | | ● | | | | | | ● | | ● | | |
| Tamarix aphylla. | ● | | | | ● | | | | ● | | | | ● | | | | | | ● | | | ● | | |
| Ziziphus spina-christi. | ● | | | | ● | | | | | ● | | | ● | | | | | ● | | | | ● | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| SMALL TREES. | | | | | | | | | | | | | | | | | | | | | | | | |
| Acacia canophylla. | | | ● | | | | ● | | | ● | | | | | | ● | | ● | | | | ● | | |
| Acacia farnasiana. | | | ● | | | | ● | | ● | | | | | | ● | | | | ● | | | | ● | |
| Caltopris procera. | ● | ● | | | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | |
| Ecalyptus camaldulensis. | | | | ● | | | | ● | | | | | | | ● | | | ● | | | | | | ● |
| Ficus psedo-sycamrus. | | ● | | | | | ● | | | | | | | ● | | | | ● | | | | ● | | |
| Ziziphus numilaria. | ● | | | | ● | | | | | ● | | | ● | | | | | | ● | | ● | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| SHRUBS. | | | | | | | | | | | | | | | | | | | | | | | | |
| Abutilon pannosum. | ● | | | | ● | | | | ● | | | | ● | | | | | | ● | | | ● | | |
| Atriplix halimus. | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | | | | ● | |
| Capparis cartilsginea | | ● | | | | | ● | | | ● | | | | ● | | | | ● | | | ● | | | |
| Capparis spinosus. | | ● | | | | | ● | | | ● | | | | ● | | | | ● | | | ● | | | |
| Cassia italica. | | | ● | | | | | ● | | ● | | | | | | ● | | | ● | | | ● | | |
| Datura inoxa. | | ● | | | ● | | | | ● | | | | | | | ● | | | | ● | | ● | | |
| Ochradinus baccatus. | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | |
| Periploca aphylla. | | | ● | | | | ● | | | ● | | | | | ● | | | ● | | | | | ● | |
| Rhazia stricta. | ● | | | | | ● | | | | | | | | ● | | | | | | ● | | | | ● |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| SMALL SHRUBS | | | | | | | | | | | | | | | | | | | | | | | | |
| Allenia subaphylla. | | | ● | | | ● | | | ● | | | | | ● | | | | | | ● | | | ● | |
| Argemone mixicana. | | | ● | | | ● | | | | ● | | | | | ● | | | | ● | | | ● | | |
| Artemisia judaicamonosperma. | | ● | | | | | | ● | | | | ● | | | | ● | | | | ● | | | | ● |
| Asparagus africanus. | | | | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | | ● |
| Atriplix leucoclada. | | | ● | | | ● | | | | ● | | | | ● | | | | ● | | | | ● | | |
| Belepharis ciliaris. | | | | ● | | | | ● | | | ● | | | | ● | | | | ● | | | | ● | |
| Ficus salisifolia. | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | |
| Hammada Elegans. | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | |
| Heliotropium digynum. | | | | ● | | | ● | | | | | ● | | | ● | | | ● | | | | | ● | |
| Lycium shawi. | | | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | | ● | |
| Peganum harmala. | | | ● | | | ● | | | | | ● | | | | ● | | | | ● | | | | | ● |
| Peganum harmala. | | ● | | | | | | | | | | | | | | | | | | | | | | |
| Penicum turgidium. | | ● | | | | ● | | | | ● | | | | | ● | | | ● | | | | | ● | |
| Recinus communis. | | | ● | | | | | ● | | | | ● | | | | ● | | | | ● | | | | ● |
| Zygophyllum coccineum | ● | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | | | | ● |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| GROUND COVER | | | | | | | | | | | | | | | | | | | | | | | | |
| Bassia eriophoria. | ● | | | | ● | | | | ● | | | | ● | | | | | | | ● | ● | | | |
| ipomea pes-capri. | | ● | | | | ● | | | | ● | | | | ● | | | ● | | | | ● | | | |
| ipomea sinensis. | | | ● | | | | | ● | | | | ● | | | | ● | | | | ● | | | ● | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| CLIMBERS | | | | | | | | | | | | | | | | | | | | | | | | |
| Citrilus colocynthis. | ● | | | | ● | | | | ● | | | | ● | | | | | | | ● | ● | | | |
| Clitoria ternata. | | ● | | | | ● | | | | ● | | | | | | ● | | | ● | | | ● | | |
| Ipomea palamata. | | ● | | | | ● | | | | ● | | | | ● | | | | ● | | | | ● | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| GRASS | | | | | | | | | | | | | | | | | | | | | | | | |
| Pennisetum setacum. | ● | | | | ● | | | | ● | | | | ● | | | | | | ● | | ● | | | |
| Phragmetus communis. | | | ● | | | | ● | | ● | | | | | ● | | | | ● | | | | ● | | |
| Phragmitus australi | | | ● | | | | | ● | | | ● | | | ● | | | ● | | | | | ● | | |
| Typha domingenis. | | | | | | | | | ● | | | | ● | | | | ● | | | | ● | | | |

Table 29: Successful and qualified species.

The following key is to be applied for this table and the later ones:

**A = high tolerance B = acceptable tolerance C = Fair D = poor tolerance. The high tolerance represents that the species managed to maintain most of its characteristics and form, while the acceptable tolerance represents some loss but still fulfilled its role as a landscape tool, poor tolerance indicates that species lost most of its physical characteristics during the test.**

The above species were found to satisfy all aspects of current urban landscape design. In order to achieve the success claimed in the first test site, those species must be irrigated during the summer only at a ratio of 25/ litre / three times every week. Although the list is not very long, it is almost similar to the available imported species.[96] Species tested for water stoppage are reported in Table 30 below:

| SPECIES | RESPONSE TO WATER REDUCTION | | | | ADAPTATION TO TEMPERATURE STRESS | | | | ADAPTATION TO SALINITY INCREASE AFTER TEST | | | | ADAPTATION TO SOIL COMPACTION AND POOR NUTRIENTS | | | | TOUGHNESS AND ENDURANCE OF HEAVY PUBLIC USE | | | | TOLERANCE TO INSECTS, PESTS OR DISEASES DURING TEST | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D |
| TREES. | | | | | | | | | | | | | | | | | | | | | | | | |
| Acacia arabica. | | • | | | • | | | | | • | | | • | | | | | • | | | | | • | |
| Prosopis juliflora. | | • | | | | • | | | | • | | | | • | | | | | • | | | | • | |
| Tamarix aphylla. | | • | | | | • | | | • | | | | • | | | | | • | | | | | • | |
| Ziziphus spina-christi. | | • | | | | • | | | • | | | | • | | | | | | • | | | | • | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| SMALL TREES. | | | | | | | | | | | | | | | | | | | | | | | | |
| Caltopris procera. | • | | | | • | | | | • | | | | • | | | | • | | | | | • | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| SHRUBS. | | | | | | | | | | | | | | | | | | | | | | | | |
| Abutilon pannosum. | • | | | | • | | | | • | | | | • | | | | • | | | | | | • | |
| Atriplix halimus. | | • | | | | • | | | • | | | | • | | | | | • | | | | | | • |
| Capparis spinosus. | • | | | | • | | | | | • | | | • | | | | • | | | | • | | | |
| Ochradinus baccatus. | | | • | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| SMALL SHRUBS | | | | | | | | | | | | | | | | | | | | | | | | |
| Ficus salisifolia. | | | | • | • | | | | | | • | | • | | | | | • | | | • | • | | |
| Heliotropium digynum. | | • | | | • | | | | | | • | | | • | | | | | • | | | • | | |
| Recinus communis. | | • | | | • | | | | | | • | | | • | | | | | • | | | • | | |
| Zygophyllum coccineum. | | | | • | • | | | | • | | | | • | | | | | • | | | | • | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| GROUND COVER | | | | | | | | | | | | | | | | | | | | | | | | |
| Bassia eriophoria. | • | | | | • | | | | • | | | | | • | | | | | • | | | • | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| CLIMBERS | | | | | | | | | | | | | | | | | | | | | | | | |
| Citrilus colocynthis. | • | | | | • | | | | | | | • | | | | | | | • | | | • | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| GRASS | | | | | | | | | | | | | | | | | | | | | | | | |
| Pennisetum setacum. | | | | • | | | | • | | | • | | | | • | | | | • | | | | • | |

Table 30: Species tolerant to gradual drought.

Table 30 *summarizes the* result of the second test site and the remaining species after water reduction. The table also shows their response to water reduction and other factors. They are targeted for use in landscape areas where water is available for an initial period only, and low maintenance areas.

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[96] For list of available species refer to M. Salama. Availability and use of plant material in central saudi arabia. M.Phil 1987.

There were a number of species that were found to be successful but not qualified as a result of disputed source and method of propagation. Also the associated species within the successful communities could be nominated as a qualified target species for non irrigated sites. Table 31 below summarises the non irrigated species that survived the third test site.

| SPECIES | ADAPTATION TO WATER STRESS | | | | ADAPTATION TO TEMPERATURE STRESS | | | | ADAPTATION TO SALINITY | | | | ADAPTATION TO SOIL COMPACTION AND POOR NUTRIENTS | | | | TOUGHNESS AND ENDURANCE OF HEAVY PUBLIC USE | | | | TOLERANCE TO INSECTS, PESTS OR DISEASES | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D |
| TREES. | | | | | | | | | | | | | | | | | | | | | | | | |
| Acacia arabica. | • | | | | • | | | | | • | | | • | | | | | | • | | • | | | |
| Acacia seyal. | | • | | | • | | | | | • | | | • | | | | | | • | | • | | | |
| Prosopis juliflora. | • | | | | • | | | | • | | | | • | | | | | | • | | • | | | |
| Tamarix aphylla. | • | | | | • | | | | • | | | | • | | | | • | | | | • | | | |
| Ziziphus spina-christi. | • | | | | • | | | | • | | | | • | | | | | • | | | • | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| SMALL TREES. | | | | | | | | | | | | | | | | | | | | | | | | |
| Caltopris procera. | • | | | | • | | | | • | | | | • | | | | • | | | | | • | | |
| Ficus psedo-sycamrus. | | • | | | | • | | | | | • | | | • | | | | | • | | | | • | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| SHRUBS. | | | | | | | | | | | | | | | | | | | | | | | | |
| Abutilon pannosum. | • | | | | • | | | | • | | | | • | | | | | • | | | • | | | |
| Atriplix halimus. | • | | | | | • | | | • | | | | • | | | | | • | | | • | | | |
| Capparis cartilsginea | | • | | | • | | | | | • | | | | • | | | | | • | | | • | | |
| Capparis spinosus. | • | | | | • | | | | | • | | | | • | | | | | • | | | • | | |
| Datura inoxa. | • | | | | • | | | | • | | | | | • | | | | • | | | | • | | |
| Ochradinus baccatus. | • | | | | • | | | | • | | | | • | | | | | | | • | • | | | |
| Periploca aphylla. | | • | | | | | • | | • | | | | • | | | | | | | • | | | • | |
| Rhazia stricta. | | • | | | • | | | | • | | | | • | | | | • | | | | • | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| SMALL SHRUBS | | | | | | | | | | | | | | | | | | | | | | | | |
| Argemone mixicana. | | • | | | • | | | | | • | | | | • | | | | | • | | • | | | |
| Atriplix leucoclada. | | | • | | • | | | | • | | | | | • | | | | | • | | • | | | |
| Belepharis ciliaris. | | • | | | | | • | | • | | | | | • | | | | | | • | | • | | |
| Ficus salisifolia. | | | • | | | • | | | • | | | | • | | | | • | | | | | • | | |
| Heliotropium digynum. | | | • | | • | | | | • | | | | | • | | | • | | | | • | | | |
| Peganum harmala. | | | • | | • | | | | | | • | | | • | | | | | • | | • | | | |
| Recinus communis. | | | • | | | • | | | • | | | | • | | | | | | | • | • | | | |
| Zygophyllum coccineum | | • | | | • | | | | • | | | | • | | | | | | | • | | • | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| GROUND COVER | | | | | | | | | | | | | | | | | | | | | | | | |
| Bassia eriophoria. | • | | | | • | | | | | • | | | | • | | | | | • | | | • | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| CLIMBERS | | | | | | | | | | | | | | | | | | | | | | | | |
| Citrilus colocynthis. | • | | | | | • | | | • | | | | • | | | | | | | • | • | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| GRASS | | | | | | | | | | | | | | | | | | | | | | | | |
| Pennisetum setacum. | • | | | | • | | | | • | | | | • | | | | | • | | | • | | | |

Table 31: Successful non irrigated native species in the third test site.

## 1.2 SELECTED SPECIES QUALIFIED FOR INCLUSION IN THE NATIVE LANDSCAPE FLORA.

### INTRODUCTION:

It has been argued throughout the thesis that native plants are more suited for use in landscaping projects in Najd than imported ones. That argument has been substantiated by the results from the three test sites. Selection was based on suitability for desert conditions, water requirement relative to the available water supply and their ability to satisfy specific landscape functions. Some plants, despite their growth success, were omitted for visual reasons. The belief is that all the plants recommended here, and included in the Flora, are suitable for landscape use in Najd.

The outcome from both tests consists of two landscape tools: Firstly the successful target species, secondly the successful target communities that uses the target community method. This chapter will introduce the results in two sections. The first section is concerned with the result of the target species which will be presented in a form of an itemised Flora. The second section will deal with the result of the target community method and introduce dominant communities with their characteristics and associated species.

### THE FLORA:

The descriptive flora is aimed at the professionals who are engaged in the landscape design process and will be willing to manipulate the successful flora as an alternative to imported species.

Some 50 plants are included in the Flora, which is classified into trees, small trees, shrubs, small shrubs and creeping vines. It will describe the physical characteristics of each species, its behaviour during the testing process, best growing, or thriving, conditions, texture, habit, suitability for landscape application and irrigation needs. This will form what is believed to be the first such manual for tested native Najdi plants, specifically suited for use by landscape architects. Their use should be confined to designs that simulate their distribution in natural habitats. The author has modified a version of a standard specification to suit the use of native species. [97]

To recap, test site one was fully irrigated; at test site two, the amount of irrigation water was gradually reduced; and at the third site, no irrigation water was used.

---

[97] See Appendix II.

**TREES:**

The following native trees can be grown almost anywhere in Najd as shown in the tests. After the palm trees, which were not tested but are obviously one of the most important trees in Najd; they represent the second tallest native plants. They were tested to fulfil most design requirements, especially those involving public contact such as shading pedestrian walkways and roads.

Some eighteen species were tested in general, and only twelve were nominated to be included in the monitoring process. Of these twelve trees, Acacia arabica, Acacia Albida, Acacia seyal, Albizia lebbeck, Ficus pseudo-sycamrus, Procopis juliflora Ziziphus spina-christi seem best to fulfil the role of the urban and semi urban tree.

Acacia arabica, Acacia Albida, Acacia seyal, could be used in alternate repetition of a single species, where they are particulary suited to extensive planting in semi urban areas, and urban fringe. All three have a distinct sculptural quality that characterize the area with a genuine desert appearance. They should be used as a monotype planting, with a variety of height and density. Acacia arabica was the only species of the three to maintain a distinct silhouette.

Acacia albida, Albizia lebbeck, Prosopis juliflora and Ziziphus spina-christi are best suited for shading and general street tree use. Only Albizia lebbeck and Prosopis juliflora were found to tolerate contained planting beds. That qualifies them to be planted in street islands. All three were successful as a shade tree, in linear planting, view enframent and space integration.

Ficus pseudo-sycamrus, qualifies as a specimen plant for its unique form and texture. Tamarix aphylla and Acacia spp are excellent as structure linear planting, to serve as a wind scoop to redirect and filter the prevailing hot and dusty wind. Fig 108 below introduces a map to locate the original source of the trees.

The next section consists of the Flora of native species. As stated previously, these have been subdivided into trees, small trees, shrubs and small shrubs.

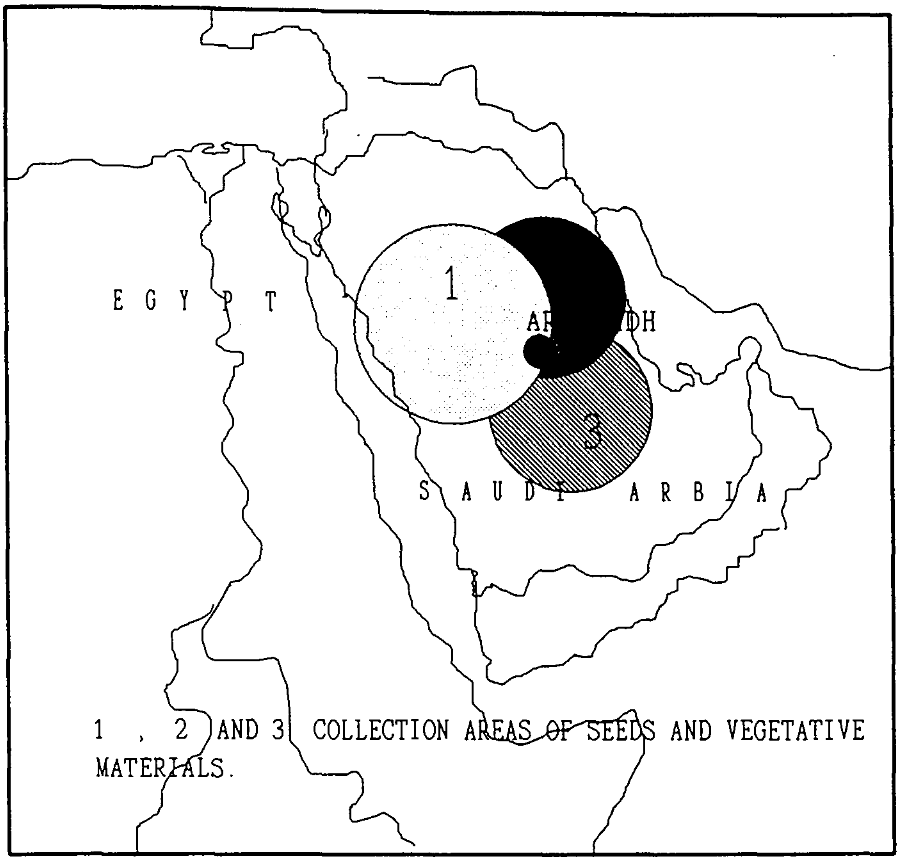


**Fig 108: The collection zones for seeds and vegetative materials.**

TREES

**BOTANICAL NAME:** Acacia albida.

**GENERAL NOTES AND DESCRIPTION:** A single trunk tree with a wide bushy crown. Only the youngest stems are armed with spines. The tree has attractive yellow flowers and pale green leaves. Suitable as a candidate for a multi purpose shade tree.

**PHYSICAL FACTORS:**

**GROWTH RATE:**Growth rate was fast. The graph below shows that its growth rate in the first test site was faster than imported Delonix regia (Fig 109 below).

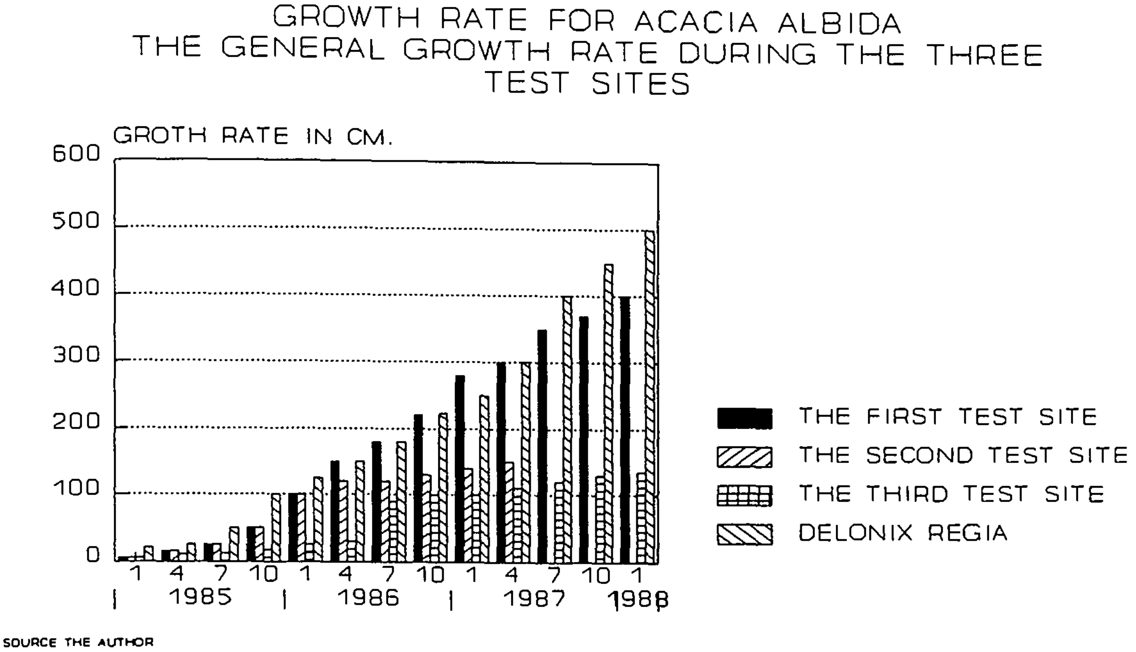


**Fig 109: Growth rate for Acacia Albida.**

The graph shows that the species was successful in the first test site and partially in the third test site. It failed to tolerate the sudden drop in the watering regime in the second test site.

**ROOT STRUCTURE:**

Its root structure is a tap root with laterals. It grows in exposed areas with poor compacted soil containing a trace of wadi soil to maintain humidity. The adaptation to salinity level was excellent. Being thornless and more resilient than Acacia arabica, it is well-adapted for public use. Though it showed maximum growth only in the first test site, it must be classified as an important urban species.

**FORM:**

A Deciduous tree with extended branches, spreading umbrella like (Fig 110 below), it grows to 5 M. high and 4 M. wide with large pinnate leaves and small clusters of yellow flowers in groups.

**PROPAGATION:**

It may be propagated from seeds or cuttings. Seeds being collected and sown manually in late summer.

NOTES:

This tree was successful only in the first test site because tested plants were propagated in the nursery and their adaptation to native environmental factors weakened as a result. However, this species is doing well in nature without any irrigation. Its failure in the second and third test site was due to the propagation process. The species could be used for extensive landscaping in non irrigated zones if it was propagated from seeds collected manually from a natural source.

**Fig 110:** Acacia Albida.

**BOTANICAL NAME:** Acacia arabica

**GENERAL NOTES AND DESCRIPTION:** A tree 8-10 m high, with a dark stem and branches. It is a legume, native mainly to the central region. Sharp linear spines (up to 7 cm.long) tend to shrink when the tree is irrigated and propagated in the nursery. When germinating, the seeds exude a substance that kills other seedlings located in the root area, which called the nutrition zone.

**GROWTH RATE:**

Its growth rate is slow, but accelerates with water supply (Fig 111 Below).

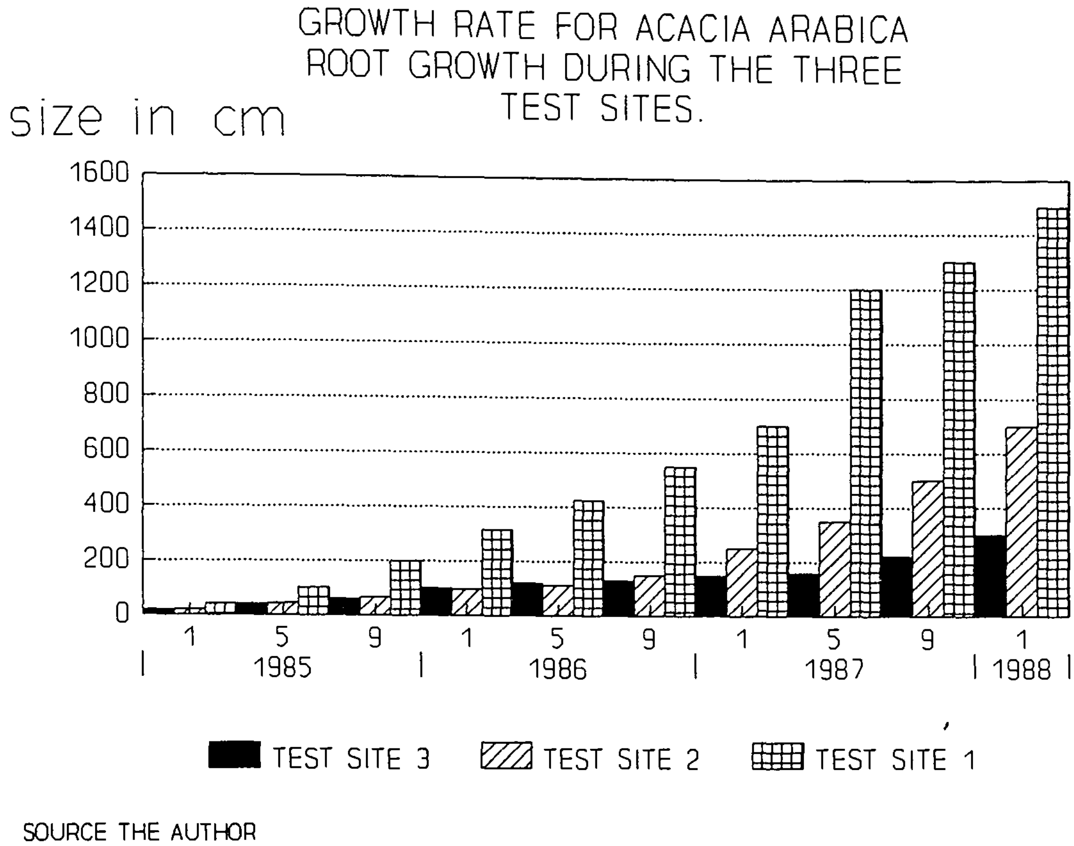


**Fig 111: Root growth rate for <u>Acacia arabica</u>. The graph indicates that the growth rate of the roots increases as the water decreases. This is because under drought stress the plant seeks water through maximum root growth. The plant can thus preserve its water balance.**

**ROOT STRUCTURE:**

The root structure is surface rooting. The species flourishes when irrigated in early summer; at a rate of 25/ litre/ day three times a week. However the plant was also successful without irrigation. The graph above shows the relationship between the growth rate for the species and the different amounts of water used in each test site.

**BEST THRIVING CONDITIONS:**

The species thrived in full sun, poor, compacted soil and tolerated high salinity levels. The tough thorny branches make it a useful public tree. It showed clear signs of thriving in high NaCL levels.

An evergreen tree shaped like an inverted cone (Fig 112). Growing 6-7 m high and 3-5 m diameter spread. The size varies according to the amount of water used in irrigation. It has pinnate foliage of numerous leaflets, (10-30 pairs pale Olive green) and produces heads of bright yellow flowers.

**TECHNIQUES**

Seed propagation is recommended for an environmental design, and for achieving maximum drought tolerance. The seed should be collected and sown manually in early winter if irrigation is used and late summer if natural germination is desired. The plant should be spaced at 7 m intervals when irrigated, and 17 m when not. This species showed a high level of drought and salinity tolerance. It is suitable for shelter belts and defining the urban limits within a green belt.

Fig 112: Acacia arabica.

**BOTANIC NAME:** Acacia Seyal

**GENERAL NOTES:** A tree 4-5 M High, a dusting of rust and red powder covers the smooth and bright green bark of the stem.

**PHYSICAL FACTORS:**

**GROWTH RATE:** Fast growth rate as the graph below shows. In the first test site the tree achieved a satisfactory growth rate only when the water ration maintained 20/1/3 times/week. It was noticed that the tree suffered when water was reduced. Also in the last test site there was no trace of it (See Fig 113).

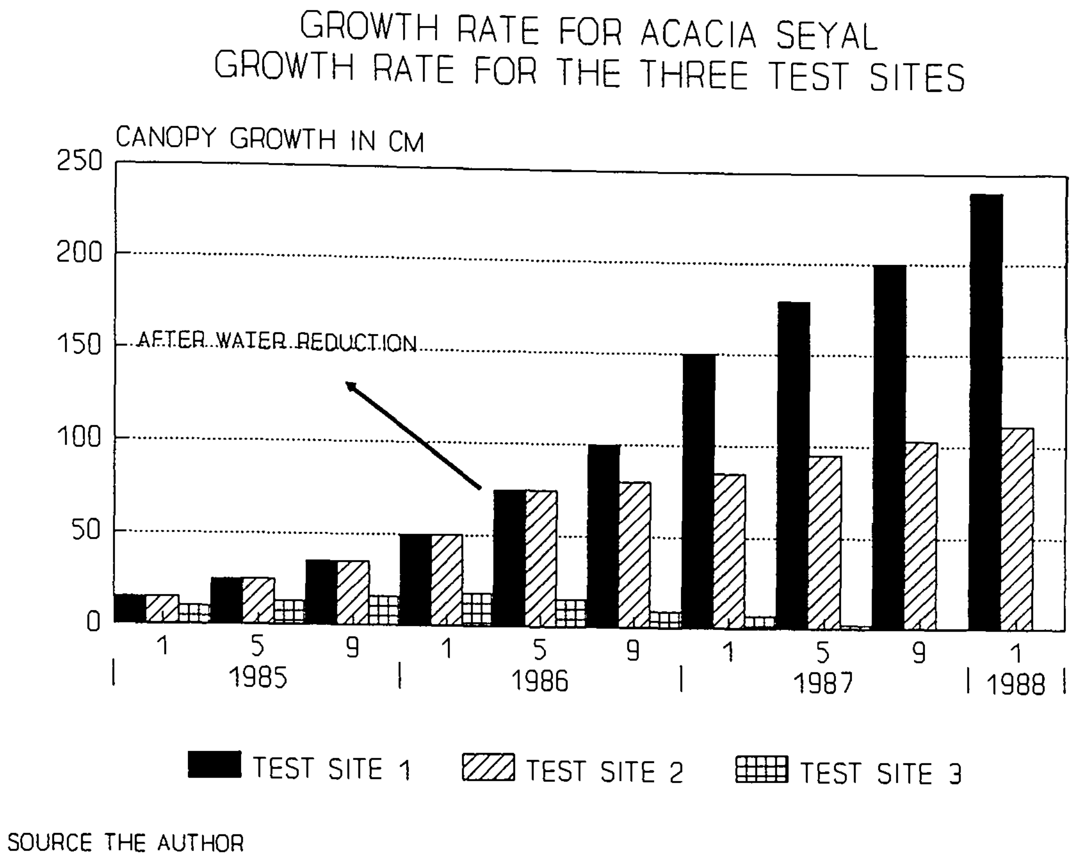


Fig 113: **Growth rate for <u>Acacia Seyal</u>.**

**ROOT STRUCTURE:** Surface roots.

**BEST THRIVING CONDITIONS:** The species prefers north facing locations with semi sheltered sites. Thrives most when irrigated and propagated from cuttings in the nursery. The test shows that this species failed to grow satisfactorily from seeds.[98] It did well in sand only.

**ADAPTATION TO TEMPERATURE STRESS:** Excellent.[99]

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[98] Questionnaire to A.D.A nursery diplomatic Quarter. Mr.Fahad Al-Fayadh.

[99] In its low form, the plant tolerates the most hot and dusty wind.

**ADAPTATION TO SALINITY LEVEL:** Can tolerate up to 10000 ppm. [100]
**EXPOSURE:**Full sun or filtered.
**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Sensitive to compacted soil but achieved a satisfactory growth rate when planted in the sandy soil in the first test site.
**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.
**IRRIGATION NEEDS AND EFFECTS:** Thrived best in the irrigated zone, showed a quick suffering when irrigation water was reduced in the second test site. The colour of the flower changed from bright yellow to yellow green when the irrigation water was reduced.

VISUAL CHARACTERISTICS

**HABIT:** Deciduous.
**FORM :** Irregular, See Fig 114.
**SIZE :** 3-4 m high, 3-5 m wide.
**FOLIAGE :** Pinnate 3-9 pairs, with 8-12 pairs of acute pinnules.
**FLOWERS :** Yellow, fragrant, appearing before leaves.

TECHNIQUES

**PROPAGATION METHOD:** Seeds and cutting. Most successful from seedlings and transplanting; however this latter method is not recommended because of the destructive effect on the desert ecology.
**SEED COLLECTION METHOD:** Manual.
**SEED COLLECTION SOURCE:** See former source Fig 108, zone 1.
**SEEDING TECHNIQUES:** Manual seeding should be implemented. [101]
**SEEDING TIME:** October or September.
**REMARKS** Although this species is not as tough as other native Acacia spp it could be considered as a substitute for imported species especially as it achieved a satisfactory growth rate during irrigation stages.

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[100] A sample of the soil were tested for salinity by Al-Rajhi lab on july 1987. (A.D.A).

[101] Refer to M.Salama M.Phil and letter in the Appendix III for the failure of the hydroseeding technique by the Eastern Company.

Fig 114: Acacia Seval.

**BOTANICAL NAME:** Albizia Lebbeck

**GENERAL NOTES AND DESCRIPTION:** A large Native tree used at present as a shade tree in Saudi Arabian towns. It proved to be successful and fulfilled its assignment. Trees planted in a scheme were irrigated by the municipality of Arriyadh followed with a daily dose of 75 litre in a rich soil. Although this achieved a fast and spreading growth rate, it contributed to the loss of tolerance to environmental factors. As reported by the maintenance department

> *"during the strong wind in 1986 the municipality lost about 75 trees of Albizia Lebbeck".*[102]

In the diplomatic Quarter this species is currently used and irrigated at a rate of 25 litre three times every week, and only during the summer and still fulfilled the same role. But in the first test site the portion was 25 litre / 3 times /week. The growth is less fast but durability is increased.

<u>PHYSICAL FACTORS</u>

**GROWTH RATE:** Fast (See Fig 115 below).

**ROOT STRUCTURE:** Tap root.

**BEST THRIVING CONDITIONS:** Fully exposed sites with sandy soil and regular irrigation.

**ADAPTATION TO SALINITY LEVEL:** Excellent.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** 25 litre three times per week found to be adequate.

<u>VISUAL CHARACTERISTICS</u>

**HABIT:** Deciduous

**FORM:** See picture. See Fig 116.

**SIZE:** 7 m. high 6 m wide.

**FOLIAGE:** Coarse feathery leaves.

**FLOWERS:** Yellow.

<u>TECHNIQUES:</u>

**PROPAGATION METHOD:** Seeds or cuttings.

**SEED COLLECTION METHOD:** Manual.

**SEED COLLECTION SOURCE:** See Fig 108 zone 2.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** October - November.

**REMARKS:** The tree was successful in the first test site but it was removed in the second test site after water stoppage, since the seeds used were obtained from a commercial pioneer species, which was suspected to have been propagated in a nursery,

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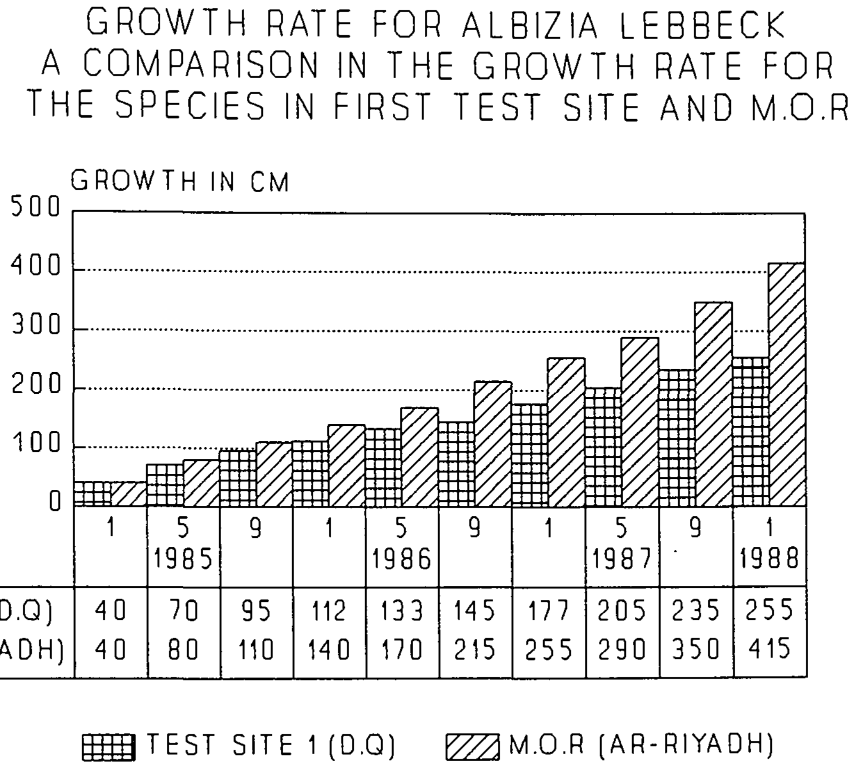
[102] Agriculture engineer, the maintenance department, Municipality of Arriyadh. Interview by the author, July 1988.

resulting in the loss of adaptation characteristics. The species found in the south of Arriyadh near Al Mansouriah was found to be thriving on the annual rain fall only. It was not tested in the third test site due to its seed collection technique. The graph below shows its growth rate during the past four years. The species is highly recommended.




| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| TEST SITE 1 (D.Q) | 40 | 70 | 95 | 112 | 133 | 145 | 177 | 205 | 235 | 255 |
| M.O.R (AR-RIYADH) | 40 | 80 | 110 | 140 | 170 | 215 | 255 | 290 | 350 | 415 |

SOURCE THE AUTHOR
M.O.R= MUNICIPALITY OF AR-RIYADH

**Fig 115: Growth rate for Albizia Lebbeck.**

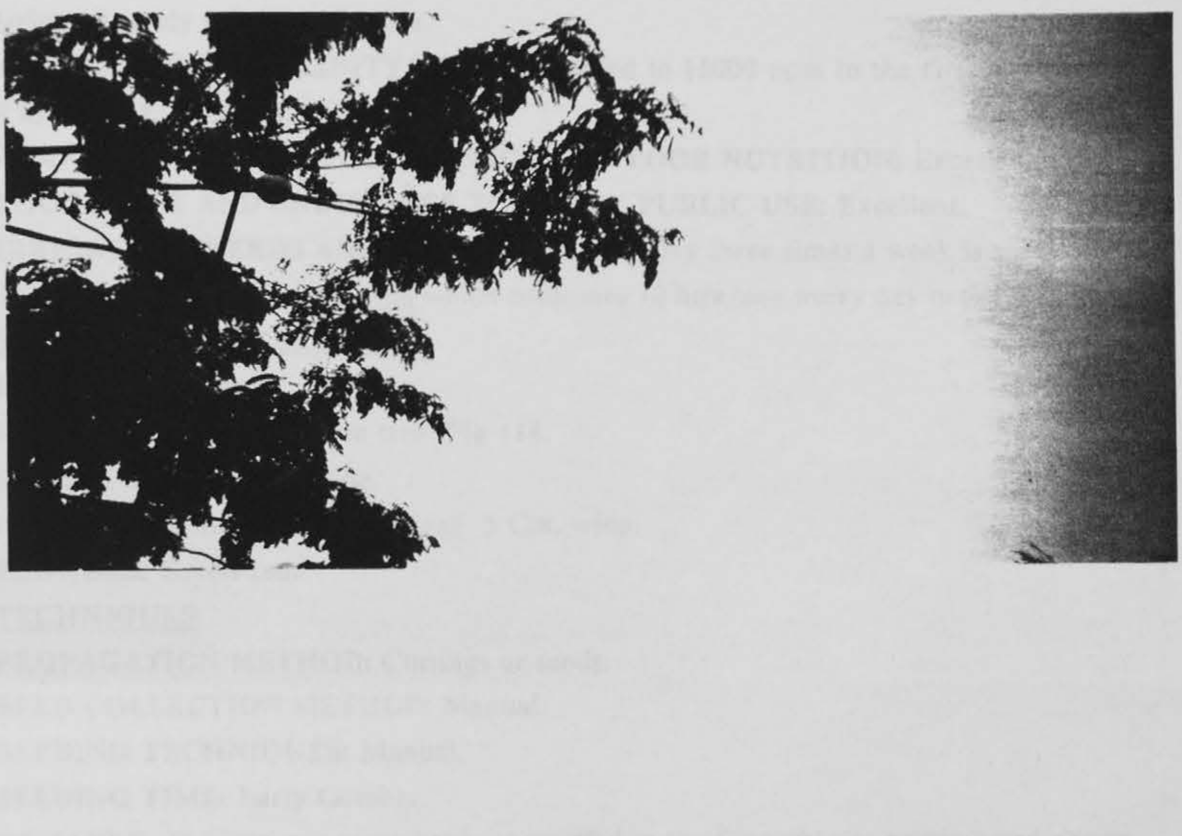


Fig 116: Albizia Lebbeck.

**BOTANICAL NAME:** Ficus pseudo-sycamrus.

**GENERAL NOTES AND DESCRIPTION:** large, stout, leafy tree, 13 m high. The small figs grow in clusters. Grows in wadi soil. Suitable as a shade tree.

PHYSICAL FACTORS

**GROWTH RATE:** Fast (see graph below). The graph below Fig 117 shows the growth rate of this species in the three test sites. One can note from the graph that during the second test site there was a decrease in the growth speed as a result of the water stoppage, while the tree maintained a slight growth rate. This is an indication of good drought adaptation. In the third test site the species sustained a uniform growth rate, as it would in nature. The species tested here were propagated from lifted seedlings prepared partially in the D.Q nursery. Therefore their growth data is directly applicable to sites similar in growing conditions to the first test but not the third one, Fig 117. However, the growth data from the third test site is also acceptable, despite propagation status, due to the recorded degree of success without any watering.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** North facing locations exposed to hot shamal wind. Irrigated sandy soil is preferable.

**ADAPTATION TO SALINITY LEVEL:** Adapted to 15000 ppm in the first test site.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** 25 litre/day three times a week is sufficient. This is compared to Ficus Nitida which consumes 70 litre/day every day in the summer.

VISUAL CHARACTERISTICS

**HABIT:** Evergreen.

**FORM:** Spreading free form tree. Fig 118.

**SIZE:** 15 M. high 7 M. wide.

**FOLIAGE:** Pointed oval. 6 Cm.long 5 Cm. wide.

**FLOWERS:** Green red.

TECHNIQUES

**PROPAGATION METHOD:** Cuttings or seeds.

**SEED COLLECTION METHOD:** Manual.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Early October.

**REMARKS:** The tree was remarkably successful in the first test site as discussed above and represented in the graph below. The growth rate which was achieved in five years was a great success for this native species growing in a semi urban environment under strained edaphical conditions and minimal water consumption. The result that was achieved is satisfactory enough that this species could be used as a street tree in Arriyadh. The growth rate in the third test site also qualifies the species as an excellent extensive landscape tool.

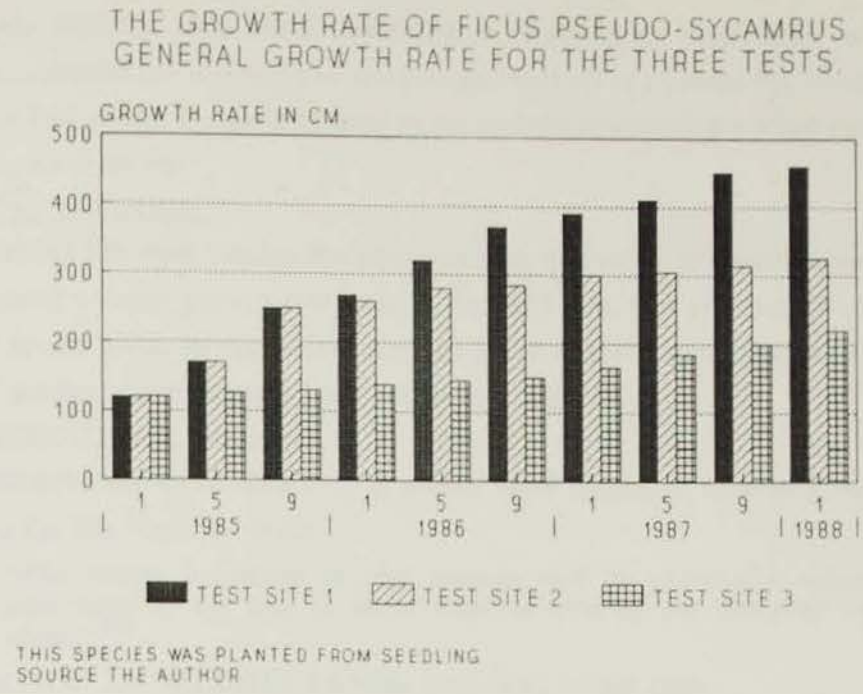



**Fig 117: Growth rate for Ficus Pseudo-sycamrus.**

**Fig 118: Ficus Pseudo-sycamrus.**

**BOTANICAL NAME:** Prosopis Juliflora.

**GENERAL NOTES AND DESCRIPTION:** A leguminous small tree, with delicate branches , suitable for screening or windbreaks; thrives in extreme dry conditions. Semi deciduous tree which is currently used in the eastern province as a wind shelter and for stabilizing sand dunes.

**PHYSICAL FACTORS:**

**GROWTH RATE:** Fast. During the first test site, as a result of water introduction, the plant showed a faster growth rate than in the third one; this affected the resistance of this tree to the wind. In the second test site the tree underwent checks in growth as a result of gradual water stoppage but recovered (Fig 119).

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Exposed semi sheltered locations. with initially irrigation for the first two years.

> *"The initial irrigation to this species will be especially valuable especially if the tree is to be used in treating the creeping sand dunes".*[103]

**ADAPTATION TO SALINITY LEVEL:** Excellent. 15000 ppm.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent supported by an early success in the third test site in a compacted soil near the playing field.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Trampling and climbing by children may cause broken branches.

**IRRIGATION (NEEDS AND EFFECTS):** Minimal after establishment.

**VISUAL CHARACTERISTICS**

**HABIT:** Semi deciduous.

**FORM:** Spreading reverse cone like (Fig 120).

**SIZE:** 4 M. wide 3-4 M High.

**FOLIAGE:** Bright green

**FLOWERS:**Creamy 3mm wide.

**TECHNIQUES:**

**PROPAGATION METHOD:** Seeds or cuttings.

**SEED COLLECTION METHOD:** Manual from selected target species.

**SEED COLLECTION SOURCE:** Central region. Near Wadi Hair. Fig 108 zone 3.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Late September.

**REMARKS:** Pruning and trimming might reduce the wind tolerance of this plant. The plant is suitable for most landscape use, if used with species like Abutilon Pannosum will form a useful visual buffer suitable for establishing alcoved areas for privacy.

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[103] Khalifah, Said, *Trees and shrubs in Kingdom of Saudi Arabia*, Firs Ed, Riyadh, 1980.

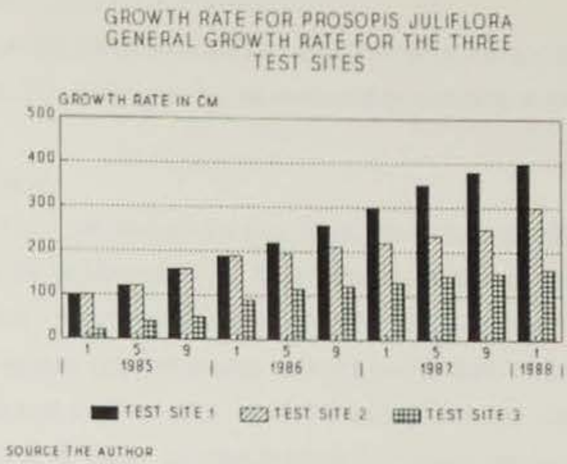



**Fig 119: Growth rate for Prosopis Juliflora.**

Fig 120: Prosopis Juliflora.

BOTANICAL NAME: Tamarix aphylla.

GENERAL NOTES AND DESCRIPTION: Shrub or tree, up to 15m high and 2-5m wide. The only leafless species, its leaves being reduced to sheaths without blades; flowers late summer.

PHYSICAL FACTORS:

GROWTH RATE: The root and shoot test found that this species is characterized by its long root system in its initial growth. One species in the third test site was found to produce a root system 15 m long after four years. While in the first and second test site it produced a root system similar to any conventional tree as a result of availability of water, in the second test site the root system begin to exceed the shoots after the initial irrigation was reduced in order to compensate for water reduction (Fig 121).

ROOT STRUCTURE: Surface.

BEST THRIVING CONDITIONS: Dry sandy soil on rocky under layer.

ADAPTATION TO SALINITY LEVEL: Excellent. 15000 ppm.

EXPOSURE: full sun.

ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION: Excellent.

TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE: Excellent.

IRRIGATION (NEEDS AND EFFECTS): Nil. Thrives in extreme drought.

VISUAL CHARACTERISTICS:

HABIT: Evergreen.

FORM: See Fig 122.

SIZE: 12 m high, 5 m wide.

FOLIAGE: See general notes.

TECHNIQUES:

PROPAGATION METHOD: Seeds or cuttings.

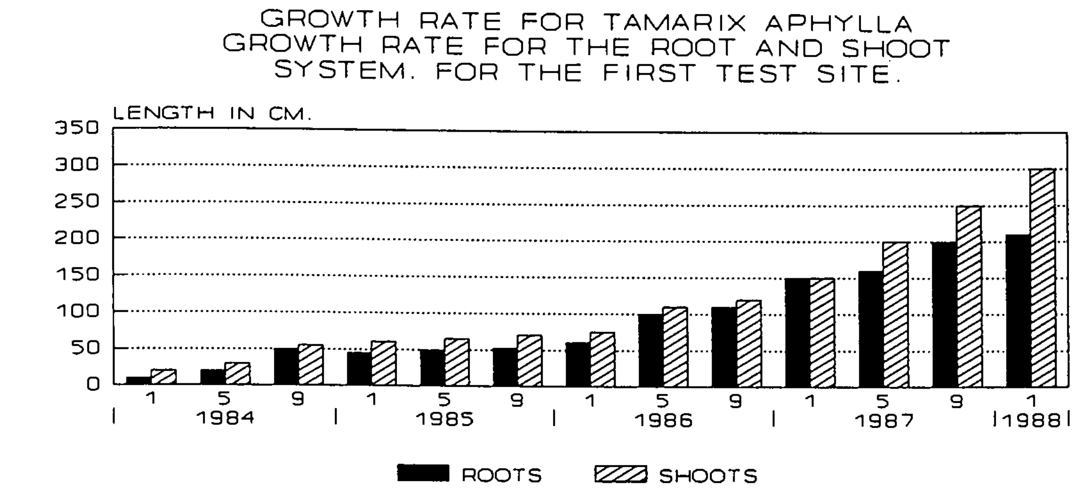
SEED COLLECTION METHOD: Manual.

SEED COLLECTION SOURCE: Buraidah, Fig 108, zone 1.

SEEDING TECHNIQUES: manual seeding is recommended and seed collection should be implemented as mentioned in the test site description.

SEEDING TIME: Late summer.

REMARKS: The species is tough and valuable for treating sand dunes and planting green belts in arid lands. Its seeds are tough and should be accurately treated before planting. The plant is attractive when irrigated and they can substitute for Casuarina Spp currently used. It will provide dense shade or wind break where little else will grow.

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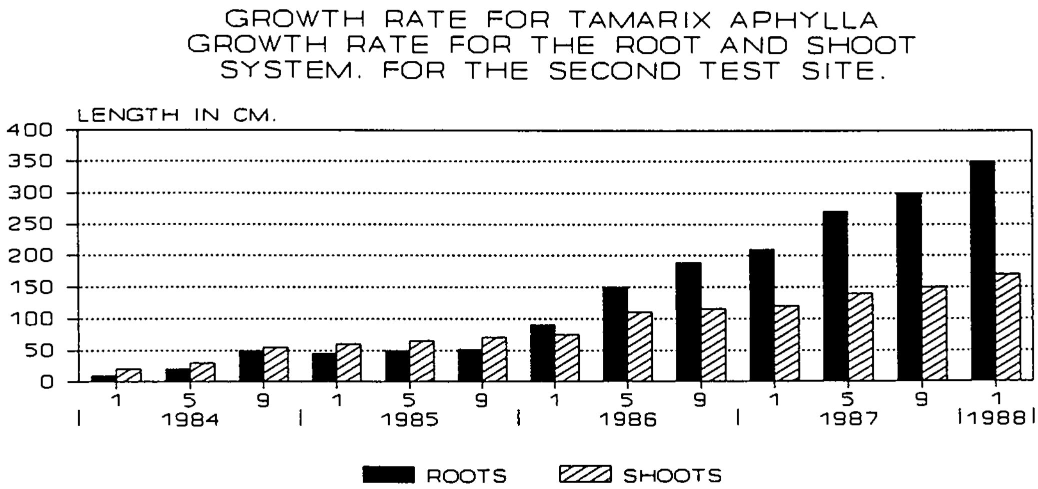


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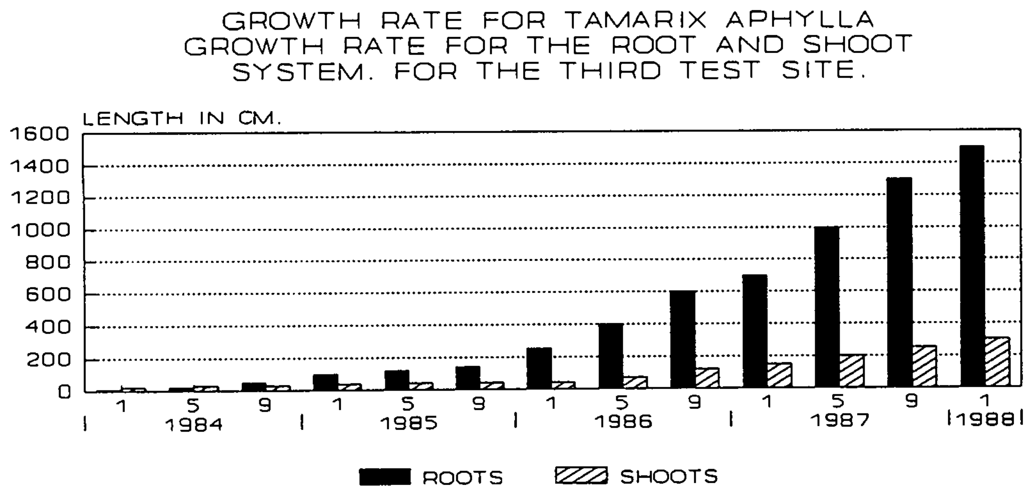


THE AUTHOR

**Fig 121: The growth rate for Tamarix Aphylla for the root and shoot growth.**

The Species as shown in the first test site managed to achieve a fast growth rate and an acceptable color, texture and form; the root to shoot growth rate is acceptable also. The species managed to recover in the second test site after water stoppage, and also maintained a reasonable growth rate, however the graph shows that root growth started to grow at a faster speed. During the third test site the species achieved a satisfactory growth rate for extensive use; there were two readings for the root system which showed a faster growth rate in this test due to the absence of irrigation water.

Fig 122: Tamarix Aphylla.

**BOTANICAL NAME:** Ziziphus spina-christi.

**GENERAL NOTES AND DESCRIPTION:** Belongs to the PHAMAACEAA family. A large evergreen tree, known in Najd as al-sidr tree. It is adapted to drought, salinity and almost every soil pattern known in the area. The tree is regarded in Islam as a special tree. It was classified by Abu-Hanifah into two varieties, pure and suitable for human consumption and unsuitable, identified by him as the same species but containing thorns.[104]

PHYSICAL FACTORS

**GROWTH RATE:** Fast. This tree achieved a satisfactory growth rate during the three tests indicated in the graph below, illustrating that the species maintained a consistent growth rate, especially during the second test site after water reduction took place (Fig 123).

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Almost any condition apart from extreme cold.

**ADAPTATION TO SALINITY LEVEL:** Excellent 8000 min -20000 approx.( thrives in saline soil and produces superior fruits).

**EXPOSURE:** Full, partial or filtered sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Minimal. The test found that this species can adapt to any water level, if it was propagated from a wild target plant native to Najdi environment.

VISUAL CHARACTERISTICS

**HABIT:** Evergreen.

**FORM:** Reverse cone like with ground level branches, which promote the ability to resist wind (Fig 124).

**SIZE:** 12-14 m high, 6 m wide.

**FOLIAGE:** 2.5 -5 cm, simple; pointed elliptical shape.

**FRUIT:** Known in Najd as Ebri; sweet, round 1.5-3.5 cm in diameter. Red or orange color.

TECHNIQUES

**PROPAGATION METHOD:** Seeds or cuttings.

**SEED COLLECTION METHOD:** Manual and should be from a native specimen.

**SEED COLLECTION SOURCE:** Wadi Hanifah.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Late summer.

**REMARKS:** This tree is currently wide spread as a street tree in Ar-Riyadh city. However, the municipality nursery pruned the trees heavily which left them vulnerable to wind and resulted in damage to 150 trees and an increased cost in tree supports. The

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[104] Tage Al-aarous. *Zubaidi.*

samples used in the test sites were not from a single species and location but from a variety of different site conditions, meteorologically and edaphically. Moreover the trees were never pruned, resulting in the plant maintaining the full adaptation to macroclimatic conditions. This tree will substitute most of the shade trees currently used in Ar-Riyadh provided that any pruning should take place after the initial 5 years of growth.

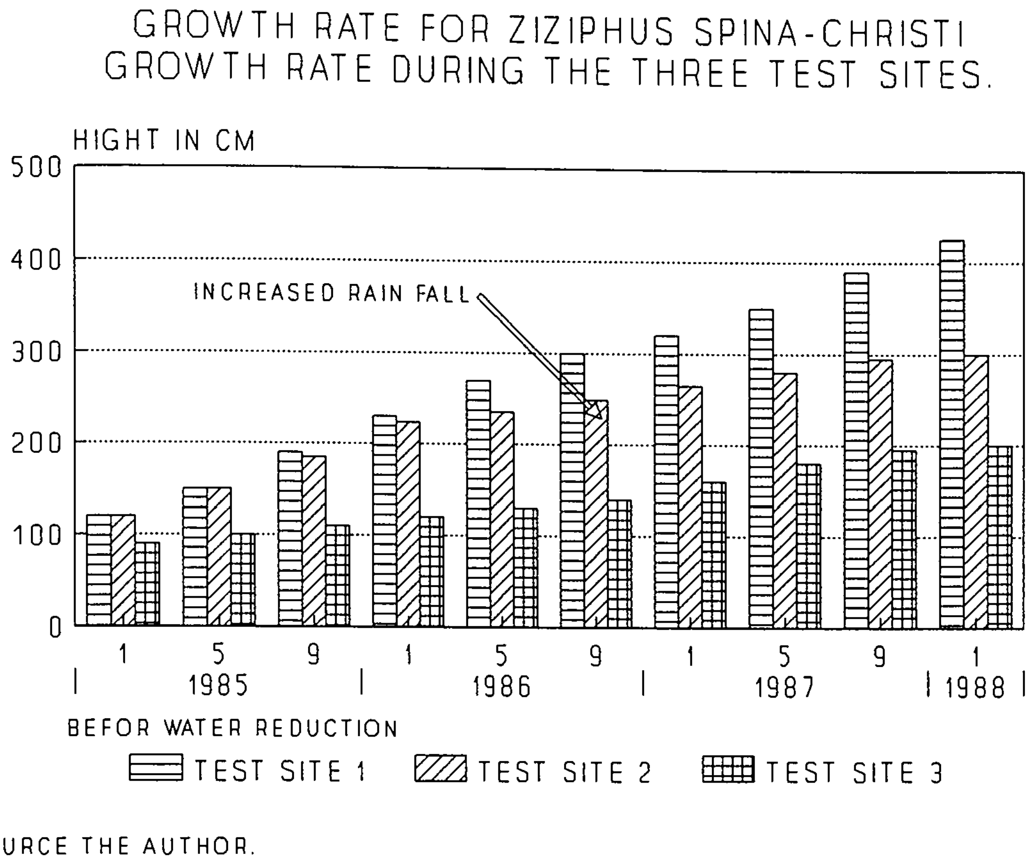


**Fig 123: Growth rate for <u>Ziziphus Spina-christi.</u>**

Fig 124: Ziziphus Spina-christi.

SMALL TREES:

Acacia farnasiana, Acacia tortilis, Acacia canophylla, Caltropis procera, Ecalyptus camaldulensis, Ziziphus numilaria, Prosopis fracta and Acacia gerrardii, were tested under the different conditions found in the three test sites. During the three test sites Acacia farnasiana, Acacaia canophylla, Acacia tortilis, Caltropis procera, Ziziphus numilaria, achieved a satisfactory growth and tolerated all the influences found in the second and third test site. During the first test site all achieved fast and safe growth and there were no signs of any loss of the adaptation characteristics.

They are useful for structure planting. Combined with large trees and shrubs, they are suitable for shelter belts and space definitions. [105] Acacia canophylla, and Caltropis procera maintain a coarse texture which prove useful in structure planting (Fig 125) especially if they were planted at different heights to achieve sequence of progression and hierarchy of masses.

**Fig 125: Acacia canophylla, (right) and Caltropis procera (left) maintain a coarse texture which prove useful in structure planting.**

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[105] See chapter 7. Matrix for conflict free planting grouping.

Acacia farnasiana, maintain fine texture and dense branches suitable for visual and physical sheltering (Fig 126). It combines well with the rest of the Acacia spp. It produces near solid shadow that should be valuable for sitting areas and camp sites. Ziziphus numilaria is appropriate for street planting especially in plazas as it is not thorny and is characterised by attractive silhouette and sculptural appearance.

**Fig 126: Acacia farnasiana, maintain fine texture and dense branches suitable for visual and physical sheltering.**

**BOTANICAL NAME:** Acacia Farnasiana.

**GENERAL NOTES AND DESCRIPTION:** Known as the sweet acacia and native to the central region and other parts. It is a multiple-branched, vase-shaped shrub with ferny foliage growing 2-3 m tall.

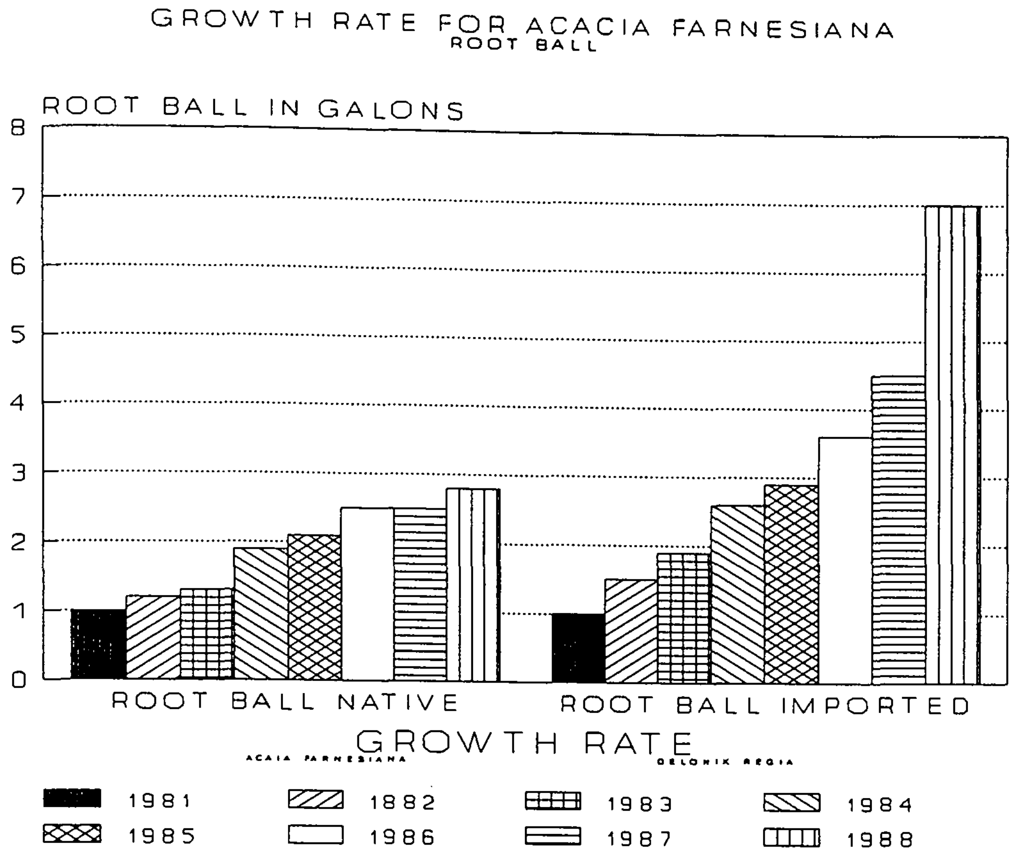


**Fig 127: Growth rate for Acacia Farnasiana.**

**PHYSICAL FACTORS**

**GROWTH RATE:**

The graph (Fig 127) shows how this species achieved an acceptable growth rate with minimal irrigation compared to the imported Delonix regia which required and received four times the amount of water. It is surface rooting and prefers north facing, semi-sheltered areas.

**ROOT STRUCTURE:** Semi surface root system, tend to be limited in diameter when irrigated. Under continual summer irrigation, and in its fifth growing year, the diameter of the root zone was smaller than the canopy. That is a valuable fact for landscape architects who may prefer more compacted structure planting.

**BEST THRIVING CONDITIONS:**

It also coped well with compacted soil and tolerates salinity up to 1200 ppm. Like other acacia it is tough and while it survives un-irrigated, 25 /litre/day three times per week in summer produced excellent growth.

**EXPOSURE:**

When irrigated it thrives best in exposed sites, while under filtered sun and lower irrigation rate, it maintained the same growth as a fully irrigated species. That again qualifies the plant for urban context.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRIENT:** Moderate. Best growth achieved by good loose aerated soil. However, the species will survive in loose or compacted sand but with slower growth rate and extensive branches. This tree can tolerate moderate salinity, poor soil and tough climatic conditions.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

VISUAL CHARACTERISTICS

**HABIT:** Deciduous.

**FORM:** Vase shaped, multiple-branched with ferny foliage. Fig 128.

**SIZE:** The plant grows to an inverted conical habit, about 2.5 m high and 3 m diameter.

**FOLIAGE:** It produces ferny, evergreen foliage and in late autumn long-lasting yellow puffball flowers.

**TECHNIQUES:**

**PROPAGATION METHOD:** Seeds or cuttings.

**SEED COLLECTION METHOD:** Seeds should be collected from carefully selected target species and sown manually in late summer.

**SEEDING TIME:** Mid september.

**Fig 128:** Acacia Farnasiana.

**BOTANICAL NAME:** Acacia Canophylla.

**GENERAL NOTES AND DESCRIPTION:** A small tree 3.5-5 m high, spreading multi branched crown, it is a good tree for space definition and a good alternative to none-native species such as Thevetia Nerifolia and Callistemon . It was found near the escarpment of Wadi Hanifah but according to the nursery, the seed was given by as Australian botanist without stating the source. Being found in the domain of Najdi desert this species was included in the first test site as it showed some encouraging signs.

The plant is suitable for stabilizing slopes, as it is characterised by the capability to hold shifting soil. It is also suitable as a low visual screen, has ornamental values and contributes generously to the nitrogen in the soil.

**PHYSICAL FACTORS:**

**GROWTH RATE:** The graph below (Fig 129) presents the steady growth pattern of the species canopy.

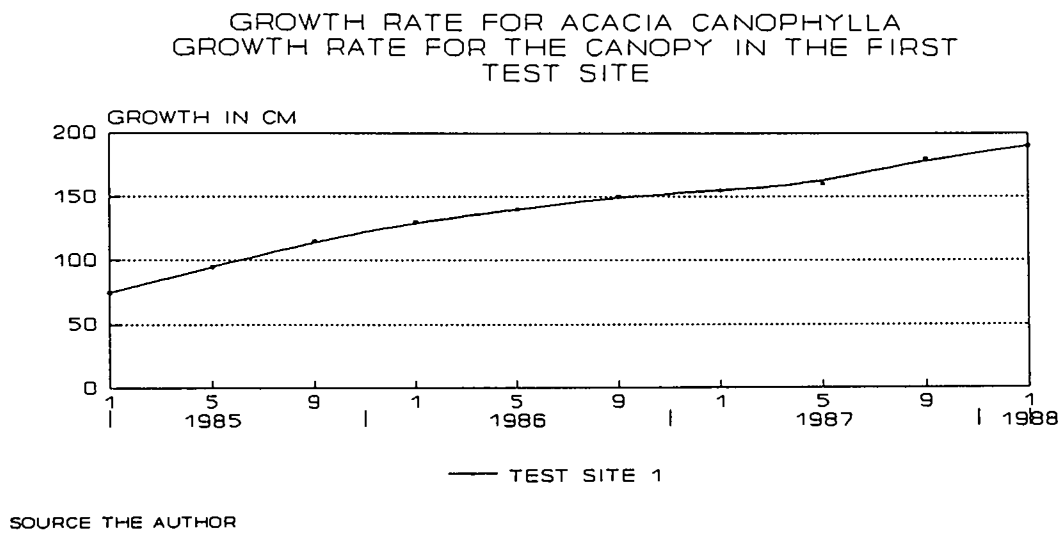


**Fig 129: Growth rate for Acacia Canophylla.**

**ROOT STRUCTURE:**

The plant has an extensive surface root system.

**BEST THRIVING CONDITIONS:** Thrives in well-drained and irrigated soil.

**EXPOSURE:** Full sun and exposed sites are beneficial.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** It is moderately tough, prefers a loose and well aerated soil.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Requires 25/litre/day three times a week, only in the summer season, to achieve full growth. The toleration of salinity is moderate, when it exceeded 7000 ppm. It showed yellowish cast on the leaves, which might be as a result of the high salinity level.

VISUAL CHARACTERISTICS:

**HABIT:** Evergreen.

**FORM:** Multistem. The plant produces many long branches (Fig 130).

**SIZE:** 3.5-5 M high, 2-5 M wide.

**FOLIAGE:** Rounded ribbon-like, (25 cm), pale green tend to get yellowish under temperature stress.

**FLOWERS:** Flower heads are yellow (6mm diameter).

TECHNIQUES

**PROPAGATION METHOD:** Seeds or cutting.

**SEED COLLECTION METHOD:** Seeds should be gathered and sown manually september-october.

**REMARKS:**

This species is suitable for urban landscape. It could be used to redefines and grade into higher plant masses.

Fig 130: Acacia Canophylla.

**BOTANICAL NAME:** Acacia tortilis.

**GENERAL NOTES AND DESCRIPTION:** Is a small tree or shrub, with long, sharp thorns, growing in sand in wadis and hammadas. It maintains the same characteristics as Acacia canophylla. It provides solid natural fencing and is a good soil binder.

**PHYSICAL FACTORS:**

**GROWTH RATE:** The plant was used in the first test site as back layer to the larger trees due to its thorny structure. (Fig 131) In the first test site, the growth rate was fast in the first and second, while in the third test the plant was not found. Although the plant was classified in the target species as a tree, it maintained the form of a small tree in both tests.

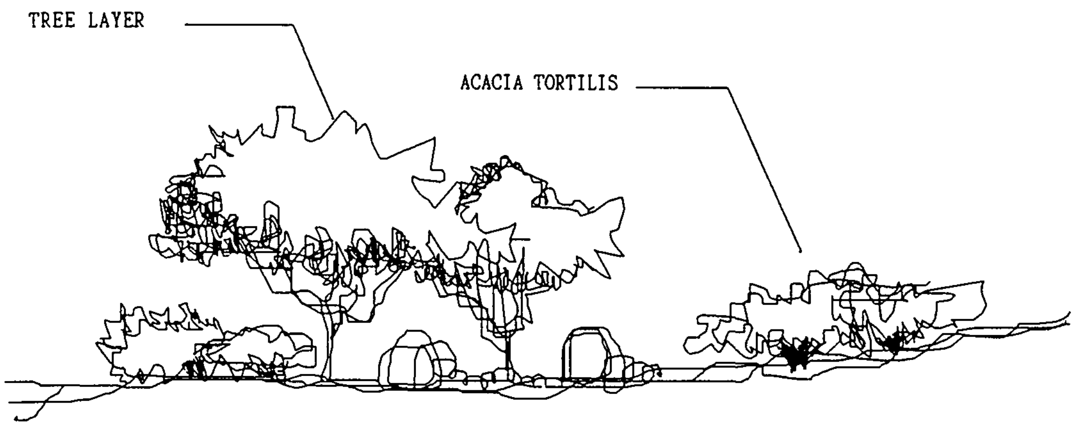


**Fig 131: Using Acacia tortilis should be confined to areas away from public access.**

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Depressions and sandy soil.

**ADAPTATION TO SALINITY LEVEL:** Tolerated 10000 ppm in the first test site.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Moderate.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Should be used away from children play areas.

**IRRIGATION (NEEDS AND EFFECTS):** Minimal after establishment, the plant was growing in the first test away from the main stream irrigation.

**VISUAL CHARACTERISTICS:**

**HABIT:** Evergreen.

**FORM:** creeping when young and high bushy as mature.

**SIZE:** 3-4 M high, 2-3 M wide.

**FOLIAGE:** It produces ferny, evergreen foliage.

**FLOWERS:** The plant did not flower during the testing process.

TECHNIQUES:

**PROPAGATION METHOD:** Seeds or cuttings.

**SEED COLLECTION METHOD:** Manual.

**SEED COLLECTION SOURCE:** South Arriyadh.

**SEEDING TECHNIQUES:** Manual seeding in sandy soil.

**SEEDING TIME:** later september.

**REMARKS:** The plant is excellent for achieving large shrub areas. Fig 132.

Fig 132: Acacia tortilis.

**BOTANICAL NAME:** Calotropis Procera

**GENERAL NOTES AND DESCRIPTION:** 3-5 m high shrub; pale green leaves; flowers green on the outside, pink on the inside; spongy fruit; evergreen; requires sandy soil; thrives in dry season. [106]. The species could be considered as a small tree rather than shrub. It is native to Najd. Found occasionally and naturally in the streets of Najdi towns. Its fruits produces a high quality fibre that was used by the Bedouin for bedding. Its wood was also used for tents and tension cables, the leaves were used as a fertilizer, while the rest of the plant was used by Arab doctors to treat dysentery, elephantiasis and asthma. [107]

PHYSICAL FACTORS

**GROWTH RATE:** The growth rate of this species was outstandingly successful in all test sites and in the target community method test. The graph and the picture below shows the succession stages of this species which will successfully substitute for imported species of medium sized trees or large shrubs such as Thevetia Nerifolia. The graph below shows its growth rate. Fig 133.

**ROOT STRUCTURE:** Surface

**BEST THRIVING CONDITIONS:** Any condition in Najd is suitable. It was found in one site thriving in both wetland and dry land.

**ADAPTATION TO SALINITY LEVEL:** Excellent. Salinity measured in the Wadi Hair, where the seed collected, was 20000ppm.[108]

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Nil.

VISUAL CHARACTERISTICS

**HABIT:** Evergreen.

**FORM:** See Fig 134.

**SIZE:** 5 M. high, 4 M. wide.

**FOLIAGE:** Large rounded pearl-like 20 Cm.long and 10 Cm.wide.

**FLOWERS:** Purple.

TECHNIQUES

**PROPAGATION METHOD:** Seeds.

**SEED COLLECTION METHOD:** Manual.

**SEEDING TECHNIQUES:** Manually, seeds will be placed 15 Cm under the soil surface

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[106] Sheila Collenette; FLOWERS OF SAUDI ARABIA.

[107] Khalifah, Said, *Trees and shrubs in Kingdom of Saudi Arabia*, Firs Ed, Riyadh, 1980.

[108] Source of seed collection.

after the necessary seed preparation.

**SEEDING TIME:** Late summer.

**REMARKS:** Perhaps the most rigorous species tested in this research. Its adaptation to drought and water fluctuation and soil were found to be phenomenal. It is also attractive in form and character. The species is anticipated to be used widely in Najdi landscape projects.

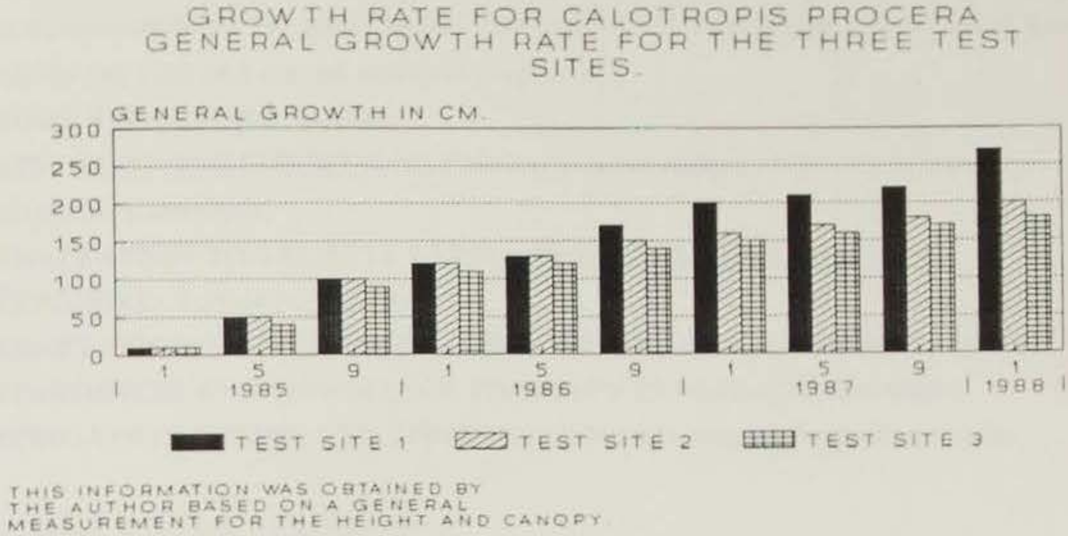


**Fig 133: Growth rate for Calotropis Procera.**

Fig 134: Calotropis Procera.

**BOTANICAL NAME:** Ziziphus Nummularia.

**GENERAL NOTES AND DESCRIPTION:** It is similar to Ziziphus spina christi in its characteristics and growth requirement except that its fruits are not edible. A tangled thorny leafy small tree, spines may be curved.

## PHYSICAL FACTORS

**GROWTH RATE:** It showed some suffering in the second test site after water reduction as demonstrated in the graph below. But generally it maintained a satisfactory growth rate in the first and second test sites (Fig 135).

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Consistent water regime under any microclimatic and edaphical conditions.

**ADAPTATION TO SALINITY LEVEL:** Similar to Ziziphus spina christi.

**EXPOSURE:** Full or partial sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Consistent water scheme is essential.

## VISUAL CHARACTERISTICS

**HABIT:** Evergreen.

**FORM:** See photo. Fig 136.

**SIZE:** 10 m high, 6 m wide.

**FOLIAGE:** Small oval leaves.

**FLOWERS:** greenish yellow flowers, 3mm wide, orange fruit.

## TECHNIQUES

**PROPAGATION METHOD:** seeds or cutting.

**SEED COLLECTION METHOD:** Manual, from selected target species.

**SEED COLLECTION SOURCE:** Wadi Hanifah , south, also found intensively around Buraidah.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Late summer.

**REMARKS:** This species is remarkably adapted to the different soil patterns in Najdi area. It also maintains the ability to adapt to any consistent water regime.

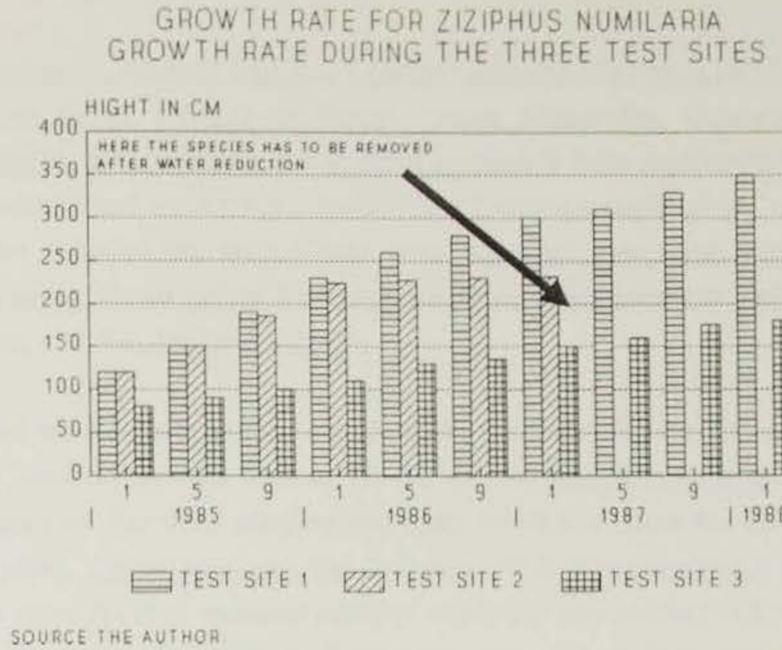


**Fig 135: Growth rate for Ziziphus Numilaria.**

**Fig 136: Ziziphus Numilaria.**

**SHRUBS:**

Abutilon pannosum, Atriplix halimus, Capparis spinosus, Capparis cartilsqunea, Cassia italica, Datura inoxa, Lycium babbarum, Noaea Mucronata, Ochradinus baccatus, Periploca aphylla, Rhazia stricta and Ricinus communis were monitored for four years, all were physically and authentically suitable for landscape application. Nine species out of the twelve satisfied the tests. These were Abutilon pannosum, Atriplix halimus, Capparis spinosus, Cassia italica, Datura inoxa, Ochradinus baccatus, Periploca aphylla, Rhazia stricta and Ricinus communis.

The qualified shrubs are important design tools, especially for their ability in structure planting to provide privacy and to define spaces. Atriplex halimus and Abutilon pannosum are ideal for mass planting and space definition. Both are also acceptable as a specimen plant. Capparis spinosa, Cassia italica and Ricinus communis are appropriate under a tree layer for their minimal conflict with other native trees and shrubs. The rest maintain strong characteristics in their form and texture that qualifies them as a monotype planting. However, all plants in this group were found to be ideal for use in a diverse design containing large trees, small trees and shrubs (Fig 137).

**Fig 137: Native shrubs are suitable for most tasks.**

**BOTANICAL NAME:** Abutilon pannosum

**GENERAL NOTES AND DESCRIPTION:** Success in all the test sites. This species showed great adaptability to water supply variation; it was thriving in the third test site which is dependent on rain water only (as the graph below shows). The species is a small velvety-leafed shrub, ideal as a secondary layer of higher ground cover and for space definition.

**PHYSICAL FACTORS:**

**GROWTH RATE:** Its growth rate varies with water supply, but may be satisfactorily maintained by natural irrigation alone (Fig 138).

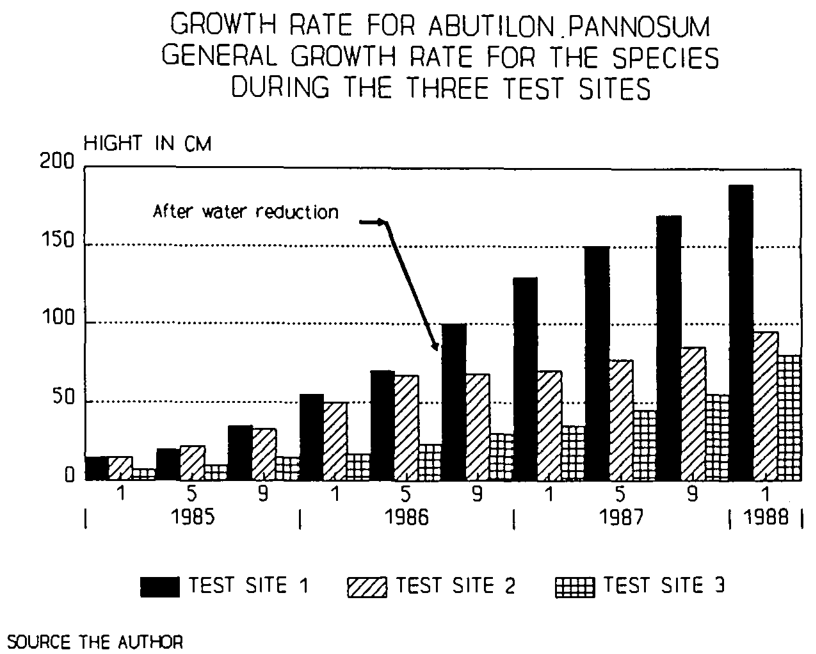


**Fig 138: Growth rate for Abutilon Pannosum.**

The graph clearly indicates the slowing down of the growth rate after water reduction in the second test site, while the species continued its steady growth un-irrigated in the third test site. This is evidence supporting the elimination of man made irrigation for this species.

**ROOT STRUCTURE:** Abutilon has a surface root system.

**BEST THRIVING CONDITIONS** : Thrives best fully exposed in areas with primary ground cover. It maintains the ability, under natural irrigation to grow in highly compacted and rocky soil.

**ADAPTATION TO SALINITY:** It requires only minimal irrigation and tolerates salinity level of up to 8000 ppm.

**EXPOSURE:** Full or filtered sun

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRIENTS:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Moderate. It has minimal thorn which reduces the natural protection.

**IRRIGATION NEEDS AND EFFECT:** Nil. As the above graph indicated the species managed to maintain a satisfactory growth rate after water reduction and without irrigation in the third test site.

VISUAL CHARACTERISTICS:

**HABIT**: Evergreen.

**FORM**: Vertical shoots forming an upright, fence-like plant,

**SIZE**: 1m high 2m wide (Fig 139).

**FOLIAGE**: The foliage is ovate-cordate, acute and dentate.

**FLOWERS**: It flowers with large, yellow blooms with purple centres (usually in pairs).

TECHNIQUES:

**PROPAGATION METHOD**: It may be propagated by seeds or vegetatively.[109]

**SEED COLLECTION METHOD**: Selective seed collection being less destructive is preferable and should be collected from a similar site approved by the landscape architect i.e where the edaphic, environmental and geomorphological conditions of the source are similar to the target site.

**SEEDING TECHNIQUE**: A manual seeding technique in late summer as such species start germination in the late summer early winter, should be implemented, under the supervision of the landscape architect.

REMARKS:

Abutilon emerged as an extremely successful candidate for landscape use, tough, fast growing, and attractive having broad leaves which might be used as a texture landscape element.

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[109] For a detailed propagation methods see chapter 3 (methodology) and chapter5 (recommendation).

Fig 139: Abutilon Pannosum.

**BOTANICAL NAME:** Atriplex Halimus.

**GENERAL NOTES AND DESCRIPTION:** An excellent shrub, through all the test sites it managed to achieve a satisfactory growth rate as shown in the graph below. It is suitable for many landscape applications and requires no maintenance and irrigation. Fig 141 below shows a sample of its composition in the first test site with other species. It is a low shrub with medium leaves and whitish grey flowers. It is commonly growing in saline depressions.

**PHYSICAL FACTORS:**

**GROWTH RATE:** Fast See Fig 140 below.

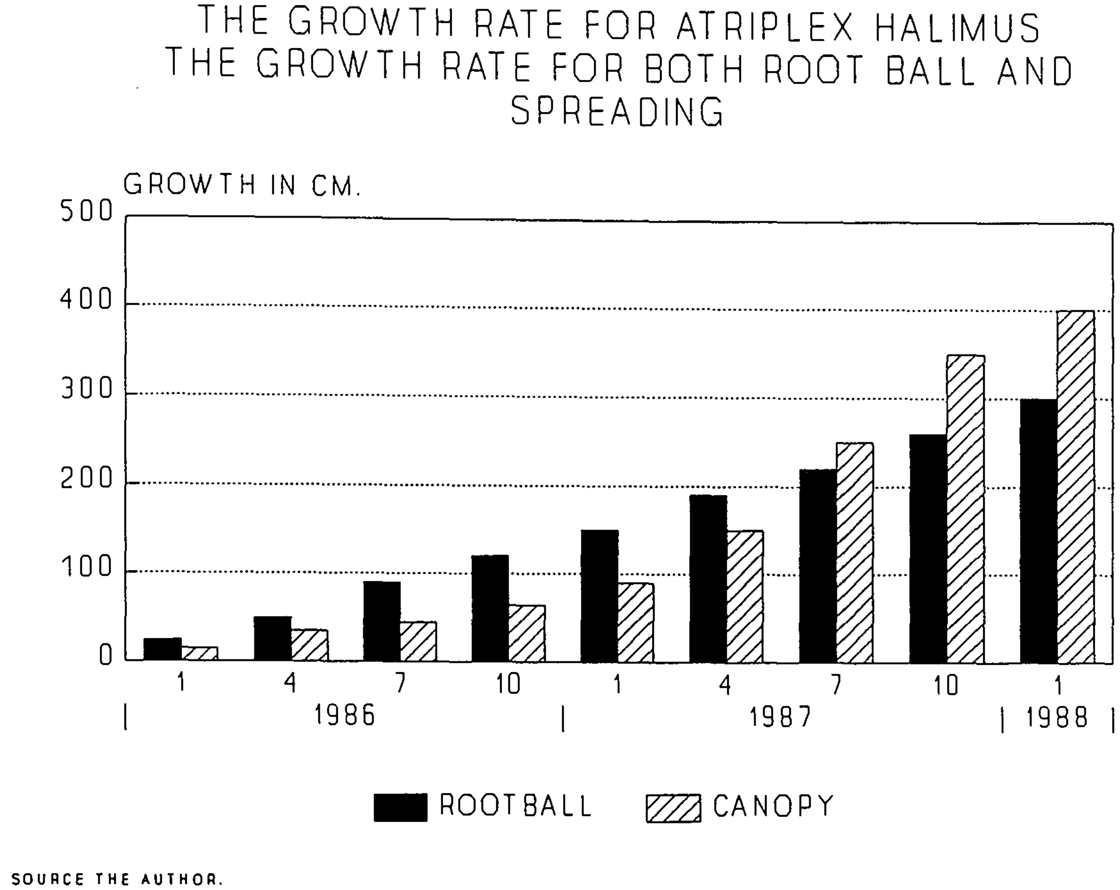


**Fig 140: Growth rate for Atriplex Halimus.**

**ROOT STRUCTURE:** Extensive deep and lateral roots.

**BEST THRIVING CONDITIONS:** Showed a success in all test sites especially the second one; after the irrigation water was stopped it showed no signs of suffering. Grows well in textured soil in addition to all known soil in the region, but favours saline sandy soil with small percentage of clay. It was also found in the wild to colonize saline depressions and wadies.

**ADAPTATION TO SALINITY LEVEL:** Excellent, known as the salt bush. Tolerated up to 17000 ppm in the first test site.

**EXPOSURE:** Full or filtered sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** In the first test site: the species achieved a slight growth rate over those found in the second and third test site. The irrigation quantity there was 25/l/twice a week.

VISUAL CHARACTERISTICS

**HABIT:** Semi evergreen. It partially loses leaves for a short period.

**FORM:** Mound like bush. Fig 141.

**SIZE:** 3 M. high and 4 M. wide.

**FOLIAGE:** Leaves , whitish pale green. Ovate triangular narrow at the end. Up to 4 cm. long and 2.5 cm. broad.

**FLOWERS:** Fruit bracts sessile, cordate-reniform, without appendix entire or nearly so. [110]

TECHNIQUES

**PROPAGATION METHOD:** The cuttings method is recommended.

**REMARKS:** This species was one of the most successful test species in all the test sites, especially in the shrub layer. It will substitute successfully for imported shrubs such as Dodonea viscose, Tecoma stans and Lantana spp.

**Fig 141: Atriplex Halimus.**

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[110] Migahid, *Flora of Saudi Arabia*. First Ed. Vol I&II, Arriyadh, Riyadh University Publication, 1978.

**BOTANICAL NAME:** Capparis Cartilaginea.

**GENERAL NOTES AND DESCRIPTION:** A large shrub, equivalent to Nerium Oleander. A pendent bushy trailing shrub, native to steep cliffs and similar geomorphological places in the region.

**PHYSICAL FACTORS:**

**GROWTH RATE:** Fast. Fig 142.

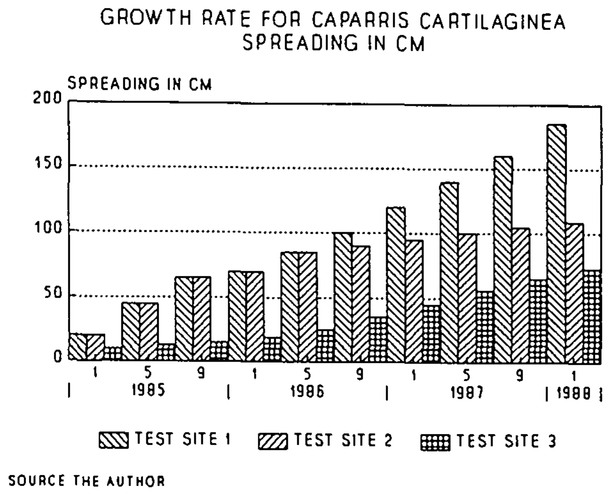


**Fig 142: Growth rate for Capparis Cartilaginea.**

Fast during the first and the initial period of the second test site till water stoppage. During the third test the species maintained a slow and uniform progress resulting in a tougher plant. The comparison above with Nerium Oleander during the first test site showed that Capparis Cartilaginea lost some of its toughness when irrigated while the first maintained most of it, due to its longer adaptation as an irrigated species.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** North facing locations which are exposed to northern shamal wind. Sandy soil with gravel cover. In its natural habitat the species tend to colonize sites that are sheltered by rocks or mud walls.

**ADAPTATION TO SALINITY LEVEL:** Moderate.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** As Capparis spinosa.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** During the first test site when summer irrigation was consistent the species showed a good growth rate combined by an intensifying in leaf color. In the second test the species failed to adapt to the water reduction.

VISUAL CHARACTERISTICS:

**HABIT:** Evergreen.

**FORM:** Large spreading mound like. Fig 143.

**SIZE:** 5m wide. 1m high.

**FOLIAGE:** Oval pearl-like.

**FLOWERS:** White.

TECHNIQUES:

**PROPAGATION METHOD:** Seeds and cuttings.

**SEED COLLECTION METHOD:** Manual.

**SEEDING TECHNIQUES AND TIME:** Manual. Late summer.

**REMARKS:** This species was successful only in the first test site. During the other two tests, its general appearance was found to be unacceptable as a landscape design instrument."In a controlled irrigated zone the species was found to be more successful than most comparable imported species". [111]

Fig 143: Capparis Cartilaginea.

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[111] Klaus Klein. BBW and partner consultant for the Extensive landscape project in the A.D.A, interview by the author, July 1988.

BOTANICAL NAME: Cassia Italica.

**GENERAL NOTES AND DESCRIPTION:** An attractive species, with qualifications to substitute imported species of shrubs. Its texture, color and habit are most appropriate for most landscape design use.

**PHYSICAL FACTORS**

**GROWTH RATE:** Fast. Fig 144.

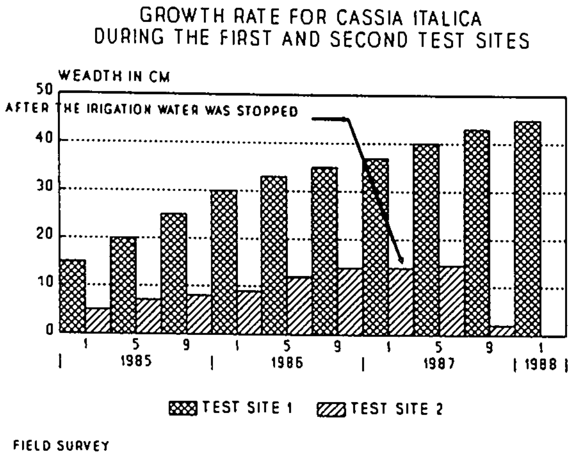


**Fig 144: Growth rate for Cassia Italica.**

The graph shows the failure of the species to tolerate the water stoppage in the second test site. However it maintained a satisfactory growth in the first one adequate enough for most landscape applications.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** It showed a faster growth rate when irrigated, the irrigation quantity was fixed at 25/Litre/3 times/ week, in summer only. After six years the irrigation should be reduced but not stopped.

**ADAPTATION TO SALINITY LEVEL:** Excellent. Current Salinity level in the first test site is 15000 ppm.

**EXPOSURE:** Full or partial sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Attractive to public therefore it is vulnerable to vandals. However it is a tough species. There are about 500 in the D.Q and there is no record of replacement except during establishment. [112]

**IRRIGATION (NEEDS AND EFFECTS):** 25/1/ 3 times a week.

**VISUAL CHARACTERISTICS**

**HABIT:** Evergreen.

**FORM:** Leafy branching mound like. (Fig 145).

**SIZE:** 30 cm. high, 80 cm. wide.

**FOLIAGE:** Large and coarse.

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[112] D.Q nursery.

**FLOWERS:** Large and yellow, 3 cm. long.

TECHNIQUES

**PROPAGATION METHOD:** Seeds or cutting.

**SEED COLLECTION METHOD:** Manual.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Late summer.

**REMARKS:** This species could be pruned and trained according to landscape need. However this was not proved by this research, as the author considers such treatment as anomalous to the plant. The plant would fit into the second layer of a shrub area. This is addressed in the next chapter.


**Fig 145:** Cassia Italica.

**BOTANICAL NAME:** Capparis Spinosus.

**GENERAL NOTES AND DESCRIPTION:** Shrub requires gravel and Sandy soil (ROCKY SOIL); densely branching from the base. Excellent form and texture.

**PHYSICAL FACTORS:**

**GROWTH RATE:** Achieved a faster growth rate with saline soil and minimal water. The graph below shows its better growth rate in comparison to Dodonea Viscosa found in the site under the same growing conditions (Fig 146).

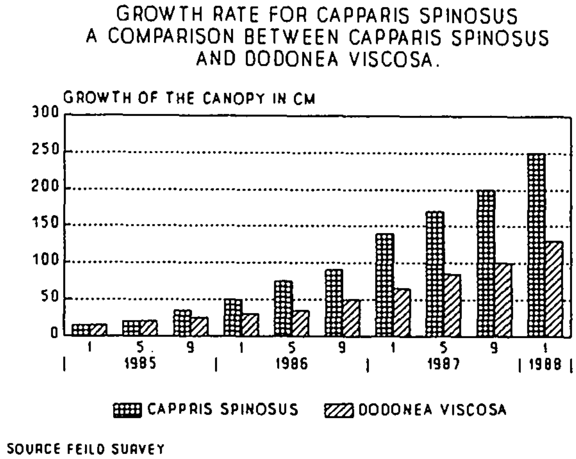


**Fig 146: Growth rate for the spread of Capparis Spinosus .**

Note that these statistics were measured on the third test site to compare the native Capparis spinosus with an imported and commonly used species.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** A west facing location away from the north hot wind with average irrigation of approx. 15 litre/ three times per week, will achieve an optimum growth rate with lavish appearance. The growth rate in the graph above was achieved without any irrigation under maximum exposure to eco-environmental factors.

**ADAPTATION TO SALINITY LEVEL:** Moderate, showed early suffering in the first test site, where irrigation was implemented and with high salinity levels. On the second site after water stoppage it thrived over the next two seasons, sensing that salinity level was decreasing with water reduction.

**EXPOSURE:** Full or partial sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** A 12 litre / three times /week is sufficient (only applicable in the summer). While this species can survive in extreme drought, its flowering season could be very short.

**VISUAL CHARACTERISTICS**

**HABIT:** Evergreen.

**FORM:** Creeping species similar to Ipomea spp. (Fig 147).

**SIZE:** 30. Cm high, 3-4 M. wide.

**FOLIAGE:** Small 2 Cm long, ellipse like.

**FLOWERS:** 4 Cm white- Yellow in the middle. Night flower. Red and bright fruit in the winter.

TECHNIQUES

**PROPAGATION METHOD:** Seeds, or cutting.

**SEED COLLECTION METHOD:** Manual.

**SEEDING TECHNIQUES:** Manual. Seeds should be laid 15 Cm. deep in the ground.

**SEEDING TIME:** Late summer.

**REMARKS:** A good species for ground cover. Similar in function to many imported species such as Clerodendrum Enerme. Also matches and can colonize the local building material, clay.

Fig 147: Capparis Spinosus.

**BOTANICAL NAME:** Ficus Salisifolia.

**GENERAL NOTES AND DESCRIPTION:** Large shrub, glaucous, blue-green, long-petalled, narrow-lancelot entire leaves, up to 12cm long and 3cm broad; medium size tree.[113]

**PHYSICAL FACTORS**

**GROWTH RATE:** Moderate. However the graph below shows that the species was successful in the three test sites especially in the third. Its form, steady growth, texture and overall performance was more successful than on irrigated sites i.e the adaptation to drought is more important in this test than growth speed which is obviously fast in the other two test sites. Fig 148.

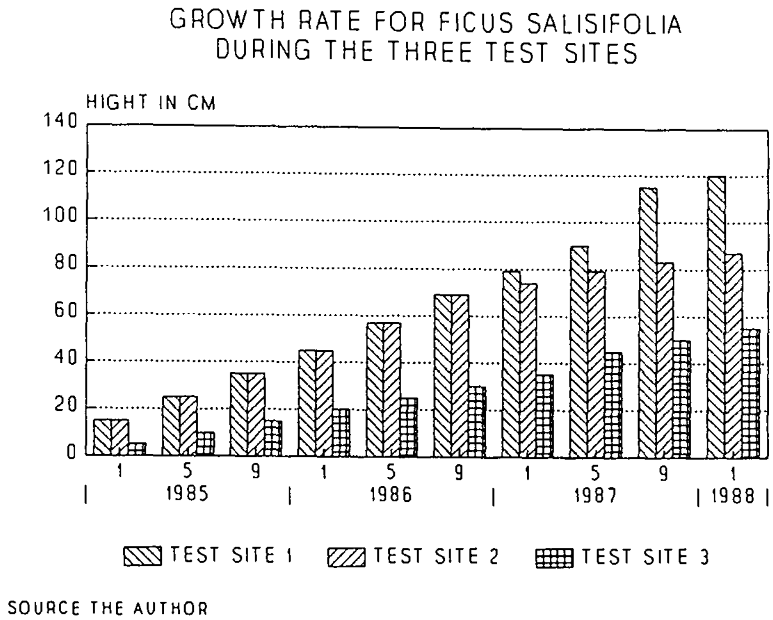


**Fig 148: Growth rate for Ficus Salisifolia.**

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Exposed and dry sites. Thrives well in a non irrigated sandy soil. The species should be planted in an extensive site as it tends to germinate in a zone measured by a circle of 20 M diameter.

**ADAPTATION TO SALINITY LEVEL:** Excellent.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Nil. Drought adaptation and toughness might be affected by excessive water.

**VISUAL CHARACTERISTICS**

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[113] Collenette, Sheila, *An illustrated guide to the flowers of Saudi Arabia*, First ed, Meteorology and Environmental Protection Administration, Saudi Arabia; Flora Publication No. 1, London: Scorpion Publishing Ltd, 1985.

**HABIT:** Evergreen.

**FORM:** Medium shrub. Fig 149.

**SIZE:** 2 M. high, 3 M. wide.

**FOLIAGE:** Small ribbon like

**FLOWERS:** There was no observation of any significant flowers during the test.

TECHNIQUES:

**PROPAGATION METHOD:** Cutting.

**REMARKS:** An excellent shrub with a distinctive texture and form. Its spreading branches enables such species to be compacted and used as a hedge and buffer zone for privacy, especially as it maintains a dense structure.

**Fig 149:** **Ficus Salisifolia.**

**BOTANICAL NAME:** Ochradenus Baccatus.

**GENERAL NOTES AND DESCRIPTION:** An excellent shrub with attractive form and texture. Very wide spread in Najd and considered to be one of the most successful species in this test. It could be combined and composed with the majority of the test plants with complete success.

PHYSICAL FACTORS

**GROWTH RATE:** Fast. The graph below shows that the growth rate during the three test sites was satisfactory even in the third site i.e without any additional water. Fig 150.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** The species thrived in most conditions during the test period.

**ADAPTATION TO SALINITY LEVEL:** Excellent.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Minimal after establishment.

VISUAL CHARACTERISTICS

**HABIT:** Evergreen.

**FORM:** Mound-like. Fig 151.

**SIZE:** 3 M. high, 3 M wide.

**FOLIAGE:** Narrow thin.

**FLOWERS:** Yellow 5mm wide.

TECHNIQUES

**PROPAGATION METHOD:** Seeds.

**SEED COLLECTION METHOD:** Manual from a selected target species.

**SEED COLLECTION SOURCE:** See source map, Fig 108, zone 1.

**SEEDING TECHNIQUES:** Manually seeding is essential.

**SEEDING TIME:** Late summer to achieve more adaptation for the seeds.

**REMARKS:** The plant is suitable for hedges, family buffer zones, compact ground cover and extensive landscape within green belts. Its performance was outstanding in all the stages of the test sites. It will substitute for Lantana Spp and Dedonea Viscosa and similar medium shrub layer.

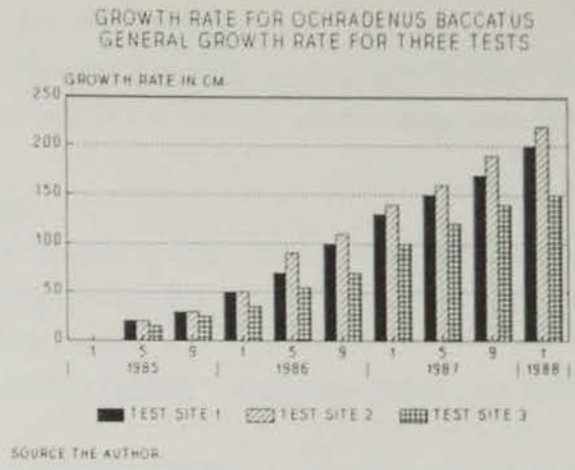


**Fig 150: Growth rate for Ochradenus Baccatus.**

**Fig 151: Ochradenus Baccatus.**

**BOTANICAL NAME:** Periploca Aphylla.

**GENERAL NOTES AND DESCRIPTION:** Shrub; up to 2m high with long virgate whip-like drooping branches which are velvety when young, then becomes glabrous when mature.

PHYSICAL FACTORS:

**GROWTH RATE:** Moderate. It was noticed that this species thrives in drought conditions and high alkaline soil. Fig 152. [114]

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Exposed unsheltered locations, with minimal irrigation.[115]

**ADAPTATION TO SALINITY LEVEL:** Excellent, thrive in alkaline soil.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Nil.

VISUAL CHARACTERISTICS:

**HABIT:** Deciduous.

**FORM:** Reverse cone like with extensive shoots. Fig 153.

**SIZE:** 2 m high, 1.5 m wide.

**FOLIAGE:** Few, small, nearly sessile, 3mm long.

**FLOWERS:** Purple, 2 Cm. Broad.

TECHNIQUES

**PROPAGATION METHOD:** Seeds.

**SEED COLLECTION METHOD:** Manual selective from target species.

**SEED COLLECTION SOURCE:** Al-Mansouriah.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Late summer.

**REMARKS:** The species will add another attractive and durable small shrub to the already rich native collection. It was almost maintenance and irrigation free with hardly any sign of suffering from drought. During the past four years the growth rate for this species ,which is recorded below, tended to be satisfactory in the third site, and in the second site where it started to colonize the site after water stoppage.

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[114] Klaus Klein. A.D.A chief landscape architect, interview by the author, audio recording material.

[115] A number of these species were planted near by stream irrigation, resulting in a clear deterioration in their general growth rate.

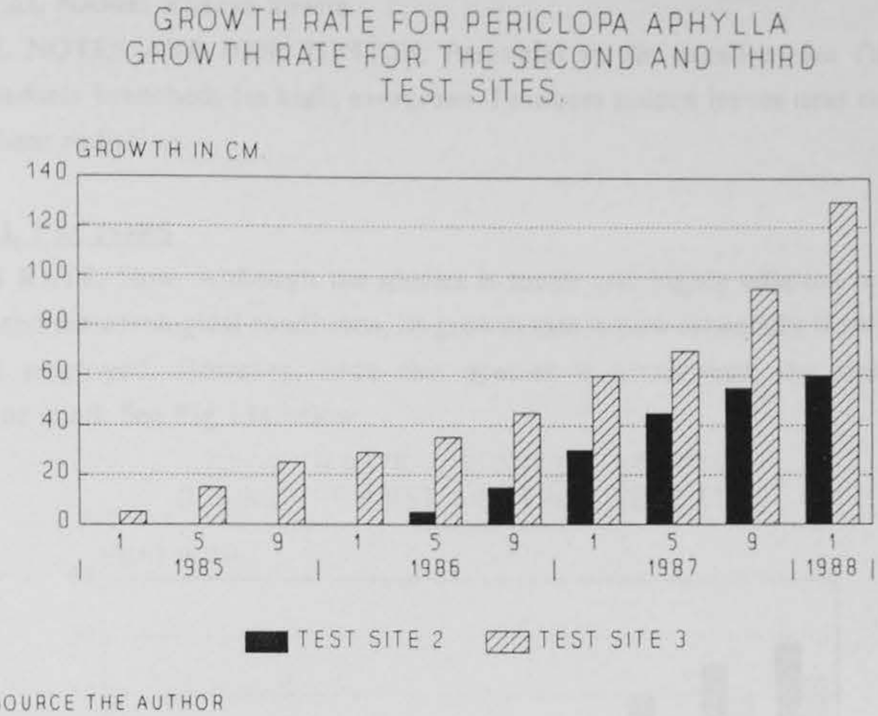


**Fig 152: Growth rate for Periploca Aphylla.**


**Fig 153: Periploca Aphylla.**

**BOTANICAL NAME:** Rhazya Stricta.

**GENERAL NOTES AND DESCRIPTION:** Perennial shrub; excellent for flat, sandy surfaces; densely branched; 1m high; evergreen. Produces golden leaves near the ground to reflect heat radiation.

## PHYSICAL FACTORS

**GROWTH RATE:** Slow. Although the species is tough and highly adapted to the local edaphical and meteorological conditions, its growth rate is slow especially if an irrigation scheme is employed. However, once this species is established the maintenance requirement is nil. See Fig 154 below.

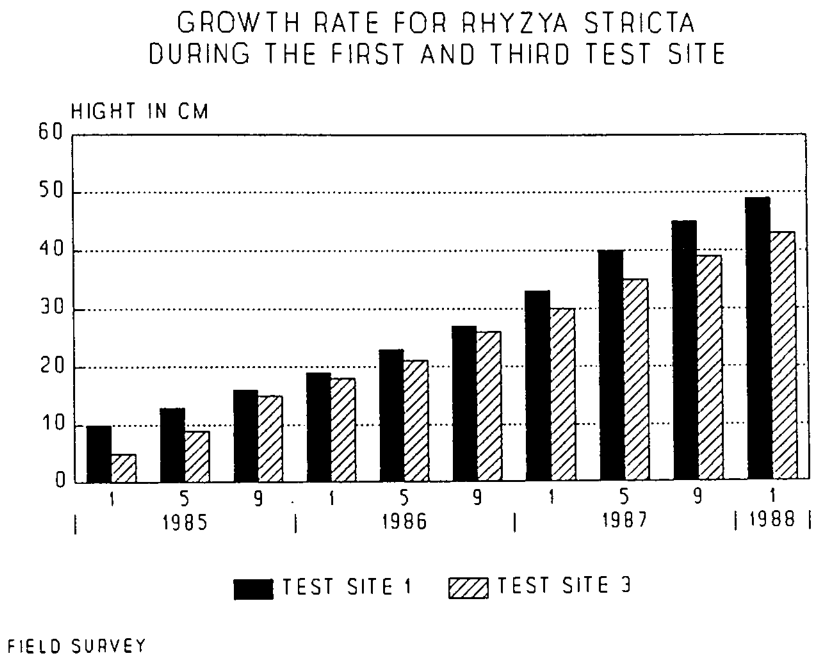


**Fig 154: Growth rate for Rhazya Stricta.**

**ROOT STRUCTURE:** Deep roots.

**BEST THRIVING CONDITIONS:** Exposed non irrigated land with sandy soil.

**ADAPTATION TO SALINITY LEVEL:** Excellent.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Nil.

## VISUAL CHARACTERISTICS

**HABIT:** Evergreen.

**FORM:** Extensive branching. See Fig 155 below.

**SIZE:** 1 M high 60 Cm tall.

**FOLIAGE:** Leaves 10cm long and 1.5Cm broad.

**FLOWERS:** Flowers pentamerous white, 2-2.5Cm long, short.

## TECHNIQUES

**PROPAGATION METHOD:** Seeds.

**SEED COLLECTION METHOD:** Manual.

**SEED COLLECTION SOURCE:** Al-Diraeyah.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Late summer.

**REMARKS:** The species is tough and durable for landscape use, it could be used in the urban context due to its form and texture.

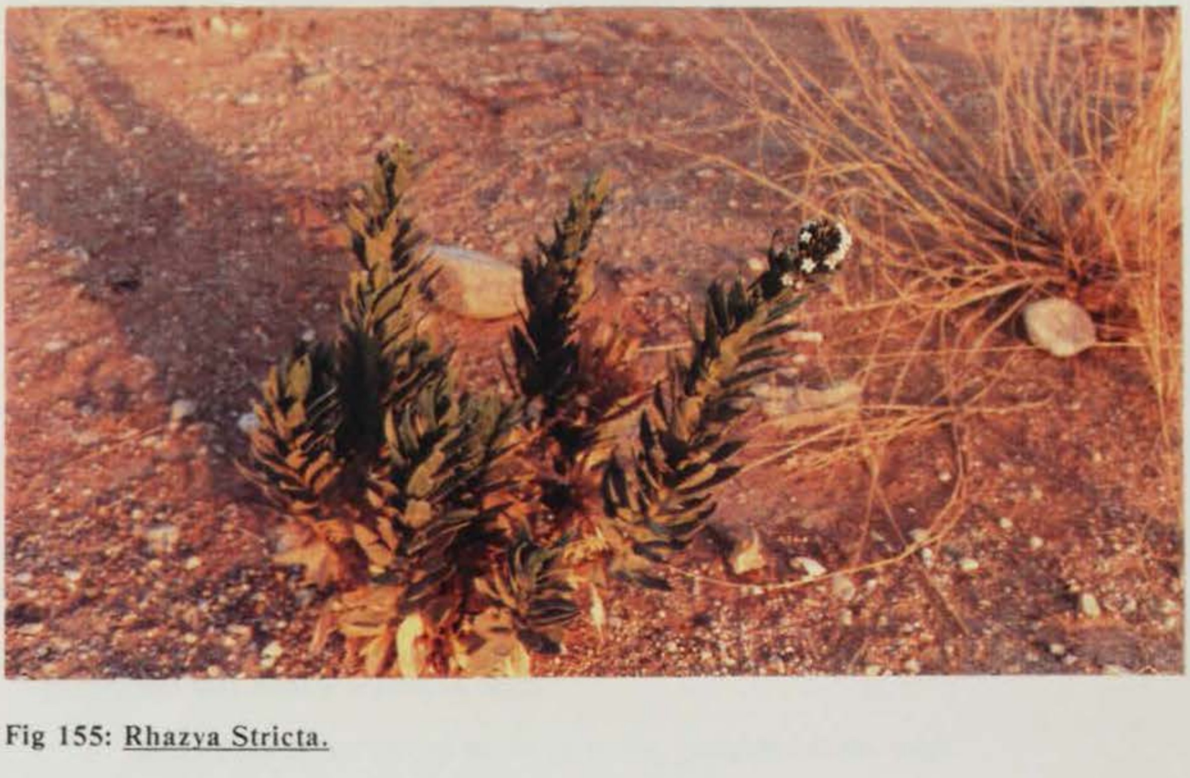

Fig 155: Rhazya Stricta.

**BOTANICAL NAME:** Ricinus Communis.

**GENERAL NOTES AND DESCRIPTION:** An erect branching herb 2M tall.[116] An attractive plant which maintains almost the character of a weed but very useful in extensive desert landscaping. The flower of this species is slightly poisonous if eaten, but most native people know the plant and some use it still as a form of Arabic medicine. Because it was highly successful, it was included to be used in extensive landscape areas.

## PHYSICAL FACTORS

**GROWTH RATE:** The species germinated successfully as a weed in the first and second test sites. There was no record in the D.Q nursery of the source of the seeds or even the source of the target species [117]. This indicates that the species germinated in the first and the second test site as seeds within the blanket method. Nevertheless, the plant is highly successful in colonizing the semi sheltered rocky soil and sandy plateaus. The graph (Fig 156) below shows the growth rate.

**ROOT STRUCTURE:** surface.

**BEST THRIVING CONDITIONS:** Semi sheltered cool and rocky soil.

**ADAPTATION TO SALINITY LEVEL:** Excellent 10000 - 15000 ppm.[118]

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Delicate and fragile.

**IRRIGATION (NEEDS AND EFFECTS):** Minimal. Not measurable.

## VISUAL CHARACTERISTICS

**HABIT:** Herb.

**FORM:** Bushy look, extensive branching, Fig 157.

**SIZE:** 200 cm height, 90 cm wide.

**FOLIAGE:** Broad, palmate 10 cm wide.

**FLOWERS:** 3 mm wide. Red, sharp smell.

## TECHNIQUES

**PROPAGATION METHOD:** Blanket method.

**SEEDING TECHNIQUES:** Blanket method.

**SEEDING TIME:** Late summer.

**REMARKS:** This herb is attractive and suitable as a fast and multi purpose species,

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[116] Sheila Collenette ; Flowers of Saudi Arabia.

[117] The species according to Migahid and Collenette is introduced but now well established and widely spread in Najd.

[118] According to last record in the first site. (irrigated areas only).

especially, on sites disturbed by human impact.[120]

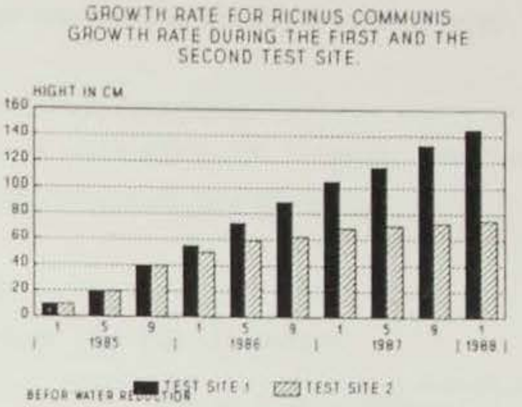


Fig 156: Growth rate for <u>Ricinus Communis.</u>


Fig 157: <u>Ricinus Communis.</u>

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120 See ecological recommendation in next chapter.

SMALL SHRUBS:

The following species are categorised as small or dwarf shrubs. They are particularly useful for planting large areas and as a secondary shrub layer.

**BOTANICAL NAME:** Aellenia subaphylla.

**GENERAL NOTES AND DESCRIPTION:** Sparsely, branched stout green-stemmed shrublet; 60 cm. tall with thick scale-like leaves;

**PHYSICAL FACTORS:**

**GROWTH RATE:** Average . See Fig 158 bellow.

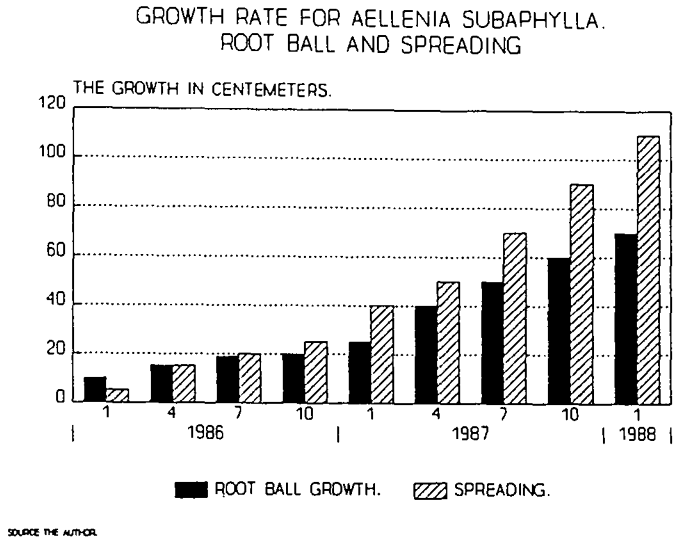


**Fig 158: Growth rate for Aellenia Subaphylla.**

The plant was tested in the third test site due to its success as a non irrigated species. The figure above shows that it achieved a steady but slow growth to reach a satisfactory height in four years. According to K. Klein (B-B-W) the species will start after this period to grow outwards, the weight of the branches bringing them close to the ground sometimes transforming it into a ground cover plant. [120]

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Non irrigated land, provided that the seeds were lifted manually by blanket method and from a similar site.

**ADAPTATION TO SALINITY LEVEL:** Excellent.

**EXPOSURE:** Full or filtered sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Can stand very high level of heavy public use.

**IRRIGATION (NEEDS AND EFFECTS):** Limited to rain fall only. The seed can stay in the soil for two years without watering.

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[120] Meeting in the A-D-A.

VISUAL CHARACTERISTICS

**HABIT:** Evergreen.

**FORM:** Creeper. Spreading mound. See Fig 159.

**SIZE:** 60 Cm. high, 1M. wide.

**FOLIAGE:** Thick scale-like leaves.

**FLOWERS:** Yellow stamens.

TECHNIQUES

**PROPAGATION METHOD:** Seeds or Seedlings.

**SEED COLLECTION METHOD:** Blanket method.

**SEED COLLECTION SOURCE:** See Fig 108, zone 2.

**SEEDING TECHNIQUES:** Manual.[121]

**SEEDING TIME:** Late summer.

**REMARKS:** Very attractive species and suitable for most landscape. It could be compacted and grouped to form a dense ground cover especially if initial irrigation is provided for the first year.

Fig 159: Aellenia Subaphylla.

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[121] See chapter 3 seeding methods.

**BOTANICAL NAME:** Argemone Mixicana

**GENERAL NOTES AND DESCRIPTION**

A multi branching and prickly dwarf shrublet, found commonly in the escarpments of Wadi Hanifah and similar locations in Saudi Arabia. This shrublet was found to be most successful in the third test site when artificial irrigation was not implemented. Here towards the end of the rainy season most of the species started to germinate and to spread. In the second test site there was no sign of them until the irrigation water was stopped. There were no signs of such species in the first test site, showing that such species thrive in dry non irrigated land.(Fig 160).

**PHYSICAL FACTORS**

**GROWTH RATE:** Fast during rainy season. See Fig (160). below.

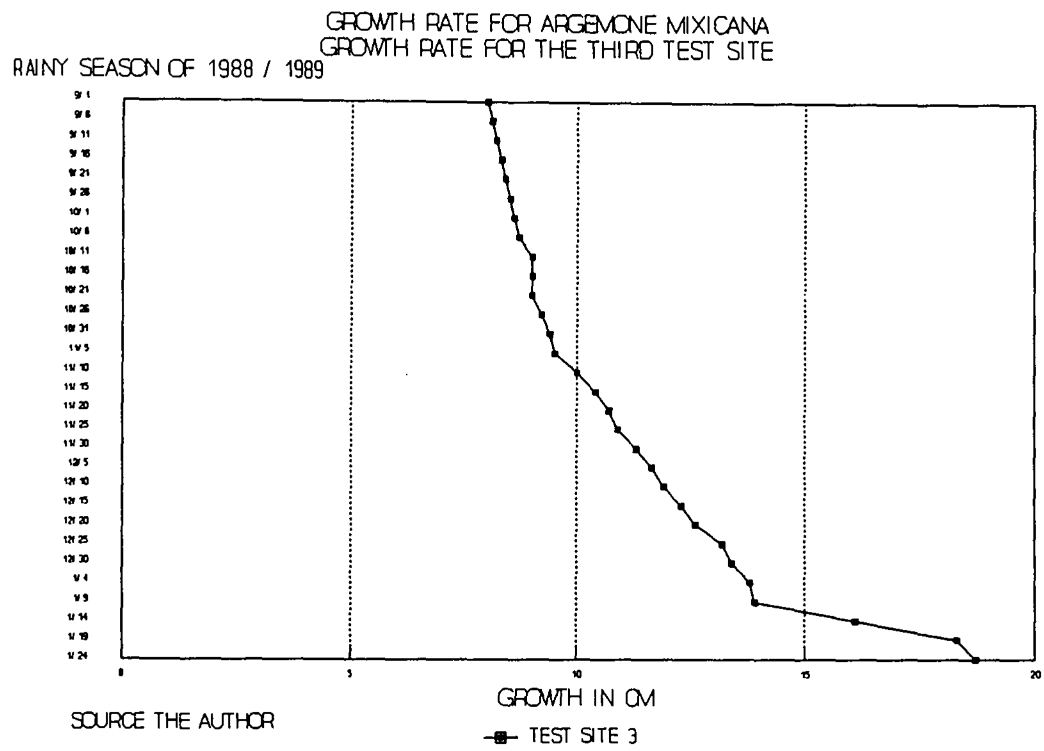


**Fig 160: Growth rate for <u>Argemone Mixicana.</u>**

The graph shows the species growth during one rainy season, 1988/1989.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Exposed non sheltered stony sites are favourable.

**ADAPTATION TO SALINITY LEVEL:** Excellent. Last soil sample 1988 summer showed a level of 15000 ppm. [122]

**EXPOSURE:** Full sun.

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[122] Sample by the A.D.A.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:**Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Very sensitive to handling and trampling but its thorny leaves protect it from possible public approach.

**IRRIGATION (NEEDS AND EFFECTS):** None.

**VISUAL CHARACTERISTICS**

**HABIT:** Annual.

**FORM:** Multi branched. See Fig 161 below.

**SIZE:** 80 cm high 40 cm wide.

**FOLIAGE:** Deeply cleft, spiny, blue-green, white-veined.

**FLOWERS:** Single, 6 cm broad, of 4-6 bright yellow or orange, obovate petals with rounded apex.

**TECHNIQUES**

**PROPAGATION METHOD:** seeds.

**SEED COLLECTION METHOD:** Blanket method. [123]

**SEED COLLECTION SOURCE:** See Fig 108, zone 2.

**SEEDING TECHNIQUES:** Soil lifting and spreading.

**SEEDING TIME:** Late summer.

**REMARKS:** The species is most suitable for extensive landscaping use. It is best used in conjunction with a stony hardscape design, as it enhances the texture of such a surface and grows well in rocky areas.

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[123] Refer to chapter 3.

Fig 161: Argemone Mixicana.

**BOTANICAL NAME:** Atriplex Leucoclada.

**GENERAL NOTES AND DESCRIPTION:** A twiggy herb 30 cm high with white stem and small greyish leaves. Bud-like flowers in special spikes. Native to the central region.

**PHYSICAL FACTORS**

**GROWTH RATE:** Fast. Fig 162.

**ROOT STRUCTURE:** Deep root.

**BEST THRIVING CONDITIONS:** A sheltered and irrigated site with other plants. However it showed a acceptable growth rate in test site three in the absence of artificial irrigation.

**ADAPTATION TO SALINITY LEVEL:** Excellent.

**EXPOSURE:** The plant succeeded most in full sun exposure but can adapt to shady places.

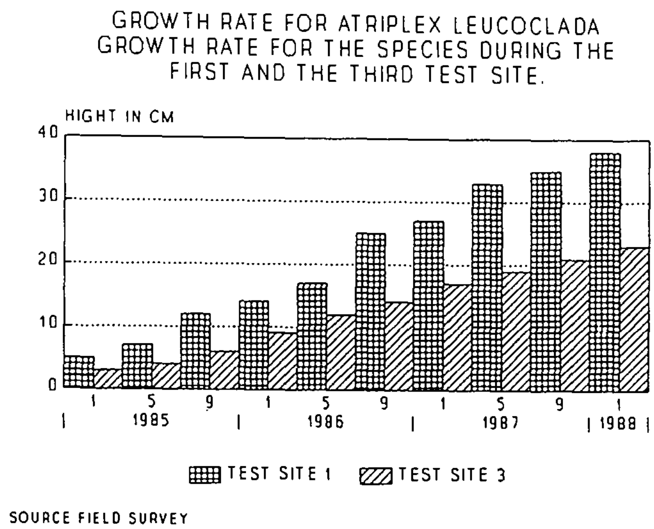


**Fig 162: Growth rate for <u>Atriplex Leucoclada</u> shown in this graph is reasonably fast especially during the first test.**

ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION: Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Minimal after establishment.

**VISUAL CHARACTERISTICS**

**HABIT:** Herb.

**FORM:** Extensive branches. Fig 163.

**SIZE:** 50 Cm. high. 20 Cm.wide.

**FOLIAGE:** Small egg-shaped, white greyish.

**FLOWERS:** Bud-like [124]; rarely appeared during the test.

**TECHNIQUES**

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[124] Collenette, Sheila, *An illustrated guide to the flowers of Saudi Arabia*, First ed, Meteorology and Environmental Protection Administration, Saudi Arabia; Flora Publication No. 1, London: Scorpion Publishing Ltd, 1985.

**PROPAGATION METHOD:** Vegetative material.

**SEED COLLECTION METHOD:** Manual

**SEED COLLECTION SOURCE:** Wadi Hanifah.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Late summer.

**REMARKS:** The species is an excellent herb which usually appears in the middle of the winter season and lasts till the middle of the summer. There was no evidence throughout the test sites that water quantity has played a major role in the distribution and growth rate of this species as it was successful in all three sites.

Fig 163: Atriplex Leucoclada.

**BOTANICAL NAME:** Belepharis Ciliaris

**GENERAL NOTES AND DESCRIPTION:** A dwarf herb that is unique in its form, colour and habit. It is associated with Najdi rocky soil and adapted to high temperature.

**PHYSICAL FACTORS**

**GROWTH RATE:** Slow. Fig 164.

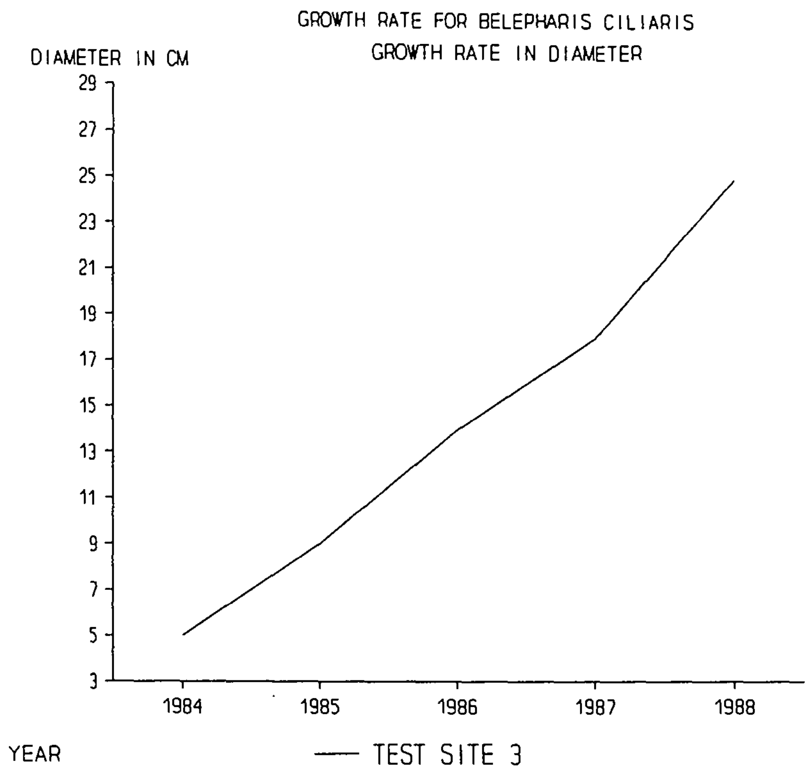


**Fig 164: Growth rate for Belepharis Ciliaris.**

**ROOT STRUCTURE:** Bulb.

**BEST THRIVING CONDITIONS:** Natural sandy soil with minimal irrigation.

**ADAPTATION TO SALINITY LEVEL:** Excellent.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Very sensitive to any public abuse. Its thorny structure may protect it against vandalism.

**IRRIGATION (NEEDS AND EFFECTS):** Nil.

**VISUAL CHARACTERISTICS**

**HABIT:** Herb.

**FORM:** Multi dwarf stems. Fig 165.

**SIZE:** 15 Cm. High 20 Cm. wide.

**FOLIAGE:** Pointed thorny leaves.

**FLOWERS:** purple

**TECHNIQUES**

**PROPAGATION METHOD:** Blanket method.[126]

**SEED COLLECTION METHOD:** Blanket method.

**SEEDING TECHNIQUES:** Manual, by soil lifting and spreading technique.

**SEEDING TIME:** Late Summer.

**REMARKS:** Due to its nature and habit this species is well suited for extensive landscaping areas where sand and rocks will be the dominant soil type.

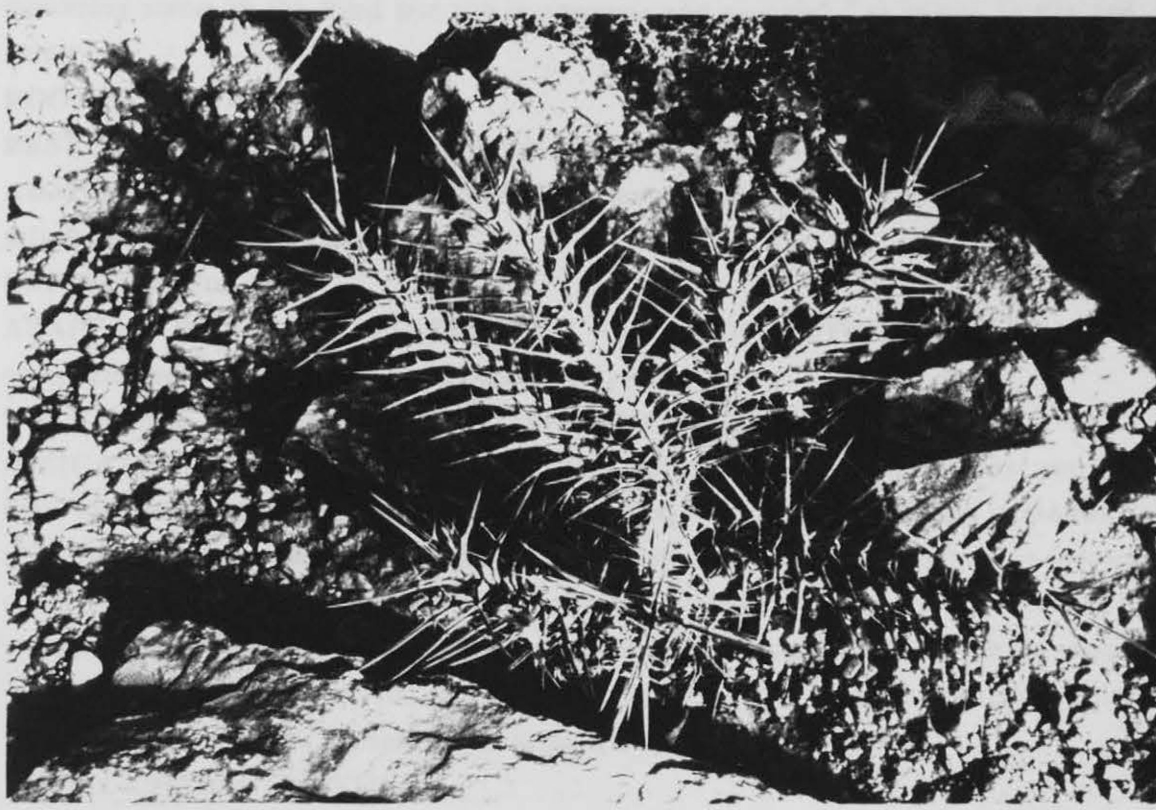

Fig 165: Belepharis Ciliaris.

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[126] See chapter 3 . Methodology.

**BOTANICAL NAME:** Datura inoxa.

**GENERAL NOTES AND DESCRIPTION:** An attractive shrub but its character texture and form only qualify it as a specimen or focus plant. It is a very leafy herb 80 cm high with dark green color. Widely available in Najdi low land and wadies. Growth rate was found to be associated with the presence of rocky sandy soil and minimal irrigation water.

**PHYSICAL FACTORS**

**GROWTH RATE:** Slow without a controlled irrigation system (Fig 166). However it is recommended that irrigation should be avoided with this species for two reasons. Firstly, it was noticed in the second test site that the species failed to tolerate water stoppage, i.e the species are adapted to a consistent water regime. Secondly, the growth rate and flowering status in the third test site is adequate and successful as shown in Fig 166 below.

**ROOT STRUCTURE:** Tap root.

**BEST THRIVING CONDITIONS:** Exposed hot dry zones.

**ADAPTATION TO SALINITY LEVEL:** Excellent. Thriving in the first test site where salinity exceeded 17000 ppm.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Sensitive to compacted soil, flourishes in loose rocky sandy soil.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** The species thrived well in the first and the third test sites; in the first test site, where irrigation water is consistent and in the third test site where rain water was the only source of water. The conclusion is that the species could be trained only over a long period of time. This is supported by the fact that it was eliminated in the second test site shortly after water reduction. The flowering season was very short during the first test and the species is likely to lose its original color intensity and the leaves became larger to get rid of excessive water.

**VISUAL CHARACTERISTICS**

**HABIT:** Herb.

**FORM:** Multi branched species with broad leaves. Fig 167.

**SIZE:** 60 Cm. high and 100 Cm wide.

**FOLIAGE:** Pointed oval like with dark green colour.

**FLOWERS:** White 5 Cm long and 7 Cm wide. See picture below. Fig 167.

**TECHNIQUES**

**PROPAGATION METHOD:** Seeds.

**SEED COLLECTION METHOD:** Selective manual.

**SEED COLLECTION SOURCE:** See Fig 108. Zone 3.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Late summer.

**REMARKS:** The species could be used as a shrub in both intensive and extensive landscaping. It is most suitable for gravel areas which are usually left behind after a construction site. It is adapted to Arriyadh stone.[126]

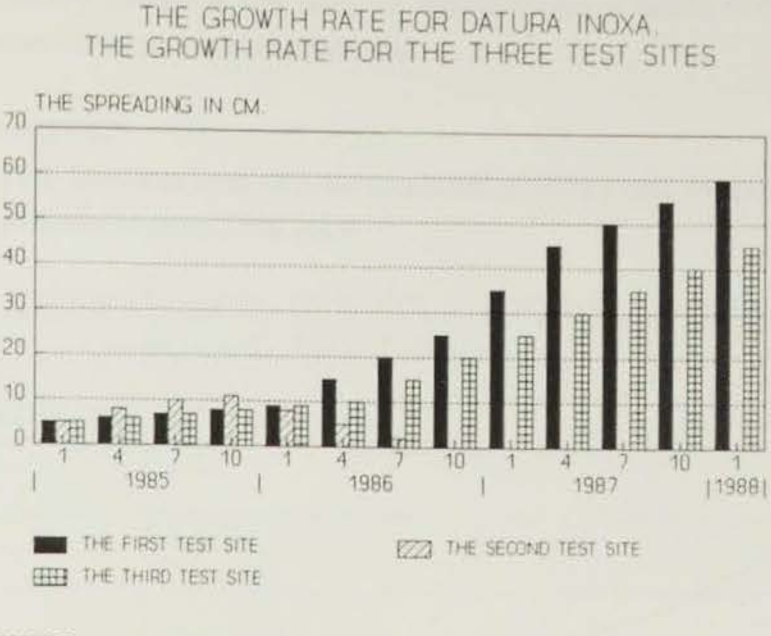


Fig 166: Growth rate for Datura inoxa.

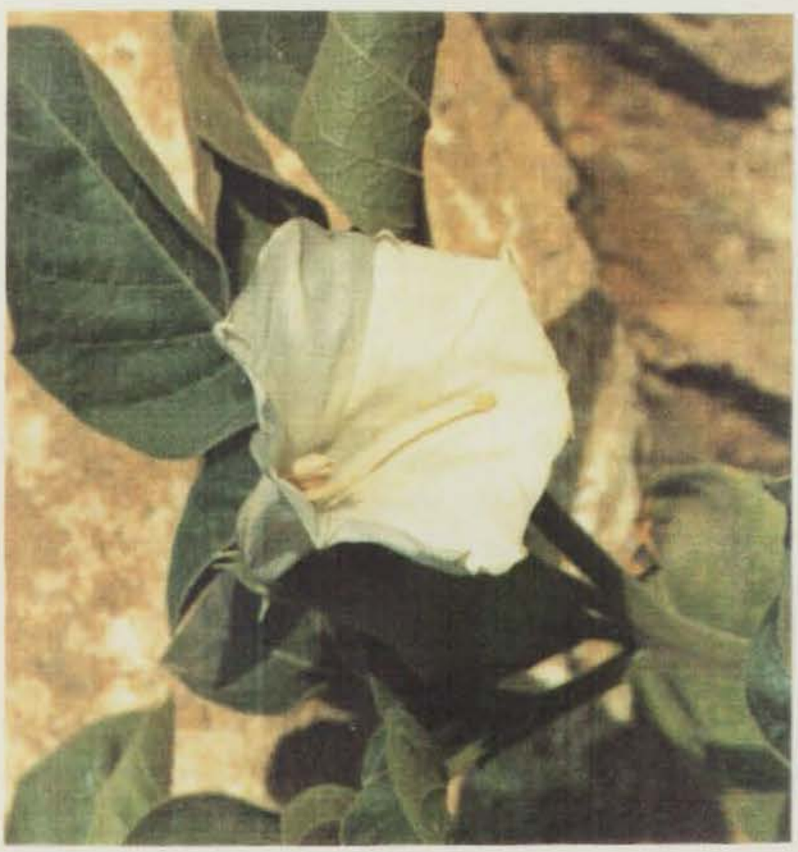

Fig 167: Datura inoxa.

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[126] Arriyadh is sitting on a layer of lime stone known as Riyadh stone.

**BOTANICAL NAME:** Heliotropium Digynum

**GENERAL NOTES AND DESCRIPTION:** A perennial and semi white stemmed shrub 25 Cm. high. yellow flowers 4 mm wide, in almost spherical heads; but no smell. An attractive species for Arid landscape projects.

**PHYSICAL FACTORS**

**GROWTH RATE:** Slow but even and the graph below shows that the growth rate does not fluctuate between seasons. (Fig 168).

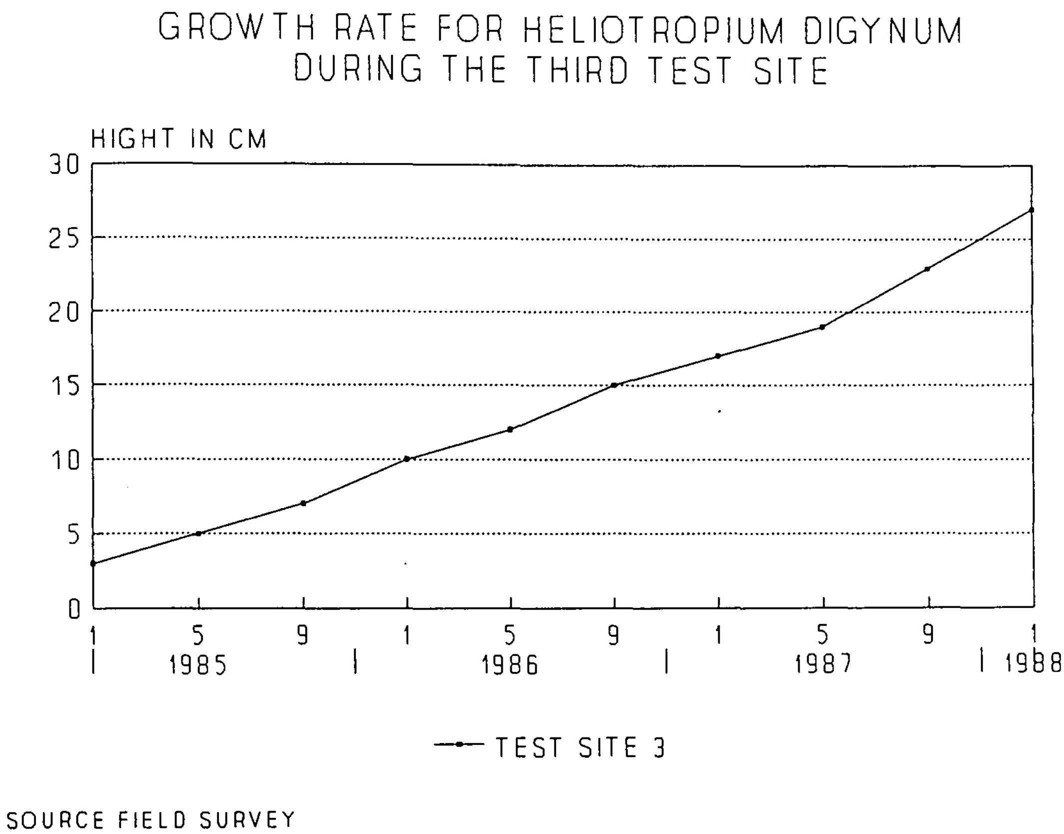


**Fig 168:** __Heliotropium Digynum__.

**ROOT STRUCTURE:** Tap roots.

**BEST THRIVING CONDITIONS:** Sandy soil with a rocky cover. Minimum water and full sun.

**ADAPTATION TO SALINITY LEVEL:** 15 ppm.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Moderate.

**IRRIGATION (NEEDS AND EFFECTS):** Nil.

**VISUAL CHARACTERISTICS**

**HABIT:** Perennial.

**FORM:** Multi individual stems extensively displayed. Fig (169).

**SIZE:** 25-30 Cm. high 20 Cm.wide.

**FOLIAGE:** Small rounded.

**FLOWERS:** Small yellowish.

**TECHNIQUES**

**PROPAGATION METHOD:** Seeds.

**SEED COLLECTION METHOD:** Blanket.

**SEED COLLECTION SOURCE:** Wadi Hanifah.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Late summer.

**REMARKS:** This species is one of the useful tools for landscape architects to treat the sandy rocky elements in landscape design projects where water is minimal and aridity is extreme.

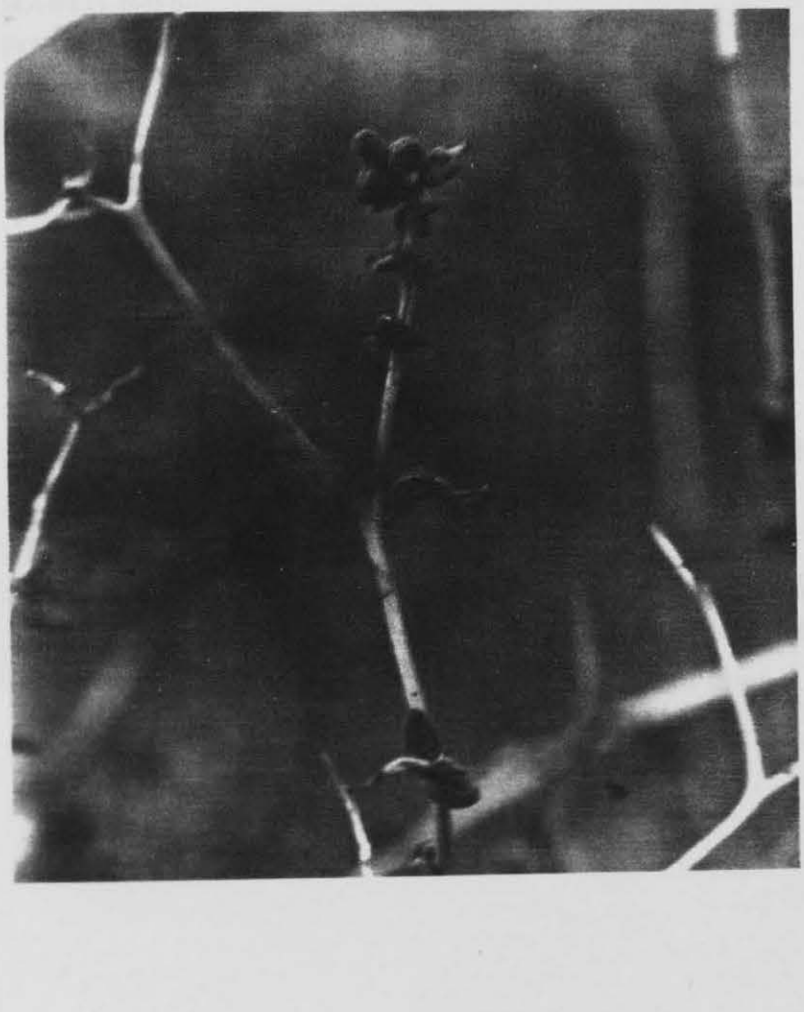

Fig 169: Heliotropium Digynum.

**BOTANICAL NAME:** Peganum Harmala.

**GENERAL NOTES AND DESCRIPTION:** A bushy leafy herb 30cm. high, extensively found in the central region and rarely grazed. Attractive in the spring and late winter.

PHYSICAL FACTORS

**GROWTH RATE:** Slow. See the statistical graph below. Fig 170.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Sandy dry soil.

**ADAPTATION TO SALINITY LEVEL:** Excellent. Sample from test location showed that salinity level was 9000 ppm. [127]

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Satisfactory.

**IRRIGATION (NEEDS AND EFFECTS):** Minimal.

VISUAL CHARACTERISTICS

**HABIT:** Herb.

**FORM:** Bushy Round Mound. Fig 171.

**SIZE:** 40 cm high. 100 cm wide.

**FOLIAGE:** Long ribbon-like.

**FLOWERS:** White 2cm wide, strong and sharp smell.

TECHNIQUES

**PROPAGATION METHOD:** Soil was lifted from the surface of the surrounding target specimen.

**SEED COLLECTION METHOD:** Manual.

**SEED COLLECTION SOURCE:** South Arriyadh near Wadi Hair.

**SEEDING TECHNIQUES:** Manual spreading of soil.

**SEEDING TIME:** Early winter.

**REMARKS:** The species will be very useful for extensive and green belt type landscaping. The form and character provide the species with the capability to survive in sites where sand and drought is part of the design brief.

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[127] See Appendix III.

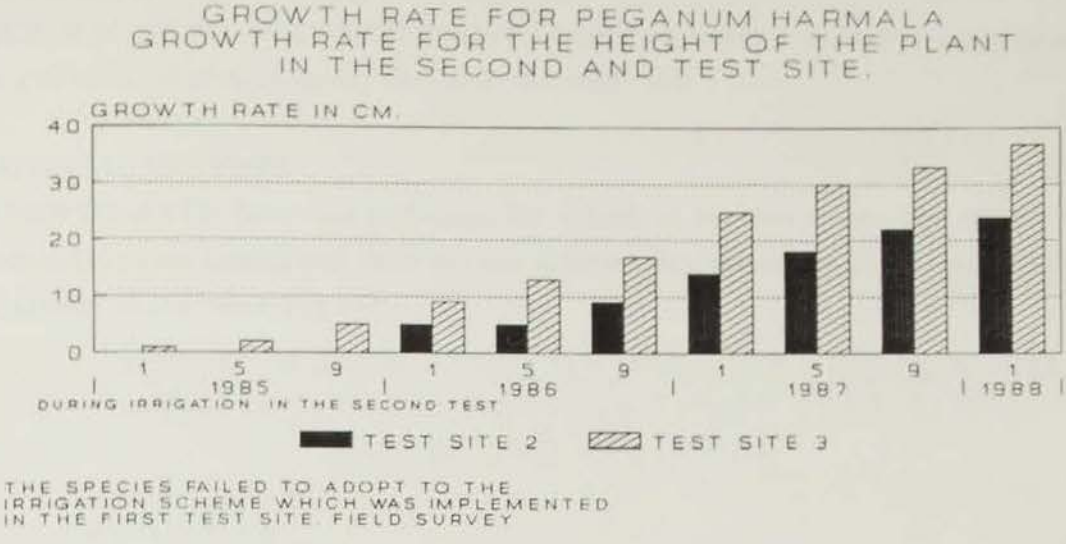


**Fig 170: Growth rate for Peganum Harmala.**

**Fig 171: Peganum Harmala.**

**BOTANICAL NAME:** Zygophyllum coccineum

**GENERAL NOTES AND DESCRIPTION:** A bushy, succulent-leaved herb could be used as a compacted ground cover; thrives in red sandy soil.

**PHYSICAL FACTORS:**

**GROWTH RATE:** Slow but sufficient for a general landscape use. The species was successful in the second and third test site despite water reduction in the second and no irrigation in the third. Fig 172.

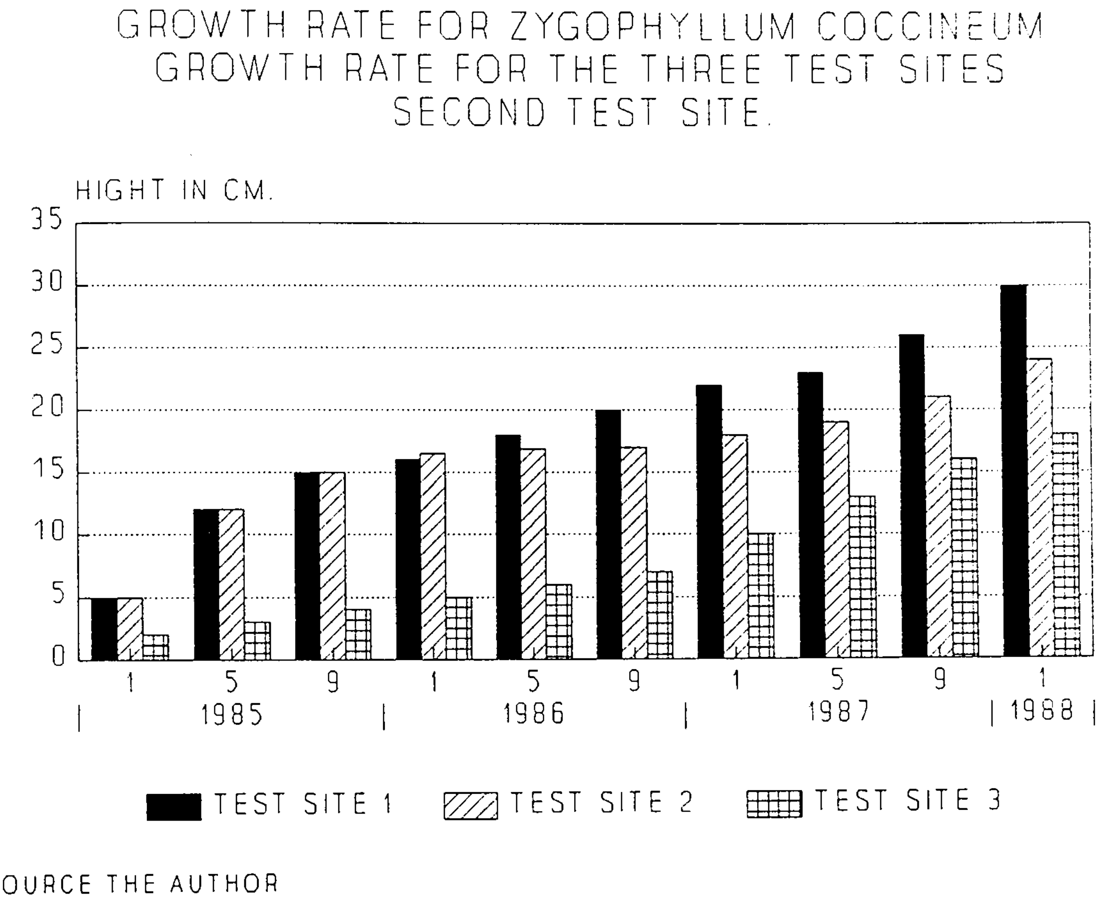


**Fig 172: Growth rate for Zygophyllum Coccineum.**

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Exposed sandy soil. Loose sand in depressions is the favourable habitat for this plant.

**ADAPTATION TO SALINITY LEVEL:** 6000 ppm.

**EXPOSURE:** Full or partial sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Requires loose sand.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Minimal after establishment.

VISUAL CHARACTERISTICS

**HABIT:** Evergreen.

**FORM:** Mound like. Fig 173.

**SIZE:**; 30 cm high.

**FOLIAGE:** Bifoliat, pale green.

**FLOWERS:** Small, yellow flowers, 4 mm wide;

TECHNIQUES

**PROPAGATION METHOD:** Vegetative material was used for propagation in the nursery under similar conditions to the habitat of the species.

**PLANTING TIME:** October.

**REMARKS:** The species can be pruned and shaped. When irrigated the species can be used as a compacted ground cover. It reaches its maximum height in five years. It also showed signs of suffering when propagated in a container, therefore it was raised in a sand box and later transplanted to the site.[128]

Fig 173: Zygophyllum Coccineum.

[128] A.D.A Nursery.

CREEPING GROUND COVER:

The following creeping vines are suitable for use as a green ground cover. The tests proved their adaptability to hot soil surfaces especially sand, gravel and even asphalt pavement.

**BOTANICAL NAME:** Bassia Eriophoria

**GENERAL NOTES AND DESCRIPTION:** Annual herb with hairy cotton like dominant appearance. Suffers in winter and almost disappears but thrives in the summer giving an attractive white ground cover. Distinguished in the summer by the coverage of a snow white fruit.

**PHYSICAL FACTORS**

**GROWTH RATE:** Slow found only in the third test site where blanket seeding method was employed. Fig 174.

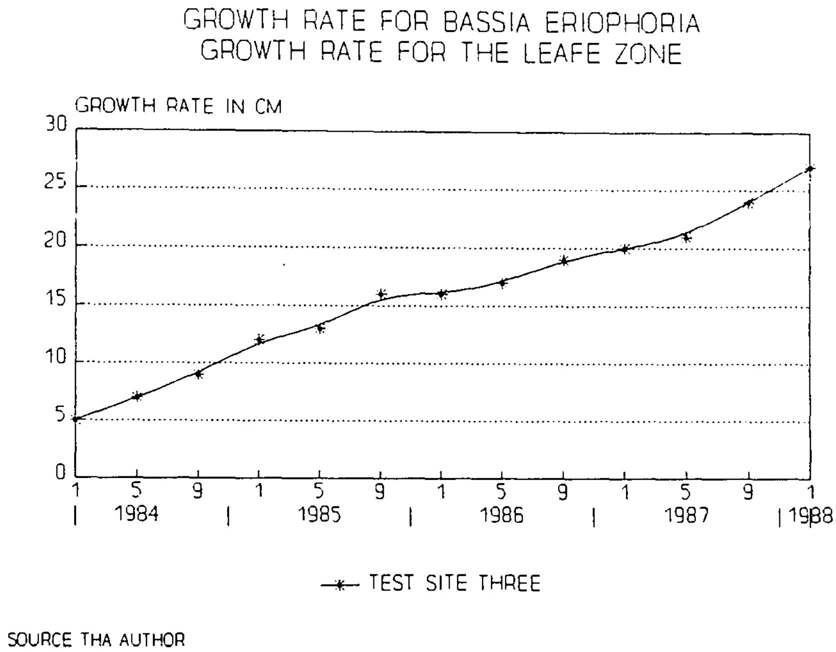


Fig 174: The growth rate for Bassia eriophoria.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Exposed and non irrigated sandy embankments areas.

**ADAPTATION TO SALINITY LEVEL:** Excellent.[129]

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Requires a loose soil and flourishes most in semi stabilized sand embankments.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Vulnerable. Should be

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[129] Not precisely known but the salinity level in the third test site where this species was planted is 9000 ppm.

used only in extensive or protected areas.
**IRRIGATION (NEEDS AND EFFECTS):** Nil.

VISUAL CHARACTERISTICS

**HABIT:** Herb.
**FORM:** See Fig 175 below.
**SIZE:** 10 Cm High 30 Cm wide.
**FOLIAGE:** Small Flat very narrow.
**FLOWERS:** White cotton-like.

TECHNIQUES

**PROPAGATION METHOD:** Blanket method, seeds should be collected from natural stands according to target species method; as recommended in chapter 3.
**SEED COLLECTION METHOD:** Blanket and manual.
**SEED COLLECTION SOURCE:** Thumamah.
**SEEDING TECHNIQUES:** soil spreading technique.[131]
**SEEDING TIME:** Summer.
**REMARKS:** The species is suitable for creating an original and typical arid landscape element of ground cover, but it is recommended that its usage should be restricted to extensive areas or controlled embankments.

**Fig 175:** Bassia Eriophoria.

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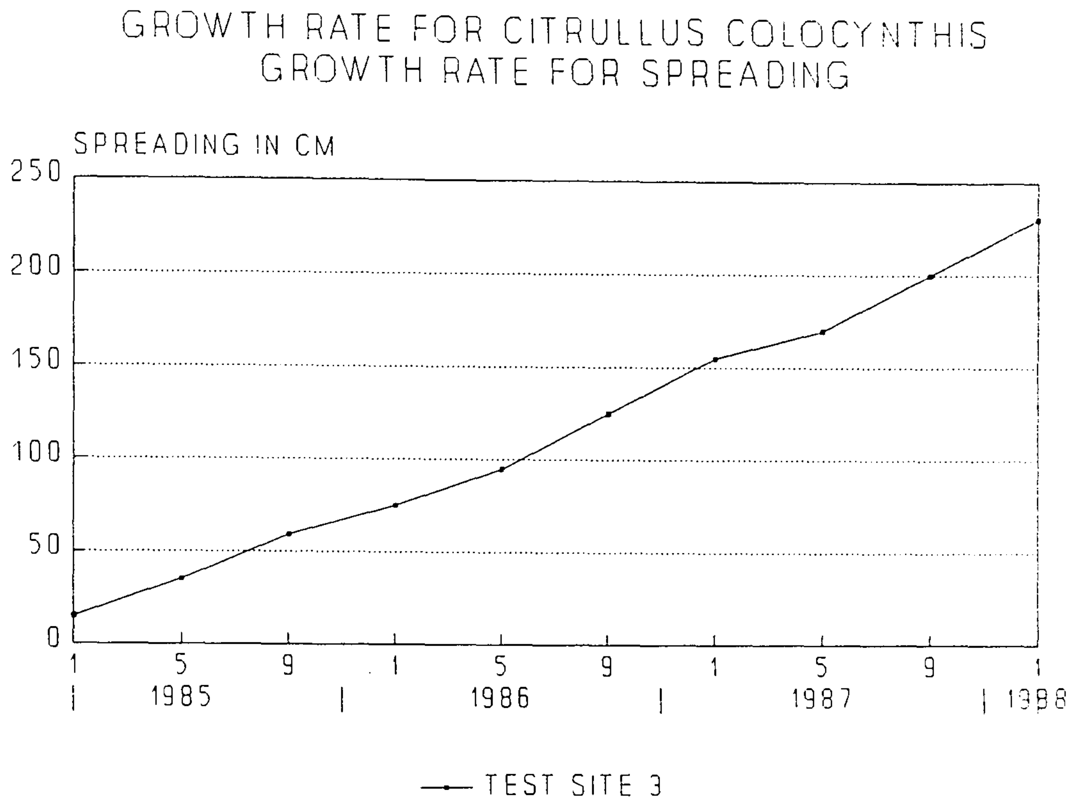
[131] see chapter 3.

**BOTANICAL NAME:** Citrullus colocynthis.

**GENERAL NOTES AND DESCRIPTION:** Prostrate vine , multi stems creeping up to 3 m. long. Attractive creeping species and very useful in landscape use. It is suitable for ground cover, expected to substitute Bougainvillaea and Jasminum Spp. See Fig 177 below.

**PHYSICAL FACTORS**




SOURCE THE AUTHOR

**Fig 176: Growth rate for Citrullus Colocynthis.**

**GROWTH RATE:** Moderate. Fig 176. The species grew slowly but once established it can form a permanent ground cover which consists of pale green leaves and an attractive fruit all the year.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Associated with rocky soil and minimal water. Requires exposed areas and full sun. Suffers in the winter time.

**ADAPTATION TO SALINITY LEVEL:** Excellent. 15000 ppm.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** Minimal. Only rain fall is recommended.

**VISUAL CHARACTERISTICS**

**HABIT:** Evergreen.

**FORM:** Creeping. Fig 177.

**SIZE:** Up to 4.M. wide and 10.Cm. High.

**FOLIAGE:** leaves narrowly triangler 5-12CM.long.

**FLOWERS:**small greenish yellow.

**FRUITS:** Small water melon-like 10-15 Cm in diameter.

**TECHNIQUES**

**PROPAGATION METHOD:** Seeds.

**SEED COLLECTION METHOD:** Manual.

**SEED COLLECTION SOURCE:** Wadi Hanifah.

**SEEDING TECHNIQUES:** Manual. The lee side of a small rock formation will help to increase germinating speed.

**SEEDING TIME:** Late summer.

**REMARKS:** The species is exceptionally tolerant to eco-environmental factors. It is attractive and useful as a landscape tool. Also the growth rate shown above is acceptable for achieving the results usually expected by the client. The plant was also found to be most flourishing in depressions.

Fig 177: Citrullus Colocynthis.

**BOTANICAL NAME:** Clitoria Ternata.

**GENERAL NOTES AND DESCRIPTION:** "A tangled leafy vine, scrambling over a 5m high shrubby tree; solitary bright rich blue flowers; 3cm wide; no scent".[131]. The species is one of the most attractive species of climbers including the imported ones.

**PHYSICAL FACTORS**

**GROWTH RATE:** The species was tested only in the first test site due to its propagation status, i.e it was propagated in the nursery under perfect conditions. Fig 178.

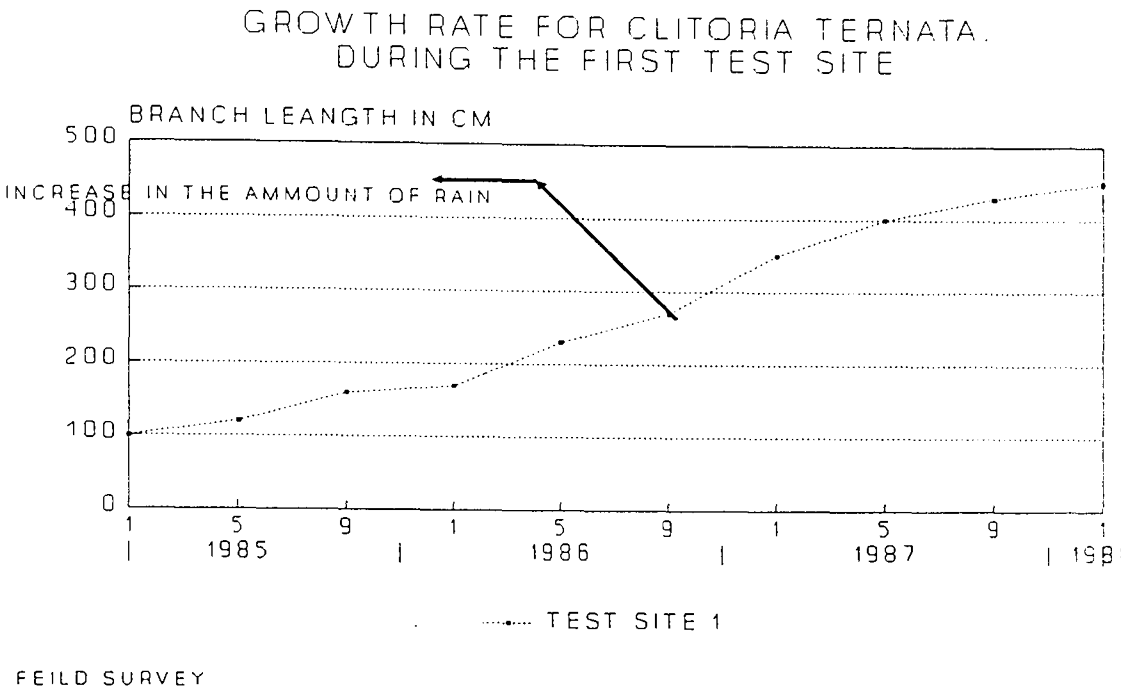



**Fig 178: Growth rate for <u>Clitoria Ternata</u>; the graph shows a satisfactory growth especially in the winter period when water reduction usually took place.**

**ROOT STRUCTURE:** Tap root.

**BEST THRIVING CONDITIONS:** The species was successful when planted in the south west facade and near a shaded concrete wall.

**ADAPTATION TO SALINITY LEVEL:** Moderate.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Moderate.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Its physical structure as a climber protected it against public abuse. However its leaves and flowers are very attractive and vulnerable.

**IRRIGATION (NEEDS AND EFFECTS):** 25/litre/three times a week in Summer. The amount will drop to 10 litre at the same rate during the winter.

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[131] Collenette, Sheila, *An illustrated guide to the flowers of Saudi Arabia*, First ed, Meteorology and Environmental Protection Administration, Saudi Arabia; Flora Publication No. 1, London: Scorpion Publishing Ltd, 1985.

VISUAL CHARACTERISTICS

**HABIT:** Semi deciduous.

**FORM:** Creeping, long trailing branches. Fig 179.

**SIZE:** Branches 10 M. long. 3 M. wide.

**FOLIAGE:** Oval-like with rounded end.

**FLOWERS:** Purple

TECHNIQUES

**PROPAGATION METHOD:** Cuttings.

**REMARKS:** As a native climber, it will contribute to the process of substituting imported species especially for wall covering, which are currently dominated by the imported Bougainvillaea glabra.

**Fig 179:** Clitoria Ternata.

**BOTANICAL NAME:** Ipomea Palmata

**GENERAL NOTES AND DESCRIPTION:** Creeping green plant. Palmately lobed leaves. Suitable for ground cover, (filtered and direct sun), semi deciduous and flowering all year. The species flourishes more in the summer season which qualifies it for wide landscape use.

**PHYSICAL FACTORS**

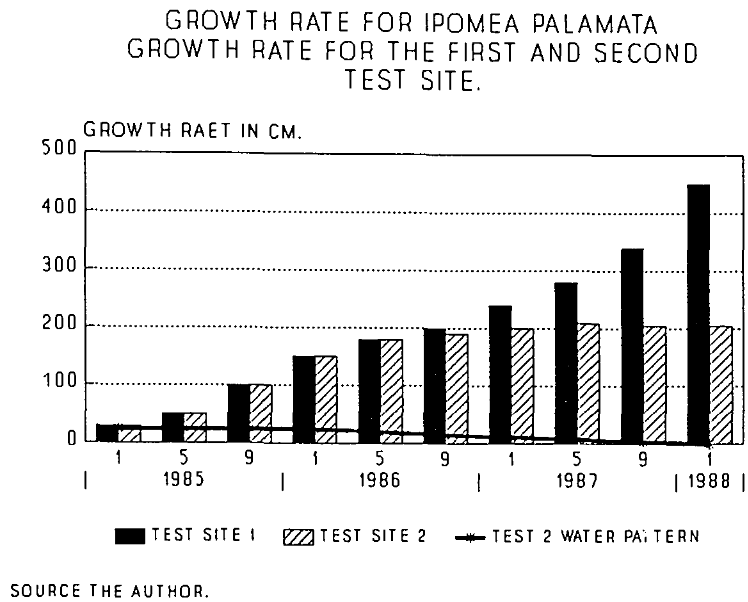


**Fig 180: Growth rate for <u>Ipomoea Palmata</u>.**

**GROWTH RATE:** Fast. Fig 180.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Semi irrigated land with sandy Wadi soil

**ADAPTATION TO SALINITY LEVEL:** 10000 ppm.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** 25/litre/ three times/ week in the first test site gave an adequate growth rate.

**VISUAL CHARACTERISTICS**

**HABIT:** Semi deciduous.

**FORM:** Spreading thin ground cover. Fig 181.

**SIZE:** Up to 8 M. spreading diameter. and 40 Cm. high.

**FOLIAGE:** Palmately lobed leaves, dark green.

**FLOWERS:** Pink.

**TECHNIQUES**

**PROPAGATION METHOD:** Cuttings.

**REMARKS:** The species is and will be widely used in landscape design projects as a ground cover (See Fig 181 below). It is a tough species which thrives in the summer and consumes a minimal amount of water. Compared to its competitive species of climbers it is far more economical to establish and propagate.

**Fig 181: Ipomea Palmata.**

**BOTANICAL NAME:** Ipomea pes-caprea.

**GENERAL NOTES AND DESCRIPTION:** A vigorous creeping plant, with a mass of stiff stems up to 12-15 M. in length. An excellent ground cover which thrives more in extreme dry and windy conditions. It is useful for soil binding and slope stabilization. It can spread to reach 15 M.

## PHYSICAL FACTORS

**GROWTH RATE:** Very fast The graph below shows the growth rate for this species during the three tests. The graph shows that the species was performing well in the second test site although water was reduced to nil from the year 1986, which indicates that this species needs only an initial watering. In the third test the graph indicates that growth rate was unsatisfactorily slow. Fig 182.

**ROOT STRUCTURE:** Surface. Extensive, 3.5 M long and 5cm thick.

**BEST THRIVING CONDITIONS:** A sandy soil with initial irrigation till establishment. The plant should be planted exposed to direct sun light.

**ADAPTATION TO SALINITY LEVEL:** 15000 ppm.

**EXPOSURE:** Full sun only.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent.

**IRRIGATION (NEEDS AND EFFECTS):** The species will thrive with continuous watering in the summer of 25/litre/three times /week; while it will actually do better with initial irrigation stopped after the first three years. (Fig 182).

## VISUAL CHARACTERISTICS

**HABIT:** Evergreen.

**FORM:** Spreading mound-like. Fig 183.

**SIZE:** !2-15 M. spreading, 60 Cm. high.

**FOLIAGE:** Leaves are large and leathery.

**FLOWERS:** Shaft like, purple colour.

## TECHNIQUES

**PROPAGATION METHOD:** Cuttings.

**REMARKS:** The species is beginning to be used widely in the region but with excessive watering is adding to the problem of salinity and water consumption. The species will tend to adapt to higher water quantity, consequently, if vegetative material from this particular plant was used for propagation, the end product will retain the same characteristics of high water consumption.

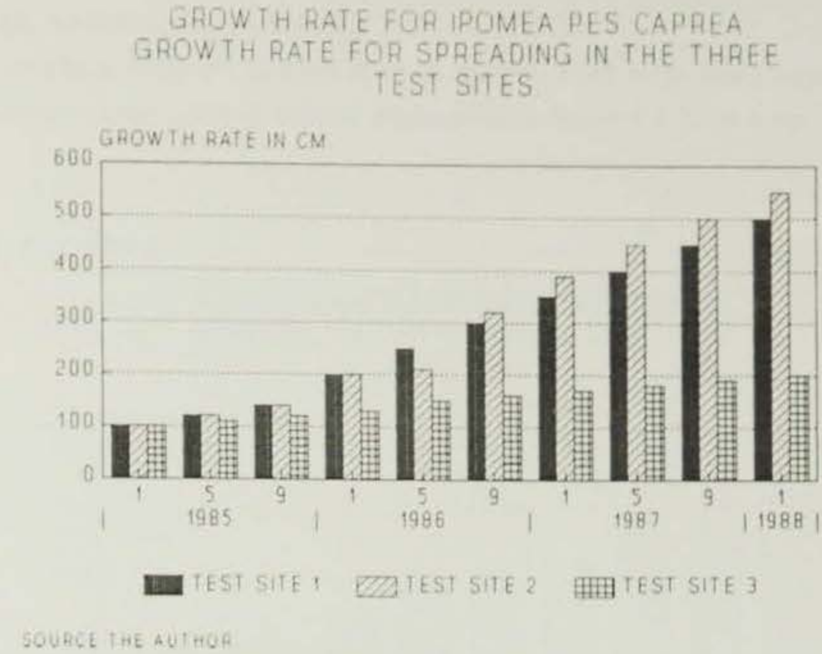


**Fig 182: Growth rate for Ipomea pes-caprea.**

**Fig 183: Ipomea pes caprea.**

**BOTANICAL NAME:** Ipomoea Sinensis

**GENERAL NOTES AND DESCRIPTION:** A trailing herb with leafy stems up to 1m long, and narrow heart-shaped leaves; pinkish lilac flowers 1.2Cm wide with darker centre.

**PHYSICAL FACTORS**

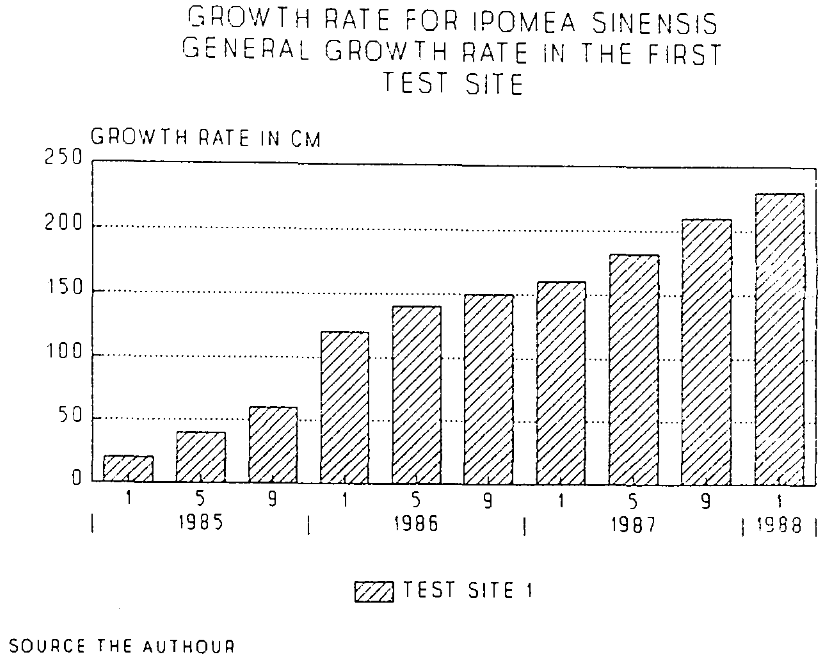


**Fig 184: Growth rate for Ipomoea Sinensis.**

The graph above shows that its growth rate is slow initially till establishment and steady there after. This graph was measured with an irrigation rate of 25/litre/three times a day.

**GROWTH RATE:** Fast. This species was planted in the first test site, as its natural habitat is wet land. The graph below shows that its growth rate is acceptable however the species is vulnerable to both salinity and drought. Fig 184.

**ROOT STRUCTURE:** Surface.

**BEST THRIVING CONDITIONS:** Irrigated sandy Wadi soil.

**ADAPTATION TO SALINITY LEVEL:** Poor.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Requires a well aerated soil.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Requires minimum public access.

**IRRIGATION (NEEDS AND EFFECTS):** 25/litre/four times a day is just adequate.

**VISUAL CHARACTERISTICS**

**HABIT:** Semi deciduous.

**FORM:** Creeping mound. Fig 185.

**SIZE:** 40 Cm high. 2 M wide.

**FOLIAGE:** Green multi division.

**FLOWERS:** -

**TECHNIQUES**

**PROPAGATION METHOD:** Cutting.

**REMARKS:** The plant is useful for luxurious, intensive and compacted ground cover. Although it is not as tough as other native ipomea species it showed a great compatibility with other native plants.

Fig 185: Ipomoea Sinensis.

GRASS:

Although, this section comprises three successful species of grass, they must be used either as a specimen, or combined with other plants, but unmodified. They must not be pruned, mowed or seen as a green carpet. None can be used as a lawn, as they are not sufficiently resistant to trampling.

**BOTANICAL NAME:** Pennisetum Setaceum
**GENERAL NOTES AND DESCRIPTION:** Densely grouped perennial grass, long narrow leaves, terminated by a long, nodding, very rich plume or false spike up to 30cm; thrives on rocky soil.

**PHYSICAL FACTORS**
**GROWTH RATE:** Very fast. The graph below shows a significant growth rate but only when irrigation was introduced. Fig 186.
**ROOT STRUCTURE:** Tap roots.
**BEST THRIVING CONDITIONS:** The species was successful only in the first test site. The most successful one was located at an irrigated and sheltered site at the plateau located opposite the Diplomatic Club.
**ADAPTATION TO SALINITY LEVEL:** Excellent.
**EXPOSURE:** Full or filtered sun.
**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Moderate.
**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Good.
**IRRIGATION (NEEDS AND EFFECTS):** 25/litre/three times per week.

**VISUAL CHARACTERISTICS**
**HABIT:** Perennial grass.
**FORM:** Large mound with shoots. Fig 187.
**SIZE:** 1 M High. 90 M wide.
**FOLIAGE:** Long ribbon like.
**FLOWERS:** Attractive seed heads.

**TECHNIQUES**
**PROPAGATION METHOD:** Seeds.
**SEED COLLECTION METHOD:** Manual.
**SEEDING TECHNIQUES:** Manual.
**SEEDING TIME:** October.
**REMARKS:** The species is attractive and comparatively less expensive than similar imported grass.

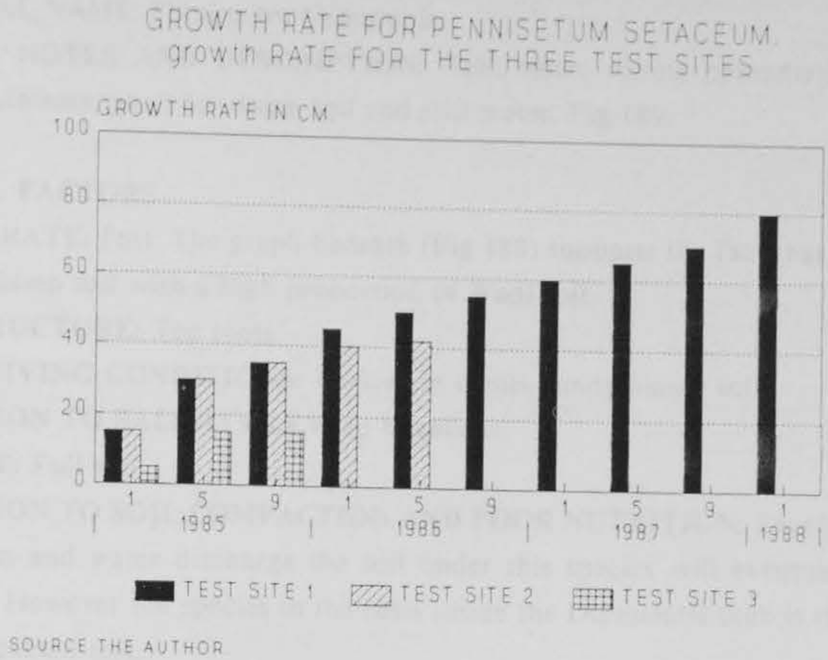


Fig 186: Growth rate for Pennisetum Setaceum.

Fig 187: Pennisetum Setaceum.

**BOTANICAL NAME:** Phragmites Communis.

**GENERAL NOTES AND DESCRIPTION:** Tall, stout, robust perennial; reed with creeping rhizomes; good for damp soil and still water. Fig 189.

**PHYSICAL FACTORS**

**GROWTH RATE:** Fast. The graph beneath (Fig 188) supports the fact that this species requires a damp soil with a high proportion of Wadi soil.

**ROOT STRUCTURE:** Tap roots.

**BEST THRIVING CONDITIONS:** Thrives in damp, sandy loamy soil.

**ADAPTATION TO SALINITY LEVEL:** Excellent.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent. Due to precipitation and water discharge the soil under this species will eventually become compacted. However the species in the oasis inside the Diplomatic club is thriving in a highly compacted soil.

**TOUGHNESS AND ENDURANCE TO HEAVY PUBLIC USE:** Excellent. Its physical structure and form do not attract vandals.

**IRRIGATION (NEEDS AND EFFECTS):** 35/litre/day.

**VISUAL CHARACTERISTICS**

**HABIT:** Evergreen.

**FORM:** Bamboo-like shoots, Fig 189.

**SIZE:** 4 M. high, 2 M.wide.

**FOLIAGE:** long 30 Cm. ribbon-like.

**FLOWERS:** White.

**TECHNIQUES**

**PROPAGATION METHOD:** Cuttings or seeds.

**SEED COLLECTION METHOD:** Manual.

**SEEDING TECHNIQUES:** Manual seeding was used late summer.

**SEEDING TIME:** Late summer.

**REMARKS:** The species is suitable for use when a pond or water body is used as a landscape element.

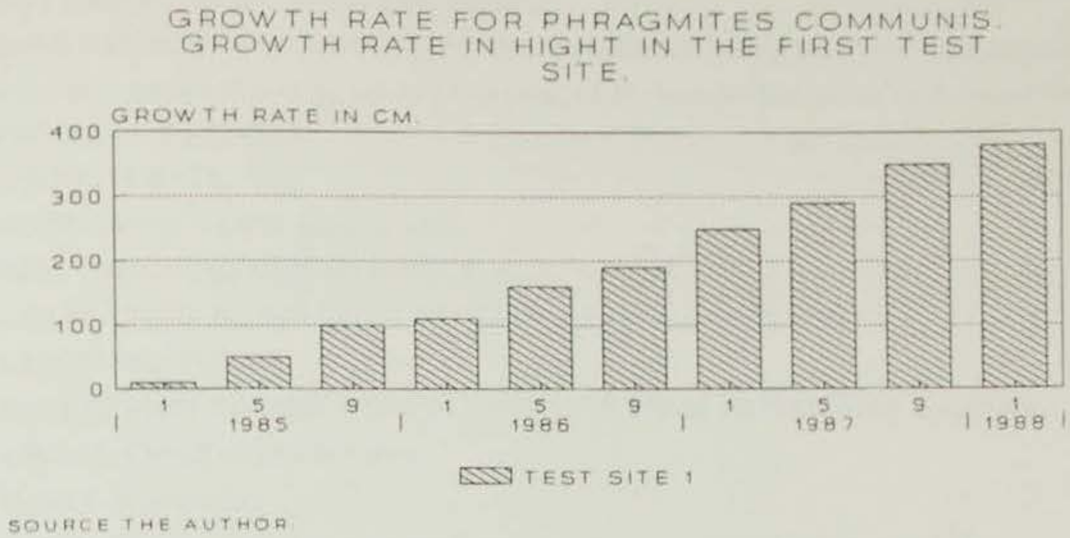


**Fig 188: Growth rate for <u>Phragmites Communis.</u>**

Fig 189: <u>Phragmites Communis.</u>

**BOTANICAL NAME:** Typha Domingensis.

**GENERAL NOTES AND DESCRIPTION:** A reed-like swamp plant with stems up to 2m high; pale brown flowering heads 14cm long; fairly widespread; exists in constant water.

**PHYSICAL FACTORS**

**GROWTH RATE:** Fast.

**ROOT STRUCTURE:** Shallow roots.

**BEST THRIVING CONDITIONS:** Exposed wet soil.

**ADAPTATION TO SALINITY LEVEL:** Requires non saline water.

**EXPOSURE:** Full sun.

**ADAPTATION TO SOIL COMPACTION AND POOR NUTRITION:** Excellent.

**VISUAL CHARACTERISTICS:**

**HABIT:** Evergreen.

**FORM:** Ribbon high thin stick with another brown ribbon flower. Fig 190.

**SIZE:** 2 m. high.

**FOLIAGE:** Long, green.

**FLOWERS:** Pale brown flowers, up to 20 Cm long.

**TECHNIQUES**

**PROPAGATION METHOD:** Seeds.

**SEED COLLECTION METHOD:** Manual.

**SEED COLLECTION SOURCE:** Al-kharj.

**SEEDING TECHNIQUES:** Manual.

**SEEDING TIME:** Late october.

**REMARKS:** Although the plant requires damp soil and constant immersion in water; it is essential to any landscape design containing an oasis or any water element.

Fig 190: Typha domingensis.

## 2. TARGET COMMUNITY RESULTS.

### 2.1 INTRODUCTION:

Before reporting the test result, Fig 191 explains and summarizes the process of target community which was employed in the third test site and reported earlier (chapter 4).

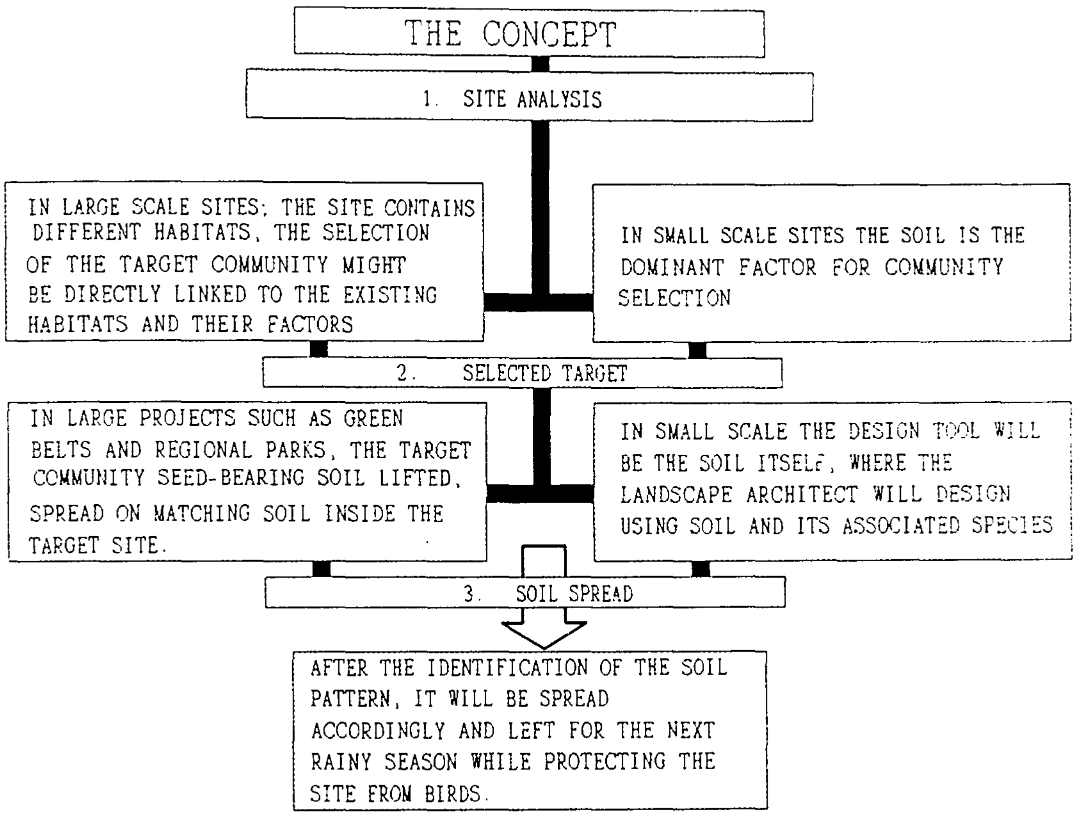


**Fig 191 & (192 below) :The process of target community method.**

This method was applied in the third test site as a small example where the soil pattern was created according to the selected target community See Fig 192 below.

This method was implemented in the third test site in the area looking to the north of the Diplomatic Quarter. Each target community was identified and surveyed after which a soil transformation operation took place to accomplish the process of planting using communities as a landscape design tool.

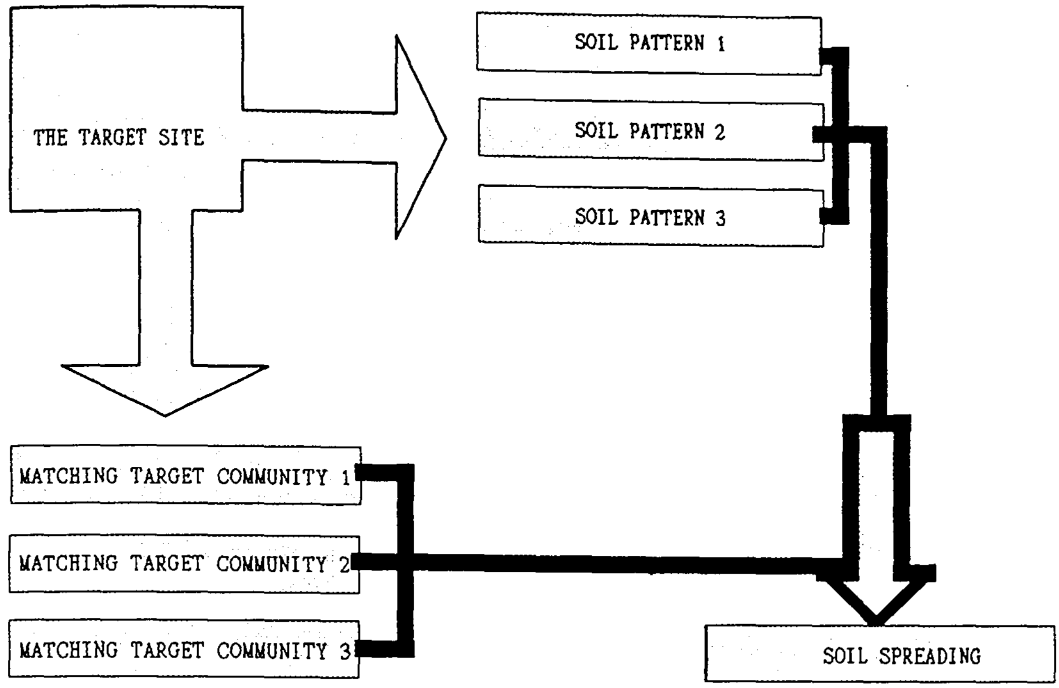


**Fig 192: The process of target community.**

The following successful communities should be used as a single planting composition. The communities were tested without any interference with their structure or associated species. Therefore, the success of implementing them is highly dependable upon this factor. The author found that each maintained its own growing zone without integrating with the neighbouring communities. The difference in soil pattern was the most obvious reason for that feature. It is recommended therefore that they should be used and executed similar to the testing method and process.

There were approximately 10 target communities used as a source to identify soil containing seeds. All were spread over the site as described earlier. Out of these there were clear dominant communities with sub communities imbedded. For the aim of this research only the few dominant communities from which some of the target species were obtained will be reported for their suitability and structure. These are the woodland, shrubland, dwarf shrub and grassland communities.

## 2.2 WOODLAND COMMUNITY, ACACIA GERRARDII COMMUNITY

As mentioned in the third test site a soil layer under this community was lifted and planted in analogous conditions to the original habitat, edaphically and micro-environmentally.[132] The initial soil was expected to contain seeds of the following species.

* Acacia gerrardii, Acacia chrenhergiana, Acacia tortitis, Acacia raddiana, Acacia fernasiana. The lifted soil was spread over the target site and left for the first three rainy seasons, after which, the target community was active and the species began to germinate on the site. After six rain seasons the test results showed the success of Acacia tortitis, Acacia gerrardii and Acacia farnasiana, with a coverage of 60% of Acacia gerrardii as shown in Fig 193 below. The growth rate for each individual species was similar to the target species test. Fig 194 illustrates the community.

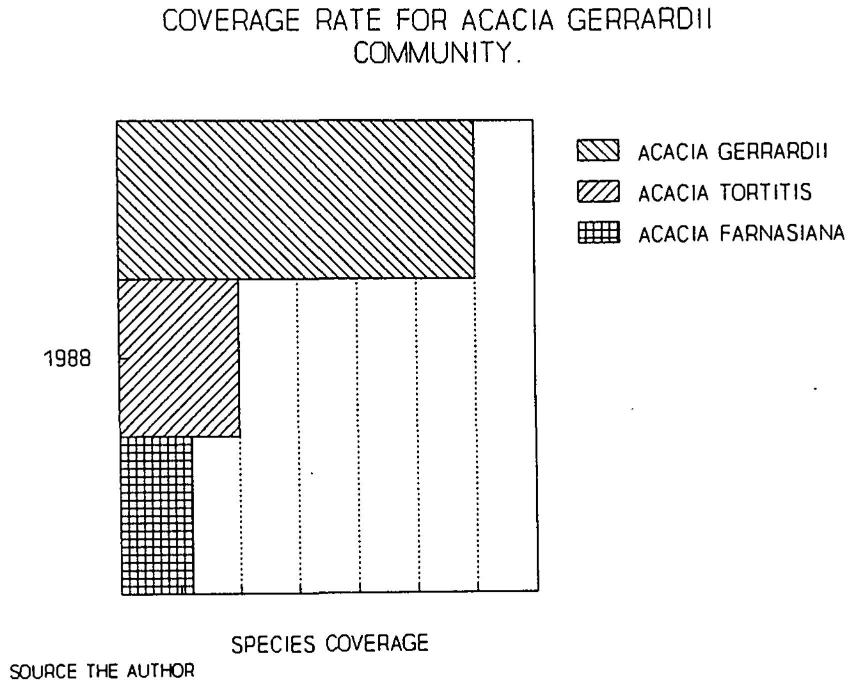


**Fig 193: The succession of Acacia Gerrardi community.**

Although not many species succeeded in germinating the community structure was varied and diverse enough to be used as a landscape element, especially as it contained a hierarchy of species, height and texture.

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[132] Described earlier. See chapter 3, environmental factors.

Fig 194: Acacia Gerrardii community.

## 2.3 SHRUBLAND COMMUNITY:

Ziziphus nummularia community (Fig 196)

This community was identified and chosen to be the target for lifting a thin layer of soil under the plant mass found to colonize the site. The soil was transported to the site and spread over the third test site on an area covered with a moist Wadi soil. The lifted soil was expected to contain the following seeds of the associated species:

Althaea ludwigii, Anastatica hierochuntica, Asphodelus temfolius, Cassia italica, Cenchrus ciliaris, Chrozophora obliqua, Citrulluys colocynthis, Francoeria crispa Heliotropium ramorissimum, Malva parviflora, Lasiurus scindicus, Plantago amplexicaulis, Prosopis fracta, Psoralea plicata, Tragus racemorus, Trigonlla stellata, Zilla spinosa. As Ziziphus nummularia community generally covers reasonably rich soil, the soil used in this test was a mixture of wadi soil and sand. The dominant species found after five years, was Ziziphus nummularia and some associate species dominated by a group of Zilla Spinosa and Cassia Italica. The graph below displays the coverage rate of the dominant species of this community and its associate species (Fig 195).

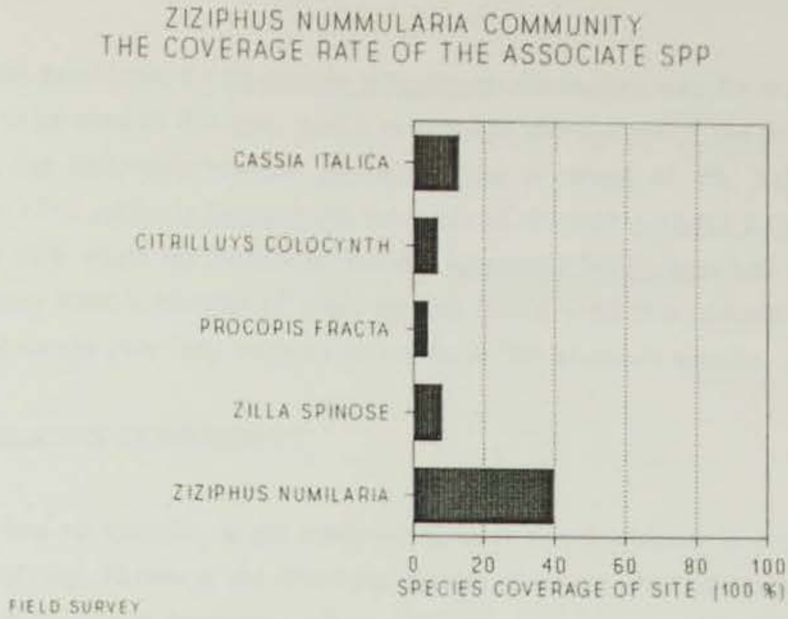


**Fig 195: The successful species in the Ziziphus Nummularia Community.**

**Fig 196: Ziziphus nummularia community. The structure of this community as the test showed qualifies it as an independent landscape element, however the aim from this test is to appraise how such method could be used successfully in landscape applications.**

## 2.3 DWARF SHRUB COMMUNITY:

A remote site dominated by Hammada Salicornica community was the target for further soil lifting to be used in this test, which resulted in the success of the dominant species along with the following species: Artemisia Spp coverage of 9%, Salsola Baryorma coverage of 12%, Aellenia Sulrophylla coverage of 4% and Atriplex Leucaclada with a coverage of 20% while the dominant species, Hammada Salicornica had a coverage rate of 60%. There were a number of other species found with this community but due to their low coverage rate they were excluded from the associate species.

## 2.4 GRASSLANDS COMMUNITY

Here there was no specific target community, as it was associated in every community during soil lifting. However the dominant species of native grass found to be successful, thriving and having a landscape value with the other communities are: Pennisetum division, Cymbopogon Commutates.

## 2.5 METHODOLOGY RESULT:

The target site was distributed with an equivalent seed bearing soil type. The lifted soil was classified and distributed over the soil pattern appropriate for each community.[133] Fig 197 below illustrates the hierarchy of plant formation and its relation to the soil pattern. As a result of this method, designing with soil pattern and target seed community can achieve a landscape characterized by the native flora which in its habit and appearance is most suitable to local environmental, social and ecological factors.

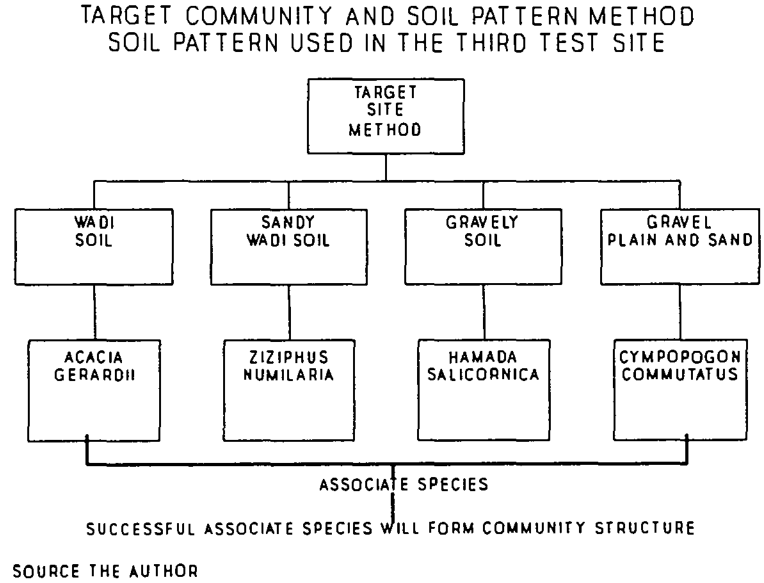


**Fig 197: The target community and soil pattern.**

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[133]This work was carried out by A.D.A Ref B.B.W Germany.

## C. CONCLUSION

After both methods testing targeting individual plant species or entire plant communities the case for using indigenous plants in Najd development projects appears possible. The success of the target species method suggests the existence of adequate and successful native species ready for use; while with the new method of target community seeding will help in many difficult areas of landscape design such as sand dune control, green belts in arid land, and extensive urban landscaping. The figures below display the three test sites after five years. They clearly show the success of the three test sites. The first test site (Fig 198) employs native species in a luxurious planting design superior to those using imported flora, while the second test site, (Fig 199), exhibits similar species after water reduction, demonstrating their adaptation to water fluctuation. Lastly the third test site (Fig 200) illustrates the employment and use of native plant material in a non irrigated site.

**Fig 198: The first test site.**

Fig 199: The second test site.

Fig 200: The third test site.

The flora provides a basic working tool for landscape designers and managers who wish to use native plant material in projects in Najd.

The next chapter will deal with how to manipulate these native species in such projects, both urban and extensive in character. This will be explained through a discussion of the process of using native plants within urban sites using the target species method, and within extensive landscaping using the target community method. In addition, the chapter will also draw the research to a conclusion and suggest how it could be developed further.

# CHAPTER 7

# MANIPULATING NATIVE FLORA, AND CONCLUSION.

## 1) MANIPULATING NATIVE FLORA, AND CONCLUSION.

### A. INTRODUCTION:

The previous chapter established two important pieces of documentation. Firstly a native flora which provides the basic information needed to start specifying native species as substitute for imported ones. Secondly, the successful target community method which is a valuable tool for extensive landscaping.

What is needed next, is to demonstrate how to use these native species in a typical landscape project and how they might satisfy the role of different landscape elements within the domain of ecological, geomorphological, edaphical morphology in Najd and equally important the Najdi socio behavioral factors.

The two methods used on the research sites targeting individual species and targeting entire communities will be disscussed in relation to normal landscape development procedures. This follows a brief description of the evaluation process to be followed for each site, prior to choosing a particular planting method.

Suitability analysis and detailed examination of the target site is an essential process, upon which consequential design decisions will be made. The level of analysis will vary depending on the size and complexity of the site, but the process of examination might include study of the following:

- Geomorphology analysis where the plateaus, shuaibs and wadi patterns will be examined to obtain the different topographical features and their eco-geomorphological characteristics. The study would obtain the pattern of reliefs and depressions from which a typographical map could be made suggesting the drainage characteristics of the site.

- A visual analysis of the site to assess the quality of the space of which the landscape unit is a part.

- Edaphical analysis in conjunction with previous analysis will enhance the landscape unit definition, regarding suitability and function for particular planting method and species.

- Previous climatic information analyzed in association with spatial requirements will narrow down the individual plant and community selection. For example, the difference in temperature between the surface of a wadi and the top escarpment will vary by 5°C. That difference in arid ecosystem is significant and will influence the nature of the selected vegetation community (Fig 201).

- Ecological analysis of the different plant-animal habitats and their compatibility with introduced human activities is essential for target community selection.

- Identification of existing on site species and community is essential to know the plant budget of that site. This will create a design base for the application of the target community and target species concepts.

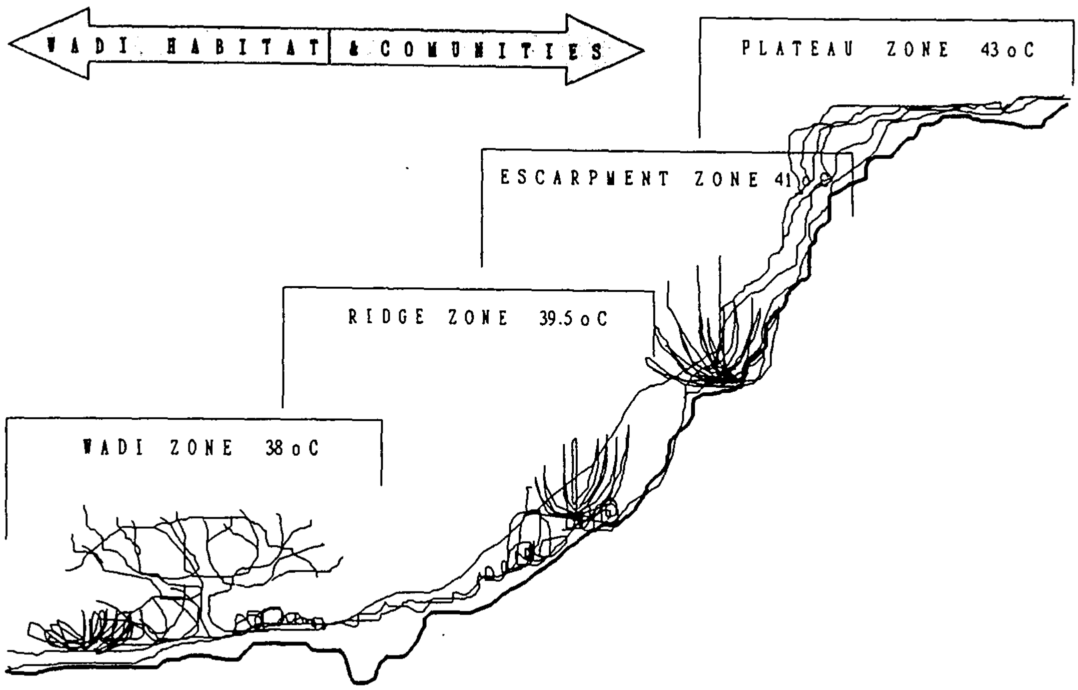


**Fig 201: The temperature difference between the lower wadi and the upper plateau will influence the choice of communities.**

Selection of species will be affected by slope, exposure, soil, hydrology and human use. Extensive landscape projects are categorized into passive and active zones: passive activities usually contain trails and paths, planting (extensively) and conservation areas. Active zones normally include buildings, play areas or any landscape physically dominated by hardscape elements. Plants will be selected which best satisfy the requirements of the brief with minimal impact on the resident habitat.

This is achieved by firstly dividing the site into zones which are either most suitable, relatively suitable or not suitable to the activities and to the character of the landscape elements. Secondly, their impact on the existing native habitat. This is summarized in the following Table 32:

| LANDSCAPE ELEMENTS | SLOPE | EXPOSURE | HYDROLOGY | CLIMATE | IMPACT |
|---|---|---|---|---|---|
| 1. URBAN LANDSCAPE ELEMENTS | 0-25% | NORTH & EAST | IMPORTANT | SEE GRAPH FIRST CHAPTER | HIGH IMPACT |
| 2. PEDESTRIAN TRAILS | 0-25% | ALL | NOT ESSENTIAL | ,, ,, | LOW NEGATIVE IMPACT |
| 3. CAMPING AND Picnicking | 0-5% | NORTH AND EAST | * | ,, ,, | ,, ,, |
| 4. GREEN BELTS OR EXTENSIVE PLANTING | 0-75% | ALL | **EFFECTIVE | ,, ,, | POSITIVE |
| 5. VEHICULAR SYSTEM | 0-7.5% | ----- | * | ,, ,, | HIGH NEGATIVE IMPACT |
| 6- CONSERVATION | NOT APPLICABLE | ----- | ----- | ---- | ----- |

* Except for flooded and accumulation areas.
** Water budget should be determined.

**Table 32: Landscape elements, their factors and impact.**

Of the two planting design methods examined in the three test sites, the target species method seems appropriate for intensive urban landscaping and target community method for nature parks and extensive landscaping. The process for each is different. In the first, the site will largely have lost its original ecological character. Here the approach is to examine the environmental, social and use factors and match particular target species to these conditions and elements. From the palette of suitable species, the landscape architect designs a composition to create spaces and a special site character. In the target community method, the landscape architect uses whole communities, either individually or collectively. Here the given site almost completely controls the choice of community to be used. There must be a close match between the two if success is to be guaranteed.

Fig 202 summarizes how to use the information achieved in this thesis in different landscape tasks within Najd. The figure links the thesis findings with the urban, semi urban and extensive landscape elements.

## B. THE PROCESS OF USING NATIVE PLANTS WITHIN URBAN SITES USING THE TARGET SPECIES METHOD:

For urban and suburban projects, planting work associated with buildings and general intensive usage, the target species method highlighted earlier seems more appropriate. As a result of the testing, almost fifty assorted species were found to be suitable for landscape use within the Najdi urban fabric.

Table 33 represents examples of urban landscape projects and the species suited most for each.

While the table explains the suitability of different species to certain functions, it is very critical how those species are used in a planting design. As described before, native plants are sensitive to other plants near their root zone. Some plants even maintain free a zone around their roots, known by the nutrition zone.

For landscape architects using those species, Matrix Table 34 displays information on species compatible with each other and which can grow with minimal conflict.

This table should be used for evaluating a planting composition, but not as a recommended composition. The information in this table was based on field observation and investigation on the history of plant failure and placement. The landscape architect should use this table to assess and amend his design with the aid of the Flora in chapter 6.

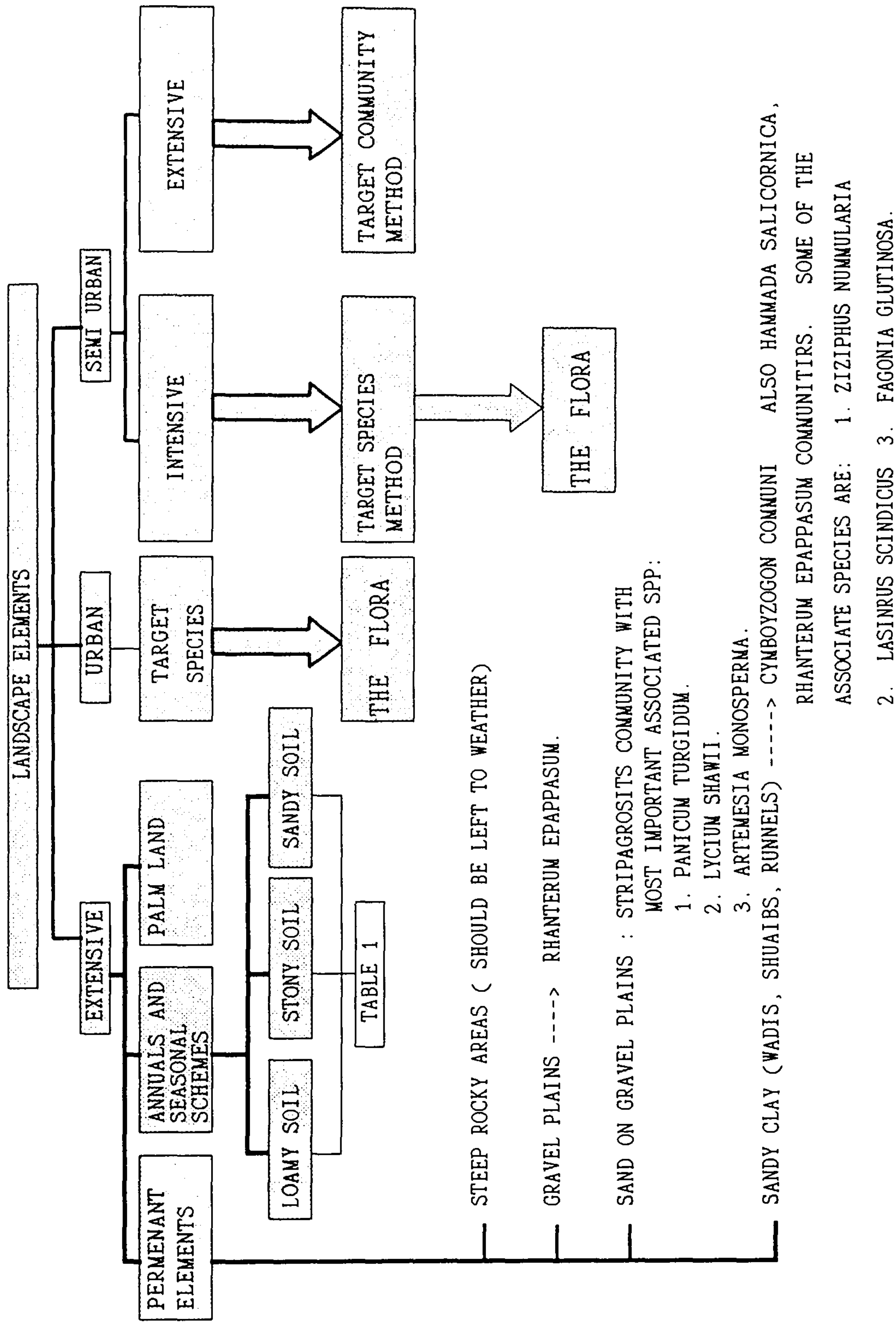


**Fig 202: Manipulating target species and target community method to fulfil different landscape functions.**

| STREET ELEMENTS. | SHADING AND DEFINING PEDESTRIAN PATHS. | SHADING CAR PARKS SINGLE OR COMBINED WITH OTHER STRUCTURES. | STREET ISLANDS EXPOSED TO FUMES AND POSSIBLE TRAMPLING. | ROUND-ABOUT. |
|---|---|---|---|---|
| SUITABLE SPECIES | Acacia albida<br>Albizia lebbeck<br>Phoenix dactylifera<br>Procopis juliflora<br>Tamarix aphylla<br>Ziziphus spina-christi | Albizia lebbeck.<br>Delonix elata.<br>Procopis juliflora.<br>Clitoria ternata and Ipomea palmata. (used in association with shade structure).<br>Tamarix aphylla. | Acacia farnaziana.<br>Acacia arabica.<br>Caltopris procera.<br>Atriplix halimus.<br>Ochradenus baccatus<br>Ficus salisifolia.<br>Rhazia stricta. | Most species succeeded in the first test site are recommended for this use provided they are protected from near vehicular trampling. Also they must be used in association with the recommended compositions mentioned later in this chapter. |
| URBAN PARKS | PLAY GROUND AND ACTIVE AREAS | TRAILS AND PATHS | SHADING SITTING ZONES | AS A VISUAL BARRIER TO SATISFY PRIVACY |
| SUITABLE SPECIES | Acacia canophylla.<br>Acacia farnaziana.<br>Phoenix dactlyfera<br>Ochradenus baccatus<br>Cassia italica<br>Asparagus africanus<br>Ipomea spp. | Acacia arabica<br>Acacia farnaziana<br>Delonix elata<br>Procopis juliflora<br>Ziziphus spina christi | Acacia farnaziana<br>Delonix elata<br>Procopis juliflora<br>Ziziphus spina christi | Abutilon pannosum.<br>Atriplix halimus.<br>Capparis spinosus.<br>Cassia italica.<br>Ochradenus baccatus<br>Pennesetum setacum.<br>Caltopris procera. |

**Table 33: Example of plant selection in relation to certain urban functions.**

Within urban landscape it is expected that plants will receive adequate initial maintenance similar to the first test site. Achieving success with native species requires special care, handling and growing conditions. These are listed in the following section covering site investigation, handling native plant material, growing requirements and maintenance. These are also detailed for each species in the Flora.

Landscape designers working in the Najd should now be able to use native plant material in their projects, confident that it will have a much higher success rate than exotic species. It is important that nurseries are now encouraged to grow native material in the manner described in this thesis (chapter 3 and 4) in order to retain natural vigour. If this happens, then urban developments in Najd should again become regional in character.

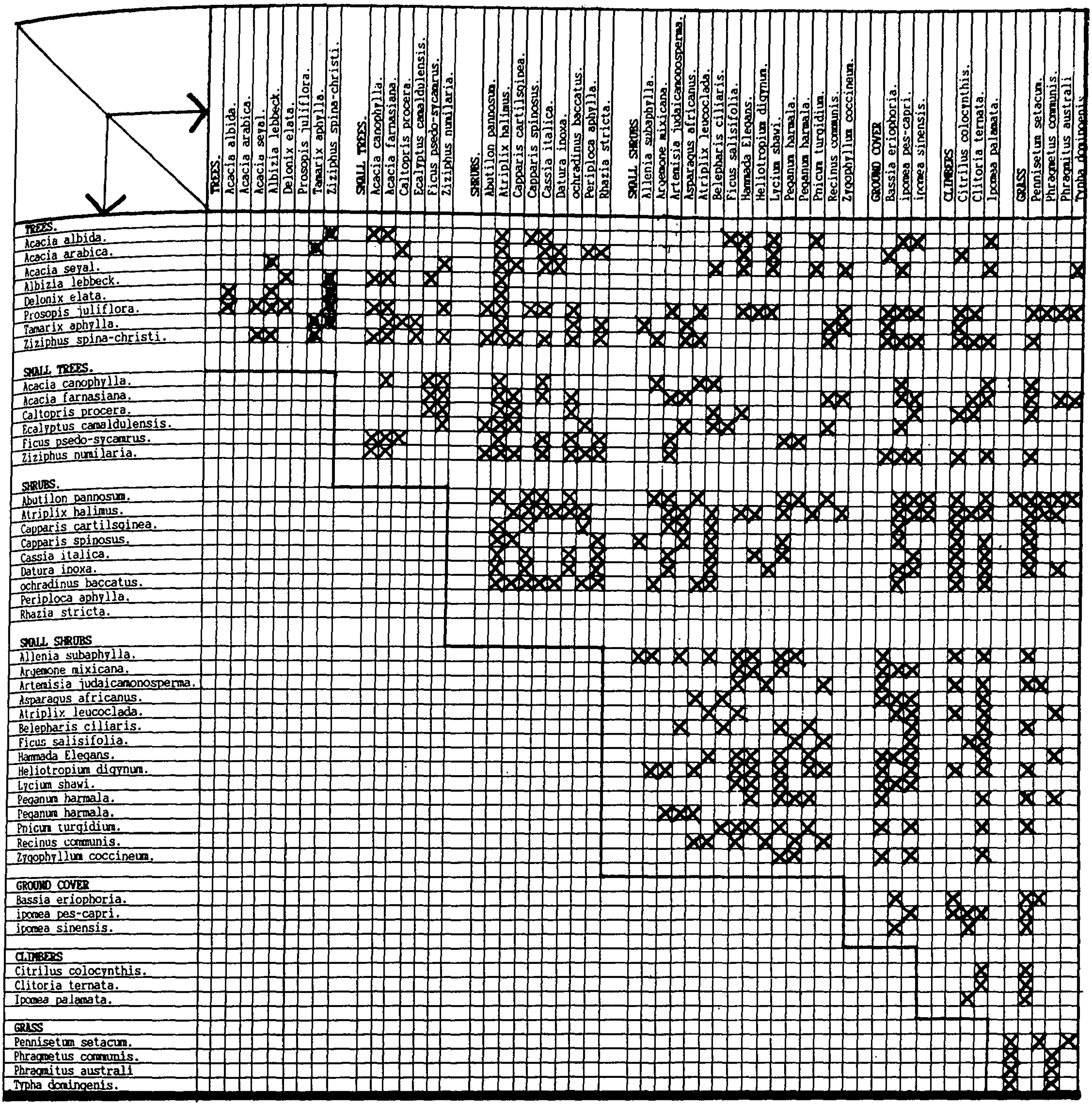


Table 34: Conflict free growth for native species.

## C. THE PROCESS OF TARGET COMMUNITY METHOD (EXTENSIVE LANDSCAPING):

Greening the edge of the city, developing the wadi system and landscaping large areas are known in Najd as extensive landscape projects. The target community method disscussed in chapter 4 and 5 is the most appropriate solution for such projects. The method can be described as a man made environmental succession that is indigenous in method and result.

Extensive projects are likely to be designed, administrated and constructed by highly qualified consultants and contractors. Also the client is usually a government agent, who is likely to consult a technical committee from the highest academic ranks. This implies a better understanding of the character and objective of the project, resulting in higher chances of success than with a private developer or small intensive landscape project.

The landscape consultant for such projects should have a knowledge of habitat design and management, and possess an understanding of the Najdi ecosystem. The design team should contain an ecologist knowledgable in arid ecosystems. This is essential since the method is highly dependant on the existing ecological features of the target site. The method starts from the existing communities and studies how it should be developed further or used as a landscape design element. For that reason, the ecologist's role is eminent during the introductory stages of the design. The next section will discuss the stages which the landscape consultant should follow and how to guide the contractor through the implementation stages.

### EXECUTION STAGES:

1. The site investigation is the most important stage in this method. The site features and edaphical characteristics will dictate the route to successful design. The landscape consultant should list, with the help of the technical experts, the resident vegetation communities and their habit, seeding time and soil pattern. This information will be classified to most sensitive communities and less sensitive communities. The most sensitive communities should be reserved and excluded from any further man made modification. The less sensitive ones, which are expected to be the woody stands, should be the target for development and incorporation in the design. Public contact with those communities is largely determined by the sensitivity factor.

The analysis of the target site should cover the following criteria:

- Naturalness of the actual vegetation and their degree of use (in respect to species composition, absence / response of grazing indicators and weeds, also density and structure of the vegetation).

* Diversity of the site or each community found in the site. Vegetation diversity; richness of an area or a community type in species, which are natural in type.

* Abundance, which is evaluated upon the number of specimens of one plant species.

* Rareness of particular plant species of the vegetation type for the Najdi zone or rarity of a habitat or a community in the park.

* Ecological function of the analyzed areas and their suitability for landscape development functions.

* Geomorphological complexity and diversity of structure.

* The conditions of the resident plants and their ability to accept modification. This depends on their character; woody communities are more tolerant to modifications, herbaceous stands are more sensitive.

2. The second stage concerns extraction of firstly the most vital community for reservation, secondly the pattern of the topography of the area, its shuaibs, wadis and plateaus, and thirdly the site's soil pattern.

3. The combination of these three factors will determine the need for the introduction of further planting. It must be stressed here that this investigation may result in the recommendation of minimal introduction of planting, i.e, the site may already contain the exact range and amount of vegetation needed to meet its calculated carrying capacity. This stage will match each topographical feature with its appropriate vegetation type.

4. At this stage the landscape architect will have a clear idea of which area requires additional vegetation. The possibility of additional planting will be limited to two options: firstly, the area requires reinforcement with vegetation communities that belong to the same soil pattern and conditions. In that case the landscape architect is limited to a particular vegetation community that can grow on the site's local soil. Secondly, the area does not contain any distinct vegetation stands; here the introduction of further planting is more challenging.

   The landscape architect has the choice of using vegetation communities which belongs to the current soil conditions or to introduce new vegetation communities and their appropriate soil. The latter should be limited by the availability and the source of introduced soil and the consequence of soil stripping on the surrounding Najdi habitats. Sand is readily available, suits some vegetation communities and will have limited destructive effect on the surrounding habitats.

5. At this stage the landscape architect may study the possibility of the creation of some man made elements, such as depressions which certain native vegetation will favour or sand dunes that will create dune habitats with their distinctive habit.

6. The designer will have a detailed description of the quality of the site, the soil pattern and the extent of planting needed. He should now extract the exact vegetation community that can be used to fulfil his design concept and the created features. The extraction will be aided by the information provided in the fourth chapter "Classification of target community according to ecogeomorphology and edaphic conditions".

7. The resulting design layout should specify the location and the identification of the selected community. The contractor should be given clear documentation on the source of the vegetation communities to be used. The plan should indicate areas to apply seeding, or community.

8. The designer may designate a mixture of seeds for each topographical element if a commercial seed is available in order to accomplish a similar structure to a natural vegetation community. The designer may follow the species compositions listed at the end of this section, which aims to concentrate on the species with the greatest chances for survival and maximum similarity to a community structure, while also include the more marginal species to provide the diversity necessary for ecological and aesthetic reasons.

9. The selected communities that match the site soil pattern and the design requirement are located in the wild. During the seeding season of each community, the landscape architect will assign the ecologist to supervise the lifting of a thin layer of soil from under each community using the blanket method. It is essential to appoint supervision of the collection process to a qualified ecologist; the consequences of doing this by unqualified personnel may result in wastage of precious time and likelihood of missing the short seeding dates as in the case of the collection of grass seeds during the extensive landscaping of the D.Q.[134]

10 The lifted soil should immediately be spread and mixed with its matching soil in the target site. After this operation the site should be monitored for three

[134] See letter in Appendix III.

rain seasons to find if any further aid is needed. The expected result is usually a slow succession that may take up to five to six years before a clear result is noticed.

The above ten stages concludes the simple methodology of the target community method. The only maintenance needed is the temporary exclusion of the public, and avoidance of other disturbance to the site such as grazing. If possible the site should be protected from birds by ecological means. The lifting of the soil should be of a shallow character, one or two millimetres should be enough for collecting the mixture of seeds that will form the community structure in the target site. At the urban fringe the landscape architect may use nursery stock with initial irrigation using the species mixture referred to later to achieve a faster greening to the area. This should be confined to small areas that have visual impact for instance at the approaches to the city. Fig 203 below illustrates a summary of the above stages.

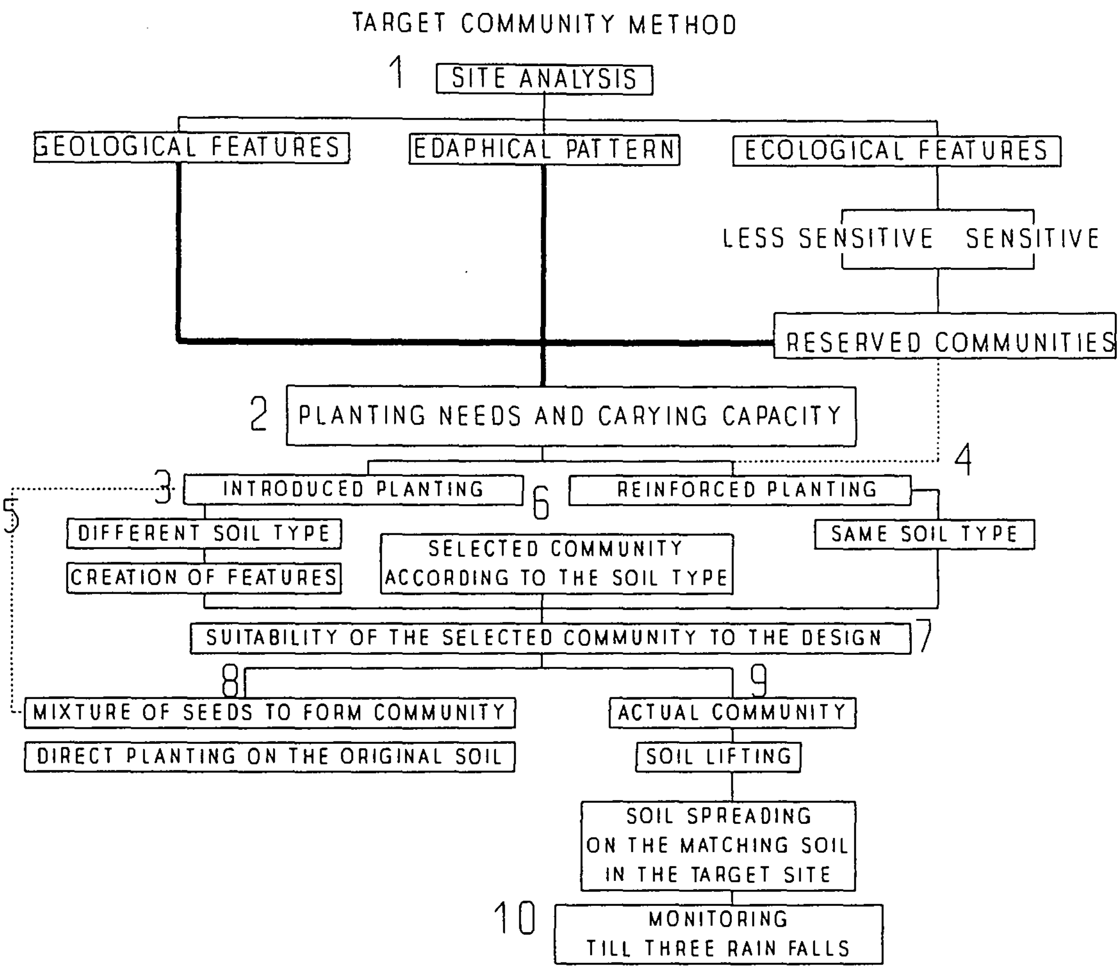


**Fig 203: The execution stages of the target community method.**

The above diagram illustrates critical stages in the process of the introduction of new plant communities or species to the target site. It should be conducted only as described in the testing methodology " **TARGET COMMUNITY METHOD USING BLANKET TECHNIQUE** " chapter 4. The lesson learned from the experience of the A.D.A's attempt to hydroseed native seeds showed that native seeds or vegetation will not tolerate such sophisticated techniques (refer to letter in Appendix III).

The next section suggests particular plants or groups of plants for particular natural or man adapted habitats. All plants are detailed in the flora.

**D. RECOMMENDED NATIVE PLANT COMPOSITIONS:**

Within the wadies surrounding Arriyadh city, natural date palmlands use the available ground water oases, even with saline water. The date palm (Phoenix datylifera) is surely one of the most fascinating trees in Saudi Arabia and played an important part in the history of country and Islam. It is possible to connect a recreation area with the tradition of the country by planting date palms in all fringe areas favourable for this tree.

In low lying areas, date palms (Phoenix dactylifera) and Al-Athel (Tamarix aphylla, T. nilotica) should be planted at the end of runnels; Acacia gerrardii and A. tortilis (A. torilis ssp. tortilis, A. tortilis ssp. raddiana) in the runnels.

Open stands of trees can be developed on particular places in lowland: Ficus sycamorus, Ziziphus spina-christi and Procopis juliflora are suitable species.

For storm water retention areas, depressions or man made lowland in a plateau area the following composition or mixture of native seeds is recommended:
55% from the following species:

Astragalus Spinosus.
Blepharus cliaris.
Fagonia cretah.
Lagonychium farctum.
Pergularia tomentosa.
Rhanterium eppaposum.
Stipagrostis plumosa.
Zilla spinosa.

35% From the following species:

Aeglops Kotschyi.
Anvellea gareini.
Artemesia herb-alba.
Atractyis carduus.
Citrillus colocynthis.
Convolvulus oxyphyllus.
Euphorbia caralluma.
Hammada elegans.

Lavandula pubeseens-dentata.
Lycium shawi
Penessetum spp.
Rhazya stricta.

And 10% from the following:

Acacaia tortilis.
Caltopris procera.
Capparis spinosa.
Cassia italica.
Cucumis prophetarum.
Francoeuria crispa.
Leptadenia pyrotechnica.
Leucophyllum frutescens.
Ochradenus baccatus.
Ricinus communis.

For flat areas with minimal depressions which maintain geomorphological characteristics similar to escarpments the following seeds mixture is recommended:

55% from the following species:

Capparis spinosa.
Cassia italica.
Cucimus Prophetarum
Heliotropum spp.
Lepatadenia pyrotechnica.
Leucophyllum frutescens.
Ochradenus baccatus.

45% from the following:

Acacia tortilis.
Caltopris procera.
Citrullus colocynthis.
Convolvulus oxyphyllus.
Lagonychium fartecum.
Ricinus communis.

For areas with Man made sand dunes or gravel formations the following mixture is recommended and was extracted from the third test site:

80% from the following species:

Acacia tortilis.
Caltopris procera.
Capparis spinosa.
lecophyllum frutescene.
Leptadenia pyrotechnica.
Ochradenus baccatus.
Procopis juliflora.
Rhazya stricta.
Tamarix aphylla.
Zygophyllum coccineum.

10% from the following species:

Aegilops kotschyi.
Anvillea garcici.

Artemesia herb-alba.
Astragalus spinosa.
Blapharis ciliaris.
Cassia italica.
Citrillus colocynthis.
Cucumis prophetarum.
Euphorbia carallum.
Fagonia cretah.
Francoeria crispa.
Hammada elegans.
Lavandula dentata.
Lycium shawii.
Panecum targedum.
Penessetum spp.
Rhanterium eppaposum.
Ricinus communis.
Stripagostis plumosa.
Zilla spinosa.

The last composition was tested in the Third test site (Fig 204). The staking out of those compositions should be by manual seeding techniques using the blanket approach. The use of nursery stock and certified commercial seeds could also be employed to achieve the above compositions. However using nursery stock may require initial irrigation till establishment. The above collections were composed to simulate natural communities using their associated species, in order to maximize aesthetic and technical succession.

**Fig 204: An illustration of the above composition using manual seeding after four years.**

The following illustrations of selected compositions of individual species which used the target community method in their assemblage technique are to be seen as examples of a thriving model for utilising native species of plant material. Some of these are found in the wild while the others are thriving on the first test site. They are an essential introductory model for arid planting design. Most of the native species are particularly sensitive to other plants that do not belong to their original community structure as mentioned in chapter 4. Therefore the following few examples will alert the designer's attention to the fact that native plants have their distinctive compositions and should only be used with care. (Fig 205-214)

1. Trees, Grass, Ground cover.

**Fig 205: The first suggested composition. Note the grass Pennisetum setacum should be used as a specimen not as a green carpet. The planted area should be utilised visually, public should not be encouraged to sit over the root zone of the tree, Procopis juliflora. Ipomea pes-caprae was used as ground cover to discourage people from using this species as a shade tree.**

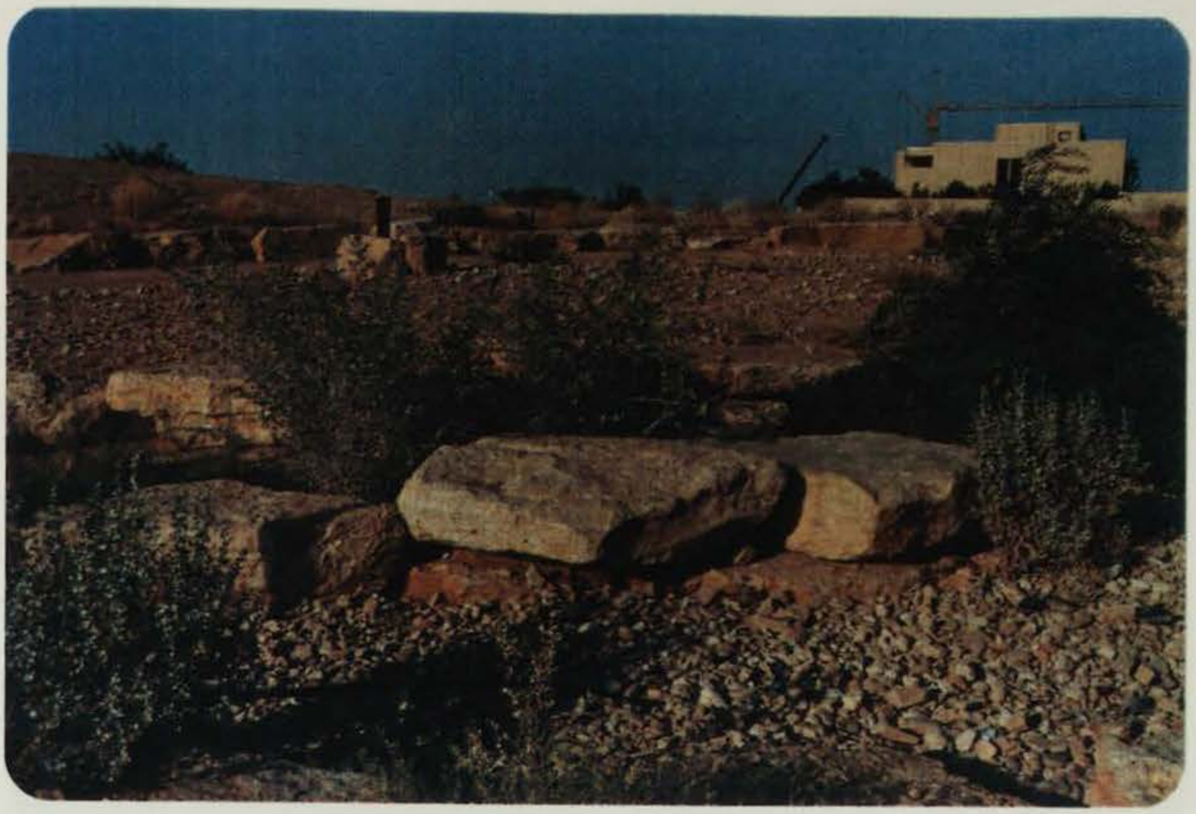

Fig 206: The shrub Atriplex halimus used as a specimen. The use of boulders and gravel reinforced the vernacular feeling of the space. The other plant is a young Acacia farnasiana.

Fig 207: The same species was used as a primary layer to gradually introduce a visually enclosed space. Hierarchy of species is as follows; ground cover, Ipomea palmata, higher shrub layer, Acacia farnasiana. Note that the whole composition is planted in a depression to obtain maximum moisture retention. Street trees are Procopis juliflora And Acacia seyal.

Fig 208: The use of Pennisetum setacum as structure planting.

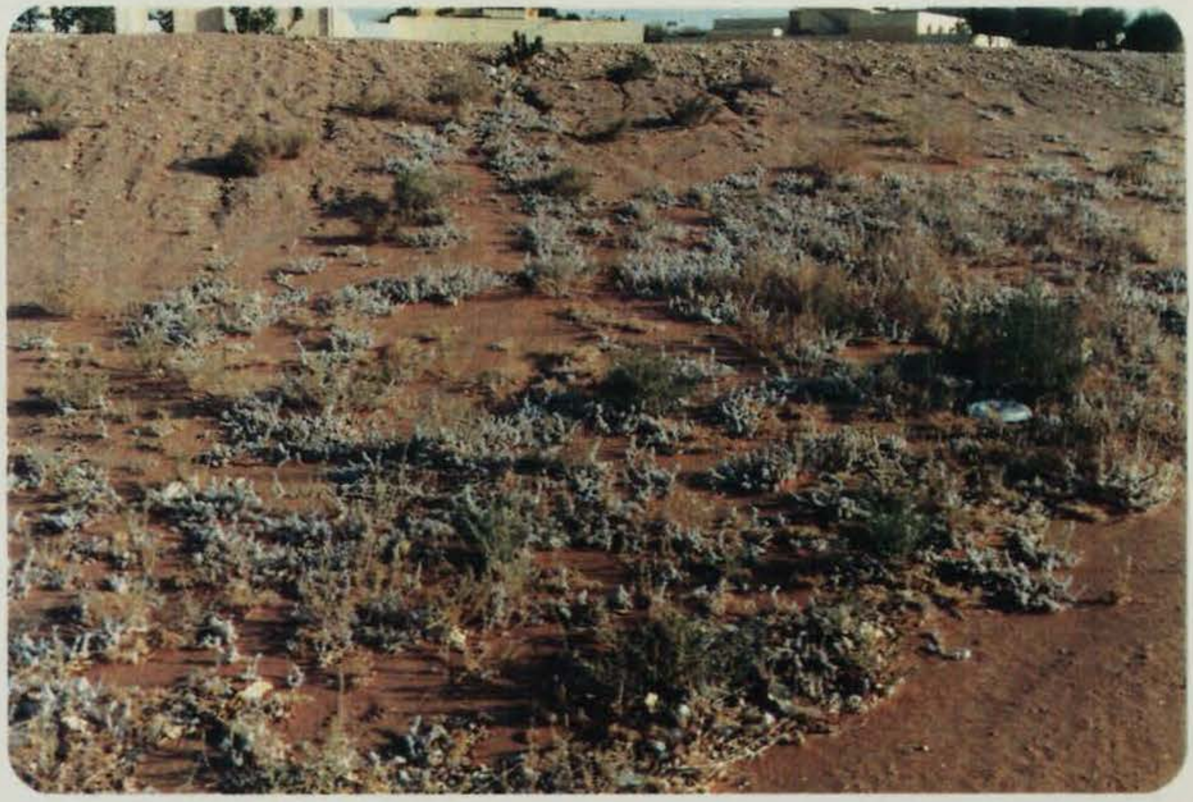

Fig 209: The use of Bassia erophoria as a distinct ground cover that maintains an arid feeling.

Fig 210: Atriplex halimus, Acacia seyal and Acacia farnesiana give definition to a pedestrian trail. The plants were used for definition only and no public access was permitted under their canopy for ecological reasons.

Fig 211: Two species can satisfy aesthetic and ecological criteria, Acacia farnesiana and Ipomea pes-caprae.

Fig 212: This distinct composition was found in the wild and represents maximum succession and aesthetic quality. Citrullus colocynthis and Aellenia spp.

Fig 213: Successful ground cover on sand; a single species of Citrullus colocynthis.

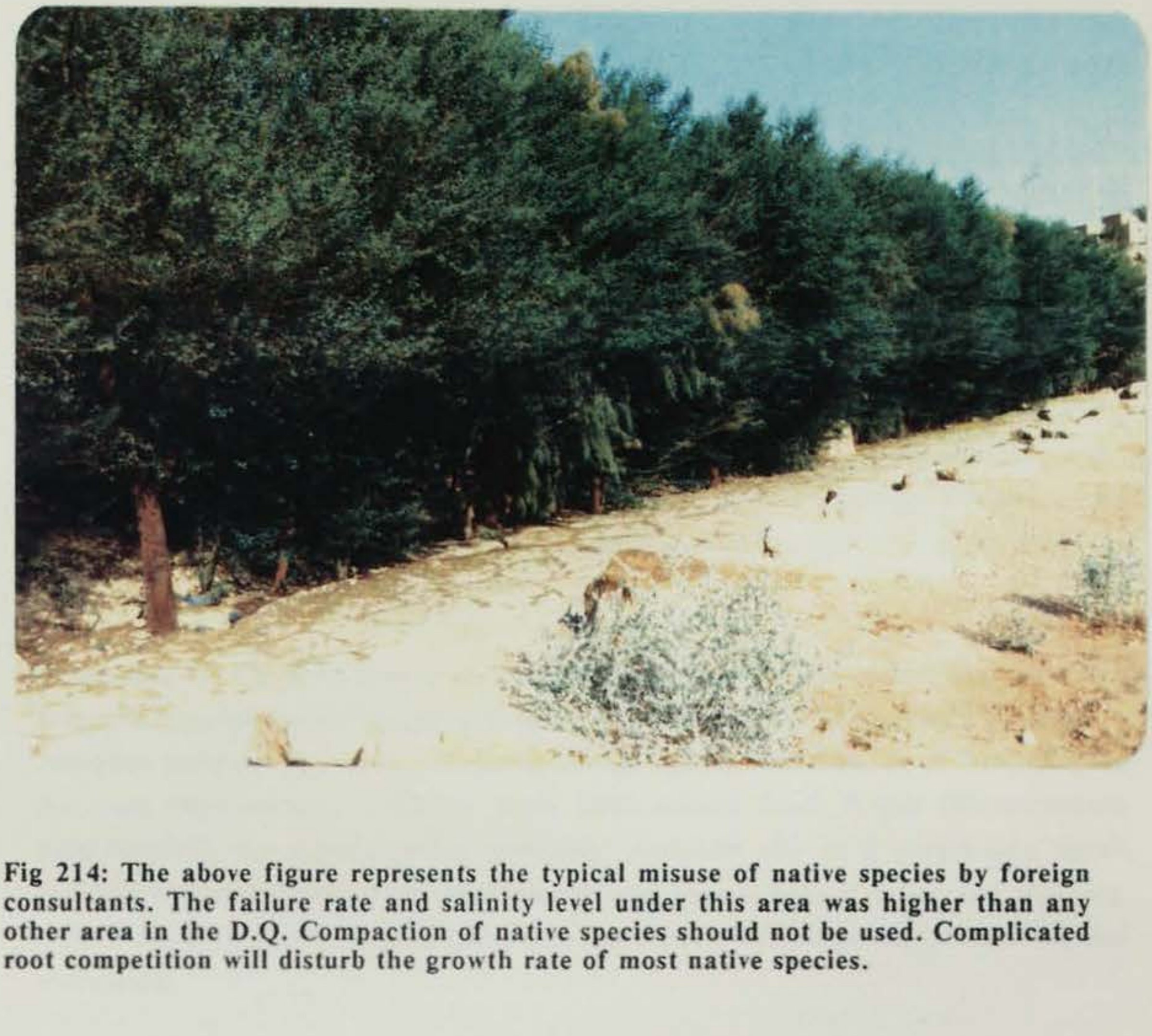

**Fig 214: The above figure represents the typical misuse of native species by foreign consultants. The failure rate and salinity level under this area was higher than any other area in the D.Q. Compaction of native species should not be used. Complicated root competition will disturb the growth rate of most native species.**

## E. CONCLUSION AND RECOMMENDATION:

### 1. SUMMARY:

The test introduced almost 50 species of native plants that can be employed directly in Najdi landscape projects. Although these plants are indigenous to the region, they are unknown to most landscape architects working there. Consequently, they would probably be misused. It is essential that these chosen species are used in accordance with their natural community structure, edaphical characteristics and moisture regime.

This chapter will summarise the hypothesis behind this attempt to substitute native for imported plant material, discuss some vernacular aspects of Arid Najd, types of projects where the plants might be used, the process of applying both target species and target community methods and directions for further needed studies.

The central region of Saudi Arabia , the Najd, is arid and usually extreme arid in the middle of summer. It is characterized by a harsh environment similar to Death valley in U.S.A. The meterological analysis shows that temperatures fluctuate from subzero in winter to over 58°C in the summer.

Najd was subjected to rapid urban growth, which divided and disintegrated its unique compacted urban fabric and consequently resulted in a mixed landuse and fragmented open spaces without meaningful characteristics or native identity. Moreover, the introduction of cars resulted in a rigid grid imposed on the urban fabric as shown in Fig 215.

Consequently, the government in its recent development plans has approved full financial support for an intensive programme to landscape Najdi towns. Already in Arriyadh there are two governmental landscape agents; Municipality of Arriyadh and Arriyadh Development Authority. Over 2000 million Saudi Riyals (approximately £400,000,000) was appointed for "greening" Arriyadh city in a programme which involves street planting, parks, play grounds and general beautification and greening. 45% of this programme has been completed and the rest is in the process of planning and evaluation.

**Fig 215: The introduction of cars which imposed a wide Grid of streets superimposed on a compacted urban fabric and consequently affected the form and characteristics of open space, recreation and distribution of green areas.**

This programme was carried out in the absence of Saudi landscape architects or qualified landscape architects who might pay attention to environmental, ecological or social factors. It took place in the form of alien design concepts and schemes with the use of exotic and imported plant material that require specially treated water, desalination units, expensive and complicated irrigation systems, imported soil fertilizers and man made microclimate.

In brief that is the core of the argument of this thesis, the failure of the current landscape programme largely as a result of the use of imported plant material. Statistics shows that the maintenance cost /$m^2$ of such landscaping is £200 /$m^2$ /year, which covers a continuous change of seedlings, maintaining a saline free soil (usually involving changing top soil every year), and the cost of running the irrigation system.

A more serious implication is that the identity of the Najdi landscape is lost: observation revealed that due to the use of imported landscape design elements and plants, the native people do not use public parks, which are characterized by a western appearance and neglect of social needs such as privacy. Moreover, the research found that some new pests and diseases have begun to contaminate native species as a result of imported plant material that bring in varieties of pests and diseases that native species may not be immune to.

So the research into the process and implication of the current programme has shown the validity of the hypothesis and pointed to the need for a solution to the implication of the current landscape programme, especially when most of the plant material in Arriyadh urban parks and streets are beginning to need replacement every three years.[135]

The answer lies in the surrounding rich Najdi habitats. Habitats that are rich in plant material surviving for thousands of years without irrigation and soil. Habitats that contain attractive species superior in texture, form and colour to the most expensive exotic plant material. Also rich vegetation stands that classify into units, each maintaining superb visual characteristics and forming excellent planting design compositions, a composition that was created by the greatest and ultimate designer.

An examination of the distribution of Najdi flora and its structure has revealed the richness of plant communities and individual species that are suitable for landscape use. The study found that Najd is characterized by species and communities that are essentially related to its soil formation. Even the poorest soil, the gravel plains, were found to contain extensive vegetation stands. Fourteen identified communities were listed and registered during the survey, undertaken with the help of A.D.A. So the Najdi habitats undoubtedly can supply a wide range of plant material suitable for potential landscape application, with which to construct successful indigenous landscape units.

But there are three main conditions for constructing a suitable environment for such units; *availability and suitability of native plant material; social factors; and technical factors*. In order to support the focal theory and the argument, a social and professional analysis resulted in:

1. Islam was born in Saudi Arabia, and applied strictly in Najd after the Wahabi movement. It is a family-society orientated religion, therefore the role, function, and design of open space should be derived from Islamic values such as high privacy and special value for social structure. In addition, Najd is socially distinct. There is strict privacy and segregation between men and women in a society which sometimes exceeds Islamic restrictions on the role of women in the community. This should be encouraged by providing suitable social open space. These socio-religious factors were tested and considered since the birth of islam, using native species as in palm lands. It

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[135] That applies to the Ground cover layer and small shrubs and sometimes large trees.

matches local architecture and satisfies public needs. Thus the rehabilitation of that role, and the development of the ancient use of native flora will justify the introduction of native species to landscape design and satisfy socio-religious factors.

2. The present commercial plant material was imported to Saudi Arabia as a result of direct specification from non Saudi Landscape architects, who specified plants from tropical sources, as a result of a lack of a comprehensive and tested native Flora. [136] That fact was supported by an intensive survey carried out by the author and re-examined in this research which revealed that this is still the case. Even palm trees, are still imported from U.S.A and north Iraq.

The alien plant material is unsuitable for Najdi eco-environmental factors and was found to require special microclimatic conditions during propagation and after planting. Although these microclimatic conditions were maintained, the imported plant material needed to be replaced three times during the first year and two times during the following four years, or if the irrigation system failed for a period exceeding 60 hours. So the availability of proven plant material, and a suitable growing environment for them are the determining factors here.

3. Technical factors played an important role in the success of planting in Najd. Firstly, in Najd the process of a typical landscape project is difficult; for example the client can by-pass the consultant, as can the contractor, and change the design or the materials used and specified by the consultant. That can seriously affect any planting design especially if native plant material was used. Secondly, the design ideas implemented in Najd are not technically suitable for native plants, for example open and exposed grass elements and compacted ground cover, resulting in a high water discharge and evaporation which consequently increases salinity level. These elements are of western origin and do not suit the environment or the ecology of Najd as shown in the environmental factors described in the earlier chapters.

All pilot studies, statistical analysis and field surveys support the unsuitability of

[136] The most common text book used, A.F Graf, *Tropia Colour Plants*. Questionnaire result.

imported material and validate the argument of the research, to establish the focal theory of using native species instead. The study was extended to describe Najd as a prosperous place for plant material, and establish the availability of plant material that needed to be *"tested"* in order to prove its suitability to substitute for imported plant material.

In the Diplomatic Quarter the German landscape architects, B.B.W started the use of native species as propagated plants in the Diplomatic Quarter's nursery. That was the start of this research, when B.B.W and the A.D.A agreed to the monitoring of three test sites, and to enhance them to meet the requirements of a thorough test of native species. The first site was a semi urban location where the native species were used as irrigated and controlled plants. Here the irrigation was applied only in the summer at a constant rate of 25 litre/week/ 3 times a week/$M^2$. Eight main measurements for the growth and habit of each species led to the elimination and qualification process.

The second test site is a site where the irrigation water was supposed to be stopped for urban expansion. Here the author managed to reduce the water gradually over 2 years [137] in order to accomplish further study about the effect of water reduction on those species, where another elimination and qualification process took place. This test site resulted in a distinctive habit for native species which showed the possible relationship between the hue of colour shift in native species and water quantity, a matter which should be researched further.

The third test site was land which had been made into a man made sand dune. It was observed that after three years of rain fall a group of plants started to appear, and was described by K. Klein [138] as *THE WEED GARDEN*. The site attracted the author's attention to the possible link between species and the source of soil that carried their seeds. There was an obvious diversity, classification and structure for the vegetation stands that were colonizing the site. A brief investigation revealed the relationship between the source of soil that was lifted, soil pattern in the site and the resultant vegetation community. Every associated factor that might affect the succession of a community was considered.

The significance of the analysis to all three sites depended on the fact that each species was monitored intensively for ten seasons and extensively for another 15 seasons. There were four main readings for the root growth [139] The canopy growth was measured twice

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[137] This was as a result of the cooperation of Mr.Said Nour, the site maintenance chief.

[138] The German landscape architect

[139] This was kept to the minimum due to its destructive effect.

every season. Salinity was measured before construction, and seven years later, 1988 (During this test).

During the tests data was collected of the nature of plant material, emphasizing its fabric, structure and pattern. The indigenous plant community was studied as a unit and spatial structure with emphasis laid on the third test site in order to obtain the most qualified community for landscape use. This part of the examination justified the final theory, by which the author tried to contribute to design theories in this region. That theory is a second part of the total theoretical design approach. The design methodology channels into using individual species or communities as design tools i.e designing with soil, moisture and communities. The collection and source of seeds or vegetation material was established with their storage and planting technique.[140] That established a firm foundation and confidence in the test results which was presented as a number of species and communities qualified for different conditions and use.

The three test sites were classified and managed to satisfy the two main forms of employment of indigenous plant material.

1. All the test sites were monitored to extract the appropriate target species which might be successful candidates for landscape use, as selective irrigated and non irrigated non selective species. That was achieved by the first irrigated site and the third test site.

2. The third test site was managed to accomplish and to prove that selective communities, which contain non selective species, could be used as a landscape tool, by using whole communities, their structural plant composition and the character of individual species to fulfil the conceptual design using those successful communities. The emphasis was on attractive plant communities.

There were forty eight successful species as minimally irrigated species, that are diverse enough to accomplish most landscape needs. Another sixteen species survived the water reduction test and proved that they could be used in an uncontrolled area with expected water fluctuation. Twenty six species achieved satisfactory growth without initial or regular irrigation, especially if they were propagated on site and from treated seeds [141].

These tests potentially equip the indigenous landscape field with a reasonable amount of species to suit most landscape needs, while also satisfying social, environmental, ecological and technical factors.

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[140] See Appendix II.

[141] See chapter 3

The Target community method resulted in three successful and identified communities all of attractive composition. Most importantly they contain a great number of woody species. The exact conditions for their growth were recorded and their success validated the community as a design tool using existing site factors. This should also start a new generation of research projects, that are likely to yield further technical information directly applicable to landscape architecture in the arid regions of the Middle East.

## 2. CONCLUSIONS AND RECOMMENDATIONS

A site suitability analysis for any suggested landscape design is essential and should be considered as a form of risk analysis. The development of an area for a particular human use will cause changes in the ecological system, man made or natural. Such an ecological system, when in stability, is a response to a set of existing conditions, which are essential and vital to each other. A change in one part of this finely interrelated system will cause changes either immediately or gradually and, in some cases, a total disruption to the system. The nature of the change is in many cases unpredictable, so intrusion will incur an element of risk.

If a chosen area is matched carefully to the activity suited to it, the risk of a negative effect and change will be decreased. For example, if an area is suitable for road construction because it has no steep and distinct slopes, is not liable to flooding but has stable soils and it does not cause bio-ecological or visual conflict, the area can be considered as most suitable, least sensitive and likely to suffer minimum impact to its ecological system.

Should an area be used for an activity not suited to it, but instead be altered to suit that activity, a change in the ecological system will occur and an adverse impact will result. For example, if the requirements for road building conflict with the natural physical characteristics of an area because it has varied slope greater than 10% and the soil is unstable and liable to flooding, and only by using involved construction and engineering techniques can the conditions be altered to make the area suitable, then the area can be considered least suitable, most sensitive and to suffer maximum impact on its ecological system.

Even if the physical characteristics are suitable for road construction but high visual or bio-ecological impact exists because the development measures will disturb areas of high value, the same results as above will occur. The planning recommendations now made are based on the principle of accomplishing the best balance between human activities and ecological security.

Each site is unique due to its physical and ecological richness and variety. Conservation of it as a rare example of the typical Central Arabian desert is considered extremely important. By retaining this original desert atmosphere and character the aims of both conservation and recreation can be achieved.

In extensive areas conservation of the present condition of the site, its physical character, ecological, edaphical stability and its harmony and attractiveness will best be served by utilizing as sources established vegetation stands, using the target community method.

All landscape facilities must be designed keeping in mind the Saudi Arabian heritage, culture and lifestyle. Wherever possible, architectural aesthetics and layout should reflect traditional needs, values, motifs and influences. Special attention should be given in the design of all landscape facilities to the need for utilizing shade and natural ventilation possibilities to minimize heat gain, radiation and glare. Plant groups should be oriented to take advantage of such conditions.

The characteristics of the national dress and consideration for modesty requires that special attention be given to screening winds from walkways, especially at entrances to buildings. The possibility of Venturi effects and of air turbulence created by building arrangements will be studied and a solution provided utilizing architectural elements, planting or a combination of both where appropriate.

According to the A.D.A reports and recommendations, the replacement of a destroyed species should be from an imported species that are native to similar environments in Najd. This is now is no longer valid according to the test result, especially the first test site where propagation of those irrigated native species was initially carried out in the local nursery from seeds or cutting and sometimes from transplanting. So the use of imported species for replacement might cause some danger to the stability of the ecological habitat in which a replacement is needed as the following quotation supports:

> *"From an ecological point of view this situation is frequently problematic. When developing nature parks, revegetation destroyed areas or doing other forms of landscaping a chief stress should be laid in the future on the use of native species instead of plants which are a foreign body in the local ecosystems".* [142]

The initial prerequisite qualifications for a nursery that can successfully propagate native species are:

1. species should be propagated on a soil typical or identical to where the seeds or cutting where obtained

2. Seeds should be treated by cracking the outdoor surface carefully to substitute the role of nature if a fast process is required.

3. Cuttings or vegetative material should be gradually transplanted into a soil and environment similar to that of the target site and the seedling should be planted in an intermediate nursery for a period of four season at least before transplanting to the target and appropriate site, noting that a site suitability analysis is an essential prerequisite.

4. The cultivation in the nursery should comply with the root system of each species, i.e for example Acacia arabica should be planted in a circle of 2.m diameter that is free from any other species and watering should be gradually reduced after initial rooting.

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[142] Kelly, Kathlen. *"Landscaping the Saudi Arabian Desert"* The Delancey Press, Philadelphia, Pennsylvania, U.S.A 1976.

5. The nursery should not have any man made microclimatic conditions apart from any initial irrigation to speed up the rooting process. Irrigation and propagation should start in the winter.

6. In the nursery regular monitoring should take place to obtain and enhance the best methods and techniques of cultivation and propagation of native plant species.

## 2.1 ECOLOGICAL CRITERIA AND RECOMMENDATION:

Human activity has a great influence on vegetation and the ecosystem. Although such influences many not be noticeable in the general appearance of the plant, there is a limit to the tolerance of a plant to human impact. This is known as the carrying capacity.

During the planning of any landscape project there should be an assumption that carrying capacity in nature exists and should be considered during planning and design stages. Any change should be applied with great care as the ecosystems are fragile and regeneration is tedious, due to the low level of primary production.

After consideration of this factor, the following objectives should be an integral part of planning of any large projects, especially those containing large planting areas. Firstly, areas which are unique to Najd that have a high conservation potential should be left untouched. Secondly, areas for strictly passive recreation activities and nature experience should be created in such areas, and in similar parts of Najd. Thirdly, any site should be analyzed to assess its suitability for the proposed activity and the implication expected. This will minimize the influence of human impact on those ecosystems.

Allowing cars into these sensitive habitats should be minimized and controlled, as it affects the soil structure, plants and the soil fauna. It also changes and alters the substratum, leading to the modification of the soil fauna which consequently weakens the vegetation carrying capacity and can alter the spatial diversity, delay succession, disturb the soil structure and cause rapid condensation which reduces the aeration of the soil, the water retention ratio and the permeability of the soil for water. Most important, such soil compaction will reduce the permeability of the soil for the infiltration of newly germinated roots.

Moreover excessive car access to the site will result in the gradual disappearance of the typical flora that has been established over the years, and weeds will colonize such soil. This applies also to the insects and animals that inhabit such soil.

Irrigation will modify environmental conditions. Most native desert plants which are adapted to the harsh desert conditions by special physiological, morphological or anatomical mechanical mechanisms, may lose such adaptation as a result. They may also lose their unique tolerance to pests and diseases. Moreover, they can lose their competitive power in the struggle for water with other species, which need more water and have a faster growth rate. All these factors will eventually lead to the disappearance for typical Najdi flora.

The more competitive plants are usually weeds, their pattern and species are directly related to the irrigation methods used whether drip, sprinkler or manual system. Their presence will also be determined by the salinity and fertility of soil. From observations on the first test site weeds were found to be absent due to the following:

1. Irrigation system used was an imitation of the desert runnel system, which naturally collected the rain forming a natural pattern, which was applied in the first test sites through a series of canals and depressions in which the water flowed twice a week during the Summer. This ensured that water is distributed to the native plants naturally. (Fig 216).

2. The soil used was identical to the soil related to each chosen species used and there was no any other additives were used.

The only negative observation found was the appearance of new species to the area along the irrigation course: these species were eliminated when the initial water was stopped.

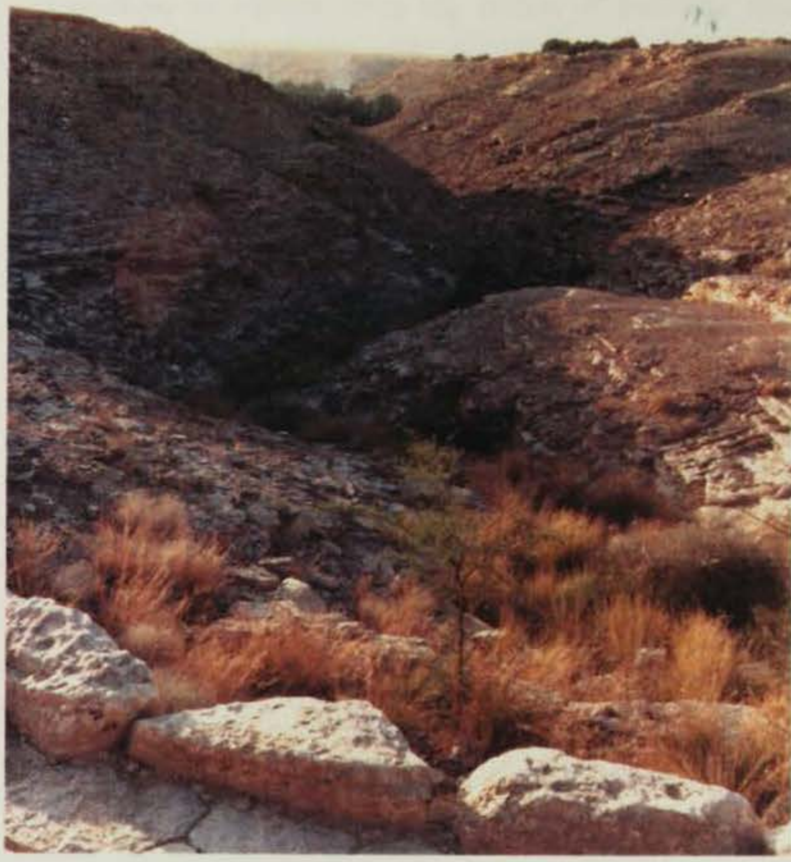

**Fig 216: The irrigation water was discharged into this Shuaib and created a vegetation community similar to those found in the wild.**

Negative human impact on vegetation habitats are most apparent in shuaibs, which are usually distinguished by their typical sensitive Acacia gerrardii stands. These act as a regeneration nucleus of the shuaibs and Wadi vegetation. An organized scheme should be implemented in order to replant [143] the damaged parts of the vegetation system.

The regeneration in such cases will be very slow due to the lack of a natural dispersed source for seed. ( Further research in this area should be carried out to determine the importance of such material on the growth rate of native species). In fact any damaged site will develop a slow succession. Extremely degraded sites have a progressive succession, if all kind of human influence are kept away from them. (birand, 1970).[144] Close observation of such sites must examine the ecological measurements during this important natural process.

The vegetation layer was never found to be in a static condition, during a close study of some of the A.D.A projects in a newly colonized area. The pioneer communities were replaced by different succession stages and finally by climax communities.

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[143] The replanting method should be of the same species and using blanket method.

[144] Arriyadh Development Authority.

According to reports from the A.D.A it was also found that there was a strong connection between the vegetation structure and animal populations. The following recommendation might help in establishing important key factors which are essential for any ecological assessment during design stages:

1. Establishment of permanent examination sites that should be monitored three times a year.The research should include :

* Calculation of the species coverage ratio and organized documentation for changes in the species composition).
* Investigation of the species which indicate succession stages.
* Analysis of alterations in the vegetation blanket concerning life forms.
* Analysis on the phenological aspects of vegetation (time and sequence of seed and flower production).
* Monitoring of the regeneration of the destroyed and degraded vegetation units.

2. The result of such research should be used for further development of semi urban and extensive landscape projects in Najd.

## 2.2 RECOMMENDATION FOR A SCIENTIFIC RESEARCH PROGRAMME TO REINFORCE THE RESULT OF THIS RESEARCH.

After this short test programme, it should be the aim of a long term testing programme for example 10-25 years for the same category of tests, in order to increase the selection of individual species and to introduce more communities to the extensive landscaping.

The future improvement of the Najdi vernacular landscape must have a close connection to further scientific research in this specific field in order to check the development objectives and correct these when necessary. The further scientific research programme should be guided by two main objectives; scientific research which mainly serves to test more native species and communities and also to continue to monitor the feature of colour shift and water quantity that was discovered here in this research; and scientific research which will gather more detailed knowledge about Najdi ecosystems. Accordingly the author recommends the establishment of a testing and research station supervised by consultants, to pioneer work in this field.

This research station should be managed through the A.D.A or similar professional organisation but not an academic institution in order to acknowledge the applied importance of test sites. This station could be a focus for the following suggested scientific research in Saudi Arabia: firstly investigation of the influence of human activity in planted areas with native species. This test might need a period of two generations but it is valuable especially in the modification and the variation of plant and vegetation types and in the devastation of areas. Secondly, the effects of grazing on plant communities. Thirdly methods of regeneration of destroyed areas. Also a research into the administrative systems that are likely to support and preserve the use of native species in Najdi landscape architecture.

Moreover, research in to the adaptation strategies of plants and animals to desert conditions is essential and also on the habit, seasons and pattern of seed and fruit dispersal of native species. Additional plant sociological research on human responses to planting heavily used urban and extensive parks is vital to the long term success of vernacular landscaping in Najd.

Further research is needed to establish the practicality of applying the discovered colour control method. The result is interesting and proved to be practical in the short term. Its effect on the plants are not known over a longer period of time, and there are some questions to be answered: Firstly, will the achieved variation of colour to a single species last after water stoppage. Secondly, the physical effects noticed on some species may have positive or negative effects on some species. The two questions need to be answered by a longer research programme. The author has set the broad lines for using water as a design feature and as a factor controlling the plant's texture and colour.

Additional formal research is required in several areas. Extensive study of the hydrology of Najd is necessary to determine the location and characteristics of existing aquifers in the region; how they recharge normally; whether they can be re-charged artificially; if so, whether the salt and mineral content of new water in the aquifers can be minimized, and to project the extent of land subsidence if the aquifers continue to be drawn down without being recharged. Research should also be undertaken to study more efficient ways of allowing rainfall to recharge aquifers, such as the establishment of small catch ponds in wadis and management of vegetation for the optimum combination of both erosion control and run-off to collecting points. Botanical and ecological research is required, both in the field and in laboratories, to develop a comprehensive inventory of indigenous plants and the conditions under which they grow. The hydrological study in Chapter 1 shows the value of water in Najd. One day there will be a sharp decrease in water resources which will result in the death of imported species which are not indigenous to similar arid zones. The use of indigenous species will eliminate this risk as the native species tolerate drought and water stress.

Also, experimental field stations should be established to study, both for agricultural and land management purposes, the propagation of indigenous plants and the collection of their seeds, broadcast planting techniques, and the best species and effective heights of boundary berms.

Intensive ecological T.V. and radio programmes should be utilized to introduce the public to an awareness of their environment and to accept parks which are planted with native species.

During design with plants, changes to the native character both in number and intensity, should be minimal. All geological, historical and topographical features should be preserved and be made accessible for educational and recreational use, yet should be protected from over use and damage. Traditional settlement patterns and building forms should be adopted because of their close relationship to natural patterns and landscape forms. Park users should be introduced to the relationship between man and his natural environment and all forms of facilities should reinforce this concept. All planning should strive to establish an equilibrium or harmony between the requirements of the user and the potential of the landscape. All necessary developments should, through design, management, and maintenance measures, be aesthetically and ecologically integrated into the existing landscape.

Traditional and intermediate technology methods of planting and irrigation should be investigated and controlled by the concerned authorities. The tendency to import sophisticated forms of irrigation system that are not suited to Najdi plants must be controlled by rigorous testing. Landscape design should aim for a full utilisation of the annual rain fall and any irrigation system must be for initial establishment stages only.

The objectives for nature education should be to facilitate the study, interpretation and enjoyment of the natural environment of the parks in particular and central Saudi Arabia in general. Higher educational facilities (perhaps an outdoor study centre for King Saudi University) should be developed as part of the parks to conserve and make use of all the natural and ancient features in the region. Foreign designers should be supervised, directed and counselled to satisfy the traditional character and to use native plant material.

Finally, this research has presented vernacular landscaping with a tool for a successful start. This start should be encouraged by further governmental sponsored research. The inventory of the qualified plants should influence local nurseries as native species start to appear in specifications for new landscape projects. As the authorities realise the favourable implications of using such species, more tests will commence and the inventory will increase. This initial attempt has initiated a model for practical research which is much needed in this rather sensitive area, where a move to environmental design is urgently required.

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# APPENDIX I
# QUESTIONNAIRE

UNIVERSITY OF EDINBURGH
ARCHITECTURE DEPARTMENT
PHD IN LANDSCAPE ARCHITECTURE

QUESTIONNAIRE FOR ACADEMIC RESEARCH PURPOS:

CLIENT, CONSULTANT AND CONTRACTOR QUESTIONNAIRE

TITLE: SAUDI ARABIN FLORA AND ITS APPLICATION IN LANDSCAPE DESIGN PROJECTS

(1) Organization:

(2) Name:

(3) Position:

(4) The roll of this organization in landscaping the central region of Saudi Arabia:

Please tick if appropriate.

| | |
|---|---|
| Governmental Project Management and Development Authority | |
| Private Developer | |
| Consultant | |
| Nursery | |
| Institution | |

Notes: 1. ____________________

2. ____________________

3. ____________________

(5) Were you involved in planting scheme within these projects? ______
Yes No

If yes, please give project name.

(6) If yes, please indicate which of the following species are most available and used in your projects:

## TREES

ACACIA CYANOPHYLLA
ACACIA FARNESIANA
ACACIA PENDULA
ACACIA SALICINA
ALBIZZIA LEBBEK
AZADIRACHTA INDICA
BRACHYCHITON POPULNEUS
BRACHYCHITON RUPESTRE
CAESALPINA FERREA
CALLISTEMON VIMINALIS
CASUARINA SPP.
CEROTINA SILIQUA
CAMAEROPS HUMILIS
CITRUS SPP.
DALBERGIA SISSO
DELONIX REGIA
DELONIX ELATA
ERYTHRINA CAFFRA
EUCALYPTUS CAMADULENSIS
EUCALYPTUS SARGENTII
EUCALYPTUS STRICKLANDII
EUCALYPTUS TORQUATA
EUCALYPTUS WOODWARDII

FICUS BENGALENSIS
FICUS HILLII
FICUS NITIDA
FICUS RELIGIOSA
FICUS VIRENS
FRAXINUS VELUTINA
KHAYA SENEGALENSIS
MELALEUCA LEUCADENDRON
MELALEUCA BRACTEATA
MELALEUCA VIRIDIFLORA
MELIA AZEDARACH
PARKINSONIA ACULEATA
PELTOPHORUM PTEROCARPUM
PITHECELOBIUM DULCE
PLUMERIA OBTUSIFOLIA
PROSOPIS JULIFLORA
SPATHODEA CAMPANULATA
SCHINUS MOLLE
SCHINUS TEREBINTHIFOLIUS
SCHOTIA BRACHYPETALA
TAMARINDUS INDICUS
TERMINALIA CATAPPA
ZIZIPHUS SPINACHRISTI
ZIZIPHUS JUJUBA

## PALMS

PHOENIX DACTYLIFERA
WASHINGTONIA FILIFERA
WASHINGTONIA ROBUSTA

## SHRUBS

ATRIPLEX SPP.
BAUHINIA GALPINII
CAESALPINA GILLESI
CAESALPINA PULCHERRIMA
CALLISTEMON VAR.
CARISSA GRANDIFLORA
CASSIA ARTEMISIOIDES
CASSIA NEMOPHYLLA
CLERODENDRON INERME
CORDYLINE TERMINALIS
CYCAS REVOLUTA
DODONEA VISCOSA
ELEAGNUS PUNGENS
HAKEA LAURINA

HIBISCUS ROSA-SINENSIS
LANTANA CAMARA
LEUCOPHYLLUM FRUTESCENS
MELALEUCA ARMILLARIS
MELALEUCA BRACTEATA
NERIUM OLEANDER
OCIMUM BASILICUM
PHORMIUM TENAX
PITTOSPORUM TRIOBA
ROSA SPP.
ROSMARINUS OFFICINALIS
TECOMA STANS
TEVETIA NERIFOLIA
ZIZIPHUS NUMULARIA

## GROUND COVER

ARABIS CAUCASIA
ARCTOTNECA CALENDULA
ASPARAGUS SPRENGERI
BACCHARIS PILULARIS
CARISSA GRANDIFLORA
DROSANTHEMUM HISPIDUM
GAZANIA LEUCOLEANA
LAMPRANTHUS SPP.

LANTANA MONTEVIDENSIS
LIPPIA NODIFLORA
LOCHNERA ROSEA
LONICERA HALLIANA
MALAPHORA SP.
PORTULACA GRANDIFLORA
SANTOLINA CHAMAECYPARISSUS
SENECIO CINERARIA

## CLIMBERS

ANTIGONON LEPTOPUS
BIGNONIA IGNEA
BOUGANVILLEA SPP.
GELSEMIUM SEMPERVIRENS
IPOMOEA PES-CAPRAE

JASMINUM OFFICINATIS
JASMINUM POLYANTHEM
LONICERA HALLIANA
PLUMBAGO AVRICULATA
QUISQUALIS INDICA

## ANNUALS

ALLYSSUM MARTINA
AMARANTHUS
CANNA INDICA
CHRYSANTHEMUM CORONARIUM
KOCHIA SPP.

NICOTINIA SPP.
PETUNIA HYBRIDA
VERBENA SPP.
ZINNIA SPP.

## SUCCULENTS, CACTI

AGAVE SPP.
ALOE SPP.
EUPHORBIA SPP.
FURCRAEA GINCANTEA

KLEINIA SPP.
OPUNTIA SPP.
SANSERIERA SPP.
YUCCA SPP.

## GRASSES

ARURDO DONAX
CORTEDARIA SELLOWINANA
CYNADON DACTYLON
FESTUCA OVINA 'GLAUCA'

PASPALUM DISTICUM 'SALPAS'
PHRAGMITES COMMUNIS
STENOTAPHRUM SECUNDATUM

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NOTE: Please give name and address of main supplier to your plant material.

(7) The following are questions in order to assess how these species are successful and qualified for use in public urban parks and should be obtained from your practice.

| SPECIES | ADAPTATION TO WATER STRESS | | | | ADAPTATION TO TEMPERATURE STRESS | | | | ADAPTATION TO SALINITY | | | | ADAPTATION TO SOIL COMPACTION AND POOR NUTRIENTS | | | | TOUGHNESS AND ENDURANCE OF HEAVY PUBLIC USE | | | | TOLERANCE TO INSECTS, PESTS OR DISEASES | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D |
| TREES | | | | | | | | | | | | | | | | | | | | | | | | |
| ACACIA CYANOPHYLLA | | | | | | | | | | | | | | | | | | | | | | | | |
| ACACIA FARNESIANA | | | | | | | | | | | | | | | | | | | | | | | | |
| ACACIA PENDULA | | | | | | | | | | | | | | | | | | | | | | | | |
| ACACIA SALICINA | | | | | | | | | | | | | | | | | | | | | | | | |
| ALBIZZIA LEBBEK | | | | | | | | | | | | | | | | | | | | | | | | |
| AZADIRACHTA INDICA | | | | | | | | | | | | | | | | | | | | | | | | |
| BRACHYCHITON POPULNEUS | | | | | | | | | | | | | | | | | | | | | | | | |
| BRACHYCHITON RUPESTRE | | | | | | | | | | | | | | | | | | | | | | | | |
| CAESALPINA FERREA | | | | | | | | | | | | | | | | | | | | | | | | |
| CALLISTEMON VIMINALIS | | | | | | | | | | | | | | | | | | | | | | | | |
| CASUARINA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| CEROTINA SILIQUA | | | | | | | | | | | | | | | | | | | | | | | | |
| CAMAEROPS HUMILIS | | | | | | | | | | | | | | | | | | | | | | | | |
| CITRUS SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| DALBERGIA SISSO | | | | | | | | | | | | | | | | | | | | | | | | |
| DELONIX REGIA | | | | | | | | | | | | | | | | | | | | | | | | |
| DELONIX ELATA | | | | | | | | | | | | | | | | | | | | | | | | |
| ERYTHRINA CAFFRA | | | | | | | | | | | | | | | | | | | | | | | | |
| EUCALYPTUS CAMADULENSIS | | | | | | | | | | | | | | | | | | | | | | | | |
| EUCALYPTUS SARGENTII | | | | | | | | | | | | | | | | | | | | | | | | |
| EUCALYPTUS STRICKLANDII | | | | | | | | | | | | | | | | | | | | | | | | |
| EUCALYPTUS TORQUATA | | | | | | | | | | | | | | | | | | | | | | | | |
| EUCALYPTUS WOODWARDII | | | | | | | | | | | | | | | | | | | | | | | | |
| FICUS BENGALENSIS | | | | | | | | | | | | | | | | | | | | | | | | |
| FICUS HILLII | | | | | | | | | | | | | | | | | | | | | | | | |
| FICUS NITIDA | | | | | | | | | | | | | | | | | | | | | | | | |
| FICUS RELIGIOSA | | | | | | | | | | | | | | | | | | | | | | | | |
| FICUS VIRENS | | | | | | | | | | | | | | | | | | | | | | | | |

| SPECIES | ADAPTATION TO WATER STRESS | | | | ADAPTATION TO TEMPERATURE STRESS | | | | ADAPTATION TO SALINITY | | | | ADAPTATION TO SOIL COMPACTION AND POOR NUTRIENTS | | | | TOUGHNESS AND ENDURANCE OF HEAVY PUBLIC USE | | | | TOLERANCE TO INSECTS, PESTS OR DISEASE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D |
| TREES (Contd.) | | | | | | | | | | | | | | | | | | | | | | | | |
| FRAXINUS VELUTINA | | | | | | | | | | | | | | | | | | | | | | | | |
| KHAYA SENEGALENSIS | | | | | | | | | | | | | | | | | | | | | | | | |
| MELALEUCA LEUCADENDRON | | | | | | | | | | | | | | | | | | | | | | | | |
| MELALEUCA BRACTEATA | | | | | | | | | | | | | | | | | | | | | | | | |
| MELALEUCA VIRIDIFLORA | | | | | | | | | | | | | | | | | | | | | | | | |
| MELIA AZEDARACH | | | | | | | | | | | | | | | | | | | | | | | | |
| PARKINSONIA ACULEATA | | | | | | | | | | | | | | | | | | | | | | | | |
| PELTOPHORUM PTEROCARPUM | | | | | | | | | | | | | | | | | | | | | | | | |
| PITHECELOBIUM DULCE | | | | | | | | | | | | | | | | | | | | | | | | |
| PLUMERIA OBTUSIFOLIA | | | | | | | | | | | | | | | | | | | | | | | | |
| PROSOPIS JULIFLORA | | | | | | | | | | | | | | | | | | | | | | | | |
| SPATHODEA CAMPANULATA | | | | | | | | | | | | | | | | | | | | | | | | |
| SCHINUS MOLLE | | | | | | | | | | | | | | | | | | | | | | | | |
| SCHINUS TEREBINTHIFOLIUS | | | | | | | | | | | | | | | | | | | | | | | | |
| SCHOTIA BRACHYPETALA | | | | | | | | | | | | | | | | | | | | | | | | |
| TAMARINDUS INDICUS | | | | | | | | | | | | | | | | | | | | | | | | |
| TERMINALIA CATAPPA | | | | | | | | | | | | | | | | | | | | | | | | |
| ZIZIPHUS SPINACHRISTI | | | | | | | | | | | | | | | | | | | | | | | | |
| ZIZIPHUS JUJUBA | | | | | | | | | | | | | | | | | | | | | | | | |
| PALMS | | | | | | | | | | | | | | | | | | | | | | | | |
| PHOENIX DACTYLIFERA | | | | | | | | | | | | | | | | | | | | | | | | |
| WASHINGTON FILIFERA | | | | | | | | | | | | | | | | | | | | | | | | |
| WASHINGTON ROBUSTA | | | | | | | | | | | | | | | | | | | | | | | | |

| SPECIES | ADAPTATION TO WATER STRESS | | | | ADAPTATION TO TEMPERATURE STRESS | | | | ADAPTATION TO SALINITY | | | | ADAPTATION TO SOIL COMPACTION AND POOR NUTRIENTS | | | | TOUGHNESS AND ENDURANCE OF HEAVY PUBLIC USE | | | | TOLERANCE TO INSECTS, PESTS OR DISEASE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D |
| SHRUBS | | | | | | | | | | | | | | | | | | | | | | | | |
| ATRIPLEX SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| BAUHINIA GALPINII | | | | | | | | | | | | | | | | | | | | | | | | |
| CAESALPINA GILLESI | | | | | | | | | | | | | | | | | | | | | | | | |
| CAESALPINA PULCHERRIMA | | | | | | | | | | | | | | | | | | | | | | | | |
| CALLISTEMON VAR. | | | | | | | | | | | | | | | | | | | | | | | | |
| CARISSA GRANDIFLORA | | | | | | | | | | | | | | | | | | | | | | | | |
| CASSIA ARTEMISIOIDES | | | | | | | | | | | | | | | | | | | | | | | | |
| CASSIA NEMOPHYLLA | | | | | | | | | | | | | | | | | | | | | | | | |
| CLERODENDRON INERME | | | | | | | | | | | | | | | | | | | | | | | | |
| CORDYLINE TERMINALIS | | | | | | | | | | | | | | | | | | | | | | | | |
| CYCAS REVOLUTA | | | | | | | | | | | | | | | | | | | | | | | | |
| DODONEA VISCOSA | | | | | | | | | | | | | | | | | | | | | | | | |
| ELEAGNUS PUNGENS | | | | | | | | | | | | | | | | | | | | | | | | |
| HAKEA LAURINA | | | | | | | | | | | | | | | | | | | | | | | | |
| HIBISCUS ROSA-SINENSIS | | | | | | | | | | | | | | | | | | | | | | | | |
| LANTANA CAMARA | | | | | | | | | | | | | | | | | | | | | | | | |
| LEUCOPHYLLUM FRUTESCENS | | | | | | | | | | | | | | | | | | | | | | | | |
| MELALEUCA ARMILLARIS | | | | | | | | | | | | | | | | | | | | | | | | |
| MELALEUCA BRACTEATA | | | | | | | | | | | | | | | | | | | | | | | | |
| NERIUM OLEANDER | | | | | | | | | | | | | | | | | | | | | | | | |
| OCIMUM BASILICUM | | | | | | | | | | | | | | | | | | | | | | | | |
| PHORMIUM TENAX | | | | | | | | | | | | | | | | | | | | | | | | |
| PITTOSPORUM TRIOBA | | | | | | | | | | | | | | | | | | | | | | | | |
| ROSA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| ROSMARINUS OFFICINALIS | | | | | | | | | | | | | | | | | | | | | | | | |
| TECOMA STANS | | | | | | | | | | | | | | | | | | | | | | | | |
| TEVETIA NERIFOLIA | | | | | | | | | | | | | | | | | | | | | | | | |
| ZIZIPHUS NUMULARIA | | | | | | | | | | | | | | | | | | | | | | | | |

| SPECIES | ADAPTATION TO WATER STRESS | | | | ADAPTATION TO TEMPERATURE STRESS | | | | ADAPTATION TO SALINITY | | | | ADAPTATION TO SOIL COMPACTION AND POOR NUTRIENTS | | | | TOUGHNESS AND ENDURANCE OF HEAVY PUBLIC USE | | | | TOLERANCE TO INSECTS, PESTS OR DISEASE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D |
| GROUND COVER | | | | | | | | | | | | | | | | | | | | | | | | |
| ARABIS CAUCASIA | | | | | | | | | | | | | | | | | | | | | | | | |
| ARCTOTNECA CALENDULA | | | | | | | | | | | | | | | | | | | | | | | | |
| ASPARAGUS SPRENGERI | | | | | | | | | | | | | | | | | | | | | | | | |
| BACCHARIS PILULARIS | | | | | | | | | | | | | | | | | | | | | | | | |
| CARISSA GRANDIFLORA | | | | | | | | | | | | | | | | | | | | | | | | |
| DROSANTHEMUM HISPIDUM | | | | | | | | | | | | | | | | | | | | | | | | |
| GAZANIA LEUCOLEANA | | | | | | | | | | | | | | | | | | | | | | | | |
| LAMPRANTHUS SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| LANTANA MONTEVIDENSIS | | | | | | | | | | | | | | | | | | | | | | | | |
| LIPPIA NODIFLORA | | | | | | | | | | | | | | | | | | | | | | | | |
| LOCHNERA ROSEA | | | | | | | | | | | | | | | | | | | | | | | | |
| LONICERA HALLIANA | | | | | | | | | | | | | | | | | | | | | | | | |
| MALAPHORA SP. | | | | | | | | | | | | | | | | | | | | | | | | |
| PORTULACA GRANDIFLORA | | | | | | | | | | | | | | | | | | | | | | | | |
| SANTOLINA CHAMAECYPARISSUS | | | | | | | | | | | | | | | | | | | | | | | | |
| SENECIO CINERARIA | | | | | | | | | | | | | | | | | | | | | | | | |
| CLIMBERS | | | | | | | | | | | | | | | | | | | | | | | | |
| ANTIGONON LEPTOPUS | | | | | | | | | | | | | | | | | | | | | | | | |
| BIGNONIA IGNEA | | | | | | | | | | | | | | | | | | | | | | | | |
| BOUGANVILLEA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| GELSEMIUM SEMPERVIRENS | | | | | | | | | | | | | | | | | | | | | | | | |
| IPOMOEA PES-CAPRAE | | | | | | | | | | | | | | | | | | | | | | | | |
| JASMINUM OFFICINATIS | | | | | | | | | | | | | | | | | | | | | | | | |
| JASMINUM POLYANTHEM | | | | | | | | | | | | | | | | | | | | | | | | |
| LONICERA HALLIANA | | | | | | | | | | | | | | | | | | | | | | | | |
| PLUMBAGO AVRICULATA | | | | | | | | | | | | | | | | | | | | | | | | |
| QUISQUALIS INDICA | | | | | | | | | | | | | | | | | | | | | | | | |

| SPECIES | ADAPTATION TO WATER STRESS | | | | ADAPTATION TO TEMPERATURE STRESS | | | | ADAPTATION TO SALINITY | | | | ADAPTATION TO SOIL COMPACTION AND POOR NUTRIENTS | | | | TOUGHNESS AND ENDURANCE OF HEAVY PUBLIC USE | | | | TOLERANCE TO INSECTS, PESTS OR DISEASE | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D | A | B | C | D |
| ANNUALS | | | | | | | | | | | | | | | | | | | | | | | | |
| ALLYSSUM MARTINA | | | | | | | | | | | | | | | | | | | | | | | | |
| AMARANTHUS | | | | | | | | | | | | | | | | | | | | | | | | |
| CANNA INDICA | | | | | | | | | | | | | | | | | | | | | | | | |
| CHRYSANTHEMUM CORONARIUM | | | | | | | | | | | | | | | | | | | | | | | | |
| KOCHIA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| NICOTINIA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| PETUNIA HYBRIDA | | | | | | | | | | | | | | | | | | | | | | | | |
| VERBENA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| ZINNIA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| SUCCULENTS, CACTI | | | | | | | | | | | | | | | | | | | | | | | | |
| AGAVE SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| ALOE SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| EUPHORBIA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| FURCRAEA GINGANTEA | | | | | | | | | | | | | | | | | | | | | | | | |
| KLEINIA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| OPUNTIA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| SANSERIERA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| YUCCA SPP. | | | | | | | | | | | | | | | | | | | | | | | | |
| GRASSES | | | | | | | | | | | | | | | | | | | | | | | | |
| ARURDO DONAX | | | | | | | | | | | | | | | | | | | | | | | | |
| CORTEDARIA SELLOWINANA | | | | | | | | | | | | | | | | | | | | | | | | |
| CYNADON DACTYLON | | | | | | | | | | | | | | | | | | | | | | | | |
| FESTUCA OVINA 'GLAUCA' | | | | | | | | | | | | | | | | | | | | | | | | |
| PASPALUM DISTICUM 'SALPSAS' | | | | | | | | | | | | | | | | | | | | | | | | |
| PHRAGMITES COMMUNIS | | | | | | | | | | | | | | | | | | | | | | | | |
| STENOTAPHRUM SECUNDATUM | | | | | | | | | | | | | | | | | | | | | | | | |

(8) Which of these native species are used and available in your projects? Please tick if appropriate.

ABUTILON
- bidentatum
- denticulatum
- figarianum
- fruticosum
- glaucum
- graveolens
- hirtum
- multicum
- pannosum

ACACIA
- albida
- arabica
- asak
- cyanophylla
- ehrenbergiana
- etbaica
- farnesiana
- flava
- glaucophylla
- laeta
- mellifera
- nilotica ssp. tomentosa
- nubica
- pterygocarpa
- raddiana
- seyal
- spirocarpa
- tortilis
- tortilis ssp. raddiana

ACALYPHA fruticosa

ACANTHACEAE

ACETOSA
- picta
- vesicaria

ACHILLEA
- arabica
- fragrantissima

ACHYRANTHES
- alternifolia
- aspera
- maricata

ACORELLUS laevigatus

ADENIA vennenata

ADENIUM
- arabicum
- obesum

ADIANTACEAE

ADIANTUM capillus-veneris

AEGILOPS
- Kotschyi v.palaestina
- triaristata
- triuncialis
- variabilis

AELUROPUS
- arabicus
- brevifolius
- lagopoides
- littoralis
- littoralis v. repens
- massauensis
- mucronatus
- repens

AERVA
- javanica
- lanata
- persica
- tomentosa

AGATHAEA dentata

AGATOPHORA alopecuroides

AGAVACEAE

AGROPYRUM
- distans
- lasianthum

AGROSTIS
- semiverticillata
- verticillata

AIZOACEAE

AIZOON
- canariense
- hispanicum

AJUGA
  chia v. tridactylites
  iva
  tridactylites

ALBIZZIA lebbec

ALCEA acaulis

ALHAGI
  mannifera
  maurorum

ALKANNA orientalis

ALLIACEAE

ALLIUM
  desertorum
  laceratum
  sphaerocephalon

ALOE
  perfoliata
  vera

ALOPECURUS
  agrestis
  myosuroides

ALSINE succulenta

ALTHAEA
  acaulis
  ludwigii

ALYSSUM homalocarpum

AMARANTHACEAE

AMARANTHUS
  angustifolius
  angustifolius v.silvester
  ascendens
  blitum
  caudatus
  graecizans
  graecizans v.sylvestris
  lividus v. ascendens
  spinsosus
  sylvestris

AMARYLLIDACEAE

AMBROSIA maritima

AMMI majus

AMMOIDES
  pusilla
  verticillata

AMMOPHILA arenaria

AMYGDALUS arabica

ANABASIS
  articulata
  setifera

ANACARDIACEAE

ANAGALLIS
  arvensis
  ssp.latifolia
  coerulea
  phoenicea

ANAGYRIS
  foetida
  neapolitana

ANARRHINNUM orientale

ANASTATICA hierochuntica

ANCHUSA
  aegyptiaca
  aggregata
  hispida
  milleri

ANDRACHINE
  aspera
  telephioides

ANDROPOGON
  annulatus
  distachyos
  faveolatus
  hirtus
  quinqueplumis
  schoenanthus

ANETHUM graveolens

ANTHEMIS
cotula
indurata
melampodina ssp. deserti
pseudocotula
rotata

ANTHEPHORA hochstetteri

ANTHISTIRIA
ciliata
imberbis

ANTICHARIS
arabica
glandulosa
linearis

ANTIRRHINUM orontium

ANVILLEA garcini

APIUM
graveolens
nodiflorum

APOCYNACEAE

ARALIACEAE

ARENARIA
graveolens
serpyllifolia

ARGEMONE mexicana

ARGYROLOBIUM
abyssinicum
uniflorum

ARISTIDA
adscensionis
ciliata
funiculata
hirtigluma
lanata
meccana
mutabilis
obtusa
plumosa v. brachypoda
plumosa
raddiana
schweinfurthii
scoparia
submucronatus

ARISTOLOCHIACEAE

ARISTOLOCHIA
bracteata
bracteolata

ARNEBIA
decumbens
hispidissima
linearifolia
tetrastigma
tinctoria

ARTEMISIA
abyssinica
herba-alba
inculta
judaica
monosperma
scoparia

ARTHROCNEMUM
fruticosum
glaucum

ARTHROPHYTUM
schmittianum
scoparium

ARUNDO
australis
donax
phragmites

ASCLEPIADACEAE

ASCLEPIAS
fruticosa
sinaica

ASPARAGUS
africanus
asiaticus
nitis
stipularis

ASPHODELUS
fistulosus v. tenuifolius
pendulinus
refractus
tenuifolius

ASPLENIACEAE

CAPPARIS
  spinosa
  spinosa v. aegyptia

CAPRIFOLIACEAE

CAPSELLA bursa-pastoris

CARALLUMA
  penicillata
  retrospiciens
  sinaica

CARDARIA draba

CARDUUS
  getulus
  pycnocephalus

CAREX
  devisa
  stenophylla

CARISSA edulis

CARRICHTERA
  annua
  vellae

CARTHAMUS
  oxyacantha
  tinctorius

CARYOPHYLLACEAE

CASSIA
  acutifolia
  alexandrina
  italica
  holosericea
  obovata
  occidentalis
  pubescens
  senna

CATHA edulis

CAYLUSEA
  canescens
  hexagyna

CELASTRACEAE

CELOSIA trigyna

CELSIA scrophularifolia

CENCHRUS
  ciliaris
  orientalis
  pennisetiformis
  setigerus

CENTAUREA
  aegyptiaca
  ammocyanus
  eryngioides
  pallescens
  schimperi
  scoparia
  sinaica
  solstitialis

CENTAURIUM pulchellum

CEPHALARIA syriaca

CETERACH officinarum

CHAMAEMELUM auriculatum

CHEILANTHES
  catanensis
  fragrans
  pteridioides

CHENOPODIACEAE

CHENOPODIUM
  album
  ambrosioides
  anthelminticum
  baryosma
  botrys
  murale
  triangulare

CHLORIS
  barbata v. meccana
  meccana
  prieurii
  punctulata
  villosa
  spathacea
  virgata
  virgata v. elegans

CHLOROCYPERUS
aureus
esculentus
laevigatus
longus
rotundus

CHROZOPHORA
brocchiana
hierosolymitana
obliqua
oblongifolia
plicata
verbascifolia

CHRYSANTHEMUM coronarium

CHRYSOPOGON
aucheri v.quinqueplumis

CICHORIUM
endivia
pumilu

CIENFUEGOSIA welshii

CIRSIUM lanceolatum

CISSUS
quadrangularis
rotundifolia

CISTACEAE

CISTANCHE
lutea
phelypaea
tinctoria
tubulosa

CITRULLUS colocynthis

CLADIUM jamaicense

CLEMATIS wightiana

CLEOMACEAE

CLEOME
africana
arabica
arabica
brachycarpa
chrysantha
droserifolia

CLEOME
gynandra
hanburyana
kotschyana
papillosa
paradoxa
pentaphylla
scaposa
trinervia
viscosa

CLITORIA ternatea

COCCINIA grandis

COCCULUS
leaeba
pendulus

COELACHYRUM brevifolium

COLCHICUM
cornigerum
ritchii
szovitsii

COLOCYNTHIS vulgaris

COMBRETACEAE

COMBRETUM molle

COMETES
abyssinica
surattensis

COMMELINA forsskalei

COMMELINACEAE

COMMICARPUS
africanus
ehrenbergii
pentandrus
plumbaginens
stellatus
verticillatus

COMMIPHORA
africana
opobalsamum
quadricincta

COMPOSITAE

DODONAEA viscosa

DRACAENA ombet

DROGUETIA debilis

DUCROSIA ismaelis

**E**

EBENACEAE

ECBALIUM viride

ECBOLIUM
linneanum
viride

ECHINOCHLOA colonum

ECHINOPS
blancheanus
galalenis
glaberrimus
hussoni
spinosissimus
spinosus

ECHINOSCIADIUM arabicum

ECHIUM
horridum
longifolium
rauwolfii

ECLIPTA
alba
erecta

EHRETIACEAE

ELEUSINE
brevifolia
compressa
coracea
flagellifera
glaucophylla
indica
scindica

ELIONURUS
hirsutus
royleanus

EMEX spinosus

ENNEAPOGON
brachystachyus
elegans
schimperianus

EPHEDRA
alata
aphylla
alte
campylopoda

EPHEDRACEAE

EPILOBIUM hirsutum

EQUISETACEAE

EQUISETUM ramosissimum

ERAGROSTIS
aegyptiaca
barrelieri
bipinnata
cilianensis
ciliaris
coelachyrum
cynosuroides
megastachya
minor
multiflora
paposa
pilosa
poaeoides
rubiginosa
tenella
tremula
tenuifolia
turgida

EREMOPOGON foveolatus

EREMOBIUM diffusum

EREMOPYRUM
distans
orientale v. lasianthum

ERIGERON
bonariensis
crispus
linifolius
trilobus

ERODIUM
aegyptiacum
bryoniaefolium
ciconium
cicutarium
glaucophyllum
hirtum
laciniatum
laciniatum
v. pulverulentum
subsp. pulverulentum
malocoides v. ribifolium
moschatum
oxyrrhynchum
subsp.bryoniifolium
pulverulentum
subtrilobum
v. aegyptiacum
triangulare

ERUCA
sativa
vesicaria

ERUCARIA
aleppica
crassifolia
hispanica
myagroides
tenuifolia

ERYTHRAEA ramosissima

EUCALYPTUS
camaldulensis
rostrata

EUCLEA
kellau
schimperi

EUPHORBIA
aegyptiaca
alexandrina
arabica
cornuta
cuncata
cyparissioides
dracunculoides
forsskalii
granulata
helioscopia
isthmia
kahirensis

EUPHORBIA
peplis
provincialis
retusa
scordifolia
terracina
thi
triaculeata

EUPHORBIACEAE

EURYOPS arabicus

EVAX contracta

EVOLVULUS sinaicus

**F**

FAGONIA
arabica
bruguieri
cretica
glutinosa
grandiflora
indica
mollis
olivieri
parviflora

FARSETIA
aegyptia
burtonae
depressa
longisiliqua
longistyla
ramosissima

FELICIA
abyssinica
dentata
richardi

FERULA sinaica

FESTUCA
barbata
dichotoma

FICUS
carica
palmata
pseudosycamorus
salicifolia

GYNANDROPSIS
  gynandra
  pentaphylla

GYPSOPHILA
  arabica
  capillaris
  rokejeka
  viscosa

## H

HAEMATOXYLON campechianum

HALOCNEMUM strobilaceum

HALOGETON alopecuroides

HALOPEPLIS perfoliata

HALOXYLON
  articulatum
  salicornicum
  schweinfurthii

HAMMADA
  elegans
  scoparia

HAPLOPHYLLUM
  longifolium
  obovatum
  tuberculatum

HEDERA helix

HEDYPNOIS cretica ssp.
    rhagadioloides

HEDYSARUM
  alhagi
  ptolemaicum

HELIANTHEMUM
  kahiricum
  intermedium
  ledifolium
  lippii
  niloticum
  salicifolium
  sessiliflorum
  ventosum

HELICHRYSUM
  conglobatum
  somalense

HELIOTROPIUM
  arbainense
  bacciferum
  digynum
  europaeum v. tenuiflorum
  hirsutissimum
  lignosum
  longiflorum
  luteum
  pallens
  persicum
  pterocarpum
  ramosissimum
  strigosum v. bicolor
  supinum
  undulatum
  villosum

HELOSCIADIUM nodiflorum

HERNIARIA
  cinerea
  hemistemen
  hirsuta
    v. cinerea

HIBISCUS
  micranthus
  ovulifolius
  vitifolius

HIPPOCREPIS
  bicontorta
  biflora
  bisiliqua
  ciliata
  constricta
  cornigera
  cyclocarpa
  elegantula
  unisiliquosa
    v. bisiliqua
  multisiliquosa

HOCHSTETTERIA schimperi

HOLCUS spicatus

HOLOSCHOENUS ramosus ssp.australis

HORDEUM
ambiguum
leporinum
murinum v. leporinum
ssp. leporinum

HORMUZAKIA aggregata

HORWOODIA dicksoniae

HYACINTHUS flexuosus

HYMENOCARPOS
circinnatus
nummularius

HYOSCYAMUS
albus
muticus
pusillus

HYPARRHENIA hirta

HYPECOACEAE

HYPECOUM
deuteroparviflorum
parviflorum
pendulum

HYPERICUM
chrysostrictum
hircinum

HYPHAENE thebaica

HYPOESTES
forsskalei
verticillaris

**I**

IFLOGA spicata

IMPERATA cylindrica

INDIGOFERA
arabica
argentea
articulata
desmodioides
glauca
leptocarpa
lotoides

INDIGOFERA
oblongifolia
paucifolia
sessiliflora
spinosa
tenuisiliqua
tinctoria
tribuloides
trigonelloides
tritoides

INULA crithmoides

IPHIONA
mucronata
scabra

IPOMOEA
coscinosperma
eriocarpa
hispida

IRIDACEAE

IRIS sisyrinchium

ISATIS
aleppica
lusitanica

**J**

JASMINUM floribundum

JASONIA candicans

JATROPHA
glauca
lobata
villosus

JAUBERTIA calycoptera

JUNCACEAE

JUNCELLUS laevigatus

JUNCUS
acutus
arabicus
bufonius
littoralis
maritimus
maritimus v. arabicus

OXALIDACEAE

OXALIS corniculata

OXYGLOTTIS tribuloides

OXYSTELMA esculentum

**P**

PALMAE

PANCRATIUM
maximum
sickenbergeri
tortifolium
tortuosum

PANDANACEAE

PANDANUS tectorius

PANICUM
colonum
coloratum
dactylon
eruciforme
geminatum
glaucum
leersioides
leiogonum
petiverti
regulare
repens
sanguinale
teneriffae
turgidum
verticillatum
viride
vulgare

PAPAVER
polytrichum
rhoeas
rhoeas v. pinnatum
somniferum

PAPAVERACEAE

PAPPOPHORUM
brachystachyus
elegans

PARACARYUM
intermedium
v. boissieri

PARIETARIA alsinifolia

PARONYCHIA
arabica
argentea
desertorum
lenticulata
sinaica

PASPALIDIUM geminatum

PASPALUM
digitaria
distichum
fluitans
paspaloides

PASSIFLORACEAE

PAVONIA triloba

PEGANUM harmala

PEGOLETTIA senegalensis

PELARGONIUM zonale

PENNISETUM
alopecuroides
ciliare
dichotomun
divisum
elatum
orientale
purpureum
ruppellii
setaceum
setaceum ssp. arientale
sinaicum
spicatus
typhoideum

PENTATROPIS spiralis

PERGULARIA
daemia
tomentosa

PERIPLOCA aphylla

SAPONARIA vaccari

SARCOSTEMMA viminale

SAVIGNYA
aegyptiaca
parviflora

SCABIOSA
aucheri
olivier
palaestina
v. calocephala

SCHANGINIA
aegyptiaca
baccata
hortensis

SCHIMPERA arabica

SCHISMUS
arabicus
barbatus
calycinus

SCHOENFELDIA
gracilis

SCHOENOPLECTUS litoralis

SCHOUWIA
purpurea
purpurea v. schimperi
schimperi
thebaica v. microcarpa

SCHWEINFURTHIA
pterosperma

SCIRPUS
brachyceras
corymbosus
holoschoenus
holoschoenus v.
australis
inclinatus
litoralis

SCLEROCEPHALUS arabicus

SCLEROPA
memphitica

SCORPIURUS
muricatus
muricatus v. subvillosus

SCORZONERA
intricata
intricata v. petraea
orientalis
papposa
tingitana

SCROPHULARIA
deserti
hypericifolia
libanotica
lucida
xanthoglossa

SCROPHULARIACEAE

SECALE orientale

SEDDERA latifolia

SEETZENIA
lanata
orientalis

SEIDLITZIA
lanigera
rosmarinus

SENEBIERA
nilotica

SENECIO
coronopifolius
desfontainei
flavus
logiflorus

SENNA
acutifolia
alexandrina

SENECIO
coronopifolius
desfontainei
flavus
longiflorus

TRIBULUS
- alatus
- longipetalus
- pterocarpus
- terrestris
- terrestris v. inermis

TRICHODESMA
- africanum
- boissieri
- ehrenbergii
- pauciflorum

TRICHOLAENA
- leucantha
- teneriffae

TRIFOLIUM
- fragiferum
- procumbens

TRIGONELLA
- anguina
- cylindrica
- foenum-graecum
- hamosa
- laciniata
- monantha
- stellata

TRIPLEUROSPERUM auriculatum

TRIPTERIS vaillantii

TRISTACHYA barbata

TRIRAPHIS
- glomerata
- pumilio

TRISETARIA
- aristatum
- koelerioides
- pumila

TRISETUM
- koelerioides
- pumilum

TRISTACHYA barbata

TRIUMFETTA flavescens

TYPHA
- angustata
- australis
- domingenis

TYPHACEAE

**U**

UMBELLIFERAE

UMBILICUS
- pendulinus
- rupestris

UROCHLOA trichopus

UROPETALUM
- erythraeun
- tacazzeanum

UROSPERMUM picroides

UROSTIGMA salicifolium

URTICA
- pilulifera
- urens

URTICACEAE

**V**

VACCARIA
- pyramidata
- segetalis
- vulgaris

VALANTIA hispida

VALERIANACEAE

VALERIANELLA eriocarpa

VARTHEMIA candicans

VELLA annua

VERBASCUM
- nubicum
- schimperianum

VERBENA officinalis

(9) Which nursery can supply these native species?
Nursery name and address:

1. ____________________

2. ____________________

3. ____________________

4. ____________________

(10) Which of the following irrigation systems are used, approved and successful in your projects?

1. drip system
2. leakage system (substituting)
3. rainbird system
4. spray head system.

(11) Which of the following water sources are used in your irrigation systems?

1. potable water
2. mixture of potable water and treated effluent
3. municipality irrigation water
4. underground water (wells)

(12) Which of the following methods are used to solve salinity problems?

1. soil washing system
2. reverse osmosis system
3. chemical

(13) Establishment problems:

Please mention briefly the difficulties faced and common during establishment for new plant material.

# APPENDIX II
# SPECIFICATION

## GENERAL SPECIFICATION FOR APPLYING AND HANDLING NATIVE TARGET SPECIES

### a. OBTAINING NATIVE SPECIES:

The landscape architect should specify the source of his native plant material. Two sources of native plant material are expected to dominate the initial phase of the introduction process, nursury grown native plants, which supplies plants propagated by common means; seeds and cuttings, and direct transplanting. The later is expected to commence as long as the inventory of the plants in the nursury does not cover the whole palette found in the flora. It is always advisable to avoid the use of transplanting from the wild habitats, however if the local authority decided to grant planning permition for urban development in areas contains native vegetation, the landscape architect should target for those areas as a source for transplanted material. Seeds or vegetative material may also be used, but only according to specific description and conditions.

Seeds of approved indigenous species collected in the wild and tested by approved means to determine percentage of germination and to ensure minimum purity of 95%. The contractor should provide the specified seeds in sealed containers acombined with: analysis of seed mixture, percentage of pure seed, dates of collection and percentage of germination from test. The same applies to commercial seeds, but with the additional strict check on the date when the seeds were collected and bagged.

Vegetative material including shoot cuttings, root cuttings, rhizomes, material grown from tissue culture, etc. to be in healthy condition free from diseases and pests and suitable for the species and for the planting techniques as approved by the designated consultant.

Generally, and for the future nursury stock is favourable for the urban application. Nevertheless, the consultant should make sure that the propagation of required material were carried similar to the techniques used for the qualified species of the first test site as discussed earlier. He should also check on the phasing of gradual reduction of controlled microclimatic conditions during the propagation procedure in the nursury. The ordering of those plants should be through a specified bill of quantity stating the special care and source for the plants as described below and in the testing process. The author will not discuss in details the propagation nursury stock since they were disscussed in details in the first test site. Care and handling of nursury and non nursury stock should commence according to the description below.

### b. HANDLING NATIVE PLANT MATERIAL:

One of the feared methods for applying newly introduced native species, is transplanting, which is the fastest answer to the client's demands for quick lavish appearance to the project. Although this method is not recommended, the landscape architect should aim to minimize the negative ecological impact and to try to conserve the lifted plant, if it was found its use is inevitable. It is also recommended to use vulnerable sites to urban growth as the source of transplanting material.

Prior to lifting a plant from natural stands, the landscape architect should inspect the ecological value of the site and the implication of disturbing the community or the individual plant. For transplanting specimen of plant material the individual plants should be inspected, dug, handled, prepared and packed with care and skill as follows:

1. During transportation, all plants should be packed adequately to ensure protection from sun, wind, climatic or seasonal injuries. Tarpaulins or other covers are not necessary if the transported plant is a shrub or a semi shrub species which does not produce a long root system, or otherwise applies.

However, if the transported plant is similar in habit to Acacia Arabica, transplanting should be avoided, the chances of loosing the plant are high unless the tree was prepared, two or three years earlier. It should be transported by trucks or in open freight cars. Root systems of all plants should not be exposed to excessive heat or to freezing temperatures Transporting such plant might result in the loss of some adaptation and habit characteristics. Some native shrubs requires special handling transportation. They should be transported only in climatically controlled containers.

2. Immediately after excavation and prior to loading, in moss or other suitable material, roots should be dipped in a solution of humectant. All earth balls should be firm and unbroken and contained in hessian or palm bark. Balled and burlapped stock should not be dropped at any time.

All balled and hessian covered plants and container grown plants, should be handled by the container and not by the plant stem. The head of each tree should be tied and secured together in order to prevent Damage to the branches. If soil or the habit of root growth is such that the finer roots are not adequately protected, wrap root systems in hessian or other suitable material.

### c. ON-SITE STORAGE OF PLANTS

Some native trees may be planted using bare-root plants. They should be "heeled-in" in damp trenches with bundles opened, plants spaced separately, sprayed with a humectant solution, and all roots covered and kept moist. Earth balled and hessian covered plants should have their earth balls protected by earth straw, peat moss or equal, or other suitable material which should be kept damp or wet to prevent drying out of root systems.

It is strongly recommended to minims the storage time for native species in the target site. In case of long storage is inevitable, all plants should be protected from excessive heat or cold and stored in an approved well ventilated and shaded place, protected from wind and sun. Planting program should be so arranged that no excessive number of unplanted plants will be stored on site for longer than the period of acclimatization. Apply antidessicant before moving plants to final on-site planting location.

### d. Handling of Other Materials

Although native plants does not require imported sand, the target site may need sand cover for certain species. Nevertheless, if sand was needed, it should be thoroughly protected from salts and drying out during storage. Compaction and mounding of stored sands should not exceed depths of 1500 mm. Storage should not exceed 12 months without turning.

Fertilizer, usually not required by correctly propagated native plants. Some landscape architects may seek optimum lavish appearance to them, then fertilizers could then applied. When used they should be delivered to the site in manufacturer's unopened containers, each fully labelled, conforming to the applicable regulations and bearing the name or trademark and warranty of the producer and should be protected from becoming Hxet and should be stored in shade.

Anti-desiccant should be of a kind suited to native species's stomatical mechanism. It should be delivered in manufacturer's identified sealed containers and stored in a climatically controlled shelter.

Composted sewage sludge, peat moss or other approved organic matter were not used in the first test top soil. Their use may be beneficial to enriching the color and general appearance of the plants. They should be delivered to the site in manufacturer's fully identified unopened containers and should be protected from becoming wet during storage and should be stored in shade.

During propagation seed hormone activator was employed should be delivered to the site in manufacturer's fully identified sealed container and stored in a climatically controlled shelter.

Soil stabilant and fibre mulch was not utilized during the test. Their absence showed no harmful consequences.

Collected native seed should be delivered to the site in sealed standard containers, fully labelled in accordance with the appropriate target site and should be inspected by the landscape architect. It is essential that a true name to type certificate is furnished by the supplier.

Prior to planting all protective windbreaks should be erected, where detailed on the drawings. Stored sand should be protected from site operations by temporary 1.5 m post and wire fence or other suitable enclosure.

All plants to be sized as the available nursery stock to avoid the need for transplanting and disturbing the surrounding habitats. The selected plants should be representative of their normal species or variety. All plants should have well branched head and vigorous rot system and should be injury free. Unless otherwise specified or indicated on drawings, only nursery grown plants should be used.

All imported plant material should be hardened off to site conditions for the appropriate length of time, per plant species and season, prior to planting out. Period of time should be a minimum of ten weeks for autumn planting, and six weeks for Spring planting.

All plants should be true to name and one plant of each bundle or lot should be tagged with the name and size of the plants in accordance with the standards of practice of the American Association of Nurserymen. In all cases botanical names should take precedence over common names.

### e. HANDLING EACH CATEGORY OF PLANTS:

#### 1) TREES AND PALMS:

Each tree should possess characteristics for its variety and growth typical to such trees. All trees should be well branched with straight trunks, or trunks characteristic of the species, with a well shaped top, intact leader and undercut at least once in the nursery.

1. Palms should have vigorous root systems, crown of new leaves, proper color of leaves of adult palms and sufficient hardiness. The height of palms should be measured from the nursery grown ground line to base of the first frond. Palm trees to be supplied earth balled and hessian covered, with the exception of imported palms which may be supplied bare rooted.

2. The height of all other trees should be measured from the nursery grown ground line to the top of the tree. Calliper should be measured at 150 mm above ground line if 100 mm calliper or less.

Native evergreen trees should be supplied earth balled and hessian covered or pot grown. Deciduous trees may be supplied bare rooted, earth balled and hessian covered or pot grown. Prior to transplanting from the nursery, the plants root ball should not be altered, trimmed or bound.

#### 2) SHRUBS AND CLIMBERS:

Each shrub and vine should possess characteristics and growth typical of the species. Shrubs should be well grown and filled out. Native deciduous shrubs and should not be supplied bare rooted. Earth balled or pot grown are accepted. Evergreen shrubs and vines should be either earth balled and hessian covered or grown in pots of large size, approximately 3x canopy width.

Small shrubs and Succulents plants which are furnished in pots or other containers and which have been acclimatized to outside conditions should be acceptable provided they are equal in quality to field grown stock and are not rootbound. For direct seeding of this type of native plants obtain seed from suitable source and pre treat to speed germination as appropriate for each particular species. Coat with suitable chemical to protect against birds and rodents.

3) GRASS:

Native grass should be treated as a small shrub. It should be planted from nursery grown seedlings. The majority of native species of grass should be planted at spacing of 15 Cm apart.

**f. PLANTING REQUIREMENT:**

**1) PANTING SOIL MIX**

Planting soil mix for al planting operations should contain the following ingredients as a percentage of volume, thoroughly admixed with fertilizers:

40% local sand [145]
40% Wadi soil. (Dry wadi soil only) [146]
10% Tree bark.
10% Organic matter
2L\m3 super absorbent Humectant [147]

Sand should be from an approved source and should be free of weeds, stones or other foreign matter taken from approved locations having removed surface crusts and gypsiferous accumulations.

Sands should have the following characteristics:

1. pH 6.0 - 7.5 Saturated soil
2. Electrical Conductivity
(EC at 25oC) Less than 2500 micro mhos saturated extract
3. Free carboantes Less than 0.5% air dried soil
4. Chlorides Less than 200 ppm in saturation extract.
5. Sulphates Less than 15% inneutral saturation extract
6. Exchangeable Less than 15% in neutral normal ammonium acetate
7. Nitrates Less than 75 ppm in saturation extract
8. Phosphorous 10-25 ppm in 1.5 ammonium nitrate sodium extractant: 1\2 hour shake
9. Potassium 100-400 ppm in 1.5 ammonium nitrate extractant: 1\2 hour shake
10. Magnesium 25-100 ppm in 1.5 ammonium nitrate extractant: 1\2 hour shake
11. Boron Less 1.0 ppm, hot water soluble
12. Sodium Adsorption Ratio (SAR) Less than 5
13. Physical characteristics:
Loamy sand made up by particle size as follows:
sand 2mm - 0.5mm 70-85% maximum silt 0.05mm - 0.02mm 25%-30% max.

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[145] Only applicable if on site sand is unsuitable.

[146] Should be obtained from dry Wadis vulnrable to urban expansion and deposited by thick layer of fine sand. If such areas are not available, red sand ffrom the empty quarter should be used instead.

[147] Optional. Only applicable for high budget projects.

clay less than 0.002mm 5% max.

A green manure crop is not recommended to be grown on stored sand as a stabilizer. [148]

## 2) WADI SOIL:

The wadi soil should be obtained from dry wadi zones that are vulnrable to urban expansion, conditioned that minimal distractive effect on ecological habitats. It should have some relative composition and structure, a fibres sandy loamy character, and be free of roots, clods and stones larger than 25mm in greatest dimension, pockets of coarse sand, noxious weeds sticks, brush and other litter. It should be free from pests and plant diseases. It should generally comply with the same description mentioned in the first test site descriptions. However, if distructive effect was feared, a red sand could be used instead.

Submittal of analysis of planting soil mix should be made prior to placing on the target site, at the following frequency and should Include:

1. Soil type, structure and texture.
2. pH
3. Electrical conductivity (EC) in micro mhos\cm at 25oC.
4. Total carbonate on content (CaCo3).
5. Percentage Nitrogen (N).
6. Total and available phosphorous (P).
7. Soluble and exchangeable Potassium (K).
8. Calcium (Ca), Magnesium (Mg), Sodium (Na), Iron (Fe), Boron (B), Chloride (Cl), Carbonate (Co3), Bicarbonate (HCo3), Nitrate (No3) and Sulphate (So4) content.
9. Total dissolved solids in PPm.
10. Organic Matter Percentage.
11. Sodium Adsorption Ration (SAR).

Organic resin foam should be resistant to breakdown in the climatic conditions, with an estimated life of 10-15 years, and should be flaked 20-40 mm size with moisture uptake of 50-70% volume, injected with all suitable chemicals for plant growth, and have ability of taking on the color of the sand it is mixed with. (Saudi organization for specification).

Manure is an acceptable organic matter but is not available in quantities anticipated to be required for large projects. The following are other acceptable organic materials that was tested in parts of the D.Q (not tested in the actual test sites) and showed positive response with native plants:

1. Composted Sewage Sludge

Wet sludge should be allowed to dry in lagoons or drying beds exposed to air, to produce a raw sludge with a moisture content of 30-50 per cent. Digested sludge should be produced from raw sludge by a process which reduces its bulk. Digested sludge should have the following minimum content. 52% dry matter, 23% organic matter, 1.4% total N, 1.1% P2O5, 0.2% K2O. (Samples should be provided).

The digested sludge should be composted with chips, other hygienically accepted bulking materials, or a combination thereof.

The compost should be produced by an aerated pile method or equal which produces internal temperatures exceeding 60oC and destroys most pathogens.

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[148] Not recommended by many landscape architects.

The finished compost should be hygienic and free of malodors. The composted sludge should be analyzed for viruses, content of heavy metals such as chromium, nickel, zinc and copper.

2. Peat Moss
Peat Moss should be of a quality acceptable for use as a soil amendment and should have a Ph range from 3.7 to 5.5.

3. Shredded Bark
Shredded bark should be proprietary bark in manufacturers sealed containers and should be nitrogen stabilized.

## 3) FERTILIZER

Fertilizers were not used in the three test sites. However their use should be restricted only in accelerating the growth of certain native deciduous species. Compound Fertilizers should be applied to extreme poor soil. When used with native species, it should be applied at the rate of 8 bags per hectare instead of 12-13 for imported species giving that:

| | | |
|---|---|---|
| N | 100 | Kg\ha |
| P2O5 | 150 | Kg\ha |
| K2O | 100 | Kg\ha |

Superphosphate Fertilizer, single superphosphate with a minimum content of 18% P2O5 applied at the rate of 2.4 kg\m3.

C. Slow Release Compound Fertilizer

| | |
|---|---|
| N | 6.5% |
| P2O5 (Soluble) | 11.5% |
| P2O5 (Insoluble) | 33.2% |
| K2O | 7.0% |
| Mg | 11.8% |

applied ar the rate of 300 gms per tree, 100 gms per shrub.

D. Controlled Release Fertilizer
Controlled release fertilizer with an N-P-K ratio of 16-9-9 + iron, composed of tablets coated with plastic resin to provide a continuous release of fertilizer for minimum of 18 months.

Fertilizer planting tablets should be tightly compressed fertilizer chips forming planting tablet and should contain the following minimum percentages of plant food by weight:

| | | |
|---|---|---|
| Available nitrogen | 20% | 15% min. |
| Available phosphoric acid | 10% | 8% min. |
| Available potash | z5% | 3% min. |

Planing tablets for trees and shrubs should weigh approximately 21 grams each.

Nitrogen Fertilizer

Urea Pills containing 32% to 46% Nitrogen applied at the rate of 300 kg\ha. Anti-Desiccant: when used should be emulsion type film forming agent designed to permit plant transpiration but retard excess loss of moisture. Apply in accordance with manufacturers instructions. Hessian Bands should be 75m and to lengths necessary for wrapping of tree trunks and main branches.

Permeable Membrane only applicable near buildings and should be non-woven 70% polypropylene, weight 70gm\sq.m, thickness 0.3mm with permeability to water of 80 liters\sq.m\sec at 100mm water head. Membrane should be resistant to all naturally occurring soil acidities and be suitably resistant to tearing and stress (tensile strength under uniform applied stress 5000 N\m). Membrane should remain unaffected by all direct sunlight for periods up to one month.

Super Absorbent Humectant Super absorbent humectant should be a Starch-Based absorbent that swells into a clear gel capable of absorbing hundreds of times its weight in water.

Seed hormone activator should be a "Catalytic pre-merge concentrate" and an organic chemical containing indole acidic gilibritic auxins and growth regulators for promoting cell proliferation.

## 4) EXECUTION INSPECTION:

Prior to all landscaping work, carefully inspect the installed work and verify that all such work is complete to the point where landscaping may properly commence. Landscape work may be installed in accordance with Design requirements. The landscape architect should set out all proposed planting areas using manual seeding, vegetative cutting or nursury stock prior to planting execution. The following surface preparation is necessary; firstly for exposed bedrock and boulder areas which are common in Najd, the debris must be removed and hand scarify any exposed existing crusted soils between rocks and in crevasses in the rock. Sand or top soil should be scattered to fill those crevasses and depressions. Secondly if the area has an existing shallow soil 10-15 cm, a 500 g/m$^2$ inorganic colloids and 500 g/m$^2$ organic material to be integrated with this soil. Finish grade to produce smooth surface. Soil compaction should be carried out between 80 and 85% density.

## 5) PLANTING SEASON

All plants should be planted during the correct season as shown in the flora. Main planting should be carried out during lower light period from mid-October until the end of March. Timing should be correct for particular native species within this period. Planting should not be done in excessively windy conditions. Large palms should be planted during period of optimum root growth from mid April to the end of September.

## 6) PREPARATION OF PLANTED AREAS

1. Excavations should all be to depths and widths specific for each tree and shrub as listed in the table below. Backfilling should be executed with extreme care using material acceptable to native species. Sand and fine gravel is appropriate.

| Native plant category | Example species | Excavation depth | Excavation width |
|---|---|---|---|
| Trees. | Acacia arabica. | .90 meter. | 3 meter. |
| Large shrubs. | Ziziphus numilaria. | .9 meter. | 2.5 meter. |
| Shrubs. | Ficus salisifolia. | .5 meter. | 1.20 meter. |
| Small shrubs. | Ochradenus baccatus | .5 meter. | .7 meter. |
| Climbers. | Clitoria ternata. | .4 meter | 1.1 meter. |

**Table 18: The amount of excavation per species.**

2. Leaching of all excavations should be thoroughly accomplished with potable water prior to backfilling and should be performed for two days at rates per day of:
80mm per tree
16mm\sq. m. of shrubs and vines
8mm\sq.m. of small shrub planting
40mm\sq.m. of grass.

This will be followed by sand and planting soil mix, or by planting soil mix only as shown in the first test site.

Areas to be planted with grass and\or small shrubs should be brought to even running grades after which they should be cultivated to a depth of 200mm. All weeds, rocks and other debris should be removed and disposed of.

Plants should be set plumb and at such a level or elevation that after the settlement they will bear same relation to level of surrounding ground as they bore to ground from which they were dug. All plants should be planted on and in soil mix. The soil mix will be properly compacted before the placement of trees with a heavy root ball. Disturbance to the root system or ball of earth should be prevented in removing plants from containers. Can cutters should be used on metal containers.

During and after planting, the plants should be thoroughly watered in to eliminate air voids around the roots and watered regularly established. Apply 300gm per tree of slow release compound fertilizer as specified herein. Palm tree should be root pruned one year prior to removal from the original growing site as follows:

1. The pruning trench should be backfilled with wetter peat or equal and the tree sprayed with anti-desiccant.

2. Prior to transporting for transplanting, palm fronds are to be sprayed with anti-desiccant during transplanting and be tied up with hessian to enclose the growing tip and upper trunk. The roots should be balled and the hessian tied with wire.

3. Palms should be planted in prepared pits, size as specified, orientated in the same direction that it was in prior to transplanting, backfilled and firmed in.

4. Fertilizer should be applied as for trees.

5. Trunk burlap, frond wrapping and dead fronds to be removed after new growth indicates adequate recovery or after second growing season.

Shrubs should be positioned in their location and spaced according to their root requirements mentioned in the flora.

Climbers should be planted in a similar manner to shrubs all as described above.

Groundcover plants and rooted cuttings should be planted with a hand trowel taking care to firm soil around roots.

**7) SEEDINGS**

Techniques for collecting, rooting and pre-transplanting growing of all material to be as set forth in the method statement approved by the designated consultant including but not limited to, shoot treatment, environmental conditions of growing area, pot sizes and soils, and techniques for hardening plants to temperature and water regimes to be practised in site. Plants from vegetative materials are to be grown under conditions free of moisture stress until good rooting is achieved.

Sowing operation should be carried during calm weather using manual techniques suitable for each involved species. Legume seeds should be kept in separate containers and added to seed mixture at time of seeding. Inoculate legume seed with approved appropriate humus culture before mixing with other seeds. Protect inoculate seed from exposure to sunlight for periods of over one-half hour. Seeds should be used within eight hours from inoculation or re-inoculate. [149]

---

[149] A.D.A, Maintenance department.

The area should be watered with fine spray, avoiding washing out of seeds. Protection against damage and birds should also be provided.

## g. MAINTENANCE OPERATIONS

### 1) TREE MAINTENANCE

#### 1.1 Irrigation

Irrigation is necessary for the target species that were tested in the first test site and should be according to the stated rate and time as mentioned in the flora, preferably at night or early or late in the day. Avoid inadequate and excessive applications of irrigation water and limit to quantities required for plant development. Leach as necessary at approved timing and rate subject to site and species. Maintain irrigation equipment to required standard. Maintain irrigation basins by removing all debris, weeds, and blown material.

#### 1.2 Fertilizer Application

Apply fertilizer as necessary to particular site. Normally give annual application of Phosphate fertilizer and if necessary combined slow release fertilizer each at specified rate. Apply dry and water well. To be applied in February or March each year.

#### 1.3 Pruning

One should be very careful with pruning woody perennial native plants. Most of the plants developed their original structure to adapt it self to the surrounding hostile conditions. In the urban amenity planting pruning may be allowed. Cutting back of certain types of trees may be permitted to encourage formation of crown. Limit amount of pruning to minimum necessary to encourage proper growth, to remove dead or injured twigs and branches, and to compensate for result;t of transplanting operations. Prune in such a manner as not to change natural habit or shape of tree. Make cuts flush leaving no stubs.

### 2) SHRUB, VINE AND SMALL SHRUB MAINTENANCE

Irrigation is similar to trees. Water budget should be combined for both. Fertilizer Application as necessary to poor sites and species. The following operations to be applied:

a. Three weeks after planting give all shrubs and small shrub beds a granular slow release nitrogen fertilizer at rate specified in 2.03. Repeat every three months after planting.

b. Give annual application of approved phosphate fertilizer and if necessary, combined fertilizer each at specified rate. Apply dry and water in well. To be applied in February or March each year.

#### 2.1 Weeding and Hoeing

All climber pockets and shrubs borders should be hoed forked or hand weeded where appropriate and all areas kept clear of weeds. Remove all debris or other refuse. Trodden ground to be hoed, forked or raked over as necessary.

#### 2.2 Removal of Water Shoots and Dead Twigs

Remove any dead twigs or water shoots occurring on clean stem of shrubs.

#### 2.3 Pruning

Cut back certain shrubs in early spring to encourage business. With the exception of hedges and small shrub plants, shrubs should be pruned to maintain natural shape. Shrub species with a significant display of flowers should not be pruned after the formation of lower buds until completion of the flowering season.

## h. PEST AND DISEASE CONTROL

1. Specific checks for pests and disease to be carried out every month by a trained member of staff.

2. All equipment should be surface sterilized (with methylated spirit) after use on the plants which are known, or suspected to be diseased. All diseased wood, fungi, pruning etc., to be burned after removal from diseased plants.

## APPENDIX III
## MAPS AND MATERIAL NOT AVAILABLE TO THE READER

For Mr. Mohammed:
Please take it and contact me further questions, your telephone number

**SEED EVER MENTIONED TO BE USED IN EXTENSIVE**

| No. | Name | XX | X |
|---|---|---|---|
| 1. | HORWOODIA DIDESONIAE | 71 | 77 |
| | | | 56 |
| 2. | ARGEMONE MEXICANA | 34 | 41 |
| 3. | RHAZYA STRICTA | 395 | 402 |
| 4. | CALOTROPIS PROCERA | 405 | 412 |
| | | | 413 |
| 5. | SARIGUNIA PARVIFLORA | 70 | 74 |
| 6. | ABUTILON PANNOSUM | 123 | 131 |
| 7. | DIPLOTAXIS HARRA | 85 | 90 |
| 8. | RUMEX VESICARIUS | 196 | 205 |
| 9. | LAVENDULA CANESCENS | 464 | 47 |
| | | 463 | |
| 10. | DATURA INNOXIA | 490 | 494 |
| 11. | BASSIA ERIOPHORA | | 256 |
| | | | 255 |
| 12. | PERGULARIA TOMENTOSA | 425 | 411 |
| 13. | ECHINOPS SPINOSSISINIUM | 595 | 570 |
| | | | 571 |
| 14. | TEUCRIUM OLIVERIANIUM | SEE PILIUM | |
| 15. | PARONYCHIA ARABICA | 222 | 230 |
| | | | 229 |
| 16. | FARSETIA BURTONE | 72 | 74 |
| | | | 75 |
| 17. | ZILLA SPINOSA | 62 | 66 |
| | | | 67 |
| 18. | ASTRAGALUS SPINOSUM | 341 | 367 |
| 19. | ACHILLEA GARANI | 567 | 583 |
| | | | 585 |
| 20. | RHANTERIUM PAPOSUM | 568 | 589 |
| 21. | CASSIA ITALICA | 313 | 318 |
| | | | 319 |
| 22. | CAPPARIS DECIDUA | 45 | 54 |
| 23. | CAPPARIS SPINOSA CARISTI | 45 | 51 |
| 24. | ZIZIPHUS SPINA ~~DUTISTA~~ NUMNIANA | 183 | 190 |
| 25. | ACACIA ARABICA | | |
| 26. | DELONIX ELATA | 300 | 311 |
| 27. | LAGONYCHIUM FARATUM | 298 | 301 |
| 28. | LAVENDULA DENTATA | 467 | 477 |
| | | 463 | 479 |
| 29. | PERIPLOCA APHYLLA | 404 | 407 |
| 30. | OCHRADENUS BACCHATUS | 92 | 96 |
| 31. | LYCIUM SHAWII | 491 | 495 |
| 32. | IRIS SIAYDISINUM | | |
| 33. | STIPAGROSTIS | | |
| 34. | PANNICUM TURGIDUM | | |
| 35. | ARTEMISIA HERBA ALBA | | |
| 36. | ECHINOSCANDIUM ARABIAN | 381 | |
| 37. | TAMARIX APHYLLA | 102 | 106 |
| 38. | MATHIDA ARABICA | 84 | |
| 39. | PEGANUM HARMALA | 139 | 142 |
| | | | 142 |

LEGEND :

X Page printed in Flora of Saudi Arabia Migahid and Hammonde's

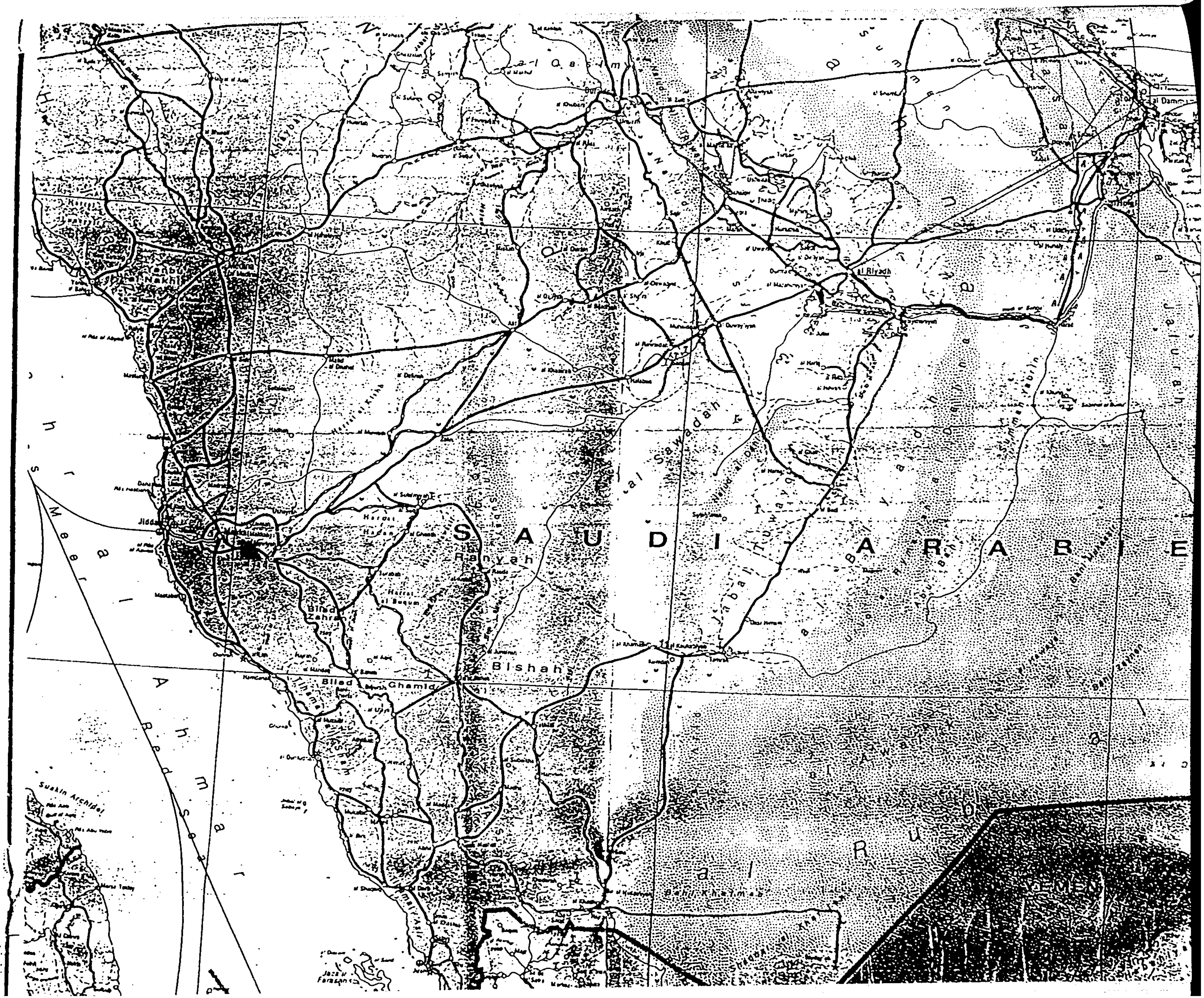
XX Page described.

| | | |
|---|---|---|
| 40. PICRIS ABESSYNICA | 542 | 547 |
| 41. PULICARIA ARABICA | 594 | 608 |
| | | 604 |
| 42. SILENE ARABICA | | |
| 43. TRIGONELLA STELLATA | 316 | 333 |
| | | 335 |
| 44. ACHILLEA FRAGANTISSIMA | 567 | 583 |
| | | 585 |
| 45. DUCRUSIA ISMAELIS | | |
| 46. FRANCOERIA CRISPA | 595 | 607 |
| 47. TEUCRIUM POLIUM | 462 | 473 |
| | 463 | 479 |
| 48. HAMADA ELEGANCE | | |
| 49. RICINUS COMMUNIS | 165 | 176 |
| | | 175 |
| 50. PITURANTHOS TRIRANDIATUS | 376 | 379 |
| 51. MALVA PARVIFLORA | 19 | 25 |
| 52. MALVA AEGYPTICOM | | 126 |
| 53. HIBISCUS MICRANTHUS | 124 | 132 |
| 54. OXALIS CORNICULATA | | 135 |
| 55. ERODIUM | 133 | 137 |
| 56. FAGONIA CRETICA | 148 | 145 |
| | 140 | |
| 57. TRIBULUS LONGIPETALUS | 140 | 150 |
| | | 149 |
| 58. GYPSOPHILA ARABICA CAPILARIS | 225 | 239 |
| 59. GUMOCARPUS DECANDIUM | 223 | |
| 60. PARONLCUDIA ARGENTA | 222 | 223 |
| 61. SPERGULA DECANDRUM | 223 | 234 |
| 62. SILENE LINEARIS/ARABICA | 226 | 240 |
| | | 241 |
| 63. ATRIPLEX HALIMUS | 247 | |
| 64. TRAGANUM NUDATUM | 289 | 267 |
| 65. HAMMADA ELEGANCE | 273 | 275 |
| 66. AERRA JAVANICA | 279 | 284 |
| 67. ACACCIAS | 298 | 339 |
| | 299 | 302 |
| 68. MELILOTHUS INDICA | 315 | 330 |
| | | 329 |
| 69. TRIFOLIUM | 316 | |
| 70. TRIGONELLA | 316 | 383 |
| | | 335 |
| 71. INDIGOFERA SPINOSA | 336 | 345 |
| | | 346 |
| 72. TEPHROSIA | 941 | 371 |
| | | 372 |
| 73. DUCROSIA ISMAELIS | 302 | 385 |
| | | 386 |
| 74. SALIX | 387 | 391 |

RHAZYA STRICTA

Date of Collection :

May '83



10

# RIYADH DIPLOMATIC QUARTER
## SITE MANAGEMENT

8509300004

INTER-OFFICE MEMORANDUM

| | | | | | |
|---|---|---|---|---|---|
| To | : | DIP ( A. W. AL-KHUDAIRY ) | No. | : | SM/CLA/DIP/IOM-086 |
| In | : | R. D. A. | From | : | CLA ( H. Kampfer ) |
| Copies to | : | | Date | : | 26.09.1985 |
| | | | Project | : | LANDSCAPING |

| Reference No. : | Authority | Contractor | SM | Other |
|---|---|---|---|---|
| | | | | |

Subject : HYDROSEEDING WITHIN THE D.Q. PROJECT.

As per "Extensive Landscaping" contract, Hydroseeding has been foreseen in the Earthberm as well as in the "Extensive" areas.

After a test, done by Eastern Corporation, has been completely failed, the SM decided for the alternative "Manual Seeding". Also the SM was convinced that the Manual Seeding will be much more effective than the Hydroseeding, because of aimed seeding.

Now, after a very successful grow-on in both areas, Extensive and Earthberm, the SM proposes, only to use in even areas the Manual Seeding, because by Hydroseeding there will be a great waste of seeds.

8

# INTERNAL MEMORANDUM

SM/SLA/I/EL/252
05.06.1983
24.08.1403

To : D I P

From : S L A

R I Y A D H D I P L O M A T I C Q U A R T E R

EXTENSIVE LANDSCAPING AND EARTHBERM
-- Change Order No.EC/003 - Supply of Native Seeds --
(Ref. 830525055 - EASTERN CORPORATION's Submittal
Note No. 8015-4533 dated 25th May, 1983) .

---

Please find attached the Corrected List of Seeds to be supplied by Eastern Corporation under Change Order EC/003 - Supply of Native Seeds.

B Schidt

B. Schmidt
S L A

Encls: As stated.

7

بسم الله الرحمن الرحيم

المملكة العربية السعودية
الهيئة العليا لتطوير مدينة الرياض
اللجنة التنفيذية العليا
مركز المشاريع الهامة والتخطيط

Date: 13/07/1404
14/04/1984

TO: Abdul Wahab Al-Khudiary

FROM: Engineer Bill Cook

COPY TO: Nursery File

SUBJECT: Collection of Native Seeds

On the 12th and 13th of April, I went out to the desert to collect seeds of the native grasses of the Kingdom. The majority of the grasses, particularly the Pennisetums and Paspalums hadn't set seed yet. This will be collected at a later date.

Regards,

Bill Cook

Bill Cook
D. Q. Nursery Engineer

6

C L A

Mr. Klein

# INTERNAL MEMORANDUM

840422085

TO : Chief Construction Engineer - DQ

CODE: DIP/CEC/1079

FROM : A. Al-Khudairy

DATE: 21.04.1984

COPY TO: Mr. Bill Cook DQ-Nursery

RECEIVED 24 APR 1984

SUBJECT: Collection of Native Seeds

Reference to the attached letter ref. 840417046, you are hereby be informed that Authority will take care of collecting the native seeds and not by the Eastern Corp.

A. Al-Khudairy

[illegible]

9

| | | |
|---|---|---|
| 1. | Horwooda Dicksoniae | 30.00 kg. |
| 2. | Argemone Mexicana | 10.00 kg |
| 3. | Rhàzya Stricta | 30.00 kg. |
| 4. | Calotropis procera | 0.20 kg. |
| 5. | Pennisetum, Panicum, Stipa agrostis | 0.50 kg |
| 6. | Savignya Parviflora | 5.00 kg |
| 7. | Abutilon Pannosum | [illegible] kg |
| 8. | Diplotaxis Harra | 8.50 kg. |
| 9. | Rumex Vesicarius | 0.50 kg. |
| 10. | Lavandula Canescens | [illegible] kg. |
| 11. | Datura Innoxia | [illegible] kg. |
| 12. | Bassia Eriophora | [illegible] kg. |
| 13. | Pergolaria Tomentosa | [illegible] kg. |
| 14. | Echinops Spinosissimus | [illegible] kg. |
| 15. | Teucrium Oliverianum | [illegible] kg. |
| 16. | Paronychia Arabica | 1.20 kg. |
| 17. | Psiadia Arabica | 3.50 kg. |
| 18. | Farsetia Burtonae | 4.60 kg. |

4

Eastern Corporation
Trading, Contracting, Industry
C. R. 3535
Riyadh Saudi Arabia

المؤسسة الشرقية
للتجارة والصناعة والمقاولات
الرياض المملكة العربية السعودية

No. 0015 - 8956
Dated, 5th June 1984

High Commission for the
Development of Riyadh
High Executive Committee
Riyadh Development Authority
Kingdom of Saudi Arabia

84 06 06 0 4 0

Dear Sirs,

Re: Extensive Landscape and Earthberm Project
Here: Collected Seeds

Reference is made to item 45/62.29, Collected Seed, of the [illegible] we wish to inform you, that we have already collected about [illegible] of native seeds. Please find attached a list of species and quantities already collected, as well as the location and the time of collection of seeds.

Samples of the seeds and the packed seeds are being submitted for approval to the nursery.

We are looking forward for your instruction regarding submittal date and time.

Furthermore we wish to ask you for clarification about remaining quantities to be collected.

Best regards.

Yours faithfully,
For Eastern Corporation

[illegible] Project Manager

Encl.: Transmittal Note
List of Collected Seeds
Description of Seeds, Areas and
Date of collection


RIYADH Dhabbab Street P.O. Box 292. Tel [illegible] Cable [illegible] Telex [illegible]
DAMMAM : King Khaled St., P.O. Box 375. Telephone 8326441. Cable HAMZA. Telex 401080 [illegible]
JEDDAH : Medina Road, P.O. Box 1800. Tel: 604310 / 654264.

RIYADH DIPLOMATIC

SITE MANAGEMENT

3

TRANSMITTAL

To : DIP (A.W. AL-KHUDAIRY)

No : CLA/DIP/EC/T-603

Resp. : Eastern Corporation

From : CLA (B. Schmidt)

Copies to :

Date : 23-6-84

Extensive Landscape and Earthberm

| Reference | Authority | Contractor | SM | Other |
|---|---|---|---|---|
| No. : | 840606046 | 8015-8956 | | |

Subject : COLLEDTED SEEDS

With refer to Internal Office Memorandum No. SM/SLA/I/EL/087 dated 7.2.83, the submitted list of collected seeds does not meet the requirements.

The SM herewith approves species and quantities, to be supplied to the DQ Nursery within 2 weeks time according to attached SM list, however, the acceptance of the seeds is subject to the approval of samples to be submitted to the nursery.

The remaining quantities will be collected by the DQ Nursery.

CEC

CLA

Encls.

## IRRIGATION WATER ANALYSIS

DATE of Sampling ; 5/APR'/86
DATE of Testing ; 6/APR'/86 ~ 8/APR'/86
Sample ref' ; Pedesrian Network "B"
Tested at ; S.T.P Laboratory

---

1) pH Value ; 7.4
2) Total Alcalinity ; 90 (mg/l)
3) Total Suspended Solids ; 0.018 "
4) B. O. D ; 1.5 "
5) C. O. D ; 10 "
6) Turbidity ; < 1 "
7) Residual chlorine ; 0.15 "

شركة بورتالز لمشاريع المياه العربية السعودية المحدودة

# Portals Water Projects (Saudi Arabia) Limited

PO Box 5364
Riyadh, Saudi Arabia
Telephone 4655830/4641002
Telex 204249 PORTAL SJ

CLIENT: Kuk Dong D.Q.

Lab.Ref: MA/86/4-013

Date rec'vd: 8/4/86

Date rept'd: 10/4/86

Sample ref: Pedstrian Networks "B"

محمد فتحي سلامه

M. Salama

| | | | |
|---|---|---|---|
| Electrical Conductivity | (m.mhos/cm) | - | 665 |
| Total Dissolved Solids | (mg/l) | - | 480 |
| Aluminium | " | - | 0.88 |
| Arsenic | " | - | 0.006 |
| Beryllium | " | - | 0.093 |
| Boron | " | - | 0.50 |
| Cadmium | " | - | 0.01 |
| Chlorides | " | - | 90 |
| Chromium | " | - | 0.016 |
| Cobalt | " | - | <0.02 |
| Copper | " | - | 0.045 |
| Cyanide | " | - | 0.01 |
| Fluoride | " | - | 1.68 |
| Iron | " | - | 0.13 |
| Lead | " | - | <0.02 |
| Lithium | " | - | 0.022 |
| Manganese | " | - | 0.085 |
| Mercury | " | - | <0.01 |
| Molybdenum | " | - | <0.01 |
| Nickel | " | - | 0.13 |
| Nitrate - N | " | - | 2.6 |
| Selenium | " | - | <0.02 |
| Vanadium | " | - | 0.03 |
| Zinc | " | - | 3.6 |

16.5
63.96

RIYADH

Portals Water Treatment

# NATIVE SEEDS FOR NURSERY

| | KGS. |
|---|---|
| ZILLA SPINOSA | 2 |
| ASTRAGALUS SPINOSUS | 2 |
| ANVILLEA GARCINII | 2 |
| RHANTERIUM EPAPOSSUM | 2 |
| CASSIA ITALICA | 4 |
| CAPPARIS DECIDUA | 4 |
| CAPPARIS SPINOSA | 5 |
| ZIZIPHUS NUMULARIA | 5 |
| ACACIA ARABICA | 5 |
| DELONIX ELATA | 5 |
| LAGONYCHUM FARCTUM | 4 |
| LAVANDULA DENTATA | 4 |
| PERIPLOCA APHYLLA | 2 |
| OCHRADENUS BACCATUS | 2 |
| CALOTROPIS PROCERA | 4 |
| LYCIUM SHAWII | 5 |
| IRIS SISYCHRINCHIUM | 2 |
| PENNISETUM SPP. | 1 |
| STIPAGROSTIS PLUMOSA | 1 |
| PANICUM TURGIDUM | 1 |
| TEUCRIUM OLIVERIANUM | 2 |
| RHAZYA STRICTA | 4 |
| | 60 Kgs. |

TABLE I

AREAS TO APPLY SEEDING

| ALONGSIDE ROAD | BERMS (SAND) | PLANTERS | RUN OFF CHANNEL and Depression | ROCK WORK |
|---|---|---|---|---|
| Rumex vescarius | Savignia parrif. | Abutilon pannos | Rumex vescarius | Capparis car. |
| Bassia eriophora | Harvodia dick. | Argamone mexicana | Psidia arabica | Paronychia |
| Farsetia burtone | Diplotaxis hara | Cucumis proph. | Bergularia tomentosa | Gramineae |
| Launea | Gramimeae | Diplotaxis hara | Pennisetum | Farsetia bur. |
| Pennisetum | Pazzia stricta | Farsetia burtane | Launea | Bassia erioph. |
| Paronichia a. | | Launea | Rohinops | |
| Cassia italica | | Peganum halmara | Teuerium | |
| Diplotaxis hara | | | | |