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# KHIRBET ROUHA FOREST MANAGEMENT PLAN

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2021

*This report is made possible by the support of the American people through the United States Agency for International Development (USAID). The content of this report is the sole responsibility of the Lebanon Reforestation Initiative (LRI) and doesn't necessarily reflect the views of USAID or the United States Government.*

## Acknowledgements

This report was developed by the Lebanon Reforestation Initiative (**LRI**) under the Livelihoods in Forestry (**LiF**) project funded by the United States Agency for International Development (**USAID**).

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The Authors would like to thank the following motivated people for their commitment in Data collection and Mapping assistance:

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## **1. Executive summary**

The objective of this document is to detail a forest management plan for Khirbet Rouha. Local people are already valuing this forest as they graze their herds into the forest, harvest honey and collect edible and aromatic plants. The communal/state land of the village is covered by a deciduous broadleaved oak forest. The field inventory identified four homogeneous stands that could be attributed to management units. Two stands are of a suitable density, one of which is pruned by the local authorities under the supervision and assistance of the Lebanon Reforestation Initiative (LRI), based on a permit from the Ministry of Agriculture (MoA). The municipality of the village seeks to extend the pruning to the other relatively dense stand, and requests to have a management plan for the forest comprising wood removal and extensive grazing, without compromising the future of the forest. Moreover, the municipality seeks to protect the less dense stands, to improve the canopy cover. In addition, a fifth management unit targets the reforestation of an isolated plot adjacent to the actual forest.

## **1. Introduction**

The proposition of management of Khirbet Rouha forest follows the forest management guidelines earlier developed by the UNDP under the Sustainable Land Management for Qaraoun Catchment (SLMQ) project, and is inspired by the general forest management plan provided for the Qaraoun Catchment, with the elaborated prototypes for other similar forests.

## 2. Khirbet Rouha Forest



Figure 1. Map representing the selected site in Khirbet Rouha

Khirbet Rouha is located in the Caza of Rachaya, at 1,150m altitude, at the northwestern foothills of Mount Hermon. The woodlands and forests are located to the south of the village, ranging between 1,040 and 1,300m. The bedrock is made of Jurassic limestone, with a shallow terra rossa or rendzine soils, characterizing semi-arid mountains.

Annual precipitations vary between 700 and 800mm. Temperatures in Rachaya, which is the most representative meteorological station in the area, vary between  $-0.3^{\circ}\text{C}$  (coldest mean of the coldest month) and  $28.9^{\circ}\text{C}$  (highest mean of the hottest month).

The forests and woodlands are located in the transitional zone between the Mediterranean and Irano-Turanian biomes, specifically in the supra-Mediterranean pre-steppic vegetation level in the semi-arid bioclimatic zone.

The selected site for the project is a large forest area ( $\sim 124\text{ha}$ ) owned by the state (Fig.1). The oak forest found in Khirbet Rouha village is dominated by *Quercus infectoria*. The forest is a low coppice with a single layer of trees, in a more or less open formation (Fig. 2), with

a relatively dense coppice on the northern aspect (Fig. 3). The stands on the southern aspect are covered with sparse vegetation, due the difficulty of trees to cope with both drier conditions and grazing activities. Shepherds use the land for grazing without any constraints/prohibitions, but they are present between September and January. In spring and summer, they roam grasslands and croplands after the harvest of cereals. The municipality is seeking to promote ecotourism by opening a hiking trail in the forest to attract residents from the village and its neighbourhood.



**Figure 2. Open Broadleaved Coppice in Khirbet Rouha**



*Figure 3. Khirbet Rouha dense broadleaved coppice (source: Melissa Korban)*

### **3. Socio-economic study**

The socio-economic survey was conducted through direct meetings with the locals during the field visits and was not conducted with the villagers due to the COVID19 restrictions.

The total number of inhabitants is 11,000 out of which 9,000 inhabitants are permanently living in the village, distributed into 900 households. In addition, there are 4,000 Syrian refugees in the village.

The mayor estimated that the total number of consumed fuel wood is 250tons/year, mostly bought from other villages, or coming from the pruning and cutting of fruit orchards (Table 1).

*Table 1 Fuelwood consumption in Khirbet Rouha*

Permanent residents	Number of families	Families relying on fuelwood	Tons of fuelwood consumed/year
9,000	900	100	250

### **3.1. Current activities in the forest**

Field survey showed that the major activities within the woodlands include small ruminants grazing, hunting, edible and aromatic plant collection.

There are twenty shepherds in the village, having 2000 heads of small ruminants (both sheep and goats) and roaming inside and outside the forest. Based on an interview with one of the shepherds during a visit to the forest, animals are grazing in the forest between September and December and fed with the scarce vegetation including tree leaves and shoots. In winter, the animals do not graze out and are kept inside until spring. From March to June, the animals graze mainly outside forest, and in June and July, they roam the post-harvest fields of wheat and other cereal crops, due to the scarcity of fodder in the rangeland.

Several persons from the village collect occasionally edible plants. Hunting is also another seasonal recreational activity.

The forest stands are separated in the valleys by arable agriculture private lands, connected with unpaved roads. These roads allow the easy access to the forest.

In 2020, the municipality received a permit for wood removal (35 tons) from pruning activities within a cadastral plot between September 2020 and April 2021. Although the main purpose is to provide cash for work for the Syrian refugees and reduce fire risk, it was also an opportunity to include this activity under the forest management plan and provide technical assistance to the municipality and workers.

On the forest edge, there is also an open-air dumping site for solid waste that are seldom burned and that may generate a fire risk for the neighbouring forest.

### **3.2. Orientations for the future**

The local authorities insist on the sustainability of the forest, with the wood removal as a secondary activity, coupled with grazing. The municipality seeks stand improvement for the open forest to reach an acceptable canopy cover, and to sustain the denser stands and the grazing activities within, and to continue with the pruning that started in 2021.

Moreover, the local communities desire to establish a hiking trail in the dense forest stands, for recreational purpose for the villagers, without seeking to develop any commercial eco-touristic infrastructure.

#### **4. Forest inventory**

The LRI team carried out the forest inventory of Khirbet Rouha in autumn 2020, as the municipality was granted the permit for pruning and wood removal from the forest.

The purpose of the inventory was to determine the profile of the forest, including forest typology, forest structure and composition and the desired future activities in order to delineate management units, with each unit having its specific management plan of forestry activities. In addition, the quantities of removals from the pruning activities were determined, which would allow to have an estimate about the potential fuel wood quantities that could be removed, and if it matches with the demand.

The field inventory was inspired from the SLMQ reports related to the provision of forest management plans for villages in the region that are under a similar context.

The prescribed forestry practices follow the national forest law and its amendments and related decrees and regulations.

##### **4.1. Technical assessments methodology**

###### **a. Forest Mapping**

An initial mapping was conducted for the forest using several techniques:

- The Google Earth Satellite Image was used as an initial background
- The cadastral map of the village was retrieved from an AutoCAD file prepared by the municipality and converted into a Kmz file to be exported to Google Earth. This allowed the team to locate the targeted cadastral units and avoid private lands.
- The delineation of the village, the defined management units from the field inventory were also drawn as polygons directly on Google Earth.
- On a second stage, the position of the field plots (from the field inventory) respective to the management units were also exported into Google Earth.

- The eventual streams, water reservoirs, springs, hiking trails, archaeological sites, civil defence barrack, roads and shepherds herds' shelter were also mapped on ArcMap, and later saved also as kmz files.
- All the information can be used both using GIS techniques and Google Earth.
- The outputs were reviewed and amended if necessary by the expert before sharing them with the local authorities for validation.

#### **b. Field inventory**

The inventory followed the following guidelines and procedures:

The partition of the forest into apparently homogeneous units based on field inventory results, vegetation characteristics, and the current and desired uses by the local authorities and community and the prevailing risks if any. The delineation was adjusted according to the vegetation cover/density as depicted from Google Earth.

The field inventory was based on the selection of sampling plots in each pre-defined management unit. The area inventoried depends on the density of the inventoried stand, the objective being to collect data from a fixed plot size.

In each plot we collected the following information:

- The coordinates and altitude of the survey point
- Locality name
- Proximity from infrastructure (roads, civil defence, water outlets, shepherds, etc.)
- Terrain characteristics (soil type/depth, organic matter, aspect, slope, topography)
- Disturbance and risks (human or natural)
- Potential features (archaeological and cultural sites, landscape, belvedere...)
- Forest type, canopy density, forest vertical structure, forest age and nature
- Tree inventory, including species, DBH (for stems above 10cm), height, health status, number of stems per tree, and the respective distance of each tree from the plot center.
- Shrub coverage and height, with the associated species

The collected information would allow to generate key parameters to determine the wood capacity of the forest:

- Number of trees and number of stems per hectare
- Basal area (m<sup>2</sup>/ha) which is the sum of the section of the largest stem in a coppice per hectare
- Wood volume per hectare and wood weight per hectare.

In addition, and since there the municipality and LRI were supervising the pruning of the forest, we used a balance to measure the weight of wood and shoots that were removed, respectively. This would allow us to validate the estimated amount of wood removal from shrub pruning and stem thinning, following the technical regulations of the MoA (wood removal for shoots only with DBH > 7cm or > 5cm respectively).

In a second step, the forest was divided into management units (MU) based on the following criteria:

- The homogeneity of the area in terms of forest cover, forest structure, terrain conditions (mainly aspect)
- Threats, features and current and desired future use.

## **5. Results**

The main results of the field inventory are displayed in the tables below. The terrain and topographic characteristics show a certain homogeneity concerning the bedrock type (limestone) and altitude (1080-1200m). Slope varied between 5 and 40%, which is optimal for forest exploitation and management. Organic matter is poor to average, with stony ground and rock outcrops in some parts, while the soil is deep on the bottom of the hills. Access to the forest is easy, since dirt roads are at proximity, with a maximum distance reaching 1500m in “Aarid el Hawa”. Forest health is unanimously good, with no pests, decay or decline evidence found during the survey.

In addition to the forest, there is a grassland site named “Tallet el Riman”, at 1300m, with an approximate slope of 30%, and a distance of 400m from road that is a potential land for reforestation.

Table 2: Main forest characteristics in each plot based for each management unit (MU)

Name of locality	MU	Plot	density trees/ha	density stem/ha	Median DBH	Ho (m)	BA (m <sup>2</sup> /ha)	area (ha)	growing stock (t)	Current or desired use
Hweish	oa	1	1061	3006	5.5	4.0	4	9	30	Fuelwood + grazing, ecotourism
	ob	5	2586	8356	7	4.5	13.1	12.6	207.6	
	oc	7	764	5475	4	3.5	3.6	17.4	68.4	
Aarid El Hawa	1	2	1368	5367	8.8	5.0	9	27.0	~178	Ecotourism
		3	753	4671	6	5.0	5.1			
		4	318	2387	5	3.5	1.5			
Tallet Rimen	2	6	NA	NA	NA	NA	NA	8.45	NA	Reforestation
Aawaynet El Hweish	3	8	2037	6112	7.5	4.5	11	46.8	627.7	Ecotourism Fuelwood + grazing
Sharafeh	4	9	1910	4584	7.7	4.5	12.7	14.7	210.9	Ecotourism Fuelwood + grazing

Table 3: Ecological characteristics of the study area

Name of locality	Plot nb.	Dominant species	Canopy cover	Forest structure <sup>1</sup>	Shrub cover	Regeneration	Threats	Features
Hweish (MU o)	1	<i>Q. infectoria</i>	60%	1 layer, even-aged	10-40% <i>Rhamnus lycioides</i>	<i>Q. infectoria</i> , <i>Q. calliprinos</i> , <i>Pyrus syriaca</i>	Hunting <sup>2</sup>	Geological features, belvedere, hiking trail
	5	<i>Q. infectoria</i>	80%	1 layer, even-aged	10% <i>Rosa spp</i>	<i>Q. infectoria</i> , <i>Q. calliprinos</i> ,	Hunting	Picnic area, belvedere
	7	<i>Q. infectoria</i>	10%	1 layer, uneven aged	<10% <i>Rhamnus lycioides</i>	<i>Q. infectoria</i>	Overgrazing <sup>3</sup> solid waste dumpsite (fire), hunting	
Aarid El Hawa (MU 1)	2	<i>Q. infectoria</i>	30%	1 layer, uneven aged	<10% <i>Rhamnus lycioides</i>	<i>Q. calliprinos</i> , <i>Q. infectoria</i> , <i>Pyrus syriaca</i>	Hunting	Belvedere
	3	Mixed <i>Q. calliprinos</i>	30%	1 layer, uneven aged	<10% <i>Rhamnus lycioides</i>	<i>Q. calliprinos</i> , <i>Q. infectoria</i>	Hunting	Belvedere

<sup>1</sup> The understory or shrub cover is not counted in the layers.

<sup>2</sup> Only uncontrolled hunting is mentioned as a threat

<sup>3</sup> Grazing becomes a threat only when regeneration and canopy cover are compromised.

		<i>Q. infectoria</i>						
	4	<i>Q. infectoria</i>	20%	1 layer, even aged		<i>Q. calliprinos, Q. infectoria, P. syriaca</i>	Hunting	Belvedere
Tallet Rimen (MU 2)	6	<i>Crataegus azarolus</i>	NA	NA	NA	Null	Overgrazing	Belvedere, picnic area, water spring
Aawaynet El Hweish (MU 3)	8	Mixed broadleaved	50%	2 layers, uneven aged	<10 % <i>Rhamnus lycioides</i>	<i>Q. calliprinos, Q. infectoria, P. syriaca</i>	Hunting	biodiversity
Sharafeh (MU 4)	9	Mixed broadleaved	20%	1 layer, uneven aged	<10 % <i>Rhamnus lycioides</i>	<i>Q. infectoria, Q. calliprinos, Crataegus azarolus</i>	Overgrazing	Ruins, abandoned terraces, camping site

During the field inventory phase, we estimated the weight of removed biomass (wood, shoots and leaves) removed from few pruned trees. However, the reduced number of weighted individual stems, and the estimate of their respective diameters was not conducted, and therefore we could not derive allometric relations between DBH, height and weight. These measures allowed us to have an approximate estimate of the amount of wood, and leaves and shoots percentage from the pruning exercise (Table 4).

**Table 4: Measured weight of pruning residues removal**

<b>MU zero</b>	<b>Plot 1</b>			<b>Plot 5</b>	
<b>Species</b>	<i>Q. infectoria</i>	<i>Q. infectoria</i>	<i>Q. infectoria</i>	<i>Q. calliprinos</i>	<i>Q. infectoria</i>
<b>Height (m)</b>	2.5	2.5	3	4.5	4.5
<b>DBH (cm)</b>	7.5	7.8	5.7	7	7
<b>Nb. of stems/stump</b>	4	5	5	12	7
<b>Nb. of stems removed</b>	2	2	3	6	3
<b>Total weight (pruning residues in kg)</b>	8.8	20.5	12.5	48	81
<b>Average removal weight/ tree / plot</b>	14			65	

The estimated wood removal over the MU o based on the forest guards' estimation following the MoA adopted methodology is 35t over 41 ha (only stems with DBH > 5cm are

considered). Our weight measurements for the removed biomass included shoots and leaves and was estimated at 58t for the same area, meaning that the wood accounts for 60% of the weight and leaves for 40%. The ratio of wood of the total biomass is particularly higher than usual due to the limited tree height, small diameters, and the presence of numerous stems per stump. This estimation is very approximate, due to the absence of accurate surface area value of the pruned area, the different methodologies in estimating the biomass to be removed, the limited sampling, and the change in practices of pruning, as shown in Table 4.

Since we did the measurements of removed biomass only on two plots of MU 0, we used the average to interpolate it into the remaining MUs as illustrated in Table 5.

**Table 5: Estimated biomass removal from each MU based on average tree density and average weight per tree for the removed biomass following the current pruning practices**

Name of locality	Growing stock in tons	Tree density/ha	Estimated average weight per tree for the removed biomass, based on current pruning practices (in tons)	Estimated total biomass removal in tons	Estimated wood removal in tons
Hweish (MU 0 a, b and c)	302.5	1470	0.039 <sup>4</sup>	58	35 <sup>5</sup>
Aawaynet El Hweish (MU 3)	331.9	2037		80	48
Sharafeh (MU 4)	346.3	1910		75	45

Based on the field inventory, the land was divided into five major management units. The units were delineated according to the following conditions:

- Current activity or use (grazing, fuel wood removal)
- Foreseen activities (forest improvement, ecotourism, reforestation)
- Forest density (open forest, dense forest, degraded land...)
- Aspect (southern, northern aspects)
- Threats (forest fire and overgrazing)

<sup>4</sup> The number is the average for the five measured trees from plots 1 and 5 in MU A

<sup>5</sup> The number corresponds to the estimation of wood removal by the MoA forest guards for the pruning license

**MU 0:** Hweish is dominantly covered by *Quercus infectoria*, but shows some heterogeneity among the plots, with a variability due to different activities (overgrazing on part of the area, leading to a decrease in canopy cover and tree density), and different history of forest practices (some parts are even-aged, due to previous coppicing, others are not). Despite this heterogeneity, we considered this area as a single management unit, because the municipality has already received an approval for pruning all the area, and activities were already started when the field survey was conducted. It is characterized by its easy access, and closeness to the dumping site. The area has many potentials for hiking trails, picnic areas, and wood removal and grazing, the latter two activities are desired by the local authorities. This MU is heterogonous, but due to the fact that works of pruning were already initiated we kept it as one MU. However, it can be subdivided into 3 plots:

- a- The area close to the road to the dumping site, in the flat and lower slopes with a majority of deciduous young coppice. Tree height (Ho): 4m; Basal area (BA): 4m<sup>2</sup>/ha
- b- The area that is close to Aawaynat el Hweish with dense canopy cover
- c- The upper part of the hills, with lower density and fertility due to rock outcrops

**MU 1:** Aarid el Hawa is another area, more or less homogeneous dominated by *Q. infectoria* or mixed with *Q. calliprinos*, with low canopy density, with variable access to dirt roads, and a dominant southern slope. The area is dedicated for ecotourism, and improvement of the vegetation cover is recommended.

**MU 2:** Tallet el Riman is a lot outside the forest, a rangeland, with no trees, but which could be potentially reforested, as suggested by the municipality.

**MU 3:** Aawaynet El Hweish is a mixed broadleaved stand, with medium to dense canopy, rich in biodiversity, and a potential for wood removal. Currently dedicated to ecotourism.

**MU 4:** Sharafeh is also a mixed broadleaved stand, but with a lower canopy density, due to grazing intensity. The stand has potential for both wood removal and managed grazing.

The delineation of the MUs is illustrated in figure 4.

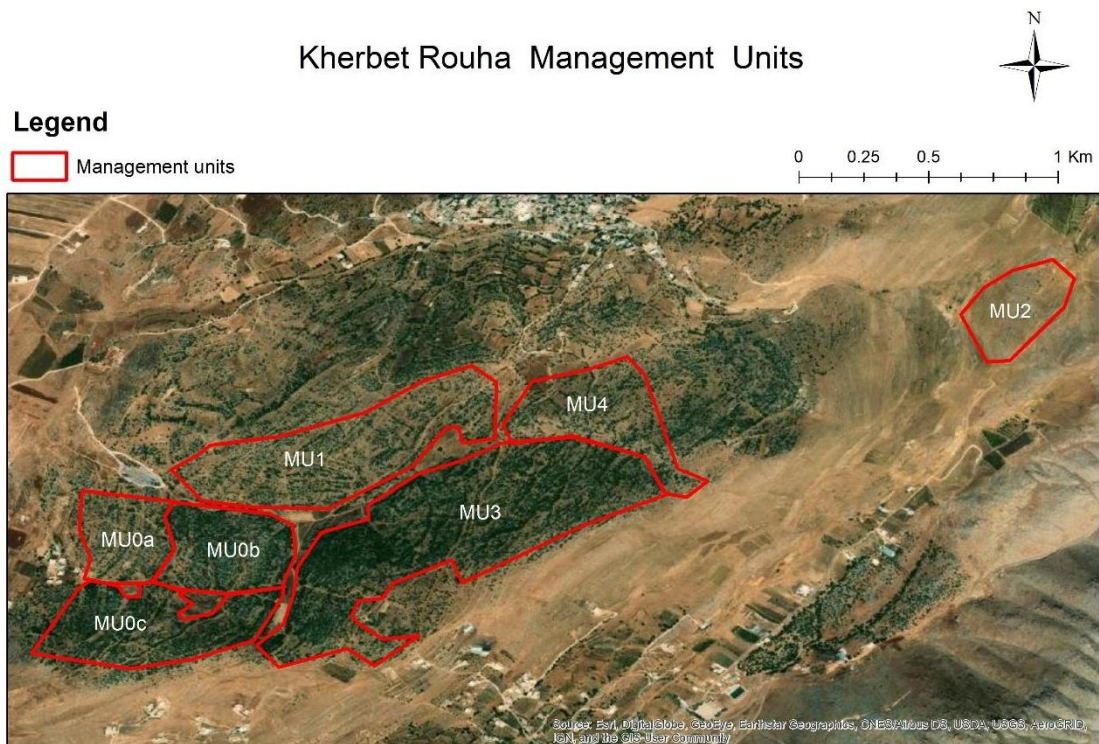
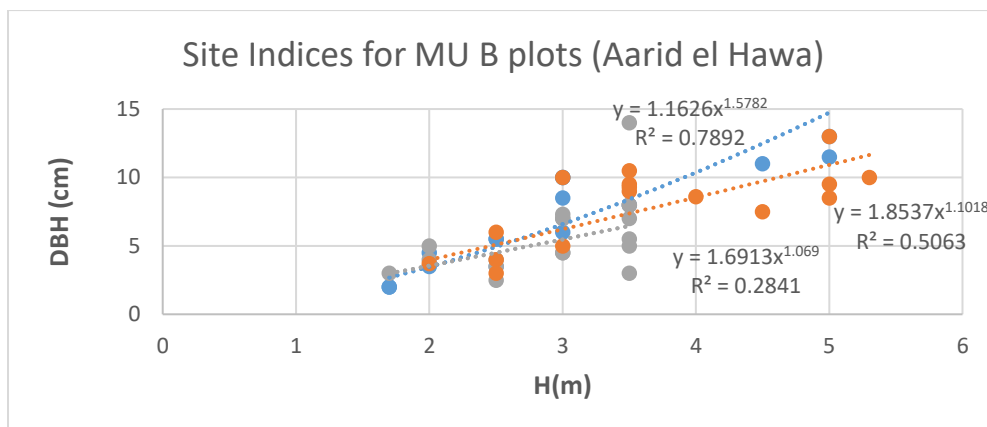
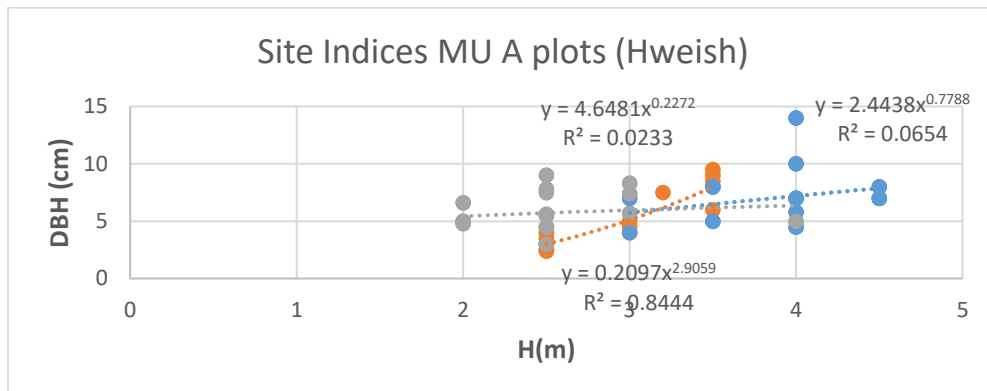
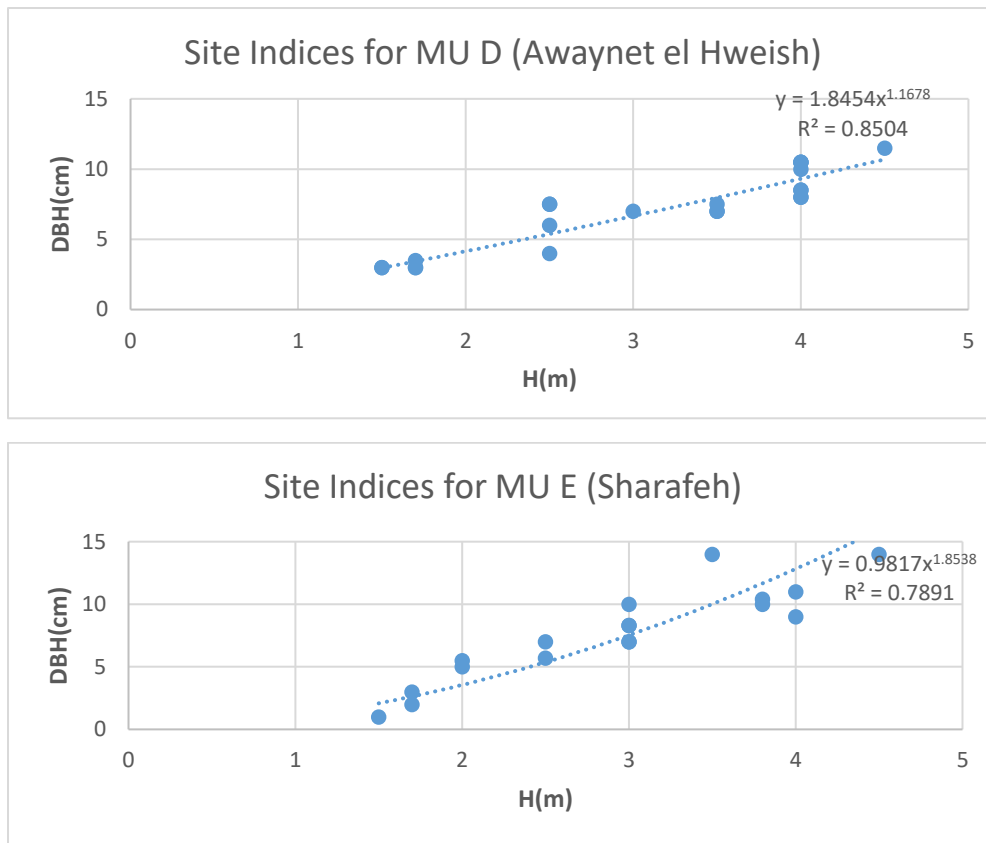


Figure 4. Management Units of Kherbet Rouha





**Figure 5. Site indices of the different plots of the respective management units**

The fertility in terms of wood production is illustrated from a basic site index (SI) retrieved from the measurements taken in the representative plots in each MU and illustrated in figure 5. The absence of correlation in two plots of MU 0 is related to the previous removal and cutting of stems. The highest trees, and higher site indices that are observed in MU 1 are due to the absence of competition for nutrients (open forest), and the limited coppicing conducted (older trees on average). The lowest fertility is observed in Aawaynet el Hweish (MU 3). The high density of stems in the other MUs resulted in lower potential growing stock. All sites indices are of a low quality (SI <6) and the management plan for wood harvesting will be based on this finding.

The MUs of Khirbet Rouha is divided into 3 management groups:

- Fuel wood removal and grazing in MU0, MU3 and MU4
- Stand improvement in MU 1
- Reforestation in MU2

## 6. Forest Management Plan

### 6.1. Current management status of the forest

MU0 is a deciduous broadleaved coppice, subject to grazing with varying intensity based on the stand structure. This year the municipality implemented the pruning of this stand, by thinning stems and keeping 2-3 main vertical stems (lowering the density of the stand). MU1 is an open forest that is rarely used by the local community. MU3 is a mixed broadleaved forest with a two-layer structure, with no signs of active human intervention. MU4 is an open mixed broadleaved coppice dedicated for grazing. MU2 is a degraded grassland with intensive grazing.

The current characteristics are favourable for various activities such as: pasture, moderate collection of fuelwood, development of ecotourism, and landscape.

Khirbet Rouha forest includes secondary roads (dirt roads) that are within the forest or 0.1 to 1.5 km away from it. The forest witnesses grazing activity mainly during autumn.

### 6.2. Management objectives

Table 6 below presents the main management objectives in the management units, as extracted from the socio-economic survey with the local authorities.

*Table 6. General management objectives for Khirbet Rouha*

Category	Objectives	Description	Priority
<b>Mixed grazing and fuelwood (MUs 0, 3, 4)</b>	Grazing, moderate collection of fuelwood, development of ecotourism, and landscape.	Selective thinning when the density is >500 stems/ha (Fuelwood). Stands opened for grazing. The relative low density permits the development of ecotourism.	Maintain the density of the stand above 1500 stem/ha while sustaining the livelihood of shepherds
<b>Improvement (MUs 1)</b>	Increase canopy and stand density development of ecotourism, and landscape.	Protection from grazing for 10 years to enhance natural regeneration	Improvement of stand's canopy cover
<b>Reforestation (MU 2)</b>	Plantation to create a shade area.	Low density plantation around the spring and picnic area	Create shade for picnic and protect the spring area.

### 6.3. Characterization of Management Units

The details of the prescriptions and indicators of the management units of each group are presented in Table 7 below. Note that the prescription targets the main objective to achieve but takes into consideration the multi-functionality of the forest. For instance, ecotourism cannot be developed in a single MU, but is rather general to the whole forest, especially in order to keep reasonable trail length, encompassing all the features of the forest (geological features, belvederes, picnic areas, ruins, interesting biodiversity) that are scattered across the different MUs.

*Table 7. Prescriptions according to the main objectives of the management units*

Main Objectives	Prescriptions	Indicators/target	MU
wood production and grazing	Stands opened for grazing and production of fuelwood by selective thinning when stand density is > 500 stems/ha	Number of livestock, stand density, tons of wood removed, healthy state.	0,3
Improvement of canopy and stand density and ecotourism	Protection from grazing. Maintaining established hiking trails Selective thinning for production of fuelwood where density is > 500 stems/ha	Canopy and stand density. Number and length of trails Licensed volume of wood	1,4
Reforestation	Plantation of native tree and shrub species and protection from grazing	Survival rate after 2 and 10 years from plantation	2

#### a. Plan overview

In order to implement the management plan, the responsibilities of each actor should be clearly predefined and the following constraints should be considered:

- Water resources and human resources for reforestation, protection and maintenance
- The compliance of the shepherds to the prohibition of grazing, and finding alternatives for them (to be detailed in the grazing management plan which is prepared independently)
- The ownership of the local community to the project, which should be normally done through a validating meeting with them, once the management plan is ready.

- The financial resources in order to implement and monitor the plan by the NGOs, municipality, etc.
- The commitment of the forest guards to supervise the implementation of the management plan and the protection from grazing and illegal cutting.

## **b. The silviculture prescriptions for the mixed grazing and wood removal MUs**

The ultimate desired density is 400 to 600 stems/ha when the trees reach their full height. Particularly MUo which canopy density may drop in some parts to only 25% should be subject to light wood removal.

The management for these units is a continuity to the current management. Given the various tree densities, it is advisable to move the grazing of the herds to the densest areas.

Management directions will aim for a balanced density of 2000 stems / ha for the next 25 years, and a canopy density of 50% favorable to all the objectives targeted by the populations: Eco-tourism, landscape, supply of firewood, grazing, hunting, and harvesting of non-forest products.

The volume of harvested wood is relatively significant. It could be used as firewood by local people and as fodder for livestock (the upper part of the stems).

For MUs with density below 60% (MUo c, MU3, MU4):

**1. Selection of sprouts at 15-20 years (4m height or less, which is the current status) at stump level:** to reduce competition and improve the vital state of the trees. For each stump, the best 3 trees are selected and kept, and the others are cut without extracting more than 50% of the tree wood volume. The trees possibly coming from seeds (single stem) should be preserved. MUo c which is a young stand, with low stem diameters, and height (Median DBH: 4cm) should not have been included, but already was subject to a thinning of sprouts under the 2020 pruning licence.

**2. Low thinning at 40-45 years (8m height, in 25 years) at stump level:** For each stump, the best 1-2 stems are selected, and the others are cut without extracting more than 50% of the wood volume of a given tree (stump).

For MUs with density above 60% (MUo a, MUo b):

**1. Selection of sprouts at 20-25 years (current status):** The initial density is reduced to 2200 trees/ha. The trees with the largest diameter and height and with the most vertical conformation should be left, and those originating from seeds must be preserved (if they can be identified).

**2. Low thinning at 50-55 years:** A maximum of 10 t/ha is extracted, representing less than 20% of the BA. The forest canopy cover has to be kept as high as possible (ideally over 70%) to avoid an undesirable regrowth. The density is reduced to around 1500 trees/ha.

Given the densities observed, it does not seem advisable to enclose these plots if the pressure of the livestock is maintained at this level.

Table 8 shows wood potential over the Management Plan period for the production group. It is evident that the MUoc which is part of the Hwiesha area, and that was under the pruning permit in 2020 should not be considered for fuel wood harvesting due to the limited diameters. Hence, the Management harvesting plan should concern only 556.83 m<sup>3</sup> or 323.5 tons of wood extracted from MUoa, MUob, MU3 and MU4.

**Table 8: Wood potential from the stems in the forest**

MU	Area (ha)	Density (Stems/ha)	Median DBH	Ho (m)	BA (m <sup>2</sup> /ha)	Stems removed	BA removed (m <sup>2</sup> /ha)	Volume extracted (m <sup>3</sup> )	Weight (t)
oa	9	3006	5.5	4.0	4	1006	1.0	19.74	11.45
ob	12.6	8356	7	4.5	13.1	6156	3.3	102.03	59.18
oc	17.4	5475	4*	3.5	3.6	3475	0.9	30.17	17.50
3	46.8	6112	7.5	4.5	11	4112	2.8	319.18	185.12
4	14.7	4584	7.7	4.5	12.7	2584	3.2	116.15	67.37
<b>Total</b>	<b>100.4</b>					<b>17332</b>		<b>587</b>	<b>341</b>
<b>Without MU oc</b>						<b>13857</b>		<b>556.83</b>	<b>325.5</b>

(\*) DBH < 5cm, most of the extracted biomass is not considered for fuel wood, and should not be prescribed as a wood harvest. It was conducted under the current pruning license.

This volume could be also broken down according to the years of the Management Plan (Table 9). The volume of wood harvested on the densest plots could be used, as it currently

is, for fuelwood for the local populations. Although the annual need is for 250t, the forest is far from meeting the demand, under the current management plan, since most stands are either young or with low density. The forest will be able to supply the demand eventually at maturity (height above 8m), if the objective will be wood production, but since the desire of the population is landscape improvement with mixed grazing and wood removal, it is not advisable to seek maximal profit from wood production.

**Table 9: Distribution of cuts and Biomass (t) from harvested stems over the years of the Management Plan**

Years	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
MUoa	11.45									
MUob	23.55	35.63								
MU3					30.8	30.8	30.8	30.8	30.8	30.8
MU4			35	32.37						
Stems removed	3456	3706	1342	1242	685	685	685	685	685	685
Biomass Total (tons)	35	35.63	35	32.37	30.8	30.8	30.8	30.8	30.8	30.8

### c. The silviculture prescriptions for the forest improvement and reforestation MUs

In a dense canopy cover, when the trees are around 4 to 5m height, the average density of stems is about 5000 stems/ha. In Aarid el Hawa (MU1), this density is far below. In order to increase the density, a protection from grazing for 10 years would allow the improvement of natural regeneration, and the vitality of the existing trees. However, under the dry southern slopes, and current climate trends, it might be insufficient to obtain the desired stem density. Therefore, some enrichment with drought resistant species (i.e. *Crataegus azarolus*, *Pyrus syriaca*, *Quercus calliprinos*, *Q. infectoria*, *Prunus dulcis*, *Prunus korshinskyi*, *Pistacia palestina*, *Acer hermoneum*, etc.) is recommended. The preservation of existing shrubs which acts as nursing plants and protects from erosion is also essential.

In Tallet el Rimen (MU2), the trees are rare, and the site is highly degraded. The presence of water would allow reforestation of species that are tolerant to those harsh conditions.

Hence, the same species mentioned above could be planted, in addition to *Pistacia atlantica* which is highly resistant to drought. Conifers should be avoided. *Fraxinus syriaca*, *Populus spp.*, *Salix libani* could be planted near the spring, where moisture and water for irrigation are available. Plantations should be in low densities, concentrated below the spring, with individual protection of seedlings against ruminants' teeth.

Once the desired density is obtained, we treat this MU as the previous, taking into consideration its future eventual use (picnic area, hiking trails, etc.).

#### **d. Additional technical aspects**

It is important in any management plan to consider the following aspects:

- Monitoring the gypsy moth (*Lymantra dispar*) which causes the defoliation of evergreen oaks, and registered an outbreak in 2017 and 2018 on the eastern slopes of Mount Lebanon. If pruning affected trees did not reduce the infection, an aerial spraying with *Bacillus thurengiensis* should be requested from the Ministry of Agriculture.
- Monitoring the witches' broom disease caused by *Candidatus phoenicium* phytoplasma on wild almond trees (*Prunus dulcis*) specifically and all stone wild fruits in general (*Prunus spp.*). Since to-date, the disease has no cure; trees should be cut and burned onsite when the symptoms appear and the causing agent is identified by experts (from LARI, AUB or Lebanese University). Note that wild trees can transmit the disease to the neighbouring orchards through various vectors, and vice-versa.
- Particular attention should be given to the existing wildlife (hyenas, squirrels, snakes, bladders, etc.) and small shrubs that are rare or endemic (*Anagyris foetida*, *Prunus microcarpa*, *Rhamnus lycioides*, etc.) that are key for biodiversity conservation, with valuable ecosystem goods and services, and an important ecological role helping in the improvement of the forest.

#### **6.4. Legal, financial and organizational aspects**

The forest is owned by the state, represented by the Ministry of Finance. It is hence necessary to get the required permission for exploiting the forest from the Ministry of Finance, and through the supervision of the Ministry of Agriculture, represented locally by the regional forest guard center.

The accessibility to all the plots is good (several roads cross the forest, some of which pass through its middle), allowing relatively an easy ship for wood.

All silviculture practices should comply with the administrative requirements and regulations. Since the land is republic, by regulation, benefits from the sales of the wood should go to the Ministry of Finance. Special approvals can be requested by the municipality in critical conditions to distribute the wood for free for families in need. Support can also be seeked at NGOs and donors ' sides to get financial support for the pruning operations to alleviate the costs on the municipality.

#### **6.5. Procedures for monitoring and evaluating the forest silviculture plan**

It is important to ensure the quality and sustainability of the stands after harvesting. For this, we recommend marking with paint the stems that must remain after operating (2 to 3 beautiful stems /stump) rather than marking the stems that must be harvested. It seems unnecessary to make a complete inventory of the stems to be harvested taking into account the cost of the inventory and the value of the products harvested.