The die-back phenomenon of *Juniperus procera* at the Al-Soudah family park

Results of the field trip to Al-Soudah family park between 23.2.2000 and 28.2.2000

by

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Introduction

The south western Asir mountains with it's high plateau and steep slopes provide an environment suitable to carry a rich and varied vegetation. Altitudes between 2000 and 3000 m are often characterised by *Juniperus procera* communities. The significance of theses woodland ecosystems as a source of biodiversity, erosion protection and water storage is well known.
Because of the climatic advantages during the summer time and the natural beauty of the region, it is highly frequented by tourists coming from all over the Arabian Peninsula. The Al-Soudah family park is located on the high plateau at an elevation of almost 3000 m. It provides a large number of camp sites and fire places between impressive *Juniperus procera* trees.
For some years the trees show obvious signs of degradation. Until now several individuals died completely. The main objective of this study was to locate the reasons for the die-back of the trees and to propose suitable measures to improve the actual situation.

Present situation

On several areas within the family park (basically the central areas near the park roads) more than 50% of the trees are already dead or extremely damaged (photo 1). Most of the dead branches were cut. The relatively flat area shows dramatic signs of soil erosion (photo 1).
Large areas are completely stripped and outcrops of the underlying sandstone with iron hard crusts dominate the surface (photo 2).
More vital trees usually show an agglomeration of several grasses around them. The dense vegetation around the trees obviously prevents the remaining soil from erosion. The impression is made that the trees are growing on little hummocks.
On many sites the trees display several signs of wood and bark cutting (photo 3, 4). Off road driving was observed as well (photo 5).

Photo 1 Dead *Juniperus procera* and soil erosion on severely degraded sites.

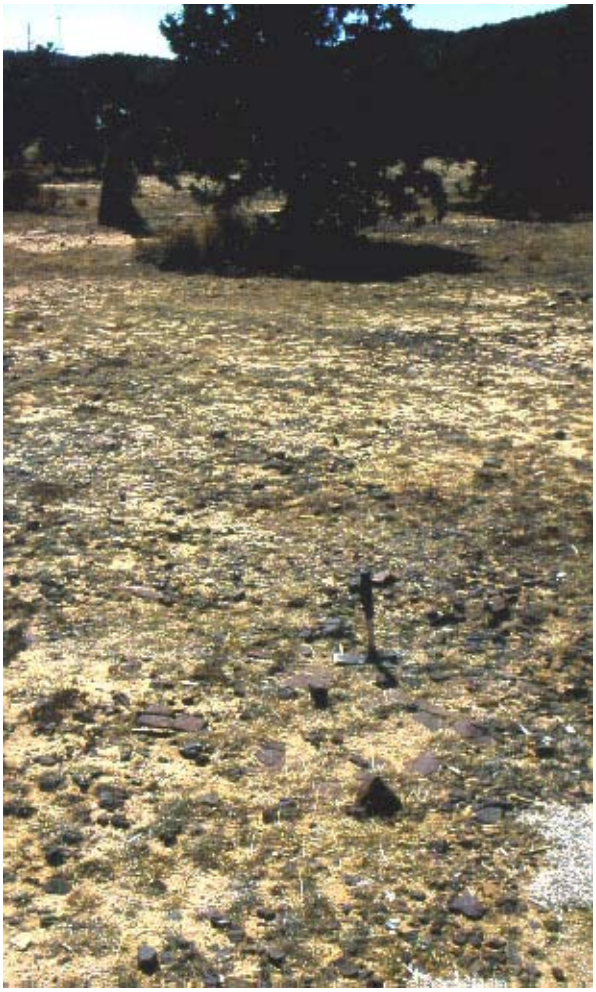

Photo 2 Iron crusts penetrate the surface due to erosion of the top soil layer.

Photo 3 Fresh wood cuts.

Photo 4 Fresh damage on the bark.

Photo 5 Cars driving off road.

Soil

Our examination was first focused on remote places within the park where most of the trees look healthy. We expected to find soils representing the original and undisturbed condition typical for this sort of environment. All stands around the trees were vegetated by different grasses forming a complete cover of the soil.
The profiles dug around several trees of *Juniperus procera* were quite similar. 60-80 cm away from the main stem the uppermost layer is 2-4 cm organic litter material (L). Below the litter is a 5-9 cm layer of partly disintegrated organic material which is characterised by a high content of white coloured mycorrhiza (O_f). The next horizon is characterised by 5-10 cm of dark coloured brown organic rich material (A_h). Then there is a clear transition to 10 -20 cm thick layer of lighter brown sand and silt material (B_v). Below the B_v horizon the underlying rock is located. It consists of dark brown to reddish iron rich sandstone (C_s) (fig. 1, 2 and photo 6).

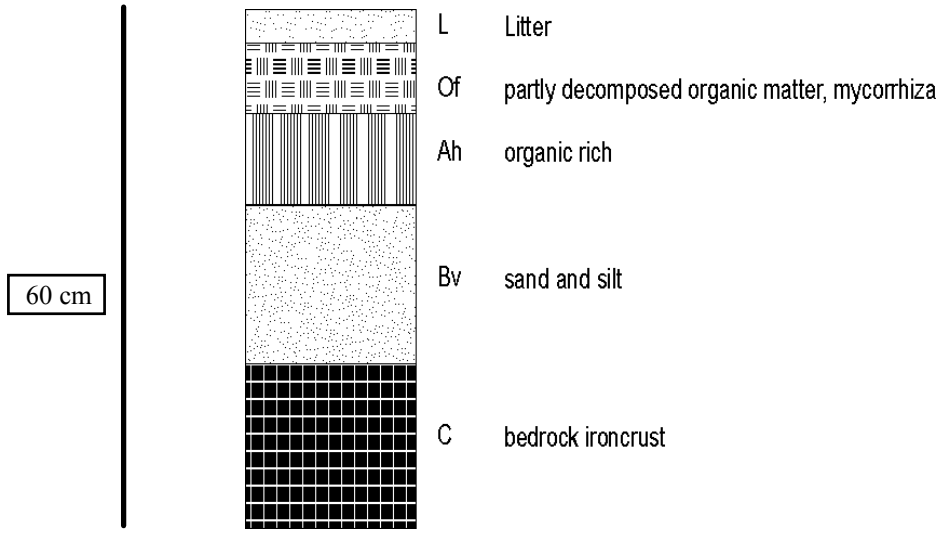

Fig. 1 Soil profile near vital trees.

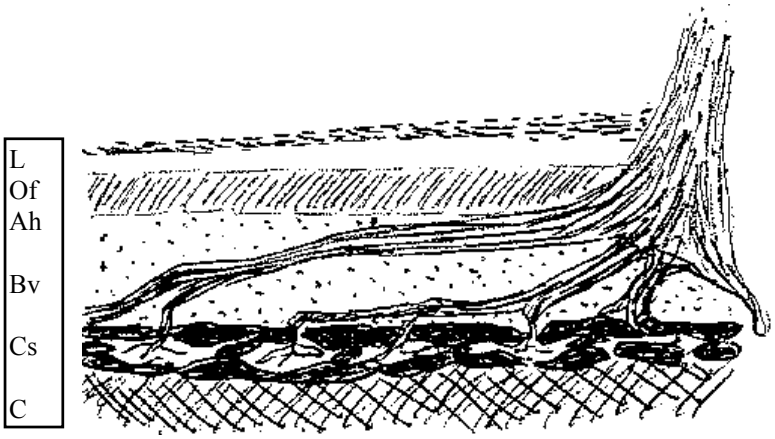

Fig. 2 Situation near vital trees. Soil thickness decreases with distance to tree.

Photo 6 Soil profile under one of the vital trees.

Near degraded trees (which is the larger part of the park) almost no soil is left. The process of sheet flooding has removed the complete top soil layers over large areas (see photo 2). Around the trees soil protecting grasses disappeared. Roots directly penetrate the slightly weathered bedrock layer (photo 7).

Photo 7 Roots penetrate the bedrock layer. Note the residual soil between the roots of the tree in the foreground.

Within the park three stages of degradation can be observed (Fig. 3):

1. Stage of minor erosion where the soil is partially preserved due to protective vegetation. Here the soil thickness reaches 30-40 cm and mycorrhiza could still be observed.

2. Stage of severe erosion where most trees are already dead and most of the soil is removed
3. Stage of complete erosion where soil has been removed entirely and ferric crusts dominate the surface. No living plants occur in this stage.

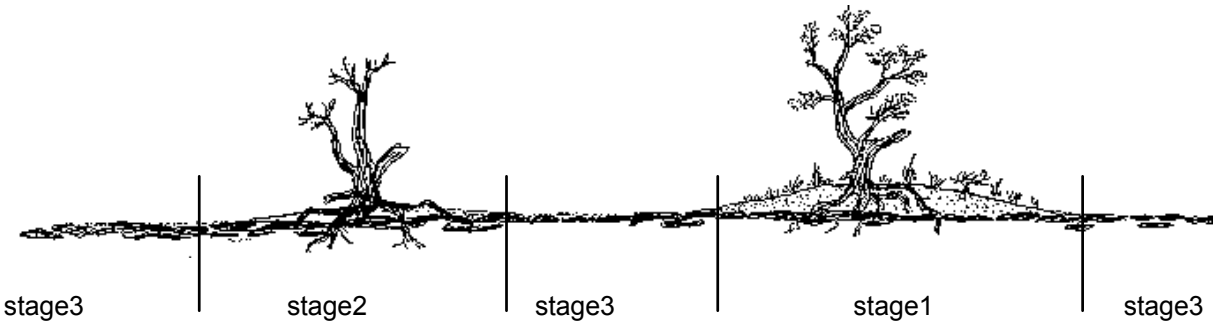

Fig. 3 Schematic profile showing the three stages of degradation in the park region.

Because the top soil has been removed by erosion, now the bedrock sandstone covers large parts of the surface. The upper parts of the bedrock sandstone form iron hard crusts which hardened the sandstone and prevent actual soil development (photo 8).

Photo 8 Iron crust forming the surface layer after all soil has been removed by erosion.

Results

Our investigation leads to the following results:

The bedrock sandstone is hardened by ferric crusts. Regarding nutrients this bedrock material is extremely poor. It consists basically of quartz and haematite as well as other iron oxides. The roots of *Juniperus procera* probably can't penetrate deep into the bedrock material.

The original soil cover was probably even initially not more than 30-50 cm thick. Degradation processes may have been initiated a long time ago by grazing activities. During the last years it is considerably intensified due to recreational and camping activities.

All *Juniperus procera* which still display a vital appearance have a remaining soil layer protected from erosion by shrubs or grasses. Generally in a distance of a few meters to the tree the grasses and soil decrease in number and thickness until they vanish completely. Within the soil layer around vital individuals of Juniperus always mycorrhiza was evident below a layer of litter material.

Most plant species exploit the soil with the help of beneficial microorganisms called mycorrhizal fungi. The fine threads that make up the fungus branch between soil particles, grow into decomposing organic matter, even explore the shells of dead insects, where they find phosphorus and other vital nutrients. The nutrients are then passed back to the roots of the plant.
Mycorrhizal fungi are key players in soil structure. Soil structure is tremendously important in the health of the vegetation, because it facilitates water infiltration, aeration, root growth, and movement of soil animals.
Both ECM (Ectomycorrhiza) and VAM (Vesicular-Arbuscular Mycorrhiza) fungi facilitate soil structure by binding soil aggregates together, to each other, and to plant roots. Soil bacteria cement soil particles and contribute importantly to soil structure, and mycorrhizal hyphae help supply some of the fuel that keeps the soil bacteria alive.

The connection between the presence of soil and mycorrhiza and the vitality of *Juniperus procera* in the Al-Soudah family park area is evident. The following process chain leads to the degradation in the area:

- Nutrient poor bedrock material does not supply trees with minerals
- Minerals (nutrients) come from organic litter material where mycorrhiza accelerates mineralisation and improves soil properties
- Organic litter can only accumulate if a vegetation cover protects it from aeolian and fluvial erosion
- Intensive recreation and camping activities destroy this vegetation cover and make the litter and soil material susceptible to erosion
- Without litter mycorrhiza (which makes nutrients available) can't exist
- Deprived of litter, mycorrhiza and soil the *Juniperus procera* die due to nutrient- and water shortage

In addition wood (and bark) cutting affects the trees directly.

Studies outside the park area on sites which are only little affected by recreation activities prove that soil is the crucial factor. On slopes where erosion naturally is high, the density of *Juniperus procera* is much less than on sites with low relief (photo 9). The same is valid for the physiognomy. The individuals at slope sites are only a

few meters high whereas trees at more preferable sits such as valley floors grow to heights of 10-15 m. Good developed soils up to 1.5 m deep in the valley floors provide nutrients as well as water enough for a dense and vital Juniperus community.

Photo 9 Slopes (background) show smaller trees and higher distance between each individual than the valley floor area (foreground).

Recommendations for park improvement

Direct measures to improve tree vitality:

1. Stone or boulder walls round the trees will protect the soil from erosion. These walls should be in a distance of 2-3 m from the stem of each Juniperus individual (see fig. 4).
2. One side of the wall should be closer to the stem (1 m) in order to allow a picnic place near the tree. If this is on the east side, the picnic place will have shadow during afternoon (see fig. 5).
3. It is then necessary to fill natural soil substrate (silt and sand from similar sites) in the space between stem and stone or boulder wall. Where still a vegetation cover is present no additional soil should be added.
4. The freshly added soil should be revegetated with common grasses and plants from the area
5. Phosphorus fertiliser will improve the establishment of the new grasses and plants.
6. Additional large boulders in the vicinity of the campsites would provide more privacy

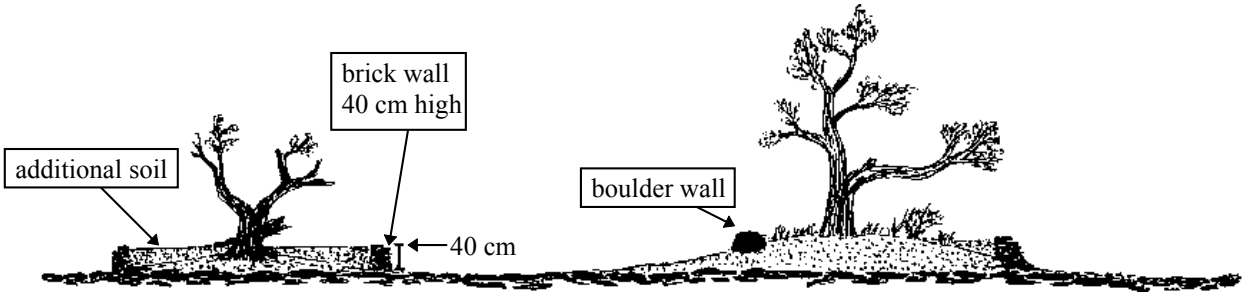

Fig. 4 Stone or boulder walls around the trees to protect soil from erosion

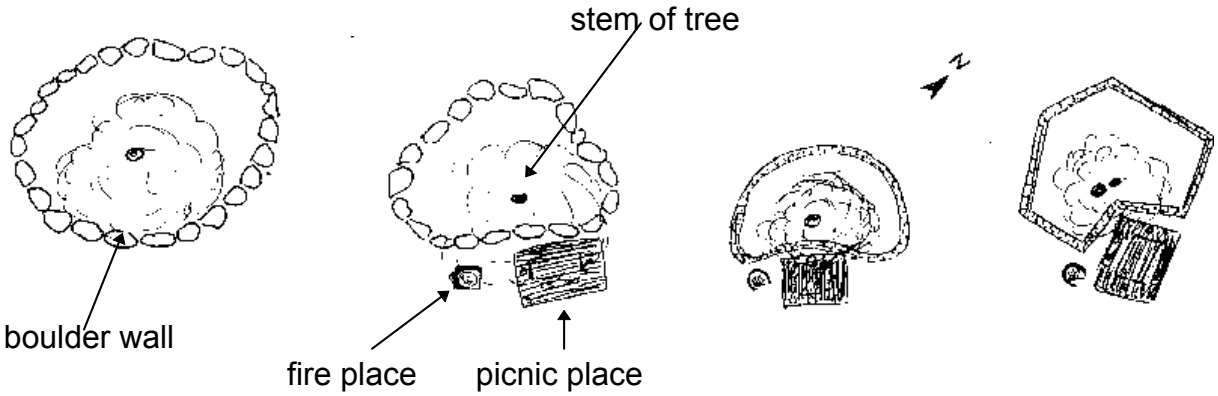

Fig. 5 Suggestions of design regarding the stone or boulder walls around the trees.

Preservation and improvement of the present condition is only possible when a strict park management regulates the use of the natural resources within the park. Exploitation of resources finally kills the ecosystem and must therefore be prevented. Each nature park, where people recover from urban life and experience the wonders and beauty of nature, can only survive if there is an adequate park management.

Measures for future park management:

1. The number of cars allowed into the park should be restricted. No more cars should be admitted than camp/picnic sites are available. Registration at the park entrance would be necessary.
2. Parking should be confined to designated areas beside the road (many places are already designed that way).
3. The western style picnic places should be replaced by a more adequate and traditional model which provides a place on the ground (where a carpet can be unrolled) as well as a fixed fire place on the ground.
4. Other fires than the ones in the fireplaces should be prohibited.
5. Wood cutting and collecting should under all circumstances be prevented (signs are necessary to remind people). Instead it is absolutely essential to provide firewood (could be sold at the park entrance).
6. Park rangers should patrol the area within the park. People need to feel their presence. The rangers should be ready to answer questions and give advice to the tourists, but they also should be ready to enforce the park regulations i.e. prevent people from making fires outside the fireplaces or from offroad driving.

With some regulations like the above mentioned it should be possible to preserve this remarkable Juniper woodland ecosystem and the beauty of this landscape for future generations.