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Identify the topographic river proximity characteristics most preferred by wild olive trees in Al Baha region, Saudi Arabia

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Abstract
The aims of this research are to identify the topographic river proximity characteristics most suited to wild olive trees in the Al Bahah region, Saudi Arabia. This study successfully identified the river proximity preferred by wild olive distribution. The results of the study show that the concentration of wild olive decreases as we move away from the river, indicating river proximity as a prominent landform preference. This exhibits that the distribution appears almost parallel at the landform. About 91.2% of wild olive are found at a distance of less than 600m from the river. However, there is no significant difference in the crown size and neighboring species that can be related to river proximity. These findings can be regarded as theoretically potential for a landform suitable for olive plantation. As the basis for olive plantation site suitability, these factors are the essential prerequisites that need to be considered. However, it is obvious that site suitability is subject to the temporal dynamics of environmental variables.

Keywords: wild olive tree, mapping, extent, distribution, Al-Baha region, remote sensing, crown size, river proximity, neighboring species

Introduction
Wild Olive Tree
Olea oleaster, wild olive, has been considered by various botanists. It is a valid species and subspecies of the cultivated olive tree, *Olea europaea*, which is a tree of multiple origins (Besnard *et al*., 2000) [7] that was domesticated, it now appears, at various places during the fourth and third millennia BCE, in selections drawn from varying local populations (Besnard 2001) [6].

Today, as a result of natural hybridization and ancient domestication and extensive cultivation of olives throughout the Mediterranean Basin, wild-looking feral forms of olive, called "*oleasters*", constitute a complex of populations, potentially ranging from feral forms to the wild olive (Lumaret *et al.,* 2004) [22].

Wild olive is a tree of the maquis shrubland and in part the result of the long presence of mankind. The drought-tolerant sclerophyllous wild olive tree is believed to have originated in the Mediterranean Basin. It still provides the hardy and disease-resistant rootstock on which cultivated olive varieties are grafted (Breton *et al*., 2006) [8].

Furthermore, wild olive has also been reported to be native to the North American evergreen tree, which is 20 feet high and 10 to15 feet wide. This small tree is rarely found and has even been reported to be close to extinction. The olive-like white fruits produced by the tree have a sweet flesh relished by birds and other wildlife, and although Thy Are edible to man, Thy Should not be eaten in quantities. However, at the United States of America (U.S.A), another olive tree species known as Russian olive (RO) (*Elaeagnus angustifolia* L.) is considered as an exotic invasive weed. According to reports, this thorny shrub or tree originated from South-eastern Europe and Western Asia (Katz *et al.,* 2003) [16]. And was intentionally introduced and planted in the United States (U.S) for windbreaks, erosion control, wildlife habitat, and other horticultural purposes. This tree was observed to have very well adapted to semiarid and saline environments. In the early 20th century, the RO escaped cultivation and spread, particularly into the large moist riparian environments in arid or semiarid regions of the western U.S (Stannard *et al*., 2002) [31].

Mapping Wild Olive Using Remote Sensing
Traditional methods (e.g., field surveys, literature reviews, map interpretation, and collateral and ancillary data analyses) have not been effective in acquiring mass vegetation covers because they are time-consuming, data lagging, and often too expensive. Conversely, remote sensing offers practical and economical means to study vegetation cover changes, especially over large areas (Nordberg *et al.,* 2004) [26].

Because of its potential capacity for systematic observations at various scales, remote sensing technology extends possible data archives from the present to over several decades back. Using this advantage, inventory and enormous efforts have been made by researchers and application specialists to delineate vegetation cover from the local to global scale by applying remote sensing imagery.

Since then, numerous efforts, regional or national, have been made to map wild olives using remote sensing. One example is a pilot project initiated to develop a cost-effective method for mapping the RO (Elaeagnus angustifolia L.), an invasive tree species, from scanned large-scale aerial photographs. This study area was established along a riparian zone within a semiarid region of the Fishlake National Forest, located in central Utah. Two scales of natural color aerial photographs (1:4000 and 1:12 000) were evaluated as part of the project. Feature Analyst, an extension of the ArcGIS software, and several image processing software packages were used to map the invasive trees. Overall, Feature Analyst successfully located the RO using the imagery with a relatively high degree of accuracy. For the map derived from 1:4000-scale photographs, the software correctly located the tree in 85% of all 4-by-4 meter transect cells where the RO was actually present. However, smaller trees were sometimes missed, and the size of trees and groups of trees were frequently underestimated. The map derived from 1:4000-scale photographs was only slightly more accurate than the map derived from 1:12000-scale photographs, suggesting that smaller scale photography may be adequate for mapping the RO (Hamilton *et al*., 2006) [12].

Another attempt was made in Australia to test the ability of remote sensing imagery to map olive groves and their attributes. In specific, this attempt aimed to (a) discriminate olives varieties and (b) detect and interpret within-field spatial variability. Using high spatial resolution (2.8 m) via QuickBird multispectral imagery acquired over Yallamundi (southeast Queensland) on 24 December 2003, both visual interpretation and statistical (divergence) measures were employed to discriminate olive varieties. Similarly, the detection and interpretation of within-field spatial variability was conducted on enhanced false color composite imagery and confirmed by the use of statistical methods. The results showed that the 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 the two varieties have very low spectral separability.

Extent and Distribution of Wild Olive Trees in Al Baha Region

The crown diameter of each tree was directly measured automatically from the Pleaides satellite imagery. Three diameter size categories were established, i.e., small (1.5–2.5 m), medium (2.5–3.5 m), and big (>3.5 m). A crown diameter size smaller than 1.5 m could not be easily discriminated from the image and hence could not be used to enumerate rendering of underestimated tree counting in this eastern Al-Mandaq, south-western Baljurashi, and at the boundary edges of Al-Baha.

Table 1: Wild olive tree presence in Al Baha by district

District	Study Area (km^2)	Area with Wild olive trees		Number of Wild olive trees	
		(km^2)	(%)	Tree	Tree/ km^2
Al-Qura	586	270	13.6	129 903	222
Al-Aqiq	165	69	3.5	3433	21
Al-Mandaq	339	150	7.5	208 034	613
Al-Mekhwa	27	10	0.5	11 851	444
Al-Baha	287	103	5.2	161 802	563
Baljurashi	506	192	9.6	178 801	353
Qelwa	81	24	1.2	24 070	297
TOTAL	1991	817	41.1	717 894	360

From the maps shown in Figure 1, it can be observed that most wild olive dense areas are located in north-eastern Al-Mandaq, south-western Baljurashi, and at the boundary edges of Al-Baha.

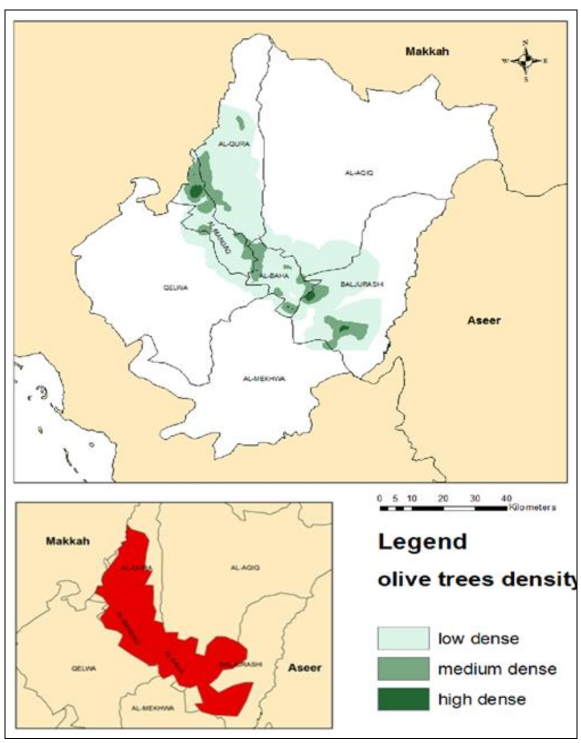

Fig 1: Density of wild olive trees at the studied area.

Extent of Wild olive tree Presence According to Crown Diameter Size

The crown diameter of each tree was directly measured automatically from the Pleaides satellite imagery. Three diameter size categories were established, i.e., small (1.5–2.5 m), medium (2.5–3.5 m), and big (>3.5 m). A crown diameter size smaller than 1.5 m could not be easily discriminated from the image and hence could not be used to enumerate rendering of underestimated tree counting in this project. The measurement indicates that most of the trees have a small crown diameter with 392,908 trees representing 54.7% of the total wild olive trees and only 13.4% having a big crown diameter. It was also observed that big crown trees and medium crown trees are mostly located at Al Qura, Al-Mandaq, Al Baha, and Baljurashi. However, Al-Mandaq, with the wildest olive trees, has a highest percentage of small crown trees (36.7% or 144,376 trees). Lower wild olive density districts such as Al-Aqiq, Al-Mekhwa, and Al-Qelwa have More Smaller crown trees (Table.2, Figure 2: Al-Ghamdi 2020 c) [4].

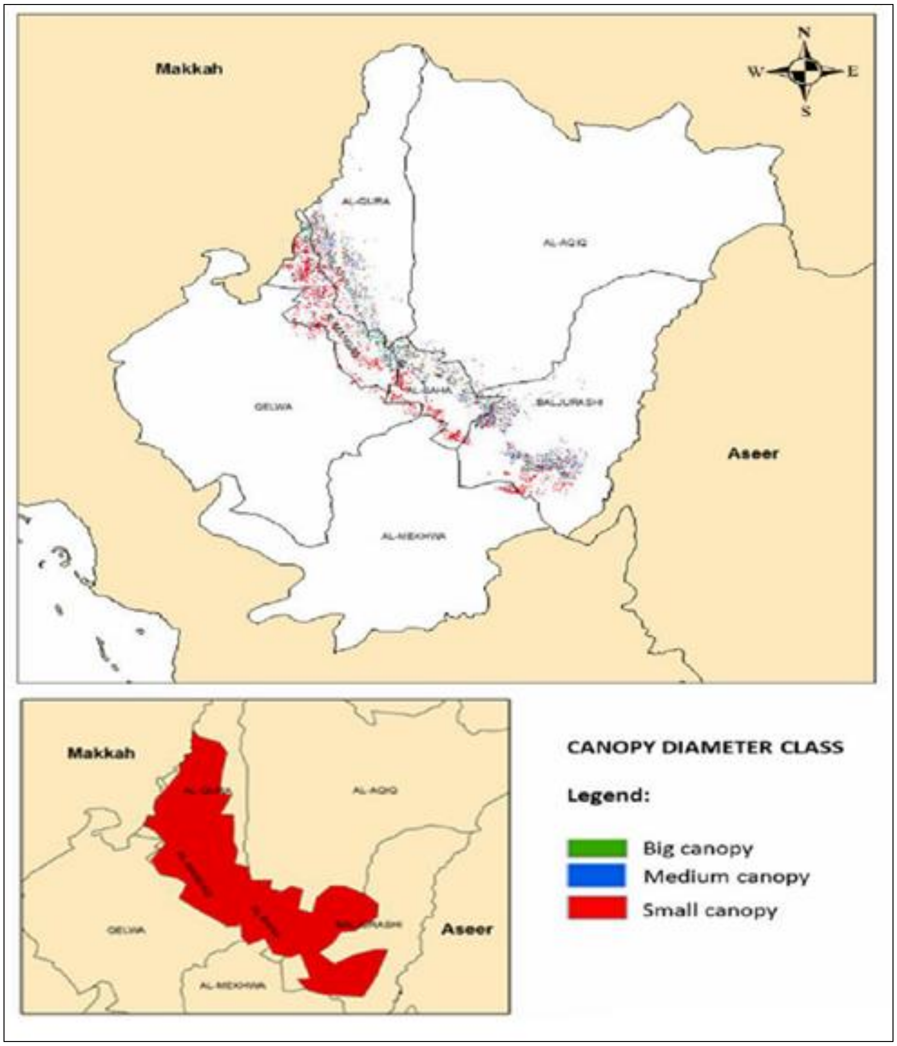

Fig 2: Distribution of Wild olive tree according to Crown Diameter.

Table 2: Wild olive crown diameter size by district.

District	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	129 903	49 645	12.6	57 913	25.3	22 345	23.3
Al-Aqiq	3433	1325	0.3	1713	0.7	395	0.4
Al-Mandaq	208 034	144 376	36.7	40 341	17.6	23 317	24.3
Al-Mekhwa	11 851	8835	2.2	2577	1.1	439	0.5
Al-Baha	161 802	89 433	22.8	50 126	21.9	22 243	23.2
Baljurashi	178 801	78 512	20.0	73 262	32.0	27027	28.2
Qelwa	24070	20 782	5.3	3064	1.3	224	0.2
TOTAL	717 894	392 908	100.0	228 996	100.0	95 990	100.0

Extent of Wild Olive Trees According to Neighboring Species

In the second-phase project, neighboring species were automatically determined by software ERDAS' classification and by enumerating trees within 5 meters around wild olive trees using ArcGIS software. Pleaides satellite imagery was used to determine the wild olive trees, juniper, acacia, and other species. It was found that the main neighboring species of the wild olive are juniper (40.2%) and acacia (36%), and other species (23.8%). juniper is the most common neighbor of wild olive in Al-Mandaq (32.2%) and Al-Baha (29.4%) while acacia is the main neighbouring species for the wild olives in Al-Baha (28.3%) and Baljurashi (29.6%). The abundance of juniper trees in Al-Mandaq and Al-Baha districts probably attributes to its higher elevations and the rugged nature of its mountains (especially in the past before the introduction of modern roads), which has protected its forest from extensive exploitation and prevented ease of access to the area. Meanwhile, the small size of the trees and irregular growth show that they have been cut in the past, and the branches growing from them as coppices are considered the current trees (Table 2 and Figure 3: Al-Ghamdi 2020 d) [4].

Table 3. Extent of wild olive tree neighboring species by district.

District	Number of Neighbor Trees*	Number of Neighbor Trees					
		Juniper		Acacia		Others	
		tree	%	tree	%	tree	%
Al-Qura	79,521	29,525	12.2	46,250	21.3	3746	2.6
Al-Aqiq	2,296	1347	0.6	836	0.4	113	0.1
Mandaq	148,886	78,219	32.2	21,359	9.8	49,308	34.3
Mekhwa	41,875	20293	8.4	14592	6.7	6990	4.9
Al-Baha	193,920	71,354	29.4	61,443	28.3	61,123	42.5
Baljurashi	102,297	30,522	12.6	64,271	29.6	7504	5.2
Qelwa	35,493	11743	4.8	8742	4.0	15008	10.4
TOTAL	604,288	243,003	100.0	217,493	100.0	143,792	100.0

* Neighbor trees are trees surrounding wild olive trees within a 5m radius

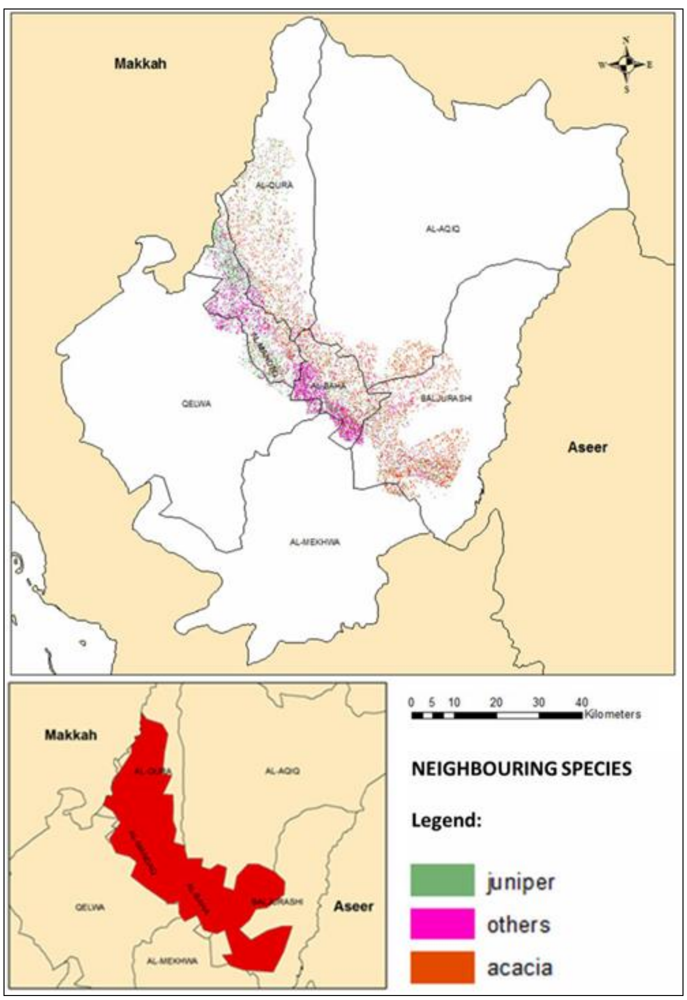

Fig 3: Distribution of Wild olive tree according to Neighbouring.

Vegetation Topographical Preference.

The study of plant communities is the best way to learn about habit, habitat, niche and vegetation structure Khan *et al*., (2016) [18]; Malik (1986) [23]. As well as various interaction among the plants in an ecosystem. Variations in plant species' composition along altitude and latitude is a well-established phenomenon (Kitayama (1992) [19]; Lieberman *et al*., (1985) [21]; Shaheen *et al.,* (2012) [29]. and one of the ultimate effects in restricting plant species and communities' types in mountainous regions (Khan *et al.*, (2011) [17]. Furthermore, soil is an environmental factor that also determines plant growth, which is influenced by organisms, climate, topography, time, and parent material, Hoveizeh (1997) [14].

Plant species by origin are restricted to a specific habitat and can be reached in that particular habitat due to the presence of optimum topographical factors such as river proximity as well as biotic and abiotic factors, which clearly show that plant communities and vegetation composition change along these factors' diversity from point to point. Topographic attributes provide significant information for the categorization of different vegetation classes. Topographical heterogeneity strongly affects other types of landscape heterogeneity, e.g. variation in mesoclimate, natural disturbances, soil conditions, or intensity of human impact. The main effect of landscape-scale topographical heterogeneity on local (microsite) species' richness can be seen in the control of the spatial configuration of habitats surrounding the target site. In a topographically homogeneous landscape, a site's neighborhood usually contains the same or similar habitats while in a heterogeneous landscape, very different habitats may be found close to the target site (Zelený *et al.*, (2010) [35]. Observations revealed that species' ranges are shifting, contracting, expanding, and fragmenting in response to global environmental changes (Chen *et al.*, (2011) [9]. The emergence of global-scale bioinformatic databases has provided new opportunities to analyze species' occurrence data in support of conservation efforts, Jetz *et al*., (2012) [15]. This has paved the way for more systematic and evidence-based conservation approaches (Margules *et al*., (2000) [24]; Sutherland *et al.*, (2004) [32]. However, records of observed species' occurrence typically provide information on only a subset of sites occupied by a species, Rondinini *et al.*, (2005) [28]. Moreover, these do not provide information on sites that have not been surveyed or that may be colonized in the future following climate change, Hoegh-Guldberg *et al.*, (2008) [13] or biological invasions, Thuiller *et al.*, (2005) [33]; Baxter *et al*., (2010) [5] Giljohann *et al.*, (2011) [11]. Nevertheless, this information is important for making robust conservation management decisions and can be provided via predictions of species' occurrences derived from environmental suitability models that combine biological records with spatial environmental data. Species distribution models (SDM), also commonly referred to as ecological niche models (ENM), are currently the main tools used to derive spatially explicit predictions of environmental suitability for a species.

Geographical and Topographical Pattern Concepts.

Both geographical and topographical ecology are concerned with understanding spatial patterns to understand process, and process to understand pattern. Geographical and topographical ecology introduce fundamental questions on the concepts of scale, space, and place, Turner *et al.*, (2001) [34].

A major difference between the two disciplines is that topographical ecology focuses solely on ecological processes, whereas geographical ecology encompasses all systems including human, ecological, biological, and physical. Ultimately, geographical and topographical ecology concern with broad-scale environmental issues and help provide insights into studies of ecological systems that operate over various scales.

For example, the ecosystem provided and maintained by bees is inherently related to geographical and topographical ecology because of the importance of spatial scale and spatial pattern in the bees' habitat. Bee distribution is geographic in nature because it is limited by climate, topography, soils, and vegetation types Michener (2000) [25].

Thousands of species of bees exist on our planet, and their distributions are limited by spatial variables that create great regional diversity in bee populations.

Topographical ecology is also important for understanding bee populations because of the discipline's focus on broad spatial scales and the ecological effects of the spatial patterning of ecosystems Turner *et al.*, (2001) [34]. One theory that is common to topographical ecology and important to the conceptualization of this research is the Percolation theory, which addresses the spatial pattern in random assembly. Applications of the Percolation theory have brought to light questions of size, shape, and connectivity of habitats Turner *et al.*, (2001) [34].

The Percolation theory has offered much insight into the nature of connectivity or the inverse fragmentation of topographical preference Gardner *et al*., (1992) [10].

Information on wild olive trees and suitable conditions for their growth in forests is still limited. Thus, a complete understanding of the topographical characteristics preferred by wild olive trees has yet to be achieved. Using remote sensing and geographic information system, local people can now trace the exact locations of wild olive trees and manage a planned future area to develop olive plantations with these established topographical characteristics compared to other olive plantation topographical areas.

It has been observed that wild olive trees are more resistant to diseases compared to normal olive plantation trees. Once affected, diseases are more easily spread in a normal olive plantation rather than in wild olive trees. Hence, it is essential to determine factors that contribute to this variation in the wild olive trees, especially in a disease-prone situation. This can be due to weather conditions such as rainfall, temperature, humidity, etc., or topographical conditions such as elevation, slope, aspect, river proximity, etc.

The Study Area.

According to Price (2004) [27], the most effective way to map plant-species ranges in an area is by demarcating a general bioclimatic envelope within biogeographic regions in which a species is known to have been found. Hence, this study requires building a database of species that includes data on the distribution of species by geographic region, major habitat type, and elevation range. Furthermore, in this project, due to the large area of study and to save time, cost, and energy, only areas with high potential of wild olive tree presence, indicated by high (61.8 km^2) and medium (790.7 km^2) density vegetated areas, were included in the first-phase study (Table 1, Figure 4 Al-Ghamdi (2020 a) [4].

Table 4: Study area according to district.

District		Study Area	
Name	**km^2**	**km^2**	**(%)**
Al-Qura	1,049	586	55.9
Al-Aqiq	3,667	165	4.5
Al-Mandaq	361	339	94
Al-Mekhwa	1,949	27	1.4
Al-Baha	298	287	96.4
Baljurashi	1,505	506	33.6
Qelwa	2,232	81	3.6
TOTAL	11, 060	1,991	18

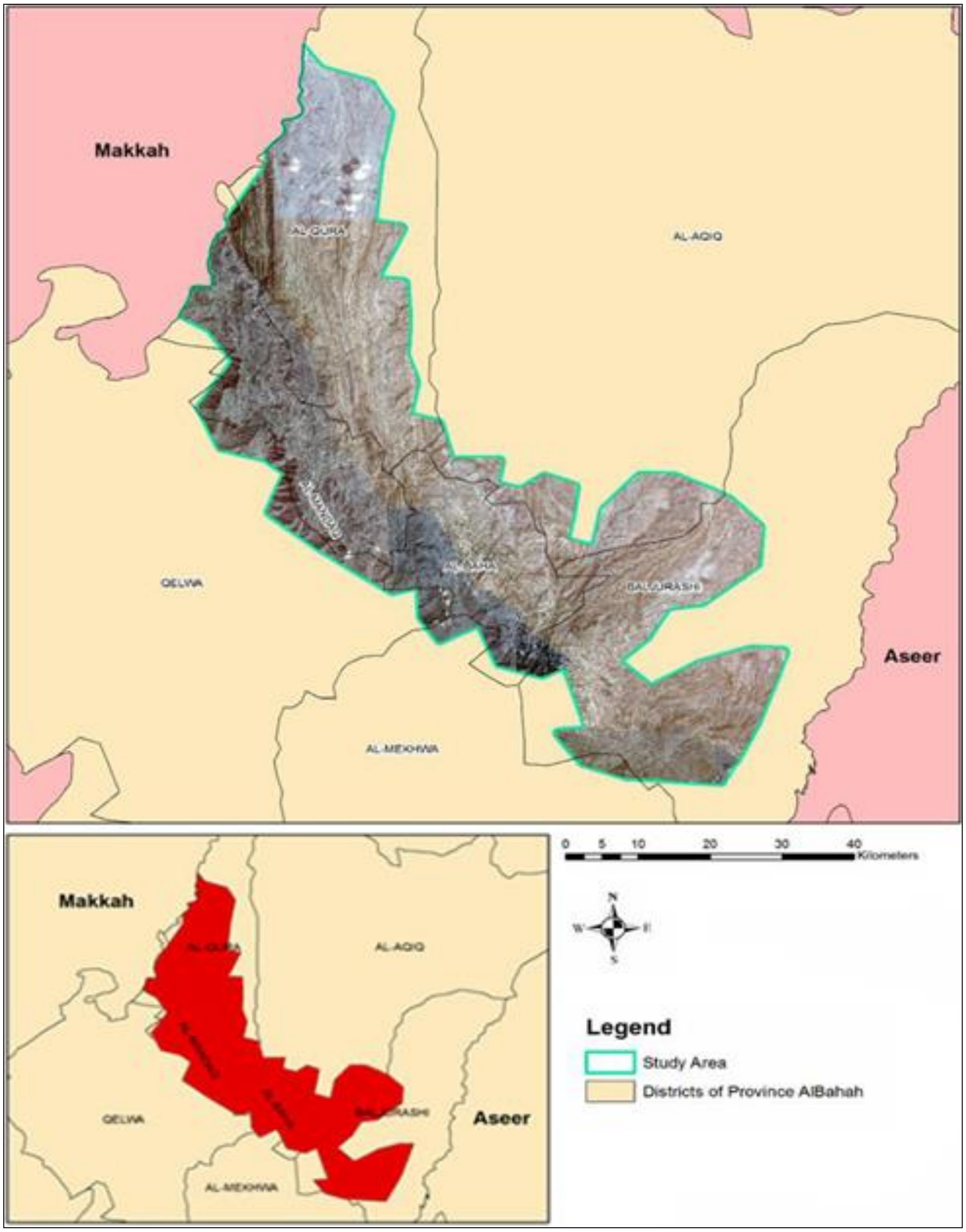

Fig 4: Satellite image Pleideas showing the extent of the study

Additional search areas were also expanded to nearby lower vegetation density areas based on the neighborhood's similar characteristics. This area expanded to the northern part but not to the southern part because the southern part, i.e. Al-Mekhwa and Qelwa, consists of a steep slope tending toward lower elevation. The overall study area, which totaled around 1991 km^2 (Figure 4), makes up only 18.0% of the entire Al Baha region.

Objectives.
This study aims to identify the topographical characteristics (river proximity) most preferred by wild olive trees in the Al Bahah region, which will act as a knowledge base for a better understanding of the occurrence and morphology of this olive species' activities in November 2016, and establish knowledge based on the location and preferred topographical characteristics of wild olive trees in the Al Bahah region.

Material and Method.
The main data source for the location of wild olive trees in the study area were provided from previous studies Al-Ghamdi (2020 a) [4]. These distribution coordinates were then overlaid with topographical parameters derived from ASTER data to identify the most preferred topographical characteristics of wild olive trees in the Al Baha region. The following sections delineate the methods applied in this project.

Material and Data.
In this study, the geospatial software used are as follows:

- ERDAS Imagine 2014 – an image processing software;
- ArcGIS ver 10.3 – a GIS software to conduct spatial analysis;
- ArcScene – an extension of ArcGIS software used to process and display 3D images;

Meanwhile, the data used in this project are as follows:

- ASTER Global Digital Elevation Model (GDEM) – used to generate rivers' proximity.
- Digital boundary of the Al Baha region and its districts.

Method
In this study, three main activities were conducted: data collection involving satellite data procurement, data analysis, and field work. The overall workflow of this study is shown in

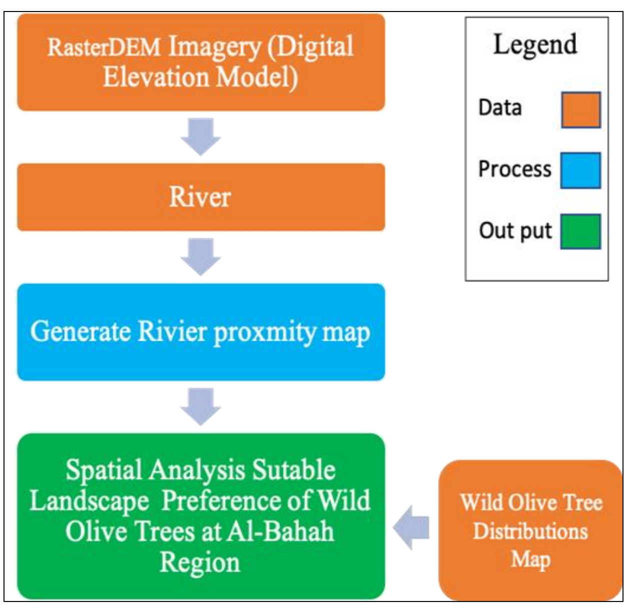

Fig 5: Activities flowchart for wild olive topographical preference

LANDSAT-8 satellite's images dated May 2016 were used as the primary source for extracting the data for this study and identifying the vegetated area in the Al Bahah region.

Digital Elevation Model
Digital elevation model (DEM) is often used as a generic term for digital surface models (DSMs) and digital terrain models (DTMs) and only represents height information without any further definition of the surface. Other definitions consider the terms DEM and DTM as equal to the other, or define the DEM as a subset of DTM, which also represents other morphological elements. There are also definitions, which consider the terms DEM and DSM as interchangeable. On the Web, definitions can be found, which define DEM as a regularly spaced GRID and DTM as a three-dimensional model (TIN). All datasets, which are captured with satellites, airplanes, or other flying platforms are originally DSMs (such as SRTM or the ASTER GDEM). It is possible to compute a DTM from high-resolution DSM datasets with complex algorithms Li *et al.*, (2005).

In this study, the topographical map was acquired from advanced spaceborne thermal emission and reflection radiometer (ASTER) images, which is a Japanese sensor on board the Terra satellite that was launched into the Earth's orbit by the NASA in 1999. The instrument has been collecting data since February 2000. ASTER provides high-resolution images of Earth in 14 different bands of the electromagnetic spectrum, ranging from visible to thermal infrared light. The resolution of images ranges between 15 and 90 meters. ASTER topographical isoline contours consist of 5m intervals that were eventually generated into GIS. Prior to that, the contour lines were assigned an attribute value according to their height in meters above the sea level. The resulting dataset was then used to produce a DEM using ArcScene software with the 3D extension analyst. Height value was added to the existing contour line used previously in generating the DEM. Adding the height information to the contour lines is the most time-consuming stage of the process to generate a DEM.

A river map was generated using the ASTER data from the ArcGIS tool. The command steps are as follows: (Spatial Analyst Tools > Hydrology > Fill > Flow Direction > Flow > Stream Order > Stream to Feature). The river was then generated with 5 classes of river buffers. The resulting dataset was then used to overlay the wild olive tree points. Subsequently, these layers were overlaid with a tree-point layer for spatial data analysis. The last output from the spatial analysis is the suitable topographical preference of Wild olive trees.

Topographic Characteristic Measurement.
Many topographic components are considered to be highly affected by wild olive tree presence. In this study, we will study river proximity topographic component. In contrast, the wild olive characteristics investigated to be associated with the topographic/landform features are crown canopy size, neighboring species, and distribution. These characteristics were overlaid with the river proximity topographical components to identify their association. River proximity was

generated by creating river buffer classes (ArcGIS software). In this project, river buffer was divided into six (6) distance (m) classes, as shown below:

Table 5

0–150 m	**451–600 m**
151–300 m	601–750 m
301–450 m	> 750 m

Result

River proximity criteria are deemed to contribute to the formulation of a habitat suitability index for wild olive trees. Distances from the river were generated using a Raster World DEM from the United States Geological Survey (USGS). Using ArcMap modules from ArcGIS, five classes of distance from the river were generated: (i) 0–50 m, (ii) 51–100 m, (iii) 101–150 m, (iv) 151–200 m, and (v) > 250 m. These classes of distance from the river were then displayed and overlaid with the wild olive tree point layer (figures 6 and 7) to determine where they intersected. Based on the observation in this study, 65,572 wild olive trees (22.51%) were found within 0–50 m from rivers.

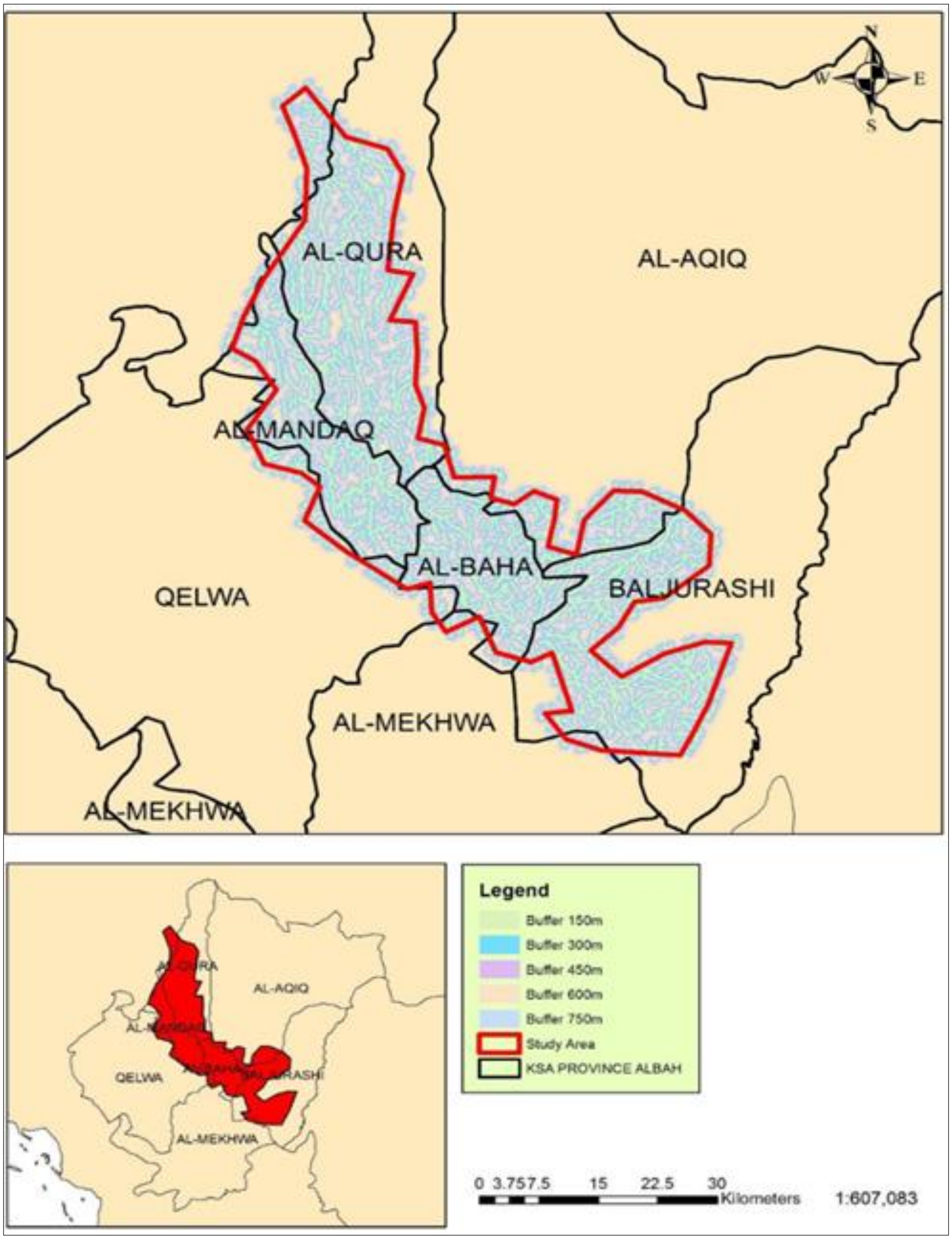

Fig 6: River proximity map of the study area.

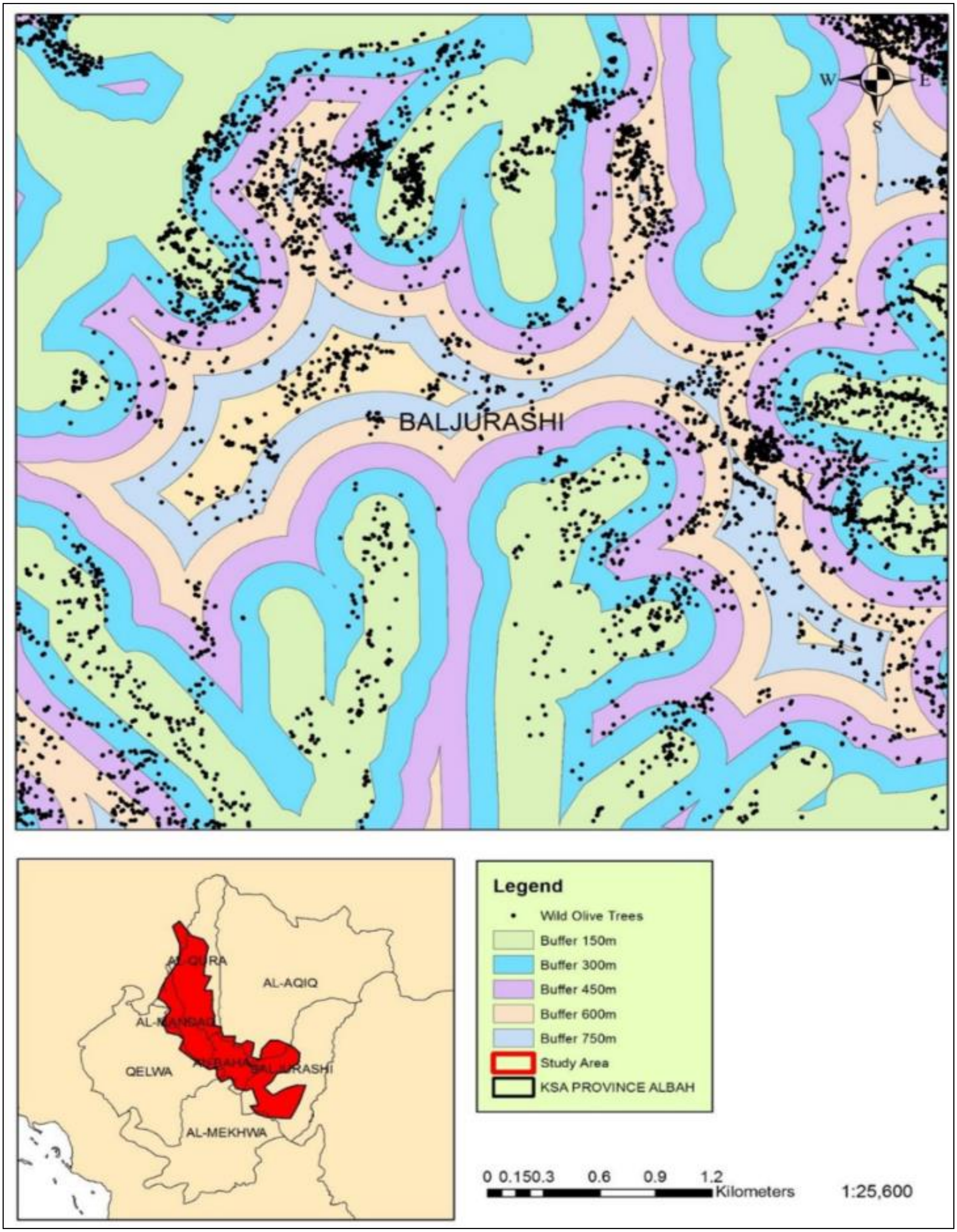

Fig 7: Close-up view on distribution of wild olive tree on the river proximity map.

Extent of Wild Olive by River Proximity According to District

Result shows that most wild olives in this study (91.2%) are less than 600 m away from the nearest river. Table 5.

Table 6: Number of wild olive trees against river proximity.

Distance from river (m)	Olive tree	Percentage (%)
0-150	219,149	30.5
151-300	177,330	24.7
301-450	156,117	21.7
451-600	102,794	14.3
601-750	46,119	6.4
> 750	16,385	2.3
Total	717,894	

The pattern among the Al Bahah districts are all the same. Table 6.

Table 7: Wild olive distribution relation with river proximity according to district.

River Proximity (meter)	Olive Density														Total	
	Al Qura		Al Mandaq		Al Baha		Al Bajurashi		Al Qelwa		Mekhwah		Al Aqiq			
	Tree	%	Tree	%	Tree	%	Tree	%	Tree	%	Tree	%	Tree	%	Tree	%
0-150	40,908	31.49	52,914	25.44	51,461	31.80	63,486	35.51	5011	20.82	3925	33.12	1444	42.06	219,149	30.53
151-300	31,805	24.48	52,323	25.15	40,004	24.72	44,674	24.99	4999	20.77	2844	24.00	681	19.84	177,330	24.70
301-450	26,825	20.65	48,444	23.29	36,699	22.68	36,748	20.55	4465	18.55	2301	19.42	635	18.50	156,117	21.75
451-600	18,176	13.99	32,011	15.39	23,379	14.45	23,093	12.92	4216	17.52	1511	12.75	408	11.88	102,794	14.32
601-750	8,112	6.24	16,189	7.78	8,379	5.18	8,773	4.91	3365	13.98	1116	9.42	185	5.39	46,119	6.42
> 750	4,077	3.14	6,153	2.96	1,880	1.16	2,027	1.13	2,014	8.37	154	1.30	80	2.33	16,385	2.28
total	129,903	100.00	208,034	100.00	161,802	100.00	178,801	100.00	24,070	100.00	11,851	100.00	3,433	100.00	717,894	100.00

* Highlighted in yellow are where most wild olive trees found (> 10%)

Extent of Wild Olive Crown Diameter Size by River Proximity

The results show that 28.92% of the small crown trees and 32.36% from both medium and big crown trees are mostly found at the 0–150 m nearest river while 24% of the small crown trees and 25% from both medium and big crown trees are mostly found at 151–300 m. from the river proximity. The result also shows that 21% from all types of crowns were found at the 301–450 m nearest river. The results also show that 15% of the small crown trees and 14 % from both medium and big crown trees are mostly found at the 451–600 m nearest river, In general, the result shows that all small, medium, and big crown size trees were mostly found at less than 600 m from the nearest river (Table 7).

The histogram pattern in Figure 8 also shows the same pattern.

Table 8: Wild olive crown diameter size relation with river proximity.

River Proximity	Crown Diameter Size						Total	
	Small		Mid		Big			
	Tree	%	Tree	%	Tree	%	Tree	%
0-150	113,614	28.92	74,601	32.36	30,394	32.18	218,609	30.45
151-300	95,720	24.36	57,761	25.05	23,849	25.25	177,330	24.70
301-450	86,146	21.93	49,549	21.49	20,422	21.63	156,117	21.75
451-600	58,889	14.99	31,371	13.61	12,534	13.27	102,794	14.32
601-750	28,281	7.20	12,786	5.55	5,052	5.35	46,119	6.42
> 750	10,258	2.61	4,482	1.94	2,185	2.31	16,925	2.36
total	392,908	100.00	230,550	100.00	94,436	100.00	717,894	100

* Highlighted in yellow are where most wild olive trees found (> 10%)

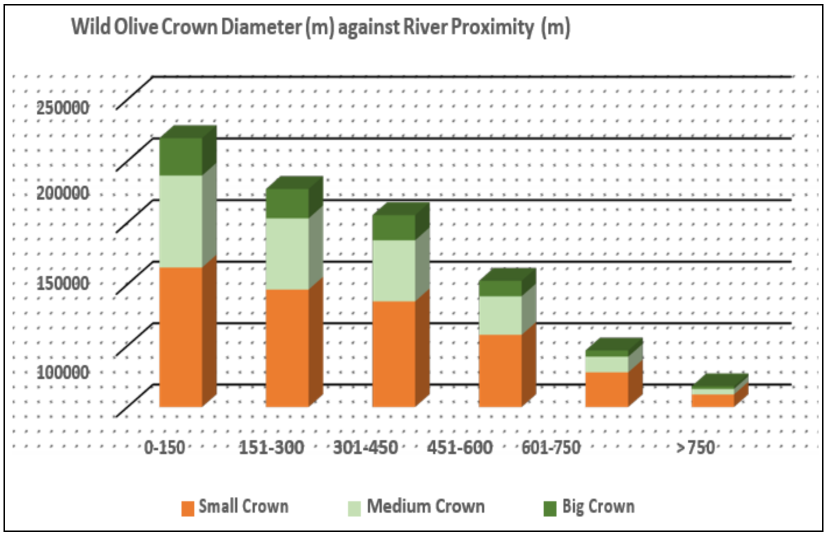

Fig 8: Histogram showing pattern of wild olive crown diameter against river proximity.

Extent of Wild Olive Neighbor Trees According to River Proximity

The result shows that the wild olive's neighboring species are found at a different distance, About 30.89% of the juniper trees, 32.54% from acacia trees, and 24.38%. Other plants are mostly found at the 0-150 m nearest river while 24 % of the juniper, acacia, and other plants are mostly found at 151-300 m from the river proximity. The result also shows 21% from juniper and acacia trees and 22% from other plants are found at the 301–450 m nearest river. The results also show that 14% of both juniper and acacia trees, and 17% from other plants are mostly found at the 451–600 m nearest river.

In general, the result shows that the wild olive's neighboring species are mostly found at a distance of less than 600 m from the river (Table 8). The histogram also shows the same pattern (Figure 9).

Discusion

Species ranges are shifting, contracting, expanding, and fragmenting in response to global and local environmental changes and human interferences with natural topography or landscapes (Chen *et al.*, 2011) [9]. Understanding the natural topography where species are abundant indicates the preference or suitability of that species. This research and development of the wild olive geoinformatics database of the local Al Baha region has provided new opportunities to analyze wild olive occurrence data in support of conservation efforts and has allowed for a more systematic and evidence-based conservation approach. In this project, the observed species' occurrence that typically provided information on areas previously demarcated as having medium-high vegetation density was recorded during the first phase of the project while the number of trees and location were acquired during the second phase of the project. In this study, the topography river proximity preference of wild olive trees was investigated to gain a better understanding of the occurrence and morphology of this tree species in the study area.

Table 9: Wild olive neighboring species relation with river proximity.

River Proximity	No of Neighbor Trees						Total	
	Juniper		Acacia		Other			
	Tree	%	Tree	%	Tree	%	Tree	%
0-150	137,612	30.89	141,262	32.54	5461	24.38	284,335	31.52
151-300	107,753	24.19	106,515	24.53	5491	24.52	219,759	24.36
301-450	95,271	21.39	91,762	21.13	5030	22.46	192,063	21.29
451-600	63,397	14.23	60,260	13.88	3836	17.13	127,493	14.13
601-750	30,630	6.88	25,743	5.93	2129	9.51	58,502	6.49
> 750	10,837	2.43	8633.00	1.99	448	2.00	19,918	2.21
total	445,500	100.00	434,175	100.00	22,395	100.00	902,070	100

* Highlighted in yellow are where most wild olive trees found (> 10%)

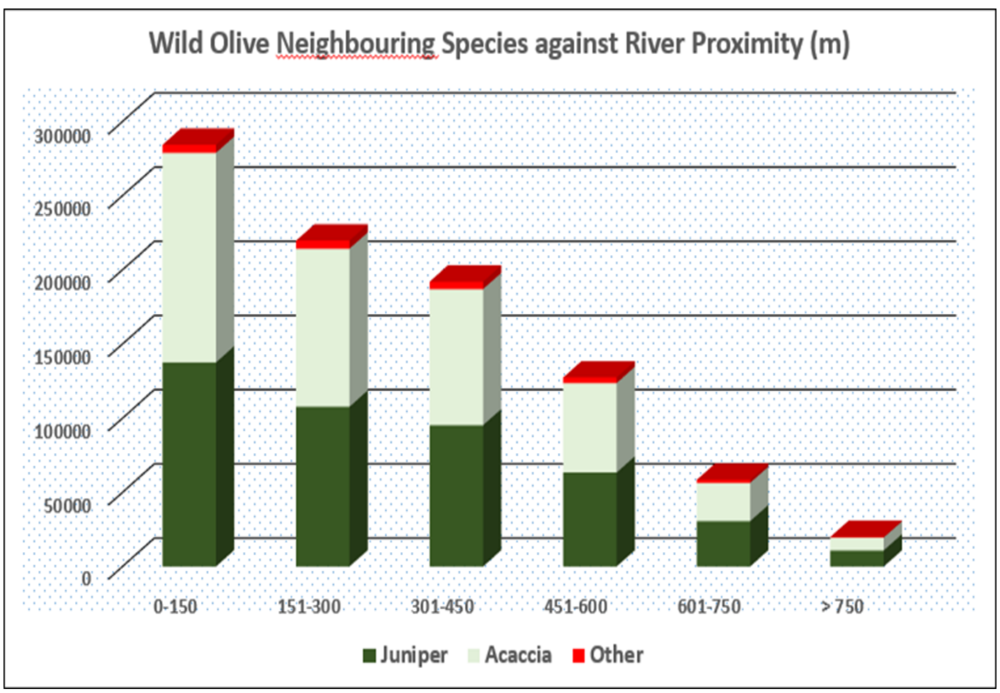

Fig 9: Histogram showing pattern of wild olive neighboring species against river proximity

Results show that the presence of wild olive decreases as it gets further from the river, indicating river proximity as one of the prominent landform preferences. This exhibits that the distribution appears almost parallel at the landform. About 91.2% of wild olive are found at a distance less than 600m from the river. However, there is no significant difference in the crown size and neighboring species relating to river proximity.

Besides these topographical factors, olive trees were known to prefer non-stratified, moderately

Fine-textured soils, including sandy loam, loam, silt loam, clay loam, and silty clay loam. Such soils provide aeration for root growth, are quite permeable, and have a high water-holding capacity. Sandier soils do not have good nutrient or water holding capacity. Heavier clays often do not have adequate aeration for root growth and will not drain well. Olive trees are shallow rooted and do not require very deep soils to produce well Sibbett, G. S. and L. Ferguson (2004).

Furthermore, according to Sibbett, G. S. and L. Ferguson (2004).Soils with an unstratified structure of four feet are suitable for olives. Stratified soils, either cemented hardpan or varying soil textures within the described profile, impede water movement and may develop saturated layers that damage olive roots and should be ripped. Olives tolerate soils of varying chemical quality. Trees produce well on moderately acid (pH greater than 5) or moderately basic (pH less than 8.5) soils. Basic (alkaline) or sodic soils should be avoided since their poor structure prevents water penetration and drainage, creating saturated soil conditions that kill olive roots.

Conclusions

This study successfully identified the preferred topographic and landform characteristics favored by wild olive distribution. The findings depicted that wild olive trees prefer topography or landform with the river proximity of less than 600 m and river proximity does not exhibit any significant influence on wild olive crown size. Wild olive trees were observed to be associated with both juniper and acacia but more associated with juniper at steeper slopes and with acacia at gentler slope.

These findings can be regarded as theoretically potential for landforms suitable for olive plantation. As a basis for olive plantation site suitability, these factors are the essential prerequisites to be considered. However, further evaluation of social and economic factors is still important. In addition, it is obvious that site suitability is subject to the temporal dynamics of environmental variables. Therefore, effects of climate variability and changes in other environmental variables also need to be evaluated so as to plan for future wild olive investment opportunities.

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