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Wild Olive Tree Mapping Extent, Distribution and Basic Attributes of Wild Olive Trees at Al-Baha Region, Saudi Arabia Using Remote Sensing Technology

II. Distribution and mapping of wild olive trees according to tree crown size

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Abstract: ***This study provided detailed information on the extent and distribution of wild olive trees in the Al-Baha region according to tree crown size. The study area concentrated along the Sarah mountain, encompassing districts including Al-Qura, Al-Mandaq, Al-Baha, the southern part of Baljurashi and a small portion of Qelwa Mekhwa Al-Aqiq districts. This indicates that wild olive trees prefer to grow in high foggy mountain conditions, which was previously predetermined study as having medium to high vegetation density zones. The information extracted from high-resolution Pleiades satellite image revealed that, in the study area (1, 991 km^2), there is a total of 717, 894 wild olive trees, of which 95, 990)13.4%) had large crown sizes (> 5.1m); out of the remaining, 228, 996 had medium (3.1–5.0m) and 392, 908 had small (< 3.0m) crown sizes. The result showed that the districts of Al-Mandaq and Al-Baha have a higher density of wild olive trees with smaller crown sizes. On the other hand, Al-Qura and Al-Baljurashi have a lower density of wild olive trees with bigger crown sizes. Meanwhile, districts such as Al-Aqiq, Qelwa and Mekhwa have the least dense wild olive trees with smaller crown sizes. Further analysis of the images through automatic measurement of the tree crown diameter revealed that most of these trees (54.7%) belong to a small diameter class (< 3.0m), whereas big diameter class (> 5.1m) were observed to a greater extent at both Al-Qura and Baljurashi districts. This information would be essential in identifying the landscape preference of wild olive in the Al-Baha region.***

Keywords: Wild olive tree, Mapping, Extent, Distribution, Al-Baha region, Remote sensing, Crown size

1. Introduction

Wild Olive Tree

Olea oleaster-the wild olive tree-is considered by various botanists as a valid species and subspecies of cultivated olive trees (*Olea europea)*, a tree of multiple origins (Besnard and Berville, 2000). Earlier it was domesticated, but it began appearing at various places during the third and fourth millennia BCE, with selections drawn from various local populations (Besnard and Baradat, 2001).

Today, as a result of natural hybridization and the very ancient domestication and extensive cultivation of olive trees throughout the Mediterranean Basin, wild-looking feral forms of olive-"*oleasters*"-constitute a complex population, potentially ranging from feral forms of olives to the wild-olive (Lumaret, Ouazzani, Michaud, and Vivie, 2004).

The wild olive tree belongs to the Maquis shrubland, which itself partly resulted from the long presence of mankind. The drought-tolerant sclerophyllous wild olive tree is believed to have originated in the Mediterranean Basin. Still today, it provides a hardy and disease-resistant rootstock on which cultivated olive varieties are grafted (Breton, *et al.*, 2006).

Meanwhile, reportedly, wild olive is also native to North America's evergreen trees, which reach up to a height of 20 feet with a width of 10–15 feet. This small tree is rarely found and reportedly close to extinction. Olive-like white fruits that are produced have a sweet flesh that is relished by birds and other wildlife; although it is edible to man, it should not be eaten in large quantities. However, in the United States of America, another species of the olive tree, known as the Russian olive (*Elaeagnusangustifolia* L.), was considered an exotic invasive weed. This thorny shrub or tree originated from South-eastern Europe and Western Asia. It was reported by Katz and Shafroth (2003) that it was intentionally introduced and planted in the United States for windbreaks, erosion control, wildlife habitat and other horticultural purposes. It was then observed that this tree was quite well-adapted to semiarid and saline environments. In the early part of the 20th century, Russian olive (RO) escaped cultivation and spread, particularly in large, moist riparian environments in arid or semiarid regions of the western part of the United States (Stannard *et al.,* 2002).

Mapping Wild Olive Trees Using Remote Sensing

Classifying and mapping vegetation is an important technical task for managing natural resources since vegetation provides the base for all living beings*; it* plays an essential role in impact global climate change in different ways, such as by influencing terrestrial CO_2 (Xiao *et al.,* 2004). Vegetation mapping also uncovers valuable information for understanding the natural as well as man-made environments by quantifying the vegetation cover from local to global scales at a given time point or over a continuous time period. Moreover, it is critical to obtain the current state of vegetation cover to initiate vegetation protection and restoration programs (Egbert *et al.,* 2002).

Traditional methods, such as field surveys, literature reviews, map interpretation and collateral and ancillary data analysis, have not been effective in achieving mass vegetation covers as they are time-consuming, date lagged and often too expensive. However, the remote sensing method offers a practical and economical means to study changes in vegetation cover, especially over large areas (Langley *et al.,* 2001; Nordberg and Evertson, 2003).

Owing to the potential capacity of performing systematic observations at various scales, remote sensing technology extends from the possible data archives in the present time to those over several decades back. This advantage led to enormous efforts being made by various researchers and application specialists for delineating vegetation cover from a local scale to a global scale by utilizing remote sensing imagery. Since then, numerous efforts have been made in regional or national extents to map wild olive using this technology. For example, the pilot project initiated to develop a cost-effective method for mapping Russian olive (*Elaeagnusangustifolia* L.) from scanned large-scale aerial photographs.

A study area was established along a riparian zone within a semiarid region of the Fishlake National Forest, located in central Utah. Two scales (1:4, 000 and 1:12, 000) of natural color aerial photographs were evaluated. Feature Analyst, an extension for ArcGIS, and several other image-processing software packages were used to map the invasive tree. The Feature Analyst located RO throughout the imagery with a relatively high degree of accuracy. For the map derived from the 1:4, 000-scale photographs, the software correctly located RO in 85% of all the 4×4 meter transect cells. However, the discrepancy existed for smaller trees, which were sometimes missed; the sizes of trees and groups of trees were frequently underestimated. The map derived from the 1:4, 000-scale photographs was only slightly more accurate than that from the 1:12, 000-scale photographs, suggesting that the smaller-scale photography may be adequate for mapping RO (Hamilton *et al.,* 2006).

Another attempt was made in Australia to test the ability of remote sensing imagery to map olive groves and their attributes. Specifically, this attempt aimed to distinguish olive cultivars and to detect and interpret within-fields patial variability. Using high-spatial-resolution (2.8m) Quick Bird multispectral imagery acquired over Yallamundi (southeast Queensland) on24December 2003, both visual interpretation and statistical (divergence) measures were employed for making this distinction. Similarly, the detection and interpretation of within-field spatial variability was conducted on enhanced false color composite imagery and confirmed using statistical methods. The results of this effort showed that two olive varieties, i.e. Kalamata and Frantoio, can be visually differentiated and mapped on the enhanced image based on texture. The spectral signature plots showed little difference in the mean spectral reflectance values, indicating that these two varieties have a very low spectral separability (Apan, 2004).

A study on olives, which used conventional-color and color-infrared aerial photographs and vegetation indices, was conducted in Spain to determine variations in cover crop, bare soil and tree areas in olive groves, as affected by the season. The researchers found that early summer was the most suitable time to distinguish between cover crops and olive trees. In addition, the study also found that indices based on blue- and red-band reflectance values were suitable for this purpose (Peña-Barragán *et al.,* 2004).

2. The Study Area

The most effective way of mapping plant-species ranges in an area is by demarcating a general bioclimatic envelope within biogeographic regions where a species is known to have been found. This study requires building a database of species, including data on the distribution of species by geographic region, major habitat type and elevation range (Price, 2004). Similarly, in this study, due to the largeness of the area and in order to save time, cost and energy, the study selected areas with a high probability of wild olive tree presence, indicated by high (61.8 km^2) and medium (790.7 km^2) density-vegetated area (Table 1) (Al-Ghamdi, 2020).

Table 1: Study area extent according to districts

District		Study Area		Vegetation Crown Density					
Name	Km^2	Km^2	(%)	High	(%)	Med.	(%)	Low	(%)
Al-Qura	1, 049	586	55.9	9	1.5	128	21.8	449	76.6
Al-Aqiq	3, 667	165	4.5	0	0.0	21	12.7	144	87.3
Mandaq	361	339	94	23	6.8	247	72.9	69	20.4
Mekhwa	1, 949	27	1.4	3	11.1	24	88.9	0	0.0
Al-Baha	298	287	96.4	17	5.9	106	36.9	164	57.1
Baljurashi	1, 505	506	33.6	7	1.4	162	32.0	337	66.6
Qelwa	2, 232	81	3.6	3	3.7	78	96.3	0	0.0
TOTAL	11, 060	1, 991	18	62	3.1	766	38.5	1, 163	58.4

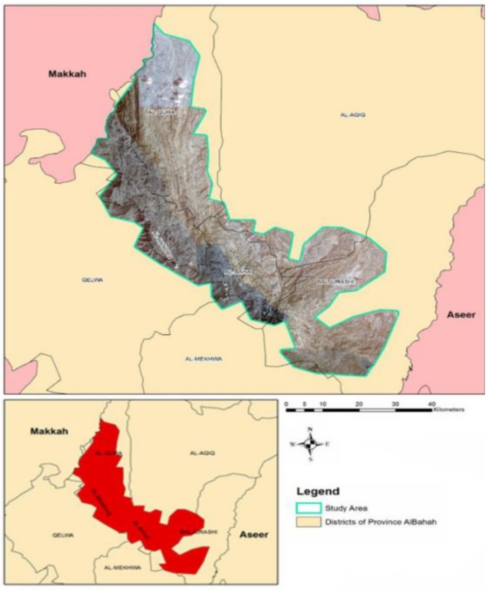

Figure 1: Satellite Pleiades image of the study area (in red)

Objectives

However, there is also a possibility of wild olive trees to be found near lower-vegetation density area; hence, the study area was expanded to the northern part low vegetation canopy density, but not to the southern part as the southern part of Al-Mekhwah and Qelwa, has a steep slope towards Tehama. This led to the total overall study area of 1, 991km^2 (Figure2) (Al-Ghamdi, 2020), which is just 18.0% of the whole Al-Baha region. The study area covers almost all areas of Al-Mandaq and Al-Baha districts, and 58.5% of the study area has low-vegetation crown density.

The main aim of this study was to produce high-quality and standardized maps of the extent and distribution of wild olive trees according to tree crown size in order to support a wide variety of resource assessment and management and conservation of wild olive. It can be a guide for a standard national vegetation classification scheme and mapping protocols, which will facilitate effective resource management by ensuring compatibility and the widespread use of the information at multiple geographic scales throughout Al-Baha's federal and provincial agencies.

3. Material and Method

3.1 Material and Data

In this study, due to the large area coverage and difficult terrain, satellite imagery was used as the main means of information extraction. The pieces of software used are as follows:

- ERDASImagine2014–An image processing software;
- ArcGIS ver 10.3 – A GIS software for the analysis of the information extracted from the satellite image
- On the other hand, the data used in this study are as follows:
- Satellite image Pleiades dated15May2016 (resolution0.50 ×0.5 m);
- Shuttle Radar Topography Mission (SRTM) (elevation data extraction);
- The digital boundary of the Al-Baha region and districts

3.2 Method

In this study, three main activities included are data collection involving satellite data procumbent, namely data collection, data analysis and fieldwork.

The image from LANDSAT-8 satellite dated 15 May 2016 were used as the primary source of data extraction for identifying the vegetated area in the Al-Baha region. After being downloaded from the USGS website, the image was processed for normalized differential vegetation indices (NDVI) to demarcate areas with vegetation or chlorophyll. Detailed presentation of the activities in the workflow is shown in Figure 2.

Satellite Data Acquisition

Remote sensing data acquired from the Pleiades satellite imagery (15 May 2016) were purchased from ARIBUS Defence and Space through a local agent. Pleiades images provide a high-resolution imagery, from 0.5 meters to 2.0 meters, of the earth's land surface and Polar Regions; Pleiades swath covers 20 km at Nadir. The high agility of the satellite allows for the acquisition of the same pass-a mosaic of images covering a larger area (up to 120km × 120km) or stereoscopic images of 300 km long.

The Pleiades bands are panchromatic (450–830nm), band 1 (blue430–550nm), band 2 (green 500–620nm), band 3 (red 590–710nm), band 4 (near infrared 740–940nm).

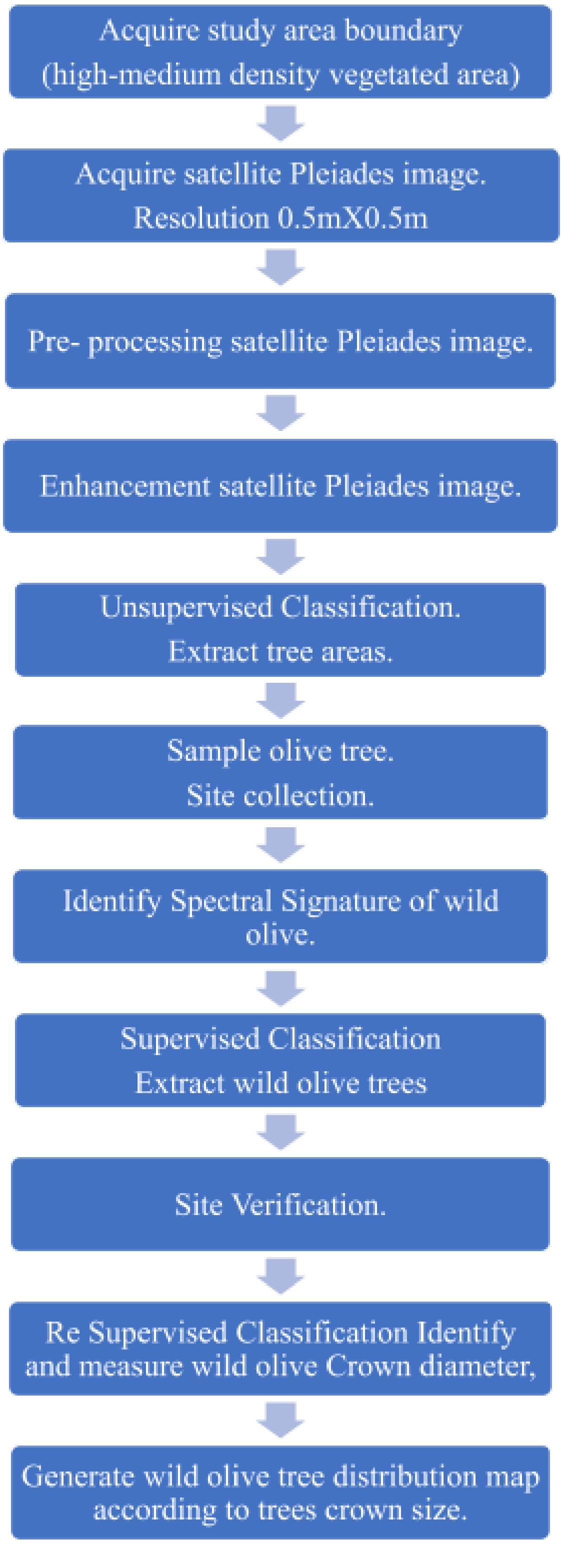

Figure 2: Overall workflow of this study; Workflow Chart

Satellite Image Pre-processing

Image pre-processing involves making an image more interpretable for a particular application. It makes important features of raw, remotely sensed data more interpretable by the human eye. Image pre-processing includes data correction methods, including radiometric correction, geometric correction and so on.

Remote sensing software-ERDAS Imagine version 2014-was used to process the raw Pleiades data, including the radiometric correction, band combination, image enhancement and other basic image-processing system for data analysis. ERDAS Imagine is a remote sensing application with editor functions designed by ERDAS for geospatial applications. It is mainly aimed at geospatial raster data processing and allows users to prepare, display and enhance digital images for the mapping function in geographic information system (GIS) software (Hexagon spatial, 2016).

Image Enhancement and Filtering

The selection of suitable band combination is essential for Pleiades. It is done by preparing the enhanced image for visual interpretation. Removing blurring and noise, increasing contrast and revealing details are examples of enhancement operations (Rapp. 1996). There is no scope for ideal or best image enhancement as the results are ultimately evaluated by a human, who is likely to make subjective judgments regarding whether a given image enhancement is useful or not (Jensen, 2005). In this study, images were enhanced using Histogram Equalize to distinguish the different land uses.

Spectral Signature

The term spectral signature refers to the relationship between the wavelength (or frequency) of electromagnetic radiation (EMR) and the reflectance of the surface. The signature is affected by many things, such as the material composition and structure. Some parts of the EMR spectrum, such as the microwave region, are more sensitive to surface structure than others. Spectral signature (or more often sampled parts of it-bands of satellite imagery) infers things about the surface such as composition (i.e., vegetation, bare soil, etc.). The features are only discriminable if they have non-overlapping spectral signatures, which can be normally viewed in the separability graph.

In this study, wild olive spectral signatures were extracted and compared from the images prior to the classification in order to ensure that they were separable. The software specifically used in this study is ENVI ver 5.4, which is another remote sensing software that combines advanced spectral image processing and proven geospatial analysis technology with a modern, user-friendly interface, specifically used for more complicated images, such as high-resolution images, hyperspectral, SAR and LIDAR.

Ground Sample Collection

For the ground sample collection activity, several locations of wild olive tree at various districts sites are required to be acquired as “training samples” for supervised classification. These locations were marked as wild olive tree coordinates on the image, and the spectral signatures or digital numbers were recognized as the guide to search and demarcate other similar reflectance characteristics. In this project, about 30 points of wild olive trees were run for supervised classification. These points are shown in Figure 3.

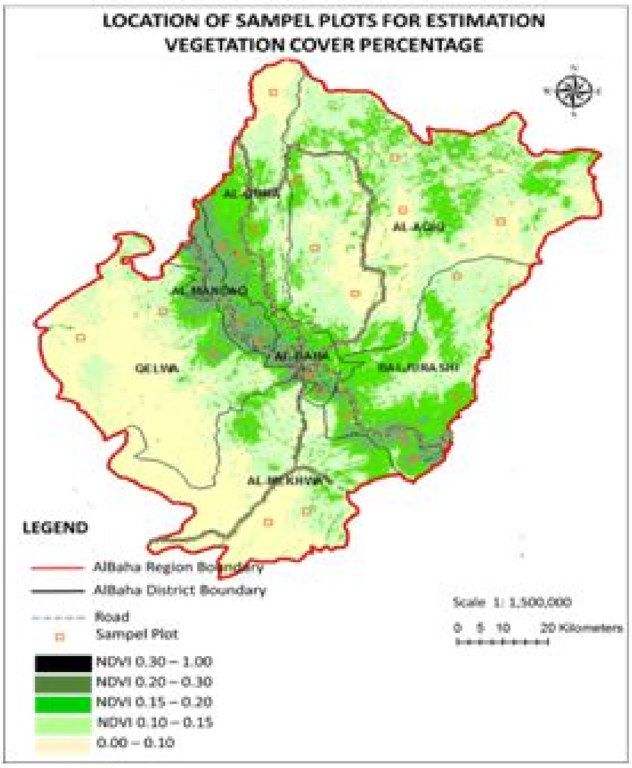

Figure 3: Location of plots for ground sample collection.

Forest Inventory Design

In this project, wild olive inventory was based on two major techniques:

- **Aerial inventory**: Using Pleiades satellite image, the measurement taken for 100% of the whole study area. The area was divided into seven administrative districts: Al-Qura, Al-Aqiq, Al-Mandaq, Al-Baha, Baljurashi, Qehwa and Al-Mekhwah. The attributes measured using aerial inventory is tree numbers and tree crown diameter.
- **Ground inventory sampling plot:** A certain number of plots statistically representing the whole area were randomly selected in the site, and 100% of the measurement was taken within the plots. The inventory process comprises creating the inventory, designing the forms of information collection, dividing the forest area into seven districts, describing the tree cover of each site, measuring the tree crown diameter attribute within each sampling plot and analyzing the extracted information.

Accuracy Assessment

Accuracy assessment is the comparison of classifications of ground truth data to evaluate how well the classification represents the real world. The step involved in accuracy assessment includes determining the number of samplings, confidence building assessment and the sampling design. In this project, the number of sampling follows Krejcie and Morgan methods, the assessment follows the producer/ consumer accuracy, and the plots selected based on the random sampling technique.

Determine the Number of Sampling

For any research study, the sample size must be determined during the designing stage. However, before determining the size of the sample, which needs to be drawn from the population, a few factors must be taken into consideration. According to Salant and Dillman (1994), these factors are as follows:

1) The extent of sampling error that can be tolerated.
2) The population size
3) The extent of variedness of the population with respect to the characteristics of interest
4) The smallest subgroup within the sample for which estimates are needed.

Using the above-mentioned methods as guidelines, the following section used Krejcie and Morgan (1970) and Cohen Statistical Power Analysis.

The estimation of the sample size in research using the method employed by Krejcie and Morgan method is quite common. Krejcie and Morgan (1970) used the following formula to determine sampling size:

$S = X^2NP\ (1-P)/\ d^2\ (N-1) + X^2P\ (1-P)$
S = Required sample size
X^2= The table value of chi-square for one degree of freedom at the desired confidence level
N= The population size
P= The population proportion (assumed to be 0.50 since this provides the maximum sample size)

d = The degree of accuracy expressed as a proportion (0.05)

For this study, the calculation was made as follows:
$S =X^2NP\ (1-P)/\ d^2\ (N-1) + X^2P\ (1-P)$
=3.841 * 236, 250 * 0.95 * (1-0.95) / 0.05 * 0.05 * (236, 250-1)
= 41, 963/575.18
= **73**
Therefore, 73 plots of 50m × 50m each were established in the study area

Determining the Sample Size

While assessing the accuracy of remotely sensed data, each sample point collected is expensive; therefore, the sample size must be kept to a minimum. However, it is critical to maintain a large enough sample size such that any analysis is performed is statistically valid. Due to the large number of pixels in a remotely sensed image, traditional thinking about sampling is not often applied (Congalton, 1991). Hence, this project followed the most common plot size established for forest inventory, i.e., 50m × 50m, similar to the one applied by El-Juhany and Aref (2012) for a recent vegetation inventory in the Al-Baha region.

Wild Olive Tree Crown Diameter Attribute Measurement

Tree crown diameter attribute measurement for the whole study was done both from the satellite PLEIADES imagery and direct measurement at the ground level. Ground measurements were conducted in October 2016 with 73 plots of 50m × 50m each. The techniques for each tree form characteristic have been briefly presented below.

Crown diameter measurement was done digitally using the ArcGIS software upon crown polygon created by the ERDAS software. In this project, crown diameter was divided into the following three classes:

- Small (<3.0m)
- Medium (3.1–5.0m)
- Large (>5.1m)

However, crown diameter less than1.5m was not easily visible in the satellite image, which means that some trees of this size range might not have been enumerated. This results in the under estimation by the system.

Stratified Random Sampling

From the vegetation map generated in the first phase of the study, it was observed that the districts of Al-Baha have a variety of vegetation density, which is quite influenced by the elevation. We may expect the measurement of the wild olive trees to vary across the districts. This variedness has to be accounted for while selecting a sample from the population so as to obtain a sample that is appropriately representative of the target population. This can be achieved by stratified sampling. A stratified sample was obtained by taking samples from each stratum or subgroup of the population. When we sample a population with several strata, we generally require that the proportion of each stratum in the sample to be the same as that in the population.

Stratified sampling techniques are generally used when the population is heterogeneous or dissimilar, from which certain homogeneous or similar sub-populations (strata) can be isolated. Simple random sampling is the most appropriate method when the entire population from which the sample is to be created is homogeneous. Some reasons for using stratified sampling over simple random sampling are as follows:

a) The cost for each observation in the survey may be reduced.
b) The estimate of the population parameters may be wanted for each sub-population.
c) Increased accuracy at a given cost.

As mentioned earlier, here, the stratification was based on district boundaries, and the numbers of plots are in proportion to the district size. As the main portion of the study area is located at a high elevation mountain region with rugged terrain and, thus, is not easily accessible, accessibility and road proximity need to be taken into consideration while selected plots. Trees, a little further away from the plot, were remotely measured using a laser range finder. In this project, verification was conducted on the accuracy of the satellite image that interpreted wild olive trees, which was classified 100% throughout the whole study area. We used the same 73 inventory plots established earlier to reduce time and energy, Figure 4**.**

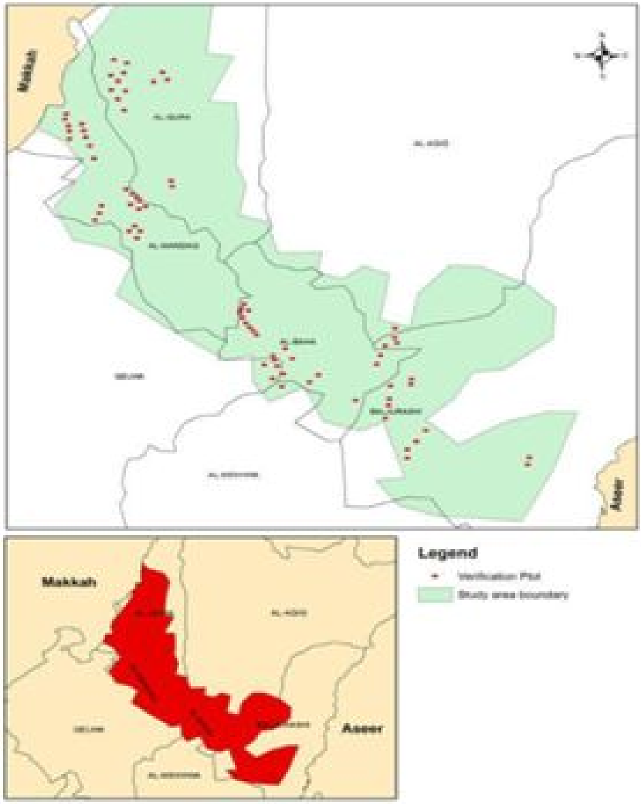

Figure 4: The location of plots for inventory and accuracy assessment

4. Result

This report provided the extent and distribution of wild olive trees in accordance with the tree crown size and accuracy assessment results, Figure 5.

In this study, the crown diameter of each tree was measured automatically direct from the Pleiades imagery. Three categories of different diameter sizes were established: small (1.5–2.5m), medium (2.5–3.5m) and big (>3.5m). Crown diameter sizes smaller than 1.5m could not be easily discriminated in the image and were discarded, leading to the occurrence of underestimated tree enumeration in this study.

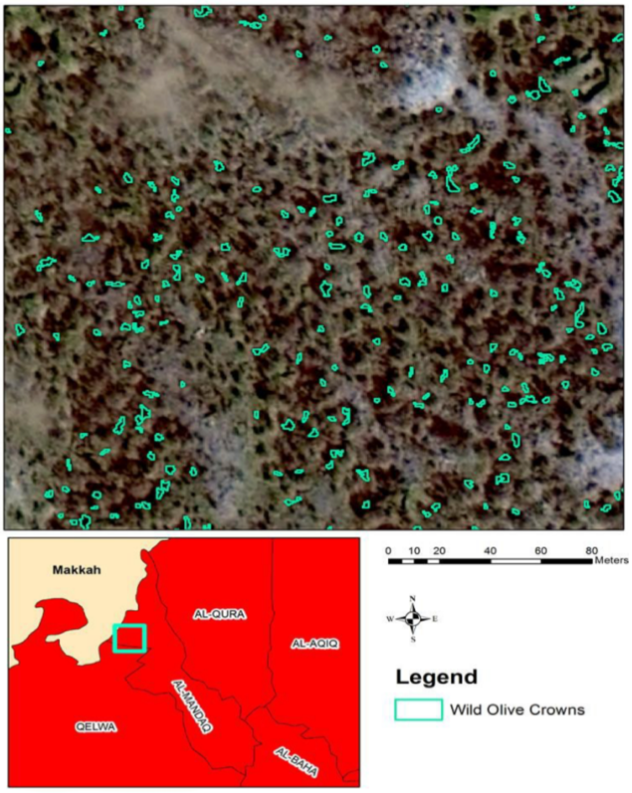

Figure 5: Satellite Pleiades imagery classification identifying wild olive crown

Extent of Wild Olive Tree according to Crown Diameter

The measurement conducted indicates that most of the trees belong to the small diameter crown category, a total of 392, 908 trees representing 54.7% of the total wild olive tree; only 13.4% were of the big diameter crown category. It was observed that Al-Qura has the highest percentage of trees with big crown at 17.2%, followed by Baljurashi at 15.1%. During the groundwork stage, most of the big crown trees were observed to be located along the riverside. Both the southern districts Qelwa and Al-Mekwa - have the highest percentages of small wild olive tree crown at 86.3% and 74.6%, respectively. Meanwhile, Table 4 shows that Al-Aqiq has the highest percentage of medium crown at 49.9%, despite the fact that these crown sizes are the least dense in the study area.

From the maps presented in Figures 6, 7, 8, 9, 10, 11, 12 and 13, it was observed that most of the small crown wild olive trees were located along the southwestern part of the study area, whereas the north-eastern part has more trees of medium and bigger crown sizes.

Table 4: Extent of Wild Olive Tree According to Crown Diameter Size Category

District	Study Area (km^2)	Total Number of Trees	Crown Diameter Size					
			Small Crown (1.5-2.5m)		Medium Crown (2.5- 3.5m)		Big Crown (> 3.5m)	
			Tree	(%)	Tree	(%)	Tree	(%)
Al-Qura	586	129, 903	49, 645	38.2	57, 913	44.6	22, 345	17.2
Al-Aqiq	165	3, 433	1, 325	38.6	1, 713	49.9	395	11.5
Al-Mandaq	339	208, 034	144, 376	69.4	40, 341	19.4	23, 317	11.2
Al-Mekhwa	27	11, 851	8, 835	74.6	2, 577	21.7	439	3.7
Al-Baha	287	161, 802	89, 433	55.3	50, 126	31.0	22, 243	13.7
Baljurashi	506	178, 801	78, 512	43.9	73, 262	41.0	27, 027	15.1
Qelwa	81	24, 070	20, 782	86.3	3, 064	12.7	224	0.9
TOTAL	1, 991	717, 894	392, 908	54.7	228, 996	31.9	95, 990	13.4

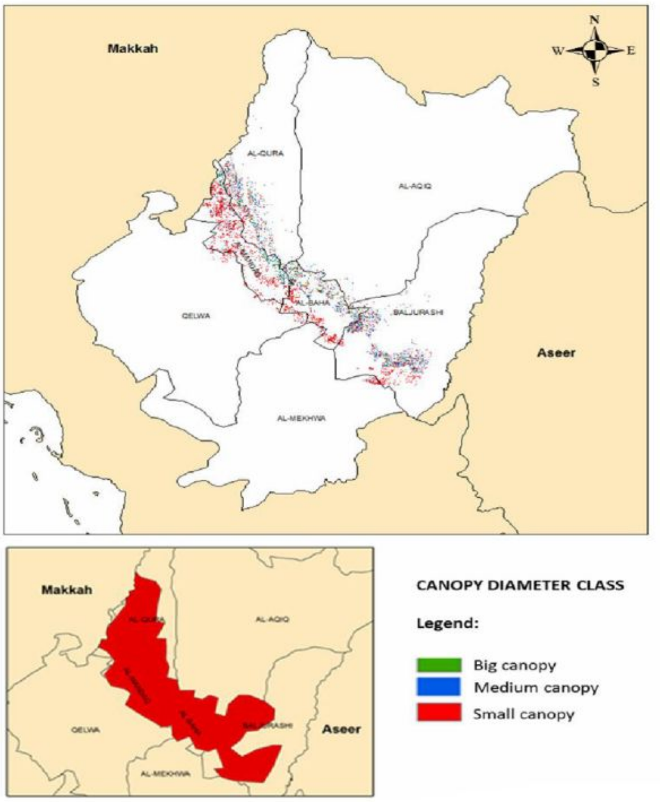

Figure 6: Distribution map of wild olive crown diameter class at Albaha region

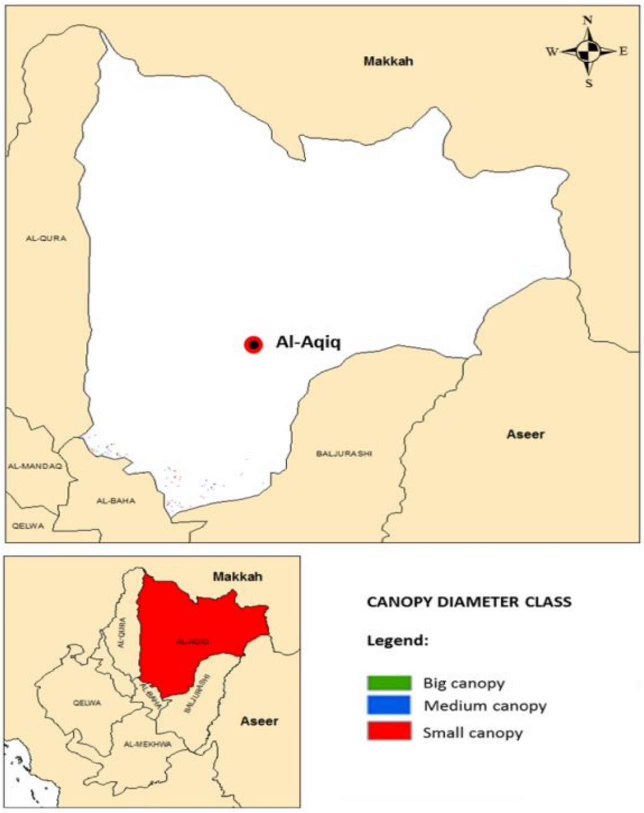

Figure 7: Distribution map of wild olive crown diameter class at Al-Aqiq district

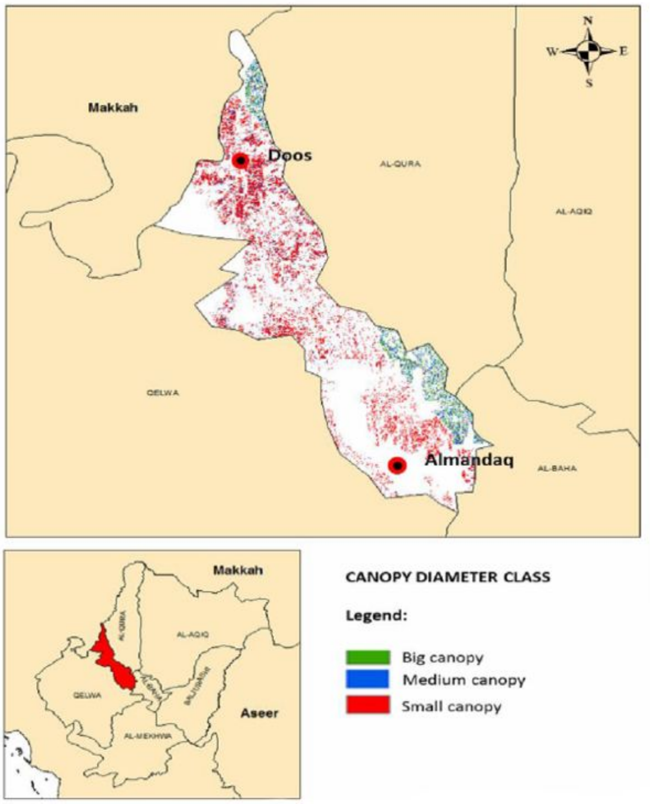

Figure 8: Distribution map of wild olive crown diameter class at Al-Mandaq district

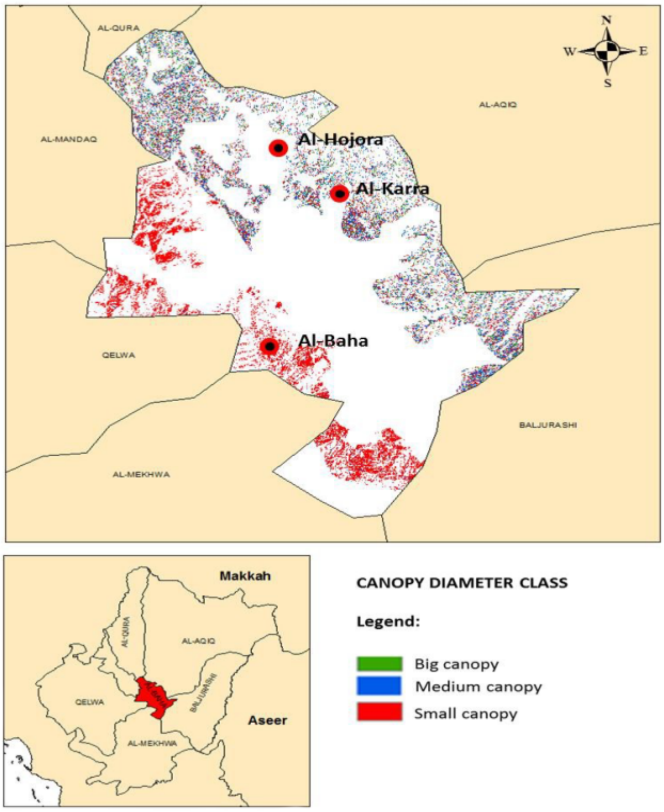

Figure 9: Distribution map of wild olive crown diameter

class at Al-Baha district

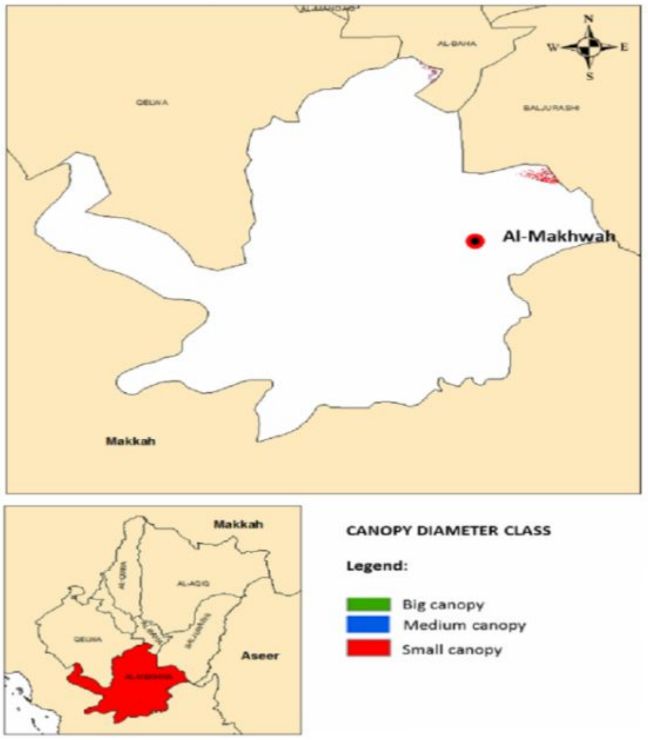

Figure 10: Distribution map of wild olive crown diameter class at Al-Mekhwa district

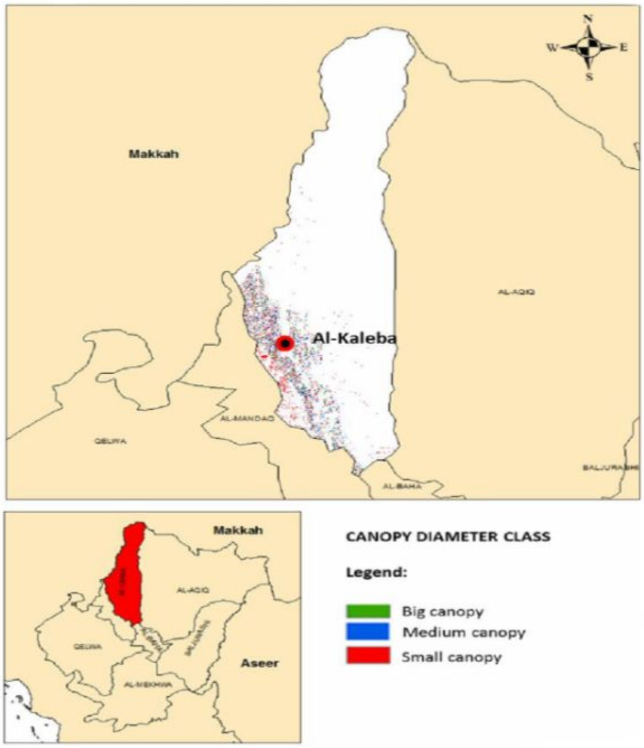

Figure 11: Distribution map of wild olive crown diameter class at Al-Qura district.

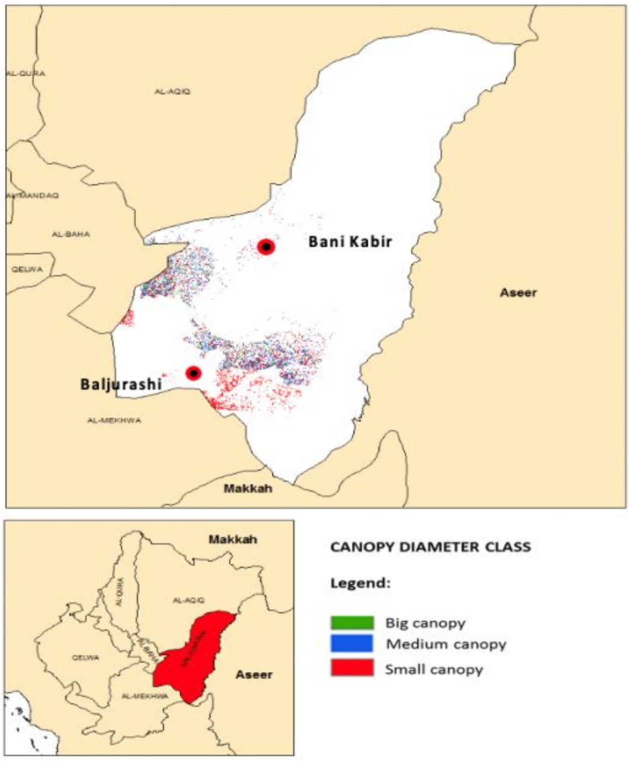

Figure 12: Distribution map of wild olive crown diameter class at Baljurashi district

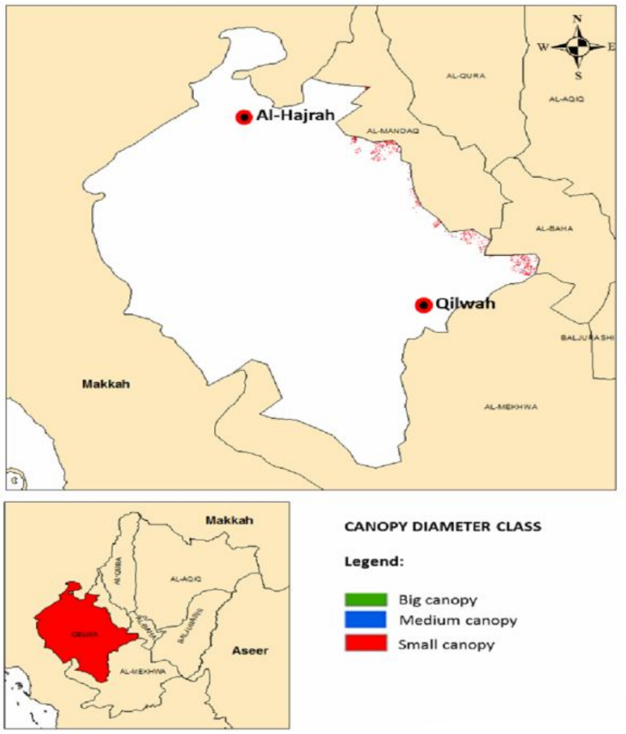

Figure 13: Distribution map of wild olive crown diameter class at Qelwa district

5. Discussion

In a previous study, the information extracted from high-resolution satellite Pleiades imagery revealed that there are 717, 894 wild olive trees (360 trees per km^2) in the area, covering 1, 991 km^2; most of these trees are found in the mountainous regions of Al-Mandaq and Al-Baha districts (Al-Ghamdi, 2020). Researchers Al-Khulaidy (2013) and El-Juhany and Aref (2012) referred to this region as the most plant-diverse area in Saudi Arabia. Previously, a similar study conducted by El-Juhany and Aref (2012) at Al-Mandaq inventoried 147 tree species per hectare, whereas another study determined 613 wild olive trees per km^2 (Al-Ghamdi, 2020). This indicates that wild olive is not the main species vegetation in the Al-Baha region, and many journals have reported juniper and acacia as the more abundant species.

Crown Diameter

Further analysis on the imagery by automatic measurement of the crown diameter revealed that most of the trees (54.7%) belong to the small diameter class (< 3.0m), whereas big diameter class (> 5.1m) were majorly observed at both Al-Qura and Baljurashi districts. According to Al-Juhany (2015), the small crown size of the trees and irregular growth indicates that they were cut in the past, and the branches grown from those areas as coppices are considered as trees in the present time.

6. Conclusion

This second phase project provided detailed information on the extent and distribution of wild olive trees and the species attributes in the Al-Baha region. The study results show that there are 717, 894 wild olive trees (360 trees per km^2) within the 1, 991-hectare study area concentrating along the Sarah mountain, encompassing districts such as Al-Qura, Al-Mandaq, Al- Baha and the southern part of Baljurashi. This indicates that wild olive trees prefer to grow in highly foggy mountain conditions, which was predetermined in the first phase project as having medium to high vegetation density zones.

The region where wild olive trees were found to be growing can be divided into three zones: (i) the districts of Al-Mandaq and Al-Baha, which has higher wild olive densities with smaller crown sizes, (ii) the districts of Al-Qura and Al-Baljurashi have lower wild olive densities but bigger crown sizes, and (iii) the districts of Al-Aqiq, Qelwa and Al-Mekhwa have the least density of wild olive trees with smaller crown sizes.

As the species distribution of plants growing in arid regions is closely related to the area's topography and landform (Aldhebiani and Howladar, 2013), this information will be essential for the third phase of the project titled "Identifying the Landscape Preference of Wild Olive in the Al-Baha Region."

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