KHENSHARA PINE FOREST MANAGEMENT PLAN

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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Executive summary

The objective of this document is to detail a forest management plan for the pine forest of the monastery of St John in Khenshara. Due to the wind throw that occurred late February 2021, a large number of trees and branches were broken and fallen all over the forest. The monastery encouraged the municipality and the locals to remove those trees and branches for fuel wood. The exploiter of the forest is also conducting actions to remove as much as possible from the fallen trees and branches, in order to reduce the fire risk in the upcoming season. There is no livestock grazing in the forest, where minimal observed activities include the collection of edible and aromatic plants and hunting. The municipality, in close collaboration with the monastery and community-based organizations (i.e. scouts), is promoting ecotourism through the establishment and maintenance of hiking trails in many parts of the forest, while other users are renting some plots for recreational activities. The forest stands of the village are diverse, with parts covered by a deciduous broadleaved oak forest, others are dominantly planted with stone pine, and some stands are mixed. The focus was on the cadastral units planted with stone pine. The field inventory identified seven homogeneous stands that are divided into management units. Cadastral units were hence segregated according to those management units' directions. High encroachment with residential and agriculture prevails in the forest, and the amount of biomass on the ground resulting from the wind throw put fire risk reduction as a highest priority. The old age of many stands and the declining production due to pest outbreaks also require radical changes in forest management, and the initiation of regeneration or shelter wood cutting to rejuvenate the forest. The owners seek a conservative management plan, in which reforestation of new sites goes in parallel with the removal of trees (regeneration cutting) to enhance natural regeneration. The implementation of the management plan should be conducted in close collaboration between the monastery, the exploiters and the municipality, and should cover also training the users on new approaches in pruning and thinning. The technical support for training and plantation is eventually ensured by the Lebanon Reforestation Initiative.

1 Introduction

The proposition of a management plan for the pine forest of Khenshara follows the international best practices for stone pine management, and the guidelines of the Food and Agriculture Organization (FAO) project on the sustainability of the stone pine production in Lebanon, which was implemented in 2014. Nonetheless, and since the Law 86 prohibits the cutting of conifer trees, the regeneration cutting will be based on the derogations allowed by the law and the Ministry of Agriculture to remove trees that are affected by pest outbreaks and that are considered as a threat for the forest or for public safety.

2 Khenshara Forest

Khenshara is located in Caza of Maten, on an altitudinal range varying between 900 and 1200m, within the watershed of Nahr el Kalb. The woodlands and forests are surrounding the village. A major cliff "Blanche or Bikfaya cliff" divides the village into two sections: above the cliff, the bedrock is siliceous sandstone, allowing the development of stone pine trees, whereas below the cliff, the bedrock is Jurassic limestone, predominantly covered by broadleaved trees.

Annual precipitations is above 1200mm. Temperatures vary between 3°C (coldest mean of the coldest month) and 28°C (highest mean of the hottest month), based on triangulation with other stations with similar conditions.

The forests and woodlands are located in the Meso-Mediterranean and lower Supra-Mediterranean vegetation levels in the humid bioclimatic zone.

The selected site for the project is a forest area of ~ 71ha, scattered over more than 275 cadastral unit, covering primarily the stone pine forest (with few exceptions mixed broadleaved woodland or mixed forests) in Khenshara, Bolognia, and Jouar. The broadleaved forest and other land cover or land use types within the aforementioned villages and those in neighboring villages (Choueir, Chrine and Bteghrine) are excluded from this management plan. All the lots are owned by the monastery of St-John-Khenshara.

Pinus pinea dominates most of the lots. Stands are very heterogeneous in terms of age, canopy density, and composition. Pine tree age varies from 60 years to more than 120 years, with an exceptional tree aged 180 years. Some lots are even-aged others are not. If

the pine dominates the forest, the understory varies from one lot to another. Sometimes *Pinus brutia* or *Quercus cerris* co-dominate with the pine, while the understory varies according to the site. *Salix libani, Sorbus torminalis, Acer obtusifolium, Rhododendron ponticum* are common on northern slopes and near streams or wet soils, while *Q. infectoria*, *Arbutus andrachne, Erica manipuliflora, Callicotome villosa* and *Cistus spp.* are common in drier spots, or lots that were subject to fire. In some lots, the understory is also poor, and the soil is eroded.

On limestone bedrock, *Pinus pinea* is rarely found, and the dominating vegetation include *Q. infectoria, Q. calliprinos, Styrax officinalis, Pyrus syriaca, Ostrya carpinifolia, Prunus ursina,* etc.

Figures 1 and 2 show some features of forest ecosystems in Khenshara.

Figure 1: Khenshara forest scenery view

Figure 2: Vertical structure of a mixed forest stand in Khenshara with a roman sarcophagi in the foreground

3 Socio-economic study

The socio-economic survey was conducted through direct meetings with the local authorities, and the monks of St John monastery.

The permanent population of Khenshara is around 2000 inhabitants. Yet the locals do not rely on the forest for their livelihood.

3.1 Current activities in the forest

The monastery leases the pine forest on an annual basis to one (or more) person(s), in order to conduct the necessary activities (pine harvesting, pruning, maintenance of planted seedlings). In addition, other persons might rent a lot inside or close to the pine forest for different activities. However, we found that only "Hillhout", which is a recreational resort, benefit directly from the forest. The municipality and local CBOs are also managing some hiking trails labelled as "Droubna" that cross different sections of the forest, and benefited from external funding, to promote eco-tourism.

Grazing is not practiced in the forest, except for the mixed or broadleaved forests that are in the neighbouring villages. Beekeeping is not a major activity as well in the village. Hunting is a seasonal recreational activity.

Several roads allow the easy access to the forest and dirt roads are present in several sections.

The forest is highly encroached with residential, industrial and agricultural areas. All this mosaic is a favourable environment for fire risk, but at the same time hinders its large expansion, due to the presence of roads, and water outlets.

3.2 Orientations for the future

The monks seek the sustainability of the forest, and its production of pine nuts. They prefer to increase plantation of new plots that are easy to maintain, rather than conducting infamous regeneration cutting activities. However, they are ready to take actions and implement any management plan that ensures its sustainability.

The municipality seeks to preserve the forest for its aesthetic and eco-touristic value, and to support the monastery in the reduction of forest fire risk.

The users of the forest, mainly the nut collectors, do not solely rely in their livelihood on Khenshara forest, and rent additional lots in other villages. Their interest in the forest is decreasing due to the decrease in the production.

4 Forest inventory

The LRI team carried out the forest inventory of Khenshara in autumn 2020 and winter 2021.

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. The inventory also assessed the damages from the wind throw of February 2021 and took into consideration forest fire and erosion risks.

Despite the importance of pest outbreaks, the suggested management plan does not include pest management from an agriculture perspective (spraying), because it is already

monitored and conducted by other parties (Holy Spirit University, Ministry of Agriculture) and only the sylvicultural practices are looked into.

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

4.1 Technical assessments methodology

4.1.1 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 lot numbers owned by the monastery were provided by the monks.
- 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 and the defined management units from the field inventory were also drawn as polygons directly on Google Earth.
- 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, civil defense barrack, roads and shepherds herds' shelter were also mapped on ArcMap, and later saved also as kmz files, whenever the information is available.
- 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.

4.2 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, as well as the timing of the last pruning and tree age as extracted during the field survey by using an increment borer. 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 centre.
- Shrub coverage and height, with the associated species.

The collected information would allow generating key parameters to determine the:

- number of trees and number of stems per hectare
- basal area (m^2/ha) which is the sum of the section of the largest stem in a coppice per hectare

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 age, forest density, terrain conditions (mainly slope)
  - Last time pruned
  - Threats, features and current and desired future use.

Initially the inventory was expected to focus on tree productivity and link its variability with tree age, tree density, pruning and terrain conditions. However, the forest exploiter did not allow us to conduct a measurement of tree productivity, and suggested to provide us with historical data on nut production, and its linkages with the pest outbreaks (mainly *Leptoglossus occidentalis*). Unfortunately, such information was never provided.

Another field visit was conducted in order to assess the damage of the wind throw, and ultimately, a fourth visit was necessary to allocated each of the cadastral lots into the different suggested management units.

5 Results

The main results of the field inventory are displayed in the tables below. The terrain and topographic characteristics show a certain heterogeneity among the different management units, namely when it comes to aspect, slope, tree age, tree density, forest composition, last time pruning and the damage from the wind throw.

Forest health is deteriorating due the combined effect of several factors including a historical mismanagement of pruning, the relatively aged trees (Most of the forest is above 90 years old), the high density due to the limited thinning, and the outbreak of both *Leptoglossus occidentalis* and *Tomicus destruens.* These factors caused the sharp decrease of the production and the decline of the trees, tree fall and reduction of crown cover after the snow storm of February 2021, leaving a forest with substantial biomass that could increase fire risk in summer, and an irreversible decrease in the production.

Tables 1 and 2 show the main characteristics of the 17 inventoried plots, and the attributed management units based on the results of the survey.

Table 1: Plot major tree and shrub characteristics retrieved from the field inventory

Plot nb.	DBH Quadratic mean (cm)	H Quadratic mean (m)	Tree taxa	Pine regeneration	Shrub taxa	Shrub cover
1	44	23	*P. pinea, P. brutia, Q. infectoria, S. torminalis,*		*Salix, Cotoneaster, Hedera*	60%
2	41	22	*P. pinea, Q. infectoria, Q. calliprinos*		*Juniperus, Pistacia, Cistus…*	90%
3	45	22	*P. pinea, Q. infectoria, Q. cerris*		*Juniperus, Cistus, Erica, Callicotome*	90%
4	44	22	*P. pinea, P. brutia*	6	*idem*	30%
5	48	24	*P. pinea*		*idem*	90%
6	41	24	*P. pinea, Q. infectoria*		*Pistacia*	10%
7	22	8	*Q. infectoria, Q. calliprinos*		*Rubus, Pistacia…*	10%
8	16	14	*Q. infectoria, Q. calliprinos, O. carpinifolia*		*Ruscus*	5%
9	64	35	*Q. infectoria, Q. calliprinos, P. pinea*		*Ruscus, Cistus, Phlomis…*	5%
10	36	16	*P. pinea*	10	*Callicotome, Cistus…*	30%
11	32	19	*P. pinea*		*Cistus…*	50%
12	36	14	*P. pinea*		*Juniperus oxycedrus*	10%
13	33	18	*P. pinea*		*Erica, Callicotome*	70%

Plot nb.	DBH Quadratic mean (cm)	H Quadratic mean (m)	Tree taxa	Pine regeneration	Shrub taxa	Shrub cover
14	42	23	*P. pinea*	15	*Erica, Callicotome, Cistus*	80%
15	37	14	*P. pinea*		*Rhododendron, Erica, Callicotome, Cistus, …*	90%
16	38	16	*P. pinea*		*Callicotome, Cistus…*	60%
17	35	23	*P. pinea*		*idem*	90%
18	24	8	*P. pinea*		*idem*	80%
19	30	13	*P. pinea*		*Juniperus, Cistus, Erica…*	80%
20	37	18	*P. pinea, Q. calliprinos*		*Spartium junceum*	15%

Table 2: Plot general characteristics

Plot nb.	**Cadastral unit**	**Lot area (m^2)**	**Forest type**	**Trees/ha**	**Pines/ha**	**Pine age**	**Wind throw (tree/plot)**	**Slope (%)**
1	1013K	1270	Mixed	740	69	NA	2	35
2	1001K	967	Mixed	1625	65	103	2	35
3	1162K	786	Pine	511	157	75	0	25
4	1152K	1895	Pine	845	195	109	0	37
5	1287K	1501	Pine	244	97	104	0	30
6	1104K	742	Pine	705	264	85	0	20
7	1096K	983	Oak	299	0	NA	0	12
8	1506K	79663	Broad-leaved	1885	0	NA	0	25
9	1506K	79663	Mixed	603	0	195	0	8
10	1415K	1022	Pine	255	191	120	0	33
11	983B	21583	Pine	531	531	98	0	10
12	950B	20309	Pine	396	340	66	0	20
13	1776B	7925	Pine	448	299	55	0	30
14	247K	782	Pine	299	299	75	1	40
15	961K	54870	Pine	348	299	91	0	40
16	962K	50254	Pine	291	291	72	0	20
17	1470K	5060	Pine	531	531	87	0	20
18	941B	19724	Pine	414	414	75	1	40
19	967B	3760	Pine	350	350	80	0	5
20	1498K	75148	Mixed	668	255	>120	0	15

Based on those characteristics, major recommendations for management are illustrated in Table 3.

Table 3: Major forestry recommendations for each plot and respective cadastral unit

Plot nb.	Cadastre unit	Forest type	BA (m^2/ha)	Tree/ha kept	Actions[a]
1	1013K	Mixed	10.5	69	Thinning and pruning of most other trees that are broken or thrown by storm (not pines, in order to allow natural regeneration, and reduce fire risk). Second management plan, a regeneration cutting of 50% of trees is required
2	1001K	Mixed	8.6	65	Remove minor trees affected by the storm, and thinning trees in the understory
3	1162K	Pine	24.6	157	Remove minor trees affected by the storm, and thinning trees in the understory
4	1152K	Pine	29.6	195	Remove minor trees affected by the storm, and all trees in the understory (removal of brutia pine when possible)
5	1287K	Pine	17.3	97	no action, or removal of minor trees affected by the storm, and thinning trees in the understory
6	1104K	Pine	35.2	200	Reduce the BA to 25.7 for better production. 200 trees/ha should be kept (5 removed) and remove broadleaved from understory
7	1096K	Oak	11.1	299	Remove minor branches affected by the storm
8	1506K	Broad-leaved	38.3	600	Thinning of broadleaved trees to keep canopy density around 50% keeping 2-3 stems/stump
9	1506K	Broad-leaved	0.3	500	Single pine tree in all the plot, the oldest. 180 years old: monument tree. Minimal thinning of broadleaved species (25% of the trees)
10	1415K	Pine	19.1	140	Gradual regeneration cut by removing 25% of the trees (cut 5 trees) to enhance regeneration
11	983B	Pine	43.1	230	Reduce the density to 230/ha for production and regeneration cutting (649 trees to cut)
12	950B	Pine	35.0	250	Reduce the BA to 24.8 for better production. 250 trees/ha should be kept (182 trees to cut)
13	1776B	Pine	25.5	235	Density of trees to be kept is 235/ha, reduce the BA to 22.7 (50 trees to cut)
14	1320K	Pine	42.3	200	Regeneration cutting should be considered, and up to 50% of the trees should be removed every 25 years to allow natural regeneration and survival of planted seedlings or BA < G15. Alternatively, reduce the BA to 26.4 or the number of trees to 200/ha (e.g. cut 8 trees)
15	961B	Pine	32.8	250	Reduce the BA to 25.5 for better production. 250 trees/ha should be kept (e.g. cut 266 trees)

Plot nb.	Cadastre unit	Forest type	BA (m^2/ha)	Tree/ha kept	Actions[a]
16	962K	Pine	32.8	250	Reduce the BA to 26.2 for better production. 250 trees/ha should be kept (e.g. cut 207 trees)
17	1470K	Pine	50.7	250	Reduce the BA to 24.1 or most urgently to be thinned to reduce the number of trees to 250/ha (e.g. cut 117 trees)
18	941B	Pine	18.4	200	Reduce the BA to 9.8 or conduct a hard thinning to reach 200 trees/ha (more than 50% of trees: example cut 422 trees)
19	977B	Pine	24.6	250	Reduce the BA to 17.7 for better production. 250 trees/ha shoud be kept.
20	1498K	Mixed	26.9	255	Clear broadleaved understory to enhance pine regeneration and reduce fire risk. Pines should be kept, with thinning to 100 trees/ha in the next plan, if regeneration of pines is desired.

(a) Actions with similar cell background colour could be grouped into the same management unit

6 Forest Management Plan

6.1 Current management status of the forest

All the forest is managed similarly for nut production from pine, without specific sylviculture practices based on the characteristics of each stand. In other words, there is no specific management according to slope, fire risk, the type and density of the understory or the canopy, or even the age of the trees. Some of the plots were subject to surface fire, and others are showing signs of erosion, but these are not accounted in the current practices. Despite the presence of traps to monitor the outbreaks of *Tomicus* and *Leptoglossus*, the forestry practice by the exploiter does not take these factors in consideration; the owner relies on the Ministry of Agriculture to conduct the necessary pest control whenever necessary.

The only difference in the management is the rotation of pruning pine trees. Most of the stands were pruned back in 2016, and fewer in 2018, and this had a severe effect on the quantity of broken branches and wind throw after the snow storm of February 2021. The monastery has also rented some lots for shepherds, however, most of these are outside the pine forest and mainly found around the broadleaved coppice in the lower part of the village. Another lot is leased for a recreational resort inside the pine forest (HillHout).

The municipality, in close collaboration with the scouts and through a small fund is maintaining hiking trails labelled "Droubna" along different sections of the forest.

6.2 Management objectives

The management objective that all stakeholders seek is the sustainability of the forest nut production through sound thinning and pruning. According to our field survey, the following actions could be defined.

Key sylviculture practices were derived for each cadastral lot in which the plots where inventoried. These practices could be grouped into 10 management units:

1- Concerns plots around roads, water streams and creeks, in which attention is focused on preserving the biodiversity, fire reduction, and enhancing pine regeneration.

2- Minimal action or removal of damaged and fallen trees and branches due to wind throw, and thinning the trees of the understory to enhance regeneration and reduce fire risk.

3- Reduction of tree density to improve the production and enhance natural regeneration for trees in their optimal production age (above 65 years: 250 trees/ha down to 200 trees/ha depending on age)

4- Thinning broadleaved coppice where pine is absent to improve the stands

5- Gradual regeneration cut for old stands (above 120 years)

6- Heavy thinning for old producing stands (around 100 years) and also to prepare for future regeneration

7- Thinning stands with optimal production age to improve productivity or enhance natural regeneration (230-235 trees/ha)

8- Hard thinning (50% of the trees) in very dense stands to prepare for optimal production (200 trees/ha)

9- Clearing broadleaved understory to reduce fire risk and eventually enhance pine regeneration

10- Reforestation sites

The cadastral lots covered with forest could be distributed based on those defined actions for the different management units (Table 4). Since the time frame doesn't allow to conduct an inventory in each of the 245 cadastral lots, a basic field survey focusing only on the density and major physical features (no tree age or DBH were measured) allowed to segregate them as follows. Nonetheless, these allocations remain only based on preliminary observation of pine stands contiguous to the existing plots within their respective management units. A more detailed inventory should be conducted once the actions start in those cadastral lots.

Table 4: Allocation of the different cadastral numbers to the suggested management units

Management units	Cadastral lots
MU1: Concerns plots around water streams and creeks, in which attention is focusing on preserving the biodiversity, fire reduction, and enhancing pine regeneration.	922, 923, 930 to 934, 993, 994, 997, 998, 1001 to 1005, 1007 to 1016, 1018, 1019, 1021, 1186 to 1188, 1353, 1356, 1358 to 1372, 1378 to 1380, 1382 to 1387, 1390 to 1393, 1405, 1406, 1409, 1411 to 1415, 1418, 1429
MU2: Minimal action or removal of damaged and fallen trees due to wind throw, and thinning the trees of the understory to enhance regeneration and reduce fire risk.	999, 1000, 1031, 1136 to 1141, 1145 to 1157, 1162, 1164, 1165, 1167, 1168, 1170 to 1172, 1174, 1175, 1191 to 1193, 1216, 1252 to 1254, 1261 to 1263, 1287 to 1289, 1302, 1343, 1373 to 1375, 1401 to 1404, 1410, 1430, 1432 to 1435
MU3: Reduction of tree density to improve the production and enhance natural regeneration for trees in their optimal production age (above 65 years: 250 trees/ha)	950, 961, 977, 1328 962, 1027, 1036, 1037, 1044, 1048 to 1053, 1055 to 1061, 1104 to 1109, 1116 to 1118, 1158 to 1160, 1181, 1290 to 1297, 1300, 1301, 1303 to 1309, 1311 to 1322, 1345, 1388, 1389, 1398 to 1400, 1448, 1784
MU4: Thinning broadleaved coppice where pine is absent to improve the stands	1098 to 1101, 1473, 1503, 1506
MU5: Gradual regeneration cut for old stands (above 120 years)	1401 to 1406, 1416, 1417, 1419, 1420, 1422, 1423, 1425 to 1428, 1448, 1451 to 1454, 1460, 1461
MU6: Thinning stands with optimal production age to improve productivity or enhance natural regeneration (230-235 trees/ha)	1470 to 1474
MU7: Heavy thinning for old producing stands (above 100 years) and also to prepare for future regeneration	983 942

MU8: Hard thinning to reach 200 trees/ha (more than 50% of trees)	941, 992, 995, 996
MU9: Managed broadleaved understory under aging monumental pines	1498, 1502
MU10: Reforestation	Khenshara: 927, 929 Jouar: 12, 35 to 38

In addition, several other cadastral lots showed characteristics that might also suggest additional management units, specific to them. For instance, some might be good for agro-forestry, or for reforestation activities, or simply as a biological corridor. However, addressing the potential land use for each cadastral lot is beyond the scope of the forest management plan. Most of the mixed broadleaved coppice fall in other villages (Jouar, Chrine, Bteghrine) and were not included in this management plan.

The management units are illustrated in Figure 3.

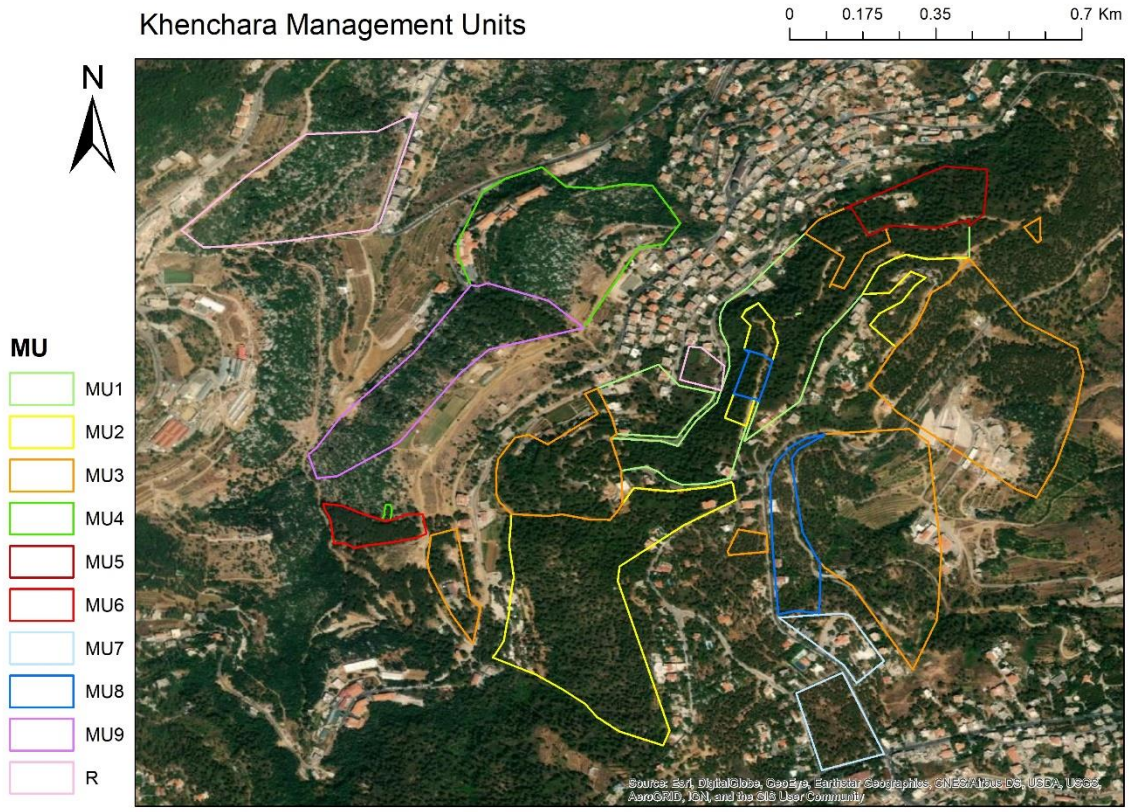

Figure 3: The different management units of the studied forest

6.2.1 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:

- The stewardship of the owner (St. John monastery) to this plan, despite the rotation of the monks responsible over the land use management of the monastery. If the management plan is not adopted by the next responsible, the plan cannot be performed.
- The ownership of the local community to the project, which should respect the plan's objectives.
- The collaboration of the forest exploiter(s) who usually benefit from a lease in order to harvest and sell the nut production, and conduct the necessary activities to sustain the health of the forest (pruning, cleaning the understory, etc.). Such collaboration might face several obstacles in the future due to the deteriorated health status of the forest and a decrease in the profit due to a sharp drop in nut production.
- The financial resources in order to implement and monitor the plan by the NGOs, municipality, etc.
- The willingness of the Ministry of Agriculture to approve the management plan, using the necessary law derogations for the sake of the sustainability of the forest and its health.
- The commitment of the forest guards to monitor the implementation of the management plan.

6.2.2 The sylviculture prescriptions for the different management units

Prescriptions varied according to the management units, and are detailed as follow:

MU1: Has a minimal intervention, with management focused on the removal of fallen trees, broken branches, and the pruning of dead branches, as well as the cleaning of understory herbaceous vegetation along roads and near trails. The remaining understory vegetation is kept for biodiversity conservation, namely along streams and creeks, and for erosion protection on slopes. Species such as *Quercus cerris, Sorbus torminalis, Salix libani, Rhododendron ponticum, Crataegus monogyna,* and *Amelanchier ovalis* should be preserved. Roads in the forest should be cleaned and restored to allow easy access during an eventual fire outbreak. More than 8.1 ha are under this MU.

MU2: Has minor interventions in the pine trees. In addition to what is mentioned for MU1, broken and unproductive trees should be removed, and the understory should be managed to reduce fire risk. Here, trees in the understory, namely broadleaved trees and weak pines should be thinned out. Shrubs hindering the harvesting could be cleared. Burning the understory should be avoided, and only prescribed burning with the presence of civil defence and forest guards could be eventually suggested. Regenerating broadleaved trees should be kept, namely those mentioned in MU1, in addition to *Erica manipuliflora*, *Cistus spp*, *Lavandula stoechas* since these attract several insect pollinators. Roughly 10.8 ha are under this MU.

MU3: In order to improve production in stands in optimal age range, Reduction of tree density should be applied to improve the production and enhance natural regeneration for trees in their optimal production age (60-80 years). According to the basal area, tree diameter and height, the reduction may vary from one stand to another. Basal area should be kept between 24 and 26 m^2/ha, with an average density of 250 trees/ha. The trees to be thinned should be determined on site and stamped or sprayed by a forester (mixed selective thinning). Weak, unstable, broken, unproductive trees affected by pest outbreaks should be those to be removed (in addition to the broken branches and fallen tree due to the last storm). The understory could be managed as in MU2. Areas subject to erosion should be preserved from fire. About 21.3 ha are under this MU.

MU4: concerns broadleaved coppice, in which thinning is essential to improve the growth of the preserved stems, reduce competition between trees, improve light penetration and reduce fire risk. The aim is to keep a 50% canopy cover and preserve 2-3 stems/stump or 500 to 600 stems/ha according to their diameter. Around 8.6 ha are under this MU.

MU5: are old growth stands (more than 120 years) but relatively dense, with urgent interventions required to reduce the tree density through a regeneration cut by removing trees every 10 to 20 years, in order to enhance natural regeneration underneath the trees in opened patches. Under this management plan, only 140 trees/ha should be kept. The understory should be managed to allow natural regeneration, by cleaning some patches in the open spots below the tree crowns and keeping some cones on the trees. Alternatively, after felling the selected trees (same criteria as for MU3), some plantations with seedlings could be implemented in open patches. Only 1.8 ha are under this MU.

MU6: are those stands with intermediate age (between 85 and 120), relatively dense. These require also thinning in order to keep no more than 235 trees/ha, in a first step to sustain a decent level of production, and prepare for the regeneration cut (25% of the trees) in 10-20 years (in the next management plan where only 100-140 trees should be kept). Also here, the understory should be managed to allow regeneration, by keeping a low vegetation cover (see prescriptions of MU2 for the understory). The current thinning is of a high priority (mixed selective thinning). Roughly one ha is under this MU.

MU7: concerns stands with old age (above 100 years) and dense. These suffered from the snowstorm. In addition to the already cut and removed branches, the BA should be reduced and the tree density should not exceed 230/ha, as a preparatory cut to enhance regeneration or to prepare a patch for future reforestation (mixed selective thinning). A regeneration cut should be prescribed in the next management plan, before doing any plantation. The understory is managed like in MU2. About 3.4 ha are under this MU.

MU8: concerns stands with varying age and relatively low height, and competing with each other. An urgent heavy crown thinning (50% of the trees that are initially at more than 400 trees/ha) is required if we want to make those tree productive. The understory is managed like in MU2. 2.4 ha are under this MU.

MU9: is a mixed stand dominated by pine with a thick broadleaved coppice in the understory. The pines should be kept during this management plan, but a regeneration cut is required in the next plan (in 10-20 years). Only dead, broken or fallen trees should be removed. The broadleaved coppice should be subject to thinning, in order to protect the stand from forest fire, allow pine harvesting, and eventually prepare for the next phase for a regeneration cut. One or two stems per stump should be kept. Around 6.3 ha are under this MU.

R (MU10): includes all the plots suggested for stone pine plantation. Most of those have already some trees (broadleaved or pine) and others only covered by shrubs (mainly *Spartium junceum*). These plots are diverse in terms of topography, soil conditions and vegetation cover, but are all easily accessible for plantation and seedlings maintenance. It is urgent to remove the shrubby and herbaceous vegetation before planting. Planting holes should be no less than 4 x 4 m, to avoid an early thinning after 10 years, so better not

exceed a density of 600 trees/ha. The sites should be protected from grazing and should be maintained with irrigation during the first years. The saplings should not be pruned before the next management plan (10 years after plantation), along with a first thinning of trees if the plantation is dense (more than 600 trees/ha or with distances less than 4 x 4 m between trees). About 7.8 ha are under this MU, yet not all the surface is suitable for plantation.

All the forest cadastral plots and the MUs to which they are attributed are shown in Fig 4.

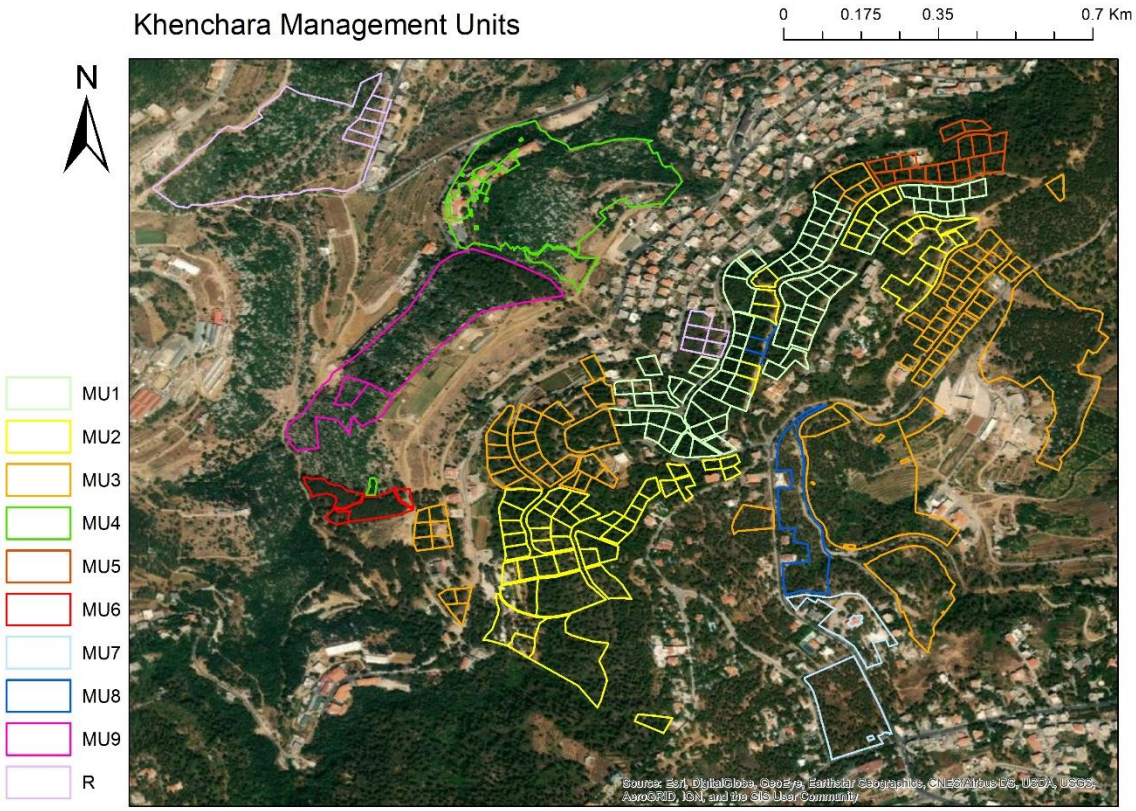

Figure 4: MUs of Khenshara forest

6.2.3 Additional technical aspects

- All the pine trees in all the MUS require minimal thinning covering only the lower part of the crown (dead branches), without any additional removal of green branches, as all the stands are quite old, and in the production phase. Broken branches due to snow could be removed. Despite the increased risk of snow damage due to crown and foliage density, it is always advisable not to cut branches

since these are productive and will not be replaced as in broadleaved trees. To allow better sunlight, thinning is favoured to pruning in pine forests.

- Stem pruning should be kept only for recently planted trees: "First pruning should be carried out only when trees are 3 – 4 m height (~10 years), and should be applied up to 1.5 – 2 m. The following pruning should never exceed 2/3 of the total height of the tree. Pruned stem height normally will not exceed 6 m. Through the whole tree life, three pruning interventions are enough (each 10-15 years). Pruning should not be applied on mature trees (> 60 years), given the low capacity of the trees to close the wounds".
- Regarding the regeneration cutting, and due to the initial high density of the forest (230-250 trees/ha and more), it is recommended to proceed into four phases of cutting, in each we thin out a certain percentage of trees. Hence, in the next management plan, it is required to include regeneration cutting for all stands having trees with more than 80 years old. The trees that are fallen and cut due to the storm snow, are accounted within the percentage to be removed. Hence, as a result of this selective and mixed thinning type, the final number of trees to be cut should be determined in close collaboration between the technical forester and the forest guards in order to get the necessary license. Trees to be removed are to be demarcated.
- Particular attention should be given to the existing wildlife (hyenas, squirrels, snakes, bladders, porcupine, etc.) and small shrubs or trees that are rare or endemic (*Amelanchier ovalis, Rhododendron ponticum, Salix libani, Quercus cerris, Sorbus torminalis, Ostrya carpinifolia, Erica manipuliflora, Lavandula stoechas,* 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.
- Monitoring *Leptoglossus occidentalis* and *Tomicus destruens* should be continued in close collaboration between the forester, the entomology expert, the MoA and the landowners. A training if necessary to monks or harvesters is key for an efficient monitoring. Should a pest outbreak affect the forest heavily, a revision of the management plan, in close collaboration with the Lebanon Reforestation Initiative and entomology experts should be envisaged.

6.2.4 Priority and time frame

In terms of time frame, the management plan is here more urgent in order to stop the decline of the forest, reduce forest fire risk and pest outbreak, and further enhance regeneration gradually in different plots, in order to shift into an un-even aged forest and sustain the stone pine production and the forest itself.

It is highly urgent to remove all the fallen trees and broken branches before the fire season starts in 2021 in all MUs, along roads, near trails and buildings. Another important activity is to restore the damaged dust roads in the forest, to allow an easy access to the forest, especially during the fire season.

It is also highly important to start with the preparatory regeneration cutting for the old growth (MU5), the heavy thinning of very dense stands (MU8), and then move to the preparatory cutting for the transitional forest stands (MU6 and MU7), and the thinning of the remaining productive stands (MU3, MU2 and MU1). As for the mixed forest stands (MU9), it is not of a high priority if fire prevention activities are implemented this year. Similarly, the broadleaved stand is not a priority (MU4). The reforestation lots have variable priority depending on the availability of seedlings, and manpower to prepare the land for plantation. It could be split in two phases: reforestation in empty areas or cadastral lots, and further after the regeneration cutting as a trial in old-growth stands (Table 5).

Table 5: Time priority for intervention in each of the MUs.

Priority (years)	1 (1-2)	2 (2-4)	3 (3-6)	4 (4-8)
Cleaning understory from all MUs (before July 2021)				
MU1				
MU2				
MU3				
MU4				
MU5				
MU6				
MU7				
MU8				
MU9				
R				

The timetable shows that there is no precise timing, but rather priority actions (from dark red to yellow) to be considered in the different years, and for each management unit, once the activity is achieved. Ideally each priority should be achieved within one year, 2 years as a maximum, in order to finish the management plan in less than 10 years, and have the time to prepare the next plan by the end of the 10 years cycle.

6.2.5 Legal, financial and organizational aspects

The forest is owned by the monastery of St John, a private entity, and therefore follows the forest code and laws. It is hence necessary to get the required permission for exploiting the forest from the MOA, and through the supervisionof the regional forest guard centre (Matn). Since conifer cutting is forbidden by law, derogations allow cuttings only for the sake of sustaining the forest (e.g. for security measures along roads, and near buildings, for controlling pest infestation, or reducing a fire or another natural risk). Based on these derogations, the removal of fallen and dead trees and broken trees and branches due to the snowstorms is possible, as well as the elimination of trees source of pests (usually weakened trees) is also possible. If the ongoing law revision sees the light before the end of the forest management plan, swifter sylviculture actions could take place.

Ideally, the permits should take place according to the cadastral lot numbers, rather than by management unit, due to their clear delineation. Hence, Table 4 allows to prepare permits for cutting based on the cadastral numbers of the corresponding MUs.

The monastery land keeper should be in charge of preparing all the necessary papers and demand for the cutting licence. The MOA shall be responsible for the supervision of works and issuing the licence. A forester is required to supervise the selective thinning and suggest the necessary action for the land keeper.

It is advisable to lease the land on an annual basis, for more than one person, in order to reduce the risk of unfair business for both the landowner and the user. A contracted forester could also check transparency of the production amount, if a budget for the latter is taken into account along the management plan.