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The Present Status of the Natural Forests in the Southwestern Saudi Arabia 2-Baha Forests

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Abstract: A forest inventory was conducted in Baha region as a second stage of the forest inventory project of the natural southwestern Saudi Arabia. Baha region was divided into six sub-regions, namely Douce, Al-Mandaq, Central Baha, South Baha, Shura and Tihama. Several sites were selected in each sub-region and within each of these sites a number of sampling plots were chosen. Thus, the inventory frame in Baha region comprised 6 sub-regions, 19 sites and 57 sampling plots. The results of the inventory revealed that the number of trees measured in all the sites of Baha region was 8199 trees, 27% of them was in the South Baha, while Douce, Al-Mandaq and Central Baha had 20, 24 and 26% of the total number of trees in the region, respectively. Shura and Tihama had the least number of trees that was only about 1.4 % of the total number of trees in the whole region. Tree density in the sub-regions ranged between 145 and 752 trees per hectare in Al-Mandaq and Shura, respectively. Number of seedlings in the sampling sites accounted for 5808 seedling, it ranged between 92 in Shura and 1664 in Douce which formed 1.4 and 28.7% of the total number of seedlings in the whole Baha region, with no seedlings at all in Tihama. The greatest number of seedlings was 857 and found in Al-Qarn area in Douce sub-region, more than 56% of them belong to *Juniperus procera*. Number of tree species that was found in one sub-region ranged between three in Tihama and nine in Douce. The main tree species found are juniper, acacia, domestic Neem and wild olive and they are present at a rate of 64.5, 18.4, 10.4 and 3.9% of the total number of trees measured in the sampling sites, respectively. The average diameters of trees in various areas ranged between 6.5 cm in Al-Mandaq and 16 cm in Tihama, while the average heights ranged from 3.4 m in both Douce and Al-Mandaq to 5.4 m in Tihama. The approximate total tree volume in all the sampling sites of Baha forests accounted for 280.346 cubic meters. The highest tree volume is 94.6747 cubic meters in South Baha, while the least is 7.0286 cubic meters in Shura. The percent of unmeasured trees in all the sampling sites of Baha region accounted for 15.7% of the total number of trees that have been inventoried in the region. It ranged between 0.08 and 32.5% of the total number of unmeasured trees in Tihama and Central Baha, respectively. The percent of trees which are affected by dieback and those are totally dead was 51.3 and 17.3% of the total number of unmeasured trees in all the sampling sites, respectively. The percent of trees affected by dieback ranged between 0.5 and 36% in Shura and Central Baha, respectively, while the percent of the totally dead trees ranged between 8.3 and 60.6% in Al-Mandaq and South Baha, respectively.

Key words: Baha region · Forests inventory · Saudi Arabia · Natural regeneration · Species composition

INTRODUCTION

Saudi Arabia has a large area of land dominated by desert. However, it comprises other forms of terrain including coastal plains, highlands, plateaus and valleys. The Southwest region of the country includes high mountains called Al-Sarawat Mountains that are parallel to the Red Sea and which extend for about 1,800 km. In this there are 27.000 km^2 (1.2 % of the area of the country) of woodland [1]. These forests remained under a system of tribal protection since ancient times, where they were an important source

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for the timber used in the manufacture of ceilings of the buildings, doors and windows and in the manufacture of agricultural tools. They were also the main source of firewood and coal, grazing land for domestic animals and under their trees, both man and animals are shaded [2]. Despite the importance of natural forests in the Kingdom as a unique ecosystem in this region, which is one of the dry areas and provided protection for agricultural land in the region where they prevent soil erosion by rain and increase the water supply in the ground and regulate the flow of water, they suffered abuse as over cutting, intensive grazing and fires, as well as the lack of take care for them in terms of development [3, 4]. These practices have resulted in a marked deterioration in these forests.

The government of the Kingdom, represented by the Ministry of Agriculture took over to issue legislation and regulations that governing the protection of forests and lands in this region and work on proper exploitation with a focus on planting trees in all parts of the Kingdom, which helped to increase the cultivated areas of forest trees. With growing environmental awareness, agricultural institutes and research centers in the Kingdom began in the study of natural forests in the Kingdom and the possibility of their development and then exploited them economically. Developing forest stands requires work on different tracks. Among these, if not the first, is having knowledge about those forests. Forest inventory, along with knowledge of forest principles are essential to develop a forest management plan and to justify the silvicultural management prescriptions applied to the forest for conducting a sustainable forest practice [5]. Forest inventory can also help to determine if the current level of timber harvesting is sustainable.

The present inventory represents a step on the way to develop and conserve the natural forests in the southwest region of Saudi Arabia and this article presents the results of the forest inventory in Baha region.

MATERIALS AND METHODS

General Description of Baha Region: Baha is the smallest region among the 13 administration regions of the Kingdom of Saudi Arabia with an area of 12.000 km^2, represents 0.6 of the total land area of the Country [6]. Baha region is located in the southwest part of the Kingdom of Saudi Arabia and occupies a portion of the mountains of Al-Sarawat (plural of Sarah). It is bounded on the north and west by Makkah and on the south and east by Asir region and located between the longitudes 41° and 42° east and between 19° and 20° latitudes south (Fig. 1).

Despite the occurrence of the region within the continental dry climate, but the highness of Al-Sarawat Mountains above the surface of the sea and their exposure to moist winds coming from the narrow plains of Tihama in the western Saudi Arabia had form a moderate

Fig. 1: Location of Baha region within the Kingdom of Saudi Arabia

climate in summer and cool in wet winters. The region is characterized by rainfall throughout the year also features a lot of fog especially in the mountains and low temperatures in summer and winter. Therefore, Baha is developing into a major tourist resort located at a distance of nearly 220 km from Makkah and 350 km from Abha.

Terrain of Baha is divided into low plains of western access to the coast of the Red Sea known as Tihama and volcanic mountains known as Hijaz or Al-Sarah. The mountainous areas are almost totally covered by *Juniperus procera* trees in addition to other forest species and fruit species.

Agricultural terraces are spread over the mountainous areas and produce wheat, barley, sorghum, millet, sesame, lentils and vegetables as a local pumpkin, potatoes, carrots, tomatoes, peppers and others [7].

Design of Forest Inventory in Baha Forests: The inventory process comprises designing the inventory, designing the forms of collecting the information, dividing the forest area into several sub-regions, describing the tree cover of each site, measuring all the trees and shrubs within each sampling plot and analyzing the information obtained.

Sampling design is implemented in several steps included stratification means to divide a heterogeneous population (sub-regions) into subpopulations (strata=sites and plots) based on common grouping criteria (elevation, aspect, tree cover, *etc*.). Therefore, Baha region was divided to six sub-regions; they are Douce, Al-Mandaq, Central Baha, South Baha, Shura and Tihama. These sub-regions were coded each with letter R and a number from 1 to 6. In each of these, several sites were selected that may vary from each other in the dominant type of tree cover or tree density or elevation or topography. In each site, a number of plots ranged from 2 to 5 were selected according to the wideness of the site and the degree of diversity in its topography. These plots are the areas within which the inventory and tree measurements were conducted and they may differ from each other in elevation or aspect or topography. The coordinates of the center of each plot and its elevation were recorded in a list (Table 1).

Determine the Number of Sampling Units Required for the Inventory: To determine the number of sampling units required for a given inventory, the decision must be made as to how close to the true parameter the sample estimate must be. Therefore, there is an upper limit of the error in the estimate can be tolerated with the expectation of

Table 1: Sampling units (plots) of forest inventory at different sites in Baha region

Sub-region	Plot No.	Coordinates		Elevation (m)
Douce	R1 S1 P1	20 20 21.4	41 10 36.0	1812
(R1)	R1 S1 P2	20 20 24.2	41 10 30.5	1818
	R1 S1 P3	20 20 22.2	41 10 42.5	1825
	R1 S2 P1	20 19 30.5	41 12 30.2	1813
	R1 S2 P2	20 19 03.3	40 12 44.9	1860
	R1 S2 P3	20 18 18.2	41 12 54.7	1870
	R1 S3 P1	20 16 30.0	41 13 28.5	2115
	R1 S3 P2	20 16 18.8	41 13 32.7	2055
	R1 S3 P3	20 15 56.9	41 13 30.0	2130
	R1 S4 P1	20 12 24.4	41 13 35.7	1975
	R1 S4 P2	20 12 02.6	41 13 35.7	1922
	R1 S4 P3	20 11 52.8	41 13 46.4	1924
Al-Mandaq	R2 S1 P1	20 11 05.6	41 14 36.2	2039
(R2)	R2 S1 P2	20 11 24.4	41 14 35.6	2130
	R2 S1 P3	20 11 28.5	41 14 27.0	2130
	R2 S2 P1	20 02 42.3	41 22 38.6	2316
	R2 S2 P2	20 05 19.7	41 18 43.1	2136
	R2 S2 P3	20 04 17.2	41 19 37.3	2167
	R2 S3 P1	20 03 59.1	41 20 26.4	2233
	R2 S3 P2	20 03 51.8	41 20 23.0	2247
	R2 S3 P3	20 04 23.0	41 19 31.9	2206
Central Baha	R3 S1 P1	20 01 23.7	41 26 18.7	2285
(R3)	R3 S1 P2	20 01 14.3	41 26 02.8	2259
	R3 S1 P3	20 01 02.6	41 25 44.7	2283
	R3 S2 P1	20 02 27.9	41 28 19.8	2343
	R3 S2 P2	20 02 44.7	41 28 42.8	2305
	R3 S2 P3	20 02 42.6	41 28 30.7	2300
	R3 S3 P1	20 06 57.2	41 35 11.1	1862
	R3 S3 P2	20 06 52.8	41 35 41.6	1850
	R3 S3 P3	20 07 41.6	41 36 31.9	1764
	R3 S4 P1	20 08 31.8	41 36 52.1	1748
	R3 S4 P2	20 09 11.7	41 37 34.8	1718
	R3 S4 P3	20 09 48.9	41 38 14.8	1692
South Baha	R4 S1 P1	19 58 51.0	41 31 08.3	2186
(R4)	R4 S1 P2	19 57 03.3	41 31 08.3	2327
	R4 S1 P3	19 57 20.9	41 31 46.4	2366
	R4 S2 P1	19 49 49.3	41 37 23.1	2116
	R4 S2 P2	19 49 42.4	41 37 30.2	2107
	R4 S2 P3	19 49 25.7	41 37 23.4	2179
	R4 S3 P1	19 51 30.9	41 39 54.3	2062
	R4 S3 P2	19 51 33.3	41 41 08.7	2179
	R4 S3 P3	19 51 59.2	41 41 15.1	1970
	R4 S4 P1	19 50 29.1	41 42 07.8	1978
	R4 S4 P2	19 50 15.6	41 42 07.7	1948
	R4 S4 P3	19 50 06.9	41 42 22.7	1980
	R4 S5 P1	19 48 70.8	41 42 81.3	1990
	R4 S5 P2	19 48 35.5	41 42 12.6	1985
	R4 S5 P3	19 48 45.9	41 41 45.5	2030
	R4 S6 P1	19 47 23.7	41 44 29.8	1940
	R4 S6 P2	19 47 53.4	41 44 45.3	1945
	R4 S6 P3	19 47 42.9	41 44 58.1	1966
Shura	R4 S1 P1	19 49 11.6	41 47 15.1	1862
(R5)	R4 S1 P2	19 48 51.7	41 47 31.5	1841
	R4 S1 P3	19 48 35.6	41 47 38.2	1864
Tihamah	R6 S1 P1	19 32 68.7	41 16 17.3	150
(R6)	R6 S1 P1	19 32 08.2	41 15 52.6	148
	R6 S1 P1	19 31 84.5	41 25 49.6	108

making a rational sampling decision based on reasonable estimates of the inventory. This limit must be defined before the preview and has expressed in units of the measured traits (volume, basal area, diameter, height, etc.) or as a percentage of value (such as 5%, 10% or 15%). When the upper limit of error it determines as a percentage called the allowed error. The allowed error is synonymous with the half-width of a confidence interval. Depending on a confidence interval of 95% confidence level or upper bound on the allowed error estimation for estimating the mean number of the sampling units (plots) required in the population as the following [8]:

$$n = 4N\, S^2y \,/\, (B^2_M N + 4\, S^2y)$$

Where, n= the number of sampling units required, B_M= the allowable error, $S_{\bar{y}}$ standard error of the mean, S^2= variance and, N= total number of sampling units in the population

Definitions

Inventory: the present forest inventory project.

Sub-Region: a peace of land occupied by trees and comprises a number of sites and plots for the inventory purpose; it is a part of a large territory or a large region.

Site: a peace of land represents the area in which it is located in and, comprises a number of sampling plots in which the inventory is conducted.

Plot: a peace of land represents the site in which it is located and, inside it the trees and other plants are measured.

Unmeasured Trees: comprise both irregular and declined trees in addition to those are partly or completely dead.

Irregular Trees: comprise curved, twisted, cleft, multi-stemmed, dwarfish and leaning trees.

Declined Trees: comprise destroyed, cut, fully cut and burned trees

Dead Trees: comprise the trees that are partly dead due to dieback or completely dead.

Scattered Forest (Poorly-stocked): has less than 1000 trees per hectare

Medium Forest (Medium-Stocked): has a number of trees ranged between 1000 and 1600 trees per hectare

Dense Forest (Well-Stocked): has more than 1600 trees per hectare

Establishing the Sampling Units: In the present inventory, the squared sampling plots of 50 m × m 50 m were used based on the fact that the majority of Baha forests are scattered. However, in few sites where the forest cover is medium or dense, rectangular sampling plots with 25 m × 50 m were used. Establishing sampling plot was done through the following steps.

- Firstly, one corner of the sampling was determined by inserting an iron wedge in the ground at that corner.
- The corner next to the first one was determined by measuring a distance equal to one of the two sides of the plot using a measuring tape. An iron wedge was inserted in the ground at that corner then, the two corners were connected to each other with a taut rope.
- The direction perpendicular to the former dimension was determined using a compass at one of the two corners that were previously assigned. Then the second dimension of the sampling plot was measured in this direction with a measuring tape, with also inserting a third wedge at the third corner.
- The previous step at the third corner or the first corner was repeated until the third side was determined.
- To close the fourth side of the plot, the third corner was connected with the fourth one or the first corner with the fourth one using a taut rope.

To establish the boundaries of the squared plot (50 m × m 50 m); we used the fact that the two diagonals of the square are perpendicular to each other. Where two lines of 70.7 m length each were marked on the ground and crossed each other at the center of the plot then, the four corners points of the plot were marked at the end of the two perpendicular diagonals. Conversion of horizontal distance (mainly 25 and 50 m) to slope distance was adopted through composing a table showing each horizontal distance and its equivalent slop distance at different slope angles ranged from 1 to 45. This was done by dividing the horizontal distance on the cosine value of each slope angles.

Recording the Specification of the Sampling Plot: The specification of sampling plot such as coordinates, elevation, topography features, slope and general characteristics of the tree cover *etc*. were recorded on a plot data recording sheet. GPS device was used to determine coordinates and elevation.

Description of Tree Cover: Description tree cover included the status of trees, shrubs and other plants and dominant species and density of tree cover.

Measuring and Counting Trees: Diameter outside bark at 30 cm above ground level and total height from ground level to the top of tree for each tree within the sampling plot were measured [9]. All the measured and unmeasured trees were counted.

Subsequent Calculations: Tree density in sampling plots, sits and sub-regions were calculated using the number of trees in each. Using the main collected data of tree measurements, the average diameter and height of each plot, site and sub-region was calculated. These collected data was also used to estimate approximate tree volume in each plot then in each site and sub-region. The approximate tree volume was estimated using "Smalian formula" [10] and the form factor of *Juniperus procera* in the forests of the Southwest region of Saudi Arabia that was determined by Abo-Hassan *et al*. [11].

Statistical Analysis: All the collected data was recorded in the inventory forms and analyzed for computing the main statistical parameters using SAS (statistical analysis software) [12].

Sampling Design

Douce Sub-Region (R1): Douce is an area belongs to Al-Mandaq County and comprises many villages as well as commercial and tourist facilities. It stretches from the beginning of the northern border of Baha region with Taif County (Makkah Region) to the north of Al-Mandaq City. Their elevations graded above sea water level from 1812 to 2130 m. Little areas cultivated with economic crops are permeates the forests of Douce. The center of this sub-region is Barahrah City and is located 28 km away from Al-Mandaq City.

Sampling in Douce: Four Sampling sites were chosen in Douce sub-region as follows:

The first site (S1) comprises three sampling plots, two of which are located on the right side of Taif-Baha Touristic Road adjacent to Al Nu'man village. The third plot is located on the left side of the same road next to Manhujah village.

The second Site (S2) is to the south of the first one and has three sampling plots. One of these plots is located on the right side of Taif-Baha Touristic Road opposite to Al Kahtout village, while the other two are located on the left side of the same road adjacent to Hawiat Douce Village.

The third site (S3) includes three sampling plots and is characterized by higher elevation than both the former two sites. Its elevations range between 2055 and 2130 m above sea water level. The first plot is located on the right side of Taif-Baha Tourist Road, in front of Barahrah City. The second plot is located next to the this city, while the third one is on the left side of the same road and next to Khajat Douce Village.

The fourth site (S4) comprises three sampling plots characterizes by elevations higher than those of either S1 or S2, but less than those of S3. The elevations of the plots of S4 range between 1922 and 1975 m above sea water level. The first sampling plot is located on the right side of Taif-Baha Touristic Road (several meters away from the road), in Al-Qarn area and in the opposite to Ghamadan Village. The other two plots are on the left side of the same road and vary in their aspects and tree density.

Al-Mandaq Sub-Region (R2): Al-Mandaq is a county in Baha region, it comprises several administration centers. It is located on Al-Sarawat Mountains, 200 km south of Taif City and 40 km northwest of Baha City. Its elevations range between 1800 and 2400 m above sea surface level. The area is covered with forests and has limited areas of agricultural lands around villages.

Sampling in Al-Mandaq: Three sites were chosen in Al-Mandaq sub-region to conduct the inventory of its forests. The first site (S1) is located on the northwest of Al-Mandaq City and known as "Al-Khalab". It comprises three sampling plots, one of them is located on the right side of Taif-Baha Touristic Road and the other two are on its left side. The elevations of these range between 2039 and 2130 m above sea surface level and each have a different aspect.

The second site (S2) is located on the south of Al-Mandaq City and comprises three sampling plots. One of these is located on the left side of Taif-Baha Touristic Road, on the front of Ikremah Village which belongs to Bani Hasan County, while the others are on the right side of the same road. These plots have elevations range between 2136 and 2316 m above sea surface level and vary in their aspects, tree density and species composition. The third site (S3) is located in Bani Hasan area and comprises three sampling plots with elevations range between 2206 and 2247 m above sea surface level. The first two plots are located on the right side of Taif-Baha Touristic Road (300 meters away from the road) next to Al-Jawfaa Village, while the third plot is on the left side of the same road in front of this village.

Central Baha Sub-Region (R3): Central Baha sub-region includes three different nonadjacent areas namely "Raghadan Forest" that is located on the northwest side of Baha City, "Shahbaa Forest" that overlooks the city from the east and Al-Aqiq Valley which extend from Baha City to the East.

Raghadan Forest is considered of the most important national parks in the south-western region of the Kingdom and characterized by its dense tree cover in the most parts of it and it is dominated by juniper trees. It has tall and straight trees as a result of appointing it as an entertaining place since a long period of time. However, the original area of the forest has shrunk a lot due to establishment of many buildings and roads within it. These also affected the natural stability of the forest.

On other hand, Shahbaa Forest as an entertaining place has been subjected to misuse similar to Raghadan but, the status of the trees in the former is much worse, where the dieback in juniper trees is more widespread.

The third area of inventory in Central Baha sub-region is Al-Aqiq Valley which characterizes by communities of acacia, in addition to scattered Buckthorn trees. The inventory sites in Al-Aqiq Valley are lower in elevations comparing with the other inventory sites in this sub-region.

Sampling in Central Baha: Four sites were selected for forest inventory in Central Baha sub-region. The first site (S1) comprises three sampling plots. These are located inside Raghadan Forest and slightly vary in elevation (range between 2259 and 2285 m a.s.w.l.). The second site is located inside Shahbaa Forest and includes three sampling plots have elevations ranges between 2300 and 2343 m a.s.w.l. and vary in their aspects. The third site is located inside the bottom of Al-Aqiq Valley and has also three sampling plots with elevations ranges between 1764 and 1862 m a.s.w.l. and dominated by acacias. The last site is also located in the bottom of Al-Aqiq Valley but with sampling plots have lower elevations (range between 1692 and 1748 m a.s.w.l.). These plots are dominated by scattered acacia and Buckthorn trees.

South Baha sub-region (R4): The area of forest inventory in South Baha extends from the southern boundaries of Baha City to the south of Baljurashy City (at the end of Gazzanah forest). The area has many villages interspersed with agricultural land in the form of terraces. The forests of this area are scattered and degraded.

Sampling in South Baha: Six sites for forest inventory were selected in South Baha sub-region. The first site is located on the sides of Taif-Abha Highway and comprises three sampling plots have elevations ranges between 2186 and 2366 m a.s.w.l. and each has a different aspect. The second site in Al-Halabah to the south of the first site and comprises three sampling plots have elevations ranges between 2107 and 2179 m a.s.w.l. and each has a different aspect. The third site is located in Mouataf area and has three sampling plots vary in their elevations which range from 1970 to 2179 m a.s.w.l.

The fourth site is located in Al-Sakran area and has three sampling plots vary in their elevations which are lower than those of the plots of the previous sites; they range from 1948 to 1980 m a.s.w.l. The sampling plots in this site have a mix of tree species composed of *Juniperus procera*, *Acacia sp.*, *Barbeya oleoides* and *Olea europea ssp. Africana*.

The fifth site is located in Al-Gemá area and has also three sampling plots have elevations ranges between 1985 and 2030 m a.s.w.l. with scattered and mixed tree cover. The last site of forest inventory in South Baha forest is located in Gazzanah forest south of Baljurashy City and has four sampling plots. This site has the lowest elevations among all the sites of inventory in South Baha sub-region where they range from 1940 to 1966 m a.s.w.l. The forests in this site are mixed species and degraded more than those in any other site of the area.

Shura Sub-Region (R5): Shura sub-region is located in the far south of Baha region and adjacent to its border with Asir region. This sub-region is considered the lowest area in Baha region on its axis from north to south and its forests are scattered and mixed.

Sampling in Shura: Because the area of Shura sub-region is small, one site only was selected for inventorying their forests. It has three sampling plots on both sides of Taif-Abha Highway. These plots have elevations range from 1841 and 1864 m a.s.w.l.

Tihama Sub-region (R6): Tihama is the name given to the coastal plain that separates the Red Sea coast and the mountain range Al-Sarawat in the southwestern part of Saudi Arabia. Thus it dose not rise much above sea level. The forest cover in Tihama varies from that in the mountains in terms of species composition and density.

Sampling in Tihama: Due to the similarity of the forests in Tihama sub-region in terms of species composition and tree density, only one site was selected for inventorying their forests. It has three sampling plots located in the bottom of Al-Ahsabah Valley south of Qilwah City which parallel to Baha City. They have elevations range from 108 and 150 m a.s.w.l. The site of inventory in Tihama is dominated by *Salvadora persica* followed by *Tamarix sp.* then *Zizyphus spina-christi*.

RESULTS AND DISCUSSION

Forest inventory in Baha region represents the second phase of the natural forest inventory project in southwestern Saudi Arabia. The area of the region is 11,184 square kilometers and is characterized by mountainous terrain interspersed with cultivated areas in addition to many large and small valleys. The region is dominated by sparse to medium density tree cover consists primarily of juniper trees in addition to other tree species such as acacia, wild olive, domestic Neem and others.

The inventory of Baha forests has a frame included 19 sites and 57 sampling plots (Table 2).

Number of Trees and Tree Density: 6909 trees of various species were measured through the forest inventory in the different sub-regions of Baha. South Baha sub-region has the highest number of trees among all the sub-regions of forest inventory; it has 26% of all the trees counted in the whole region. On the other hand, Douce, Al-Mandaq and Central Baha sub-regions have a close number of trees that formed 22.3 and 23.1 and 25% of the total number of trees in the whole region, respectively. Shura and Tihama sub-regions were the least in terms of the number of trees counted, which amounted to 1.6 and 1.7% of the total number of trees in the whole Baha region, respectively (Table 3).

As the most basic measure of stand density is the number of trees per unit of area, density is calculated by adding up the number of trees in a plot and dividing it by the area in hectares. In terms of tree density, Al-Mandaq sub-region has the greatest number of trees per unit area; its tree density accounted for 752 trees per hectare, while the least in tree density was Shura sub-region with only 145 trees per hectare (Table 3).

Table 2: Forest inventory frame in Baha region

Symbol	Sub-region	No. of sites	No. of sampling plots
R1	Douce	4	12
R2	Al-Mandaq	3	9
R3	Central Baha	4	12
R4	South Baha	6	18
R5	Shura	1	3
R6	Tihama	1	3
	Total Baha	19	57

Table 3: Number of tree species, total number and percent of measured and unmeasured trees and tree density in different sub-regions in Baha region

		Measured trees		Unmeasured trees		
Sub-region	No. of species	Total number	% of total Baha	Total number	% of total Baha	Density (tree/ha)
Douce (R1)	7	1534	22.20	118	7.14	511
Al-Mandaq (R2)	4	1598	23.13	395	19.8	752
Central Baha (R3)	4	1728	25.01	419	19.5	576
South Baha (R4)	4	1825	26.41	352	16.2	405
Shura (R5)	5	109	1.58	5	4.4	145
Tihama (R6)	3	115	1.66	1	0.9	307
Total Baha	13	6909	100	1290	15.7	449

Table 4: Tree and shrub species grown in Baha forests

Symbol	Scientific name	Family
1	*Juniperus procera* Hochst. ex Endlicher	Cupressaceae
2	*Acacia sp.*	Memosaceae
3	*Barbeya oleoides* Schweinf.	Barbeyaceae
4	*Olea europea ssp. Africana* (Mill.) P. Green.	Oleaceae
6	*Rhus retinorrhea* Steud. Ex. A. Rich.	Anacardiaceae
7	*Teclea nobilis* Del.	Rutaceae
8	*Euclea shimperi* (A. DC.) Dandy	Ebanaceae
9	*Pistacia falcata* Becc. ex Martelli	Anacardiaceae
10	*Dodonaea viscosa* Jacq.	Sapindaceae
13	*Azedarachta indica* A. Juss.	Meliaceae
14	*Zizyphus spina-christi* (L.) Willd.	Rhamnaceae
15	*Salvadora persica* (L.)	Savadoraceae
16	*Tamarix sp.*	Tamaricaceae

The results of the forest inventory in Baha region reveals that Shura sub-region was the least in number of trees, tree density and number of seedling. This may be due to several reasons such as the small size of the area, its lower elevation comparing with surroundings and its location near Taif-Abha Highway; all make it susceptible to various types of intensive exploitation.

On the other hand, South Baha sub-region which has the largest number of trees includes the area from the Baha City to Gazzanah in the south represents the areas of the highest elevations in the region (range between 1940 and 2366 m a.s.w.l.). In addition, this sub-region occupies a large area of land and its forests may have found protection under its high population density.

Species Composition: Species composition of the plot will give a snapshot of what the forest is currently comprised of. This is particularly important when monitoring the influences of silvicultural treatment on forest composition over time, or 'natural' forest dynamics [5]. On the other hand, information on growing stock composition offers a proxy indicator that aids better understanding and monitoring of the dynamics of the relative abundance of forest tree species [13].

Number of tree and shrub species that have been inventoried in one sub-region of the forest areas of Baha region ranged from three species in Tihama to 13 species in Douce (the shrubby and less occurrence species were omitted) (Table 5). The main tree species found are juniper, acacia, domestic Neem and wild olive and have formed 64.7 and 18.1, 10.4 and 3.9% of the total number of trees measured in the sampling areas, respectively. While the other tree species such as Buckthorn, Tooth-brush and Tamarisk accounted only about 2% of all species in the region (Table 4 and Table 5).

It seems that the few remaining number of Buckthorn and Tamarisk trees in the sampling area of Tihama has left in order to make the valley more suitable for grazing. While the presence of large numbers of Tooth-brush trees is because of the direct benefit which comes from extracting branchlets from the roots of live trees and marketing them as teeth brushes (miswaak in Arabic).

The abundance of juniper trees in Al-Mandaq sub-region probably attributes to its higher elevations and the rugged nature of its mountains (especially in the past before incision modern roads) that protected its forest from the extensive exploitation as it was not easy to be accessible. While the small size of the trees and irregular growth show that they were cut in the past and branches grew from them as coppices are considered the current trees.

Characteristics of Tree Cover: The inventory data showed that the number of unmeasured trees in all sampling sites in Baha region accounted for 1290 represent 15.7% of the total number of trees that have

Table 5: Species composition in the forests of different sub-regions of Baha region

	Species composition (%)									
Sub-region	1*	2	3	4	7	8	9	14	15	16
Douce	54.6	5.4	34.6	2.9	1.2	0.6	0.5	0.0	0.0	0.0
Al-Mandaq	80.1	14.6	3.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0
Central Baha	70.6	26.3	1.5	0.0	0.0	0.0	0.0	1.6	0.0	0.0
South Baha	62.1	26.6	5.5	5.7	0.0	0.0	0.0	0.0	0.0	0.0
Shura	0.0	10.1	2.8	83.5	0.0	0.0	0.9	2.8	0.0	0.0
Tihama	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	70.4	24.3
Total Baha	64.5	18.4	10.4	3.9	0.1	0.13	0.12	0.52	1.2	0.4

*1, 2, 3, …*etc*. are referring to the different tree species (see table 4)

Table 6: Numbers and percentages of irregular, declined and dead trees in different sub-regions in Baha region

			Dead trees			
Sub-region	Irregular trees	Declined trees	Dieback	% of total	totally dead	% of total
Douce (R1)	0	7	71	11	40	18.3
Al-Mandaq (R2)	52	144	181	27.9	18	8.3
Central Baha (R3)	75	83	233	36	28	12.8
South Baha (R4)	28	32	160	24.7	132	60.6
Shura (R5)	2	0	3	0.5	0	0
Tihama (R6)	1	0	0	0	0	0
Total Baha	158	266	648	100	218	100
% of total Baha	12.3	20.6	50.2		16.9	

Table 7: Number of seedlings of the main species in the different inventory sub-regions in Baha region

	Main species						Total	
							of no.	No. of
Sub-region	1	2	3	4	10	14	seedlings	seedlings/ha
Douce	519	39	484	00	619	00	1664	579
Al-Mandaq	233	171	888	00	00	00	1293	609
Central Baha	89	308	731	00	00	4	1132	412
South Baha	120	501	451	00	563	00	1635	635
Shura	00	10	38	10	26	00	84	112
Tihama	00	00	00	00	00	00	00	00
Total Baha	961	1029	2592	10	1208	4	5808	491
% of total Baha	16.5	17.7	44.6	0.17	20.8	0.07	100	

*1, 2, 3, …*etc*. are referring to the different tree species (see table 4)

been inventoried in the whole region. The percentage of unmeasured trees ranged between 0.08 and 33.2% of the total number of trees measured in the sampling sites in Tihama and Central Baha, respectively (Table 3).

The percentage of the trees that are stricken by dieback and those are totally dead was 50.2 and 16.9% of the total number of trees measured in all sampling areas, respectively. The trees affected by dieback ranged from 0.5 to 36% in Shura and Central Baha, respectively, of the total number of trees affected by dieback in the whole region. While the proportion of the totally dead trees ranged between 8.3 and 60.6% in Al-Mandaq and South Baha, respectively of the total number of totally dead trees in the whole region (Table 6).

About 11% of the total number of the inventoried trees in Central Baha are affected by dieback; this represents 55.6 of the total number of unmeasured trees in this sub-region. On the other hand, the totally dead trees in South Baha represents 6.1% of its total inventoried trees which form a rate of 37.5% of their total number of unmeasured trees (Table 6).

Natural Regeneration: Natural regeneration of tree species is a feature of forest trees in their natural habitats and requires suitable environmental conditions for seed production, germination and growth [14].

Number of seedling found in the sampling areas in Baha forests reached 5808 seedlings. The numbers ranged from 92 seedlings in Shura to 1664 seedlings in Douce that formed 1.6 and 28.6% of the total number of seedlings in the whole region, with no seedlings at all in Tihama (Table 7). Although, 54% of of the total number of juniper seedlings in Baha region are found in Douce sub-region, however, more than 37% of the seedlings in this sub-region belong to undesirable shrubby species (*Dodonaea viscosa*), while juniper seedlings represent 31% of the total number of seedlings in this sub-region.

About 45% of the total number of seedlings in Baha region are of domestic Neem; 34% of them are in Al-Mandaq sub-region. Number of *Acacia sp*. form only about 18% of the total number of seedlings in Baha region; half of them are in South Baha. This means that the capacity of natural generation of the economical tree species in these forests is limited.

Table 8: Mean stem diameter (cm tree^{-1}), height (m tree^{-1}), volume (m^3 tree^{-1}) and total volume (m^3) of tree measured of different species in different sub-regions of Baha region

Symbol	Sub-region	Mean diameter (cm tree^{-1})	Mean height (m tree^{-1})	Mean volume (m^3 tree^{-1})	Total volume (m^3)
R1	Douce	8.5	3.4	0.0210	53.78
R2	Al-Mandaq	6.5	3.4	0.0145	34.77
R3	Central Baha	8.9	4.0	0.0302	74.78
R4	South Baha	10.2	4.2	0.0357	94.68
R5	Shura	8.3	4.1	0.0277	7.03
R6	Tihama	16.0	5.4	0.0777	15.30
	Mean Baha	9.73	4.08	0.0330	280.35

Calculted number of seedlings per unit area (hectare) showed that South Baha has the greatest one followed by Al-Mandaq, Douce, Central Baha and Shura with a rate of 635, 609, 579, 412 and 112, respectively. El-Juhany *et al.* [15] reported only 35 seedlings per hectare of *Juniperus procera* in Ridah Reserve; a suburb of Abha City in Asir region which is next to Baha region from the south. While in Taif Forests, which is next to Baha region from the north, only 2% of its total number of seedlings belongs to *Juniperus procera* comparing with about 59% for *Dodonaea viscosa* [16]. These authors also reported that number of seedlings per unit area in Taif Forests ranged between 4 and 1152 seedlings per hectare, but unfortunately, within the later there are only 13 juniper seedlings represent 20% of the total number of juniper seedlings in the whole Taif region. Aref and El-Juhany [17] mentioned that low capacity of natural regeneration in the south west part of Saudi Arabia is noticed from the scarcity of seedlings and presence of many gaps in the forests.

Comparing with Taif County, Baha region has more juniper, lower acacia and much more domestic Neem seedlings based on the results reported by El-Juhany ad Aref [16]. Juniper and acacia seedlings represent 16.5 and 17.7% of the total number of seedlings in Baha forests comparing with only 2.07 and 35.5% for them in Taif forests, respectively. While *Dodonaea viscosa* shrubs represent 20.8% of the total number of seedlings in Baha Forests comparing with 58.9% in Taif Forests.

Tree Measurements: The dimensions of trees measured in the different sub-regions of the forest inventory in Baha region have averaged as between 6.5 cm for diameters of trees in Al-Mandaq and 16 cm in Tihama, with an overall average of 9.73 cm. While the average heights ranged from 3.4 m in both Douce and Al-Mandaq to 5.4 m in Tihama, with an average of 4.08 m (Table 8).

Total tree volume in all the sampling sites accounted for 280.346 cubic meters. The highest value for total tree volume was 94.675 cubic meters in South Baha sub-region, while the least was 7.029 cubic meters in Shura (Table 8).

Total tree volume in all the sampling sites of Baha forests is greater than that in those of Taif forests which was estimated at 114.72 m^3 [16]. Although the area of sampling in Baha forests which accounts 11.8250 ha is not much lower than that of Taif forests which is 15 ha, however the total estimated tree volume in the later is only 41% of that in the former. This may attributed to the protection that was available in the past for the forests in Baha region by tribes, while the location of Taif in the way of travelers in the past and appointing Taif as an area for recreations in the present make its forests subjected to excessive exploitation.

In this inventory the approximate tree volume in sampling sites depends on the number of trees on the one hand and the dimensions of the trees on the other hand. It was found that the largest total tree volume in one site is 15.3 cubic meters which in Tihama sub-region and this because of the large size of the trees. This can be verified from its average tree volume which amounted to 0.078 cubic meters per tree (Table 8). El-Osta [18] estimated the standing timber volume in both Taif and Baha forests through a timber cruise and found that in Baha is much larger that that in Taif and mentioned that this is due to the quality of standing trees in Baha forests which is better than that in Taif ones. Calculating total tree volume in the sampling sites per unit area of Baha region accounted for 23.708 m^3 per ha. While El-Juhany and Aref [16] found that the total tree volume estimated in the sampling area of Taif County accounted only for 7.648 m^3 per ha, this comparison may support El-Osta's finding about the standing timber volume in both Taif and Baha forests.

CONCLUSION

By looking at what it was in the past, the forests of Baha region look degraded in general. This can be noticed from the low density of tree cover, increase the numbers of irregular trees, degraded, dieback and totally dead trees. However, the forests of Baha seem better than Taif forests and characterized by increasing the number of juniper seedlings in the inventory sites; the main economic tree species.

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