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The Magnitude of Dieback on *Juniperus procera* Trees in the Natural Forests in the Southwestern Region of Saudi Arabia

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The natural forests of Saudi Arabia occupied a large area in the mountainous southwestern region. This forest area is considered a unique ecosystem in Saudi Arabia representing a semiarid zone while the rest of the country lies within arid zone. The forests in Saudi Arabia have been important for human life in this region for a long time, where it was the main source of woods used for house constructions, cooking and warming. In addition, they are important habitats for wildlife and flora. Now, they are open as recreation centers and for tourism. These forests have been suffering from varying degrees and types of degradation due to both human-induced and natural factors. *Juniperus procera* trees in these forests have exhibited a widespread decline with extensive tree dieback and die-off. Dieback is a phenomenon affects different tree species overall the world. It occurred in the natural forests of Saudi Arabia since about 35 years. Now, vast tracts in these forests are seen full of trees affected by dieback and die-off. The causes of dieback have not been clarified yet. Many researchers have expected natural disturbances, such as drought, sand storms, fire, floods, insects and diseases, climate change that may lead to die-back and die-off. The magnitude of dieback of juniper trees vary from place to place and it existed in both lower and high areas. Indeed, it spreads overall the forest area in the southwestern Saudi Arabia. The percentage of juniper trees which are affected by dieback in Taif, Baha and Asir sub-region accounted for 5.1, 14.5 and 11.4, respectively. Solving this problem must base on information about its magnitude, effects, causes and then the way by which it can be eliminated.

Key words: Dieback, Juniperus procera, natural forests, Saudi Arabia

The importance of forests and trees in the world is widely recognized. The benefits and services that the people overall the world gain from forests are more than can be enumerated. Forests and trees play very important social, economic and environmental roles. The environmental protection role of forests is well known, while economically, they are crucial to land stabilization, watershed protection, desertification control, sand dune fixation, windbreaks, erosion control, agroforestry, soil fertility restoration and microclimate mitigation (El-Juhany 2009). They are also important sources of wood and non-wood forest products as well as browse for domestic animals. In addition, they are important habitats for wildlife and flora. Many communities over the world derive their livelihoods from the wide range of goods and services that forests provide. On the other hand, Forest ecosystems store a significant global carbon stock in its biomass (Joint Liaison Group of the Rio Conventions 2008).

Although the importance of forests they are subjected to degradation overall the world and particularly in developing countries. Forest degradation refers to changes within the forest class which negatively affect the stand or site and,

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in particular, lower the production capacity. Forest degradation involves the loss of ecosystem services or changes in species composition due to various factors including overexploitation, plant parasites, exotic species invasion, pollution, or fires (Sasaki and Putz 2008). In most cases, degradation does not show as a decrease in the area of woody vegetation but rather as a gradual reduction of biomass, changes in species composition and soil degradation (Jinlong 2004). Dieback of trees represents one of the most dangerous degradation forms that affect the forests. Dieback refers to the progressive death of twigs and branches, which generally starts at the tip.

Junipers tolerate a wide range of sites, extreme and rapid temperature fluctuations and arid sites where other plant materials would fail. However, in many areas in the world there are reports on decline and dieback of different species of juniper. The dieback phenomenon of juniper occurred in 1980's and expanded with time leading to forest degradation in the natural forests of the southwestern region of Saudi Arabia. This problem is not confined to a specific area but has been reported in different countries.

The present article is focusing on the dilemma of dieback of *Juniperus procera* in terms of its effects on the forests health and production as well as reviewing of its potential causes. The magnitude of dieback on *Juniperus procera* trees in the natural forests in the southwestern region of Saudi Arabia has been presented based on data collected from these forest areas.

Natural forests in Saudi Arabia

The natural forests of Saudi Arabia are located in the southwestern region. According to the data of the Ministry of Agriculture, there are 27,000 km² of woodland or 1.2 percent of the country's national land area. About 80 percent (21,000 km²) of this area is scattered throughout the Sarawat Mountain range in the southwestern region (NCWCD and JICA 2006). These forests have been familiar with human life in this region for a long time, where it was an important source of woods that were used mainly for house constructions, cooking and warming (El-Juhany 2009).

The natural forests of Saudi Arabia are a mountainous area extended from Taif in the north to northeast Jazan parallel to the Red Sea. This mountains area ranges in width from 10 to 40 km and the highest point of the Aseer - Jabal Soodah reaches 3050 meters above sea level in elevation (Chaudhary 1997). The climate of the region varies considerably depending on altitude, aspect and season. The highlands receive variable rainfall caused by the southwestern monsoon, which brings damp oceanic winds. These winds are uplifted by the mountains and trigger thunderstorms, particularly during the summer, with most rain falling in April/May and July/August. Annual average rainfall in the Escarpment Mountains is 600-800 mm, rising to over 1,000 mm in the wettest areas. The high plateau receives 300-500 mm, dropping rapidly to below 100 mm in the east. Temperatures in the highlands are highest in the summer, reaching 20-25°C, and lowest in winter with a mean of 10°C, although frosts can occur above and snow occasionally falls on the highest peaks (Miller 1994).

The southwestern mountainous region of Saudi Arabia is characterized by semi-arid climate which is suitable for the growth of certain non-xerophytic trees and shrubs. The entire southwestern region is the richest in terms of species diversity and contains the highest concentration of endemism, despite the fact that these high altitude areas are heavily populated with human settlements dating to ancient times (NCWCD 2005).

Species composition in the natural forests of Saudi Arabia

Woodlands of *Juniperus procera* Hochst. ex Endl. (The African pencil cedar) are present at altitude 3000 m. a. s. l. In the lower zones (<2000 m. a. s. l.) other tree and shrubs (*e. g. Olea europaea ssp. cuspidata*, *Pistacia palastina*, *Dodonaea viscose* Jacq. *etc*.) grow with *Juniperus procera*. In the zones less than 1000 m. a. s. l. where there are noticeable changes in the climate conditions juniper trees disappear and *Acacia spp*. predominate (Zahran 1999).

Juniperus procera

Juniperus procera is the most prominent component of vegetation at or above 1600 m elevation. It is present as *Juniperus procera* forest or *Juniperus procera* woodland or *Juniperus procera* open woodland or as co-dominant with some other tree species (Chaudhary 1997). *Juniperus procera* represents approximately 95 per

cent of the tree species grown in these forests (Abo Hasan *et al*. 1984). Beside *Juniperus procera, Olea europea ssp. cuspidata* and *Acacia spp*., the forest area comprises also other forest species such as *Barbeya oleoides* Schweinf., *Celtis Africana* Burm.f., *Dodonaea viscose, Ficus salicifolia* Miq., *Euryops arabicus* Steud. ex Jaub. & Spach, *Tarchonanthus camphorates* L.

Junipers species

Junipers are coniferous evergreen trees and shrubs. The genus *Juniperus* L. belongs to the family of *Cupressaceae* and comprises about 60 species which are widely distributed in the Northern Hemisphere with the exception of *Juniperus procera* that grows in the southern hemisphere (Adams 2000). *Juniperus* is the largest genus in the family Cupressaceae with approximately 70 species. It is also the third genus in the numbers among the conifers (Andersson and Lhoir 2006). Classification of genus *Juniperus* up to kingdom plantae is as follows: This paragraph seems odd so that I suggest writing it in a list (after as follows):

Genus	:	*Juniperus* L.,
Family	:	*Cupressaceae*,
Order	:	*Pinales,*
Class	:	*Pinopsida,*
Division	:	*Coniferophyta,*
Superdivision	:	*Spermatophyta,*
Subkingdom	:	*Tracheobionta,*
Kingdom	:	*Plantae* (USDA 2014).

The genus *Juniperus* L. consists of 67 species. The number of juniper species is disputed, with two different studies giving very different totals, Farjon (2001) accepting 52 species, and Adams (2004) accepting 67 species.

Juniperus procera

Juniperus procera Hochst. ex. Endl. is the only juniper that grows naturally in both the northern and southern hemispheres; all other *Juniperus* species are confined to the northern hemisphere (Adams, 2011). This species distributed in a native range in Congo, Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, Kenya, Malawi, Saudi Arabia, Somalia, Sudan, Tanzania, Uganda, Yemen, Republic of and Zimbabwe. It is existed also in Australia, India and South Africa but as an exotic species (Orwa *et al*. 2009). Adams (2004) mentioned that *Juniperus procera* naturally grows between the Arabian Peninsula in Asia to Zimbabwe in Africa (Fig. 1). He adds that it consists of two major populations: in Saudi Arabia/ Yemen and the high mountains of east Africa (Adams 2013).

Juniperus procera is one of the biggest trees in its genus reaching to a height of over 40 m and a diameter of above 3 m (Pohjonen and Pukkala 1992, Negash 1995). The tree is usually monopodial, but exposed trees sometimes multistemmed or branching very low. Crown is pyramidal in young trees while in mature tree it becomes broad, irregular and open (Farjon 1992). Young African pencil cedars have needle-like leaves, one to two centimeters long, and as the plant ages the foliage gradually changes to the scale-like adult leaves, which are light-green or yellowish-green and only up to six millimeters long (World Agroforestry Centre 2007). Bark at first is smooth, very soon changes to papery flakes and fibrous on older tree, deeply longitudinally furrowed, peeling in long in narrow strips with pale brown or grey-brown color (Farjon 1992).

Juniperus procera is dioecious where the male and female reproductive organs are borne on separate trees. Pollen, from the tiny cones on the male plants, is carried by the wind, birds, insects, animals or others to the waxy berry-like cones of the female plants. Fertilized by pollen, the ovules within the female cones develop into brown seeds.

El-Juhany *et al*. (2008a) mentioned that the shape of the cone of *Juniperus procera* tree is almost globular and it is light green before ripening changes to violet to brown color coated with a white film of wax after ripening with diameter ranges between 5.56 and 10.04 mm (a mean of 7.35 mm). On the other hand, the seed of *Juniperus procera* tree almost looks like an irregular prism and its color is light yellow. The dimensions of the seeds are 4.25, 2.69 and 2.25 mm for length, width and thickness, respectively. These range between 2.4 - 5.5, 1.5 - 3.9 and 1.3 – 3.8 mm, respectively.

Importance of *Juniperus procera* trees

Juniperus procera tree is planted as an ornamental tree and it is useful as a shade tree due to its spreading crown. The tree grows will in extreme conditions and tolerates poor soils, high temperatures and dryness so that it suitable for reforestation, soil conservation and for erosion control. *Juniperus procera* trees are effective when

planted as windbreaks. The wood of *Juniperus procera* (trade name: African pencil cedar) is widely used for building, joinery, flooring (strip and parquet), furniture and all sorts of outdoor work such as roofing shingles, fence posts, water flumes and transmission poles (Couralet and Bakamwesiga 2007).

Juniperus procera trees have good, workable and decay-resistant wood that is used for fence posts and shingles on roofs, for construction, furniture, cabinet making, and the manufacture of pencils.

It can be used for making veneer and plywood, hardboard and particle board, and as pulpwood. The wood is used as firewood and to make charcoal. The bark is used for roof shingles and for covering beehives. Essential oil distilled mainly from the sawdust is used in the cosmetic industry in soaps and perfumes (Couralet and Bakamwesiga 2007). Different parts of *Juniperus procera* tree are used in traditional medicine for man and animals.

In the southwestern area of Saudi Arabia, the wood of *Juniperus procera* trees was used for house construction (floors, ceilings, doors and windows), agricultural tools, walls for wells, firewood, charcoal and others.

Juniper problems

Junipers tolerate a wide range of sites, extreme and rapid temperature fluctuations and arid sites where other plant materials would fail. Junipers are generally considered to be low maintenance because they are relatively free of major insect and disease problems. Nevertheless, several fungal diseases may adversely affect the appearance and health of these trees in certain locations (Tisserat 1997). But, the diseases that occur on junipers are almost always associated with poor cultural practices, such as over-watering or too much shade (Westerfield 2012).

The rapid decline of junipers due to overexploitation and habitat degradation in recent times draws attention towards the need of conservation of this species and along with its associates (Rawat *et al*. 2006).

Dieback and declines of uncertain cause in several countries in the Near East Region affect some forest species include *Juniperus procera* in the Asir highlands, Saudi Arabia; *Cedrus libani*, *Juniperus excelsa* and *Abies cilicica* in Lebanon; and *Juniperus polycarpus* in Kyrgyzstan and Oman (FAO 2009). Of the 52 recognized species of juniper, 12 (23%) are on the *International Union for Conservation of Nature* Red List (IUCN 2006).

Degradation of the natural forests of Saudi Arabia

Unfortunately, the natural forests in the southwestern region of Saudi Arabia have been subjected to misuse mainly through intensive

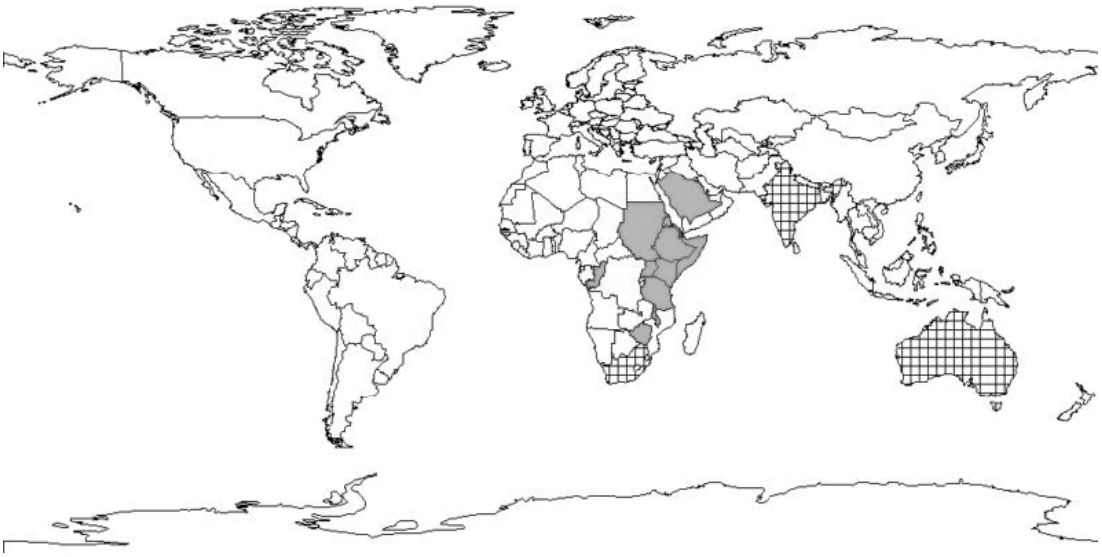

Fig. 1. Distribution of *Juniperus procera* over the world where it spreads naturally in the gray colored countries on the map while exotic in those filled with grid shape (Source: Orwa *et al*. 2009).

cutting and overgrazing. They also have not received the deserve care in terms of applying silvicultural practices and protection. Therefore, these forests have been suffering from varying degrees and types of degradation due to both human-induced and natural factors. Aref and El-Juhany (2004) mentioned that juniper forests in the southwest region of Saudi Arabia have become more susceptible to deterioration. This indicated by many gaps, symptoms of diseases on trees, low capacity of natural regeneration as may be noticed from the scarcity of seedlings. Moreover, El-Juhany (2009) asserted that the most obvious indications of forest degradation in the southwestern region of Saudi Arabia are low capacity of natural regeneration of the main forest species, high proportion of irregular and deteriorated trees, disappearing most of the larger trees, loss of shiny appearance of trees, die-back and die-off of trees, marked wood cutting and others.

Causes of this deterioration may attributed to extensive forest clearing for cultivation, over-grazing, and exploitation of forests for firewood and construction materials without replanting has reduced the forest area of the country (Aref and El-Juhany 2004). Molan (2010) reported on the presence of 21 fungal species belong to 12 genera of plant pathogenic fungi associated with roots and twigs of *Juniper procera* trees in the natural forests of southwestern Saudi Arabia. The phenomenon of juniper deterioration is not unique to Saudi Arabia but was also reported in Kenya, Kyrgyzstan, Morocco, Pakistan and the USA (El Atta 2006).

Dieback

Dieback is a common symptom or name of disease, especially of woody plants,

Table 1. Percentage of *Juniperus procera* trees that are affected by dieback at the locations of forest inventory in the southwestern Saudi Arabia

*Sub-region	Location	Elevation (m)	Total no. of inventoried juniper trees	No. of trees affected by dieback	Percentage of trees affected by dieback
**Taif	Shafa	2318	517	30	5.8
	BaniSaad	2471	165	6	3.6
	Balhareth	2356	275	36	13.1
	Thaquif	1914	363	5	1.4
	Bani Malik	1873	303	10	3.3
	WadiThi-Ghazal	2077	200	7	3.5
	Al-Hada	2135	230	11	4.8
Total sub-region			2053	105	5.11
Baha	Douce	1936	824	71	8.6
	Mandaq	2178	1280	181	14.1
	Baha- center	2296	1220	233	19.1
	Bahah- south	2070	1133	160	14.1
	Shura	1864	11	2	18.2
Total sub-region			4468	647	14.48
Asir&East	Balqurn	2121	2106	282	13.4
Jazan	El-Nemas	2511	1799	107	5.9
	Ballasmar	2543	1994	162	8.1
	Ballahmar	2671	252	46	18.3
	North & West Abha	2766	815	186	22.8
	South Abha	2335	274	32	11.7
Total sub-region			7240	815	11.26
Total southwestern region			13761	1567	11.39

*Sub-region is a term used to point to the major areas of forest inventory within the main administrative regions of the southwestern Saudi Arabia (*i. e.* Mecca, Baha, Asir and Jazan).

**Taif is a county represented Mecca Al-Mukarramah region.

characterized by progressive death of twigs, branches, shoots, or roots, starting at the tips (Encyclopædia Britannica 2014). Dieback describes a condition where trees die or decline in condition prematurely and often rapidly (Nadolny 2002).

Dieback is a general term describing a widespread long-term decline in tree health. It may be caused by a range of factors but has widely recognizable symptoms.

The first sign of dieback is usually canopy thinning which starts at the branch tips, followed by defoliation, epicormic growth (from the trunk and branches), and dead branches, eventually leading to tree death (Ross 2013).

Decline or dieback of trees and forests is a condition characterized by episodes of premature, progressive loss of tree or stand vigor without obvious evidence of physical injury or attack by a primary disease or pest (Ciesla and Donaubauer 1994).

"Decline" is a term often used to describe a more general set of symptoms or syndrome associated with loss of tree vigor. These include reduced growth, reduction in size and quantity of foliage, chlorotic foliage, death of twigs and branches and, in some cases, tree death. Dieback can be part of the decline syndrome (Ciesla and Donaubauer 1994).

Feasibility study on means of combating forest dieback in the European Union (2007) mentioned that the causes of most important forest damaging agents in Europe are storm/ windfall, snow/ avalanches, drought, insects, diseases, browsing, domestic animals, invasive species, inappropriate management, illegal logging, pollution and fire.

Ross (2013) mentioned that dieback may be caused by a range of interacting factors, making it very difficult to predict or treat. Some suggested causes include agricultural practices (grazing, improved pastures, fertilization, clearing), altered fire regimes, and climatic effects (warming, extreme events *e.g.* flood, drought). She added that dieback is often associated with insect outbreaks, which may take advantage of trees under stress.

From a pathological viewpoint, dieback can always be considered as symptomatic of a disease, even when biotic agents play only a minor role in the causal chain. From an ecological viewpoint, however, it should be possible to distinguish between dieback as the result of disease and dieback as a natural phenomenon (Mueller-Dombois 1988). The exact causes of this dieback are unknown but possible causal factors include local climate change, stand dynamics and secondary biotic agents.

Dieback is not the result of any single factor like a disease organism or a long hot summer. Usually there are several effects working against a tree for years (regent honeyeater 2014).

Dieback of *Juniperus procera*

FAO (2007) in its Working Paper FBS/20E about overview of forest pests in Kenya mentioned that during the mid-1900s, extensive dieback and mortality of *Juniperus procera* forests was detected in the highlands of central Kenya. Symptoms included a slow, progressive dieback of the branches beginning in the upper crown. Affected trees eventually die. In some locations, up to 80-90 percent of the junipers were affected. Damage was heaviest at the lower elevations and there were indications that the dieback began in the early 1980s (Ciesla *et al*. 1994; Ciesla *et al* 1995). Dieback was more pronounced in large trees, particularly in the case of *Juniperus procera*. Since large trees use more water per unit time than smaller trees (Meizner 2003). The higher dieback rate of larger trees following elevated temperatures may be related to the higher vulnerability of larger trees to xylem cavitation especially during extreme drought conditions (Brodribb and Cochard 2009).

Dieback of *Juniperus procera* in Saudi Arabia

In Saudi Arabia, *Juniperus procera* and *Juniperus phoenicea* woodlands in the western highlands are declining dramatically in areas of low altitude (Asmodé 1989), and in the Asir highlands, *J. procera* woodlands have exhibited a widespread decline with extensive tree death below 2400 m (Blot 1994, Fisher 1997).

Ma (2008) asserted that the overall health of *Juniperus procera* woodlands in the Sarawat Mountains in Saudi Arabia is generally considered to be poor, with extensive decline and dieback. Also, Chaudhary and Le Houerou (2006) mentioned that over hundreds of square kilometers of the junipers forests at lower elevations have died in Saudi Arabia. The features of the deterioration of the juniper forests in the southwestern region of Saudi Arabia can be seen in large areas lost their trees and other areas stricken by dieback where

many of their trees are partly or completely dead (El-Juhany 2009). It is worth to mention that the phenomenon of dieback in *Juniperus procera* trees in the natural forests had been noticed and recorded by the author in the first forest inventory that had been achieved from 1980 to1984 (data not shown). Similar observations were reported in some locations in Kenya, where up to 80-90 percent of the junipers were affected. Now vast tracts in the natural forests in southwestern region of Saudi Arabia are seen full of trees affected by dieback and die-off, in particular in Al-Shaabah, Bani-Obaid and Al-Muaalem forests within Ballasmar area, Asir region. In Jazan region, most of the juniper trees on Al-Hasher Mountain are affected by dieback or completely dead.

Causes of dieback of juniper forests in Saudi Arabia

(El-Juhany *et al.* 2008a) mentioned that dieback of *Juniperus procera* trees is a phenomenon has occurred since about 35 years in the southwestern forests of Saudi Arabia and affecting other tree species, however, yet there is no a single reason has been accused in this problem. Moreover, El-Juhany (2009) stated that dieback affects juniper trees and is considers the main problem facing the forests not only in Saudi Arabia but in many other countries; however, there was no real progress toward detecting what is causing this dieback. Also, the Presidency of Meteorology and Environment (2010) in its efforts to overcome a range of obstacles impeding the improvement of ecosystems pointed to a need for further positive steps to address the threats to the ecosystem such as diseases, pests, dieback and mass mortality currently surround forests. It warned that if no intervention occurs, the situation will worsen with time.

Hypotheses proposed for the decline include temperature-induced dieback, periodic droughts and a long-term increase in aridity and overgrazing. In this example, grazing and extraction of wood play a minimal role, but water stress has been partially blamed for the decline: Junipers inhabiting wadis are significantly healthier than those distant from wadis. Hydrology is thus thought to have a role in the health of juniper woodlands (Fisher and Gardner 1995).

Fisher (1997) proposed four hypotheses for the decline of the Arabian juniper woodlands and all the four hypotheses depend on climate change and were overgrazing, global warming, periodic droughts combined with long regeneration cycles and a long-term increase in aridity.

Japanese International Cooperation Agency's team stated that although the cause of die-back has not been completely proven, the possibility is high that the damage seen in all the mountains of Jabal Tallan and Jabal Fyfa in the southwestern region of Saudi Arabia is due to global warning (JICA 2002). However, climatic effects in general may be driving juniper forest dieback, but in different areas death may be exacerbated by factors such as unsustainable wood-use and grazing (Fisher 2007).

A number of major scientific uncertainties are associated with forest dieback phenomena. For instance, the magnitude of climatic stress that forests can withstand before massive dieback kicks in is not known thus forest dieback in response to projected climate changes cannot accurately be modeled (Allen 2007). Darfaoui (2011) postulated that natural forests in Saudi Arabia identified as being at risk. He add that anticipated negative impacts of climate change on range and forest lands over the 50-100 years include: increases in the frequency and changes in the patterns of natural disturbances, such as drought, sand storms, fire, and floods leading to increase die-back and die-off in forests and woodlands; spread of diseases; change in species composition and richness, drop in productivity; and a decrease in biodiversity.

Nevertheless, anthropogenic factor seems to be the main suspect in dieback and decline of juniper forests in Saudi Arabia. Barth and Strunk (2000) who the main objective of their study was to locate the reasons for the die-back of the trees and to propose suitable measures to improve the actual situation reported that the trees in Al-Soudah family park in Asir mountains show obvious signs of degradation for some years and on several areas within the family park more than 50% of the juniper trees are already dead or extremely damaged. They attributed this degradation to the intensive recreation and camping activities that destroy the vegetation cover and make the soil material susceptible to erosion. Aref and El-Juhany (2000) stated that irregular distribution of water within the forests after rainfall because of the change in the natural

water streams which results from the road construction within the territory forests leads to depriving some of the trees from their water requirements. NCWCD and JICA (2006) reported that juniper woodlands have declined mainly due to human activities, such as tree felling, overgrazing, road construction, expanding farmland, building recreational facilities, and housing. Water stress, human impacts, climate change, impacts of diseases are the package of juniper forests dieback causes (Al-Hemaid 2007). Regent honeyeater (2014) added physical compaction by stock hooves, mechanical changes to soil structure, loss of friable top soil, loss of protective leaf letter, increased exposure to high temperatures and drying winds as factors lead to more run off and less water retention in the root zone that makes tree becomes stresses from lack of water and nutrients.

Data on dieback of *Juniperus procera* in Saudi Arabia

The last inventory that had been accomplished in the natural forests southwestern region of Saudi Arabia included elaborated work on dieback phenomenon of *Juniperus procera* (Department of Natural Resources 2007). The obtained data showed that there is a serious threat not only to *Juniperus procera* but also to other forest species.

Table (1) shows the percentage of juniper trees which are affected by dieback in Taif sub-region ranged from 3.3 in Bani Malik to 13.1 in Balhareth with 5.1 as an average. While it increased in Baha sub-region to 8.6 in Mandaq and 19.1 in south Baha with an average of 14.5. In Asir, the percentage of juniper trees that are affected by dieback ranged between 5.9 in El-Nemas and 22.8 in North and West Abha with a mean of 11.4.

We noticed that the proportion of trees that affected by dieback is high within the highest population density areas or near them revealing the impact of human activities. There is also a correlation between the increased percentage of dieback and the humanitarian activities including expanding infrastructure, building construction, recruitment, road construction,...*etc*.

Population density (people per sq. km) in Saudi Arabia was last measured at 12.77 in 2010, according to the World Bank. The administrative areas of the kingdom which include the natural forests are of the highest population density in the country. They can be arranged in descending order as Jazan, Mecca, Baha then Asir region with 56, 33, 31 and 23.9 inhabitants /km, respectively (NASA 2014).

Treating dieback of trees

There are different causes of dieback in trees. Many junipers over the world are experiencing branch dieback, both in new and mature plants and this as a result of either biotic or abiotic factors causes. The key to control of dieback is the early diagnosis and stop spreading the symptoms either to other parts of the tree itself or to other trees. The treatment of dieback is done according to the diagnosing its cause. Feasibility study on means of combating forest dieback in the European Union (2007) asserted that in order to prevent, mitigate and control the negative impacts of biotic, abiotic or human induced damages to forests in Europe, it is essential to have available sound, reliable, comparable and up-to-date information on the multiple causes of forest dieback. Only by this effective and efficient prevention and/or mitigation measures can be developed and implemented.

In areas where the cause of dieback is known as a result of fungal infection (*e. g. Phytophora spp*.) plants must be treated with fungicides.

Pruning may be desirable and necessary to remove dead, dying, and diseased wood, to reduce the crown size and put it into balance with a weakened or reduced root system, and to promote new growth (University of Illinois Extension 1996). Cutting the tip of a shoot will encourage the lower lateral buds to develop and grow. However, corrective practices such as proper watering, fertilization, and pruning are not guaranteed solutions in all cases (Illinois IPM).

Juniper forests in southwestern Saudi Arabia are currently exposed to dieback, and scientists and researchers have not find a solution for this dilemma yet (Encyclopedia of Saudi Arabia 2012). In 2006, and in collaboration with FAO, the Ministry of Agriculture implemented a successful juniper ecosystem rehabilitation project based on runoff water harvesting, removal of dead trees and branches and planting local juniper saplings in an effort aiming to combat the juniper dieback in the Sarawat Mountains in Saudi Arabia for a year

(Darfaoui and Al Assiri 2011). However, the success in rehabilitation of an ecosystem does not occur within short time and makes juniper trees show considerable recovery and flourishing inside the repaired terraces as a result of improvement in rainwater harvesting and soil conservation. Also, the project was concerned with rehabilitation process and has not look for the causes of forest degradation; particularly dieback.

The efforts of combating juniper dieback in the natural forests of Saudi Arabia is based on only removing the affected trees (or branches of trees) and planted new trees. This is considered a jump to a forward stage of dealing with the dieback phenomena as a dilemma without studying its causes and find out the most appropriate treatment to stop it. Until now, there was no a single study has proved the presence of any of the fungal diseases that are known to cause dieback in juniper trees. The hypothesis of climate change as a potential cause of dieback of juniper forests in Saudi Arabia has not been proved also.

Dealing with the problem needs more insight about its magnitude, effects, causes and then the way by which it can be stopped or reduced at least. This can achieved only through elaborated investigation processes by a team work include researchers from different disciplines related to forestry and according to the results of their investigation they can propose the treatment needed. After that the role of the executive institutions may come to carry out the proposed actions on the field and thereafter to evaluate the progress in the achieved activities.

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