

8 Social Importance of the Junipers

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8.1 Introduction

The aim of this research is to clarify the social importance of the juniper in order to set an appropriate plan for conservation of the juniper woodlands. Resources would be sustainable only if both the condition of the ecosystem and the human condition are satisfactory or improving.

One of the possible causes of death or decline of the junipers has been thought to be human disturbances such as farming, stock raising and construction activities. The relationship between human factors and the die-back and die-off phenomena of *Juniperus procera* needs to be carefully examined in local context.

What are the main resources supplied by this ecosystem? So far, little is known about local peoples' knowledge and their small scale subsistence use of wild species of plants and animals in the juniper woodlands. Traditional ecological knowledge (TEK) may help to assess the economic values and the sustainability of uses of wild species.

At the same time, the study of a contemporary situation of the traditional resource management system in this region is critical to know what is required to achieve long term sustainability of natural resources and community development. It also illustrates the relevance and applicability of indigenous strategies to global sustainability.

8.2 Methodology

Data collection methods are interviews of key informants and groups of adults with questionnaires, and direct observations on any kinds of human activities in the juniper woodlands. I carried out a comprehensive field study intensively in the surrounding area of the Raydah Nature Reserve, and additionally in the Abha markets, in cooperation with two staff members of NCWCD; Muhammad Ahmad Asiri (55 years old, head of rangers and farmer in Raydah village) and Rabia Abd al-Rahman Hasanin (41 years old, agricultural technician).

First, I grasped social conditions of subsistence economy and human life in general. In particular, I observed cultivation, stock-breeding and honey-collecting both in Raydah village (< 1800m) and al-Siga village (> 2500m) located below and above the Raydah Nature Reserve.

Secondly, I interviewed the local people to make an adequate evaluation of the types of use (e.g., building material or fuelwood cutting), levels of use (e.g., numbers and places of cutting), manner of use (e.g., permission, restriction or prohibition in particular periods) of *Juniperus procera* and other plant resources as well as animal resources.

Thirdly, I also made some literature researches in the libraries in al-Riyadh and Abha, in order to get some information on the history, social organization, and natural resources utilization of the Asir Mountain areas. My

research periods lasted from 7 September to 14 November, 2001.

8.3 Results

8.3.1 Human life in the juniper woodlands

1. When did people start to recognize "juniper" and "juniper woodlands"?

Strabo, who accompanied Aelius Galus, the Roman general, in his campaign against the Sabaians and their capital Marib in 25-24 B.C., named the region just north of Negrana, the present Najran, "Ararena", the land of *arar*, which must mean the juniper (Abdulfattaha 1981: 17-18).

The name of *arar* has meant juniper in Arabic literature to this date. For example, al-Dinawari, a natural historian in the medieval times, explained a lot about *arar* in his "Book of Plants (Kitab al-Nabat)", and many other plants of Southwestern Mountains of Arabian Peninsula (Jrais 1994: 38).

As these historical resources taught us, people did recognize juniper at least two thousand years ago, and have lived in juniper woodlands and used it for many purposes.

In the following sections, I survey human life in general, focusing on social conditions of subsistence economy in juniper woodlands. Cultivation, stock-breeding and honey-collecting are observed both in Raydah village in Tuhama (< 1800m) and al-Siga village in al-Sarat (> 2500m) located below and above the Raydash Nature Reserve.

The people used to stay in al-Sarat for six months of summer and in Tuhama for six months of winter. Therefore, many of them have two dwelling houses; one in al-Sarat and another one in Tuhama. Now, it became much easier for them to come and go between these two places by car. Many families stay in houses in Tuhama at weekends, when their children have no school. It is because schools are located in al-Siga village in al-Sarat, though they used to have traditional schools at mosque in Raydah village before. In these areas, the people use two terms as seasons of year; *rabia* (that normally indicates spring of four seasons) and *saif* (that normally indicates winter of four seasons). *Rabia* means relatively cold months between December and April, and *saif* means relatively hot months between May and November.

2. Cultivation

Many kinds of agricultural products are harvested mainly for domestic use (Table 8-1).

1) In the Raydah village

Two grains, *dhurah* (sorghum; *Sorghum bicolor*) and *dukhn* (bulrush millet; *Pennisetum americanum*), are cultivated here. *Dhurah* has two kinds of brands; *dhurah hamra'* (red sorghum) and *dhurah baida'* (white sorghum), that are slightly different in terms of tastes. Farmers sow these grains in June after rain, and harvest in October. Some farmers also cultivate *sha'ir* (barley; *Hordeum vulgare*) in winter.

Farms are fenced to prevent entry of cattle, goats, baboons and Indian porcupine. The farmers also cultivate

muz (banana; *Musa acuminata*), *fasuliya* (common bean; *Phaseolus vulgaris*) and *gutah* (tomato; *Lycopersicon esculentum*), using waters from wells.

In addition to these crops, we can also see trees of *bunn* (coffee; *Coffea arabica*), *limun* (lemon; *Citrus limon*) *kadi* (screw-pine; *Pandanus tectorius*) of which the aromatic flowers are taken for houses, and *hinna'* (henna; *Lawsonia inermis*), of which a traditional cosmetic powder is obtained from leaves and stalks. Almost all the crops and other agricultural products are for domestic consumption.

Local farmers have been using a plow, *mahrath yadawi*, that is pulled by two bulls. But many farmers started to use tractors now. For instance, Muhammad Ahmad al-Zulmani (80 years old, farmer in Raydah village) is still using a plow. He made the plow by himself six years ago. He processed the wood of *itum* (*Olea europaea*), that had cut before that time. The plow of *itum* lasts about fifty years, if they take care of it well.

Alab or *sidr* (*Ziziphus spina-christi* var. *inermis*), *talh* (*Acacia origena* and *Acacia gerrardii*), *shabarik* (*Celtis africana*), *durm* (*Teclea nobilis*), *shariyan* (not identified) can be processed to local plow, other than *itum*. He build a small watch house, called *isshah* or *wakur*, that is made of trunks of *gummar* (*Tarchonanthus camphoratus*) and lumbers called *hashab abyad* and is roofed with straw of bulrush millet. He uses *marjama* (stone throwing tool), *mishab* (wooden stick) and *mafga* (whip) to get rid of birds from farms. We can also observe *khaiyal al-magat* (scarecrow).

Grains of sorghum and bulrush millet are ground into flour, and mixed with those of wheat and barley, and cooked with hot water until this become chunk. These are eaten with meat soup, honey, or milk. This dish is called *asid*. Straws of sorghum and bulrush millet are dried in the sun and given to cattle and goats.

Many owners of farms employ one or two foreign workers from Ethiopia, Eritrea or Yemen. They teach them every kind of works of cultivation, and the owners often work with them.

2) Inside the Raydah Nature Reserve

Inside the Raydah Nature Reserve, there are farms that had been cultivated before the time when the Reserve was established. They used to cultivate *jirjir* (rocket-salad; *Eruca vesicaria*), *fujl* (radish; *Raphanus sativus*), *basal* (onion; *Allium cepa*), *thum* (garlic; *Allium sativum*), *khas* (lettuce; *Lactuca sativa*) in winter. Two kinds of sorghum, tomato, *kusa* (summer squash; *Cucurbita pepo*), *batatis* (potato; *Solanum tuberosum*), *qara* (pumpkin; *Cucurbita* sp.), *khiyar* (cucumber; *Cucumis sativus*), *jazar* (carrot; *Daucus carota*), *bazinjan* (eggplant; *Solanum melongena*), *bamiya* (okra; *Abelmoschus esculentus*), *ful* (broad bean; *Vicia faba*) and common bean were for the summer.

But the farms have been targets of wild animals. According to Mahabub Ahmad Masud (school teacher, one of the owners of a farm inside the Raydah Nature Reserve), for example, Hamadryas baboon especially likes to dig and eat tomato, summer squash, potato and pumpkin. Rats and mice, Indian porcupine, ratel and black hedgehog also eat some of these vegetables. Furthermore, many kinds of birds a source of worry to the farmers,

too. The owners, now, are willing to hand over these farms, and on the way of negotiation with NCWCD.

3) In the al-Siga village

Farmers in this village cultivate *burr* or *gamh* (wheat; *Triticum* sp.), barley and *adas* (lentil; *Lens esculenta*) in winter. In December, they start cultivating from wheat, then lentil, and finally barley. Wheat takes about six months, lentil five month, and barley four or four and half month of periods. Some farmers also cultivate sorghum, some vegetables such as tomato and common bean in summer. Their traditional bread is called *gors* that is a mixture of flours of wheat, barley, sorghum, bulrush millet and lentil.

3. Stock-breeding

1) In the Raydah village

Cattle and goats are kept in the Raydah village. As far as cattle are concerned, people milk cows for domestic use and they use bulls and oxen as work power of plowing. They usually do not castrate male cattle up to ten years old, which is called *sadas*. An individual animal that always has trouble with people can be castrated, when it reaches over the age of two.

For example, Muhammad Ahmad al-Zulmani owns nine heads of cattle (three bulls, three cows and three calves). All animals are kept mainly in al-Siga village, and bulls are taken to Raydah village for the work of plowing in May. They are sometimes brought down to Raydah village at cold times in winter and spring.

Goats are for meat. For example, my counterpart, Muhammad Ahmad Asiri (head of rangers) is taking care of about two hundred goats in the Raydah village. Two head are left for mating male, and all heads of the rest of males are castrated. One adult goat can be sold to Abha market in approximately four hundred Riyal. Some parts of straws of sorghum and bulrush millet are bought in markets with ten or twelve Riyal for one bundle, and fed to goats. Purchased grains of barley are also given to goats.

Many of herders of goats would be foreign workers from Ethiopia, Eritrea, and Yemen. For example, Muhammad Ahmad Asiri has been employing an Eritrean origin Ethiopian for thirteen years. The employee is about thirty years old.

Before the construction of a new vehicle road about twenty years ago, the people used to breed camels and donkeys to carry human beings, luggage, and wood. Now almost all the people have stopped using animals because they can use a car instead. Only one person, Abdallah Muhammad Muadi (63 years old, farmer in al-Mathabah and al-Siga village) had kept a donkey to use until September 2001 in al-Mathabah village, because his house is located at a place that is inaccessible by motor car. He went from the point that could be reached by car to his house with a donkey, taking thirty to sixty minutes to complete the journey.

We can see camels in the Raydah village, but their owner lives in the Tuhama area.

There were two old mountain roads connecting Tuhama and al-Sarat. One is called *Aqabat Ghaitan* that

connects al-Mathabah and al-Siga. It took approximately four hours to reach al-Siga by donkey or camel. The other road is called *Aqabat Raydah* and connects Raydah and al-Siga. These old roads had been used until the time a new car road was made approximately twenty years ago. We can still observe cattle excrement on the *Aqabat Raydah* Road.

In the past people had more livestock than now. But now, cattle have lost their importance as plow power, as well as milk and meat producer, because the villagers depend on tractors for farming and industrial milk products. Goats, that used to provide milk, butter, and meat have also decreased in number, because children started to go to schools instead of herding them. Goats are now for domestic consumption and sold in the market primarily for meat.

A few chickens are also bred in the village.

2) Inside the Raydah Nature Reserve

The owners of a farm inside the Raydah Nature Reserve are not permitted to have livestock such as goats and cattle, because of effects on the vegetation and wildlife in the reserve.

We can see old traditional houses made of juniper and stones. These are used as goat-keeping houses seasonally until sixty or sixty-five years ago.

3) In the al-Siga village

Cattle, goats, and sheep are kept in the Raydah village.

Herders of goats and sheep would be young men, old men, or even women. Some of herders are foreign workers from Eritrea, Yemen or India.

4. Bee-keeping and honey-collecting

Bee-keeping and honey-collecting have been one of the most important subsistence economy in this area. They keep honeybees (*Apis mellifera yemenitica*) with a traditional form of a beehive that is called *ud nahl*.

Its length is about one meter with approximately forty centimeter in diameter. The woods are taken from many kinds of trees such as *talh* (*Acacia origena* and *Acacia gerrardii*), *arar* (*Juniperus procera*), *ibra'* (*Ficus sycomorus*), *itum* (*Olea europaea* subsp. *cuspidata*) in these areas, and *labukh* (*Mimusops laurifolia*) and *arab* (*Dracaena serrulata*) in lower Tuhama areas.

It needs to dry up woods under sunshine for about one year after collecting, particularly if that trunk was taken from healthy trees. Beekeeper make them by themselves with sickle and iron drill. At first, they make a hole in the middle of wood. At that time, it needs to leave two parts called *khailan* and *kal*. *Khailan* is a part protruding from a lower parts of beehive, that is for bees to come to stop and enter inside. *Kal* is a cover of beehive, which allows bees to enter at small holes found at the bottom.

Now we can also purchase beehives in the market. The price would be between 300 and 1000 Riyal, depending on the size of wood. Some of them are made not with native wood, but with pieces of processed wood imported from other places. This wood can be used as *ud nahl* for many years; more than twenty years until seventy years, when they take care well.

They collect honey from beehives usually at night with a flashlight. At that time, they make a fire with a dried excrement of cattle and smoke with a piece of cloth in order to let bees inactive. After taking disk-like shaped comb filled with honey, they put back a cover on beehives carefully. If they do not cover them well, bees would be dead because of coldness. The honeycomb can be put under sunshine for a while. Then, they press and filter honey with fabric such as a piece of cloth with some holes.

In markets of Asir region, there are three kinds of honey from different nectar plants; *asal sidr*, *asal shukah*, and *asal majra*. The first kind, *asal sidr*, means honey of *sidr* (*Ziziphus spina-christi* var. *inermis*) (Table 8-2). Its color is brown. The second kind, *asal shukah*, means honey of thorny shrubs such as acacia. Its color is yellowish brown. The third kind, *asal majra*, means honey of shrubs and herbs along the riverbed pouring down a water. Its color is whitish yellow or white. The prices of *asal sidr*, *asal shukah*, and *asal majra* are 150, 200, 400 Riyal per one kilogram. The honeycomb of *asal majra* costs 250 Riyal per one kilogram.

Many villagers have three to ten beehives. There would be more than one hundred of beehives set on the study areas, I suppose. Almost all of them would be consumed by villagers domestically. People can collect honey once or twice a year, depending on rains that let the land be filled with flowers. In a good year, they can get six kilogram per year per one beehive.

On the other hand, in lower Tuhama areas, there are more beehives; some of which are managed by a company that often produces honey from sugar-fed bees by putting soft drinks beside beehives.

Generally speaking, seasons of collecting and kinds of honey differ in following places.

1) In the Raydah village

In the Raydah village, they collect honey approximately in October. The color of honey is yellowish brown or dark brown.

For example, Muhammad Ahmad Asiri has eight beehives. He kept four of them inside the concrete house that has 4.5 m in width, 3 m in depth, 2 m in height. The rest of these are put on a roof of that house, covered carefully with pieces of clothes and iron shield.

2) Inside the Raydah Nature Reserve

Inside the Raydah Nature Reserve, they collect honey approximately in September. The color of honey is yellowish brown.

For example, I identified eight beehives on a tree of *talig* (*Ficus vasta*), located at about thirty meters from the road in the altitude of approximately 1950 m. The tree has a trunk of two meters in circumference and ten meters in height.

These beehives are supported with dead branches of *arar* (*Juniperus procera*), *talh* (*Acacia origena* and *Acacia gerrardii*) and *garad* (*Acacia etbaica*). They also cover the beehives with pieces of clothes, parts of tents or plastic bags, put an iron shield on it, and tie up all together with ropes (Table 8-3).

We also identified four beehives on a tree of *ibra'* (*Ficus sycomorus*), located at about ten meters from the road in the altitude of approximately 1900 m.

3) In the al-Siga village

In the al-Siga village, they collect honey approximately in August. The color of honey is whitish yellow or yellowish brown.

8.3.2 Economic value of the junipers and the woodlands

1. Why haven't the junipers and the woodlands disappeared?

Almost all civilizations in the past, it is suggested, have ruined themselves by over-exploitation of natural resources of surrounding areas. Interestingly, however, this historical tragedy does not apply to the area around the Raydah Nature Reserve.

Both al-Siga and Raydah were capitals of the whole Asir areas in the middle of 19th century. When al-Amir/ Said b. Mushlat al-Maghidi revolted against the regime of al-Sharif Muhammad b. Abd al-Muin b. Awan in Asir in 1823 (1238 H.), he took his village known as al-Siga as a capital city for his power. In the year of 1826 (1241 H.), al-Amir/ Ali. b. Mushlat al-Maghidi took his position and made the first governmental fortress at Abha. After seven years of his rule, Amir/ Aid b. Marai seized his position and started to govern lands of Asir in 1833 (1249 H.). Then during the ruling times of Aid and his son Muhammad, all of the military bases were settled in al-Siga and Raydah in order to watch the Ottoman forces (Jrais 1999: 19-24). In fact, historical resources recorded many battles took place between the Ottoman forces and the peoples of al-Siga and Raydah during their ruling times between the year of 1833 and 1872 (Asiri 1986).

We can still see ruins of their castles in Raydah village. Two castles of Aid b. Marai and Muhammad b. Aid stand together. These are nicknamed by the local people as *Mushurif* and *Alma*, that are the names of their neighboring tribes. Furthermore, two castles of Ali b. Mujattal are also located there. One of them is at the border of the contemporary Raydah Nature Reserve, and that is nicknamed as *Gahatan*. Another one, nicknamed as *Shaharan*, is reused as a part of a modern house, and inhabited by Said b. Aid Al Mujattal, the head of al-Siga areas. The wood of junipers is used as a part of these castles with orderly constructed stones.

In spite of these historical circumstances, the nature in this area has been kept in a good shape. That is the reason why a part of this area was chosen as a natural reserve. Such a contradiction, at first sight, makes us more

curious to know the social utilization of natural resources in the juniper woodlands, especially the Raydah Nature Reserve.

2. Animal hunting

Here, I would discuss the reasons why they used to hunt wild animals in these areas, in order to see their relation with wild and domesticated animals. I mainly depend on the information given by Abdallah Muhammad Mudi, who is 63 years old and farmer in al-Mathabah and al-Siga village (Table 8-4).

He informed us that he has killed three leopards, three gray wolves, one striped hyenas, twenty Indian porcupines, one red fox, approximately one hundred bats, and more than one hundred Hamadryas baboons with rifles or traps, before the Raydah Nature Reserve was established in this area.

Animal hunting was not their subsistence economy. The reasons why they killed wild animals are that a) livestock was damaged by leopards, gray wolves, striped hyenas, caracals and red foxes; b) agricultural products were damaged by Hamadryas baboons and Indian porcupines; c) beehives were damaged by black hedgehog, ratel and bats. We will know the reasons in detail in the following descriptions.

* *nimr* (leopard; *Panthera pardus*)

Leopards attacked their cattle and goats. Therefore, they used to catch a leopard with a trap that is called *muzaiyab*. *Muzaiyab* is constructed with stone walls that has 2-2.5 m in depth, 1.5 m in width and 1 m in height. It has two small openings; one on side with a door supported by a wood and a rope, another one on upper part.

A hunter put meats of livestock inside *muzaiyab* and waited until a leopard entered from the side opening. When it reached inside, he pulled the rope to shut the door. After that, he shoot it with a rifle, called as *shujan*, from an upper opening.

A ruin of *muzaiyab* is left inside the Raydah Nature Reserve near the old goat keeping houses, and that is now reused as a holder of beehives.

They had three purposes of hunting leopards. The first reason was that they attack livestock such as cattle and goats. The second purpose was to sell their hide as stuffed animals in a market. The third purpose was to boil its grease to sell as a medicine for curing burns.

Abdallah describes yellow eyes of leopard as *hadaq*, a fruit of *Solanum incanum*. He have not seen a leopard for last ten years, but he just heard its bark at the al-Safhah mountains at the back of Wadi Marabah in October, 2001. Said b. Aid Al Mujattal witnessed a leopard inside the Rayda Reserve recently.

* *zi'ib* (gray wolf; *Canis lupus*)

Gray wolves attacked their livestock, particularly goats. That was the primary reason of hunting; however they had another reason, too.

They used four canine tooth, gall, eyes and face of a male wolf in order to cure an obsessed, *majnun*, person. They made an amulet, *hijab*, with some of dried powder of these. Or they put these on the door of residential houses not to let demons, *jinn*, enter. They did not use its hide, and did not eat its meat, too.

Gray wolves are sometimes witnessed in the Raydah Nature Reserve.

* *dabia* (striped hyena; *Hyaena hyaena*)

Striped hyenas attacked their livestock, particularly donkeys. That was the primary reason of hunting, however they also had another reason, which was the same reason for wolf hunting. They used meat of rear part of a hyena to cure back-pain of women. They ate its meat or drank soup of its meat called *maragat* for treatment. They did not eat other parts of meats, and did not use its hide.

Striped hyenas are also sometimes witnessed in the Raydah Nature Reserve.

* *nis* (Indian porcupine; *Hystrix indica*)

Indian porcupines ate many kinds of agricultural products such as tomato, cucumber, potatoes, zucchini, lettuce and sorghum in their farms in Tuhama, especially at night. That was the reason they killed them with rifles. Only foreign workers from Yemen or Eritrea hunt them and ate its white meat.

* *durban* (ratel; *Mellivora capensis*)

Ratals eat bees and its honey. People do not eat or use them at all.

* *fahad* (caracal; *Felis caracal*)

Caracals were often found in Tuhama before, and they attacked goats. But they can not be seen recently.

* *thalab* (red fox; *Vulpes vulpes*)

Red foxes attacked their chickens. That was the reason people killed them with rifles before.

* *gunfud* (black hedgehog; *Paraechinus hypomelas*)

Black hedgehogs, found in Tuhama, like to eat bees and its honey. When they stand against people, they killed with rifles before.

* *watuwat* (bats)

Bats also like to eat bees and its honey. That was the reason they killed them with sticks.

* *aranab* (rabbit)

Many rabbits are found in al-Sarat and some found in Tuhama. But people do not kill or hunt them.

* *far* (rats and mice)

Rats and mice can be found in houses, and eat many kinds of human foods. That is the reason why they keep cats with them.

* *gird* (Hamadryas baboon; *Papio hamadryas*)

Hamadryas baboons destroy and eat any kinds of agricultural products. When they come to their farms, people killed with rifles before.

3. Plant gathering

I list each plant used for human resources in the juniper woodlands, with their concrete purposes of utilization (Table 8-5).

* *arar* (*Juniperus procera*)

The wood can be used as beehives. This tree is also used as a holder of beehive inside the Raydah Nature Reserve. Dead branches are used to support beehives.

Twigs with seeds are gathered in winter as carpets for goats in a pen, and seeds are also eaten by them. This had been practiced by the mother of Dr. Muhammad Yahiya Muzhar al-Shahrani (Informed by himself) in Tamunia area.

Trunks, stems, and twigs are used as building materials of traditional houses (see later sections for details).

Dead branches and twigs had been used as heating and cooking fuel. Ashes of these are scattered on farms as a kind of fertilizer.

Barks are grind until they become smooth in order to rub into the wounds at the skin above the penis at the time of male circumcision (see later sections for details).

* *alub* or *sidr* (*Ziziphus spina-christi* var. *inermis*)

Flowers of olive tree is recognized as main contributor of honey called *asal sidr*. The wood can be used for plowing or burn them to make charcoal. People consume its fruits as food.

* *ibra'* (*Ficus sycomorus*)

The wood can be used as beehives. Many owners of houses plant this tree beside their house to make a shadow for resting.

**talig* (*Ficus vasta*)

This tree is preferred as a holder of beehives in the Raydah Nature Reserve.

**athab* (*Ficus cordata* ssp. *salicifolia*)

Twigs can be used as *miswaq*, a toothbrush. In Abha and even al-Riyadh, we will find *miswaq* of *arak* (*Salvadora persica*), that is brought from Tuhama of southwestern areas.

**talh* (*Acacia origena* and *Acacia gerrardii*)

The wood can be used as beehives. Dead branches are used to support beehives. The wood can also be used for plow. The wood can also be used for making some parts of doors and windows, and wooden wheel of bringing out water from wells. However, that will easily be affected by wood worm.

**garad* (*Acacia etbaica*)

Dead branches are used to support beehives. The wood can be used as fuel. We can find these in markets in Abha as charcoal and fuel. These are brought from Tuhama areas in general.

**samurah* (*Acacia ehrenbergiana*)

The wood can be used as charcoal and fuel. These are good especially as charcoal. We can find these in markets in Abha. The price is almost double the one from *garad* (*Acacia etbaica*).

**saiyal* (*Acacia seyal*)

The wood can be used as charcoal and fuel. These are good especially as charcoal.

**itum* (*Olea europaea* subsp. *cuspidata*)

The wood can be used as beehives. The wood can be used as fuel. These are the best as charcoal. The wood can also be used for plowing. This is known as the best kind. Leaves can be used for treatment of the gums. Twigs can be used as *miswaq*, toothbrush. Trunks are used for a wooden stick to make *asid*, traditional dish.

**gummar* (*Tarchonanthus camphoratus*)

Trunks are used for a small watch house beside farms.

**shuhatt* (*Grewia tembensis*)

Trunks are used for a wooden stick to make *asid*.

* *shabarik* (*Celtis africana*)

The wood can be used for plowing.

* *durm* (*Teclea nobilis*)

The wood can be used for plowing.

* *shariyan* (not identified)

The wood can be used for plowing.

* *thua* (not identified)

Trunks are used as building materials of traditional houses (see later sections for details).

* *gadd* (*Cadia purpurea*)

Trunks are used as building materials of traditional houses (see later sections for details).

* *khirwa* (*Ricinus communis*)

Leaves are used on the wound of male circumcision to cover (see later sections for details).

4. Social utilization of natural resources in the juniper woodlands

As we have seen in above sections, I tried to establish information databases on local knowledge of flora and fauna. Their cultural, social and economic values of natural resources in the juniper woodlands reflect practical experiences of uses as follows.

Wild animals were used as medicine for curing back-pain and burns, and materials as stuffed animals, an amulet, and protection of demons. Objectives of wild plants utilization include building materials such as roof, door, window, wheel of well, and watch house, plow, kitchen utensils, beehive log and its support, fuel such as firewood and charcoal, fertilizer, toothbrush, forage, medicine, food and shadow tree.

8.3.3 Traditional system of management

1. What are the ways in which the people have used natural resources sustainably?

The *hima* (usually transcript as "hima" or "hema" in English), a traditional natural resource management system, was previously widely practiced in the Arabian peninsula, particularly in the western mountains of Saudi Arabia. The survey of the *hima* within 25 km of al-Bahah in the northern Asir Mountains revealed very sophisticated use of lands; 71 separate protected or semi-protected areas. For example, in the *hima* of Bani Sar near al-Bahan, animal grazing has been prohibited, but cutting of fodder permitted during drought years (Child

and Grainger 1990: 55-65).

But we have not acquired concrete information on the traditional system of management in the juniper woodlands particularly. The following description of the system will show a slight different case of management of natural resources from the *hima* categorized in more arid lands of Asir Mountains and other parts of the Arabian peninsula.

2. Leaving juniper in agricultural fields while pruning its branches

We can observe that many trees of juniper are left inside farms, especially along the stone walls of terraced fields. In these areas, farms are collectively called as *bilad* and each of that section is called *rakib*, and terraces can be mentioned as *mudarrajat*. Some of stems and twigs of juniper from 2 to 4 m in height are lopping.

There would be multiple reasons for this practice. First, this will help not to interfere with most of their agricultural works. And this also makes more spaces for farming. Secondly, supposedly, this kind of trees may be left to make shadow in farms, that can be the place for them to rest.

However, as a primary reason, this is their intentional way to make trunks straight. The people are engaged in clipping branches till they grow upright. The people also take care of the lowest sections of terraced fields, called *haram*, that would be occupied with some junipers and acacias even in the middle of fields. The owner hire about five persons to work together to prune the branches of these trees. In Tuhama areas, *alab* or *sidr* (*Ziziphus spina-christi*) is also looked after as juniper is.

The reason why they need straight trunks of juniper is to use them as building materials of their traditional houses in particular.

3. Constructing traditional houses with juniper

Traditional houses in these areas are made of trunks, stems and twigs of juniper, stones and clay. All walls are made of stones taken from surrounding mountains, and clay called *sahara* is painted on walls. Top of roof is also painted with clay.

Roof of the house consists of three kinds of wooden components. *Madal*, a main big component is build over stone walls, and is made of a big and long trunk of juniper. *Sawari*, a second component is build between a stone wall and *madal*, and is made of a medium size trunk or stem of juniper. *Shaza*, a third component, is built on numbers of *sawari* between stone walls.

For example, the house of Ahmad Muhammad Yahiya Al Musa al-Hanishi, that is now occupied by Rabia Abd al-Rahman Hasanin, consists of ground and upper floors. The ground floor was made more than one hundred years ago, had been used as rooms for cattle, goats and agricultural tools. The walls have approximately 70 cm thick and 2.5 m in height.

The upper floor was made about forty years ago, according to the brother of the owner, Lahiq al-Hanishi. It

consists of five rooms. The meeting room, *majlis*, has approximately 5.5 m in width, 3.5 m in depth, 1.6 m in height. I counted numbers of trunks and stems used for roofing.

There are 2 *madal*, that has 4 m in length and 35 cm in diameter. Out of 33 *sawari*, 25 has more than 8 m in length and 15 cm in diameter, and 8 has about 6 m in length and 10 cm in diameter. There are 136 *shaza*, that has 2 to 4 m in length and 3 to 5 cm in diameter.

In an another case of the house of Muhammad Ahmad al-Zulmani in Raydah village built approximately thirty-five years ago, other kinds of woods are used with juniper. His house consists of six rooms; three living rooms, one guest room called *majlis*, one farm tool room and one cattle room. In farm tool room and cattle room, half of *sawari* from *thua* (not identified; local people say that small numbers at some places north from al-Hadan village) and almost all of *shaza* from *gadd* (*Cadia purpurea*).

They did not use other kinds of trees for houses such as *talh* (*Acacia origena* and *Acacia gerrardii*) or *itum* (*Olea europaea* subsp. *cuspidata*) that will be easily affected by *sus*, wood worm. The house of juniper stands more than fifty to seventy years.

4. Communal lands as a former tribal territory for the people in al-Siga

The land of the Raydah Nature Reserve is located inside a former tribal territory of the people of al-Siga of Bani Mughaid tribe. The Raydah Nature Reserve is an escarpment between al-Siga village in al-Sarat and other villages in Tuhama. Therefore, almost all of the land had not been used by them as farms except a few locations.

All of the people in al-Siga are from Bani Mughaid. They can be divided into five sections living in al-Siga village in al-Sarat and other villages in Tuhama; 1) Al Yazid al-qauwa in Raydah village, 2) Al Tammam in Raydah village, 3) Al Yazid al-garn in Zuhar village, 4) Al Falah in Raydah, al-Wadi al-Hadan and al-Mathabah, and 5) Al Haji in Raydah village. Their tribal territory was bordered with the tribes; Rijal al-Maa in the west, Al Nijim in the north, and Al Wiman in the south.

The number of families in al-Siga is suggested by Said b. Aid Al Mujattal (the head of al-Siga areas) as one thousand, meaning that the population would be between twenty and fifty thousands.

The mountainous land of escarpment, filled with juniper, had been under the management and protection of *naib*, the tribal representative of the village, who is also named as *shaikh*, the elderly head of the village.

When any individual of the village intended to build a new dwelling house with wood of juniper, he had to request to *naib* for a permission at their council. After they approved his request, the *naib* and other elders of the sections of the village and four or five persons went with him to the mountain to cut a proper number of juniper.

This was the custom that all members of the community helped to construct his house. A group of the people, approximately thirty to sixty persons, went together to the cutting locations. In this occasion, the *na'ib* gave orders not to cut juniper at a single location, but at many different locations of the mountains of their territory. He ordered particular numbers for each *madal*, *sawari*, *shaza*.

Particularly, they were concern about locations and numbers of *madal*, big trunks of dried or even living juniper. Each of *madal* was carried with a group of twelve to sixteen young men. After clearing timber, they put *madal* on three or four wood that were carried by each corner by two men. Then they went down or up the slopes of mountains. When this group of the people became tired, they were substituted with an another group of men. When they reached the place intended, they also helped building, too.

Other than *madal*, some people carried trunks and twigs of juniper on the back of donkeys or camels, and some carried trunks one by one. The people also brought numbers of stones from mountains or water streams on camels, donkeys and cattle.

This also applied to other kinds of trees than juniper, such as *talh* (*Acacia origena* and *Acacia gerrardii*) and *itum* (*Olea europaea* subsp. *cuspidata*). The wood of *talh* was used to make some parts of doors and windows, and wooden wheel of bringing out water from wells. The wood of *itum* was excellent to make a plow and to use for many purposes.

Dead branches and twigs of juniper had been used as heating and cooking fuel. Ashes of these were scattered on farms as a kind of fertilizer. *Garad* (*Acacia etbaica*), *alub* (*Ziziphus spina-christi* var. *inermis*), *samurah* (*Acacia ehrenbergiana*) were used as charcoal. Therefore, some people sold them to traders before, but now they stop doing this at all.

When anybody was cheating to cut trees and bring to markets or sell to traders without any permission from the community, he would be arrested by the people. The group of the people appointed by the *naib* to collect his reparations was called *barhah*. He would be penalized by paying some amount of money. For example, he must pay 10 Riyal for big size of wood, 5 Riyal for middle size, and 3 Riyal for small size of juniper at that time.

If that person was unable to pay some money, he offered his property instead, such as cattle and goats. This kind of customs lasted until about thirty years ago.

In terms of beehives, people could put them only on their farms and communal lands of the tribal territories. They could not put them on another tribal lands. In some sense, that custom is still effective until now.

On the other hand, grazing any kinds of livestock such as cattle, sheep and goats had been permitted at any tribal territories. However, they had to pay, if they entered farms and damaged agricultural products.

Concerning the permission of setting up a new farm in the middle of mountains, which was a communal land of the tribe, an individual had to have its proper reasons. All members of the community gathered and discussed, for example, whether he did not have any other farms before, and so on. If the case was approved with an agreement, he could have farms without any payment to the community. This kind of authority is not in hands with the local people now.

On the other hand, the local people of al-Siga strongly felt that they had stopped having any kinds of problems with other peoples concerning their natural resources as previously they had had, because the

governmental institution of NCWCD could protect the nature without any kinds of problems.

8.4. Discussion

8.4.1 Bridge between social practices and the latest scientific knowledge in local context

When I asked the local people why the die-back and die-off phenomena of *Juniperus procera* had happened, I was given some reasons. One man said that the rain was sufficient and the condition of juniper was fine until the time of the Gulf War. After that time, they observed black traces of the rain on the walls of their houses. He supposed that would be one of the reasons of these phenomena.

However, an another man said that these phenomena are not recent problems. What we have stopped collecting dead branches of the juniper for firewood and charcoal can be the reason. Because dead branches and twigs of juniper had been used as heating and cooking fuel, and its ashes had been scattered on farms as a kind of fertilizer.

I, as scientist, propose that these different observations must be assessed from many aspects.

An another problem is the extinction of some species. The Asir mountain areas preserve many kinds of native species, some of which are on the verge of extinction. *Centaurothamnus macimus* is one of these plant species there. *Centaurothamnus macimus*, called *kharshuf*, can be in a healthy condition in the Raydah Nature Reserve.

However, there is a little concern for their future. According to local peoples' recognition, cattle and goats eat the flowers. In particular, cattle loves to eat the flowers. As far as contemporary situation of this plant is concerned, nothing would be worried about. But it needs to be carefully watched.

Managing to protect the nature and keep local people's life at the same time would be needed for better protection of the nature. How can we assess an impact of herding goats and cattle around the Raydah Nature Reserve? We need to research this issue furthermore scientifically.

8.4.2 Re-developing cultural knowledge for preservation of biodiversity

I had a great opportunity to observe an environmental education for local children from al-Siga and Abha on 1 November, 2001. It is an excellent program for children to notice the importance of natural resources.

At the same time, I suppose that it will be better if the local children would have the chance to learn cultural knowledge of their ancestors and elders in order to motivate their consciousness of resource utilization and preservation of biodiversity.

For example, a unique utilization of juniper in these areas was for curing wounds of male circumcision. In Asir mountain areas, until forty years ago, the people used to cut not only the foreskin of penis but also all the skin above penis that have hairs. The operation was taken place not right after birth, but at the age of between 18 and 25 years old. That was the time before his marriage, and the circumcision had a role to show his manhood.

Usually five or six men were circumcised together at the same occasion.

First, they gathered at particular places to show their poems for the people. Then they moved to the public spaces, and were circumcised in front of a few hundreds of men. The men are supposed to put some sands on his foot to show that he cannot move or shake even at the time of travail. He even stood by one leg to show his bravery to the crowd of men and boys, who celebrated with a salute of rifle and a traditional dance.

After cutting his skin above his penis, they rubbed *qalif*, bark of juniper, that was grind until it became smooth, into the wounds. Then they put leaf of *khirwa'* (*Ricinus communis*) on it, and tied with ropes for a month. The purpose of rubbing bark of juniper is to prevent an infection.

Ahmad Abdallah Ahmad (80 years old farmer in al-Hadan), who was circumcised at age of twenty, told us the poem, categorized as *tarhibah*, recitated before by Abdallah al-Zulmani who had already passed away.

Secret nature at night, staying behind the darkness
No, it is not him but a threatener [circumciser]
Do not imagine in my consideration and in mind
I am excellent, but the enemy is with Abdallah [reciter]
He came into sight, and I saw him in public space
Go a liar, with flags, I am a bravery man
Come the men of al-Shaab and al-Hadan villagers, men under sunshine
And all of circumcised men and boys come to see me

I suppose that this kind of traditional wisdom with their cultural practices in terms of social and historical importance of juniper also helps young generations of the local communities to ensure the sustainable utilization of species and ecosystems.

8.4.3 Application of the traditional resource management for sustainable resource use in a new form

Let me discuss this issue, focusing on a particular case happened in the Raydah Nature Reserve.

A big acacia tree was cut by an electric saw inside the Raydah Nature Reserve someday in the summer of 2001 and found in 20/1/1422 H.. This seemed to be the first illegal accident since this reserve was established. The rangers reported to the central office of NCWCD and the local police. The head of rangers, Muhammad Ahmad Asiri, offered a prize for giving any kinds of information, but nothing has been reported yet. They guess that a group of people came from lowlands by a car, and passed the entrance that has no ranger to steal into the reserve in a midnight.

The tree was located at just five meters from the road in the altitude of approximately 1900 m. The stump has

40-45 cm in diameter at height of 10-20 cm. This species should be *talh* (not *Acacia origena* but *Acacia gerrardii* because of its altitude).

The purpose of cutting the tree is clear. That is for beehives, because the upper part of trunks (< 30 cm in diameter) and all of stems and twigs (< 20 cm in diameter) were left there. It is suggested that at least three beehives seem to be made from this trunk.

As discussed earlier, honey-collecting is important not only for their domestic use but also for cash income, particularly for the people in lower lands of the Tuhama areas. It means that, even if the nature of this reserve had been preserved in a good manner, when the nature of other areas are over-exploited, all of plants and animals of the reserve can be put in a dangerous situations.

That is why we need to apply the traditional resource management system for sustainable resource use in a new form. A new form would be 1) cooperated with foreign workers and scientists at many aspects; 2) watching herders to graze livestock in an appropriate manner; 3) educating staff members, including a cook, to know values of reserves; 4) keeping a cooperation with scientists to set a better plan for conservation of the juniper woodlands in the Asir Mountain areas.

8.5 Summary

The aim of this research is to clarify the social importance of the juniper in order to set an appropriate plan for conservation of the juniper woodlands.

People are engaged in clipping branches of the junipers till they grow upright. The reason why they need straight trunks is to use them as building materials of their traditional houses. The mountainous land of escarpment, filled with juniper, had been under the management and protection of *naib*, the tribal representative of the village. When any individual of the village intended to build a new dwelling house with wood of juniper, he had to request to *naib* for a permission at their council. They were concern about cutting locations and numbers of big trunks of dried or even living juniper. Dead branches and twigs of juniper had been used as heating and cooking fuel. Ashes of these were scattered on farms as a kind of fertilizer. On the other hand, grazing any kinds of livestock such as cattle, sheep and goats in the juniper woodlands had been permitted at any tribal territories.

In terms of social aspects for conservation of the juniper woodland, we need to concern three aspects; 1) bridge between social practices and the latest scientific knowledge in local context; 2) re-developing cultural knowledge for preservation of biodiversity; 3) application of the traditional resource management for sustainable resource use in a new form.

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Table 8-1. Farms and Cultivated Seasons of Various Crops

Kind	Crops		Farms				
	Scientific	Species names	Common	Vernacular	Raydah village 1600 to 1800m	Inside reserve around 2500m	al-Siga village 2500 to 2800m
cereals	<i>Sorghum bicolor</i> (L.)		sorghum	dhurah	summer	summer	summer
cereals	<i>Pennisetum americanum</i> (L.)		bulrush millet	dukhn	summer	—	—
cereals	<i>Triticum</i> sp.		wheat	burr, gamh	—	—	winter
cereals	<i>Hordeum vulgare</i> L.		barley	shair	winter	—	winter
beans	<i>Lens esculenta</i> Moench		lentil	adas	—	—	winter
beans	<i>Vicia faba</i> (L.)		broad bean	ful	—	summer	—
beans	<i>Phaseolus vulgaris</i> L.		common bean	fasuliya	summer	summer	summer
vegetables	<i>Lycopersicon esculentum</i> Mill.		tomato	gutah	summer	summer	summer
vegetables	<i>Cucurbita pepo</i> L.		summer squash	kusa	—	summer	—
vegetables	<i>Solanum tuberosum</i> L.		potato	batatis	—	summer	—
vegetables	<i>Cucurbita</i> sp.		pumpkin	qara	—	summer	—
vegetables	<i>Cucumis sativus</i> L.		cucumber	khiyar	—	summer	—
vegetables	<i>Daucus carota</i> L.		carrot	jazar	—	summer	—
vegetables	<i>Solanum melongena</i> L.		eggplant	bazinjan	—	summer	—
vegetables	<i>Abelmoschus esculentus</i> (L.)		okra	bamiya	—	summer	—
vegetables	<i>Eruca vesicaria</i> (L.) Cav.		rocket-salad	jirjir	—	winter	—
vegetables	<i>Raphanus sativus</i> var. <i>sativus</i>		radish	fujl	—	winter	—
vegetables	<i>Allium cepa</i> L.		onion	basal	—	winter	—
vegetables	<i>Allium sativum</i> L.		garlic	thum	—	winter	—
vegetables	<i>Lactuca sativa</i> L.		lettuce	has	—	winter	—
fruits	<i>Musa acuminata</i> Colla		banana	muz	summer	—	—
fruits	<i>Citrus limon</i> (L.) Burm.		lemon	limun	summer	—	—
drinks	<i>Coffea arabica</i> L.		common coffee	bunn	summer	—	—
incense	<i>Pandanus tectorius</i> Soland. ex Parkins.		screw-pine	kadi	summer	—	—
incense	<i>Ocimum basilicum</i> L.		common basil	rihan	summer	—	—
cosmetic	<i>Lawsonia inermis</i> L.		henna	hinna'	summer	—	—

Table 8-2. Kinds, Etymology, Color and Price of Honey

Kinds	Etymology	Color	Price
asal sidr	"honey of Ziziphus spina-christi"	brown	150 Riyal/kg
asal shukah	"honey of thorny trees such as Acacia spp."	redish brown	200 Riyal/kg
asal majra	"honey of shrubs/herbs along the riverbed pouring down water"	yellow or white	400 Riyal/kg

Table 8-3. Support Materials for Beehives

Beehive No.	<i>Juniperus procera</i>	Dead branches of <i>Acacia origena</i> <i>Acacia gerrardii</i>	Materials			Parts of tents	Plastic bags	Iron shields	Ropes
			<i>Acacia elbaica</i>	Lumber	Pieces of clothes				
1	—	+	+	+	+	—	—	+	+
2	+	+	—	—	—	—	+	+	+
3	+	+	—	—	—	+	—	+	+
4	+	—	+	—	—	+	—	+	+
5	+	+	—	—	+	—	—	+	+
6	+	+	—	—	+	—	—	+	+
7	—	—	—	—	+	—	—	+	+
8	—	+	+	—	+	—	—	+	+

Table 8-4. Wild Animals Hunted

Family name	Wild animal species		Vernacular name	Livestock and human products attacked by wild animals	Utilization	Numbers hunted by Abudallah Muhammad Muadi
	Scientific name	Common name				
Canidae	<i>Canis lupus</i>	Gray wolf	zi'ib	goats	dried powder of canine tooth, gall and eyes for an amulet; face of a male wolf on door of residential houses not to let demons enter	3
Canidae	<i>Vulpes vulpes</i>	Red fox	thalab	chicken	—	1
Cercopithecidae	<i>Papio hamadryas</i>	Hamadryas baboon	gird	crops	—	more than 100
Erinaceidae	<i>Paraechinus hypomelas</i>	Black hedgehog	gunfud	beehives	—	0
Felidae	<i>Felis caracal</i>	Caracal	fahad	goats	—	0
Felidae	<i>Panthera pardus</i>	Leopard	nimr	cattle and goats	hide as a stuffed animal to sell in a market; grease as a medicine for curing burns to sell in a market	3
Hyaenidae	<i>Hyaena hyaena</i>	Striped hyena	dabia	donkeys	meat of rear part and its soup as a medicine for curing back-pain of women	1
Hystriidae	<i>Hystrix indica</i>	Indian porcupine	nis	crops	white meat to eat (only for foreign workers from Yemen or Eritrea)	20
Mustelidae	<i>Mellivora capensis</i>	Ratel	durban	beehives	—	0
—	—	Bats	watuwat	beehives	—	100
—	—	Rats and mice	far	food in general	—	numberless

Table 8-5. Wild Plants for Utilization

Wild plants species			Utilization															
Family name	Scientific name	Vernacular name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Compositae	<i>Tarchonanthus camphoratus</i> L.	gummar	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—
Cupressaceae	<i>Juniperus procera</i> Hochst.ex Endl.	arar	+	+	—	—	—	—	+	+	—	—	+	—	+	—	—	—
Euphorbiaceae	<i>Ricinus communis</i> L.	khirwa	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—
Leguminosae	<i>Acacia ehrenbergiana</i> Hayne	samurah	—	—	—	—	—	—	—	—	+	+	—	—	—	—	—	—
Leguminosae	<i>Acacia etbaica</i> Schweinf.	garad	—	—	—	—	—	—	—	+	+	—	—	—	—	—	—	—
Leguminosae	<i>Acacia gerrardii</i> Benth.	talh	—	+	+	—	+	—	+	+	—	—	—	—	—	—	—	—
Leguminosae	<i>Acacia origena</i> R.Br.ex Hunde	talh	—	+	+	—	+	—	+	+	—	—	—	—	—	—	—	—
Leguminosae	<i>Acacia seyal</i> Delile	saiyal	—	—	—	—	—	—	—	—	+	+	—	—	—	—	—	—
Leguminosae	<i>Cadia purpurea</i> (Picciv.) Aiton	gadd	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Moraceae	<i>Ficus cordata</i> Thunb. ssp. <i>salicifolia</i>	athab	—	—	—	—	—	—	—	—	—	—	—	+	—	—	+	—
Moraceae	<i>Ficus sycomorus</i> L.	ibra'	—	—	—	—	—	—	+	—	—	—	—	—	—	—	+	+
Moraceae	<i>Ficus vasta</i> Forssk.	talig	—	—	—	—	—	—	—	+	—	—	—	—	—	—	+	—
Oleaceae	<i>Olea europaea</i> L. ssp.	itum	—	—	—	—	+	+	+	—	+	+	—	+	—	+	—	—
Rhamnaceae	<i>cuspidata</i> (Wall .ex G. Don)																	
	Ciferri forma <i>dulcis</i> P.S.Green																	
	<i>Ziziphus spina-christi</i> var. <i>inermis</i> Boiss.	alub,sidr	—	—	—	—	+	—	—	—	—	—	—	—	—	—	+	—
Rutaceae	<i>Teclea nobilis</i> Delile	durm	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—
Tiliaceae	<i>Grewia tembensis</i> Fresen.	shuhatt	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—
Ulmaceae	<i>Celtis africana</i> Burm.f.	shabarik	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—
—	not identified	shariyan	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—
—	not identified	thua	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1: building materials; roof			2: building materials; door/window			3: building materials; wheel of well			4: building materials; watch house									
5: plow			6: kitchen utensils			7: beehives; log			8: beehives; support									
9: fuel; firewood			10: fuel; charcoal			11: fertilizer			12: toothbrush									
13: forage			14: medicine			15: food			16: shadow tree									

9 Conservation and management of the juniper woodlands

Kazumori Nagao, Tarik Abbasi

1. Outline of the system for wildlife conservation in the Kingdom of Saudi Arabia

Conservation of the environment, including wildlife, is one of the most important concerns of people worldwide. Wildlife conservation is considered to be very valuable in improving environment aspects and achieving its safety.

During the 1970s, the Government of Saudi Arabia realized that the overexploitation of resources was degrading rangelands and woodlands, and that a sound system of protected areas was needed. In 1986, wildlife conservation officially started in the Kingdom.

1.1 NCWCD Regulations

In 1986, the National Commission for Wildlife Conservation and Development (NCWCD) Regulations were issued by Royal Decree No. M22 dated 12/9 1406H (1986).

They were designed to regulate the deterioration of the natural environment in the Kingdom and to protect wildlife at national and international levels. Based on those regulations, the NCWCD was established as an independent governmental authority that reported to the prime minister. The NCWCD is the only body responsible for the care of wildlife in the Kingdom.

The main purpose of the NCWCD is to conserve terrestrial and marine wildlife within the Kingdom and to preserve, protect and develop it, to carry out relevant biological research, and to apply the findings in a way that will guarantee environmental balance. The role of the NCWCD is as follows.

To encourage and carry out scientific research in all fields of the life sciences, particularly those related to wild creatures in the natural environment.

To care for environmental matters related to wildlife and to solve problems through meetings, conferences, and seminars.

To carry out research and studies related to wildlife and the natural environment in the Kingdom and to publish the results in various local and international forums.

To develop and implement plans and projects aimed at conserving wildlife, to enforce regulations, and to give instruction in the said areas.

To coordinate with the meteorology and environmental protection agencies, government

parties, scientific organizations and research centers in the Kingdom to achieve lasting goals.

The NCWCD has a Board of Directors composed as follows:

- | | |
|--|------------------------|
| 1) HRH Second Deputy of Prime Minister, Minister of Defense and Aviation | ---- Chairman |
| 2) HRH Minister of Foreign Affairs | ---- Managing Director |
| 3) HRH Minister of Interior | ---- Member |
| 4) HRH Amir of Riyadh Region | ---- Member |
| 5) HRH Amir of Asir Region | ---- Member |
| 6) HE Minister of Agriculture and Water | ---- Member |
| 7) HE Minister of Petroleum and Minerals | ---- Member |
| 8) HE President of KACST | ---- Member |
| 9) HE President of PME (previous name MEPA) | ---- Member |
| 10) HE NCWCD General Secretary | ---- Member |

The NCWCD Board of Directors is the sole authority to supervise, carry out work, and make decisions to achieve its goals, such as deciding national policies regarding the conservation of wildlife, approving work programs and projects to be implemented by the NCWCD, and issuing regulations needed to implement the NCWCD's goals.

The NCWCD has a Secretary General who is the executive director and is responsible for enforcing the regulations and overseeing the decisions of the NCWCD Board of Directors. The general secretary proposes national policies and projects to conserve wildlife, develops plans, projects and programs, determines the annual budget, prepares financial administrative rules and regulations, and directs all NCWCD work.

Fig. 9-1 shows the organizational chart of the NCWCD.

One of the first important works of the newly established NCWCD was to establish protected areas. To do so, the NCWCD staff formulated a national strategy, called the System Plan of Protected Areas for Wildlife Conservation and Sustainable Rural Development in Saudi Arabia.

The document was completed in 1990, with the aid of the International Union for the Conservation of Nature (IUCN). It proposed 103 terrestrial and marine protected areas (56 on land, 47 marine). At present, 15 protected areas in the Kingdom have been established.

(Table 9-1, Fig. 9-2)

1.2 Wildlife Protected Area Regulation

In 1995, the Wildlife Protected Area Regulation was issued as Royal Decree No. M12 dated 26 October 1415 H (1995).

This regulation is enforced by the NCWCD and consists of 18 articles that prescribe the relevant rules, such as the aims of the regulation, establishment procedures for protected areas, the NCWCD's roles for protected areas, the management system in protected areas, prohibited activities, penalties to violators, and so on.

It appears that NCWCD prepared a draft of this regulation soon after the NCWCD was established in 1986. Several protected areas were designated based on the draft. The promulgation of this regulation assured the establishment of protected areas in the Kingdom.

The NCWCD is also attentive to all living organisms in the protected areas of the Kingdom and is responsible for their conservation, especially in relation to natural habitats and biodiversity.

In wildlife conservation, the NCWCD, in coordination with the Ministry of the Interior, is responsible for the supervision and organization of all hunting activities through the enforcement of the Land Animals and Birds Hunting Regulations.

There is also coordination between the NCWCD and the Ministry of Agriculture and Water in enforcing the Regulation of Catching, Investing and Protecting Marine Resources in the Terrestrial Waters of KSA.

2. Current situation in the juniper woodlands in the Raydah Nature Reserve (Protected Area) and surroundings

Present situation

The total area of woodlands in the Kingdom of Saudi Arabia is estimated to be 27,000 km², which represents 1.2% of the Kingdom's total area. Most of these woodlands are located in the Sarawat Mountains, a mountainous chain running parallel to the Red Sea. The chain is divided into two parts, the Hijaz Mountains in the north and the Asir Mountains in the south.

These mountains extend to more than 2,000 m above sea level in Taif, and become higher to the south, where they reach 3,000 m in Abha. They have steep slopes on their west side with small, deep valleys that feed the Tehama Plains along the Red Sea. The slope to the east is gentle, with long valleys that feed the ground water in the Najd Hills.

The average annual rainfall in most of the Kingdom is less than 100 mm. In the Sarawat Mountains, however, the average annual rainfall reaches 300–450 mm. It is hot in the winter,

monsoon rains arrive in the summer, and rain falls in all months of the year.

In general, there are thick woodlands on the tops and slopes of these mountains. Junipers grow on the mountains from 2,000 m upward. Wild olives growing on the slopes from 1,700 to 2,000 m and are mixed with junipers. From 1,500 to 1,700 m are mainly wild olives. *Acacia* dominates on slopes below 1,500 m.

In June 2002, we observed the juniper woodlands along the Abha-Taif road. Most of the juniper woodlands were healthy, especially at Al-Sudaha, Billasmar, Tanumah. However, we sometimes observed individual dieback or die-off in trees along the roadside in rocky sites. We also saw junipers with weakened vigor in some woodlands because of a prolonged water shortage.

In Raydah Nature Reserve, the juniper woodlands as described in other chapters in this report are divided into four zones according to elevation.

Zone 1 from 2,700 to 2,900 m.

Pure juniper forests. Trees with dieback and dead trees seldom seen. No tree layer, but a few shrubs.

Zone 2 from 2,500 to 2,700 m.

Juniper forests mixed with *Acacia origena* and *Olea europaea*. Dieback and die-off mainly on roadsides and rocky sites (Fig. 9-6).

Zone 3 from 2,200 to 2,500 m.

Core zone of dieback and die-off. Dead juniper stands are expanded on rocky sites, places with thin soil, and on steep slopes where *Nuxia oppositifolia* forests grow. There is rich species diversity in this zone.

Zone 4 from 1,900 to 2,200 m.

Primarily small populations of junipers. Dieback and die-off are evident not only in junipers but also in other trees. Dead juniper stands have been replaced by *Tarachonanthus camphoralus* shrub forests.

The four zones above will be grouped into two areas—upper and lower—according to their elevation.

Upper area (above 2,500 m).

In this area, the junipers are healthy, except for individuals showing dieback and those that have died. It is difficult to prevent dieback caused by natural conditions such as drought and poor

sites (rocky slopes). It is believed that stands with dead junipers will become *Olea europaea* woodlands.

Lower area (below 2,500 m)

In this area, dead trees and trees with dieback of juniper due to climatic factors are evident. The dead juniper stands are being replaced by other woodlands. The decline of junipers, therefore, does not indicate the loss of woodlands.

Various trees have adapted themselves to particular elevations on the escarpment. It is expected that other woodlands, perhaps with higher biodiversity, will replace the junipers if they decline in the area. It also is expected that proper management will reduce the negative effects of human activities such as road construction, overgrazing, and the introduction of exotic plant species.

3. Social situation

The Hijaz and Asir Mountains are believed to have been covered 1,000 years ago with woodlands thicker than at present. At that time, juniper woodlands grew on the tops and slopes of the mountains.

For more than 2,000 years, people have recognized junipers, called A'r-a'r, and have lived in juniper woodlands and used the wood for many purposes. Junipers must have been considered the most important tree for the human life.

Many juniper trees, however, were felled hundreds of years ago to heat furnaces to melt iron, copper, and other metals. In the 20th century, these woodlands were subjected to intensive use because of the increase in population and diversification of human activities. This has led to cutting down and removal of trees and shrubs to use as fuel and building materials, and clearing of woods to create agricultural land and house sites. Accidental fires have been caused by several of these activities. These all have caused the decline of many types of woodland and their ecosystems in these mountains. Many juniper woodlands remain, however, in the high mountains and deep valleys which are difficult for people to reach.

In the last quarter of the 20th century, the use of junipers for fuel and housing materials decreased because of a switch from firewood to heating oil and a change from wood to concrete houses. Although these changes have been hopeful for the conservation of the juniper woodlands, it has caused a negative effect in that the people have become indifferent to the woodlands and have lost an awareness of the need to be kind to the natural woodlands.

It is necessary to enlighten the local people and visitors to the fact that the woodlands provide

us not only with such things as firewood, housing materials, and a place to locate beehives, but also indirect benefits such as water resources, soil protection, air purification, wildlife, and so on.

As for Raydah Nature Reserve, this area had been strictly managed by local communities to protect it and to use its resources before being designated a protected area in 1989. It was designated a protected area because of the scientific and social importance of the juniper woodlands.

A highway runs through Raydah Nature Reserve from the top (Al- Sugha Village) to the bottom (Raydah Village). The road was constructed by the Ministry of Communication and Transport for the purpose of providing convenience to the local communities. Both the design and construction of the road were crude, however, and the presence of the road has produced some negative effects on the juniper woodlands in the reserve. The road has become wider each year because of rock falling from the cut slopes and scraping by bulldozers, although it was narrow just after its construction.

From the viewpoint of wildlife conservation, closing the road and allowing the cut slopes to stabilize and re-vegetate, and freeing wild animals and birds from the threats of vehicles, would have a positive effect on the reserve. It is not realistic for the NCWCD to demand the closing of the road because the Ministry of Communication and Transport constructed it before the establishment of the reserve for the local communities, which had hoped for public facilities such as roads and a reliable power supply from the government.

There is the possibility that the road will be sealed in the near future. The NCWCD should work with the Ministry of Communication and Transport to ensure that the work is carried out with consideration for rock falls and the impact of drain pipes. All rocks and soil from new and old road construction should be removed to reduce the negative effects on the juniper woodlands.

After the establishment of the reserve, the NCWCD has managed its conservation. A Draft Master Management Plan for the reserve was prepared in 2001. The NCWCD should now complete and institute the draft as early as possible to ensure the conservation and management of the reserve.

4. Policy for juniper woodlands management

4.1 Policy of the NCWCD

The NCWCD was established in the Raydah Nature Reserve to conserve the representative woodlands in Asir. The policy and aim of the NCWCD for the reserve are represented in the Draft Master Management Plan as follows.

NCWCD policy: The Raydah Nature Reserve was created to preserve a relatively pristine example of Asir juniper woodlands habitat and their associated wildlife.

Aim 1: Conservation

Conserve and address causes of environmental degradation and change, and the loss of biological diversity.

Aim 2: Research and monitoring

Improve understanding of the biodiversity and ecosystem processes in the juniper woodlands habitat.

Aim 3: Public awareness and education, and stakeholder involvement

Educate local communities, regulatory and management agencies, and the general public about the features and value of the juniper woodlands ecosystem, and actively involve stakeholders in management issues.

4.2 Policy of the woodlands authorities

The Woodlands Administration in the Kingdom is undertaken by the Grasslands and Woodlands Department of the Ministry of Agriculture and Water.

The department is in charge of establishing plans and programs related to the maintenance and development of grasslands and woodlands, which cover about 77% (grasslands 75%, woodlands 1.2%) of the Kingdom.

According to a pamphlet provided by the department, the view of woodlands by the department is as follows:

Because of a shortage of woodlands in the Kingdom, the present woodlands are considered to be protective and recreational woodlands rather than productive woodlands. They are to be conserved and developed for the purpose of soil protection on the escarpment, to mitigate the effects of heavy rains and floods, to provide beautiful vistas to visitors, and recreational sites to the people.

The department also recognizes the importance of wildlife and biodiversity in the Kingdom, and appears to favor the plans by the Department of National Parks of the Ministry of Agriculture and Water to establish national parks and by the NCWCD to establish wildlife protected areas.

5. Importance of conserving the juniper woodlands

Trees are said to be the strongest organisms on earth. Trees have lived on earth from ancient

times and individual trees are among the longest living organisms on earth. Trees grow collectively in woodlands, where there are many kinds of plants, animals, and microbes, and other forms of life. Woodlands are treasuries of biodiversity. About 60% of the land area of the world is potentially woodland. Humans depended on woodlands but they have consumed and altered woodlands for millennia. Currently, only 25% of the total land area of the world remains as woodland. Human cultures prospered with woodlands, but have fallen after the consumption and ruin of woodlands since ancient times. Woodland conservation is one of the most important global environmental problems. The study of woodlands and the conservation of nature will form the basis for woodland conservation worldwide.

In the Kingdom of Saudi Arabia, woodlands occupy 27,000 km² of the land. The juniper woodlands in Asir are estimated to occupy about 7,600 km² (based on A System Plan for Protected Area).

It was determined in this study that *Juniperus procera* has high water use efficiency, meaning that juniper trees can adapt to stressful environments and grow. *Juniperus procera* is better adapted to the Asir Mountains environment than most other trees and forms an important component of the woodlands there.

The juniper woodlands have the highest biodiversity in the Arabian Peninsula and contain many species, families, and genera besides endangered species that are not seen in other woodlands. Many kinds of birds and animals, including endangered species, live and breed in the woodlands.

The importance of conserving the juniper woodlands should be considered from various points of view.

Water resources: The juniper woodlands catch and hold rainfall and release it slowly to the many streams that feed the Tihama Plains in the west and the Najd Hills in the east.

Soil protection and flood prevention: The woodlands prevent erosion from rainfall and solifluction, promote stable soil, and protect the lands against heavy rains and floods.

Improvement of environment and public health: The juniper woodlands assist in absorbing carbon dioxide, produce oxygen, remove dust and improve the climate, and in general purify the air to contribute effectively to improving the public health of citizens.

Public awareness and ecotourism: There is a limit to the government's ability to conserve the juniper woodlands. It is therefore indispensable that people understand and coordinate conservation efforts with the government. It is necessary that the NCWCD provides information on the juniper woodlands as a contribution to the quality of human life. Juniper woodlands provide the best place to

demonstrate an enlightened understanding of nature and a place to conduct ecotourism.

6. Proposal toward a system of conservation

6.1 Principal basis of management

Woodlands, especially the juniper woodlands in Asir, are extremely important internationally because of their biodiversity. The NCWCD is responsible for the conservation of the juniper woodlands, in particular to preserve the wildlife, and to advise and recommend relevant measures to the Ministry of Agriculture, which is responsible for managing and maintaining nearly all the woodlands in Asir.

The principals for well managed juniper woodlands are as follows:

1) Develop a new understanding of the juniper woodlands

Juniperus procera is a most adaptable tree in the Asir Mountains. The biological diversity in the juniper woodlands in Asir is relatively high. Many plants, animals, and birds including rare, endemic, and endangered species occur in the woodlands. It is necessary that the importance of the juniper woodlands as an international resource is recognized fully by the government, and that legal measures are instituted and public awareness is raised to ensure their conservation and importance.

2) Prevent any further decline of the juniper woodlands

The juniper woodlands have continued to decline since ancient times due to human activities. Recently they have also declined due to effects beyond the activities of local peoples. The juniper woodlands are threatened with desertification. Preventing any further decline and trying to reverse this decline should be our goal.

3) Long term measures are needed to protect the juniper woodlands in Asir

The location and size of all the juniper woodlands are not known in detail. It is urgent for the NCWCD to determine the location and size of each woodland and to accurately map them and then monitor changes in the woodlands over time.

6.2 Basic points for a management plan

The basic points for managing the juniper woodlands in the Asir Mountains are as follows:

1) Prepare a detailed vegetation map of the area of the juniper woodlands

Conducting a census and monitoring of the juniper woodlands is indispensable for the

NCWCD to prepare a detailed vegetation map covering the whole area (7,600 km²), with information on the range and distribution of the woodlands and their state of preservation.

A vegetation map on a scale of 1/50,000 should be based on field surveys, with the aid of aerial and satellite photos, to record the vegetation. Aerial photos should be obtained by professionally conducted aerial photographic surveys using fixed-wing aircraft of the juniper woodlands. Satellite photos can be obtained from NASA of the United States of America for a fee.

It is desirable to update the vegetation map every 10 years. To note rough changes in the juniper woodlands from the past to present, a scale of the vegetation map of 1/200,000–1/500,000 is sufficient.

2) Expand Raydah Nature Reserve

Relatively healthy juniper woodlands are distributed to the north and south of Raydah Nature Reserve. For example, Al-Shahab Park north of Raydah Nature Reserve has relatively healthy juniper woodlands on the ridges of its steep escarpments. It is desirable to incorporate areas with healthy juniper woodlands both north and south of Raydah Nature Reserve into the reserve as early as possible after relevant research is conducted on their biological and social conditions (Fig.9-3,4,5).

3) Designate new reserves

Unknown juniper woodlands in the Asir Mountains are expected to be discovered. After an overview based on a scientific investigation including inventory and the production of a vegetation map, those areas with juniper woodlands should be designated protected areas.

Protected areas should consist of two zones: a special zone (core zone) and an ordinary zone (buffer zone). Distinguishing two zones promotes the acceptance by the people and local communities, particularly in areas where they were utilized by those people.

4) The possibility of afforestation

Afforestation with junipers in areas suspected of once harboring juniper woodlands is a means of recovering vegetation. It is not clear whether afforestation will be successful in the Asir Mountains, but it will become clear once experiments have been carried out.

During the experimental process, there will be many things to try, such as the selection of tree species (*Juniperus procera* or native trees), techniques for raising seedlings (including drought-resistant seedlings), the size of seedlings to be planted, and conditions of the locality to be

restored (water, soil, slope of land, hole size, etc.). Properly trained personnel, resources, and facilities will be needed to carry out afforestation. It is also necessary to continue to study the regeneration of junipers in the Raydah Nature Reserve.

5) *Pruning experiments*

Juniperus procera is extremely efficient in utilizing water in comparison with other trees and has a high endurance for water stress. Under water stress, the branches of *Juniperus procera* die back to maintain water balance, but the tree continues to live. A lower frequency of dieback may occur if branches are removed in advance of drought. Pruning may be an effective method to prevent dieback and die-off, and it may be worthwhile to conduct experimental field trials.

6) *Reduce the impact of development activities*

More than 30 years ago, we had many experiences in Japan where road construction seriously impacted forest vegetation and caused soil erosion. Nowadays, road construction within forests is carried out in a constructive manner. Native trees and grasses are planted on cut slopes after an environmental impact assessment has been completed.

Road construction has one of the most negative impacts in many development activities(Fig.9-6). In the mountainous woodlands of the Kingdom of Saudi Arabia, it is important that road construction operations adopt appropriate methods, such as removing from the site all unstable rocks and soils so that they will not cause damage to the junipers.

The population in the Asir region is likely to increase at a fast pace because of the fine location of the area. It is desirable to consider a system that will have minimum impact on the forests during house site selection and construction and during other projects near the juniper woodlands.

7) *Control grazing*

Grazing has been carried out in the Asir Mountains for hundreds of years. The local people are aware of the prohibition against grazing and they have moderated their activities. Still, the number of livestock in Raydah and Al-Suga Villages remains at the same level or has tended to decrease slightly because the number of farmers has decreased and meat from larger farms outside the region has been increasing in the markets.

Overgrazing can result in worse ecological conditions and have a negative impact on the

juniper woodlands. At present, it does not appear to be a serious problem for junipers on gentle slopes of Raydah Nature Reserve. When special zones are established in the reserve in future, human activities including grazing should be strictly controlled.

In general, it is necessary to carry out further studies and research on the impact of grazing.

8) *Monitor the juniper woodlands in the Raydah Nature Reserve*

Much equipment has been brought to Raydah Nature Reserve to survey juniper trees and the juniper woodlands during this project. The monitoring of meteorological and physiological conditions in the juniper woodlands in Raydah Nature Reserve should be continued by the NCWCD. It is necessary to care for the equipment and to collect the many data necessary for the scientific analysis of the junipers in Raydah Nature Reserve. Such studies will provide basic, useful information for their management and for the management of other juniper woodlands in the Asir region.

9) *Establish a new Wildlife Research Center*

The NCWCD has three wildlife research centers in the Kingdom—in Taif, Tummama, and Qassim—of which the main research objective is animal life.

It is desirable to establish a new center with the objective being the study of the ecosystem and biodiversity of the juniper woodlands in the Kingdom. The center also will monitor scientific conditions and collect meteorological data in the Raydah Nature Reserve. It will coordinate with the new Weather Forecast Training Center of PME (Presidency of Meteorology and Environmental Protection) in Abha.

10) *Strengthen the NCWCD*

It is desirable that the NCWCD is strengthened to reach an international level of competence in the field of wildlife conservation and development. There is no doubt that wildlife conservation and development will become more and more important nationally and internationally. Therefore, the responsibilities and roles of the NCWCD will increase in the near future in accordance with international actions involving global environmental problems. The staff of the NCWCD are expected to perform their duties with confidence, hope, and pride. The NCWCD is expected to properly train the existing staff members and to employ excellent personal.

Thirty years ago, Japan's Nature Conservation Bureau, which is similar to the NCWCD, was a

small government organization belonging to the Ministry of Health and Welfare, but it has become larger in organization, personnel, budget, and authority. As a part of the Ministry of Environment, it contributes to nature conservation at both a national and international level.

To conserve the juniper woodlands in the Kingdom, the NCWCD needs to strengthen its organization, personnel, budget, and authority. In particular, it is necessary that planning units are enlarged to promote the expansion of Raydah Nature Reserve and the designation of new protected areas.

11) Amend/upgrade the protected area regulations

It is desirable to add the following articles to the protected area regulations to make them stronger in conserving the juniper woodlands.

- (1) To regulate and control human activities that negatively effect the flora and fauna in the core protected area. For example, controlling the construction of roads and buildings and the alteration of land forms to regulate the collecting of rocks and soil and the catching of insects and other small animals that are part of the ecosystem of the juniper woodlands.
- (2) To raise rangers to a higher level through training and to give them the authority to carry out their duties. Their tasks are important for conserving the juniper woodlands in protected areas where they are neither officially empowered to arrest or detain offenders, nor to confiscate property.
- (3) To indicate clearly in the regulation that the NCWCD is not only conserving wildlife but is also developing and using wildlife sustainably and using wildlife resources and the recreational use of wildlife habitats under the strict guidance of the rangers.

12) Promote environmental education and public awareness

It is important to educate the general public, including students and visitors, about the features, including the ecological characteristic and biodiversity, and value of the juniper woodlands.

Abha is the Kingdom's premier resort destination, attracting more than 1.3 million visitors a year. Al-Shahab Park, which is a great place to view Raydah Nature Reserve, has about 1 million visitors a year(Fig.9-7). Those visitors should be the target for environmental education and increased public awareness. The park has the most suitable location for constructing facilities such as a visitor center and administration station. Part of the Raydah Escarpment could be used for strictly regulated, low-volume, public access, which, in a word, is ecotourism.

13) Coordinate with other authorities and cooperate with local communities

There are many authorities and local communities, such as the Ministry of Agriculture, the Ministry of Transport, the local Emirate, Abha municipality, the inhabitants of Raydah and Al-Suga Villages, and members of two tribes that are concerned with the future of Raydah Nature Reserve.

It is necessary to coordinate and consult with the authorities and local communities when the NCWCD considers designating and managing new protected areas. In particular, it is desirable to establish liaison conferences with local communities and to establish partnerships.

7. Basic points for an action plan

In a previous section, the basic points (actions) for a management plan are described. Although these actions are to be carried out in parallel, they have different priorities and some of them might be difficult to initiate early or will take more time to achieve their goals because of social, personnel, budgetary, or organizational limitations.

On the assumption that conservation of the juniper woodlands is assured as early as possible, actions are ranked into three levels of priority in accordance with their importance. (Table 9-2). A rough, but desirable, time schedule for instituting them is shown without regard to the limitation. (Table 9-3)

On Table 9-3, no goal actions (4,5,6,7,13) mean that they need long term works more than about 15 years, in particular 6 and 13 will need to be carried out on an almost permanent basis.

Concerning afforestation and pruning, Yes (proceed) or No (stop) should be decided in accordance with their previous experiment results.

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Fig. 9-1. Organization Chart of National Commission for Wildlife Conservation and Development (NCWCD)

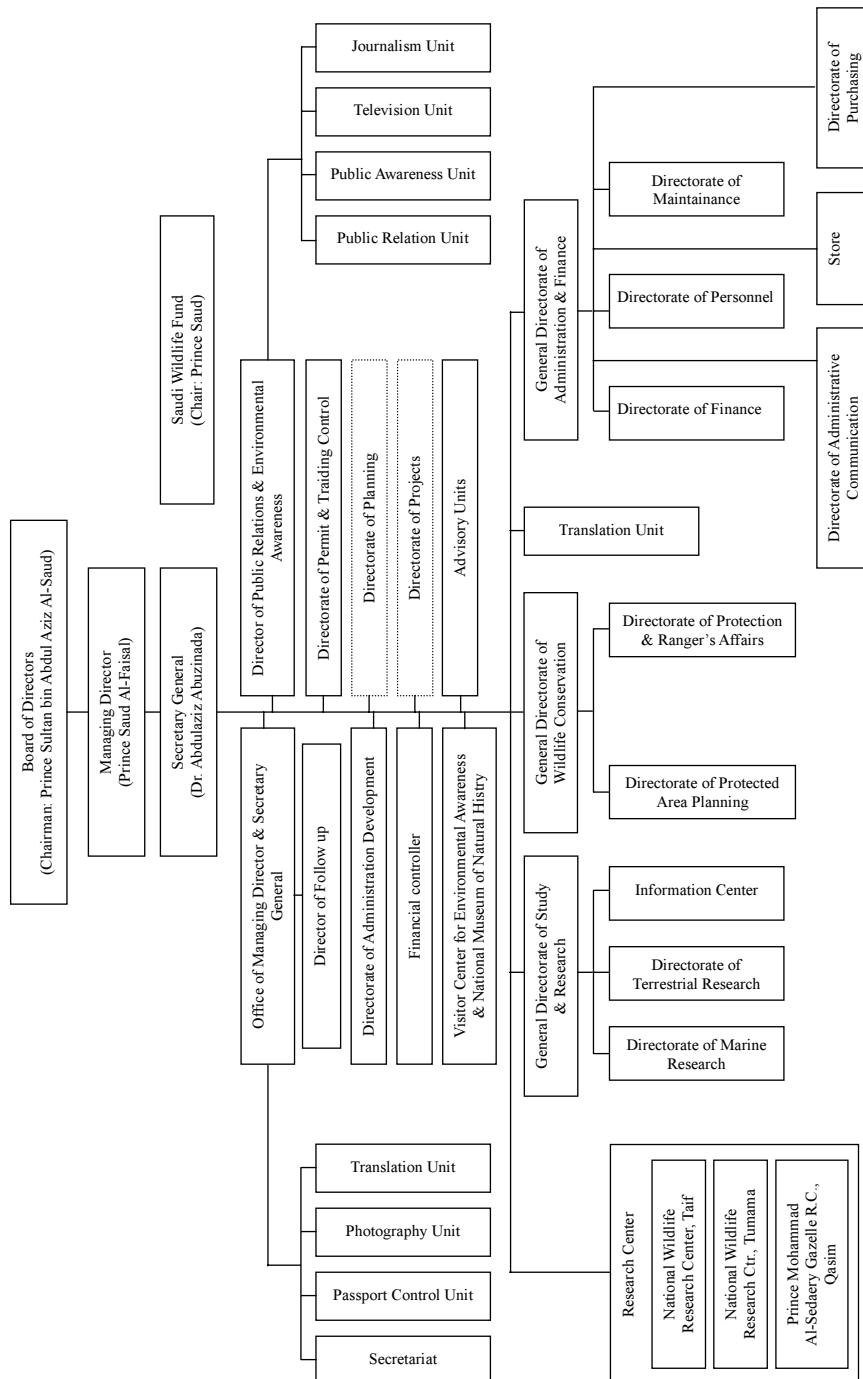


Fig. 9-2. Location of Protected Areas and Hunting Prohibited Regions

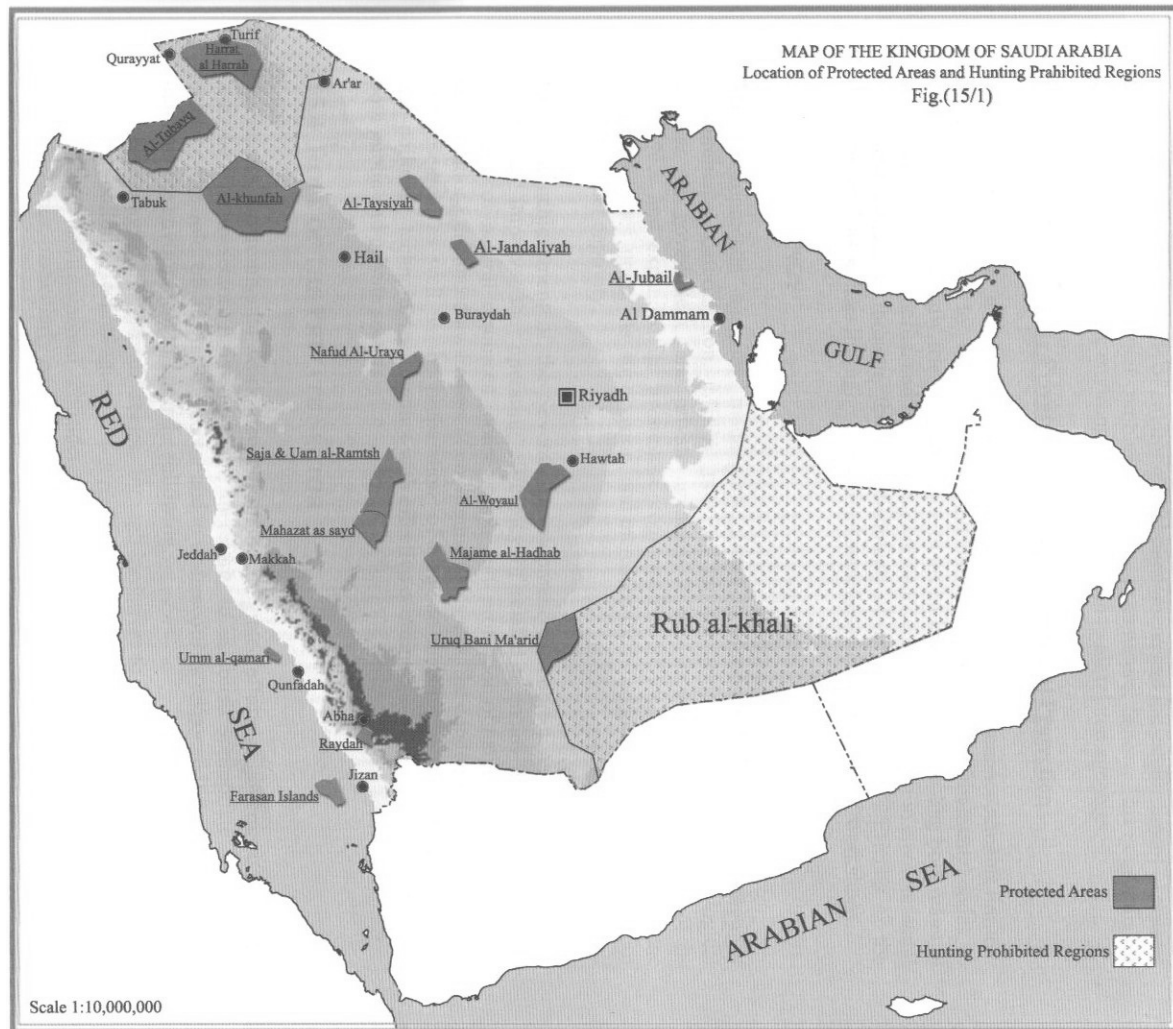




Fig. 9-4 Photos of proposed expansion areas of Raydah Nature Reserve (in south)
- View of the escarpment from Hibub village –



Fig. 9-5 Photos of proposed expansion areas of Raydah Nature Reserve (in north)



Fig. 9-6 Photos of negative impacts to juniper



Negative impacts caused by road (in As-Suda)



Die-off and die-back caused by erosion of road construction (in Billasma)

Fig. 9-7. Photo of Al-Shahab Park with a great view



Table 9-1 The List of Reserves in the Kingdom of Saudi-Arabia

No.	Reserves	IUCN Category	Area(ha)	Year of designation	Number of rangers	Notes
(Protected Area)						
1	Harrat Al-Harrah	IV	1,377,500	1987	44	
2	Al-Tubayq	III	1,220,000	1989	5	
3	Al-Khunfah	VI	2,045,000	1987	40	
4	Al-Jubail	II	230,000	1995	3	
5	Saja/Umm Al-Rimth	VI	719,000	1995	4	
6	Mahazat Al-Sayd	IV	214,100	1988	16	
7	HawtatBaniTamin (Ibex Reserve)	II	236,900	1988	23	
8	Majami Al-Hadb	II	340,000	1993	12	
9	Uruq Bani Maarid	II	1,198,000	1994	21	
10	Umm Al-Qamari		18	1987	0	Protected by Coast Guard
11	Raydah	Ia	900	1989	4	
12	Farassan Islands	Ia	69,600	1989	9	
13	Al-Taysiyah	VI	426,000	1995	-	Announced
14	Al-Jandaliyah	VI	116,000	1995	-	Dito
15	Nafud Al-Urayq	VI	196,000	1995	-	Dito
	Semi Total		8,389,182		181	
(Hunting prohibited region)						
1	Nothorn Wildlife Management Zone	VI	10,087,500	1988		Protected by Ministry of Interior
2	Al-Rubal-Khali	VI	64,000,000	1994		
	Semi Total		74,087,500			

Notes (1) : Protected Area— Based on the Protected Area Laws

Hunting prohibited region— Based on the Land Animals and Birds Hunting Laws

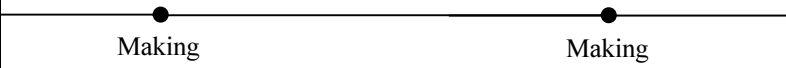

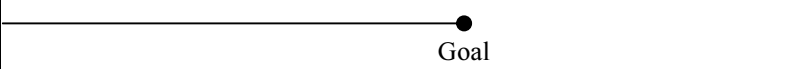
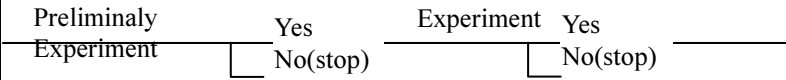
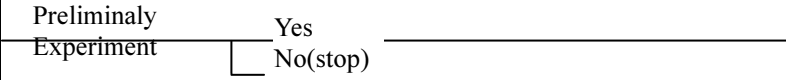
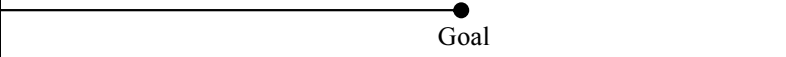
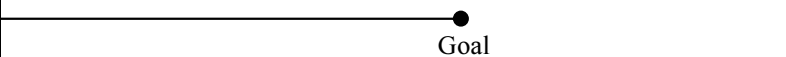


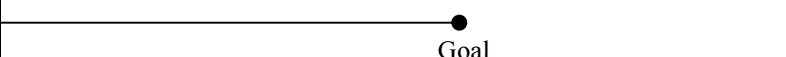
Notes(2) IUCN Category : IUCN has created a system of six categories for which protected area managed.

- Ia Strict Nature Reserve — protected area managed mainly for science.
- Ib Wilderness Area — protected area managed mainly for wilderness protection.
- II National Park — protected area managed mainly for ecosystem protection and recreation.
- III Natural Monument — protected area managed mainly for conservation of specific natural features.
- IV Habitat/Species Management Area — protected area managed mainly for conservation through management intervention.
- V Protected Landscape/ Seascape — protected area managed mainly for landscape/ seascape conservation and recreation.
- VI Managed Resource Protected Area — protected area managed mainly for the sustainable use of natural ecosystems.

Table 9-2. Priorities for each actions

Action	Priority		
	1st	2nd	3rd
1. To grasp juniper woodland macroscopically	<input type="radio"/>		
2. To extend Raydah Researve	<input type="radio"/>		
3. To designate new Reserve	<input type="radio"/>		
4. To study towards afforestation	<input type="radio"/>		
5. To try pruning	<input type="radio"/>		
6. To reduce the impact of human activities		<input type="radio"/>	
7. To control grazing			<input type="radio"/>
8. To monitor in Raydah Nature Reserve	<input type="radio"/>		
9. To establish new Wildlife Research Center			<input type="radio"/>
10. To strengthen NCWCD		<input type="radio"/>	
11. To amend the Laws		<input type="radio"/>	
12. To promote environmental education	<input type="radio"/>		
13. To co-ordinate with other outhorities		<input type="radio"/>	

Table 9-3. Time schedule for each actions

	2003	2008	2013	2018
1. To grasp juniper woodland macroscopically				
2. To extend Raydah Researve				
3. To designate new Reserve				
4. To study towards afforestation				
5. To try pruning				
6. To reduce the impact of human activities				
7. To control grazing				
8. To monitor in Raydah Nature Reserve				
9. To establish new Wildlife Research Center				
10. To strengthen NCWCD				
11. To amend the Laws				
12. To promote environmental education				
13. To co-ordinate with other authorities				

Conclusion and General Discussions

Hideaki Ohba and Tarik Abbasi

This, the Joint Study Project on the Conservation for Juniper Woodlands in Saudi Arabia, aims primarily to provide scientific evidences for the conservation and effective management of the juniper woodlands of the Asir Mountains, particularly the matter on the dieback and die-off phenomena of *Juniperus procera*, the dominant tree of the juniper woodlands in the Asir Mountains.

Remarkable points from each study mentioned in Chapters 1 to 9

Before discussing the purposes and remarkable points from each study described in the chapters 1 to 9 here.

Chapter 1. The purpose of the study is to provide accurate meteorological data in the Asir Mountains, especially the Raydah Nature Reserve. The study provided data on climate, meteorology and hydrology in the Asir Mountains. Meteorological data are important as fundamental data for discussing the matter of the juniper woodlands. Observations done revealed some significant climatic conditions of the Asir Mountains. In these the water supply through fog is notable, even though little precise data were obtained. This has been also pointed out to be the case for the woodland consisting of *Juniperus excelsa* in Oman by Price et al. (1988). As in the mossy forests in tropical mountains, the juniper woodlands in the Asir Mountains play an important role in trapping moisture and thus serving as a source of water for other components of the vegetation.

Chapter 2 shows the results of some physiological experiments on seed dispersion, germination and regeneration, and also drought tolerance. The fact that the seeds of *Juniperus procera* is not barachoric but zoochoric. In there birds are important in seed dispersing, and the role of baboons and goats are insignificant. The healthy seeds well germinated in the experimental conditions, and thus the juniper has a high potential for natural regeneration because of the higher ability of seed germination. Their physiological studies on *Juniperus procera* are very import to know the range of tolerance and also reserve the suitable environment to the juniper woodlands. However, the results seem to be insufficient to reveal the physiological nature in wide ranges, however severe water stress showed a tendency to reduce the biomass increment of needles, roots and the total biomass of the seedlings.

Chapter 3 is the results of ecological studies of the juniper woodlands. As mentioned there various topics and items were analysed. Data obtained reveal the structure and dynamics of the

woodlands and status of *Juniperus procera* within the woodlands. Such vast range analyses of the woodlands were made probably for the first time. The data become the ecological basis of considering of the conservation of the juniper woodlands. Their analyses on the dieback are also important, especially providing the severe situation of the *Juniperus* in lower elevations.

Chapter 4 is related to the phytopathological study mentioned in Chapter 5. Even though these were preliminary, this is the first real phytopathological study done on the Juniper trees in the Asir Mountains. The result that the dieback of *Juniperus procera* in the Asir Mountains is not caused by any known pathogenic fungi of *Juniperus* is remarkable to deny the possibility of pathological causes.

Chapter 6, 7 and 8 are related to the diversity and features of the flora and vegetations, and also social importance of the juniper woodlands in the Asir Mountains. These results are basic information on the juniper woodlands and the roles for local peoples, and will mention the following sections.

Chapter 9 is essentially a proposal for conservation and management of the juniper woodlands based on the results of this study project.

On causes and related matter of the dieback and die-off of the Junipers will also summarize and discuss in the last section in detail. This represents the present scientific understanding of dieback and die-off of the Junipers.

Biodiversity of plants in the juniper woodlands in the Raydah Reserve and in adjacent areas

The juniper woodlands have the highest plant diversity in the Arabian Peninsula, plus many species of birds and animals including endangered species, that live and breed there. Conserving global and regional biodiversity is one of our major tasks in the 21st century, and the Raydah Reserve harbors an important portion of that diversity.

Four hundred and sixty species of vascular plants were collected in the Raydah Reserve, 385 of which have been identified. Seventy-five species have not been identified and 10 species are cultivated or naturalized. One hundred and thirty-four species are distributed widely in paleotropical regions in the northern hemisphere and other regions. A checklist of the vascular plants collected is given in the Appendix of Chapter 6.

The Raydah Reserve and the adjacent areas are notable in having the highest species diversity on the Arabian Peninsula. Miller and Cope (1996) estimated the number of native species of plants

in Saudi Arabia as 1,800. Of them, about 25% (450 species) of all Saudi Arabian species of plants occur in the Raydah Reserve and in adjacent areas. This indicates the high diversity of vascular plants in the areas surveyed.

Miller and Cope regarded 35 species (2%) to be endemic to Saudi Arabia. The following species are considered to be endemic to the Arabian Peninsula, including Yemen, the United Arab Emirates, and other countries:

Phragmanthera austroarabica (Loranthaceae)

Maerua triphylla var. *calophylla* (Capparaceae)

Reseda sphenocleoides (Resedaceae)

Kalanchoe deficiens (Crassulaceae)

Rubus asirensis (Rosaceae)

Polygala schwartziana (Polygalaceae)

Grewia velutina (Tiliaceae)

Swertia polynectaria (Gentianaceae)

Galium aparinoides and *G. kahelianum*, *Pavetta longiflora* and *P. pammalaka* (Rubiaceae)

Micromeria imbricata, *Nepeta deflersiana*, *Plectranthus asirensis* (Lamiaceae)

Anthemis yemenensis, *Centaurothamnus maximus* (Asteraceae)

Aloe castellorum, *A. fleurentiniorum*, *A. sabaesa*, and *A. shadensis* (Asphodelaceae).

The number of the endemic species will likely increase through further studies, especially in the genera *Plectranthus* (Lamiaceae), *Anthemis*, *Echinops* (Asteraceae), *Galium* (Rubiaceae), and *Aloe* (Asphodelaceae). Because the present study is the first detailed investigation of the flora of the Asir Mountains and it has covered only a small part of the area, it is most likely that the number of endemic species present will increase through further studies. The genera *lectranthus* (Lamiaceae), *Antehmis*, *Echinops* (Asteraceae), *Glaium* (Rubiaceae) and *Aloe* (Asphodeliaceae) are particularly likely to be rich in endemics. It is therefore very important that further studies of the flora of the Asir and the Hijaz Mountains is given high priority.

The most remarkable species is undoubtedly *Centaurothamnus maximus*. *Centaurothamnus* is a genus represented by only a single species, *Centaurothamnus maximus*, which was found at several sites on steep, collapsed, roadside banks in the juniper woodlands in the Raydah Reserve at elevations around 2,800 m. The size of the population changes year by year, and the plants are adventitious. To conserve *Centaurothamnus maximus*, it is necessary to maintain its preferred

habitat of unstable, exposed situations in the juniper woodlands that destroy climax juniper woodland vegetation.

Phytogeography of the Asir Mountains

Phytogeographically, *Juniperus procera* is isolated from the main range of the distribution of the species in east Africa from Tanzania to Ethiopia, where it also occurs in montane areas. The Asir Mountains are the only locality for *Juniperus procera* on the Arabian Peninsula and are at its northern limit of distribution. A considerable number of species associated with the woodlands are disjunctly distributed between Africa and the Arabian Peninsula.

The Asir Mountains are classified into the Afro-montane archipelago-like regional center of endemism. This region is characterized by the presence of *Juniperus procera* forests and woodlands with *Acacia origena*, *Buddleija ploystachya*, *Catha edulis*, *Cussonia holstii*, *Dombeya torrida*, *Erica arborea*, *Hypericum revolutum*, *Nuxia congesta*, *Rosa abyssinica*, and *Teclea nobilis* (Miller and Cope, 1996). All except *Catha edulis* and *Cussonia holstii* have been found in the Raydah Reserve and in adjacent areas.

The flora of the Raydah Reserve and adjacent areas has a strong affinity with the flora of the highlands of Ethiopia, Somalia, and Kenya. Representative plants are *Commiphora* spp., *Dobera glabra*, species of Capparaceae, *Rosa abyssinica*, *Cadia purpurea*, *Indigofera amorphoides*, *Geranium arabicum*, *Clusia myricoides*, *Rhus retinorrhoea*, *Grewia* spp., *Euclea schimperi*, *Acokanthera schimperi*, *Lavandula dentata* and *L. pubescens*, *Micromeria imbricata*, *Otostegia fruticosa* subsp. *schimperi*, *Solanum schimperianum*, *Euryops arabicus*, *Felicia abyssinica*, *Senecio hadiensis* and *S. schimperi*, and *Tarchonanthus camphoratus* (Table 6-1). A comparison of the floras in the Asir Mountains and in the highlands of Ethiopia, Somalia, and Kenya will be necessary before further discussion on the floristic relationships is possible.

Endangered species

To conserve the rare and endangered species in our research area it is necessary to conserve the habitat, particularly the habitat of the herbaceous plants, which grow sporadically in and by the woodlands and which are presumed to be vulnerable to any disturbances. Such endangered species are tentatively considered to be *Centaurothamnus maximus*, *Oncocalyx glabratus*, *Oncocalyx schimperi*, *Phragmanthera austroarabica*, *Dianthus strictus*, *Kalanchoe citrina*, *Kalanchoe deficiens*, *Kalanchoe glaucescens*, *Umbilicus rupestris*, *Rosa abyssinica*, *Rubus asirensis*, *Gnidia somalensis*,

Primula verticillata, *Swertia polynectaria*, *Adenium obesum*, *Plectranthus asirensis*, *Anthemis yemenensis*, *Kleinia odora*, and all the species of *Aloe*.

Woodland vegetation

In the Asir Mountains including the Raydah Reserve, the juniper and *Acacia* woodlands are the representative woody vegetation.

Juniper woodlands vs. *Acacia* woodlands

The juniper woodlands are distinguishable from the *Acacia* woodlands by the presence of *Euphorbia schimperiana*, *Asparagus africanus*, *Asplenium officinarum*, *Minuartia filifolia*, *Themeda triandra*, *Lavandula dentata*, *Felicia abyssinica*, *Andropogon distachyos*, *Otostegia fruticosa* subsp. *schimper*, *Psiadia punctulata*, *Hypoestes forsskalii*, *Hypoestes forsskalii*, *Solanum schimperianum*, *Vulpia muralis*, *Osteospermum vaillantii* in the *Juniperus procera*, and by the absence of *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*.

The juniper woodlands are distinguishable from the *Acacia* woodlands by the presence of *Euphorbia schimperiana*, *Asparagus africanus*, *Asplenium officinarum*, *Minuartia filifolia*, *Themeda triandra*, *Lavandula dentata*, *Felicia abyssinica*, *Andropogon distachyos*, *Otostegia fruticosa* subsp. *schimper*, *Psiadia punctulata*, *Hypoestes forsskalii*, *Hypoestes forsskalii*, *Solanum schimperianum*, *Vulpia muralis*, *Osteospermum vaillantii* in the *Juniperus procera*, and by the absence of *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*.

Altitudinal range of the juniper woodlands and *Acacia* woodlands

The altitudinal range of the juniper woodlands varies. At Tanumah and Billasmar, north of the Raydah Reserve, they are between 2,400 m and 2,800 m, and relatively lower than in Jabal

Sudah. The woodlands at Ghara and Tamnyah, south of the Raydah Reserve, are between 2,400 m and 2,650 m. On the east slope of Jabal Sudah, the highest peak in Saudi Arabia, juniper woodlands occur between 2,600 m and 3,050 m. Within the Raydah Reserve, they range between 1,900 m and 2,900 m, which is wider than in other areas. The lowest juniper woodlands are as low as approximately 1,000 m.

The altitudinal range of the *Acacia* woodlands overlaps the ranges of the juniper woodlands on the eastern slope of Jabal Sudah, where the juniper woodlands are at higher elevations than the *Acacia* woodlands. In Billasmar and Tamnyah, the difference in range of the *Acacia* woodlands and juniper woodlands was not clear. The *Acacia* woodlands, however, do not occur in the Raydah Reserve, but *Acacia origena* appears in the juniper woodlands.

Altitudinal differences

In the Raydah Reserve woodlands, vegetation between 1,900 m and 2,900 m can be classified into four groups. The woodlands above 2,700 m consist of *Juniperus procera* in the tree layer and dead trees are seldom seen. These woodlands contain *Euryops arabicus*, *Clusia myrioides*, and *Dodonaea angustifolia* in the shrub layer. Young trees of *Juniperus procera* are unable to grow under a closed canopy and are found only in sunny places. The juniper woodlands at elevations between 2,700 m to 2,500 m contain *Acacia origena* and *Olea europaea* subsp. *cuspidata* in the canopy. Dead and dead trees were found only on roadsides and in rocky places. In woodland vegetation between 2,200 and 2,500 m, the dominant species in the canopy is *Juniperus procera*, *Acacia origena*, *Olea europaea* subsp. *cuspidata*, and *Nuxia congesta*. The species diversity is richest after the death of the junipers. Die-off of *Juniperus procera* is most conspicuous especially around 2,400 m, where dead juniper trees are abundant in rocky places and on steep slopes with thin soil. In the woody vegetation below 1,900 to 2,200 m, *Juniperus procera* is smaller and sparsely distributed and is hardly dominant. Large, dead trees of *Juniperus procera* are in the shrubby vegetation of *Tarchonanthus camphoratus*. Trees of *Juniperus procera* are nearly dead in areas below 2,000 m.

Classification of vegetation of the juniper woodlands

Applying the so-called table operation method, the juniper woodlands are classified into two communities, with six subcommunities and six composition groups, indicating that the juniper woodlands are not homogenous.

The two communities are the *Juniperus procera-Euryops arabicus* community and the *Juniperus procera-Senecio hadiensis* community. The diagnostic species of the former are *Euryops arabicus*, *Rhamnus lycioides* subsp. *oleoides*, *Hyparrhenia hirta*, *Themeda triandra*, and *Felicia abyssinica*. The diagnostic species of the latter are *Acacia origena*, *Solanum schimperianum*, *Euryops arabicus*, *Hypoestes forsskalii*, *Clusia myricoides*, *Rhamnus lycioides* subsp. *oleoides*, *Lavandula dentata*, *Dodonaea angustifolia*, *Helichrysum forsskalii*, and *Euphorbia schimperiana*.

The *Juniperus procera-Euryops arabicus* community (JE) is found at various sites, but the *Juniperus procera-Senecio hadiensis* community (JS) may be more extensive than the JE community in the Raydah Reserve. The JS community was found only in the Raydah Reserve, and is expected to be found on the west slope of Jabal Sudah (on the Red Sea side of the Asir Mountains). The dead trees with dieback of *Juniperus procera* are conspicuous in the JS community. The die-off is nearly confined to this community. The JS community has a rich flora in comparison with the JE community. The species richness appears to be related to fog and topography.

The JE community is mostly limited to the inland side of the Asir Mountains, except at higher elevations in the Raydah Reserve. The JE community overlaps the JS community only in the Raydah Reserve. On the inner side of the Asir Mountains, on the eastern slope areas of Jabal Sudah and Sugha, all the juniper woodlands are classified as JE communities. Neither dead trees of *Juniperus procera* nor trees with dieback are found in 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 JE community. The JS community is not found on the inner side of the Asir Mountains.

As shown in Table 7-3, the representative *Acacia* woodlands classified in the *Acacia gerrardii-Commicarpus plumbagineus* and *Acacia origena-Vulpia muralis* subcommunities differ clearly from those of the juniper woodlands in floristic composition. The *Acacia origena-Solanum schimperianum* and *Juniperus procera-Hypoestes forsskalii* subcommunities, however, are similar with many shared species (Table 7-3). The *Acacia origena-Solanum schimperianum* and *Juniperus procera-Hypoestes forsskalii* subcommunities are actually close in their floristic composition. Moreover, they are found in the same areas.

A remarkable fact is that the juniper woodlands with the highest species diversity contain many dead trees of *Juniperus*. In the Raydah Reserve, both the *Juniperus procera-Tarchonanthus camphoratus* and *Juniperus procera-Nuxia congesta* subcommunities in the JS community are

conspicuous in dead trees and trees with dieback, but their species diversity is the highest of all the juniper communities. Both the *Juniperus procera*-*Hypoestes forsskalii* and *Juniperus procera*-*Dodonaea angustifolia* composition groups of the JE community, occurring on the inner side of the Asir Mountains, have the lowest species diversity. Dead trees and trees with dieback of *Juniperus procera* are not related to species diversity. Generally, species diversity is higher in transitional rather than in stable vegetation.

Vegetational significance for conservation

Our studies reveal that conservation of the juniper woodlands needs to consider the vegetational diversity of the woodlands. For conservation and protection of the juniper woodlands it is necessary to employ or train expert persons in administration who can diagnose vegetation patterns and communities based on floristic composition.

Our research revealed that die-off and dieback are fundamentally different phenomena. That is, dieback is an adaptive mechanism in *Juniperus*, but die-off results in dead trees. Although the causes of die-off appear to vary, most sporadic die-off is related to disturbance, especially at lower elevations or on steep slopes with thin soils, such as in sites with road construction and heavy grazing. Our findings indicate that the traditional utilization of junipers, including wood cutting and grazing, is a better means of conservation and management of the juniper woodlands. It is desirable to manage the juniper woodlands in a stable condition through grazing.

Sociological aspects

The Raydah Reserve was managed by the local communities to protect it and to use its resources before being designated a protected area in 1989. It was designated a protected area because of the scientific and social excellence of the juniper woodlands.

A road runs through the Raydah Reserve from the top (Al- Suga Village) to the bottom (Raydah Village). The road was constructed by the Ministry of Communication and Transport for the conveniences of the local communities. Both the design and execution of this road were crude, however, and the presence of the road has produced some negative effects on the juniper woodlands in the reserve. The road has become wider every year because of rock falls from the cut slopes and scraping bulldozers. It has had a negative effect, since the road was narrower just after it was constructed.

From the viewpoint of wildlife conservation, it would have a positive effect on the reserve to

close the road and to leave the cut slopes to stabilize and re-vegetate. Wild animals and birds, too, would be free from the threat of vehicles. There is the possibility that the road will be sealed in the near future. The NCWCD should work with the Ministry of Communication and Transport to ensure that this work is carried out with consideration for rock fall prevention and draining, and that all loose rocks and soil from both new and old road construction should be removed from the site to reduce the negative effects on the juniper woodlands.

Die-off and dieback of the junipers

The term dieback is withering of branches gradually from terminal portion towards base; die-off is extensive withering that results in death of the whole tree. The reason to distinguish these two words is that dieback has been thought as an adjustment property of the trees of the genus *Juniperus* to periodic or long term drought stresses.

Various degrees of dieback and die-off are observed in the juniper woodlands, even in the healthy woodlands along the Abha- Taif road, and especially at Al-Souda, Bilasma, and Tamuma. As mentioned above dieback is defined here dieback does not always lead to the entire collapse of a juniper woodland. Individual trees will suffer dieback every several decades. The main cause of dieback, therefore, appears to be a random and unexpected fluctuation in rainfall. Dieback is an adaptation of *Juniperus procera* and of many other species of *Juniperus* in response to drought.

Many hypotheses can be proposed from our general understanding of the causes of dieback or die-off of junipers. Various factors being considered as the cause of these phenomena are listed below and compared with the results of our research and with information from former studies.

1) Factors

Factors suspected to be the cause of partial or complete damage to juniper trees are summarized as follow.

- (1) Global warming
- (2) Drought stress
- (3) Biotic factors
- (4) Human activities
- (5) Physical damage

These causes must be examined carefully using scientific methods to determine their

influence on the three main aspects of forest conservation: regeneration, tree growth, and forest dynamics.

(1) Global warming

Warming may cause shifting of the distribution area of plants. If the limit of plant distribution is restricted by temperature, the lower limit in the vertical distribution may be raised and the southern limit in the horizontal distribution may shift northward due to warming. As mentioned in Chapter 1, the air in this region has a tendency to become warm. The average air temperature has increased at the rate of 0.0557 degrees/year on average in seven cities in Saudi Arabia and has increased in total by 1.225 degree over a 22-year period. The lapse rate was 0.748 degrees/100 m on average from measurements in the Raydah Reserve. In Raydah, a 1.225-degree increase in average air temperature for 22 years is equivalent to about 160 m in elevation. If the average air temperature limits the lower limit of distribution of the juniper woodlands, the lower limit of the distribution might shift upward by about 160 m. Global warming may be a cause of die-off and dieback of the juniper trees in and near the lower limit of vertical distribution, as seems to be shown by die-off in the junipers in Jabel Fyfa. In the sections below the effects of climatic change are discussed in more detail.

(2) Drought Stress

We consider drought stress from three points of view: weather conditions, global warming, and water balance.

Weather conditions

As mentioned in Chapter 1, the monthly total precipitation for seven cities in Saudi Arabia has shown no obvious tendency over 20 years. Even if the annual total precipitation has not changed, sometimes the fluctuation in precipitation in a year can affect plant growth. It is necessary to analyze precipitation in more detail and to measure it continuously in the juniper woodlands.

Fog is also important for the supply of water as shown in data gathered at weather stations in the Raydah Reserve. The importance of water supplied by fog is different in different habitats. Usually the amount of water supplied by fog is greater at higher rather than at lower elevations. Fog can affect the growth of juniper trees more seriously at lower elevations where the amount of water from fog fluctuates.

Humidity and temperature can affect not only the occurrence of fog but also the physiological

aspects of the growth of juniper trees, such as transpiration and photosynthesis. The fluctuation in meteorological factors can affect the growth of the juniper trees seriously, especially in aspects of water stress. The effects of fluctuation in meteorological factors differ in importance among the habitats of the juniper woodlands. The heterogeneity in meteorological factors appears to explain the heterogeneity in the distribution of dieback and die-off.

Global warming

As mentioned in (1), dieback and die-off are inexplicable by global warming alone. To explain the heterogeneity in the distribution of the effects of global warming is not enough. In considering the effects of water stress caused by global warming, it appears possible to explain both the heterogeneity and inclination at lower elevations for dieback and die-off. Warming can raise the elevation range of fog where the temperature is lower than the dew point. In habitats where fog is a very important source of water, the warming may cause dieback or die-off in the lower part of the distribution of the juniper woodlands. In habitats where fog is not important, warming does not always cause dieback or die-off.

In general, an increase in CO₂ concentration cannot cause dieback or die-off directly. If CO₂ concentration causes the phenomena, it is through competition between the juniper trees and other tree species. Where dieback and die-off are observed, however, there are no obvious competitors.

Water balance

All terrestrial plants are fated to suffer from water stress during their growth. Maintenance of water balance is, therefore, a necessity for the survival of terrestrial plants.

- a. Cause of water shortage. Water imbalance within a tree is caused by transpiration exceeding water absorption. Factors controlling these functions are:

Difficulty in water absorption

Water supply: rainfall, change in the soil water channel

Water absorption: root damage, change of water quality

Excessive transpiration

Promotion of transpiration: solar radiation, wind velocity, reduced humidity

Inhibition of transpiration: stomata response, structure of cuticle layer

- b. Soil moisture

Usually plants take up water from the soil. The water content of the soil is, therefore, critical

for maintaining water balance. The water content of the soil is affected by rainfall. One of the most important factors affecting water supply is rainfall. Other factors are surface water and ground water from surrounding sites, and sometimes fog may supply water to the soil and directly to the leaves. As mentioned in Chapter 1, water content of the soil is strongly affected by precipitation. Other influencing factors are the water retention ability of the soil, soil temperature, air humidity, wind, and competition from other vegetation. The importance of soil water content differs among habitats. Where fog supplies little water, soil water content is relatively more important.

c. Water use efficiency (WUE)

By analyzing the ^{13}C of the needles, the WUE of *Juniperus procera* was proven to be higher than in other tree species. The effective inhibition of water loss in coincidence with a high photosynthetic rate in arid condition is an important characteristic for survival and growth in a stressful environment. The high WUE has adapted *Juniperus* well to arid conditions.

d. Acute water stress

Most inhibition of water loss is by response of the stomata. Even after complete stomata closure, however, transpiration continues through cuticular transpiration. The effect of inhibition of water loss is therefore not infinite. Since the annual and seasonal fluctuation in precipitation is wide in arid regions, water supply in each season varies widely and plants are likely to suffer acute water stress. Under severe water stress, plants can endure unfavorable growing conditions only by the closure of the stomata. In severe drought, dieback of the crown occurs, thereby reducing the transpiration surface and lessening water loss.

Pruned junipers seldom show dieback under natural conditions, which appears to confirm our interpretation of dieback in nature.

A large number of trees showing dieback grow in the Raydah Reserve. Most of them show appreciable re-growth of their shoots. Some have re-established a crown with dead branches still remaining. The same phenomenon can be observed from Abha to Taif. Trees with dieback seldom die after damage but start to re-grow. It, therefore, appears unlikely that dieback will lead to the entire collapse of a juniper woodland. Judging from the number of damaged branches exceeding several centimeters in diameter, each individual tree suffers dieback every several decades. The main cause of dieback, therefore, appears to be a random and unexpected fluctuation in rainfall.

e. Chronic water stress

Climatic change caused by global warming makes growing conditions worse and, as a result, affects water balance. However, such a gradual change in the water situation does not result in an endogenous imbalance of water within the crown, but a decrease in needle biomass in all parts of the crown. Therefore, the decline in crown density caused by a water deficit increases the possibility of death to the whole tree (i.e. die-off, through dieback).

f. Regional difference

Near Taif City, there is a healthy juniper woodland without signs of dieback. The annual precipitation in that area is, however, less than in Abha, and the trees grow under severe water stress. One of the possible explanations for this is that woodlands established under a great water deficit are made of trees with high drought tolerance under harsh growing conditions. For example, pine trees growing under dry conditions in Japan have higher drought tolerance than those growing on wet sites. The useful characteristics for regulating transpiration activity under strong water stress, such as prompt stomata response and a low cuticle transpiration rate, must be analyzed to clarify the factor(s) determining the northern limit of distribution.

g. Effects on regeneration

Regeneration begins when seeds germinate and continues through the survival and growth of seedlings.

A sufficient supply of water is necessary for seed germination. Soil moisture after rain and the occurrence of fog appears sufficient for seed germination in almost the entire Raydah Reserve. The contiguous distribution of seedlings on the woodland floor suggests that seedlings can survive only within a certain area where conditions are constantly mild and wet. Compaction of the soil by livestock must also contribute to the desiccation of seedlings by preventing water absorption.

h. Permeability of xylem

Decrease in xylem permeability may be affected by a physical block, such as tyloses and cavitation. There are no reports on widespread and frequent dieback caused by tyloses. In general, an extreme decrease in the xylem water potential and/or freezing in winter are the main causes of cavitation. Freezing of the sap never occurs in the Raydah Reserve. Cavitation caused by extreme low water potential is a result of excessive transpiration and/or lack of water and is likely to

occur in arid areas such as the Raydah Reserve. Therefore, some causes of dieback appear to be promoted by cavitation in the sap wood. The main cause of wilt of the apical branch is still drought stress. There is no evidence for the decline in xylem permeability caused by other factors, such as diseases or pests.

(3) Biotic factors

Conceivable biotic factors causing dieback or die-off in *Juniperus procera* are divided into two categories: external factors including pathogens, pests, parasitic plants, and grazing pressure; and internal ones including senescence and changes in stress adaptability.

External factors

a. Pathogens

Pathogenic factors include various microorganisms such as fungi, bacteria, mycoplasma, and viruses. In the present project, various fungi were detected by Suhaibani and Ogiwara in juniper trees showing dieback (Chapter 2.6). Neither pathogenic fungus nor a specific syndrome was identified, however. In general, pathological syndromes caused by microorganisms vary in woody species. In coniferous species, several fungi such as the shoot withering disease of *Larix kaempferi* and the blister rust disease of *Pinus strobus* causing crown withering in mature trees are typical pathogens relating to dieback. These diseases, however, show specific syndromes in infected organs. Although other microorganisms besides fungi were not studied in this project, pathogenic factors are suggested to be unlikely in dieback or die-off.

b. Pest (insects, nematodes)

Pests such as insects and nematodes can be possible causes of dieback or die-off in juniper trees. A list of various creatures, mainly insects, is provided in Chapter 2.7 by Saitoh. Several species of sawyers and bark beetles were collected in the juniper woodland of Raydah. Although those species cause damage to wood, most of them oviposit on dead or dying stems and branches, not on living trees or living parts of them. Sometimes lepidoptera cause drastic damage to leaves and shoots of woody species, in general. Environmental changes such as prolonged dry weather are possible triggers for a drastic increase in the number of insects such as locusts. However, such symptoms were not found in trees with dieback or in dead trees in forests of junipers. In addition, there was no increase in the number of specific insects or their larvae in the juniper woodlands.

Nematodes were not studied in the juniper woodlands in Asir. In eastern Asia, the pine nematode disease caused by *Bursaphelenchus xylophilus* increasing in number in the xylem is a well known cause of die-off in pine forests. The dying process caused by nematodes invading pines is drastic and only die-off occurs. The dieback and die-off phenomena in junipers is completely different from the dying process in the pines invaded by nematodes.

One parasitic plant, a kind of mistletoe, was identified in the juniper woodlands (Chapter 2.6). This species, however, does not cause damage to junipers.

c. Grazing pressure

Grazing and browsing pressures by livestock, including sheep, goats, and cows were considered as a possible cause of dieback or die-off in the juniper woodlands. According to the opinions of inhabitants in Raydah and our own observations, the livestock prefer to eat cones of junipers, but seldom browse the needle-like leaves and other organs. These observations indicate that there is little browsing pressure by livestock directly on junipers. Livestock pressure, however, should be considered as a factor affecting plant species diversity in the juniper woodlands, the regeneration of junipers, and soil conditions. For instance, soil compaction and ground devastation are frequently caused by livestock.

Internal factors

a. Senescence

Senescence or age advancement was considered to be a possible internal factor causing dieback and die-off in junipers. According to our data on tree ring analysis, the rate of increase in the stem diameter of four harvested junipers, which were 62, 82, 98, and 107 years of age, was continuous and did not reach a ceiling. Our observations suggest that senescence of juniper trees is not the major cause of dieback or die-off. Large or old junipers, however, may have a greater tendency to show dieback than younger trees because they have large stems, are taller, and have many old branches.

b. Stress adaptability (or crown reduction)

According to the results reported in Chapter 3.2, seedlings of *Juniperus procera* showed a high ability to accumulate ABA in leaves under weak or moderate water stress, but not under severe stress, indicating an efficient adaptability of this species to endure moderate water deficits, but not

severe stress. The data for both seedlings and mature trees indicate that individuals of this species are no more sensitive to drought stress during shoot elongation than during an increase in stem diameter. Our observations indicate that dieback occurs easily during shoot elongation in times of water shortages.

(4) Human activity - abiotic and external

Soil water content

As mentioned in (2), stable soil water supply is important for the growth of plants. Disturbance by livestock causes erosion and compaction of the soil, which causes a decline in the ability of the soil to retain water. Moreover, a decrease in the vegetation cover, caused by cutting, grazing, dieback, die-off, and so on, can reduce soil water content.

Salinity

Plant growth is greatly affected by the concentration of various minerals. Toxic minerals such as aluminum, zinc, lead, and copper, and high levels of salt in saline soils and coastal areas, sometimes cause serious damages to plants. Symptoms of the toxic effects vary, but there is no evidence of salt stress in trees with dieback or in dead junipers in Asir.

Pollution (industrial, agricultural)

Agricultural chemicals are not used for cultivation in large quantities, particularly within the juniper woodlands, so they cannot be factors causing dieback or die-off in the junipers, although we need to acquire more concrete information on industrial pollution.

There is also no evidence that the black rain during the Gulf War caused die-off or dieback. If it did, it would be observed in an extensive area (Yoshikawa and Yamamoto, 1995). Some people in Raydah Village recognized that dieback and die-off became conspicuous in the early 1990s, but it was also at a time when rainfall was less than before.

(5) Physical damage

Soil conditions

a. Erosion and road construction

Stable soils in the juniper woodlands are sometimes disturbed by human activities, including timber harvesting, road construction, and livestock pasturing. All of these can cause serious soil erosion. Above all, road construction in the Raydah Reserve caused serious erosion and the

destruction of mountainsides in the juniper woodlands. There were several dead or dying junipers with exposed roots from erosion caused by road construction in the reserve.

The effect of pasturing on soil is not noticeable in the Raydah Reserve, but serious soil erosion related to pasturing of livestock was observed in Jabel Taran. In general, soil erosion causes serious damage to the relationship between the soil and root system of the juniper trees. The expansion of soil erosion caused by human activities is a serious threat to the juniper woodlands.

b. Compaction by livestock

Compaction of the soil by livestock results in a desiccation of seedlings. Overgrazing should be considered in the regeneration of junipers and soil conditions over the long term.

According to the local people in Raydah Village, the number of livestock have not increased recently. Grazing pressure, therefore, does not appear to cause dieback or die-off in the junipers directly. For the future we need to watch carefully whether the number of livestock increases or decreases both at the local level and at regional levels.

Human activity

a. Timber harvest

A high intensity of both partial and whole tree harvesting has occurred in the Raydah Reserve. From an analysis of the spatial distribution of stumps and trees remaining in the forest, it is clear that whole trees have been carefully harvested at equal distances to avoid disturbing the forest canopy. The method of cutting the trees is therefore not a cause of forest destruction. Felling trees does not directly affect dieback, but has a great effect on forest dynamics. There is a remarkable difference in the intensity of harvest among sites depending upon the growing conditions of each site. The lack of a clear relation between tree density and harvest intensity shows overexploitation of trees in some of the stands, which must be a serious factor resulting in forest decline.

b. Pruning

No trees are pruned in the Raydah Reserve, but most junipers growing in rural areas on gentle east-facing slopes in the Asir Mountains are pruned from the bottom of the crown to 2 or 3 m above the ground. Dieback is seldom observed in these pruned trees. Due to the level of the ground surface water supply from rainfall for agriculture, the trees in the rural area have sufficient water, but at the same time are susceptible to acute water stress as mentioned above. Artificial control of the transpiration surface area by pruning is a very effective way to improve drought tolerance during

acute water deficiencies. Although pruning is useful for preventing dieback, further experimental analysis is necessary to determine the intensity and method of pruning under natural conditions.

c. Change in traditional uses

We also need to evaluate dieback and die-off in relation to changes in traditional uses of dead branches for firewood and charcoal. Based on the recollections of the local people, there is a possibility that dieback and die-off became conspicuous at almost all locations only recently as a result of a decrease in the importance of juniper as a fuel

In terms of timber harvest, cutting juniper trees for building materials has declined rapidly. Modern concrete houses have replaced the traditional houses made of juniper trees. An increase in human population will not result in overexploitation, as well as dieback or die-off of juniper trees.

Effects of water shortages on juniper growth

The results of plentiful field observations on dieback are summarized in the four categories as follows. All observations and evaluations indicate drought stress to be the cause of dieback.

(1) Physiological viewpoint

The main cause of dieback is brought on by inadequate water supply to individual trees. Almost all trees with dieback can re-establish their crown at the end of a drought. The loss of the apical part of the crown is one of the effective strategies of juniper to adapt temporarily to water shortages and appears to be a normal phenomenon under arid conditions. Artificial control of the transpiration surface by pruning the branches from the bottom of the crown is a useful measure to both prevent dieback and to promote growth for the production of good quality timber.

(2) Ecological viewpoint

In not only the Raydah Reserve, but also in the Asir Mountains, dieback is a normal response by juniper trees to a lack of water. Dieback, however, has not resulted in the entire collapse of the juniper woodlands. Felling trees by the inhabitants is done in a careful manner and there is no evidence of forest destruction by timber harvesting.

Since a special set of environmental conditions are necessary for seed germination and the survival of seedlings, regeneration can only occur at restricted sites with favorable weather conditions each year. Young seedlings are seen to grow into the open canopy after the death of a dominant tree. There is a low survival rate of seedlings in the understory. The death of dominant

big trees by acute and chronic drought stress, therefore, has a serious effect on forest structure. In arid areas covered only by juniper trees, decrease in tree density expands the bare land and accelerates ground erosion. Development of reforestation techniques, including nursery care, tree planting, and forest management are the most important objectives for a future project.

(3) Meteorological viewpoint

Meteorological change and fluctuation, including warming, can be causes for dieback or die-off. The inclination toward warming was observed in the Asir Region. It is possible that warming is shifting the lower limit of distribution of the juniper woodlands upward. If warming causes dieback or die-off directly, the distribution of these phenomena must be observed universally near the lower limit and the southern limit of the forests. These phenomena are observed only in specific areas, however. If meteorological change and fluctuation cause dieback or die-off by influencing the water supply, the heterogeneity and the inclination to the lower elevation area of the distribution of these phenomena can be explained.

Water shortages result in dieback and die-off, even in areas that normally have adequate supplies of ground water where fog is a significant source of moisture.

(4) Sociological viewpoint

There is no evidence that human disturbance directly results in dieback or die-off in junipers. All human activities have indirect effects.

Human activities such as timber harvesting, road construction, and livestock herding may cause serious soil erosion and damage to the root system of trees. Grazing and browsing pressure from livestock may be considered a possible cause of dieback or die-off in the regeneration of junipers.

Pruning branches is a very effective way to improve drought tolerance when there are acute water deficits. The primary reason for pruning, however, is to encourage the trunks of the trees to grow straight so that they can be used as building materials for traditional houses. The most important outcome of the sociological research was the discovery that the local people have nearly stopped their gathering of the branches for fuel and charcoal and stopped cutting the trunks for use as building material.

Conclusion

The importance of the conservation of the juniper woodlands was considered from the

perspective of biodiversity, vegetation, water resources, soil protection, flood prevention, improvement of the environment, and public health, and its impact on public awareness of the importance of ecotourism. A discussion on the importance was made in Chapter 9, in which we presented our proposal for conservation and management. The basic points for action are also described in Chapter 9 (see Tables 9-2, 9-3).

Summary

The Joint Study Project was provided scientific evidences for the conservation and effective management of the juniper woodlands of the Asir Mountains and the cause of dieback and die-off of *Juniperus procera*.

The Asir Mountains are the only locality where *Juniperus procera* occurs on the Arabian Peninsula and are at its northern limit of distribution. A considerable number of species associated with the woodlands are disjunctly distributed between Africa and the Arabian Peninsula, and indicate a strong affinity with the flora of the East African highlands.

The juniper woodlands have the highest diversity plants in the Arabian Peninsula. About 25% (460 species) of all Saudi Arabian species of plants (1800 species) occur in the Raydah Nature Reserve and the adjacent areas. *Centaurothamnus maximus*, only one representative of such endemic species, survives only several sites on steep, collapsed, roadside banks in the juniper woodlands in the Raydah Nature Reserve at elevations around 2,800 m.

The juniper woodlands, differing from the *Acacia* woodlands and ranging between 3050 m and 1900 m (exceptionally 1000 m), are not homogenous and classified into two different vegetation types named *Juniperus procera-Euryops arabicus* community and the *Juniperus procera-Senecio hadiensis* community.

Our research revealed that die-off and dieback are fundamentally different phenomena. Dieback is an adjustment property of *Juniperus*, but die-off results in dead trees. All observations and evaluations indicate drought stress to be the cause of the dieback. Though the degree and distribution of the die-off and dieback vary, most sporadic die-off and dieback are related to disturbance, especially at lower elevations or on steep slopes with thin soils, such as in sites with road construction and heavy grazing.

Juniperus procera has a high potential for natural regeneration because of the higher ability of seed germination. Shortage of water resources induces retardation of the regeneration and biomass production. The seeds are zoochoric and birds are important in seed dispersing.

The juniper woodlands in the Asir Mountains play an important role in collecting large amounts of water from fog in the same way do mossy forests in tropical mountains.