

## The Present Status of the Natural Forests in the Southwestern Saudi Arabia: 3- Asir and East Jazan Forests

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**Abstract:** Forest inventory in Asir and East Jazan area represents the third phase of the inventory project of the natural forests in southwestern Saudi Arabia. The borders of the sampling area start from Asir region's northern border with Baha region to Bani Malik in Jazan region in the south. The forest area in Asir and East Jazan has been divided into 7 sub-regions, each with as many sites as breadth, different terrain and geographical location. Each site also included a number of sampling plots. Thus, the sampling frame of forest inventory in Asir and East Jazan has become includes 40 sites include 117 sampling plots. The results showed that total number of trees that have been counted in different sampling sites in Asir and East Jazan reached 12,441 trees, 30.6% of them is in Balqarn sub-region while the least is in East Jazan sub-region with only 1.4% of the total number of trees in the whole region. Tree density ranges between 90 and 892 trees per hectare in the East Jazan and El-Namas, respectively. Number of seedlings of the different tree and shrub species in all the sampling areas ranges between 1.3 and 27.1% in the East Jazan and Baqarn of total number of seedling in the whole area of inventory, respectively. Number of seedlings per hectare ranges between 49 and 382 in East Jazan and Ballasmar sub-regions, respectively. Number of unmeasured trees from different tree species in the sampling area accounted for 1881 tree represents 15.2% of total number of trees in the whole area of inventory. The number varied between 16 trees in East Jazan and 706 trees in Balqarn at a rate of 0.6 and 25.8% of the total number of trees found in the sampling areas, respectively. Among the unmeasured trees, the percentage of the trees affected by dieback ranges between 3.9% in South Abha and 34.6% in Balqarn, while the totally dead trees ranges between 1% and 42.5% of total number of unmeasured trees in the whole Asir and East Jazan inventory areas, for the same sub-regions, respectively. Number of tree and shrub species that have been identified in one sub-region of the forest areas in Asir and East Jazan ranges from 5 in El-Namas, Ballahmar, South Abha and East Jazan to 9 in Balqarn and Ballasmar. Regarding the dimensions of trees, average diameters of trees in different sampling sites ranges between 7.6 cm in El-Namas and 21.6 cm in East Jazan, while the average heights of trees ranges between 3.0 and 8.5 m in the same sub-regions, respectively. Finally, the approximate tree volume in different sub-regions of forest inventory areas in Asir and East Jazan ranges between 21.4 m<sup>3</sup> in Ballahamr and 161.1 m<sup>3</sup> in Balqarn represent 2.9 and 21.6% of total approximate tree volume in Asir and East Jazan areas of forest inventory, respectively. On the other hand, the average approximate tree volume ranges between 0.025 and 0.818 m<sup>3</sup>/tree in El-Namas and East Jazan sub-regions, respectively with an average of 0.071 m<sup>3</sup>/tree for the whole region.

**Key words:** Saudi Arabia % Asir % East Jazan % Natural forests % Inventory % Natural regeneration % Species composition

### INTRODUCTION

Asir region occupies the bulk of Al-Sarawat Mountain range in southwestern Saudi Arabia, where its northern border begins from the southern border of Baha

region and its southern borders end at the northern border of Jazan region. Asir region includes large tracts of land stretching across the eastern slopes of these mountains to the borders of the Empty Quarter and across its western slopes until the Red Sea coast.

The geographical area of Asir region is estimated about 81,000 square km [1]. While, the East of Jazan area is considered a natural extension of Asir region in terms of terrain as it includes rugged mountainous areas, although the bulk of the Jazan region is a flat land.

The heights of Asir region receive amount of rainfall up to 500 mm per year [2]. Asir region's forests characterized by botanical diversity may not be available to another area of the forest areas in southwestern Saudi Arabia and it is more divers as compared with the Arabian Peninsula as a whole [3]. Juniper trees prevail these forests, especially in the most high places in addition to other different tree species such as *Acacia spp.*, *Olea europaea ssp. africana* (Mill.) P. Green. *Ziziphus spina-christi* (L.) Willd. *Tamarix aphylla* (L.) H. Karst. grown in the lower elevations. There is also some tree species in Asir that not found in other forest areas like *Dobera glabra* Forssk. *Adenium obesum* (Forssk.) Roem. & Schult. *Mimusops laurifolia* (Forssk.) Friis, *Ficus sycomorus* (L.) and *Tamarindus indica* (L.).

The eastern parts of Jazan region share Asir region in the presence of this tree species, but its rainfall is less. The forests of both Asir region and eastern Jazan are most vulnerable to deterioration as a result of undesirable change in biodiversity due to natural and anthropogenic external factors.

The main problems that are facing these forests in the present are the loss of environmental equilibrium as a result of changes made in the natural streams caused by building roads, declining biodiversity due to use the forests as parks that forced many of the forest animals to escape and others (like monkeys) to increase with increasing the wastes and, finally decreasing the area of these forests as a result of the random expanding in constructional and agricultural activities and, fires [4]. Currently, large areas of juniper forests have suffered degradation as a result of dieback, like what is seen now in areas such as Balqarn and Ballasmar.

We see that as the natural forests and tree communities in the Kingdom are of the most renewable natural resources, their maintenance, development and conservation is one of the priorities. Unfortunately there are no studies on the natural forests in the Kingdom concerning its present forests in terms of productivity, age, species composition, the capacity of natural regeneration, the status of its constituent species and risks that affected them and deterioration of their soil and trees. Such studies are essential to develop plans for maintaining these forests and promoting appropriate policies to take advantage of them in an optimal way.

The present study therefore includes data collected from an elaborated forest inventory as a primary step on the way to achieve the desired actions to improve the natural forests in the southwest part of Saudi Arabia.

## MATERIALS AND METHODS

### General Description of Forest Areas in Asir and East Jazan:

Asir region is located in the center of the southwestern part of the kingdom between latitudes 17°25' and 19° 50' in the north and 50°00' and 41°50' east longitude. Asir region extends from the borders of Al-Dareb, Al-Sheqaiq and Baich (Jazan region) in the southwest to the borders of Yemen in the south-east. It also shares borders with Wadi Al-Dawasir (Riyadh region) in the north to Raniah County (Mecca Al-Mukrramah region) and Baha region and to Mecca Al-Mukrramah region in the coastal plain of Al-Qunfidah. It is bordered from the east by Najran region, from the west by Al-Qunfudah County and a part of the Red Sea coast and the south Al- Mekhwah County (Baha region) (Fig. 1). Asir region is essentially a highland one, but includes a large area of the desert to the north and east as far as Bisha and Tathlith [5]. It characterizes by different natural geomorphological forms, where it includes a mountain range Al-Sarawat, eastern plateau and Tihama Asir, which overlooks the Red Sea coast and each has a different climate varies from that of the others. Consequently, the topography and vegetation of the region is very varied, from juniper forests in the highlands to palm thickets in the coastal plain [5].

The mountainous parts of the region receive seasonal rain in summer in addition to continental rain in winter range between 350 and 500 mm per year. Subyani [6] mentioned that in the Southwest Region, the average annual precipitation can reach more than 600 mm on the mountains and it decreased to 120 mm on the coast side to the west and to 100 mm on the leeward side to the east. Asir region is dominated by sparse tree cover in general, but it seems denser than that in either Taif or Baha regions.

On the other hand, Jazan is one of the administrative regions in the Kingdom of Saudi Arabia. Its estimated area is about 35 thousand square kilometers represents approximately 0.7% of total area of Saudi Arabia and thus it is one of the smallest regions of the Kingdom area after Baha region.

It is located in the far southwest of the country between longitudes 42° and 43° east and between latitudes 16° and 17° north. It shares borders on the north

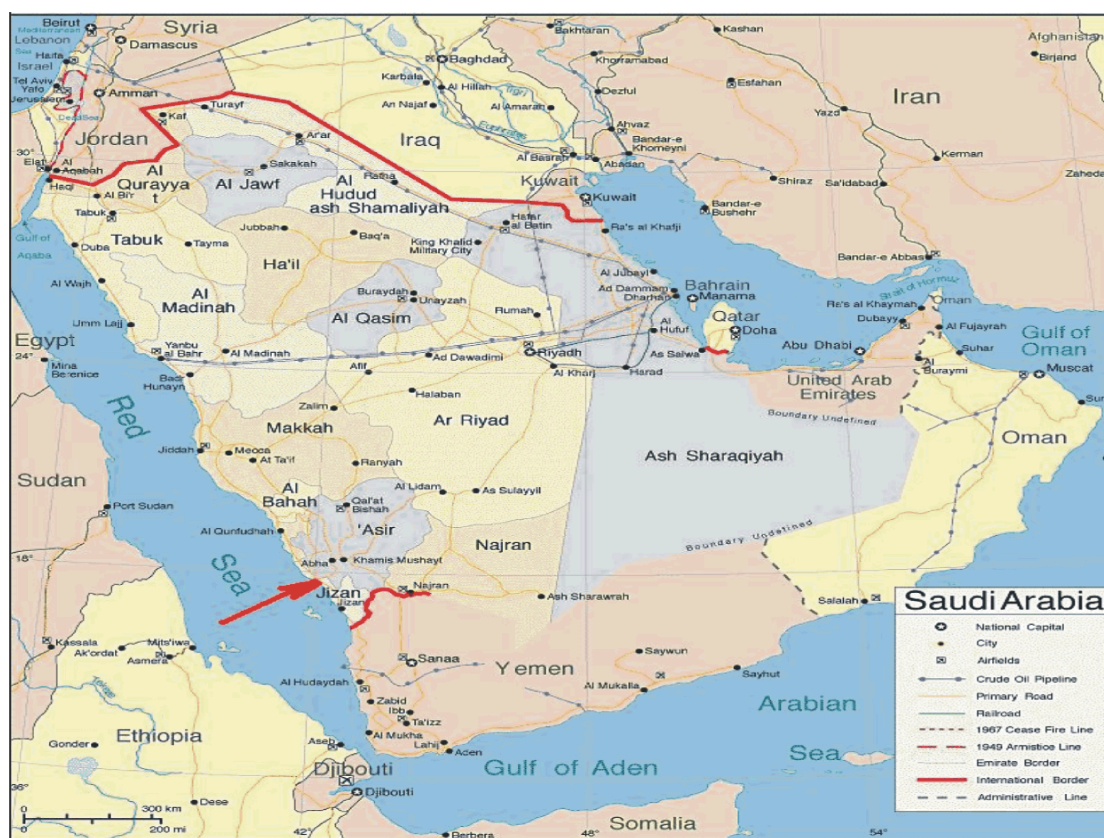


Fig. 1: Asir region and East Jazan within the Kingdom of Saudi Arabia

Table 1: Sampling units of forest inventory in Asir and East Jazan Forests

Area	Plot No.	Coordinates		Elevation (m)	Site name
(R1) Balqarn	R1 S1 P1	19 50 11.4	41 51 13.1	1765	Khath'am (1)
	R1 S1 P2	19 49 59.2	41 51 39.4	1887	
	R1 S1 P3	19 48 36.7	41 51 49.5	2266	
	R1 S2 P1	19 47 40.5	41 54 18.3	1769	Khath'am (2)
	R1 S2 P2	19 47 29.9	41 54 17.3	1779	
	R1 S2 P3	19 46 31.8	41 54 21.4	1796	
	R1 S3 P1	19 42 46.8	41 55 14.0	1957	Al-Bashaier
	R1 S3 P2	19 42 24.6	41 55 19.6	1961	
	R1 S3 P3	19 42 16.4	41 55 07.2	1986	
	R1 S4 P1	19 38 14.8	41 54 44.3	2072	North Bashout
	R1 S4 P2	19 37 21.9	41 55 03.0	2018	
	R1 S4 P3	19 37 16.3	41 54 18.5	2033	
	R1 S5 P1	19 38 08.2	41 52 43.5	2195	West Bashout
	R1 S5 P2	19 38 41.5	41 52 55.7	2185	
	R1 S5 P3	19 39 24.1	41 53 26.7	2190	
	R1 S5 P4	19 39 33.5	41 53 19.8	2118	
	R1 S6 P1	19 37 36.0	41 52 31.0	2183	Medha
	R1 S6 P2	19 37 50.5	41 52 37.0	2198	
	R1 S7 P1	19 32 21.9	41 55 08.4	2168	South Bashout
	R1 S7 P2	19 31 54.4	41 56 02.6	2076	
	R1 S7 P3	19 30 47.1	41 56 50.9	2089	
	R1 S8 P1	19 45 45.0	41 59 52.7	1739	Wadi Mashhath
	R1 S8 P2	19 44 58.5	42 00 47.8	1759	
	R1 S8 P3	19 43 49.9	42 00 47.8	1790	

Table 1: Continuee

Area	Plot No.	Coordinates		Elevation (m)	Site name
	R1 S9 P1	19 27 45.8	41 57 22.2	2313	Sabt El-Alaya
	R1 S9 P2	19 27 43.8	41 57 16.8	2301	
	R1 S10 P1	19 27 24.1	41 58 08.3	2299	South Sabt El-Alaya
	R1 S10 P2	19 27 35.8	41 58 17.7	2310	
	R1 S11 P1	19 24 50.5	42 00 43.2	2328	Al Salamah
	R1 S11 P2	19 24 57.7	42 01 10.2	2310	
	R1 S11 P3	19 25 25.8	42 00 29.2	2307	
	R1 S12 P1	19 24 02.7	42 03 10.5	2310	South Al Salamah
	R1 S12 P2	19 23 58.6	42 00 04.2	2303	
	R1 S12 P3	19 23 53.3	42 00 05.9	2290	
(R2) El-Namas	R2 S1 P1	19 23 16.3	42 00 46.0	2378	Bani Amr
	R2 S1 P2	19 23 16.9	42 00 29.4	2391	
	R2 S1 P3	19 22 48.4	42 00 57.0	2390	
	R2 S2 P1	19 20 27.2	42 03 14.5	2575	South Bani Amr
	R2 S2 P2	19 20 13.9	42 03 27.0	2558	
	R2 S2 P3	19 19 38.5	42 03 12.1	2546	
	R2 S3 P1	19 13 12.2	42 03 02.5	2624	El-Nemas (1)
	R2 S3 P2	19 12 51.9	42 02 42.8	2703	
	R2 S3 P3	19 12 43.7	42 02 36.6	2714	
	R2 S4 P1	19 10 52.7	42 04 25.9	2566	El-Nemas (2)
	R2 S4 P2	19 11 06.0	42 04 12.3	2627	
	R2 S4 P3	19 11 24.4	42 04 23.0	2635	
	R2 S5 P1	19 07 29.7	42 06 02.0	2460	(3) El-Nemas
	R2 S5 P2	19 10 18.5	42 05 47.2	2533	
	R2 S5 P3	19 10 21.7	42 05 34.8	2500	
	R2 S6 P1	19 01 55.5	42 12 46.1	2042	Wadi Tarj
	R2 S6 P2	19 02 34.1	42 13 06.5	2043	
	R2 S6 P3	19 03 24.3	42 16 33.9	1968	
(R3) Ballasmar	R3 S1 P1	18 57 08.9	42 08 48.9	2407	Tannoumah
	R3 S1 P2	18 57 49.0	42 07 58.2	2269	
	R3 S1 P3	18 59 14.6	42 07 33.2	2270	
	R3 S2 P1	18 52 36.0	42 13 00.8	2293	North Ballasmar
	R3 S2 P2	18 52 22.9	42 12 46.5	2307	
	R3 S2 P3	18 52 21.5	42 12 43.6	2292	
	R3 S3 P1	18 50 23.9	42 13 48.9	2493	South Ballasmar (1)
	R3 S3 P2	18 50 53.5	42 13 31.5	2434	
	R3 S3 P3	18 51 34.3	42 13 29.6	2354	
	R3 S4 P1	18 48 45.2	42 14 02.2	2696	South Ballasmar (2)
	R3 S4 P2	18 49 10.7	42 13 49.3	2694	
	R3 S4 P3	18 49 17.9	42 13 45.7	2684	
	R3 S5 P1	18 46 58.7	42 13 40.4	2859	South Ballasmar (3)
	R3 S5 P2	18 46 45.2	42 13 25.4	2800	
	R3 S5 P3	18 46 20.9	42 13 38.7	2768	
	R3 S6 P1	18 39 56.4	42 14 35.1	2686	South Ballasmar (4)
	R3 S6 P2	18 39 59.3	42 14 20.2	2736	
	R3 S6 P3	18 39 54.6	42 14 11.0	2736	
(R4) Ballahmar	R4 S1 P1	18 37 15.5	42 15 38.5	2708	Ballahmar (1)
	R4 S1 P2	18 37 30.8	42 15 37.4	2740	
	R4 S1 P3	18 37 11.9	42 16 41.6	2647	
	R4 S2 P1	18 37 31.4	42 17 05.1	2705	Ballahmar (2)
	R4 S2 P2	18 37 24.4	42 17 07.5	2750	
	R4 S2 P3	18 37 28.9	42 19 59.1	2527	
	R4 S2 P4	18 37 03.2	42 20 1403	2622	

Table 1: Continuee

Area	Plot No.	Coordinates		Elevation (m)	Site name
(R5) North and West Abha	R5 S1 P1	18 28 43.4	42 55 10.0	2012	Khamis Mushait
	R5 S1 P2	18 29 45.2	42 55 22.3	1971	
	R5 S1 P3	18 30 31.6	42 55 21.8	1937	
	R5 S2 P1	18 17 33.7	42 21 51.1	2904	Assodah (1)
	R5 S2 P2	18 17 57.8	42 21 13.3	2802	
	R5 S2 P3	18 16 51.5	42 21 47.5	2937	
	R5 S3 P1	18 18 56.2	42 20 43.2	2772	Assodah (2)
	R5 S3 P2	18 18 59.1	42 20 30.4	2780	
	R5 S4 P1	18 10 34.0	42 26 05.6	2727	Sheaab Al Sakran
	R5 S4 P2	18 10 21.0	42 26 07.0	2722	
	R5 S4 P3	18 10 02.9	42 25 51.4	2711	
	R5 S5 P1	18 09 34.2	42 25 40.6	2707	Khaishaah
	R5 S5 P2	18 09 31.6	42 25 25.0	2595	
	R5 S6 P1	17 58 50.2	42 21 03.1	511	Wadi Haswah
	R5 S6 P2	17 59 07.6	42 20 54.1	523	
	R5 S6 P3	18 01 14.1	42 19 20.3	675	
(R6) South Abha	R6 S1 P1	18 02 59.3	42 42 43.1	2259	Al-Faraa
	R6 S1 P2	18 03 05.3	42 42 27.1	2238	
	R6 S1 P3	18 02 58.8	42 42 55.0	2273	
	R6 S2 P1	18 00 04.1	42 44 44.1	2457	Tamniah
	R6 S2 P2	18 00 06.0	42 44 22.1	2448	
	R6 S3 P1	17 49 01.8	42 27 01.9	2310	Sarat Abidah (1)
	R6 S3 P2	17 48 16.1	42 26 49.8	2351	
	R6 S3 P3	17 47 26.1	43 28 56.9	2216	
	R6 S4 P1	18 12 10.4	43 09 27.6	2166	Sarat Abidah (2)
	R6 S4 P2	18 13 14.2	43 10 14.7	2230	
	R6 S4 P3	18 18 10.6	43 14 28.4	2168	
	R6 S5 P1	17 40 40.0	43 10 39.9	1177	Al-Farshah
	R6 S5 P2	17 40 15.8	43 10 14.9	1166	
(R7) East Jazan	R7 S1 P1	17 21 40.8	43 08 26.9	880	Bani Malik
	R7 S1 P2	17 21 33.5	43 08 48.9	762	
	R7 S1 P3	17 21 29.2	43 08 15.3	742	
	R7 S1 P4	17 21 06.9	43 08 00.4	739	
	R7 S2 P1	17 17 09.0	43 57 36.6	291	Wadi Qusai
	R7 S2 P2	17 17 39.4	43 57 52.5	285	
	R7 S3 P1	17 34 14.4	43 00 01.1	961	Al-Raith
	R7 S3 P2	17 17 41.5	42 54 49.5	1277	

and east with Asir region and to the west with the Red Sea along the coastline for about 330 km, from the south and south-east with the Republic of Yemen.

Jazan region comprises three different geomorphological forms namely the coastal plain dominated by Sabkhas and beaches with fine sand, the wide open areas as we move away from the sea to the east characterize by large valleys such as Jazan, Dhamad, Sabia and Baish, then the mountainous area which surround Jazan region from the east and it is a part of range Al-Sarawat. The rain falls in the spring, summer and increase their share in inland areas may reach more than 55 mm [7].

Forest areas in Asir and East Jazan include highlands located between 19°50'11.4 and 17°17'41.5 N latitudes and between 41°51'13.1 and 43°28'56.9 E longitudes within the

southwestern part of the kingdom, which is characterized by mountainous terrain interspersed with cultivated areas. Tree cover in Asir region and East Jazan is primarily consists of juniper trees, as well as different species of broad-leaved such as acacia and wild olive. However each sub-region within this area has its own characteristics.

**Determine Number of Sampling Units Required for the Inventory:** To determine 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 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]:

- C  $n = 4N S^2_y / (B^2_M N + 4 S^2_y)$  Where,  $n$ = the number of sampling units required,  $B_M$ =the allowable error,  $S_y$ = 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 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 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):** the forest that has less than 1000 trees per hectare

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

**Dense forest (Well-Stocked):** the forest that 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.

- C Firstly, one corner of the sampling was determined by inserting an iron wedge in the ground at that corner.
- C 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.
- C 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.
- C The previous step at the third corner or the first corner was repeated until the third side was determined.
- C 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, dominant species and density of tree cover.

**Measuring and Counting Trees:** Diameter outside bark at 30 cm above ground level using a tree caliper and total height from ground level to the top of tree for each tree within the sampling plot were measured using an aluminum hypsometer [9]. All the trees that meet specified criteria and fall within plot boundaries are measured.

**Subsequent Calculations:** Tree density in sampling plots, sites 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 merchantable volume for each tree 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]. Volume estimates are expanded to account for the merchantable timber of the entire population of trees.

**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].

## Forest Inventory Results in Asir and East Jazan

### 1- Balqarn Sub-Region (R1)

**General Description of the Area:** Balqarn is a county in Asir region occupied a large area of land starts from the region's northern border with Baha region (19°50') to the end of Bani Amr; which is an administration center of El-Namas County in the south (19°24'). Balqarn sub-region is a mountainous area includes many towns and villages and punctuated by many valleys. It has a low-density tree cover generally except in a few locations.

**Sampling in Balqarn:** Twelve sites were selected for conducting the forest inventory in Balqarn (Table 1), they have the following specifications: The first site (S1) includes three sampling plots located on the "Mount Balas" in Khath'am area, which their elevations reach up to 2266 m a.s.w.l. The site contains very large rocks, making it rugged, in addition to the severity of the slope

and it has a sparse tree cover. The sampling plots that were selected on this site vary in elevation and each has a different aspect which has reflected on the characteristics of the tree cover.

The second site (S2) includes three sampling plots located on the both sides of the "Valley of Gubgab" in Khath'am area and their altitudes range between 1769 and 1796 m a.s.w.l. and density of tree cover on this site is low. The sampling plots that were selected are vary in elevation and aspect.

The third site (S3) includes three sampling plots located within the confines of Al- Bashaiyer Center in Khath'am area. The site is located in a high mountainous area, where the maximum elevation in plot 1 record is 1986 m a.s.w.l. The site is characterized by a slope ranges between 25 and 30 degrees. The plots that were chosen in this site vary in elevation and aspect.

The fourth site (S4) also includes three sampling plots located on the left side of Taif-Abha road, north of Bashout City. The site includes mountainous areas and valleys. Three sampling plots were chosen within this site, one of them in the mountainous area (Ajabat Shamran) and the other in the valley of Muhrah while the third is looking over the same valley. The plots do not vary much in their elevations but have different aspects.

The fifth site (S5) is located west of Bashout City, characterizes by higher mountainous areas more than those of the former site. Forests in this site are denser than those in any other previous site. Four sampling plots were chosen within this site vary slightly in elevation but with different aspects. Only one of them has a medium density tree cover. We called them West Bashout, Al Laala, Shegaig Shamran-1 and Shegaig Shamran-2 according to their locations.

The sixth site (S6) is also belongs to Bashout Center and called Al-Medhah but lower in elevation than the previous site. Relative remoteness of these two sites from each other represents another difference. Two sampling plots were chosen in this site; the tree cover in one of them has been classified as medium density.

The seventh site (S7) is located south Bashout City and has three sampling plots. The average density of tree cover in this site is lower than that of the former site and it is lower. It is located on a relatively long distance from the previous site and their plots differ in aspects.

The eighth site (S8) is called "Wadi Mashhath" and different from all other selected sites in Balqarn because it is located in the far east of the region and characterized

by different species composition being a valley. Three sampling plots were chosen in this site; they differ in species composition and density of tree cover.

The ninth site (S9) is called "Al-Hasnah" and situated a little to the south of the entrance of Sabt El-Alaya City on the right side of Taif-Abha road. It is one of the highest sites in Balqarn, where its elevation reaches 2307 m a.s.w.l. but it has a flat ground. The two sampling plots that were selected in this site have a medium density tree cover.

The tenth site (S10) is located in "Al Sherieh" area and has lower elevations than the previous site, but it has a sparse tree cover with different species composition. In this site two sampling plots were chosen differ only in their aspects.

The eleventh site (S11) is located in Al Salamah area on the left side of Taif-Abha road and represents a high mountainous area. The average elevation of this site is 2324 m a.s.w.l.; it the highest site among all the sampling sites in Balqarn sub-region. The tree cover of this sit is considered scattered. Three sampling plots were chosen do not differ in their species composition but differ in the density of tree cover and in their aspects.

The twelfth site (S12) is located also in Al Salamah on the right side of Taif - Abha road, but at a lower elevation than the previous site. Three sampling plots were chosen in this site vary in species composition, tree density and aspects.

### **El-Namas Sub-Region (R2)**

**General Description of the Area:** El-Namas is a county belongs to Asir region and located South to Balqarn County. It is located away from the Taif City south 450 km and Abha City north 150 km. It is a mountainous area and is considered the highest in Asir region, interspersed with limited agricultural areas around the villages and includes some valleys. Its forests are the densest in the region.

**Sampling in El-Namas:** El-Namas sub-region was divided to six sites (Table 1) vary in topography, elevation, tree density and species composition as follows:

The first site (S1) includes a part of "Bani Amr Center", which is the first administration center in the County from the north. The three sampling plots that were selected in this site do not differ much in height, but they have different aspects, different tree density and species composition.

The second site (S2) includes the area of south "Bani Amr" and three sampling plots were selected within it, they have different aspects, different tree density and species composition. They called Al-Hakeef, Sahwah Forest and Halbah Forest, respectively.

The third site (S3) includes "Shaaf Al-Jumeirah which is considered the highest in El-Namas County. Three sampling plots were selected within this site; they have different aspects, different tree density and species composition.

The fourth Site (S4) includes the south area of "Mount Al Sultan" in which three sampling plots were selected vary in elevation and in its dense tree cover.

The fifth Site (S5) includes "Mount Nasser" area north of El-Namas. Three sampling plots were also selected in this site differ slightly in elevation and in their aspects, but close in tree density and species composition.

The sixth Site (S6) has specifications differ from all the previous sites as it is located in a known Valley in the left side of Taif-Abha road, "Tarj Valley." Three sampling plots were also selected in this site do not differ much neither in elevation nor in tree density nor in aspects (they are in flat ground), but they differ in species composition.

### **Ballasmar Sub-Region (R3)**

**General Description of the Area:** Ballasmar is a county belongs to Asir region; its center "Ithnain Ballasmar" is located away from Abha about 100 km. Forest inventory in Ballasmar started from the north "Tannumah" City to Al-Shaabah Forest south of "Ithnain Ballasmar" City. Ballasmar area is characterized by lower altitude of their mountains in its northern part comparing with El-Namas area, while the south sites rising to more than 2,800 m a.s.w.l. which has not been recorded in any site in El-Namas. There are no large valleys with forest cover have been observed in Ballasmar sub-region, except Matees Valley in "Sidwan Center". Tree cover in the sampling sites in Ballasmar is generally sparse and symptoms of dieback appear on the juniper trees in most sites, so there are large tracts of completely dead forests.

**Sampling in Ballasmar:** Six sites were selected in Ballasmar sub-region for inventorying its forests (Table 1). These sites vary in their elevation, aspects and species composition but do not differ in the density of their tree cover. All these sites are located on the right side of Taif-Abha road. The specifications of these sites are as the following:

The first site (S1) is located on the right side of Taif-Abha road, a few kilometers from it, where it can be accessed through a narrow paved road passes between the villages. The site includes three sampling plots vary slightly in elevation, aspects and species composition, but do not vary much in tree density. One of these plots falls within a park (Al-Shraf Park) and the other two are located in an agricultural area (Al-Mehfar and Shaaf Assodah).

The second site (S2) is located on the right side of Taif- Abha road also and at a short distance from it within the confines of "Sidwan Center" and can be accessed through an emerging rugged mountainous road to the right of Matees Valley. Three sampling plots were chosen in this site vary slightly in elevation, tree density and with different aspects.

The third site (S3) is located within the boundaries of "Sidwan Center" in "Al Khalid" area and to the south of the former site. In this site three sampling plots were chosen vary in elevation, tree density, aspects and species composition. The plots called Matees Al Khalid-1, Matees Al Khalid-2 and Matees Al Khalid-3.

The fourth site (S4) is located south of "Ithnain Ballasmar City" in a mountainous area higher than the previous site and to the south of it. This site included three sampling plots do not differ much in their elevations nor in tree density, but differ in their aspects and to a small extent in species composition. We called them Shaaf Al Muaalem-1, Shaaf Al Muaalem-2 and Shaaf Al Muaalem-3.

The fifth site (S5) is located on the right side of Taif-Abha road and to the south of S4; it is called Al Khuraim. It is the highest among all the sites of forest inventory at all; their elevations range from 2,768 to 2,859 m a.s.w.l. In this site three sampling plots were chosen vary in elevation, tree density, aspects and to a small extent in species composition.

The sixth site (S6) is in Al Shaabah and located to the south of the former site (S5), but it has lower elevations and characterized by obvious deterioration of the trees where most of them are suffering sever dieback or rather entirely dead. In this site three sampling plots were chosen vary in elevation, aspects and do not differ in tree density or in species composition.

#### **Ballahmar Sub-region (R4)**

**General Description of the Area:** Ballahmar is one of the largest counties in Asir region; it is located 40 km north Abha City and 60 km south Ithnain Ballasmar City.

The forest inventory area in Ballahmar has elevations similar to those of south Ballasmar area. However, the forest cover in Ballahmar is scatter.

**Sampling in Ballahmar:** Two sites were selected in the forest area in Ballahmar (Table 1); they differ in elevation, slope, tree density and species composition. This sub-region characterized in general by the presence of a small number of tree species, no more than five. The specifications of these two sites as follows:

The first site (S1) is located in the northern part of the sampling area in Ballahmar within the "Al-Ja'd" region and characterizes by elevation reaches 2,700 m a.s.w.l. in average. The site has a scattered tree cover dominated by juniper. In this site three sampling plots were chosen to conduct the inventory within them. Two of these are on the right side of Taif-Abha road and the other is on the left side of the same road; they vary in elevation, aspect, tree density and species composition.

The second site (S2) is located in "Subh Ballahmar" area to the south of the former site but with lower elevations in average. Four sampling plots were chosen in this site, some of them on to the right side of Taif-Abha road and the others on its left side. These plots vary in elevation, aspect, tree density and species composition. Their tree covers are lower in density than in the plots of the previous site.

#### **North and West of Abha Sub-Region (R5)**

**Description of the Area:** Forest inventory area in North and West of Abha sub-region extends from "Al-Shaig valley" in "Khamis Mushayt" in the north to the highlands overlooking the city of Abha from the west, which includes Sheab Al Waimen and Assodah Park then Haswa Valley behind these heights. Thus, it is embraces high heights and valleys which reflected on the characteristics of its tree cover.

**Sampling in North and West of Abha:** Because the wideness of North and West Abha sub-region comparing with the other sub-regions in Asir region, six sites were selected on it represent a large area of this sub-region (Table 1) including heights and valleys and differ in their specifications like geographic location, elevation, tree density and species composition. The following are the specifications of each of these sites:

The first site (S1) includes a part of the "Al-Shaig valley" in "Code Shahrani" area which belongs to "Khamis Mushayt" County. This valley is located at an altitude of about 2000 meters above sea water level and it has a

sparse tree cover. It is the least in tree density between all the inventory sites in North and West Abha sub-region. Although the population density in the valley is low, however it is very desirable grazing area. Three sampling plots were chosen in this site vary in elevation, tree density and species composition,

The second site (S2) includes the Asir National Park known as Assodah. This is one of the suburb outskirts of the city of Abha (the capital of Asir region), It is one of the highest mountains in the southwest part of the kingdom with altitude exceeds 3,000 meters above sea water level. It has been appointed as a national park since a long time. Being a park, facilities have been set up to suit its situation as entertainment place where roads have been incited within it and buildings are established for residence, commercial and recreation for hikers and visitors, whose number is increasing year after year. In the past, Assodah was one of the areas with high density forests but now have become classified as scattered forests. Moreover, deterioration of the remaining trees has been noted. In this site three sampling plots were chosen vary in elevation, tree density and to some extent in species composition.

The third site (S3) is located to the south of the previous site but has lower altitudes. It varies much in tree density as it has a scattered tree cover. In this site two sampling plots were chosen vary in tree density and to some extent in species composition.

The fourth site (S4) overlooks Abha city from the west and is located to the north of the former site but with lower elevation and, not vary much in tree density; it is called Sheab Al Waimen. It has a scattered tree cover. Three sampling plots were chosen to conduct the inventory within them; they graded in elevation and vary in tree density.

The fifth site (S5) is located to the south of the former site and not far from it, but is lower in elevation and tree density. The tree cover in this site is significantly deteriorated. In this site two sampling plots were chosen vary in tree density, aspect and composition and different facets.

The sixth site (S6) is Wadi Haswah which a valley extended to long distance located west to the highlands that overlooking Abha City. The Valley is inhabited where it embraces some villages, although there no presence of valuable tracts of agricultural lands has been noticed. This site has lower elevations, tree densities and species composition comparing with the fifth site (S5). Three spaced sampling plots were chosen in this site vary in tree density and species composition.

### **South Abha Sub-Region (R6)**

**General Description Of The Area:** Forest inventory sites in South Abha sub-region are located on Abha–Dhahran South Road. It is a mountainous area but includes parts with lower elevations than the mountain sites of North and West Abha sub-region. South Abha sub-region characterizes by mostly sparse tree cover. The species composition in this sub-region varies from that in the former sub-region; where the number of species in any site does not exceed three species.

**Sampling in South Abha:** Because of the largeness of the area of forest inventory in South Abha and including it highlands and valleys, five somewhat spaced sites were selected for sampling on it (Table 1). These are different in elevation, tree density and species composition. The following are the specifications of these sites.

The first site (S1) represents a part of Al-Faraa Tourist Park south Abha City. Due to incision of roads and paved them and the continuous attendance of hikers since long time, this park has lost a significant areas of its tree cover in addition to the deterioration of the remaining trees. Three sampling plots were chosen in this site differ slightly from each other in elevation, tree density and species composition.

The second site (S2) includes a mountainous area with a steep slope oversees a narrow valley descended to Tihama Plain. The elevation of this site is higher than that of the previous site and also surpassed it in tree density, as the current site is considered medium density. It also differs slightly in species composition. Two sampling plots were chosen in this site does not differ much in elevation or in species composition but differ in terms of tree density.

The third site (S3) represents the southern part of "Sarat Abeida" County in Asir region. It is a mountainous area also but its elevations are lower than those of the previous site. This site has a scattered tree cover and it varies from the other sampling sites of south Abha in terms of species composition, as it contains only one tree species, it is *Acacia spp.* Three some what spaced sampling plots were chosen in this site differ only in elevation.

The fourth site (S4) is an extension of the previous site and located to the south of it, but at a relatively long distance and lower in elevation with tree density relatively higher though it is classified as sparse. In this site three sampling plots were chosen vary in elevation and tree density.

The fifth site (S5) is different from all the previous sites in South Abha sub-region, as it represents a part of "Al-Hayah Valley" (it is called Death Julat in the past) which is located in the extreme south of Asir Region at "Al-Farshah Center" near the border with Jazan region. This valley is located between mountainous areas also but with elevation is the least among all the sampling areas in Asir Region. Tree density in the site is very low, but it is different in the species composition from the previous site, it contains more than one tree species. Two sampling plots were chosen in this site vary in elevation, tree density and species composition.

### **East Jazan Sub-region**

**General Description of The Area:** The area of forest inventory in East Jazan includes the eastern part of Jazan region adjacent to the borders of the southern Asir region which is known by its rugged paths, narrow valleys and the eastern part of which is characterized by high and steep mountains such as Mount Al-Hashr, Mount Tallan and Mount Al-Qahr. This topography nature reflected on the tree cover in this area where new species appeared that did not exist in the northern areas that have been inventoried through the current project.

**Sampling in East Jazan:** Due to the wideness of East Jazan sub-region and its irregular terrains and consequently isolation of some areas of it and scatterings of its tree cover, three sites for forest inventory had been on this sub-region (Table 1) and their specifications are as follows:

The first site (S1) includes part of "Mount Tallan" the steep known mountain in Bani Malik area which belongs to Al-Dayer County at the extreme of the far eastern Jazan region. This site includes also a part of "Jura Valley", which runs down the mountain from the south to the north. In this site, four sampling plots were chosen vary in elevation, tree density and species composition.

The second site (S2) includes a part of "Qusay Valley" which stretches from south to north in Bany Ghazi area northeast region of Jazan. It is a narrow and swirled valley with agricultural areas on its either sides. It is inhabited and is a good place for grazing, but the entrance to the valley is rugged. Two sampling plots were chosen in this site vary in elevation, tree density and species composition.

The third site (S3) includes a part of "Bashima Valley" which stretches from east to west, parallel to the southern borders of the Asir region to Raith City in the

extreme north of Jazan region. The valley is rugged and forked to smaller inhabited valleys and has an active grazing movement with spaced agricultural areas. The site also comprises a part of "Mardous Valley" which is an extension of "Bashima Valley" from the west. Two sampling plots were chosen in this site vary in elevation and tree density.

## **RESULTS AND DISCUSSION**

Forest inventory in Asir and East Jazan represents the third phase of the natural forest inventory project in southwestern Saudi Arabia. The area of the inventory 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 forest inventory of Asir and East Jazan includes 40 sites and 117 sampling plots (Table 2).

**Number of Trees and Tree Density:** The most basic measure of stand density is the number of trees per unit of area, which is often expressed as trees per hectare according to the metric system. In the present inventory, 1, 2441 trees have been counted in all the sites of Asir and East Jazan; 15% of which is unmeasured trees. The results showed that about 31% of total number of trees in all the inventory sites in Abha and East Jazan are found in Balqarn sub-region, followed by both El-Namas and Ballasmar with about 24%, while only 1.4% is found in East Jazan sub-region (Table 3). The highest number of trees in Balqarn may resulted from its large inventory area (8.5 ha) that includes 35 sampling plots not to high tree density, while both El-Namas and Ballasmar have higher tree density comparing with Balqarn (Table 3).

Tree density of each plot was estimated in the present inventory using number of trees counted within the plot. Estimates of stand density are made to express the degree to which the growing space available for tree growth is utilized [13]. El-Namas sub-region has the highest tree density as 892 trees per ha while East Jazan has the lowest one as 90 trees per ha. The overall average of tree density for the whole Asir and East Jazan area of forest inventory accounted for 481 trees per ha (Table 3). This figure is greater than that in either Taif Forests (216 tree per ha) [14] or Baha Forests (449 tree per ha) [15]. Tree density in El-Namas is greater than any other single sub-region in all the forest inventory areas in the

Table 2: Design and frame of forest inventory in Asir region and East Jazan Forests

Code	Sub-region	No. of sites	No. of sampling plots
R1	Balqarn	12	35
R2	El-Nemas	6	18
R3	Ballasmar	6	18
R4	Ballahmar	2	7
R5	North and West Abha	6	18
R6	South Abha	5	13
R7	East Jazan	3	8
Total Asir and East Jazan		40	117

Table 3: Total number of trees (intact and unmeasured) and tree density in the forest inventory sites of Asir and East Jazan Forests

Code	Sub-region	Total no. of trees	Total no. of intact trees	Unmeasured trees		Tree density (tree/ha)
				No.	% of Asir & North Jazan	
R1	Balqarn	3806	3100	706	18.5	447.8
R2	El-Namas	3011	2862	149	4.9	892.2
R3	Ballasmar	3037	2510	527	17.4	694.4
R4	Ballahmar	396	335	61	14.4	226.3
R5	North & West Abha	1376	1017	359	26.0	305.8
R6	South Abha	636	573	63	9.9	203.5
R7	East Jazan	179	163	16	8.9	89.5
Total Asir and East Jazan		12441	10560	1881	15.2	481.3

Table 4: Forest species grown in sampling sites of Asir and East Jazan

Code	Scientific name	Family
1	<i>Juniperus procera</i> Hochst. ex Endlicher	Cupressaceae
2	<i>Acacia spp.</i> Willd	Mimosaceae
3	<i>Barbeya oleoides</i> Schweinf.	Barbeyaceae
4	<i>Olea europaea subsp. africana</i> (Mill.) P.S. Green.	Oleaceae
5	<i>Tarchonanthus camphorates</i> L.	Asteraceae
6	<i>Rhus retinorrhea</i> Steud. Ex. A. Rich.	Anacardiaceae
7	<i>Teclea nobilis</i> Del.	Rutaceae
8	<i>Euclea shimperi</i> (A. DC.) Dandy	Ebanaceae
9	<i>Pistacia falcata</i> Becc. ex Martelli	Anacardiaceae
10	<i>Dodonaea viscosa</i> Jacq.	Sapindaceae
11	<i>Ficus salicifolia</i> Vahl.	Moraceae
12	<i>Schinus terebinthifolius</i> Raddi.	Anacardiaceae
13	<i>Azedarachta indica</i> A. Juss.	Meliaceae
14	<i>Zizyphus spina-christi</i> (L.) Willd.	Rhamnaceae
15	<i>Salvadora persica</i> L.	Salvadoraceae
16	<i>Tamarix spp.</i> L.	Tamaricaceae
17	<i>Ficus carica</i> L.	Moraceae
18	<i>Rosa spp.</i> L.	Rosaceae
19	<i>Erica arborea</i> L.	Ericaceae
20	<i>Euryops arabicus</i> Steud. ex Jaub. & Spach	Asteraceae
21	<i>Celtis africana</i> Burm.f.	Cannabaceae
22	<i>Mimusops laurifolia</i> (Forssk.) Friis	Sapotaceae
23	<i>Ficus sycamorus</i> L.	Moraceae
24	<i>Tamarindus indica</i> L.	Caesalpinaceae
25	<i>Ficus palmate</i> Forssk.	Moraceae

Table 5: Number and percent of species grown in of Asir and East Jazan inventory sites

Sub-region	No. of trees of different species							Total sub-region
	*1	2	3	4	10	14	19	
Balqarn (R1)	2106	584	232	150	6	12	0.0	3806
El-Namas (R2)	1799	604	100	0.0	16	0.0	343	3011
Ballasmar (R3)	1994	363	77	0.0	39	0.0	0.0	3037
Ballahmar (R4)	252	77	4	0.0	0.0	0.0	0.0	396
North & west Abha (R5)	815	164	00	0.0	13	13	0.0	1376
South Abha (R6)	274	276	10	0.0	0.0	0.0	0.0	636
East Jazan (R7)	0.0	100	0.0	0.0	0.0	50	0.0	179
Total Asir & East Jazan	7240	3356	423	150	74	75	343	12441
% of total Asir & East Jazan	58.2	27	3.4	1.2	0.6	0.6	2.8	

\*1, 2, 3,... etc. are referring to the different tree species (Table 4)

Table 6: Number and percentage of partly (affected by dieback) and totally dead trees and its percentages to the total number of unmeasured trees in different sampling sites of Asir and East Jazan Forests

Code	Sub-region	Dead trees			
		Partly dead (dieback)		Totally dead	
		Number	%	Number	%
R1	Balqarn	282	34.6	307	42.5
R2	El-Namas	107	13.2	13	1.8
R3	Ballasmar	162	19.9	240	33.3
R4	Ballahmar	46	5.6	9	1.2
R5	North & West Abha	186	22.8	131	18
R6	South Abha	32	3.9	7	1
R7	East Jazan	00	00	16	2.2
Total Asir & East Jazan		815	29.8	723	26.4

Table 7: Number and percentage of seedlings of the main tree and shrub species grown in the different sub-regions of Asir and East Jazan forests

Sub-region	Number and percentage of seedlings of the main tree and shrub species						% of total region
	1*	2	3	10	19	Total	
Balqarn (R1)	335	533	395	742	00	2014	27.1
% of total R1	16.6	26.5	19.6	36.8	00		
El-Namas (R2)	378	293	143	95	108	1017	13.7
% of total R2	37.2	28.8	14.1	9.3	00		
Ballasmar (R3)	249	246	125	1045	00	1671	22.2
% of total R3	14.9	14.7	7.5	62.5	00		
Ballahmar (R4)	7	19	30	391	00	447	6.0
% of total R4	1.6	4.3	6.7	87.5	00		
North & west Abha (R5)	116	115	00	1631	00	1846	23.2
% of total R5	6.3	6.2	00	88.4	00		
South Abha (R6)	66	202	59	00	00	327	4.4
% of total R6	20.2	61.8	18	00	00		
East Jazan (R7)	00	98	00	00	00	98	1.3
% of total R7	00	100	00	00	00		
Total Asir & East Jazan	1151	1506	752	3904	108	7420	
% of total Asir & East Jazan	15.5	20.3	10.1	52.6	1.5		

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

Table 8: Mean stem diameter (cm treeG<sup>1</sup>), height (m treeG<sup>1</sup>), volume (m<sup>3</sup> treeG<sup>1</sup>) and total volume (m<sup>3</sup>) of tree measured of different species in different sub-regions of Abha and East Jazan Forests

Code	Sub-region	Mean diameter (cm treeG <sup>1</sup> )	Mean height (m treeG <sup>1</sup> )	Mean tree volume (m <sup>3</sup> treeG <sup>1</sup> )	Total volume (m <sup>3</sup> )
R1	Balqarn	10.2	3.7	0.0520	161.1116
R2	El-Namas	7.6	3.0	0.0253	73.0551
R3	Ballasmar	8.2	3.6	0.0366	92.3564
R4	Ballahmar	12.2	3.4	0.0636	21.3570
R5	North & West Abha	14.9	4.6	0.1091	112.0903
R6	South Abha	13.3	4.5	0.2653	152.5320
R7	East Jazan	21.6	8.5	0.8181	134.9820
Mean Asir & East Jazan					747.4838

southwestern region of Saudi Arabia. This because the mountainous nature of the area and the protection that had been offered to the forests by the inhabitant tribes for long time ago.

On the other hand, the low tree density in East Jazan reflects the deteriorating status of the forest cover as the area comprises foothill and valleys where there is an active grazing in addition to extensive exploitation of wood as these areas are inhabitant and used as a pathway.

**Species Composition:** The species composition of a forest is often unique to that forest, with some forests consisting of many hundreds of species of trees while others consist of just a handful of species [16]. Information on growing stock composition can be used as a proxy indicator of forest tree species richness and relative abundance. The percentage of growing stock represented by a given number of tree species is expected to be inversely correlated to tree species richness (and the number of tree species present in the area) [17].

Table 4 shows the most important tree and shrub species that have been found in the sampling sites of the present forest inventory.

Number of tree and shrub species that have been inventoried in Asir and East Jazan inventory region ranges from 5 in El-Namas, Ballahmar, South Abha and East Jazan to 9 species in Balqarn and Ballasmar. 58% of the total number of trees that have been inventoried in Asir and East Jazan region belongs to *Juniperus procera* followed by *Acacia* spp. with 27% (Table 5). This figure does not surprising as Abo-Hassan *et al.* [11] mentioned that *Juniperus procera* represents approximately 95 per cent of the tree species grown in the natural forests in southwestern region of Saudi Arabia. Considering the importance and the abundance of these two species in the

natural forests of the southwest part of Saudi Arabia, we compare these with those in Taif and Baha forests as they all share this part of the country.

The percent of juniper trees in Asir and East Jazan is greater than that in Taif Forests (47.7%) [14], while it is less than that in Baha Forests (64.5%) [15]. Regarding *Acacia* species, its percent in Asir and East Jazan is lower than that in Taif Forests (38.2%) [14], but it is greater than that in Baha forests (18.4%) [15].

Juniper trees have been found in all the inventory sub-regions except East Jazan, while *Acacia* spp. has been found in all sites (Table 5).

The inventory process showed a presence of tree species were not found in the two areas that have been inventoried in the first and second stages of the forest inventory project of the natural forests in the southwestern part of Saudi Arabia. Of these species *Mimusops laurifolia* (The Giant lebbck), *Ficus sycamorus*, *Tamarindus indica* and others, but their numbers are small. Some other species is found only in one sub-region like *Olea europaea subsp. africana* which present only in Balqarn sub-region and *Erica arborea* which found only in El-Namas (Table 5).

In southwestern Saudi Arabia there area a number of acacia species such as *Acacia abyssinica* Benth. *Acacia asak* (Forssk.) Willd. *A. ehrenbergiana* Hayne. *Acacia etbaica* Schweinf. *Acacia hamulosa* Benth. *Acacia laeta* R. Br. ex Benth. *Acacia mellifera* (Vahl) Benth. *A. origina* R. B. *Acacia tortilis* (Forssk.) Hayne. and others. However, we referred to acacia as any species of genes *Acacia* because the present inventory has not focused on identifying the species.

**Characteristics of Tree Cover:** Status of tree cover is evaluated through the apparent effects upon the standing trees. Conifers trees are known with their stem straightness up to the top of tree, while the trunk of

broadleaf trees does not reach the top of the tree but it divides into spreading branches that form the tree's crown, so irregular trees such as those which are curved, twisted, cleft, multi-stemmed, dwarfish and leaning affect the quality of the tree cover. While declined trees like those which are destroyed, cut, fully cut and burned trees or those which are partly dead due to dieback or completely dead as a result of any reason affect forest density. Such a decline may suggest that the forest had been heavily exploited or severely subjected to pests. The diameters and heights of such trees can not be measured and thus estimate their wood volume. Deteriorating trees are not suitable for the production of wood, which is the first return of forest and degraded forest trees may be threatened with extinction.

In the present study, we used term "unmeasured trees" to refer to irregular, declined and dead (partly or totally) trees. Unmeasured trees represent 15.2% of the total number of trees counted in the whole Asir and East Jazan inventory area. Number of unmeasured trees ranges between 16 in East Jazan to 706 in Balqarn at a rate of 8.9 and 18.5% of the total number of trees counted in these sub-regions, respectively (Table 3).

El-Juhany *et al.* [18] attributed the existence of irregular and deteriorated juniper trees in Ridah Reserve at Asir Mountains to various factors such as the mechanical effects of wind, soil erosion, competition between trees, animal grazing and others.

About 30% of unmeasured trees in Asir and East Jazan are affected by dieback and 26.4% are totally dead (Table 6). Number of trees which affected by dieback ranges between 0% in East Jazan and 34.6% in Balqarn, while those are totally dead ranges between 1% and 42.5% in South Abha and Balqarn, respectively (Table 6). Ballasmar sub-region has also a high number of trees that are stricken by dieback represents one fifth of the total number of the partly dead tree due to dieback and one third of the totally dead trees in Asir and East Jazan forests (Table 6). In this County, vast tracts of juniper forests are seen affected by die-back including partly and totally dead trees.

**Natural Regeneration:** Natural regeneration is the process by which the forest is naturally renewed; it is based on the recruitment of young plants deriving from seeds (seedlings) [19]. Thus, assessment of natural regeneration is an important part of evaluation of forest status. This process depends on seed production, seed dispersal, seed germination and seedling establishment. Each of these is a function of different factors.

Total number of seedlings that have been found in the whole inventory area in Asir and East Jazan accounted for 7420 seedlings. Balqarn sub-region has the greatest number of seedlings which represents 27.1% of the total number of seedlings in the whole region followed by North and West Abha with 23.2 then Ballasmar with 22.2%, while East Jazan has only 1.3% of the total.

*Juniperus procera* seedlings represent 15.5% of total number of seedlings in Asir and East Jazan which is lower than number of seedlings of either *Acacia spp.* (20.3%) or *Dodonaea viscosa* (52.6%) (Table 7). These figures reflect the status of the natural regeneration in Asir and East Jazan forests. Large percentages of *Dodonaea viscosa* seedlings were found in Ballasmar, Ballahmar and North and West Abha with 62.5, 87.5 and 88% of the total number of seedlings in each, respectively.

*Dodonaea viscosa* is of little economic importance comparing to *Juniperus procera* or *Acacia spp.* El-Juhany and Aref [14] asserted that this shrubby species has spread in Taif forests at the expense of other tree species such as *Juniperus procera* and *Acacia spp.* that may be considered as an indication for site degradation.

Similar results have been reported by Hameed *et al.* [20] who pointed to continuously changing species composition and vegetation structure in the Murree region in Pakistan, where a complete dominance of scrub species like *Carissa carandas* and *Dodonaea viscosa* is rapidly replacing tall vegetation, which includes *Pinus roxburghii*, *Acacia modesta* and *Olea ferruginea*.

In the present inventory, number of seedlings per unit area found range between 49 to 410 seedling per hectare in East Jazan and North and West Abha sub-regions, respectively with an average accounted for 269 seedling/ha for the whole Asir and East Jazan forests. The density of seedling expressed as per unit area in these forests is lower comparing with that in Taif Forests which is 412 seedlings/ha [14] or that in Baha Forests which is 419 seedlings/ha [15].

**Estimating Wood Volume:** The results of the present inventory show that the average diameter of trees ranges between 7.6 cm in El-Namas to 21.6 cm in East Jazan sub-region. This large difference is a result of a presence of different tree species in the two sub-regions, *Juniperus procera* in El-Namas and *Acacia spp.*, *Zizyphus spina-christi* and *Mimusops laurifolia* (The Giant lebbeck) in East Jazan. This can be also interpreted in light of the fact that most of juniper trees found are either old and irregular

or young and straight. The irregular trees have not been measured in the present inventory. The dimensions of trees have influenced the approximate tree volume, as it ranges between 0.0253 m<sup>3</sup>/ tree in El-Namas to 0.8181 m<sup>3</sup>/ tree in North Jazan sub-region. Balqarn sub-region with its large number of trees as it has the higher number of sampling plots has total approximate tree volume exceeds any of those of the other sub-regions. On the other hand, South Abha sub-region has an equal number of juniper and acacia trees, less number of irregular trees, but has trees large in diameter and height. The total tree volume in this sub-region is divided between *Juniperus procera* with 8.3%, *Acacia spp.* with 19% and *Mimusops laurifolia* with 72.7%

Total approximate wood volume in Asir and East Jazan Forests exceeds those of both Taif and Baha Forests together. It accounted for 747.48 m<sup>3</sup> comparing with 114.72 and 280.35 m<sup>3</sup> in Taif [14] and Baha [15] Forests, respectively.

## CONCLUSION

Forest inventory in Asir and East Jazan Forests represents the third phase of the Forest Inventory Project in the Southwestern Region of Saudi Arabia. The first and second phases are devoted for inventorying Taif and Baha forests. The results of the whole inventory show that the main forest species in these forests are juniper and acacia where they represent 85.9, 82.9 and 85.2% of total number of tree species in Taif, Baha and Asir and East Jazan Forests, respectively. Tree density in these forests accounted for 216, 449 and 481 tree per ha in Taif, Baha and Asir and East Jazan Forests, respectively. These figures are low comparing with those in other forests elsewhere. The status of trees in the forests suggests that they have been exploiting since long time as obvious effects on existing trees can be seen right now. The main threats for these forests can be summarized as low capacity of natural regeneration of the main forest species, die-back and die-off of trees, spread of forest fires, wood cutting, grazing, insects break out and spread of recreation areas. Numbers of seedlings that have been counted in these forests represent low capacity of natural regeneration of the main forest species as they are 412, 419 and 269 seedlings/ha in Taif, Baha and Asir and East Jazan forests. The forests in southwestern region of Saudi Arabia have become vulnerable to serious degradation that threatens this unique ecosystem.

Therefore, a set of actions must be taken in a holistic manner and directed sooner not later toward rehabilitate this forests.

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## REFERENCES

1. Masood, M.F. and A.A. Asiry, 2012. Ecological study of diversity of Herpetofauna in Asir region, Kingdom of Saudi Arabia. Egyptian Academic Journal of Biological Sciences, 4(1): 143-163.
2. UNU *Global Environmental Forum V*. 1997. Freshwater Resources in Arid Lands. Juha I. Uitto and Jutta Schneider (Editors). United Nations University Press.
3. Henedidy, S.Z. and L.M. Bidak, 2001. Biodiversity of the plant species in Bisha, Asir region, southwestern Saudi Arabia. Pakistan Journal of Biological Sciences 4(11): 1323-1330.
4. Aref, I.M. and L.I. El-Juhany, 2000. The Natural and planted forests in Saudi Arabia; their past and present. Arab. Gulf J. Sci. Res. ,18: 64-72. (In Arabic).
5. Mauger, T., 1993. Undiscovered Asir. Stacey International, London, pp: 143.
6. Subyani, A., 1999. Topographic and seasonal influences on precipitation variability in southwest Saudi Arabia. Journal of King Abdul Aziz University: Earth Sciences. 11: 89-102.
7. The secretariat of the city of Jizan. 2009. Jizan Region. Available at <http://www.jazan.sa/portal/jazan/about-jazan.html>
8. Shiver, B.D. and B.E. Borders, 1996. Sampling Techniques for Forest Resource Inventory. John Wiley & Sons Inc. New York, U.S.A.
9. Philip, M.S., 1994. Measuring Trees and Forests, 2<sup>nd</sup> Ed. CAB International, Wallingford, Oxon, UK.
10. Avery, T.E. and H.E. Burkhardt, 1983. Forest Measurements, 3<sup>rd</sup> Ed. McGraw-Hill Book Company, New York, U.S.A.

11. Abo-Hassan, A.A., M.L.M. El-Osta and M.M. Sabry, 1984. The Natural Forests in the Kingdom of Saudi Arabia and the Possibility of Exploiting Them Economically. National Center for Science and Technology (Now: King Abdulaziz City for Science and Technology), Book No. 1 (in Arabic), Riyadh, Saudi Arabia, pp: 177.
12. SAS Institute, 2001. SAS User's Guide Statistics, version 8.2. SAS Inst. Cary, NC, USA.
13. Australian National University 1996. Stocking, density and competition. Cris Brack (editor). Available at: <http://online.anu.edu.au/Forestry/mensuration/DENSITY.HTM>
14. El-Juhany, L.I. and I.M. Aref, 2012a. The present status of the natural forests in the southwestern Saudi Arabia: 1- Taif Forests. *World Applied Sciences Journal*, 19(10): 1462-1474.
15. El-Juhany, L.I. and I.M. Aref, 2012b. The Present Status of the Natural Forests in the Southwestern Saudi Arabia 2-Baha Forests. *World Applied Sciences Journal*, 20(2): 271-281.
16. Klappenbach, L., 2012. The Structure of a Forest, the Six Layers of Vegetation in a Forest. About.com Guide. Available at: <http://animals.about.com/od/forest/a/structureforest.htm>
17. FAO, 2012. Global Forest Resources Assessment 2010. Chapter 3 : Forest biological diversity, p 62. Food and Agricultural Organization of the United Nations, Rome, Italy.
18. El-Juhany, L.I., I.M. Aref and M.A. Al-Ghamdi, 2008. The possibility of ameliorating the regeneration of juniper trees in the natural forests of Saudi Arabia. *Research Journal of Agriculture and Biological Sciences*, 4(2): 126-133.
19. Borghetti, M. and R. Giannini, 2001. Natural Regeneration in Woodland Management. In: *Encyclopedia of Life Support Systems*. Eolss Publishers.
20. Hameed, M., T. Nawaz, M. Ashraf, F. Ahmad, K.H.SH. Ahmad, M.S.A. Ahmad, S.H. Raza, M. Hussain and I. Ahmad, 2012. Floral biodiversity and conservation status of the Himalayan foothill region, Punjab. *Pakistan Journal of Botany* 44(Special Issue May 2012): 143-149.