7 Vegetation of the Asir Mountains

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Introduction

After the Persian Gulf War in 1991, dieback of branches, or the distal part of branches, or entirely dead trees, became conspicuous in the *Juniperus procera* woodlands of the Asir Mountains. From the viewpoint of conserving the landscape and biodiversity of the Arabian Peninsula, the disappearance of *Juniperus procera* and juniper woodlands was a serious problem. Since nearly all the Arabian Peninsula is covered with desert and arid vegetation, woodland vegetation isolated from others of its type are like islands. Many animals are restricted to the woodlands. The Asir Mountains are covered with various woodlands, in which many endemic and rare plants and animals live.

As part of our project, we carried out a phytosociological investigation to determine the diversity of the juniper and *Acacia* woodlands, which are found together in the Asir mountains. Phytosociology is a method for classifying vegetation into units based on differences in floristic composition and allows us to discuss the correspondence of vegetation units with site factors.

The woodland vegetation on the Arabian Peninsula was studied by König (1986, 1987) and Fischer et al. (1998). The Ministry of Agriculture and Water (1998) prepared a map showing the vegetation communities of Saudi Arabia. According to the vegetation map, the woodland vegetation is divided into three communities characterized by differences in the dominant species: the *Juniperus procera* community, the *Acacia origena-Acacia tortilis-Salsola spinescens* community, and the *Teclea-Tarchonanthus* community.

König (1987) recognized that vegetation units were based on differences in floristic composition in southwest Saudi Arabia. He classified the juniper woodlands into two types: the *Juniperus-Olea* forest and the juniper open forest. In his study, the number of stands examined was not enough to recognize vegetation units within each forest. It was also impossible to discuss the floristic diversity and relations between floristic composition and dieback or die-off.

In this study, we wanted to determine if there were certain vegetation units in which dieback or die-off occured. Although we used the same method and viewpoint as König (1987), we examined enough stands to clarify the floristic diversity of the juniper woodlands and to be able to recognize vegetation units that subdivide König's *Juniperus-Olea* forest and juniper open forest.

Research area

Investigations were made on juniper woodlands and *Acacia* woodlands on the Raydah Escarpment (a reserve area) and neighboring areas of the Asir Mountains. The northern limit of the area investigated was Tanumah and Billasmar, and the southern limit was Tamnyah and Ghara. Jabal Sudah, an area close to the Raydah Nature Reserve area, and Jabal Fayfa, where juniper woodlands are also found, were investigated.

Method

The floristic composition of the juniper woodlands was surveyed in selected stands that represent different types of vegetation. Occurrence, frequency and coverage of all the species in each stand was also determined. The data from each stand were analyzed and used to define vegetation units according to phytosociological methods (Braun-Blanquet, 1964; Mueller-Dombois and Ellenberg, 1974). With this method we have tried to determine whether dieback or die-off occur within particular vegetation units.

Classification of vegetation units

All data on species composition in each stand were used to classify the vegetation units. In the synthetic tables, many uncertain species were treated as companion species.

The vegetation data were collected based on the classification methods proposed by Blaun Brounquet (1964) and Mueller-Dombois and Ellenberg (1974). The square of each stand was determined by the species-square curve. Each stand was analyzed by a table operation based on species composition. Vegetation units were established as a result of the table operation.

The coding in the synthetic tables and the composition tables are explained as follows.

Synthetic tables

The occurrence frequency 80–100% is coded as V; the occurrence frequency 60–80% is IV; the occurrence frequency 40–60% is III; the occurrence frequency 20–40% is II and the occurrence frequency 10–20% is I. Further, + shows the occurrence frequency 5–10%. And "r" is the occurrence frequency under 5%.

Floristic composition tables

Coverage of 75–100% is coded as 5; coverage of 50–75% is 4; coverage of 25–50% is 3;

coverage of 10–25% is 2; and coverage of 1–10% is 1; + represents the coverage less than 1%.

Results

1. The general condition of juniper woodlands on the Raydah Escarpment

On the Raydah Escarpment, both dieback and die-off of *Juniperus procera* are conspicuous, especially at lower elevations and in rocky places. The vegetation greatly differs according to elevation as follows.

(1) Vegetation according to elevation

1) 2,700 to 2,900 m

Pure juniper communities occur at elevations of 2,700 to 2,900 m. No die-off of *Juniperus* was found in these stands, but a few trees with dieback were found at 2,700 m.

Pure juniper communities have no other tree species in the tree layer. The associate species are all shrubby, such as *Euryops arabicus*, *Clutia myrioides*, and *Dodonaea angustifolia*. Trees that make up the canopy at lower elevations in the Asir Mountains, such as *Acacia origena*, *Olea europaea* subsp. *cuspidata*, and *Nuxia congesta* were not found in the pure community.

Because a well developed stand of *Juniperus procera* provides heavy shade, young trees cannot grow in such areas. Young trees are found only in sunny places. Sometimes, the juniper community lacks a shrub layer.

2) 2,500 to 2,700 m

At 2,500 to 2,700 m, the stands dominated by *Juniperus procera* contain *Acacia origena* and *Olea europaea* subsp. *cuspidata* in the canopy.

Trees with both dieback and die-off were found only on roadsides and in rocky places. On roadsides, in most cases, trees with dieback appear to be the result of disturbance by road construction and management. Die-off was found only on steep rocky sites. Dying appears to be related to severe edaphic conditions at those sites. *Olea europaea* subsp. *cuspidata* remained sparse in stands in which the junipers had died.

3) 2,200 to 2,500 m

The juniper dominant stands at 2,200 to 2,500 m had a higher species diversity as compared

with those in higher elevations, even when the jumpers had died. Other dominant species in the canopy were *Acacia origena*, *Olea europaea* subsp. *cuspidata*, and *Nuxia congesta*. On the bottom of valleys, *Nuxia congesta* was the exclusive dominant. The juniper dominant stands contain *Solanum schimperianum* and *Cadia purpurea* in the shrub layer and *Hypoestes forsskalii*, *Helichrysum forsskalii* and *Euphorbia schimperiana* in the herb layer.

Elevations between 2,200 and 2,500 m show the most conspicuous die-off of *Juniperus procera* on the Raydah Escarpment, especially around 2,400 m. Stands with dead juniper trees were more extensive in rocky places and on steep slopes with thin soil. On steep slopes, *Nuxia congesta* became dominant after the junipers died.

4) 1,900 to 2,200 m

At 1,900 to 2,200 m, *Juniperus procera* was small and sparse and was not dominant. The dominant vegetation was the *Tarchonanthus camphoratus* shrublands. Large dead trees of *Juniperus procera* remained in the shrublands. Some were more than 20 m tall, especially those in the bottom of valleys. Generally, junipers became huge due to lower population density in the canopy layer at low elevations.

Both dieback and die-off were conspicuous, especially at elevations below 2,000 m where the junipers were nearly dead.

(2) Juniper woodlands and *Acacia* woodlands

In the Asir Mountains, juniper woodlands and *Acacia* woodlands are the representative woody vegetation (some areas are shrublands and open forest).

Juniper woodlands are distinguishable from *Acacia* woodlands and shrublands by differences in associated species. Juniper woodlands contain *Juniperus procera*, *Euphorbia schimperiana*, *Asparagus africanus*, *Asplenium officinarum*, *Minuartia liliifolia*, *Themeda triandra*, *Lavandula dentata*, *Felicia abyssinica*, *Andropogon distachyos*, *Otostegia fruticosa* subsp. *schimperi*, *Psiadia punctulata*, *Hypoestes forsskalii*, *Hypoestes forsskalii*, *Solanum schimperianum*, *Vulpia muralis*, and *Osteospermum vaillantii*.

Species characterizing the *Acacia* woodlands are *Solanum incanum*, *Teucrium yemense*, *Oxalis corniculata*, *Andrachne aspera*, *Phragmanthera austroarabica*, *Fagonia indica*, *Ochradenus baccatus*, *Echinops abuzinadae*, *Pulicaria crispa*, *Acacia gerrardii, Commicarpus plumbagineus*, *Kleinia odora*, *Pupalia lappacea* var. *velutina*, *Anarrhinum forsskalii*, *Rhamnus lycioides* subsp.

Oleoides, *Micromeria imbricate*, *Euryops arabicus*, *Clutia myricoides, Dodonaea angustifolia*, *Helichrysum forsskali*, and *Nepeta deflersiana*.

Acacia woodlands

The *Acacia* woodlands contain mainly *Acacia origena* and *A. gerrardii*. They are related to the juniper woodlands as a neighbor community in their similarity of both structure and floristic composition.

The juniper woodlands differ from the *Acacia* woodlands in their dominant species. However, in their floristic composition, they resemble each other and have many shared species. Stands with various intermediate compositions between juniper and *Acacia* woodlands were also found. Additionally, *Acacia* trees were found in some juniper woodlands and some junipers were found in *Acacia* woodlands.

It was noted that *Acacia* woodlands consisting of *Acacia origena* and *A. gerrardii* were restricted to inland regions and were never found on the slopes directly facing the Red Sea in the Asir Mountains. Juniper woodlands were found on slopes facing both inland and the Red Sea. The factors influencing the growth of *Acacia* woodlands are thought to be the limited water supply, less rocky soil, and more gentle slopes in comparison with the juniper woodlands.

Floristic composition of the *Acacia* woodlands

As shown in Table 7-3, the representative *Acacia* woodlands are classified into two kinds: the *Acacia gerrardii-Commicarpus plumbagineus* community and the *Acacia origena-Vulpia muralis* subcommunity. They differ clearly from the juniper woodlands in floristic composition. The *Acacia origena-Solanum schimperianum* subcommunity and the *Juniperus procera-Hypoestes forsskalii* subcommunities are similar, however, in their many shared species, as shown in species groups 3, 4, 10, and 15 in Table 7-3. The *Acacia origena-Solanum schimperianum* subcommunity and the *Juniperus procera-Hypoestes forsskalii* subcommunity are actually close vegetational units in their floristic composition. Moreover, they are found within the same areas. There are some transitional stands between the two woodlands and a few stands were difficult to distinguish.

2. Classification of vegetation units

Two communities, six subcommunities, and six composition groups are recognizable in the juniper woodlands. Two communities, two subcommunities, and three composition groups are

Acacia woodlands, and one community is *Dodonaea angustifolia* shrubland.

(1) Juniper woodlands and shrublands

1) *Juniperus procera-Euryops arabicus* community

Diagnostic species: *Euryops arabicus, Rhamnus lycioides* subsp. *oleoides, Hyparrhenia hirta, Themeda triandra,* and *Felicia abyssinica*

Based on differences in floristic composition, the *Juniperus procera-Euryops arabicus* community is subdivided into two subcommunities and six composition groups.

This community was found at various sites. The *Juniperus procera-Senecio hadiensis* community may surpass the *Juniperus procera-Euryops arabicus* community on the Raydah Escarpment.

Juniperus procera-Euryops arabicus was mostly limited to the inland side of the Asir Mountains, except at higher elevations on the Raydah Escarpment. This community overlaps with the *Juniperus procera-Senecio hadiensis* community only on the Raydah Escarpment. On the inland side of the Asir Mountains, as on the eastern slope of Jabal Sudah and Sugha, all the juniper stands are classified as this community. The *Juniperus procera-Senecio hadiensis* community was not found on the inland side of the Asir Mountains.

a] *Juniperus procera-Euryops arabicus* subcommunity

The *Juniperus procera-Euryops arabicus* subcommunity has no diagnostic species, and is restricted to Tanumah and Al-Kamar in the northern part of our research area. It is notable that *Euphorbia schimperiana* and *Minuartia filifolia* were not found in the juniper dominated stands of this subcommunity.

a. *Juniperus procera-Euryops arabicus* composition group

The *Juniperus procera-Euryops arabicus* composition group has no diagnostic species, and is distinguishable from the *Juniperus procera-Ephedra foeminae* composition group by the absence of *Ephedra foeminae*. It is restricted to the northern part of our research area at elevations between 2,600 and 2,800 m. The trees of *Juniperus procera* were healthy and no trees with dieback and no dead trees were found in the stands of this group. The floristic composition is shown in Table 7-11.

b. *Juniperus procera-Ephedra foeminae* composition group

Differential species : *Ephedra foeminae*, *Cheilanthes pteridioides*, *Bromus pectinatum*, *Scandix pecten-veneris*, *Meriandra bengalensis*, and *Eragrostis braunii*

The *Juniperus procera-Ephedra foeminae* composition group is distinguishable from the *Juniperus procera-Euryops arabicus* composition group by the diagnostic species above. The diagnostic species of this group are found on the Raydah Escarpment and Jabal Sudah. However, these species are strongly connected with the juniper woodlands in the northern part of our research area.

Within this group, trees of *Juniperus procera* were healthy and trees with dieback and dead trees were not found. Table 7-12 lists the species in this group.

b] *Juniperus procera-Euphorbia schimperiana* subcommunity

Differential Diagnostic species: *Euphorbia schimperiana, Minuartia filifolia, Silene hockstetteri, Andropogon distachyos,* and *Anagallis foemina*

The main distribution area of the *Juniperus procera-Euphorbia schimperiana* subcommunity is in the southern part of our research area at Sudah and Tamnyah. This subcommunity occurs above approximately 2,800 m in Jabal Sudah, but in Tanumah and Billasmar in the north the lower limit is approximately 2,500 m. It is probably related to fog that hovers at lower elevations in the north than in the south, since the mountains are lower in the north.

Trees of *Juniperus procera* in this subcommunity were healthy and dieback and dead trees were not found in the stands of this group.

a. *Juniperus procera-Euphorbia schimperiana* composition group

The *Juniperus procera-Euphorbia schimperiana* composition group has no particular differential species. However, it is distinguishable from the *Juniperus procera -Salvia* sp. aff. *merjamie* composition group by the absence of *Cichorium intybus* and *Salvia* sp. aff. *merjamie*.

The distribution is restricted to Jabal Sudah at elevations between 2,780 and 3,050 m. The floristic composition is shown in Table 7-13-1, 2.

b. *Juniperus procera -Salvia* sp. aff. *merjamie* composition group

Differential species : *Cichorium intybus*, *Salvia* sp. aff. *merjamie*, *Brachypodium sylvaticum*, *Rosa abyssinica*, *Dichondra repens*, *Scabiosa columbaria*, and *Senecio asirensis*

The *Juniperus procera -Salvia* sp. aff. *merjamie* composition group is found in Tanumahat from 2,850 to 3,050 m and in Jabal Sudah from 2,480 m to 2,710 m in the north. This is the highest juniper woodland in the Asir Mountains.

This composition group is transitional from the *Juniperus procera-Euryops arabicus* community to the *Juniperus procera-Senecio hadiensis* community in floristic composition. *Senecio hadiensis* and *Osteospermum vaillantii* are in the stands at lower elevations. The floristic composition is shown in Table 7-14.

c] *Juniperus procera-Hypoestes forsskalii* subcommunity

Differential species : *Hypoestes forsskalii, Psiadia punctulat, Solanum schimperianum, Solanum schimperianum, Vulpia muralis, Teucrium yemense.*

The *Juniperus procera-Hypoestes forsskalii* subcommunity is found in juniper woodlands at the lowest elevations. Some diagnostic species, such as *Hypoestes forsskalii*, *Solanum incanum*, *Teucrium yemense*, *Oxalis corniculata*, and *Andrachne aspera*, are shared with the *Acacia* woodlands. This subcommunity appears to be closest to the *Acacia* woodlands phytosociologically. The floristic composition is shown in Table 7-15-1, 2, Table 7-16. This subcommunity is subdivided into two composition group.

a. *Juniperus procera-Dodonaea angustifolia* composition group

Differential species : *Dodonaea angustifolia, Helichrysum forsskalii, Asparagus africanus, Clutia myricoides, Lavandula dentate*

The *Juniperus procera-Dodonaea angustifolia* composition group is found on the eastern slope of Jabal Sudah in Al-Sudah, Tanumah and Al-Kamar in the northern part, and at Tamnyah in the southern part of our research area. It occurs at elevations between 2,700 and 3,000 m in Al-Sudah, between 2,600 m and 2,800 m in the north, and between 2,500 m and 2,600 m in the south.

The condition of the trees of *Juniperus procera* was worse, especially in Tamnyah and Ebalah, in the northern part of our research area. Stands of this group had conspicuous dieback and dead trees of *Juniperus procera*. The floristic composition is shown in Table 7-15-1, 2.

b. *Juniperus procera-Hypoestes forsskalii* composition group

The *Juniperus procera-Hypoestes forsskalii* composition group has no diagnostic species and

is distinguishable from other groups by the absence of *Dodonaea angustifolia*, *Helichrysum forsskalii* and *Asparagus africanus*.

This group was found only in Tamnyah, where *Dodonaea angustifolia* and *Asparagus africanus* are rare. The trees of *Juniperus procera* are in rather worse condition here, with many showing dieback. The floristic composition is shown in Table 7-16.

3) *Juniperus procera-Senecio hadiensis* community

Differential species : *Senecio hadiensis, Osteospermum vaillantii, Otostegia fruticosa subsp*. schimper, *Achyranthes aspera var. sicula, Olea europaea subsp. cuspidata, Asplenium trichomanes, Cheilanthes coriacea*

The *Juniperus procera-Senecio hadiensis* community is found only on the Raydah Escarpment. It has a rich flora as compared with the *Juniperus procera-Euryops arabicus* community. Trees with dieback, and particularly dead trees, of *Juniperus procera* are conspicuous. Die-off was confirmed only in this community. This community type is expected to be found on the west slope of Jabal Sudah (on the Red Sea side of the Asir Mountains).

A *Juniperus procera-Nuxia congesta* subcommunity

Differential species: *Solanum incanum, Nuxia congesta, Celtis africana, Geranium robertianum*

Although only three stands of the *Juniperus procera-Nuxia congesta* subcommunity were examined at elevations about 2,400 m, this subcommunity is clearly distinguishable from the others by its unique floristic characters. This subcommunity sometimes forms *Nuxia congesta*-dominant forests and *Celtis africana*-dominant forests, but those forests are considered to be variants of juniper woodlands from their floristic composition and structure. The overall flora is rich.

These communities occur on valley bottoms where there is frequent fog and where water is plentiful. Some juniper trees showed dieback. The floristic composition is shown in Table 7-17.

B *Juniperus procera-Fumaria abyssinica* subcommunity

Differential species: *Fumaria abyssinica, Silene hockstetteri, Poa* spp., *Felicia dentata, Arabis alpina, Eragrostis cilianensis, Sisymbrium erysimoides, Rhus retinorrhoea, Geranium molle*

The *Juniperus procera-Fumaria abyssinica* subcommunity occurs at elevations between 2,500 and 2,880 m on the Raydah Escarpment. Trees with dieback and dead trees of *Juniperus procera* are found in stands below 2,700 m. On the Raydah Escarpment, the upper limit where

dead trees and trees with dieback were found was 2,700 m.

Trees of *Juniperus procera* with dieback were limited to sites along roads and the dead trees were on steep, rocky slopes. Only trees of *Juniperus procera* showed dieback or were dead. The floristic composition is shown in Table 7-17.

C *Juniperus procera-Tarchonanthus camphoratus* subcommunity

Differential species: *Eragrostis cilianensis, Sisymbrium erysimoides, Rhus retinorrhoe, Geranium molle, Tarchonanthus camphoratus, Teclea nobilis, Cadia purpurea, Lantana viburnoides, Monechma dabile, Opuntia ficus-indica, Aloe sabaea, Pupalia lappacea var. velutina, Cruciferae spp., Aloe* sp.2*, Sageretia thea var. bornmuelleri, Plectranthus asirensis, Commelina* sp.*, Cenchrus pennisetiformis, Grewia tembensis, Commicarpus plumbagineus, Actiniopteris semiflabellata, Digitaria s. abyssinica, Digitaria ciliaris, Pavetta longiflora*

As shown above, the *Juniperus procera-Tarchonanthus camphoratus* subcommunity has many diagnostic species and is quite different in floristic composition from other types of *Juniperus procera-Senecio hadiensis* communities. I consider this subcommunity to be a different alliance from the *Juniperus procera-Silene hockstetteri* subcommunity and the *Juniperus procera-Nuxia congesta* subcommunity.

This subcommunity occurs between 1,960 and 2,400 m. The lower limit of the juniper-mixed stand was 1,960 m. The tree of *Juniperus procera* at the lowest elevation was at 1,740 m in Raydah Village, where it was found in a shady place at the bottom of a rocky valley.

Trees with dieback and dead trees of *Juniperus procera* were found in this subcommunity. Some stands are juniper woodlands consisting only of dead juniper trees. The dominant subcommunity is the *Tarchonanthus camphoratus* shrublands.

The Differential species in this subcommunity, such as *Teclea nobilis*, *Cadia purpurea*, *Aloe sabaea*, are restricted to the Red Sea side of the Asir mountains. Those species appear to prefer warmer temperatures and the more humid air on the Red Sea side of the Asir Mountains.

Die-off was seen throughout this subcommunity between 1,960 and 2,400 m, and at lower elevations dieback became evident. Die-off was not limited to *Juniperus procera*, but occurred in other species, such as *Tarchonanthus camphoratus*. *Tarchonanthus camphorates* shrublands are treated as part of the juniper woodlands because of their floristic composition (including dead trees of *Juniperus procera*). The now pure *Tarchonanthus camphoratus* shrublands contained many dead juniper trees at approximately 2,000 m. The floristic composition is shown in Table 7-18.

(2) *Acacia* woodlands and shrublands

1) *Acacia gerrardii-Commicarpus plumbagineus* community

Differential species : *Acacia gerrardii, Commicarpus plumbagineus, Kleinia odora, Leguminosae* sp.1 and 2*, Pupalia lappacea var. velutina.*

The *Acacia gerrardii-Commicarpus plumbagineus* community is clearly distinct from the *Acacia origena-Solanum schimperianum* community in the above diagnostic species. Stands of this community are only at Al-Mahallah, but *Acacia gerrardii* dominant woodlands were seen at Kamis Musayt. Those shrublands are probably close to the *Acacia gerrardii-Commicarpus plumbagineus* community in composition. The *Acacia gerrardii-Commicarpus plumbagineus* community consists of sparse shrubs. It is distributed at elevations below 2,400 m. The floristic composition is shown in Table 7-6.

2) *Acacia origena-Solanum schimperianum* community

Differential species: *Acacia origena, Solanum schimperianum, Euryops arabicus, Hypoestes forsskalii, Clutia myricoides, Rhamnus lycioides* subsp*. oleoides, Lavandula dentate, Dodonaea angustifolia, Helichrysum forsskalii, Euphorbia schimperiana.*

The *Acacia origena-Solanum schimperianum* community is distinguishable from the *Acacia gerrardii-Commicarpus plumbagineus* community by the differential species above. It occurs from 2,300 to 2,850 m and overlaps the distribution range of the juniper woodlands. This community is not found on steep slopes on the Red Sea side. *Acacia* woodlands on the slopes of the Red Sea side contain *Acacia etbaica* and *Acacia ehrengergiana*. *Acacia etbaica* woodlands are also found at Waji Deli (1,000–1,200 m). *Acacia ehrengergiana* woodlands are at the foot of Jabal Fayfa (below 100 m), at Al-Darb (40 m) and at Sabya (60 m). These *Acacia* shrublands do not coexist with juniper woodlands. The *Acacia origena-Solanum schimperianum* community is divided into the two following subcommunities.

A. *Acacia origena-Vulpia muralis* subcommunity

Differential species: *Vulpia muralis, Phragmanthera austroarabica, Cenchrus* sp. *Felicia abyssinica, Solanum glabrata* var*. sepicula, Blepharis ciliaris.*

This subcommunity is distinguishable from the *Acacia origena-Solanum schimperianum* subcommunity by its difference of floristic composition. It is further subdivided into three groups.

a] *Acacia origena-Lavandula pubescens* subgroup

Differential species: *Lavandula pubescens*, *Otostegia fruticosa* subsp. *Schimper*, *Anarrhinum forsskalii*, *Fagonia indica*, *Ochradenus baccatus*, *Echinops abuzinadae*, *Pulicaria crispa*

The distribution of this group is restricted to the east slopes of Jabal Sudah at elevations between 2,550 and 2,650 m. In Jabal Sudah, it lies next to juniper woodlands at higher elevations. The floristic composition is shown in Table 7-7.

b] *Acacia origena-Micromeria imbricata* subgroup

Differential species: *Chenopodium album*, *Micromeria imbricata*, *Oxalis corniculata*, *Bromus pectinatum*, *Plantago cylindrica*, *Euphorbia serpens*, *Cruciferae* sp. 1, *Anagallis arvensis* var. *caerulea*, *Argyrolobium confertum*, *Commicarpus grandiflorus*

The *Acacia origena-Micromeria imbricata* composition group is found on east-facing slopes of Jabal Sudah between 2,400 m and 2,600 m, at Ghara and Tamnyah between 2,330 m to 2,470 m, and at Tanumah at 2,460 m. The floristic composition is shown in Table 7-8.

c] *Acacia origena-Vulpia muralis composition* subgroup

The *Acacia origena-Vulpia muralis* composition group has no particular differential species.

It occurs on eastern slopes of Jabal Sudah, Ghara, Tamnyah, and Tanumah, and is concentrated at elevations between 2,300 and 2,600 m in Ghara and Tamnyah and between 2,450 m and 2,600 m in Tamumah. On the eastern slope of Jabal Sudah, however, it is distributed widely at elevations between 2,450 and 2,850 m. The floristic composition is shown in Table 7-9-1, 2.

B. *Acacia origena-Solanum schimperianum* subcommunity

This vegetation unit has no particular differential species.

The *Acacia origena-Solanum schimperianum* subcommunity is found on the eastern slopes of Jabal Sudah and Billasmar. On the eastern slope of Jabal Sudah, it ranges in location between 2,600 m and 2,800 m, and it is found around 2,650 m at Billasmar. The floristic composition is shown in Table 7-10.

(3) *Dodonaea angustifolia* shrubland

The *Dodonaea angustifolia* shrubland is phytosociologically classified in the following community.

1) *Dodonaea angustifolia* community

Differential species : *Dodonaea angustifolia*, *Themeda triandra*, *Euryops arabicus*, *Hyparrhenia hirta*, *Eragrostis barrelieri*, *Acacia origena*, *Helichrysum forsskalii*

The dominant type of this community is the *Dodonaea angustifolia* shrublands.

The *Dodonaea angustifolia* community is found in many places at elevations of 2,000 m and higher, neighboring the juniper woodlands and *Acacia* woodlands. We believe that this community was established because of small differences in the environment (including anthropogenic) in places where primarily juniper woodlands or *Acacia* woodlands were established. The floristic composition is shown in Table 7-19.

3. Altitudinal range of vegetation in the Asir Mountains

(1) Altitudinal range of juniper woodlands

The altitudinal range of the juniper woodlands differed in each research area. The woodlands at Tanumah and Billasmar, between 2,400 and 2,800 m, in the northern part of our research area, are lower in comparison with those at Jabal Sudah. At Ghara and Tamnyah, in the south, they are between 2,400 and 2,650 m. On the east slope of Jabal Sudah, the highest peak in the Kingdom of Saudi Arabia (more than 3,000 m), juniper woodlands occur between 2,600 and 3,050 m. On the Raydah Escarpment they range in location between 1,900 and 2,900 m. The altitudinal range of the juniper woodlands on the Raydah Escarpment, where they reach their lowest level of approximately 1,000 m, is the widest.

(2) Altitudinal range of each vegetation unit

The altitudinal range of each vegetation unit is shown in Figs 7-1 ~ 4. With few exceptions, the ranges differ between research areas (Tanumah, Billasmar, Tamnyah, Ghara, Jabal Sudah, and the Raydah Escarpment). For example, the distributional range of the *Juniperus procera* -*Salvia* sp. aff. *merjamie* composition group is between 2,820 and 3,050 m in Jabal Sudah and between 2,480 and 2,710 m in the north.

(3) The relationship between juniper woodlands and *Acacia* woodlands

The altitudinal ranges of the *Acacia* woodlands overlap the juniper woodlands on the eastern slope of Jabal Sudah, where juniper woodlands are at higher elevations than *Acacia* woodlands. In Billasmar and Tamnyah, the differences in the altitudinal ranges of *Acacia* woodlands and juniper

woodlands were not clear.

Acacia woodlands were not found on the Raydah Escarpment, but *Acacia origena* was found in the juniper woodlands. In the Asir Mountains, *Acacia* woodlands with *Juniperus procera* and *Acacia origena* as the only dominant species were found on inland-facing slopes.

Discussion

Plant species adapted to particular habitats generally grow in associations. The populations of different plant species found living together in a particular area are called communities. Thus, when we consider protection and conservation of species, it is important to understand with which other species they grow in the area concerned, because to protect and conserve a particular species requires that we know with which other species it coexists. In other words, it is necessary to protect and conserve communities that include the species of concern.

Vegetation maps show the distribution of plant communities. Through vegetation maps we can understand the distribution ranges of plants and their communities and use them as a means of protecting appropriate areas and protecting and conserving particular plants. Vegetation map provide essential information for establishing policies for the protection and conservation of plant species and communities. In Europe and in Japan especially, vegetation information and vegetation maps that cover entire political areas, including whole countries, are already completed. Those vegetation maps have been used as an important basis for devising policies for the protection and conservation of biological resources.

Phytosociological remarks on dieback and die-off

From the results of our study, juniper woodlands are divided into several vegetation units. It was further determined that species diversity differed between vegetation units.

In the study of juniper woodlands, it is significant to ascertain whether dieback of *Juniperus procera* is an early stage of die-off or is a usual physiological phenomenon without relation to die-off. The species of genus *Juniperus* are generally adapted to habitats under severe water stress. *Juniperus procera* appears not to be an exception and dieback in the species is also known from other regions outside Saudi Arabia. When the trees are under severe water stress they can survive by reducing the number of branches. Thus dieback, which we found in the Asir Mountains, appears to be a physical response to water stress within the species.

Die-off of *Juniperus procera* was found commonly in the juniper woodlands of the Raydah

Escarpment and other areas in the Asir Mountains, and also on steep slopes of Jabal Ghahar and Fayfa including Jabal Tarran facing the Red Sea. Die-off, however, was not found on the inner side of the Asir Mountains. Although dieback and die-off in *Juniperus procera* are sometimes found in the same stands, dead trees are found in many stands that are different from stands with trees showing dieback.

It was determined that dieback and die-off occur in particular vegetation units. Dead trees and trees with dieback of *Juniperus procera* were not found in stands classified as the *Juniperus procera-Euryops arabicus* composition group, *Juniperus procera-Ephedra foeminae* composition group, *Juniperus procera-Euphorbia schimperiana* composition group, or *Juniperus procera -Salvia* sp. aff. *merjamie* composition group in the *Juniperus procera-Euryops arabicus* community.

Stands with dieback were in the *Juniperus procera-Hypoestes forsskalii* composition group, *Juniperus procera-Dodonaea angustifolia* composition group, *Juniperus procera-Fumaria abyssinica* subcommunity, or *Juniperus procera-Nuxia congesta* subcommunity. The stands with dead trees were in the *Juniperus procera-Fumaria abyssinica* subcommunity, *Juniperus procera-Nuxia congesta* subcommunity, or *Juniperus procera-Tarchonanthus camphoratus* subcommunity in *Juniperus procera-Senecio hadiensis* community. Among them, the dead trees of *Juniperus* were restricted to rocky or steep slopes in the *Juniperus procera-Fumaria abyssinica* subcommunity and the *Juniperus procera-Nuxia congesta* subcommunity. The *Juniperus procera-Tarchonanthus camphoratus* subcommunity is a vegetation unit at the lower altitudinal limit of the range between 1,960 and 2,400 m. Some stands consisted only of dead juniper trees. *Juniperus procera* at lower elevations is exposed to greater water stress and higher evaporation.

In vegetation units with dead trees, dieback is transitional to die-off, but in units without dead trees the dieback can be regarded as a normal mechanism to protect against water and other environmental stresses.

Species diversity in juniper woodlands

The mean number of species per stand clearly differs among vegetation units. The gap is especially large in woodlands on the Red Sea side and those on the inland side. The mean number of species per stand is 26.6 in the *Juniperus procera-Senecio hadiensis* community on the Red Sea side, but is 14.4 in the *Juniperus procera-Euryops arabicus* community on the inland side of the Asir Mountains. Species richness in the *Juniperus procera-Senecio hadiensis* community appears to be related to fog and edaphic and topographic conditions.

The *Juniperus procera-Tarchonanthus camphoratus* subcommunity is highest in species diversity per stand (Table 7-5). The second highest is the *Juniperus procera-Nuxia congesta* subcommunity, the third is the *Juniperus procera-Fumaria abyssinica* subcommunity. All these have many dead trees of *Juniperus*. The *Juniperus procera-Tarchonanthus camphoratus* subcommunity is considered to be transitional between juniper woodlands and *Tarchonanthus camphorates* shrublands. Generally, the number of the species increases in transitional vegetation, and it remains true within the *Juniperus procera-Tarchonanthus camphoratus* subcommunity.

On the Raydah Escarpment, both the *Juniperus procera-Tarchonanthus camphoratus* and *Juniperus procera-Nuxia congesta* subcommunities are conspicuous because of dieback and dead trees, but species diversity in these communities is high. Both the *Juniperus procera-Hypoestes forsskalii* and *Juniperus procera-Dodonaea angustifolia* composition groups on the inland side of the Asir Mountains are lower in species diversity and have trees with dieback. The trees with dieback and dead trees of *Juniperus procera* are not related to the species diversity of vegetation units.

General remarks

From the results of this study, the juniper woodlands are divided into several vegetation units, indicating that the juniper woodlands are not homogenous.

One remarkable discovery was that the juniper woodlands with the highest species diversity had many dead trees of *Juniperus*. In conserving the juniper woodlands, care needs to be taken in considering the vegetational diversity of the woodlands. For the conservation and protection of the juniper woodlands, it is necessary to employ or train personnel who can diagnose vegetation based on floristic composition.

Our research revealed that die-off and dieback are fundamentally different phenomena. That is, dieback is an adjustment mechanism in *Juniperus*, but does not necessarily result in dead trees. Although the causes of die-off appear to be variable, most die-off is related to disturbance, especially at lower elevations or on steep slopes with thin soils, such as in areas with road construction and heavy grazing. Die-off in huge areas, especially at lower elevations, appears to be related to rapid climatic changes such as those brought on by global warming. Die-off was concentrated in certain vegetation units, such as in the *Juniperus procera-Tarchonanthus camphoratus* subcommunity. The community appears to shift to *Tarchonanthus camphoratus* shrublands after the death of the junipers.

Our vegetational study indicates that traditional utilization of junipers, including wood cutting and grazing, are better ways to conserve and manage the juniper woodlands, although concrete data on the influence of grazing on vegetation was not considered in our study.

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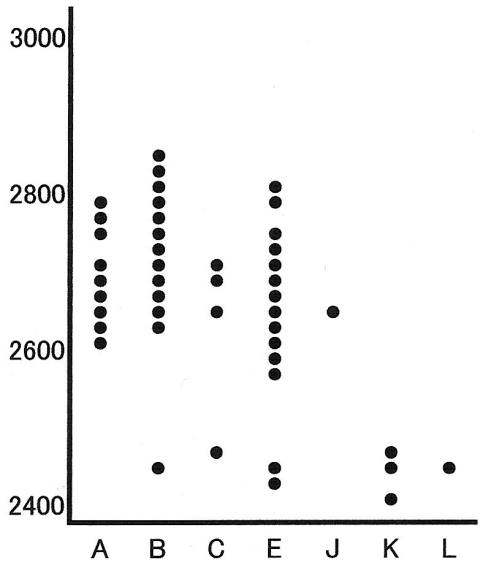
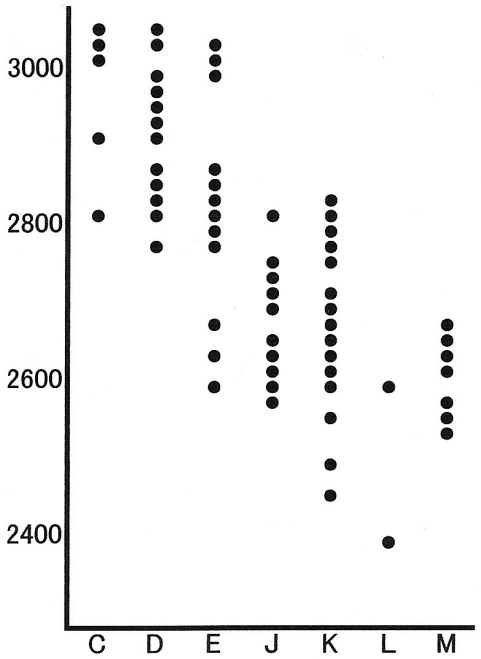


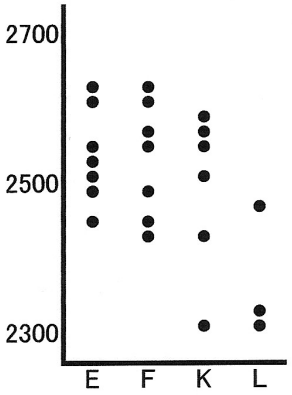
A: *Juniperus procera–Euryops arabicus* composition group
B: *Juniperus procera–Ephedra foeminae* composition group
C: *Juniperus procera–Salvia sp. aff. S. merjamie* composition group
E: *Juniperus procera–Dodonaea angustifolia* composition group
J: *Acacia origena–Solanum schimperianum* sub–community
K: *Acacia origena–Vulpia muralis* composition group
L: *Acacia origena–Micromeria imbricata* composition group

Fig. 7-1 Vertical distribution of vegetation units in the north part of research area



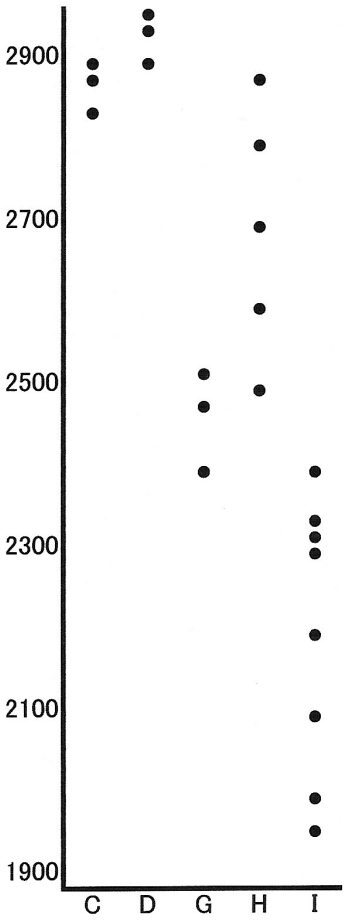
C: *Juniperus procera–Salvia sp. aff. S. merjamie* composition group
D: *Juniperus procera–Euphorbia schimperiana* composition group
E: *Juniperus procera–Dodonaea angustifolia* composition group
J: *Acacia origena–Solanum schimperianum* sub–community
K: *Acacia origena–Vulpia muralis* composition group
L: *Acacia origena–Micromeria imbricata* composition group
M: *Acacia origena–Lavandula pubescens* composition group
N: *Acacia gerrardii–Commicarpus* plumbagineus composition group

Fig. 7-2 Vertical distribution of vegetation units on the east slope in Jabal Sudah



E: *Juniperus procera–Dodonaea angustifolia* composition group
F: *Juniperus procera–Hypoestes forsskalii* composition group
K: *Acacia origena–Vulpia muralis* composition group
L: *Acacia origena–Micromeria imbricata* composition group

Fig. 7-3 Vertical distribution of vegetation units in the south part of research area



C: *Juniperus procera–Salvia sp. aff. S. merjamie* composition group
D: *Juniperus procera–Euphorbia schimperiana* composition group
G: *Juniperus procera–Nuxia congesta* sub-community
H: *Juniperus procera–Silene hockstetteri* sub-community
I: *Juniperus procera–Tarchonanthus camphoratus* sub-community

Fig. 7-4 Vertical distribution of vegetation units in Raydah escarpment

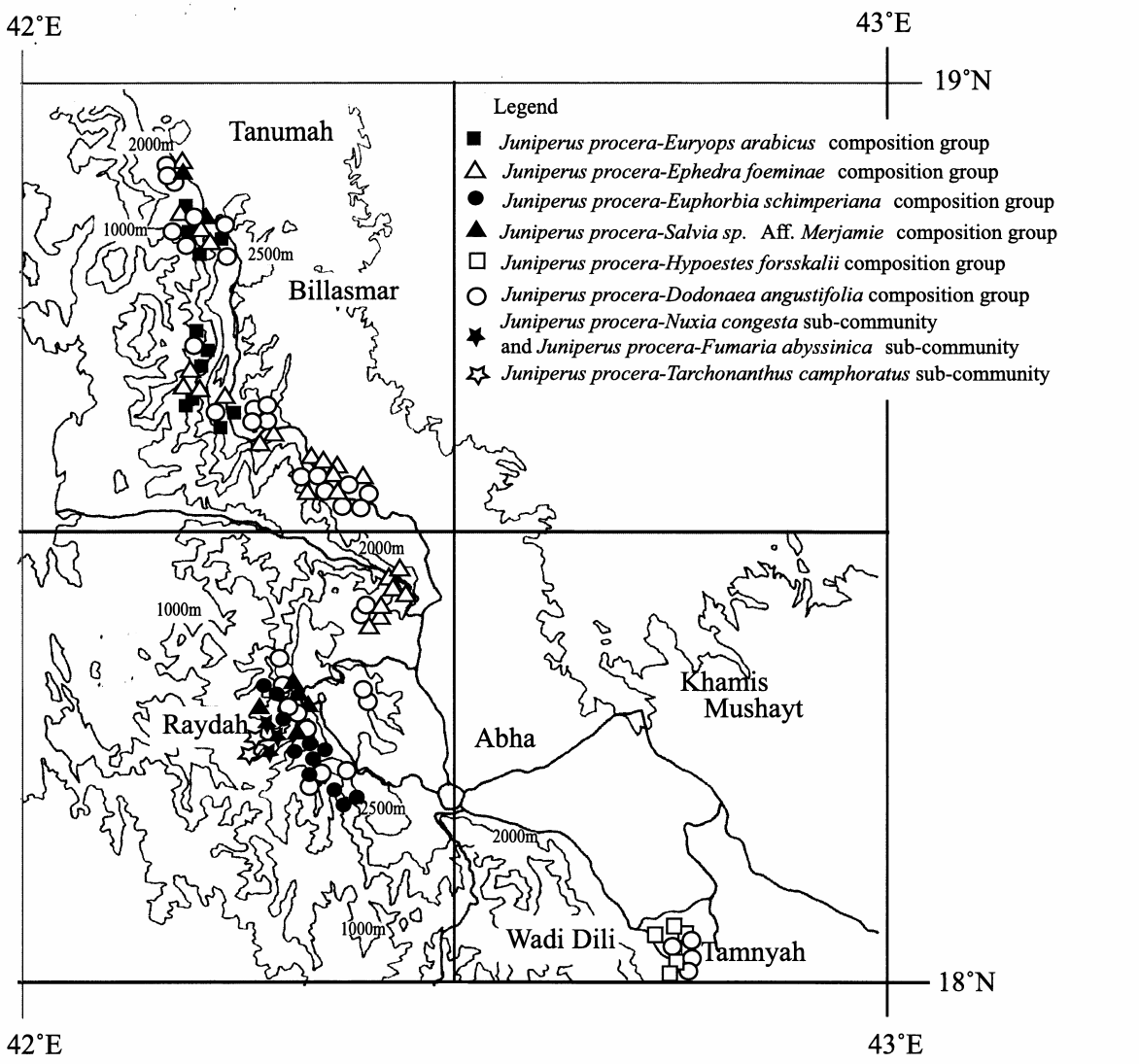


Fig. 7-5 Distribution map of Juniper Woodland in Asir mountains

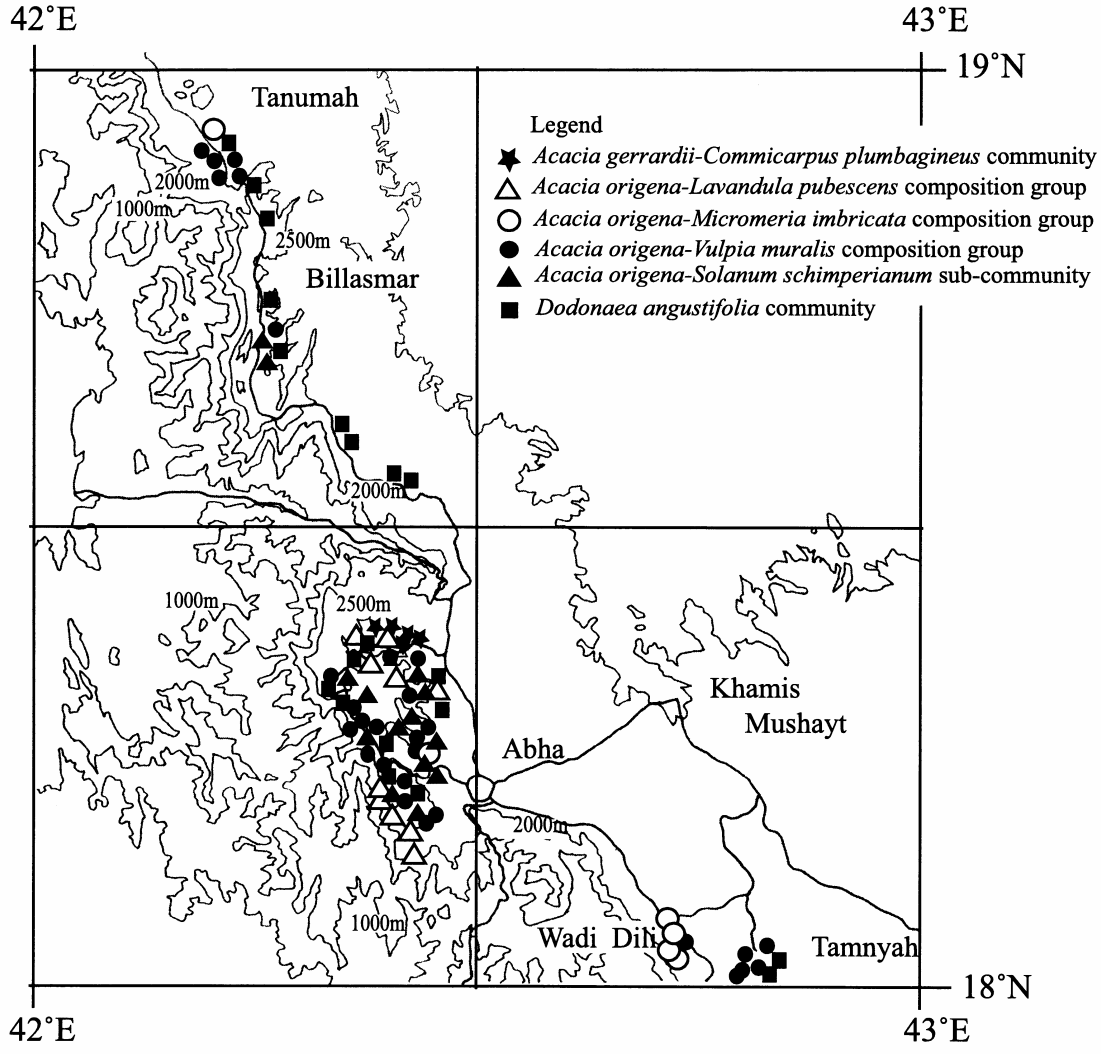


Fig. 7-6 The distribution map of Acacia Woodland and *Dodonaea angustifolia* community in Asir mountains

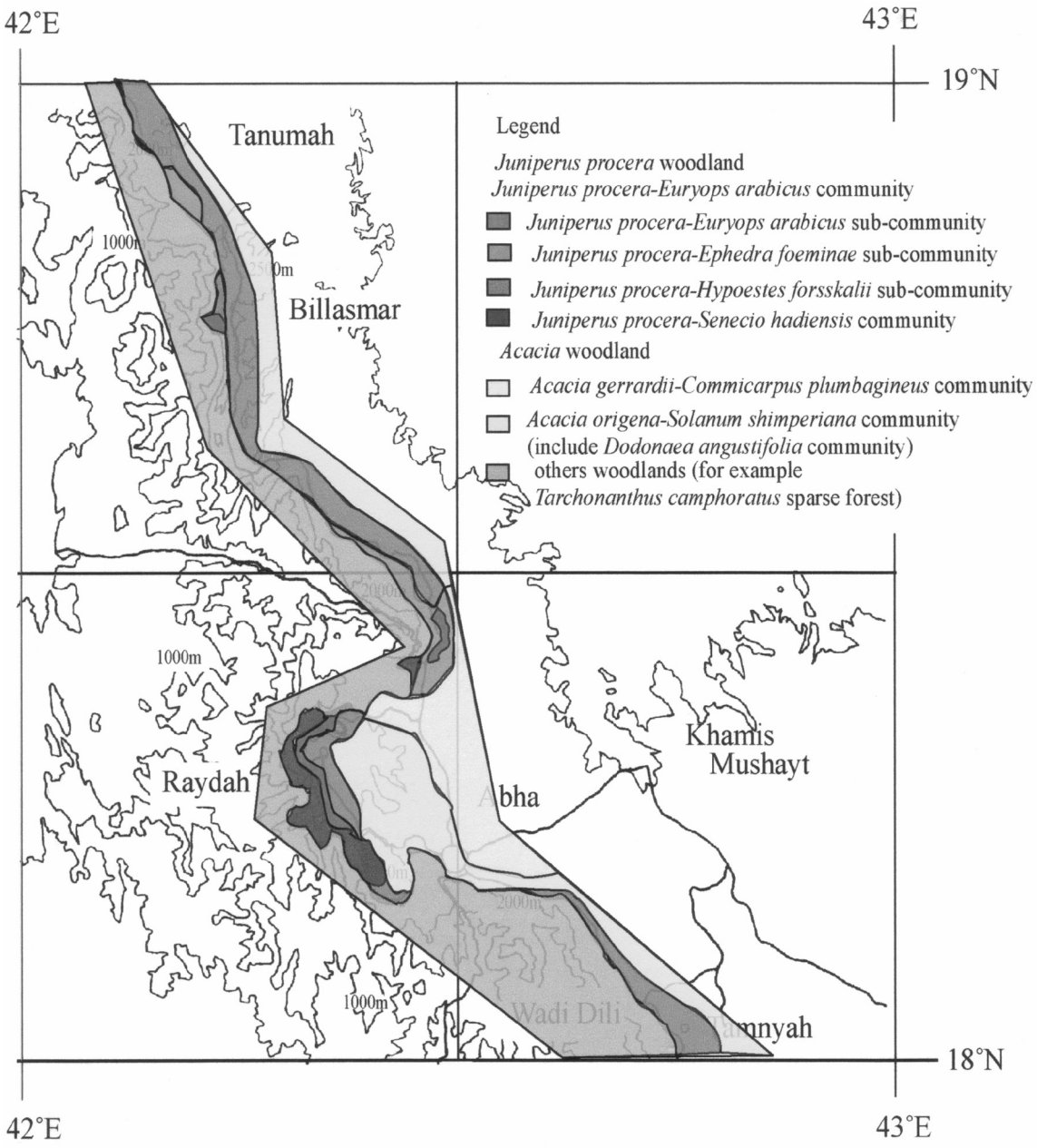


Fig. 7-7 Vegetation map of the research area in Asir mountains

Table 7-1-1 Location data of standss

No.	Locality	latitude	longitude	altitude
1	Raydah, Abha	18° 11,78N	42° 24,47E	2470m
2	Raydah, Abha	18° 11,69N	42° 24,51E	2510m
3	Raydah, Abha	18° 11,74N	42° 24,52E	2480m
4	Sudah, Abha	18° 12,48N	42° 24,53E	2840m
5	Raydah, Abha	18° 12,34N	42° 24,60E	2830m
6	Sudah, Abha	18° 16,51N	42° 21,76E	3025m
7	Sudah, Abha	18° 16,54N	42° 21,75E	3050m
8	Sudah, Abha	18° 16,54N	42° 21,82E	3020m
9	Sudah, Abha	18° 16,75N	42° 21,82E	3040m
10	Sudah, Abha	18° 16,79N	42° 21,81E	3030m
11	Sudah, Abha	18° 17,01N	42° 21,94E	3000m
12	Sudah, Abha	18° 17,16N	42° 21,84E	3000m
13	Sudah, Abha	18° 17,18N	42° 21,83E	2970m
14	Sudah, Abha	18° 17,24N	42° 21,77E	2980m
15	Sudah, Abha	18° 17,16N	42° 21,73E	2970m
16	Sudah, Abha	18° 18,45N	42° 21,08E	2840m
17	Sudah, Abha	18° 17,93N	42° 21,60E	2950m
18	Sudah, Abha	18° 17,92N	42° 21,59E	2940m
19	Sudah, Abha	18° 17,91N	42° 21,56E	2910m
20	Sudah, Abha	18° 18,00N	42° 21,49E	2880m
21	Sudah, Abha	18° 17,96N	42° 21,46E	2900m
22	Sudah, Abha	18° 18,67N	42° 20,77E	2830m
23	Sudah, Abha	18° 18,71N	42° 20,76E	2820m
24	Sudah, Abha	18° 18,80N	42° 20,65E	2830m
25	Between Sudah and Bukhayrah, Abha	18° 14,09N	42° 25,13E	2760m
26	Between Sudah and Bukhayrah, Abha	18° 14,11N	42° 25,11E	2760m
27	Between Sudah and Bukhayrah, Abha	18° 14,19N	42° 25,09E	2730m
28	Between Sudah and Bukhayrah, Abha	18° 14,40N	42° 24,97E	2760m
29	Between Sudah and Bukhayrah, Abha	18° 14,35N	42° 25,02E	2730m
30	Between Sudah and Al-Mahallah, Abha	18° 14,05N	42° 26,93E	2600m
31	Between Sudah and Al-Mahallah, Abha	18° 13,99N	42° 26,89E	2600m
32	Between Sudah and Al-Mahallah, Abha	18° 13,84N	42° 27,06E	2600m
33	Between Sudah and Al-Mahallah, Abha	18° 13,83N	42° 27,14E	2590m
34	Between Sudah and Al-Mahallah, Abha	18° 13,88N	42° 27,08E	2620m
35	Between Sudah and Al-Mahallah, Abha	18° 14,03N	42° 27,28E	2640m
36	Between Sudah and Al-Mahallah, Abha	18° 14,04N	42° 27,93E	2620m
37	Between Sudah and Al-Mahallah, Abha	18° 21,68N	42° 22,98E	2590m
38	Between Sudah and Al-Mahallah, Abha	18° 21,63N	42° 23,04E	2590m
39	Between Sudah and Al-Mahallah, Abha	18° 21,54N	42° 23,07E	2580m
41	Between Sudah and Al-Mahallah, Abha	18° 19,98N	42° 23,66E	2740m
42	Between Sudah and Al-Mahallah, Abha	18° 19,93N	42° 23,69E	2730m
43	Between Sudah and Al-Mahallah, Abha	18° 19,75N	42° 23,66E	2770m
44	Between Sudah and Al-Mahallah, Abha	18° 19,73N	42° 23,59E	2790m
45	Between Sudah and Al-Mahallah, Abha	18° 19,73N	42° 23,56E	2780m
46	Between Sudah and Al-Mahallah, Abha	18° 19,80N	42° 23,50E	2780m
47	Between Sudah and Al-Mahallah, Abha	18° 19,68N	42° 23,73E	2730m
48	Between Sudah and Al-Mahallah, Abha	18° 19,67N	42° 23,79E	2700m
50	Between Sudah and Sugha, Abha	18° 15,65N	42° 23,09E	2940m
51	Sudah, Abha	18° 15,46N	42° 22,34E	3040m
52	Sudah, Abha	18° 15,43N	42° 22,41E	3020m
53	Sudah, Abha	18° 15,40N	42° 22,46E	3040m
54	Sudah, Abha	18° 15,29N	42° 22,42E	3030m
55	Sudah, Abha	18° 15,29N	42° 22,36E	3050m
56	Sudah, Abha	18° 15,30N	42° 22,35E	3050m
57	Sudah, Abha	18° 15,27N	42° 22,42E	3030m
58	Sudah, Abha	18° 15,28N	42° 22,44E	3030m
59	Sudah, Abha	18° 15,73N	42° 22,63E	3050m
60	Sudah, Abha	18° 15,73N	42° 22,61E	3040m
61	Raydah, Abha	18° 12,36N	42° 24,72E	2900m
62	Raydah, Abha	18° 12,33N	42° 24,74E	2930m
63	Raydah, Abha	18° 12,30N	42° 24,72E	2930m
64	Raydah, Abha	18° 12,26N	42° 24,74E	2950m
65	Raydah, Abha	18° 12,18N	42° 24,76E	2890m
66	Raydah, Abha	18° 11,97N	42° 24,87E	2880m

Table 7-1-2 Location data of stands

No.	Locality	latitude	longitude	altitude
67	Raydah, Abha	18° 11,94N	42° 24,88E	2880m
68	Raydah, Abha	18° 11,95N	42° 24,85E	2890m
69	Raydah, Abha	18° 11,95N	42° 24,86E	2890m
70	Raydah, Abha	18° 12,04N	42° 24,77E	2890m
71	Between Sudah and Bukhayrah, Abha	18° 10,71N	42° 26,16E	2860m
72	Between Sudah and Bukhayrah, Abha	18° 10,76N	42° 26,20E	2850m
73	Between Sudah and Bukhayrah, Abha	18° 10,82N	42° 26,18E	2840m
74	Between Sudah and Bukhayrah, Abha	18° 10,80N	42° 26,21E	2810m
75	Between Sudah and Bukhayrah, Abha	18° 10,76N	42° 26,25E	2790m
76	Between Sudah and Bukhayrah, Abha	18° 10,87N	42° 26,24E	2870m
77	Between Sudah and Bukhayrah, Abha	18° 10,89N	42° 26,20E	2790m
78	Between Sudah and Bukhayrah, Abha	18° 10,94N	42° 26,19E	2780m
79	Between Sudah and Bukhayrah, Abha	18° 10,91N	42° 26,23E	2780m
80	Between Sudah and Bukhayrah, Abha	18° 10,87N	42° 26,13E	2780m
81	Between Sudah and Bukhayrah, Abha	18° 10,80N	42° 26,09E	2790m
82	Between Sudah and Bukhayrah, Abha	18° 10,44N	42° 26,14E	2880m
83	Between Sudah and Bukhayrah, Abha	18° 10,46N	42° 26,20E	2820m
84	Between Sudah and Bukhayrah, Abha	18° 12,22N	42° 28,65E	2500m
85	Between Sudah and Bukhayrah, Abha	18° 12,20N	42° 28,74E	2550m
86	Between Sudah and Bukhayrah, Abha	18° 12,15N	42° 28,74E	2570m
87	Between Sudah and Bukhayrah, Abha	18° 11,48N	42° 28,50E	2600m
88	Between Sudah and Bukhayrah, Abha	18° 11,43N	42° 28,51E	2620m
89	Between Sudah and Bukhayrah, Abha	18° 11,38N	42° 28,48E	2620m
90	Between Sudah and Bukhayrah, Abha	18° 11,41N	42° 28,42E	2650m
91	Between Sudah and Bukhayrah, Abha	18° 11,50N	42° 28,58E	2610m
92	Between Sudah and Bukhayrah, Abha	18° 11,29N	42° 28,32E	2610m
93	Between Sudah and Bukhayrah, Abha	18° 11,29N	42° 28,30E	2640m
94	Between Sudah and Bukhayrah, Abha	18° 11,33N	42° 28,34E	2660m
95	Between Sudah and Bukhayrah, Abha	18° 11,37N	42° 28,33E	2640m
96	Al-Mahallah, Abha	18° 22,10N	42° 26,77E	2380m
97	Al-Mahallah, Abha	18° 22,09N	42° 26,79E	2370m
98	Al-Mahallah, Abha	18° 22,05N	42° 26,85E	2360m
99	Al-Mahallah, Abha	18° 22,12N	42° 26,87E	2360m
100	Al-Mahallah, Abha	18° 22,19N	42° 26,86E	2390m
101	Al-Mahallah, Abha	18° 22,28N	42° 26,82E	2400m
102	Al-Mahallah, Abha	18° 22,39N	42° 26,84E	2380m
103	Al-Mahallah, Abha	18° 22,42N	42° 26,85E	2400m
104	Al-Mahallah, Abha	18° 22,15N	42° 26,35E	2380m
105	Al-Mahallah, Abha	18° 22,10N	42° 26,46E	2400m
106	Al-Mahallah, Abha	18° 22,09N	42° 26,50E	2400m
107	Al-Mahallah, Abha	18° 22,18N	42° 26,50E	2390m
108	Between Bukhayrah and Al-Mahallah, Abha	18° 19,47N	42° 22,98E	2680m
109	Between Bukhayrah and Al-Mahallah, Abha	18° 19,48N	42° 23,96E	2680m
110	Between Bukhayrah and Al-Mahallah, Abha	18° 19,50N	42° 23,91E	2670m
111	Between Bukhayrah and Al-Mahallah, Abha	18° 19,58N	42° 23,93E	2710m
112	Between Bukhayrah and Al-Mahallah, Abha	18° 19,57N	42° 24,03E	2700m
113	Between Bukhayrah and Al-Mahallah, Abha	18° 19,58N	42° 24,06E	2700m
114	Between Bukhayrah and Al-Mahallah, Abha	18° 19,61N	42° 24,08E	2710m
115	Between Bukhayrah and Al-Mahallah, Abha	18° 19,63N	42° 24,11E	2740m
116	Between Bukhayrah and Al-Mahallah, Abha	18° 19,67N	42° 24,12E	2740m
117	Between Bukhayrah and Al-Mahallah, Abha	18° 19,72N	42° 24,15E	2720m
118	Between Bukhayrah and Al-Mahallah, Abha	18° 19,78N	42° 24,12E	2710m
119	Between Bukhayrah and Al-Mahallah, Abha	18° 22,21N	42° 23,88E	2600m
120	Between Bukhayrah and Al-Mahallah, Abha	18° 22,26N	42° 23,86E	2630m

Table 7-1-3 Location data of standss

No.	Locality	latitude	longitude	altitude
121	Between Bukhayrah and Al-Mahallah, Abha	18° 22,28N	42° 23,78E	2640m
122	Between Bukhayrah and Al-Mahallah, Abha	18° 22,29N	42° 23,73E	2660m
123	Between Bukhayrah and Al-Mahallah, Abha	18° 22,28N	42° 23,72E	2650m
124	Between Bukhayrah and Al-Mahallah, Abha	18° 22,26N	42° 23,61E	2620m
125	Between Bukhayrah and Al-Mahallah, Abha	18° 22,19N	42° 23,52E	2560m
126	Between Bukhayrah and Al-Mahallah, Abha	18° 22,15N	42° 23,52E	2550m
127	Between Bukhayrah and Al-Mahallah, Abha	18° 22,15N	42° 23,58E	2550m
128	Between Bukhayrah and Al-Mahallah, Abha	18° 22,11N	42° 23,50E	2540m
129	Between Bukhayrah and Al-Mahallah, Abha	18° 22,19N	42° 23,59E	2550m
130	Between Bukhayrah and Al-Mahallah, Abha	18° 21,96N	42° 23,71E	2600m
131	Al-Kamar north of Abha, A'sir	18° 37,20N	42° 16,37E	2730m
132	Al-Kamar north of Abha, A'sir	18° 37,20N	42° 16,39E	2750m
133	Al-Kamar north of Abha, A'sir	18° 37,19N	42° 16,41E	2730m
134	Al-Kamar north of Abha, A'sir	18° 37,19N	42° 16,42E	2730m
135	Al-Kamar north of Abha, A'sir	18° 37,16N	42° 16,52E	2700m
136	Al-Kamar north of Abha, A'sir	18° 37,14N	42° 16,59E	2720m
137	Al-Kamar north of Abha, A'sir	18° 37,15N	42° 16,62E	2700m
138	Al-Kamar north of Abha, A'sir	18° 37,19N	42° 16,64E	2750m
139	Al-Kamar north of Abha, A'sir	18° 37,16N	42° 16,62E	2780m
140	Al-Kamar north of Abha, A'sir	18° 37,02N	42° 16,65E	2770m
141	Sudah, Abha	18° 14,22N	42° 24,83E	2770m
142	Sudah, Abha	18° 14,23N	42° 24,58E	2780m
143	Sudah, Abha	18° 14,27N	42° 24,87E	2770m
144	Sudah, Abha	18° 14,32N	42° 24,37E	2800m
145	Sudah, Abha	18° 14,36N	42° 24,82E	2810m
146	Sudah, Abha	18° 14,31N	42° 24,88E	2810m
147	Sudah, Abha	18° 14,23N	42° 24,92E	2810m
148	Sudah, Abha	18° 14,24N	42° 24,94E	2820m
149	Sudah, Abha	18° 14,36N	42° 24,76E	2830m
150	Sudah, Abha	18° 14,32N	42° 24,75E	2840m
151	Between Sudah and Bukhayrah, Abha	18° 14,18N	42° 25,39E	2800m
152	Between Sudah and Bukhayrah, Abha	18° 14,20N	42° 25,39E	2790m
153	Between Sudah and Bukhayrah, Abha	18° 14,29N	42° 25,40E	2800m
154	Between Sudah and Bukhayrah, Abha	18° 14,27N	42° 25,48E	2800m
155	Between Sudah and Bukhayrah, Abha	18° 14,21N	42° 25,51E	2820m
156	Between Sudah and Bukhayrah, Abha	18° 14,19N	42° 25,47E	2810m
157	Between Sudah and Bukhayrah, Abha	18° 14,19N	42° 25,43E	2810m
158	Between Sudah and Bukhayrah, Abha	18° 14,28N	42° 25,33E	2810m
159	Between Sudah and Bukhayrah, Abha	18° 14,23N	42° 25,32E	2830m
160	Between Sudah and Bukhayrah, Abha	18° 14,17N	42° 25,30E	2840m
161	Between Sudah and Bukhayrah, Abha	18° 14,19N	42° 27,07E	2630m
162	Between Sudah and Bukhayrah, Abha	18° 14,25N	42° 27,06E	2640m
171	Sugha, Abha	18° 14,26N	42° 23,61E	2920m
172	Sugha, Abha	18° 14,27N	42° 23,57E	2920m
173	Sugha, Abha	18° 14,24N	42° 23,59E	2930m
174	Sugha, Abha	18° 14,25N	42° 23,54E	2990m
175	Sugha, Abha	18° 14,12N	42° 27,07E	2660m
176	Sugha, Abha	18° 14,10N	42° 27,09E	2650m
177	Sugha, Abha	18° 14,08N	42° 27,13E	2650m
178	Sugha, Abha	18° 14,03N	42° 27,06E	2630m
179	Sugha, Abha	18° 14,01N	42° 27,07E	2630m
180	Sugha, Abha	18° 19,10N	42° 20,51E	2820m
181	Sudah, Abha	18° 12,09N	42° 26,32E	2660m
182	Sugha, Abha	18° 12,09N	42° 26,34E	2670m
183	Al-Mahallah, Abha	18° 21,83N	42° 24,28E	2450m
184	Al-Mahallah, Abha	18° 13,06N	42° 26,50E	2550m
185	Tanumah, north of Abha, A'sir	18° 52,83N	42° 10,14E	2460m
186	Tanumah, north of Abha, A'sir	18° 52,81N	42° 10,16E	2480m
187	Tanumah, north of Abha, A'sir	18° 52,86N	42° 10,14E	2460m
188	Tanumah, north of Abha, A'sir	18° 52,92N	42° 10,15E	2450m
189	Tanumah, north of Abha, A'sir	18° 52,96N	42° 10,18E	2480m
190	Tanumah, north of Abha, A'sir	18° 52,83N	42° 10,17E	2460m

Table 7-1-4 Location data of stands

No.	Locality	latitude	longitude	altitude
191	Tanumah, north of Abha, A'sir	18° 53,60N	42° 10,80E	2450m
192	Tanumah, north of Abha, A'sir	18° 53,65N	42° 10,81E	2440m
193	Tanumah, north of Abha, A'sir	18° 54,44N	42° 12,69E	2430m
194	Tanumah, north of Abha, A'sir	18° 54,51N	42° 12,73E	2450m
195	Tanumah, north of Abha, A'sir	18° 54,47N	42° 12,23E	2440m
196	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,97N	42° 14,28E	2660m
197	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,94N	42° 14,28E	2650m
198	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,93N	42° 14,30E	2650m
199	Between Tanumah and Billasmar, north of Abha, A'sir	18° 52,01N	42° 14,28E	2640m
200	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,41N	42° 14,48E	2710m
201	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,44N	42° 14,48E	2690m
202	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,46N	42° 14,46E	2660m
203	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,47N	42° 14,44E	2650m
204	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,41N	42° 14,41E	2640m
205	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,35N	42° 14,45E	2630m
206	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,31N	42° 14,42E	2640m
207	Between Tanumah and Billasmar, north of Abha, A'sir	18° 51,31N	42° 14,50E	2650m
208	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,07N	42° 15,38E	2710m
209	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,06N	42° 15,38E	2720m
210	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,08N	42° 15,41E	2750m
211	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,10N	42° 15,39E	2760m
212	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,13N	42° 16,23E	2600m
213	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,18N	42° 16,30E	2620m
214	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,35N	42° 16,35E	2640m
215	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,22N	42° 16,40E	2650m
216	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,16N	42° 16,37E	2660m
217	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,15N	42° 16,33E	2650m
218	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,05N	42° 16,34E	2690m
219	Between Tanumah and Billasmar, north of Abha, A'sir	18° 50,02N	42° 16,29E	2670m
220	Between Tanumah and Billasmar, north of Abha, A'sir	18° 49,16N	42° 16,22E	2650m
221	Between Tanumah and Billasmar, north of Abha, A'sir	18° 49,98N	42° 16,18E	2640m
222	Between Tanumah and Billasmar, north of Abha, A'sir	18° 45,83N	42° 15,42E	2580m
223	Between Tanumah and Billasmar, north of Abha, A'sir	18° 45,84N	42° 15,45E	2600m
224	Between Billasmar and Ebalah, north of Abha, A'sir	18° 43,84N	42° 15,42E	2620m
225	Between Billasmar and Ebalah, north of Abha, A'sir	18° 43,38N	42° 15,50E	2650m
226	Between Billasmar and Ebalah, north of Abha, A'sir	18° 43,36N	42° 15,52E	2660m
227	Between Billasmar and Ebalah, north of Abha, A'sir	18° 43,35N	42° 15,53E	2660m
228	Ebalah, north of Abha, A'sir	18° 40,53N	42° 14,76E	2660m
229	Ebalah, north of Abha, A'sir	18° 40,54N	42° 14,77E	2670m
230	Ebalah, north of Abha, A'sir	18° 40,51N	42° 14,80E	2710m
231	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 40,06N	42° 14,63E	2760m
232	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 40,05N	42° 14,66E	2770m
233	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 39,94N	42° 14,56E	2780m
234	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 39,94N	42° 14,53E	2780m
235	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 39,93N	42° 14,49E	2800m
236	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 39,98N	42° 14,46E	2810m
237	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,38N	42° 15,57E	2810m
238	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,40N	42° 15,60E	2790m
239	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,42N	42° 15,61E	2770m
240	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,42N	42° 15,64E	2790m,
241	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,44N	42° 15,67E	2810m
242	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,25N	42° 15,62E	2780m
243	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,69N	42° 17,08E	2760m

Table 7-1-5 Location data of stands

No.	Locality	latitude	longitude	altitude
244	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,63N	42° 17,08E	2760m
245	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,61N	42° 17,06E	2770m
246	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,51N	42° 17,04E	2800m
247	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,38N	42° 17,08E	2850m
248	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,06N	42° 17,00E	2830m
249	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,02N	42° 17,06E	2790m
250	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,00N	42° 17,03E	2800m
251	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 36,99N	42° 16,98E	2820m
252	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,00N	42° 16,93E	2850m
253	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,92N	42° 17,16E	2760m
254	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,86N	42° 17,16E	2650m
255	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,38N	42° 17,18E	2810m
256	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,26N	42° 17,36E	2790m
257	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,20N	42° 17,50E	2770m
258	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,20N	42° 17,61E	2750m
259	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,27N	42° 17,68E	2730m
260	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,32N	42° 17,71E	2730m
261	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,45N	42° 17,79E	2720m
262	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,57N	42° 17,94E	2690m
263	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,59N	42° 18,05E	2650m
264	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,66N	42° 18,04E	2660m
265	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,69N	42° 18,01E	2660m
266	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,70N	42° 17,89E	2660m
267	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,58N	42° 17,84E	2670m
268	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,41N	42° 17,73E	2710m
269	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,33N	42° 20,07E	2610m
270	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,35N	42° 20,00E	2590m
271	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,37N	42° 19,98E	2590m
272	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,30N	42° 20,01E	2600m
273	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,13N	42° 20,32E	2660m
274	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,17N	42° 20,36E	2700m
275	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,16N	42° 20,42E	2710m
276	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,14N	42° 20,48E	2670m
277	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,06N	42° 20,55E	2650m
278	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,03N	42° 20,64E	2630m
279	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 37,07N	42° 20,63E	2650m
280	Between Ebalah and Al-Kamar, north of Abha, A'sir	18° 36,48N	42° 20,32E	2650m
281	Tamnyah, Abha	18° 00,11N	42° 45,44E	2580m
282	Tamnyah, Abha	18° 00,20N	42° 45,34E	2610m
283	Tamnyah, Abha	18° 00,23N	42° 45,30E	2610m
284	Tamnyah, Abha	18° 00,23N	42° 45,34E	2620m
285	Tamnyah, Abha	18° 00,23N	42° 45,41E	2640m
286	Tamnyah, Abha	18° 00,20N	42° 45,48E	2640m
287	Tamnyah, Abha	18° 00,13N	42° 45,52E	2630m
288	Tamnyah, Abha	18° 00,46N	42° 46,05E	2560m
289	Tamnyah, Abha	18° 00,46N	42° 46,11E	2570m
290	Tamnyah, Abha	18° 00,49N	42° 46,07E	2560m
291	Tamnyah, Abha	18° 01,21N	42° 46,06E	2430m
292	Tamnyah, Abha	18° 01,15N	42° 45,94E	2450m
293	Tamnyah, Abha	18° 01,16N	42° 45,98E	2430m
294	Tamnyah, Abha	18° 01,12N	42° 45,97E	2460m
295	Tamnyah, Abha	18° 01,06N	42° 45,92E	2450m
296	Tamnyah, Abha	18° 01,04N	42° 45,92E	2460m

Table 7-1-6 Location data of stands

No.	Locality	latitude	longitude	altitude
297	Tamnyah, Abha	18° 00,96N	42° 45,92E	2510m
298	Tamnyah, Abha	18° 00,92N	42° 45,95E	2550m
299	Tamnyah, Abha	18° 00,45N	42° 42,97E	2550m
300	Tamnyah, Abha	18° 01,00N	42° 45,95E	2530m
302	Ghara, Abha	18° 08,05N	42° 40,14E	2340m
303	Ghara, Abha	18° 08,01N	42° 40,12E	2330m
304	Ghara, Abha	18° 07,97N	42° 40,09E	2340m
305	Ghara, Abha	18° 07,99N	42° 40,04E	2340m
306	Ghara, Abha	18° 08,14N	42° 40,04E	2340m
307	Ghara, Abha	18° 08,11N	42° 40,28E	2320m
308	Ghara, Abha	18° 08,13N	42° 40,29E	2320m
309	Tamnyah, Abha	18° 01,15N	42° 46,17E	2460m
310	Tamnyah, Abha	18° 01,13N	42° 46,21E	2470m
311	Tamnyah, Abha	18° 01,17N	42° 46,22E	2480m
312	Tamnyah, Abha	18° 01,20N	42° 46,26E	2510m
313	Tamnyah, Abha	18° 01,21N	42° 46,27E	2520m
314	Tamnyah, Abha	18° 01,20N	42° 46,32E	2550m
315	Tamnyah, Abha	18° 01,19N	42° 46,35E	2580m
316	Tamnyah, Abha	18° 01,23N	42° 46,32E	2570m
317	Tamnyah, Abha	18° 01,24N	42° 46,29E	2570m
318	Tamnyah, Abha	18° 01,23N	42° 46,16E	2500m
319	Tamnyah, Abha	18° 01,08N	42° 46,12E	2460m
320	Tamnyah, Abha	18° 01,05N	42° 46,09E	2500m
322	Raydah, Abha	18° 11,61N	42° 23,51E	1960m
323	Raydah, Abha	18° 12,68N	42° 23,65E	2000m
324	Raydah, Abha	18° 11,68N	42° 2375E	2000m
325	Raydah, Abha	18° 11,60N	42° 23,84E	2100m
326	Raydah, Abha	18° 11,61N	42° 23,83E	2000m
327	Raydah, Abha	18° 11,81N	42° 24,04E	2200m
328	Raydah, Abha	18° 11,78N	42° 24,02E	2200m
329	Raydah, Abha	18° 11,82N	42° 24,49E	2500m
330	Raydah, Abha	18° 11,80N	42° 24.50E	2500m
331	Raydah, Abha	18° 11,81N	42° 24.51E	2500m
332	Raydah, Abha	18° 11,91N	42° 24,56E	2600m
333	Raydah, Abha	18° 11,92N	42° 24,56E	2600m
334	Raydah, Abha	18° 11,94N	42° 24,55E	2600m
335	Raydah, Abha	18° 12,18N	42° 24,54E	2700m
336	Raydah, Abha	18° 12,14N	42° 24,56E	2700m
337	Raydah, Abha	18° 12,16N	42° 24,55E	2700m
338	Raydah, Abha	18° 12.37N	42° 24,62E	2880m
339	Raydah, Abha	18° 12,28N	42° 24,59E	2800m
340	Raydah, Abha	18° 12,24N	42° 24,61E	2800m
341	Raydah, Abha	18° 12,24N	42° 24,60E	2800m
342	Between Sudah and Bukhayrah, Abha	18° 12,22N	42° 28,73E	2500m
343	Raydah, Abha	18° 11,78N	42° 24,06E	2330m
344	Raydah, Abha	18° 11,75N	42° 24,15E	2310m
345	Raydah, Abha	18° 11,76N	42° 24,11E	2290m
346	Raydah, Abha	18° 11,67N	42° 24,31E	2400m
347	Raydah, Abha	18° 11,75N	42° 24,30E	2400m