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LEBANON REFORESTATION INITIATIVE

OUTPLANTING MONITORING AND INSPECTION PRACTICES AND RESULTS

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This technical report is developed by the Lebanon Reforestation Initiative – Outplanting component. It includes the results of 4 years of reforestation work across Lebanon, from October 2011 till the end of December 2014.

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I. INTRODUCTION AND STANDARD PROTOCOLS

1. INTRODUCTION

The Lebanon Reforestation Initiative (LRI) is a program funded by the United States Agency for International Development (USAID) and implemented by the US Forest Service Office of International Programs (USFS/IP). The project aims to restore Lebanon's native forests and to install commitment to reforestation and wildfire prevention and response, through capacity building of local communities and organizations. Project activities include building increased capacity to sustainably manage and expand the country's forests and catalyzing the planting of several hundred thousand native trees on sites throughout Lebanon. The project favors a decentralized approach to engaging communities at the municipal level and focuses on:

1. Assisting native tree nurseries with technical improvements and enhanced business planning;
2. Developing comprehensive forest mapping to help identify existing forest resources and priority areas for the reforestation of native tree species;
3. Promoting the importance of reforestation and biodiversity through community-led activities that foster local ownership and forest sustainability;
4. Supporting the planting of quality native seedlings, and especially threatened species, throughout Lebanon; and
5. Strengthening capacities to prevent and respond to wildfires through technical assistance and specialized training of communities and firefighting agencies.

One of the key parameters to measure success in reforestation projects such as LRI is to build a strong monitoring system that allows for the measurement of seedling survival in the field as well as the identification of potential causes of mortality and the synthesis of lessons learned to be used by decision-makers in subsequent planting events. For this purpose, LRI adapted internationally used inspection and monitoring protocols to Lebanon's site conditions and operational capacities. This document presents those protocols along with actual monitoring and inspection results for LRI's ten reforestation sites, namely from north to south: Bcharre, Tannourine, Ainata, Maqne, Kfardebiane, Aanjar, KfarZabad, Rachaya el Wadi, Rmadiye and Qlaiaa (Fig. 1), as well as smaller-scale reforestation sites, for two consecutive years, 2012 and 2013. Chapter 12 also provides an overview of all small-scale reforestation sites supported by LRI through three planting seasons (Fig. 2), highlighting particularities of those sites compared to the ten large sites mentioned above.

In 2011, seedlings planted in LRI large sites were produced in plastic containers by two nurseries, Association for Forests, Development and Conservation (AFDC) and Native Nurseries, which had started implementing advanced techniques in seedling production. Starting 2012, all seedlings planted on LRI-supported sites were produced by nine nurseries, members of the recently-established Cooperative of Native Tree Producers of Lebanon (Fig. 3), following LRI seedling production protocols (for details see "Lebanon Reforestation Initiative: A Guide to Container Tree Seedling Production") and under ongoing technical assistance from LRI staff.

Figure 1. Map of LRI's ten large reforestation sites showing their geographical distribution. Green areas on the map represent cadastral limits of the towns where the sites are located and are not indicators of the size of reforestation sites.

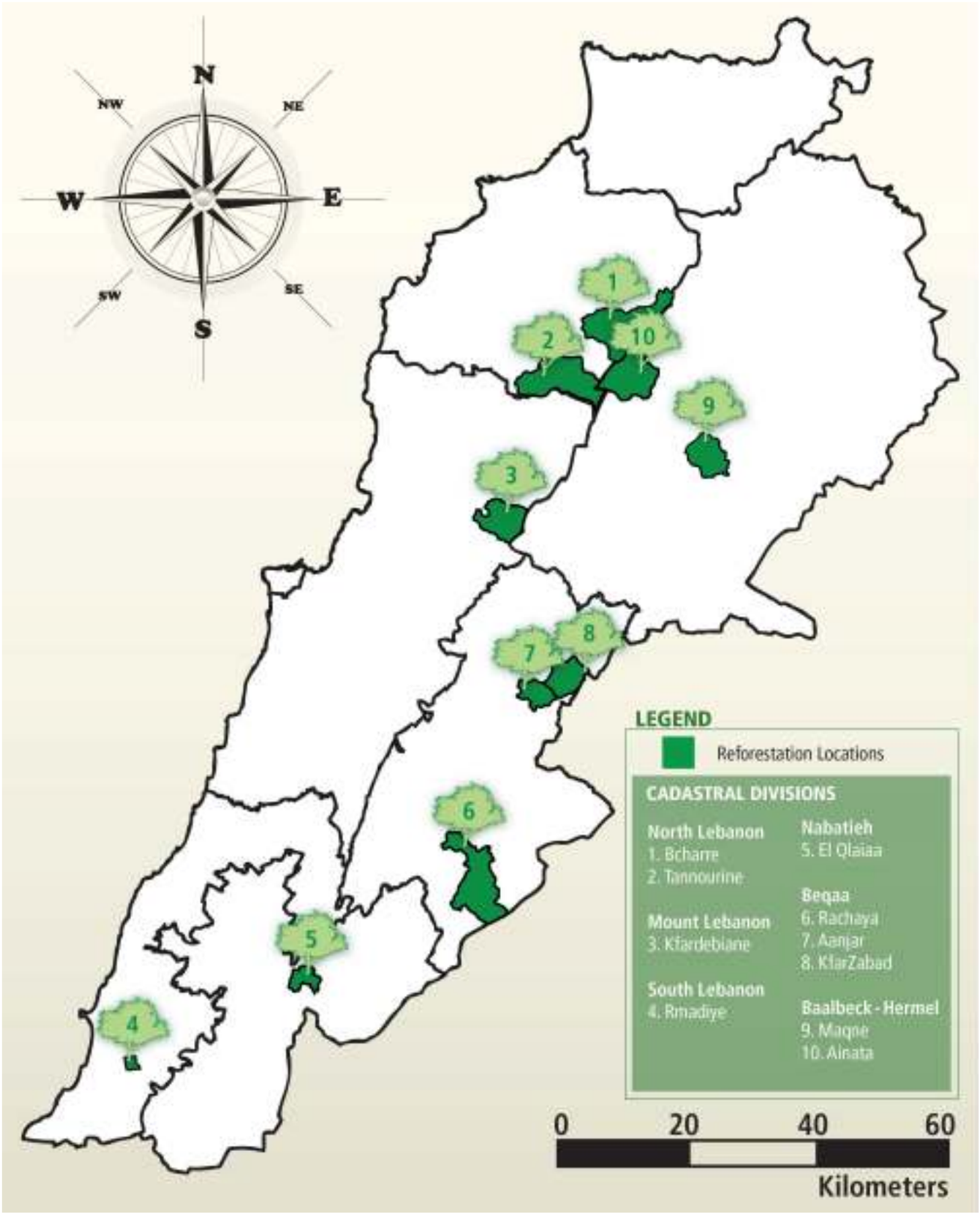


Figure 2. Map of all LRI's reforestation sites showing their geographical distribution and segregated by site size. LAF sites are sites planted with seedlings purchased by LRI from the Cooperative of Native Tree Producers of Lebanon, planted by LAF volunteers during two campaigns.

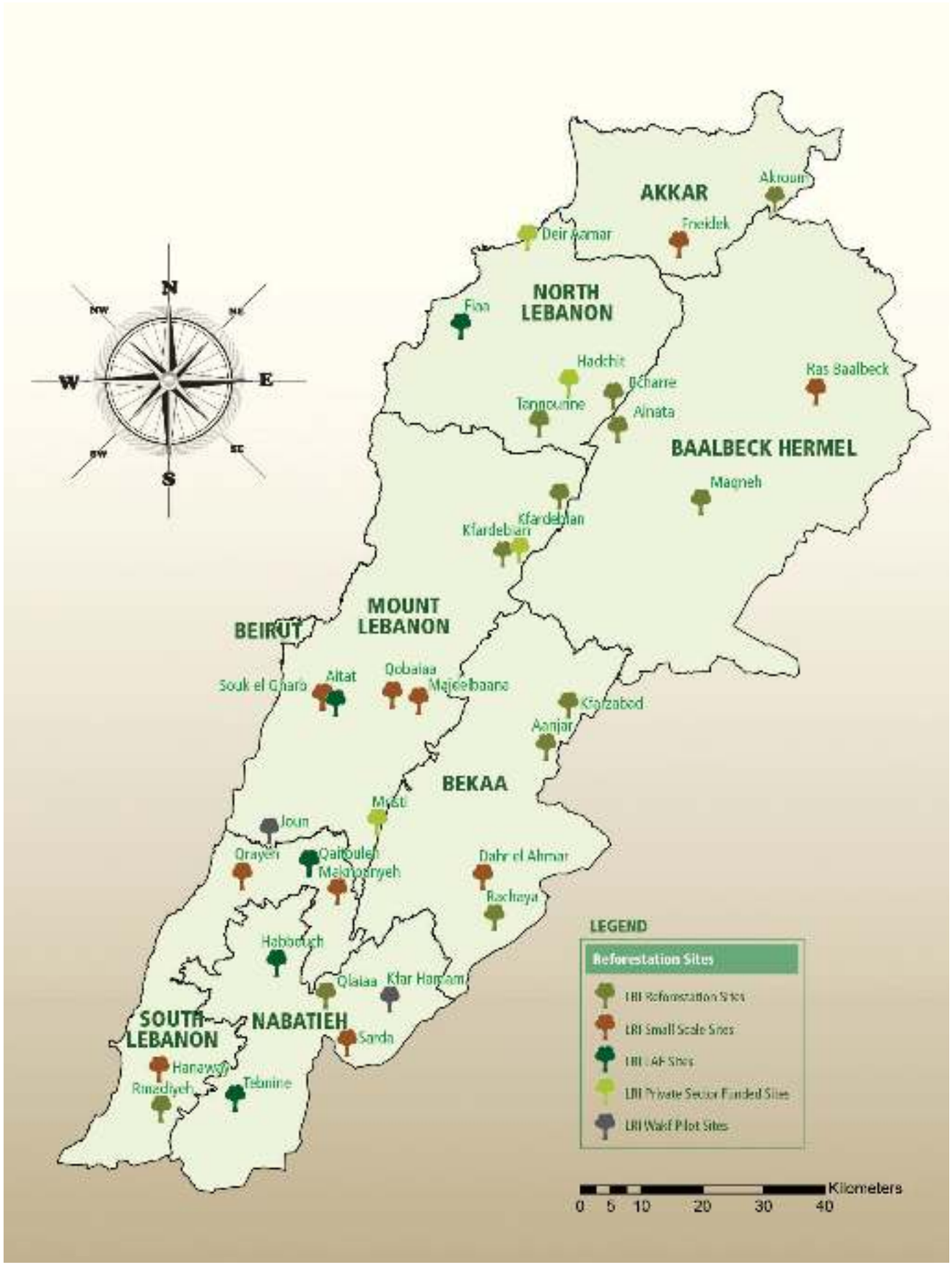
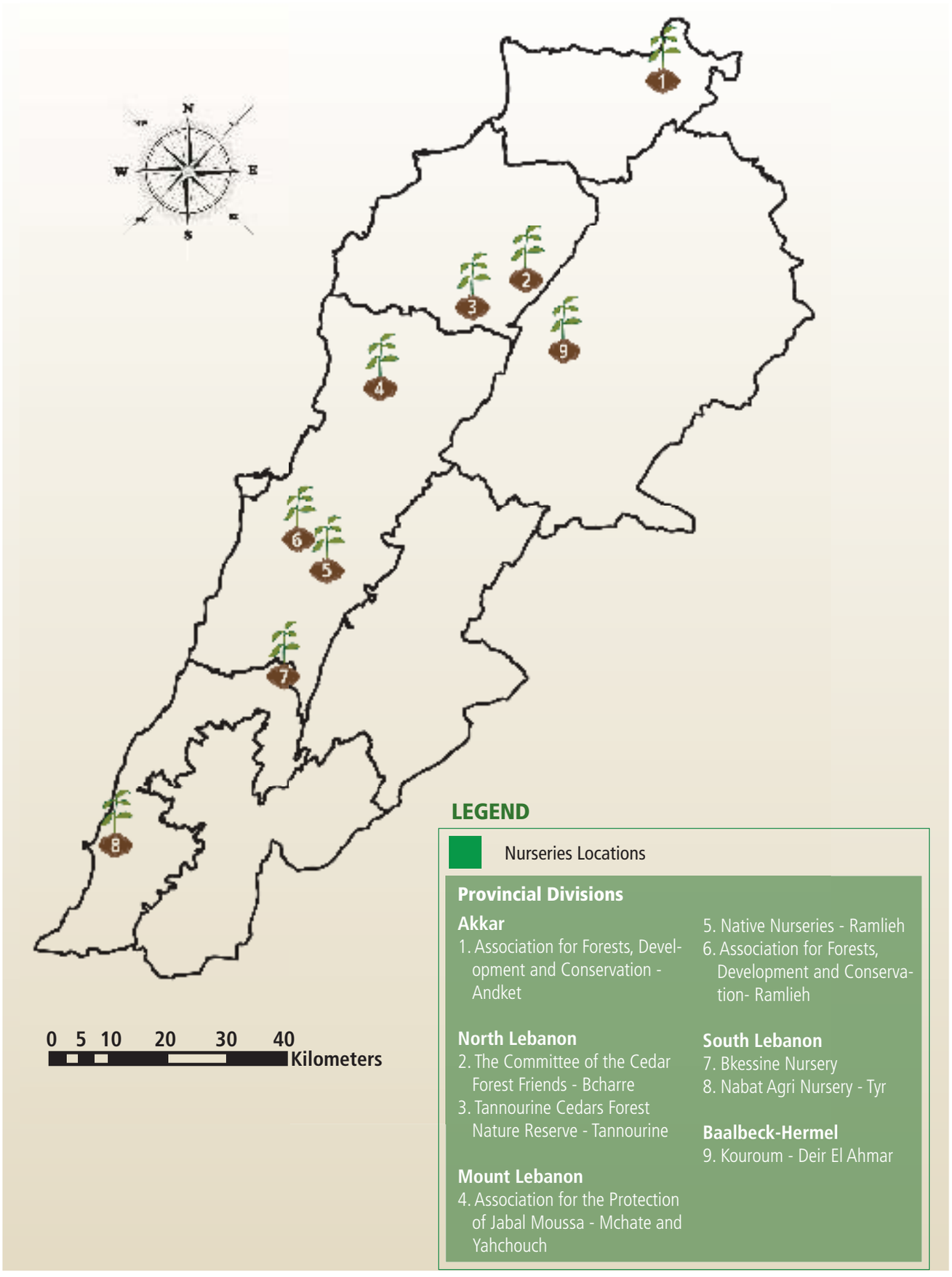


Figure 3. Map showing the location of native tree nurseries supported by LRI and members of the Cooperative of Native Tree Producers of Lebanon



2. PLANTING QUALITY INSPECTION

2.1. Purpose and outcomes

Planting quality inspection conducted daily during the planting season serves many valuable functions by providing:

a. An organized approach to controlling the quality of seedlings received from the nursery, stored locally and sent to the planted site. The planting inspector can sort the seedlings both upon arrival at the storage site and upon delivery to the planting crew. He/she can recommend and ensure actions are quickly taken (e.g., irrigation, aeration or other storage related measures) to address issues.

b. A process to rapidly correct planting mistakes and provide continuous feedback to the planting crew to evaluate the quality of planting and their productivity while providing live on-site training.

c. Quantifiable and up-to-date information for reporting to the managing organization to continuously evaluate the planting operation in terms of planting quality, crew planting production, quality of seedlings coming from the nursery, and the overall efficiency of operations.

d. A way to map planted areas and to calculate tree density.

e. Baseline records that can be used to help evaluate the planting over time including monitoring results.

Following a well-organized and designed inspection protocol will considerably improve worker productivity and performance and result in higher planting quality and survival while reducing costs associated with failed outplanting efforts. Examples of the kinds of information that inspections provide include:

a. Percentage of seedlings planted well versus poorly.

b. Percentage of seedlings with various planting concerns.

c. Seedling density and average spacing by daily planted area.

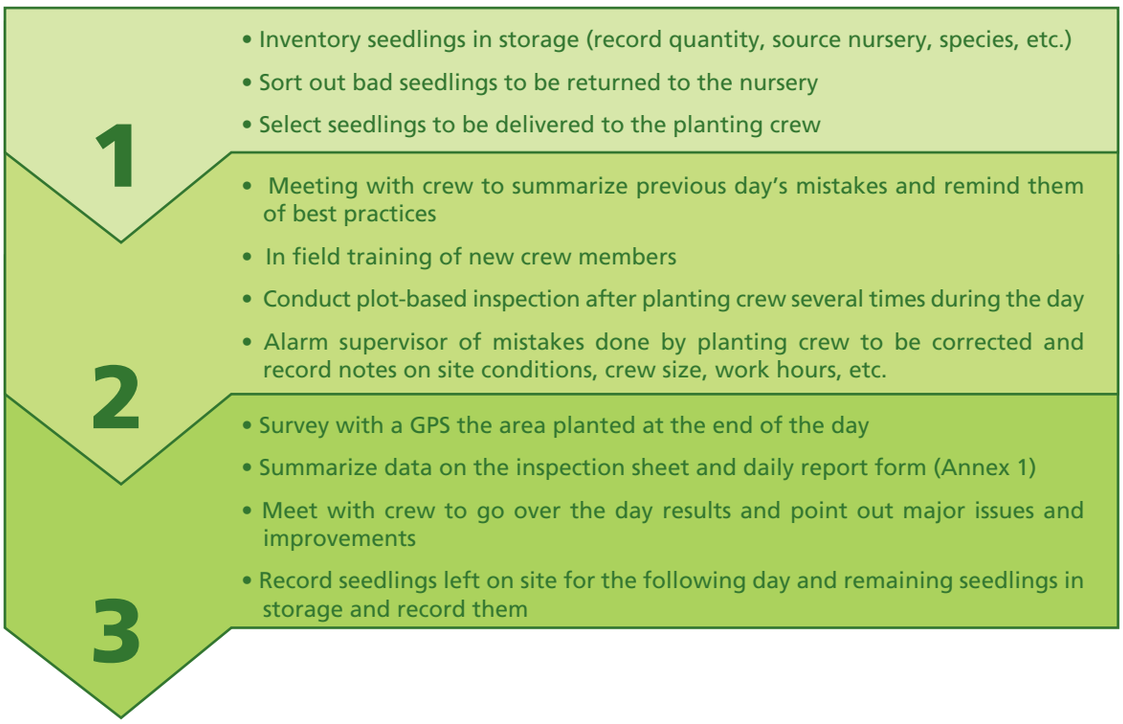
d. Total number of trees planted by species and location within the planting site on a daily basis.

e. Quantity and condition of seedlings received from each nursery with every shipment.

f. Weather conditions during each planting day.

2.2. The Inspection Process

A typical inspection day begins with inventorying seedlings in storage and briefing the planting crew on best practices, followed by spending the day on site monitoring activities, installing plots to check quality, sharing results and providing training. The day ends with mapping the day's planting area, tallying seedlings, finishing paperwork and debriefing the planting supervisor. The following chart represents major activities to be conducted by an inspector during each planting day, with step 1 representing daily pre-planting activities; step 2 daily planting activities; and step 3 daily post-planting activities.



The LRI-designed inspection process uses two record-keeping forms including: i) a planting inspection sheet (for recording results of seedling inspections); and ii) a daily planting report (for summarizing the inspection data, tallying seedling inventories, documenting observations, crew size, weather, etc.) Samples of daily inspection sheets and daily planting reports with their user instructions are available in Annex 1.

Installing sampling plots allows information on planting quality of individual seedlings to be assessed and quantified to provide objective feedback to the planting crew. These circular plots are selected (typically along a grid pattern to reduce bias) and completed across the planting area the same day trees are planted. The plot diameter is defined by the stocking or planting density used. For example, if seedlings are spaced 5 m apart on average, a plot radius of between 2.5 and 3 m is typically used. The inspector records the percentage of plantable area within the plot to account for large rocks, structures or any planting obstacles. Up to three seedlings should be inspected per plot.

At least three rounds of inspections should be conducted in one planting day, with each round consisting of ten plots. These plots should be distributed evenly over the area planted to ensure all workers are assessed across the full range of site conditions. All seedlings within the plot receive an above-ground inspection, while approximately 10% of seedlings are below-ground inspected. These inspections are described below:

Above-ground inspection All seedlings in the plot are checked for the quality of the planting location, hole preparation, scalping, seedling orientation (if seedling is straight upright or bent), planting depth (good, too deep or too shallow), and proper planting (by tugging on seedling) (Fig. 4).

Figure 4. Example of a planted seedlings that is both bent and too shallow (notice upper roots exposed above soil level)

Below-ground inspection A subsample of seedlings in the plot are below-ground inspected by digging a hole with a small shovel to expose one complete side of the root plug without damaging the roots (Fig. 5). The inspector should then look for the following: i) if the root plug is straight, L-shaped or J-shaped; ii) if the soil is well pressed around the roots or if there are air pockets; iii) if debris and small stones are close to the root plug. Problems should be communicated to the planting supervisor immediately to ensure problems are not repeated and existing issues are corrected. J-or L-rooting are especially common and serious mistakes that can be minimized with quality inspections (Fig. 6).

Figure 5. Roots exposed for below-ground inspection without causing damage to the seedling

Figure 6. Example of a J-rooted seedling

Other outplanting actions the inspector may evaluate include quality of installation of mulching, shelters, shade cards or any other materials used and planting density and planting spot selection.

At the end of each day, the inspector should GPS the area planted and meet with the crew supervisor to discuss issues and concerns recorded. An inventory of seedlings returned to and remaining in storage should be done to calculate seedlings planted during the day and limit any losses. Planting density can then be calculated by dividing the total number of seedlings planted by the area planted in that same day. Inspection forms, daily reports and GPS files should be routinely submitted (at least once a week) to the managing organization to ensure records are not lost.

3. MONITORING SEEDLING SURVIVAL

Monitoring seedling survival is essential to evaluate reforestation project successes and failures. Monitoring can provide information on survival, vigor, and density of the planting. Seedling monitoring is generally assessed twice in the first year after planting, and then annually for at least three years thereafter. The initial "baseline" monitoring is done in late winter to primarily assess mortality due to bad seedling quality. Though high mortality may also suggest poor planting and/or harsh winter conditions. Yearly monitoring is then conducted at the end of the first summer. Yearly monitoring can indicate issues such as mortality and when combined with inspection data can assess potential causes (e.g., bad seedling quality, poor planting, limiting site condition).

YEAR 1			YEAR 2		YEAR 3	
Nov - Jan	Mar - Apr	Aug - Sep	Nov - Jan	Aug - Sep	Nov - Jan	Aug - Sep
Planting Season	Baseline Monitoring	Yearly Monitoring	Replacing Dead Seedlings	Yearly Monitoring	Replacing Dead Seedlings	Yearly Monitoring

Protocols for monitoring differ by size of planting site, number of seedlings and technologies and resources available. Small-scale reforestation sites (less than 1,000 seedlings) can be monitored by assessing 100% of the seedlings planted. For sites with 1,000 - 5,000 seedlings, up to 50% of the seedlings can be assessed. For sites with more than 5,000 seedlings, monitoring every seedling requires a lot of time and labour. On these larger sites, a sub-sample of seedlings can be tested to represent the entire planting. Generally at least a 2% or 5% sample is needed for a reasonably accurate assessment.

A simple monitoring system can provide information to assess the survival rate of planted seedlings. More detailed protocols can evaluate the density, vigor, and growth of seedlings and can provide data on quality of other treatments such as mulching and irrigation and identify issues such as grazing. Based on the reforestation manager's decision, monitoring can be done using permanent or temporary plots. Permanent plots allow direct comparison of change for individual plots, while temporary plot data can only be grouped for analysis. Permanent plots also provide good opportunities for comparison of repeated photos of an exact area to see changes. Because permanent plots require installation of plot stakes and location referencing, they are more time consuming and costly. For a given budget, many more temporary plots can be installed, allowing more thorough coverage of the site. LRI used the temporary plot system in monitoring seedling survival in their sites.

Below are two alternative monitoring protocols tested by LRI on its reforestation sites. Both are appropriate for use on sites with more than 1,000 seedlings. Monitoring Protocol 1 was used on all LRI reforestation sites planted in fall 2011 and monitored in 2012. The protocol requires expensive high-accuracy GPS devices and receivers and a sophisticated GIS package with experienced personnel. With the growing demand from local NGOs and municipalities to learn the monitoring process, and after facing issues with satellite reception and even in some cases security issues when using a receiver in border and conflict zones, LRI found the need to develop a less expensive and more user friendly system. Monitoring Protocol 2 was then developed and tested by LRI for this purpose.

3.1. Monitoring Protocol 1

This protocol was used by LRI on all reforestation sites planted in fall 2011 and for some of the sites planted in 2012.

Field and Office Procedures

1. Survey the outer boundaries of the planted area with a GPS (either a Garmin® 62S with 5 m accuracy level or a Trimble Pro XRT with Ominstar with less than 1 m accuracy level).

2. Export the GPS generated boundary polygon to ArcMap to calculate the total area.

3. Create a 5 m buffer zone along the inner edge of the polygon to reduce error due to edge effects. For very large planting sites, 2 or 3% of the polygon interior excluding the buffer is used for monitoring.

4. Establish a systematic grid of sampling points using Hawth's Tool (an extension in ArcMap) with 31.6 m equidistance between plots. A plot radius of 2.5 m is used.

5. Create a data collection form using ArcPad Studio. This form will then be used on a Trimble Nomad ruggedized hand-help computer for field data entry. ArcPad Studio allows parameters (e.g., seedling status, mulching and shelter options, soil preparation methods, etc.) to be entered, stored and later downloaded for analysis and reporting.

6. Upload site boundary and monitoring plot locations and other needed layers and the data form to a Trimble Nomad. (For tips on using Trimble GPS and receivers in the field, please consult LRI monitoring guide on www.lri-lb.org). Then proceed to the field to collect your data.

7. The ArcPad map on the Trimble Nomad is used along with the GPS and/or a hand held compass to guide the monitoring team to the center of each plot.

8. Once at the center, a 2.5 m radius is delimited with a tape or straight bar and seedlings within the plot are identified.

9. Once the number of seedlings within the plot is recorded on the first screen form, the team member holding the GPS stands over the seedling, records its location and the seedling status (dead, damaged or alive), and any other information included in the monitoring process (e.g., irrigation, mulching, shelters, soil preparation, seedling species, etc.) in second screen form.

10. Data is saved for each seedling under a new ID. After surveying all seedlings, the team navigates to the next monitoring plot using a combination of the GPS and compass.

11. After completing the field work data input is downloaded to ArcMap and exported from there into Excel for analysis and reporting.

3.2. Monitoring Protocol 2

This protocol, developed by LRI, provides a more simplified, and time and cost-effective approach to monitoring. It also addresses security and satellite reception issues that occurred with GPS technology used in Monitoring Protocol 1. This method simply requires a readily purchasable GPS device such as a Garmin® 62S and an open source GIS software.

Field and Office Procedures

1. Prepare a form in Excel containing the information to be collected in the field (Sample provided in Annex 2).

2. Once in the field, walk the planting site in a grid pattern starting in one corner, establishing plots along a fixed distance of 31.6 m. These fixed distances between plots and the plot size are the same as those used in Protocol 1.

3. At each plot center record operator's position on the GPS and assess all seedlings within a 2.5 m radius same as in Protocol 1. Record data in the excell sheet or on the notes section of the GPS.

4. The operator would then walk the site back and forth, recording data, until the site is completed.

5. After completing the field work, data is entered into the Excel spreadsheet for analysis and reporting.

Testing Monitoring Protocol 2 in the field in 2013 on sites planted in the fall of 2012 has shown a satisfactory level of accuracy and a substantial reduction in time and resources needed. Table 1-1 below details advantages and disadvantages of both protocols based on LRI experience.

Table 1. Analysis of two monitoring protocols used by LRI monitoring team

	Monitoring Protocol 1	Monitoring Protocol 2
Advantages	- High Accuracy - No risk of revisiting the same plot - Objective choice of plots	- User friendly - Fast procedure in the field - Higher worker safety as operator can choose plots based on where he/she can walk - Larger sample size (non-plantable plots are replaced by the nearest plantable plot and each plot would have three seedlings)
Disadvantages	- Resource intensive (expensive GPS receiver, data logger and software), satellite subscription needed - Requires highly trained personnel - Time-consuming	- Slightly lower accuracy - High risk of revisiting the same plot more than once, especially with more than one operator or with hilly areas with limited longsight visibility - Risk of missing areas / samples less representative and less equally distributed over the site - Choice of plots influenced by operator

4. LRI PLANTING APPROACH

Monitoring of LRI reforestation sites was based not only on adopted international best practices but it was also influenced by the project's planting approach and other considerations. These issues facilitate our understanding of site-specific monitoring results provided in subsequent chapters.

For all ten LRI sites, site selection was based on the following set of criteria:

- Interest of and benefits to the local community;
- Public lands over which municipality has control;
- Depth of soil of more than 40 cm;
- Soil type conducive to successful tree growth;
- Topography conducive to planting and ensuring worker safety;
- Access to planting site;
- Availability of or accessibility to irrigation water;
- Geographic distribution and social diversity, with at least one site per *mouhafaza*;
- Significant land area available to reforest, with a preference for more than 25 hectares.

For all ten sites, LRI followed the sequence of events shown in figure 7 below.

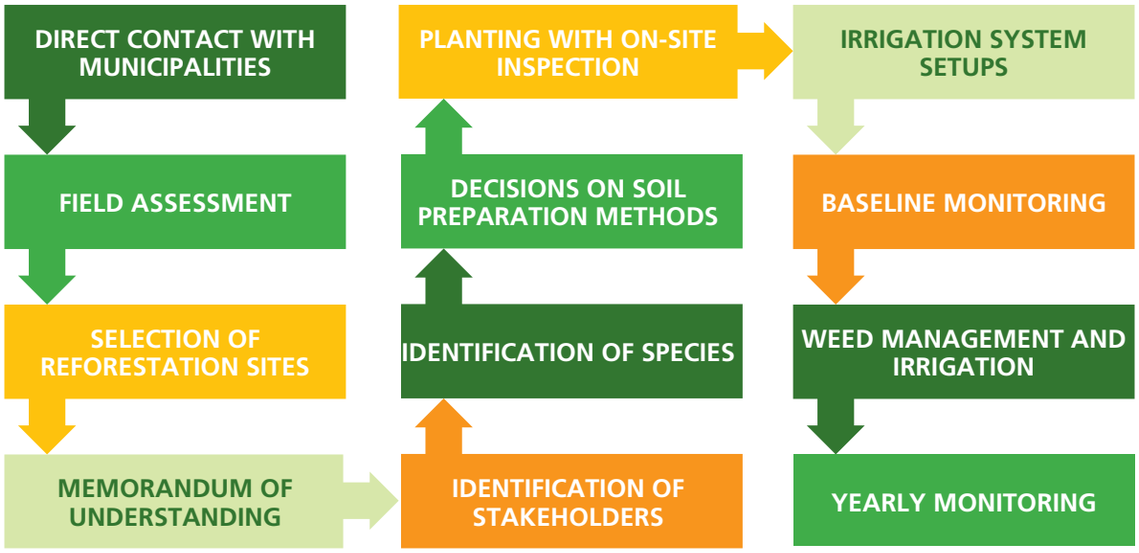


Figure 7. Sequence of events for each LRI reforestation site

In parallel to the procedure shown in figure 7 above, a community engagement strategy was developed by LRI. Community engagement activities were designed to start as early as in the field assessment phase, where a community assessment is conducted in the same time. At all sites, roundtables with major stakeholders were conducted to gauge the community's interest in reforestation and find solutions to raised issues such as shepherds grazing areas and alternatives. The community is then involved in all the planting process. After or during the planting season, the community develops a long-term action plan to protect and maintain the planted area, replicate the work done and develop activities related to the reforestation site. An existing or created environmental committee is then empowered by the community to follow-up on the application of the action plan.

Monitoring protocols used by LRI differed by site and sometimes for the same site by year. The monitoring protocol used is mentioned in the monitoring results summary table for each site and

referred to by the corresponding monitoring protocol number (1 or 2).

Seedlings status was recorded in all cases as healthy, damaged or dead. A seedling was considered healthy whenever it had a green top bud and was more than 50% green. A seedling was considered damaged when the top was still green but more than 50% of its leaves were brown or dead. Seedlings that were broken, grazed on or slightly burnt but still showed signs of survival were also considered damaged.

Notes for the Reader:

When counting survival rates, healthy and damaged seedling number were lumped together.

In the monitoring results summary tables for the sites, the percentage of damaged seedlings is represented as a percentage of total survival and not of total seedlings planted.

In the second year after planting, monitoring was conducted for all seedlings and the survival rate obtained is thus the rate of survival of all seedlings existing on the field at the time of monitoring. To see the total number of remaining seedlings at each site, please see Table 3, page 76.

Seedling survival in the field usually depends on a set of factors related to the seedlings used, planting crew performance and outplanting practices used. In some cases, other site-specific conditions and incidents such as flooding, grazing or security issues might also affect the results in the outplanting field site. In analyzing the monitoring results for each site, LRI focused mostly on the following factors:

- **Seedling quality**: high seedling quality is usually reflected by the following indicators
  - Green healthy color
  - Shoot-to-root ratio around 1
  - Height of 10 - 30 cm (based on species and container type)
  - Stem diameter of 2 - 4 mm
  - Well-hardened (usually dormant and showing large dormant buds at the time of planting)
- **Planting quality**: measured during the inspection for above- and below-ground (see Annex 1 for codes of planting quality assessment)
- **Weed management and moisture availability**: weeds compete with seedlings for moisture and can cause serious drought stress. Weeds should be controled for at least 1 m^2 around the seedling (see chapter 5 of the *Lebanon Reforestation Initiative: A Guide to Reforestation Best Practices*, for more details)
- **Other site-specific factors and incidents**: including factors related to the topography and demographics of the site, incidences of fire, grazing, or others.

II. LEBANON REFORESTATION INITIATIVE:
LARGE REFORESTATION SITES

1. AANJAR REFORESTATION SITE

1.1. SITE FACTS

Mouhafaza: Bekaa - Central

Caza: Zahle

Partners: • Municipality of Aanjar

• Society for the Protection of Nature in Lebanon (SPNL)

GPS coordinates of site entrance: 33˚44'00.64''N 35˚56'50.33''E

Elevation: 800 - 900 m

Slope: Medium – West-facing

Rockiness: High Rockiness - Large bedrocks

Soil type: Chromic luvisols[1]

1.2. SITE DESCRIPTION

The reforestation site in Aanjar is a large area of public land situated on the western slopes of the eastern Anti-Lebanon range bordering Syria. The same ridge of mountains extends into the neighboring town of Kfarzabad, where a second reforestation site is also supported by LRI.

The site has several important characteristics:

1) It is a highly rocky area with large bedrocks situated in the center of the Bekaa Valley, very close to the Syrian border, at around 800 - 900 m above sea level. The site presents the serious challenge of finding deep soil pockets that could sustain tree growth among all the large rocks from which soil has been eroded through the years.

2) It was previously covered with mature conifer trees planted by the Green Plan in the 1960's. Incidental fires and random cutting during the years left only a few trees standing around an army checkpoint. According to the municipality, a plan to reforest the whole mountain was once developed with the Syrian government. While the Syrians fulfilled their part of the deal and reforested their slopes, the Lebanese government failed to support the local municipalities in planting the Lebanese side.

3) The site faces the town and borders the road to Kfarzabad and neighboring villages and is frequented by local inhabitants and visitors for star gazing and hiking.

4) The site contains two old caves, and is viewed by the municipality as a potential destination for eco-tourism.

5) The upper section of the site constitutes one of the few habitats for an endangered local bird species, the Syrian Serin, and is recognized for that as an International Bird Area (IBA).

[1] All soil types are identified following the CNRS- Remote Sensing Center. 2006. Monograph Series no. 4. Soil Map of Lebanon 1:50,000.

1.3. OUTPANTING SPECIFICATIONS

A total of 45,940 seedlings of 14 species were planted in Aanjar over a total area of 45.2 ha. Details on planting on the Aanjar site are provided in Table 1-1 below.

Table 1-1. Outplanting information for Aanjar reforestation site

Planting season	Number of seedlings planted	Number of hectares planted	Species planted	Planting start date	Planting end date
Fall 2011	16,500	35.4	*Amygdalus sp., Acer monspessulanum, Arbutus andrachne, Cedrus libani, Celtis australis, Cercis siliquastrum, Fraxinus angustifolia, Laurus nobilis, Pinus pinea, Prunus ursina, Quercus calliprinos, Quercus infectoria*	23 Nov 2011	14 Dec 2011
Fall 2012	21,940	9.3	*Amygdalus sp., Acer microphyllum, Cupressus semperviens, Fraxinus angustifolia, Pinus brutia, Pinus pinea, Pyrus syriaca, Quercus calliprinos*	31 Oct 2012	13 Feb 2013
Fall 2013	7,500	0.5	*Amygdalus sp., Pinus brutia, Pinus pinea, Quercus calliprinos*	18 Dec 2013	14 Feb 2014
Total	45,940	45.2			

1.4. MONITORING AND INSPECTION RESULTS

Monitoring started in Aanjar in the spring of 2012 and was conducted yearly in summers of 2012, 2013 and 2014. Yearly monitoring results are shown in Table 1-2 below. The seedling survival rate was very low the first year of planting, with only 18% of seedlings surviving, 39% of which were showing clear signs of stress (classified as damage). Survival rates improved significantly in 2013, with almost 60% surviving and only 10% of those were damaged. In 2014, total survival rates of newly planted and old seedlings reached 91.47%, the majority of which were very healthy with no signs of stress or damage.

Table 1-2. Monitoring results summary for Aanjar reforestation site - 2012, 2013 and 2014

Monitoring Results	Year 2012	Year 2013	Year 2013
Yearly monitoring dates	08/22 - 08/31/2012	09/04 - 09/09/2013	06/23 - 07/11/2014
Number of days	8	4	4
Monitoring Protocol used	1	1	2
Number of Plots	313	363	947
Number of Seedlings monitored	189	432	1299
Survival rate	**18.00%**	**59.49%**	**91.47%**
Percentage of damaged seedlings out of total survival	**38.88%**	**10.00%**	**2.77%**

Planting inspections were then introduced to Aanjar (as well as to all LRI sites) in the planting season of 2012-2013 (results shown in Table 1-3 below). With an average of 15 workers per day, Aanjar crew, composed mostly of young men from the town, achieved relatively high levels of planting quality, reaching 89% with above-ground quality and 73% below-ground. The below-ground quality level is particularly remarkable knowing the inherent challenge at the Aanjar site of finding deep soil pockets. In fall 2013, inspection was conducted only through weekly visits since the planting crew was already well trained and able to perform good quality planting.

Seedlings were randomly distributed over the site and density was variable depending on the level of rockiness and soil distribution. Overall, average planting density achieved by the Aanjar planting crew was very close to the 600 seedlings/ha standard required on LRI sites.

Table 1-3. Inspection results summary for Aanjar reforestation site - planting season of 2012-2013

Inspection Metric	Result Value
Number of seedlings planted	21,940
Number of inspection days[2]	38
Average number of workers per day	15
Average worker productivity[3]	27
Average planting quality above ground[4]	89.20%
Average planting quality below ground[5]	72.70%
Average seedlings density per ha	685

Note: Footnotes in this table apply to all similar subsequent tables in this document

1.5. INTERPRETATION OF MONITORING AND INSPECTION RESULTS

Seedling survival results and their variation year-to-year can be interpreted by changes in seedling quality, planting quality, weed management, and moisture or other site-related factors. Below is a summary description of each of those factors and their effect on seedling survival.

a. Seedling quality

There were numerous issues with seedling quality, storage and handling during the 2011 planting season. Seedlings planted at the Aanjar site were removed from their containers and placed in plastic bags prior to shipping to the site. Bags were then stacked horizontally in cardboard boxes and sent to Aanjar where they were stored in a closed room adjacent to the site. The horizontal stacking of seedlings inside their bags caused several to lose the substrate around their roots. Mold started to grow inside bags due to high moisture.

In addition, seedlings were not well hardened and shoot-to-root ratios were above 4 for most of the pine seedlings. Consequently, seedling moisture requirements were very high when they were transferred to the site. With the dry weather of Central Bekaa, water stress affected seedlings very early after they were planted and mortality started as early as the baseline monitoring dates in the spring.

During the following planting seasons (2012 and 2013), seedlings were grown in deepots (D40 for pine seedlings) and were transported in their containers to the planting site in a covered truck equipped with shelves to minimize damage. The LRI seedling production protocol was followed for all seedlings sent to Aanjar and the trees were hardened and had shoot-to-root ratios between 1 and 2.

Figure 1-1. J-rooted seedling removed from Aanjar site in summer 2012

b. Planting quality

Because inspections were not done during the 2011 planting season, no data is available. However, j-rooting (Fig. 1-1) and shallow planting were noted during site visits. The limited experience of the planting crew, combined with extremely rocky conditions, resulted in poor planting, which in turn contributed to poor seedling survival.

[2] Inspections were not carried out during weekends and therefore the number of inspection days is lower than the actual number of planting days.

[3] Average productivity is calculated based on daily productivity recorded for each inspection day. Worker productivity on a given day = number of seedlings planted / total crew size. Ideally, only workers who are planting should be counted, but because workers often mixed roles (not all were always planting trees) the entire crew was included in the calculation.

[4] Percentage of planting quality above ground = number of seedlings showing good quality planting seen above-ground / total number of seedlings inspected *100.

[5] Percentage of planting quality below ground = number of seedlings showing good quality planting when roots underground are exposed / total number of seedlings inspected below-ground *100

In 2012, daily inspection of planting quality allowed for better tracking of planting issues and quick on-site feedback and correction of mistakes. This lead to a slight increase in worker productivity, mostly noticeable at the end of the planting season (Fig. 1-2). Below-ground planting quality also improved clearly during the season as a result of continuous feedback and daily briefing of planting workers (Fig. 1-3). Although J-rooting was still noticed in some seedlings, the rate was much lower than the previous year and decreased gradually during the planting season.

Figure 1-2. Changes in worker productivity in Aanjar during the planting season of 2012-2013 based on inspection data

Figure 1-3. Changes in planting quality above and below ground in Aanjar during the planting season of 2012-2013 based on inspection data

In the fall of 2013, planting was done only to replace dead seedlings across the site. Weekly inspection visits were conducted only to ensure planting quality was maintained and to check on seedling stocks and worker needs.

c. Weed management and moisture availability

In Aanjar, weeds were previously controlled by grazing. Protection of the site from grazing has resulted in increased vegetation (mostly grass) which competed seriously with seedlings for limited moisture.

In 2011-2012, stone mulching was used to reduce weeds around seedlings. However, the implementation of the stone mulching was not satisfactory. Monitoring results of mulching status showed that 8% of seedlings had no mulching. Rock mulching was inadequate (less than 1 m^2 of rock cover around seedling) for 83% of seedlings sampled. In addition, the set-up of the irrigation system by the provider company was delayed for logistical reasons and the first irrigation was started in late May-early June, using water trucks. Subsequent irrigations were done using the installed drip irrigation system.

Figure 1-4. One-year-old seedling planted in Aanjar site in 2012 - photo taken in 2013 showing the drip irrigation system already set

In 2012-2013, weeds were scalped in the spring for around 1 m^2 around each seedling for a large proportion of the site. The irrigation system, installed the previous year, was used to irrigate the seedlings early into the dry season, which prevented any drought stress (Fig. 1-4).

Only one area at the edge of the site was left without irrigation for trial purposes and seedlings planted above the irrigation system were irrigated only once. As shown in figure 1-7 below, mortality in 2013 was mostly concentrated in those two areas, which reflects the high effect of moisture in seedling survival.

Based on the clear difference in seedling survival between irrigated and non-irrigated areas and between the first year with serious drought stress and the following years when irrigation was applied on time, the moisture factor was found to be, along with seedling quality, a major cause of seedling mortality in the reforestation site in Aanjar.

d. Other site-specific factors and incidents

In the first week of June 2013, a small brush fire was started accidentally on the LRI reforestation site in Aanjar, close to an LAF checkpoint. The fire burned an area of approximately 2 ha, with an estimated loss of about 1,000 seedlings. The team of youth who worked with LRI on planting and maintenance activities in Aanjar played a major role, along with Civil Defense, in extinguishing the fire. Dirt roads within the site acted as effective fire breaks and stopped the fire from spreading further. Seedlings that had a full 1 m^2 of area scalped around them were able to survive the fire. LRI technical staff coordinated with the local forest guard and had the burned area well irrigated immediately following the fire. Surviving seedlings already appeared in good shape by the following week.

In summary, seedling quality, planting quality and moisture stress could have all contributed to the high seedling mortality observed in the summer of 2012. Further mortality seen in the non-irrigated section of the site in 2013, when higher quality seedlings were used and planting quality was improved by daily planting inspections, reinforces the importance of moisture for seedling survival. Improvements accomplished during the planting season of 2012 in the three factors listed above positively correlate with the improvement in seedling survival by the end of summer 2013, suggesting that a combination of good seedling quality, good planting quality and good moisture are needed to achieve successful reforestation in sites similar to Aanjar.

1.6. MONITORING MAPS OF AANJAR SITE

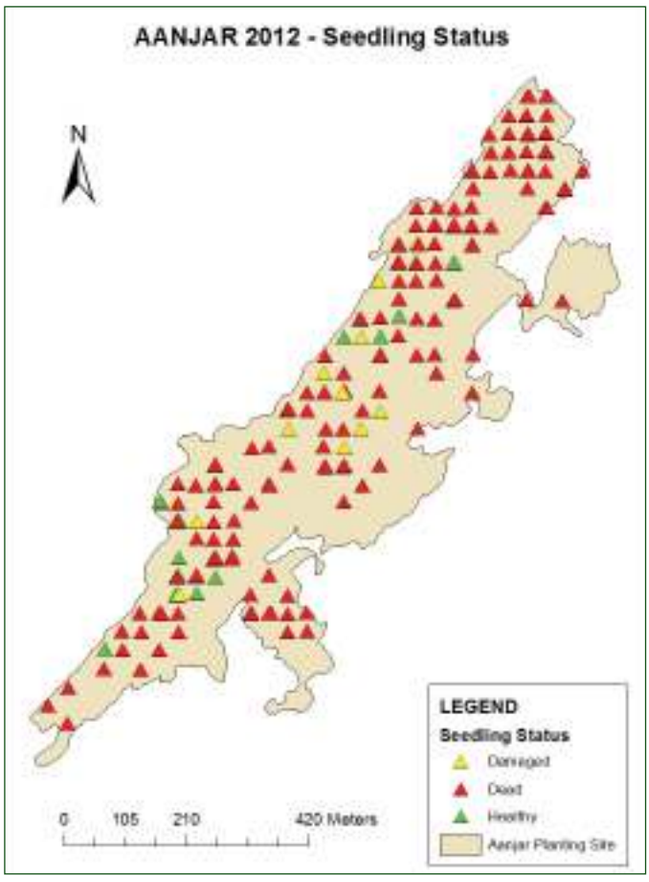


Figure 1-5. Seedling status map of Aanjar reforestation site based on the yearly monitoring data - summer 2012

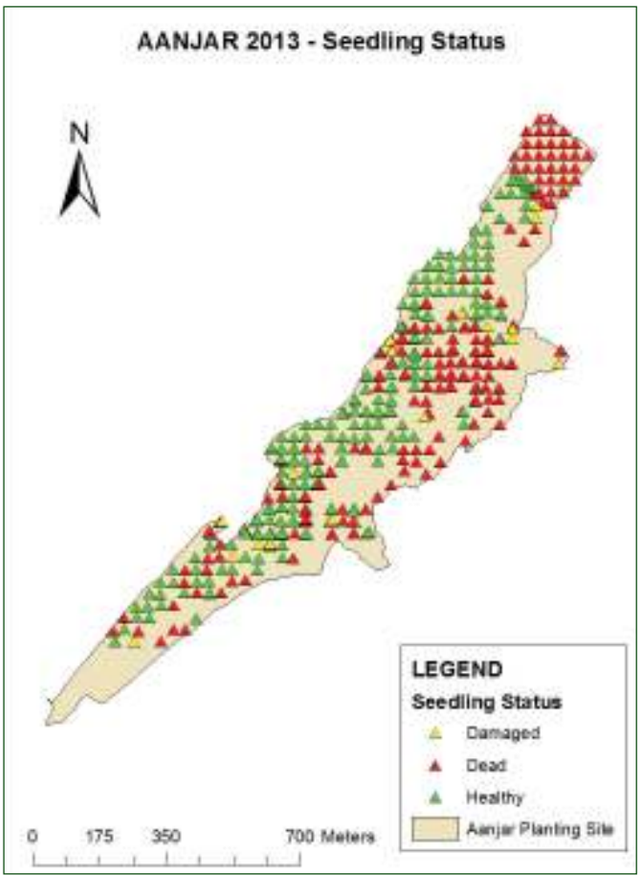


Figure 1-6. Seedling status map of Aanjar reforestation site based on the yearly monitoring data - summer 2013

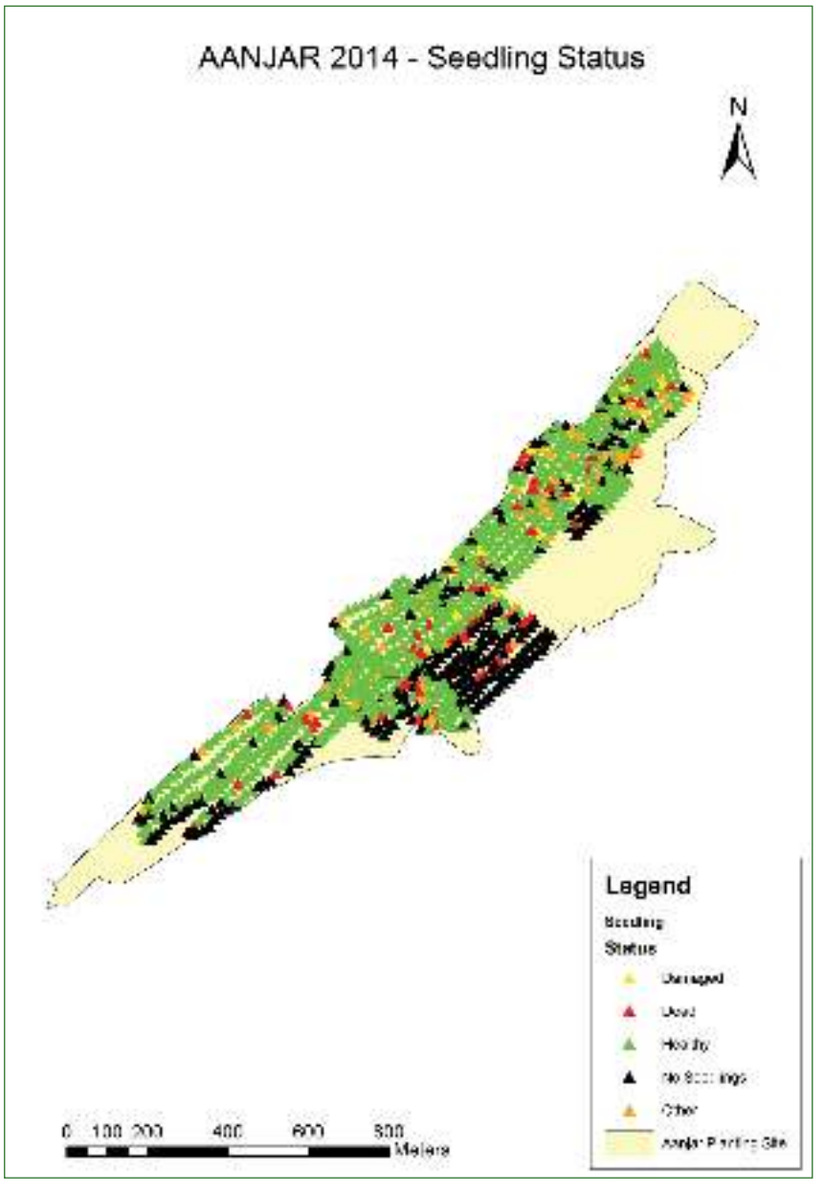


Figure 1-7. Seedling status map of Aanjar reforestation site based on the yearly monitoring data - summer 2014

2. AINATA REFORESTATION SITE

2.1. SITE FACTS

Mouhafaza: Baalbeck - Hermel

Caza: Baalbeck

Partners: • Municipality of Ainata

• Center for Development, Democracy and Governance (CDDG)

GPS coordinates of entrance: 34°11'25.88''N 36°04'30.61''E

Elevation: 1,640 -1,780 m

Slope: Medium on top hill, high on bottom

Rockiness: Medium - gravel on surface

Soil type: Chromic luvisols

2.2. SITE DESCRIPTION

Reforestation in Ainata started in 2012 and was done in two sites. The first site, called the "Hill of the Cross", is a steep area facing the town, and more precisely the town's church. The municipality insisted to reforest the hill and local workers, a group of young men and women, did an amazing job planting it all by hand. The hill is very rocky and the upper sections have little soil left, so planting was done in places where the soil was deep enough.

The second site is a higher elevation hill behind the first one, partially hidden from the town, but nicely located in the middle of the mountain range separating Ainata from Bcharre. The hill next to it has some regenerating junipers, thought to be transmitted by birds from the facing hills of Aaqoura. Both sites are covered with small gravel and have almost only rhubarb plants.

The site has several important characteristics:

1) It forms an extension of the western slope forests in Bcharre.

2) It covers part of a large barren area that is at high risk of erosion.

3) Bird migration area in need of bird habitat.

4) Significant water holding capacity from melting snow.

2.3. OUTPLANTING SPECIFICATIONS

A total of 34,061 seedlings of 10 species were planted in Ainata over a total area of 22.91 ha. Details on planting on the Ainata site are provided in Table 2-1 below.

Table 2-1. Outplanting information for Ainata reforestation site

Year	Nb of seedlings planted	Nb of hectares planted	Species planted	Planting start date	Planting end date
1	22,811	22.31	*Abies cilicica, Cedrus libani, Quercus cerris, Acer syriacum, Acer tauricolum, Pistacia palaestina, Sorbus flabellifolia, Crataegus monogyna, Ostrya carpinifolia, Sorbus torminalis*	30 Oct 2012	03 Dec 2012
2	11,250	0.6	*Amygdalus sp., Cedrus libani, Quercus cerris*	23 Oct 2013	08 Dec 2013
Total	34,061	22.91			

2.4. MONITORING AND INSPECTION RESULTS

Since the Ainata site was first planted in fall 2012, two years of monitoring results are available (Table 2-2). The overall survival rate shown in Table 2-2 below is calculated for both sites shown in the monitoring map (Fig. 3-4). However, survival was highly variable among sites. The "Hill of the Cross", shown on the lower right side of the map, which had an installed drip irrigation system and was planted first with a majority of cedars, had a 70.93% survival rate; while the upper hill shown on the left lower site of the map and planted with cedars and oak mostly, did not have drip irrigation, was irrigated late in the season with water trucks, and had only 49.2% survival. Almost all oak seedlings planted in that upper hill died and all seedlings planted in the no-irrigation trial area died.

Table 2-2. Monitoring results summary for Ainata reforestation site - 2013 and 2014

Monitoring Results	Year 2013	Year 2013
Yearly monitoring dates	10/09/2013 - 10/10/2013	11/08/2014 - 12/08/2014
Number of days	2	2
Monitoring protocol used	2	2
Number of plots	218	449
Number of seedlings monitored	215	918
Survival rate	**43.80%**	**83.18%**
Percentage of damaged seedlings out of total survival	**1.06%**	**3.87%**

Planting inspections were conducted in Ainata during the planting seasons of fall 2012 and 2013. Workers planting in Ainata were young people from the town, some of them agriculture engineering students. Worker productivity was high compared to other sites, with an average above 50 seedlings/worker/day (Table 2-3). This average is particularly remarkable considering the harsh topography of the site, its steepness and level of surface gravel that makes it very hard to navigate.

Worker performance was also relatively high. The relatively low value of 57.58% of the below-ground planting quality was mostly due to the presence of gravel in the planting hole. However, the Ainata site soil is full of gravel and it is almost impossible to have a planting hole with clean soil (Fig. 2-1).

Figure 2-1. Cedar seedling planted in Ainata – fall 2012. Photo shows the amount of gravel in the soil

In the fall of 2013, planting was done to replace dead seedlings across the site and to expand the planted area. Daily inspections were carried out by the same inspector who was given a second briefing on the planting protocol at the start of the planting season. The planting crew was the same as the previous year, with a slightly smaller crew size. As shown in Table 2-3, planting quality improved from 2012 and 2013. The increase in the average planting quality below-ground was partly due to improved planting practices of the workers and partly to adjustments made in 2013 to the inspection protocol to take in consideration the high level of gravel in Ainata's soil.

Planting density was very high in Ainata, with more than 1,000 seedlings per ha in 2012. Although advised otherwise, the Ainata planting crew preferred to plant a higher density to limit the need for replacing dead seedlings during the following season, especially because of the steepness of the site. Density was much higher in the Hill of the Cross (steeper site) than on the upper hill.

Table 2-3. Inspection results summary for Ainata reforestation site - planting seasons of 2012 and 2013

Inspection Metric	Result Value 2012	Result Value 2013
Number of seedlings planted	22,811	11,250
Number of inspection days	22	7
Average number of workers per day	18	12
Average worker productivity	57	54
Average planting quality above ground	84.37%	95.12%
Average planting quality below ground	57.58%	80.95%
Average seedlings density per ha	1076	1076

2.5. INTERPRETATION OF MONITORING AND INSPECTION RESULTS

Below is a summary analysis of the factors affecting seedling survival in Ainata and that could have accounted for the difference in seedling survival among the two planting sites, the Hill of the Cross and the upper hill.

a. Seedling quality

Seedlings planted in Ainata in fall 2012 in the two larger sites differed in provenance and composition.

- The Hill of the Cross received seedlings from one nursery (Nursery A), with a majority of cedars. The upper hill received *Quercus cerris* seedlings from Nursery A and *Sorbus*, *Crataegus* and *Ostrya* spp. from Nursery B.
- Seedlings were in general well-hardened when delivered to the site. Broadleaf species seedlings were dormant and cedar seedlings had large dormancy buds.

b. Planting quality

Planting quality was in general good for Ainata. As shown in figure 2-2, worker productivity increased during the planting season.

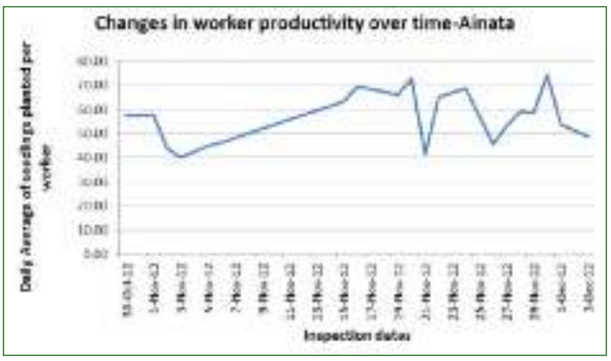


Figure 2-2. Changes in worker productivity in Ainata during the planting season of 2012-2013 based on inspection data

Figure 2-3. Changes in planting quality above and below ground in Ainata during the planting season of 2012-2013 based on inspection data

Below-ground mistakes done at the beginning of the season were fixed and planting quality improved considerably by early December 2012 (Fig 2-3). Overall, average planting quality above and below-ground was the same for both sites in Ainata (data not shown), suggesting that planting quality had no effect on seedling survival in this case.

c. Weed management and moisture availability

In Ainata, weeds are not much of an issue because of the amount of surface gravel that creates natural mulch over the whole site.

Moisture, however, can be an important factor affecting seedling survival. The Ainata hills are located on the eastern side of Mount Lebanon. They are steep and their soil contains high proportions of gravel, which reduces the water holding capacity of the soil. Although the hills receive significant snow in the winter, very little of that moisture persists later in the summer, which is usually very dry and hot in that area. Seedlings left without irrigation and observed in late June - early July were showing signs of drought stress. A small section left non-irrigated had 100% mortality at the end of the summer. The rest of the upper hill was irrigated with water trucks only twice durind the dry season, compared to the Hill of the Cross, where a drip irrigation irrigation system was installed, and where seedlings were irrigated more than four times during that same summer.

d. Other site-specific factors and incidents

The site surface gravel and steepness create a natural protection for the seedlings from weed competition. Grazing was only an issue on one side of the site, which was later fenced to avoid seedling damage and problems with shepherds.

In summary, neither seedling quality nor planting quality were different among the two sites, and thus could not have affected the observed difference in seedling survival. Moisture, however, was significantly variable between the Hill of the Cross irrigated with drip irrigation and the upper hill that is more exposed to direct sunlight and was irrigated fewer times, with water trucks. As a result, we believe that moisture stress was the major factor affecting survival and causing the difference in mortality rates between the two sites.

2.6. MONITORING MAPS OF AINATA SITE

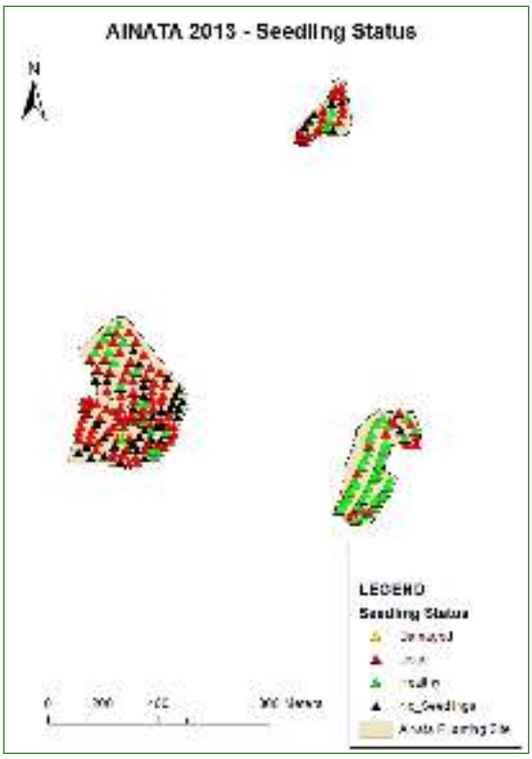


Figure 2-4. Seedling status map of Ainata reforestation site based on the yearly monitoring data - summer 2013

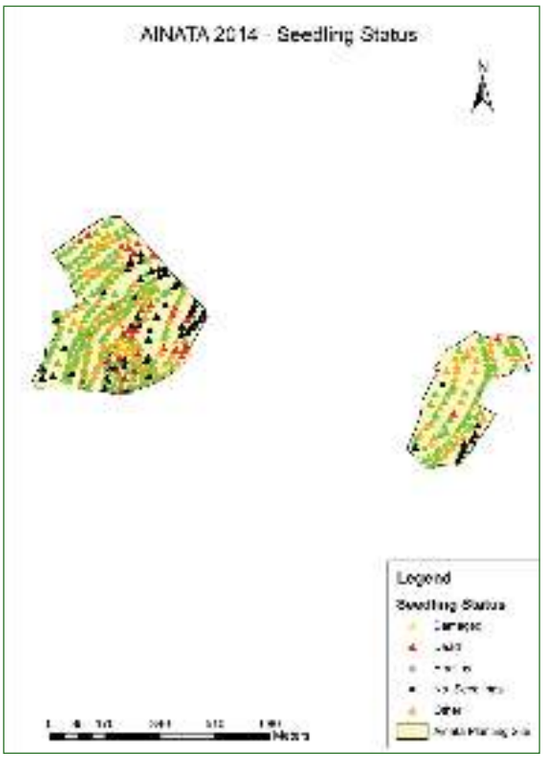


Figure 2-5. Seedling status map of Ainata reforestation site based on the yearly monitoring data - summer 2014

3. BCHARRE REFORESTATION SITE

3.1. SITE FACTS

Mouhafaza: North Lebanon

Caza: Bcharre

Partners: • Municipality of Bcharre

• Committee of the Friends of the Cedar Forests of Bcharre

GPS coordinates of entrance: 34°13'58.19''N 36°03'58.95''E

Elevation: 2,000 - 2,400 m

Slope: Medium to high

Rockiness: Surface rockiness low - stoniness medium

Soil type: Haplic Luvisols (LVha) with associated Haplic Calcisols (CLha) and Petric Calcisols (CLpt)

3.2. SITE DESCRIPTION

Reforestation in Bcharre was started earlier through different funding sources by the Committee of the Friends of the Cedar Forests - Bcharre (CFC). LRI and CFC worked together in fall 2013 on an extension of the sites already reforested, all being extensions of the existing old cedar forest.

The site has several important characteristics:

1) Rich deep soil.

2) Varying topography that leads to intra-site variations.

3) Bcharre is a location with high symbolic value for all Lebanese because of the old Cedars of God trees located there (and a major touristic attraction).

4) The CFC members are highly experienced in planting and have conducted successful reforestation in the past (higher chance of replicating success).

5) LRI is working with the CFC nursery and planting in Bcharre provides a unique example of linking planting to seedling production.

3.3. OUTPLANTING SPECIFICATIONS

To date, 38,206 seedlings of four native species have been planted in Bcharre over a total area of 86.39 ha. Details on planting on the Bcharre site are provided in Table 3-1 below.

Table 3-1. Outplanting information for Bcharre reforestation site

Year	Nb of seedlings planted	Nb of hectares planted	Species planted	Planting start date	Planting end date
1	25,286	56	*Acer tauricolum, Cedrus libani, Quercus cerris, Ostry carpinifolia*	19 Oct 2012	06 Nov 2012
2	12,920	30.39	*Cedrus libani*	22 Oct 2013	17 Nov 2013
Total	38,206	86.39			

3.4. MONITORING AND INSPECTION RESULTS

The Committee of the Friends of the Cedar Forests - Bcharre (CFC) has a long experience in planting compared to other LRI partners. This experience has facilitated the planting process and led to a successful collaboration.

The model used in Bcharre was also different from other sites. The planting was not done by trained community members mostly because local hand labor is hard to find in Bcharre in the fall season. Instead, CFC contracted both digging and planting to a local contractor with whom they've successfully completed previous planting projects.

Planting in Bcharre started in 2012 and thus two years of monitoring data are available to date (see Table 3-2). The survival rate in Bcharre was one of the highest for the 2012 planting season, with 82.04% of seedlings planted surviving and healthy and only around 3% of the surviving seedlings showing signs of damage. The following year, the survival rate increased further to reach 90.64% at the end of summer 2014.

Table 3-2. Monitoring results summary for Bcharre reforestation site – 2013 and 2014

Monitoring Results	Year 2013	Year 2014
Yearly monitoring dates	08/12/2013 - 08/14/2013	08/20/2014 - 09/02/2014
Number of days	3	7
Monitoring protocol used	2	2
Number of plots	460	242
Number of seedlings monitored	451	652
Survival rate	**82.04%**	**90.64%**
Percentage of damaged seedlings out of total survival	**2.97%**	**5.52%**

Inspections were carried out in Bcharre by two different local inspectors trained by LRI for 2012 and 2013 planting seasons.

Worker productivity in Bcharre was also remarkably high for both seasons. On average, each worker planted around 115 seedlings per day in 2012 and 117 in 2013 (Table 3-3). These averages are far above the other sites, probably due to the long experience of the planting crew in reforestation and to the strong supervision of the contractor who was always present on site to follow up on the work. Planting quality was also high, again reflecting the experience of the planting crew (Table 3-3). Average planting quality was lower in 2013 both for above- and below-ground parameters. Above-ground planting mistakes in 2013 were mostly related to seedlings planted too deep or too shallow, while the most common below-ground mistake was the presence of rocks in the planting hole, which is hard to avoid completely in a rocky site such as the Bcharre sites planted in 2013. The change of inspectors could have also accounted for part of the difference in inspection results, especially below-ground, since the assessment of the proportion of rocks in the planting hole could be subjective and could thus differ from one inspector to the other.

Planting density was highly different between 2012 and 2013. In 2012, the number of seedlings planted was low compared to the area provided, so the planting crew abided by the suggested average density of 400-500 seedlings per ha. In 2013, the density was almost double that of 2012, which could be due to change in members of the planting crew or to changing site conditions.

Table 3-3. Inspection results summary for Bcharre reforestation site - planting season of 2012 and 2013

Inspection Metric	Result Value 2012	Results Value 2013
Number of seedlings planted	25,286	12,920
Number of inspection days	18	11
Average number of workers per day	11	8
Average worker productivity	115	117
Average planting quality above-ground	81.79%	77.67%
Average planting quality below-ground	91.61%	70.00%
Average seedlings density per ha	384	798

3.5. INTERPRETATION OF MONITORING AND INSPECTION RESULTS

Below is a summary analysis of the factors that could have led to the observed good seedling survival rate in Bcharre.

a. Seedling quality

Seedlings planted in Bcharre were almost all produced in the CFC nursery, also located in Bcharre, except for a small quantity transported from another nursery. This reduced seedling stress related to transportation or change in weather conditions between the nursery and the planting site.

Moreover, seedlings produced in the CFC nursery in 2012 had an final stem height of 15.1 cm, collar diameter of 2.75 mm and a shoot-to-root ratio close to 1 (refer to "Lebanon Reforestation Initiative: Native Tree Nurseries Culturing Practices and Results" for more details), which all show very good seedling quality. Seedlings were well hardened with well-developed dormancy buds. Seedlings planted in 2013 had even higher quality than those of 2012, due to improved experience of the Bcharre nursery team.

b. Planting quality

Planting quality averages were high in 2012, showing very good planting performance of the crew, in addition to their high productivity. As shown in figure 3-1, worker productivity fluctuated throughout the season, reaching 200 seedlings/worker/day in one day and never falling below the 50 seedlings/worker/day average productivity rate for LRI sites. This high productivity did not affect planting quality that improved fast after the first few days of planting and almost stabilized around 100% well-planted seedlings below ground and over 85% above ground (Fig. 3-2). Although planting quality was slightly lower in 2013, it did not seem to affect the seedling survival rate, which reinforces the potential effect of the change of inspector on result values.

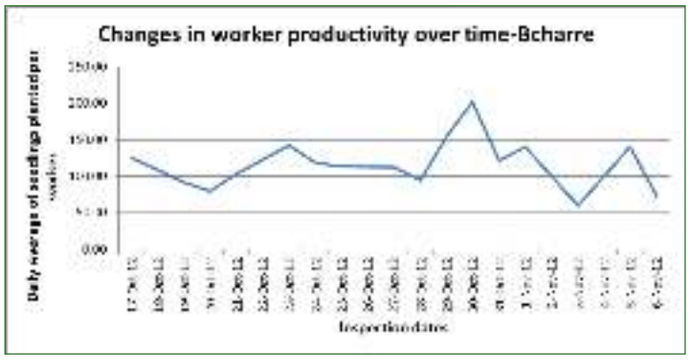


Figure 3-1. Changes in worker productivity in Bcharre during the planting season of 2012-2013 based on inspection data

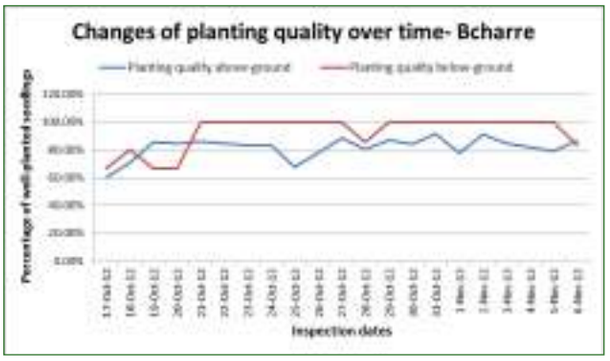


Figure 3-2. Changes in planting quality above ground and below ground in Bcharre during the planting season of 2012-2013 based on inspection data

c. Weed management and moisture availability

In Bcharre, weeds were not considered an issue. Weed populations are moderate and suppressed in most areas by surface rocks.

The site was irrigated from a pond made and maintained by CFC (Fig. 3-3). Irrigation was done by hand by the same contractor's crew. Seedlings were irrigated four times in summer 2013 and CFC was supervising the irrigation to ensure all seedlings are well-irrigated.

Figure 3-3. Pond used to irrigate the surrounding planting site in Bcharre – photo taken in September 2012 before the lining and the irrigation system were added

d. Other site-specific factors and incidents

All planting activities went smoothly in Bcharre, with no noted incidents.

Overall, we believe that the good seedling quality, proximity of the nursery to the planting site, the experience of the planting crew, and the availability of soil moisture and irrigation, all contributed to the good survival results seen in the Bcharre site for the planting season of 2012-2013.

3.6. MONITORING MAPS OF BCHARRE SITE

Figure 3-4. Seedling status map of Bcharre reforestation site based on the yearly monitoring data - summer 2013

Figure 3-5. Seedling status map of Bcharre reforestation site based on the yearly monitoring data - summer 2014

4. KFARDEBIANE REFORESTATION SITE

4.1. SITE FACTS

Mouhafaza: Mount Lebanon

Caza: Kesrwan

Partners: • Municipality of Kfardebiane

• Jouzour Loubnan

GPS coordinates of entrance: 34°00'34.64''N 35°53'03.36''E

Elevation: 2,020 - 2,050 m

Slope: Numerous hills with medium slopes

Rockiness: High

Soil type: Haplic Luvisols (LVha) with associated Haplic Calcisols (CLha) and Petric Calcisols (CLpt)

4.2. SITE DESCRIPTION

The Kfardebiane planting site is situated on the left side of the road leading from Kfardebiane-Mzaar to the neighboring village of Aaqoura, on rocky hills fluctuating between 2,020 to 2,050 m in altitude. The site is very rocky and suitable only for junipers and cedars. It is right next to a ski resort, in a major all-terrain vehicle (ATV) area, in a highly touristic zone. The area is also frequented for bird hunting and hiking.

Fencing was required to protect the seedlings from grazing and other outdoor activities that might harm the seedlings, such as ATV use.

Junipers were planted on the upper parts of the hills, while cedars were planted in the valleys.

This site presents a different model of partnership since LRI's direct partner was the NGO Jouzour Loubnan which had an agreement with the municipality. Implementation was based on a contracting model with the NGO.

4.3. OUTPLANTING SPECIFICATIONS

A total of 63,450 seedlings of two species were planted in Kfardebiane over a total area of 130 ha. Details on planting on the Kfardebiane site are provided in Table 4-1 below. In 2012, LRI contributed only part of the seedlings and all reforestation activities were carried out by Jouzour Loubnan. Consequently, only limited information will be presented below for the 2013-2014 planting season.

Table 4-1. Outplanting information for Kfardebiane reforestation site

Year	Nb of seedlings planted	Nb of hectares planted	Species planted	Planting start date	Planting end date
1	41,350	117	*Cedrus libani, Juniperus excelsa*	10 Oct 2012	21 Nov 2012
2	22,100	13	*Cedrus libani, Juniperus excelsa*	23 Oct 2013	08 Dec 2013
Total	63,450	130			

4.4. MONITORING AND INSPECTION RESULTS

Similar to all sites planted first in 2012, two year of monitoring data are available. Those results are represented in Table 4-2 below. The overall survival rate was around 69% in 2013, with higher mortality in cedar seedlings than in junipers. This rate dropped further in 2014 to reach 45%.

Table 4-2. Monitoring results summary for Kfardebiane reforestation site - 2013 and 2014

Monitoring Results	Year 2013	Year 2014
Yearly monitoring dates	09/25/2013 - 09/27/2013	
Number of days	3	
Monitoring Protocol used	2	
Number of Plots	783	
Number of Seedlings monitored	555	
Survival rate	68.65%	45.00%
Percentage of damaged seedlings out of total survival	14.69%	

Inspection was conducted in fall 2012 by a trained local agricultural engineer during the planting season. To ensure completion of planting in the narrow planting window available between the first rain and the first heavy snow, Jouzour Loubnan's contractor hired three planting crews with supervisors towards the middle of the planting season. This slightly complicated the inspection process since crews were planting in different areas across the large site. Despite the challenges and the number of crews planting, average above-and below-ground planting quality were both higher than 90%. Average worker productivity was also among the highest across all sites, with 93 seedlings planted per worker per day. Planting density was very much affected by the level of rockiness of the site and maintained a low average of 423 seedlings per ha. No inspection was done in 2013. LRI conducted scattered inspection visits to check on planting progress mostly.

Table 4-3. Inspection results summary for Kfardebiane reforestation site - planting season of 2012-2013

Inspection Metric	Result Value
Number of seedlings planted	41,350
Number of inspection days	33
Average number of workers per day	20
Average worker productivity	93
Average planting quality above-ground	90.61%
Average planting quality below-ground	96.61%
Average seedlings density per ha	423

4.5. INTERPRETATION OF MONITORING AND INSPECTION RESULTS

The survival rate in Kfardebiane was slightly less than 70%. Factors that could have affected seedling survival in 2012-2013 include:

a. Seedling quality

Mortality in the field was mostly observed for cedar seedlings. Those were all purchased from one nursery. For lack of adequate numbers of cedar seedlings grown in LRI-provided deepots, seedlings sent to Kfardebiane were grown in 120 and 150 cc containers. Shoot-to-root ratios were higher than 1. Seedlings were removed from their containers, stored in plastic bags horizontally inside cardboard boxes and shipped as such to the field site. Seedlings were found to have lost some of their substrate when retrieved from the bags due to storage conditions and the horizontal stacking of the bags. In addition, they were not well hardened.

Figure 4-1. Cedar seedling roots damaged by inadequate packing and transportation

On the other hand, juniper seedlings were kept at a local nursery where they were grown for several months before planting. They were better adapted to the local conditions and did not undergo transportation stress.

Later studies on species distribution also showed that the Kfardebiane (Ouyoun el Simane) area is more suitable for junipers than cedars. Besides the low seedling quality, the choice of species could have played a role in the high mortality of cedars on the site.

b. Planting quality

Crews hired for planting were experienced in tree planting and their experience was reflected in relatively high planting quality (Table 4-3). Planting quality was only slightly lower when volunteers were recruited to plant during specific days.

Average worker productivity was the second highest among all sites, also mostly due to the experience of the planting crew and the continuous presence of the supervisors. An improvement in worker productivity can be seen in November compared to earlier planting days in October 2012 (Fig. 4-1), reflecting the positive impact of daily planting inspections.

Figure 4-2. Changes in worker productivity in Kfardebiane during the planting season of 2012-2013 based on inspection data

Figure 4-3. Changes in planting quality above- and below-ground in Kfardebiane during the planting season of 2012-2013 based on inspection data

Worker performance was very high, probably due to the long experience of the hired crews. The two peaks with lower planting quality, both above and below ground, shown in figure 4-2, correspond to days when volunteer activities were carried out. Major mistakes done on those days were later fixed by the hired planting crew.

c. Weed management and moisture availability

Weeds were not much of an issue the first year since the site was overgrazed and too rocky. Soil preparation by workers included removal of small shrubs from the planting spots, which also reduced competition with the seedlings.

However, moisture issues in the Kfardebiane site were mostly due to delays in installing the irrigation system, which was partly caused by the presence of snow on site for an extended period of time and partly by the logistics of designing and installing such a system on a large piece of land with several hills of equal altitude. The summer of 2013 was particularly dry and temperatures rised quickly after snow melt. This lead to serious drought stress of the seedlings and cracking of the soil surface (Fig. 4-4)

Figure 4-4. Cedar seedling surviving the drought. Photo taken in late May 2013 shows soil cracking due to drought

d. Other site-specific factors and incidents

Beside the more technical factors, problems with shepherds in Kfardebiane led to serious grazing issues that affected more than 5 ha of the fenced area (Fig. 4-5). Problems were later solved by changing the fence location and releasing half of the previously fenced area back for grazing.

Figure 4-5. Cedar seedling showing signs of grazing – Kfardebiane - June 2013

In summary, the 30% mortality observed in Kfardebiane is probably due to the combination of lower quality seedlings, inadequate seedling storage and transportation conditions, inadequate choice of species and drought. Grazing also contributed to the loss of about 2,000 seedlings.

4.6. MONITORING MAPS OF KFARDEBIANE SITE

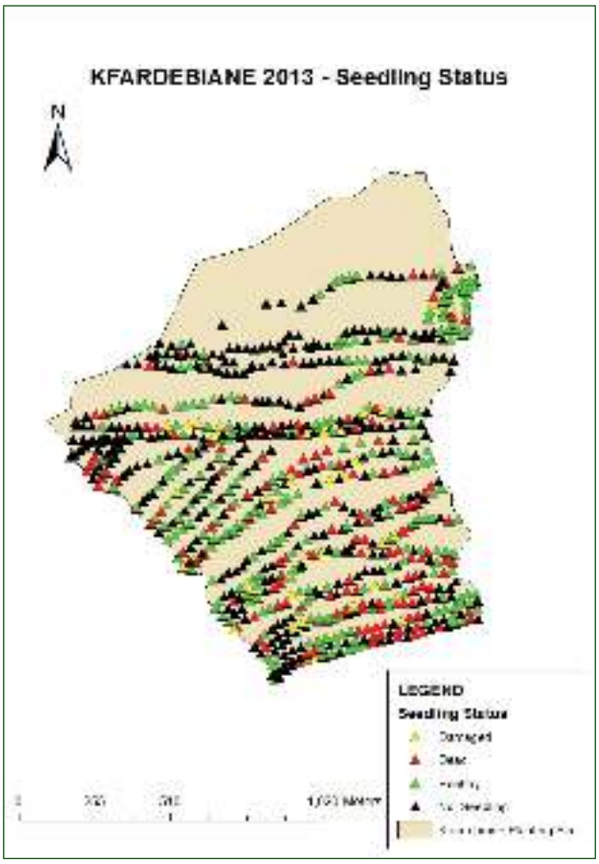


Figure 4-6. Seedling status map of Kfardebiane reforestation site based on the yearly monitoring data - summer 2013

5. KFARZABAD REFORESTATION SITE

5.1. SITE FACTS

Mouhafaza: Bekaa - Central

Caza: Zahle

Partners: • Municipality of Kfarzabad

• Society for the Protection of Nature in Lebanon (SPNL)

GPS coordinates of entrance: 33°45'45.97''N 35°59'26.96''E

Elevation: 1,100 - 1,250 m

Slope: Medium – West-facing

Rockiness: Medium - less rocky than Aanjar

Soil type: Chromic Luvisols

5.2. SITE DESCRIPTION

The reforestation site in Kfarzabad is a part of the large extent of public land situated on the western slopes of the eastern Anti-Lebanon range bordering Syria. Since the land is extensive, LRI chose, with guidance from the municipality, two hills facing the town for the reforestation site.

The site has several important characteristics:

1) It is an extension to the Aanjar important bird area (IBA).
2) The site faces the town and the municipal building.
3) If reforested, the site will represent an incentive for Kfarzabad people to extend the reforestation on both sides.
4) The combination of Aanjar and Kfarzabad presents a unique experience in terms of creating habitat and biocorridors for wildlife and on the social side, encouraging collaboration between two neighboring communities with diverse political and social backgrounds.

5.3. OUTPLANTING SPECIFICATIONS

A total of 38,040 seedlings of 15 species were planted in Kfarzabad over a total area of 31.70 ha. Details on planting on the Kfarzabad site are provided in Table 5-1 below.

Table 5-1. Outplanting information for Kfarzabad reforestation site

Year	Nb of seedlings planted	Nb of hectares planted	Species planted	Planting start date	Planting end date
1	16,500	22.82	*Amygdalus sp., Acer monspessulanum, Arbutus andrachne, Celtis australis, Ceratonia siliqua, Cercis siliquastrum, Fraxinus angustifolia, Laurus nobilis, Pinus pinea, Quercus calliprinos, Quercus infectoria*	24 Nov 2011	15 Dec 2011
2	21,540	8.88	*Amygdalus sp., Acer microphyllum, Cupressus semperviens, Fraxinus angustifolia, Pinus brutia, Pinus halepensis, Pinus pinea*	30 Oct 2012	08 Feb 2013
Total	38,040	31.70			

5.4. MONITORING AND INSPECTION RESULTS

The LRI reforestation project in Kfarzabad has faced since 2011 several challenges that limited its potential for success. Although the community was first motivated to reforest their land, internal town conflicts, the security issue on the Syrian border located too close to the site, and other more technical factors have resulted in a low survival rate both in 2012 and 2013 and in a complete mortality in 2014 (see Table 5-2). Due to security issues, the site remained inaccessible to LRI employees and to local workers and forest guards, which rendered further work on that site impossible.

Table 5-2. Monitoring results summary for Kfarzabad reforestation site - 2012, 2013 and 2014

Monitoring Results	Year 2012	Year 2013	Year 2014
Yearly monitoring dates	09/01/2012- 09/07/2012	08/20/2013 - 08/22/2013	Aug 2014
Number of days	6	2	
Monitoring protocol used	1	2	
Number of plots	239	295	
Number of seedlings monitored	183	492	
Survival rate	16.00%	22.97%	All dead
Percentage of damaged seedlings out of total survival	75.00%	10.00%	

In 2011, inspection data were not available. However, field visits during the planting season revealed a serious issue with land preparation that led to several mistakes in planting. The excavator used to prepare the planting hole had created, despite the training given to the operator on the first day of work, large deep holes that became very hard for the workers to refill with soil. This resulted in seedlings planted in the middle of a very deep hole. When asked to fix the problems, workers refilled the holes with soil while the seedling was still there instead of re-planting the seedling in a filled hole. This resulted in seedlings covered with soil almost to half of their height. Poor hole location was also common (Fig. 5-1) where seedlings were planted too close to a large rock and between clumps of soil.

Figure 5-1. Seedling planted in 2011 in Kfarzabad in a deep hole full of large rocks

Inspection was introduced to Kfarzabad in the planting season of fall 2012. In fall 2013, no further planting was done on the site. Hence, only one year of inspection data is available for the Kfarzabad site. On average, in 2012, worker productivity was relatively moderate compared to other sites (Table 5-3).

Although planting quality above ground was acceptable, the below-ground average was too low, with only 35% of the seedlings inspected planted well. Most of the mistakes below ground related to J-rooting and rocks in the planting hole, although Kfarzabad was one of the few LRI sites where soil was abundant and rocks could have been easily cleaned from the planting hole.

Planting density was higher than the required 500-600 seedlings per ha. In 2011, the planting holes were prepared with an excavator and spacing was followed regularly on the whole site. However, in 2012, while replacing the dead seedlings, workers ended up adding more seedlings between the excavator prepared holes while looking for better planting spots, thus increasing seedling density.

Table 5-3. Inspection results summary for Kfarzabad reforestation site - planting season of 2012-2013

Inspection Metric	Result Value
Number of seedlings planted	21,540
Number of inspection days	27
Average number of workers per day	15
Average worker productivity	36
Average planting quality above-ground	75.13%
Average planting quality below-ground	35.36%
Average seedlings density per ha	725

5.5. INTERPRETATION OF MONITORING AND INSPECTION RESULTS

The low survival rates reported in Table 5-2 above were due to several factors related to the four major areas summarized below:

a. Seedling quality

There were numerous issues with seedling quality, storage and handling during the 2011 planting season in Kfarzabad. Seedlings planted at the Kfarzabad site that year came from the same nursery as in Aanjar. They were grown in 150ml containers. Seedlings were removed from their containers and placed in plastic bags prior to shipping to the site. Bags were then stacked horizontally in cardboard boxes and sent to the site where they were stored in a closed room close to the site. Seedlings were not hardened well and shoot-to-root ratios were above 4 for most of the pine seedlings.

During the planting season of 2012, seedling quality was highly improved. Seedlings were grown in deepots (D40 for pine seedlings) and were transported in their containers to the planting site in a covered truck equipped with shelves to minimize damage. The LRI seedling production protocol was followed for all seedlings sent to Kfarzabad and the trees were hardened and had shoot-to-root ratios between 1 and 2.

b. Planting quality

Planting inspection results in Kfarzabad showed a continuous fluctuation both in worker productivity (Fig. 5-2) and planting quality (Fig. 5-3). Notes of the inspector revealed a continuous turnover of crew members and a repetition of common mistakes despite the morning briefings and the daily feedback provided by the inspector.

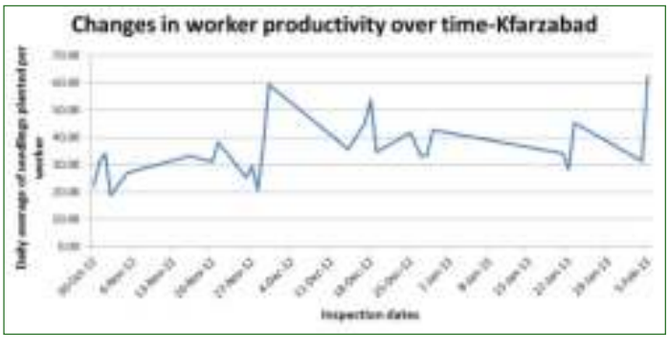


Figure 5-2. Changes in worker productivity in Kfarzabad during the planting season of 2012-2013 based on inspection data

Figure 5-3. Changes in planting quality above and below ground in Kfarzabad during the planting season of 2012-2013 based on inspection data

Planting quality below ground was notably low, reaching 0% in some days, with a low average of 35%. Although the same planting inspector was working in both Aanjar and Kfarzabad, the impact of planting inspection was neutralized in Kfarzabad by the quick turnover of crew members and their very limited experience.

c. Weed management and moisture availability

In Kfarzabad, weeds were previously controlled by grazing. Protection of the site from grazing has resulted in increased vegetation (mostly grass) which competed seriously with seedlings for limited moisture.

In 2011-2012, stone mulching was used to reduce weeds around seedlings. However, the implementation of the stone mulching was not satisfactory. Monitoring data on mulching status showed that ~12% of seedlings had no mulching. Rock mulching was inadequate (less than 1m2 of rock cover around seedling) for 65% of seedlings sampled. In addition, the set up of the irrigation system by the provider company was delayed for logistical reasons and the first irrigation was started in late May-early June, using water trucks. Subsequent irrigations were done using the installed drip irrigation system.

In 2012-2013, weeds were supposed to be scalped in the spring for around 1 m^2 around each seedling for a large proportion of the site. However, scalping was not fully completed for all seedlings. The irrigation system, installed the previous year, could have been used to irrigate the seedlings early

into the dry season, which could have prevented drought stress. However, the security situation due to the proximity of the site to the Syrian border, along with internal conflicts, prohibited the forest guards from getting to the site and irrigating the seedlings and prohibited LRI staff from checking regularly on work progress on site. When the situation allowed LRI staff to arrive to the site in July, around 80% of seedlings were dead and others were showing clear signs of drought stress.

Ironically, the area LRI had decided to leave non-irrigated for trial purposes had the highest survival rate across the site. The location had better soil and lower sun exposure than the two major planted hills.

d. Other site-specific factors and incidents

Aside from the security situation and town conflicts, the site in Kfarzabad experienced several instances of grazing due to the absence of the forest guards during the high security risk times. This also increased the amount of seedling mortality on the site.

Overall, improved seedling quality in 2012 should have resulted in a major improvement in seedling survival, such as was the case in Aanjar, if planting and irrigation practices were done following LRI protocols. This improved seedling quality neverthless contributed to the slight improvement in survival from 16% in 2012 to 23% in 2013. Low planting quality, along with lack of irrigation in the critical period at the end of spring, resulted in the mortality of most of the seedlings on the Kfarzabad site by summer 2013. The effect of the absence of irrigation was reinforced by the high exposure of the majority of the site except for the small section left non-irrigated on purpose, located in a small valley shaded by the major hill. Further neglect due to security issues and site inaccessibility led to the complete mortality of seedlings that remained alive from 2013.

5.6. MONITORING MAPS OF KFARZABAD SITE

Figure 5-4. Seedling status map of Kfarzabad reforestation site based on the yearly monitoring data - summer 2012

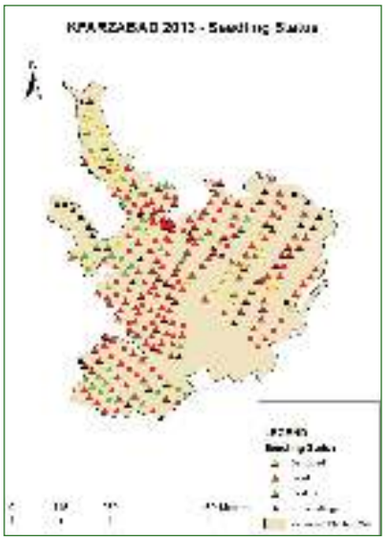


Figure 5-5. Seedling status map of Kfarzabad reforestation site based on the yearly monitoring data - summer 2013

6. MAQNE REFORESTATION SITE

6.1. SITE FACTS

Mouhafaza: Baalbeck-Hermel

Caza: Baalbeck

Partners: Municipality of Maqne

GPS coordinates of entrance: 34°04'51.63''N 36°13'03.26''E

Elevation: 1,060 - 1,100 m

Slope: Medium on hill, flat in the larger site

Rockiness: Large rocks on hill - surface rocks on larger site

Soil type: Association of Chromic Luvisols (LVcr), Ferric Luvisols (LVfr), Calcaric Cambisols (CMca), and Hypoluvic Arenosols (ARlvw) (with mostly Cambisols

6.2. SITE DESCRIPTION

Maqne is situated in the arid area of North Bekaa. Reforestation in Maqne was done in two large areas, a rocky hill and a plain next to it, surrounded on one side by a river, and covered with surface rocks. Soil preparation in Maqne was particularly expensive because of surface rocks, which necessitated the use of a ripper (Fig. 6-1). The pattern was also less random than in other areas due to how the machine circulates around the site.

Figure 6-1. Soil preparation of the Maqne site - photo shows the ripper used to remove the surface rocks and expose soil underneath. The pattern created is inevitably less random than with other techniques

Additionally, the head of municipality planted olives on one small plain next to the road and LRI planted experimental plots in a second small section by the road.

The site has several important characteristics:

1) It is located in the most arid area of Lebanon and thus presents challenging conditions compared to other sites.
2) The site's surface rocks present an additional challenge.
3) The municipality is highly motivated and had previously conducted successful reforestation activities.

6.3. OUTPLANTING SPECIFICATIONS

A total of 37,830 seedlings of nine species were planted in Maqne over a total area of 28.52 ha. Details on planting on the Maqne site are provided in Table 6-1 below.

Table 6-1. Outplanting information for Maqne reforestation site

Year	Nb of seedlings planted	Nb of hectares planted	Species planted	Planting start date	Planting end date
1	22,430	28.02	*Amygdalus sp., Cedrus libani, Pinus pinea, Pinus brutia, Quercus calliprinos, Quercus infectoria*	12 Nov 2012	14 Dec 2012
2	15,400	0.5	*Crataegus monogyna, P. brutia, P. pinea, Pyrus syriaca, Quercus calliprinos, Quercus infectoria, Salix spp.*	19 Dec 2013	16 Jan 2013
Total	37,830	28.52			

6.4. MONITORING RESULTS

In Maqne, despite the hard and arid conditions of the site, the seedling survival rate was relatively high both in 2013 and 2014 and few surviving seedlings showed signs of stress (Table 6-2).

Table 6-2. Monitoring results summary for Maqne reforestation site - 2013 and 2014

Monitoring Results	Year 2013	Year 2014
Yearly monitoring dates	07/23/2013 - 08/01/2013	07/03/2014 - 07/24/2014
Number of days	3	5
Monitoring Protocol used	2	2
Number of Plots	228	827
Number of Seedlings monitored	302	1605
Survival rate	79.80%	84.74%
Percentage of damaged seedlings out of total survival	2.08%	10.34%

6.5. INTERPRETATION OF MONITORING RESULTS

The high survival rate observed in Maqne can be related to the following factors:

a. Seedling quality

Seedlings planted in the Maqne site came largely from a nursery located close to the site, with similar environmental conditions. Seedling quality at that nursery was also satisfactory. Seedlings were well hardened and with an adequate shoot and root growth.

b. Planting quality

Inspection was not performed in the Maqne reforestation site and consequently, no inspection data are available to explain the monitoring results. Overall planting quality observed during field visits was considered satisfactory. The planting crew was a group of local citizens who worked for several years with the head of municipality on planting fruit and forest tree seedlings and their experience could have accounted for the good monitoring results.

c. Weed management and moisture availability

In Maqne, due to the arid conditions of the site and the presence of surface rocks and the soil preparation techniques used, weeds were almost absent.

An irrigation system was installed early enough after the planting season and the municipality was very committed to providing enough water for irrigation. Seedlings were irrigated several times during the dry season and experienced almost no drought stress, despite the arid conditions of the area.

d. Other site-specific factors and incidents

In 2012, the Maqne hill site experienced few cases of grazing. While the plain site was fenced from the beginning, the hill site was left without fencing for two main reasons: limited seedlings were planted and the municipality had agreed on protecting the site without fencing. However, stray goats caused damage to one side of the planted area on the hill. The whole hill was then fenced to allow for safer planting conditions for the fall of 2013.

6.6. MONITORING MAPS OF MAQNE SITE

Figure 6-2. Seedling status map of Maqne reforestation site based on the yearly monitoring data - summer 2013

Figure 6-3. Seedling status map of Maqne reforestation site based on the yearly monitoring data - summer 2014

7. QLAIAA REFORESTATION SITE

7.1. SITE FACTS

Mouhafaza: Nabatiyeh

Caza: Marjayoun

Partners: • Municipality of Qlaiaa

• Reforest Lebanon

Qlaiaa sites	Site 1. "Waer"	Site 2. Sand Quarry
GPS coordinates of entrance	33°20'33.96''N 35°34'11.06''E	33°20'02.19''N 35°33'32.68''E
Elevation	550 - 650 m	400 - 500 m
Slope	Medium	Medium - with steep cuts
Rockiness	High	Very low
Soil Type	Limestone with high clay content	Sandy

7.2. SITE DESCRIPTION

Qlaiaa is a small town located near the Lebanese/Israeli border. The town was occupied by Israeli forces and cut off from Beirut and most of Lebanon until 2000. LRI worked with the local NGO Reforest Lebanon and the municipality of Qlaiaa to reforest two major sites, the "waer" site named after its rockiness and harsh topography, and an abandoned sand quarry. Smaller plots of municipal land around the town were also planted. Outplanting data shown in Table 7-1 below present total number of seedlings planted across the sites and monitoring data focus mostly on the two larger sites.

The "waer" site in Qlaiaa is where Qlaiaa's old pine forest used to stand. What remains of it now is a bouquet of a couple of dozen trees and a large extent of surrounding barren land, in the rough rocky edges inaccessible for grazing, with medium-sized oak trees. Landmines were previously found on the upper section of the site and, although cleared, fear of them remains in the hearts of Qlaiaa citizens. Only the shepherds and a few courageous young men ventured into the waer from time to time. Grazing has kept hundreds of small oaks limited to ground level and has prohibited young pine seedlings from surviving.

The reforestation of the waer site presented:

1) A potential opportunity for limiting grazing and allowing naturally regenerating oaks and pines to grow.

2) The establishment of a long-term investment in pine nut trees that will create future revenues for the municipality.

3) And on the community level, the reconnection of Qlaiaa citizens to the previously-mined waer site, their largest potential recreational area, and the realization of their dream to see their old forest come back.

The second largest site in Qlaiaa is a sand quarry that was established on municipal land. The quarry has been abandoned but little regeneration has occurred on the heavily disturbed landscape.

The site has several important characteristics:

1) It represents an excellent example of restoration of damaged areas. The quarry happens to be located over natural springs. With the quarrying disturbance, serious soil erosion and land shifting occurred every winter. A major objective of planting the quarry was to stabilize the land and protect properties located above.

2) The sandy soil type of the quarry and the presence of natural springs make it a perfect site for successfully growing *Pinus pinea*, which is an important economic species that would increase revenues of the municipality in the long term.

3) On a social level, planting the quarry, like the "waer", represents for citizens of Qlaiaa a renewal from their history of war and conflicts.

7.3. OUTPLANTING SPECIFICATIONS

A total of 61,815 seedlings of 15 species were planted in Qlaiaa over a total area of 32.18 ha during three consecutive planting seasons. Details on planting of the Qlaiaa sites are provided in Table 7-1 below.

Planting was done the first year by a group of youth from the town, together with a few women and older citizens. In the second year, the planting crew was limited to a few retired citizens.

In 2011, the sand quarry and a small part of the "waer" site were planted. In 2012 and 2013, most of the planting was done to expand the "waer" site. In 2013, planting depended mostly on volunteers and municipality-supported labor.

Table 7-1. Outplanting information for Qlaiaa reforestation site

Year	Nb of seedlings planted	Nb of hectares planted	Species planted	Planting start date	Planting end date
1	27,000	24.66	*Acer monspessulanum, Amygdalus sp., Arbutus andrachne, Celtis australis, Cercis siliquastrum, Fraxinus angustifolia, Laurus nobilis, Pinus pinea, Pistacia terebinthus spp. Palaestina, Prunus ursina, Quercus calliprinos, Quercus infectoria*	26 Nov 2011	20 Apr 2012
2	30,015	7.52	*Acer syriacum, Amygdalus sp., Arbutus andrachne, Fraxinus angustifolia, Laurus nobilis, Pinus Halepensis, Pinus pinea, Pistacia terebinthus spp. Palaestina, Quercus calliprinos, Quercus infectoria*	23 Oct 2012	23 Jan 2013
3	4,800	In same area	*Pinus brutia, Pinus pinea*	10 Feb 2014	28 Feb 2014
Total	61,815	32.18			

7.4. MONITORING AND INSPECTION RESULTS

Monitoring was conducted for all sites planted in Qlaiaa in 2012, 2013 and 2014. Tables 7-2 and 7-3 below show the monitoring results for the two larger sites. The smaller sites planted all had very high survival rates, reaching 100% in one of them. In the "waer" site, which is rockier with higher clay content and a lower water holding capacity, seedling survival was low the first year but improved substantially in the following years (Table 7-2). In the sand quarry, survival rates were high across the three years (Table 7-3).

Table 7-2. Monitoring results summary for Qlaiaa reforestation site 1: "waer" – 2012, 2013 and 2014

Monitoring Results	Year 2012	Year 2013	Year 2014
Yearly monitoring dates	09/11/2012-09/14/2012	08/23/2013	08/18/2014 – 08/20/2014
Number of days	4	1	3
Monitoring protocol used	1	2	2
Number of Plots	150	640	437
Number of seedlings monitored	**98**	**891**	**1791**
Survival rate	42.00%	95.62%	95.14%
Percentage of damaged seedlings out of total survival	16.67%	3.39%	3.40%

Table 7-3. Monitoring results summary for Qlaiaa reforestation site 2: sand quarry – 2012, 2013 and 2014

Monitoring Results	Year 2012	Year 2013	Year 2014
Yearly monitoring dates	09/08/2012 – 9/10/2012	08/28/2013 - 08/30/2013	08/01/2014 - 08/04/2014
Number of days	3	3	2
Monitoring protocol used	1	2	2
Number of plots	73	182	236
Number of seedlings monitored	37	325	950
Survival rate	84.00%	93.85%	94.10%
Percentage of damaged seedlings out of total survival	35.71%	7.86%	6.84%

In 2011, inspections of planting quality were not performed but field visits revealed satisfactory planting quality in both sites in Qlaiaa.

Planting inspections were introduced to Qlaiaa (as well as to all LRI sites) in the planting season of 2012-2013 (results shown in Table 7-4 below). Overall, planting quality averages were very good both above- and below-ground. Planting density was also within the required range of 500-600 seedlings/ha.

Table 7-4. Inspection results summary for Qlaiaa reforestation site - planting season of 2012-2013

Inspection Metric	Result Value
Number of seedlings planted	30,015
Number of inspection days	58
Average number of workers per day	6
Average worker productivity	37
Average planting quality above ground	80.59%
Average planting quality below ground	98.99%
Average seedlings density per ha	582

7.5. INTERPRETATION OF MONITORING AND INSPECTION RESULTS

Factors contributing to the high seedling survival in Qlaiaa and affecting the improvement seen in the "waer" site after 2012 are detailed and analyzed below.

a. Seedling quality

In the fall season of 2011, seedlings sent to Qlaiaa were produced in two different nurseries. However, there was no difference in seedling provenance among the two sites that could have accounted for the difference in seedling survival.

All seedlings produced in 2011 were not well-hardened, were stored and transported in plastic bags and cardboard boxes, and had high shoot-to-root ratios. On-site storage in Qlaiaa met the criteria needed to conserve seedling quality until planting time. Qlaiaa workers took extra care straightening seedlings when they were received and placing them upright in open bags (Fig. 7-1). This might explain the higher survival results in Qlaiaa compared to other sites planted in the same year with the same seedling quality, but where boxes were stored as received until planting time (e.g. Aanjar and Kfarzabad).

Figure 7-1. Seedlings placed in Qlaiaa storage space. All bags were opened upon arrival and placed straight inside their cardboard boxes

During the planting season of 2012, seedlings were grown in deepots (D40 for pine seedlings) and were transported in their containers to the planting site in a covered truck equipped with shelves to minimize damage. LRI desirable seedling production protocol was followed for all seedlings sent to Qlaiaa and the trees were hardened and had shoot-to-root ratios between 1 and 2.

Although seedling quality did not clearly affect the difference among sites in seedling survival at the end of summer 2012, it probably played a major role in the improvement in seedling survival observed in the "waer" site between the summers of 2012 and 2013.

b. Planting quality

Worker productivity fluctuated during the fall season of 2012. No clear trend was observed and the overall average was within the range observed for all sites (Fig. 7-2).

Planting quality was also high, with below-ground planting almost always at 100% (Fig. 7-3).

Figure 7-2. Changes in worker productivity in Qlaiaa during the planting season of 2012-2013 based on inspection data

Figure 7-3. Changes in planting quality above- and below-ground in Qlaiaa during the planting season of 2012-2013 based on inspection data

c. Weed management and moisture availability

Moisture is a key factor that differentiates the sand quarry from the other sites in Qlaiaa. The quarry, situated over water springs, was found to still hold moisture at 30cm depth even in the middle of the summer. On the opposite side, the clay-based soil of the "waer" site was losing moisture very early in the dry season.

A drip irrigation system was set in both sites planted in 2011. However, the one in the quarry was placed earlier, while the irrigation system in the "waer" site was delayed and seedlings were irrigated after they had shown signs of stress.

Weeds were an issue in both sites and scalping was done to a limited extent in 2012 and was repeated several times with the help of mechanized weeders in 2013 in both sites. No major difference in weed management was observed across sites in 2013, but the improved scalping and better irrigation could have contributed to the improved survival rate in the "waer" site in 2013 and 2014.

d. Other site-specific factors and incidents

The only incident recorded on the Qlaiaa site was in 2012 when heavy rainfall led to severe soil movement in the quarry site, causing the displacement of about a thousand seedlings, almost half of which died.

Two site-specific factors that also contributed to the difference in survival rates among the sites are:

- The sandy soil of the quarry is easier for roots to develop than the clay-based soil of the "waer" site. Seedlings dug out in mid-May 2012 in the quarry had already developed roots more than 40cm deep (Fig. 7-4).

Figure 7-4. Seedling dug out on May 17th, 2012 from the Qlaiaa sand quarry site showing deep root growth

- In 2011, the sand quarry site was planted earlier in the season while the "waer" site was planted partly as late as March and April 2012, too close to the dry season. With the delay in irrigation, those latter seedlings were subjected to higher drought stress after they were soon planted and before they had a chance to develop deep roots. Higher mortalitty was observed in the areas planted last.

In addition to the high survival, seedling growth was notably faster in the Qlaiaa sand quarry compared to the "waer" or any other LRI site. Seedlings were reaching a meter of height less than two years after their planting date (Fig. 7-5).

Figure 7-5. Two-year-old seedlings in Qlaiaa quarry (A & B) and in Qlaiaa "waer" site (C & D). Shelter and wooden stakes are 90cm above-ground level

7.6. MONITORING MAPS OF QLAIAA SITES

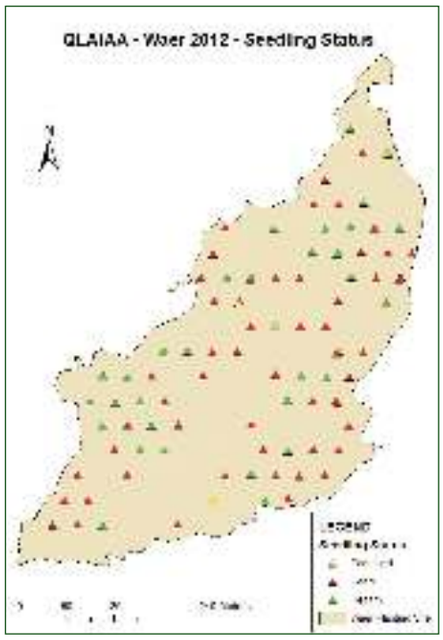


Figure 7-6. Seedling status map of Qlaiaa waer reforestation site based on yearly monitoring data - summer 2012

Figure 7-7. Seedling status map of Qlaiaa waer reforestation site based on yearly monitoring data - summer 2013

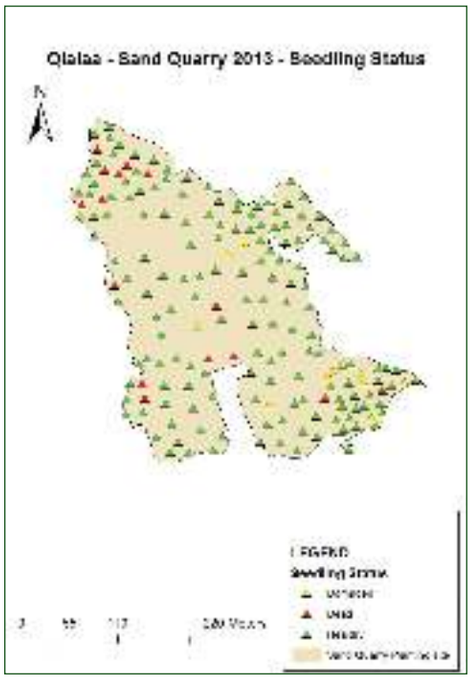


Figure 7-8. Seedling status map of Qlaiaa waer reforestation site based on yearly monitoring data - summer 2014

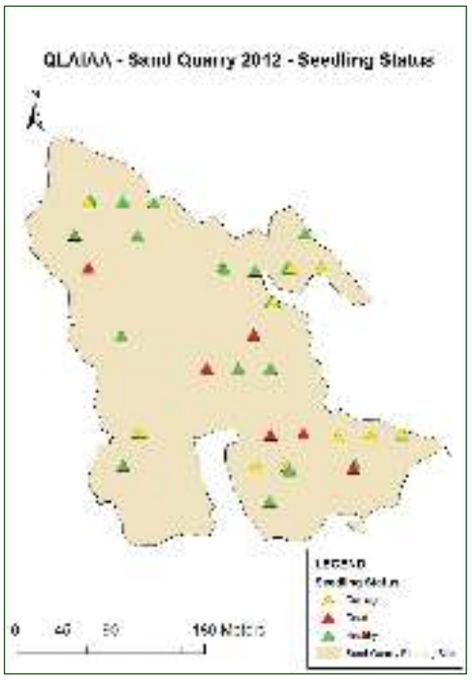


Figure 7-9. Seedling status map of Qlaiaa sand quarry reforestation site based on yearly monitoring data - summer 2012

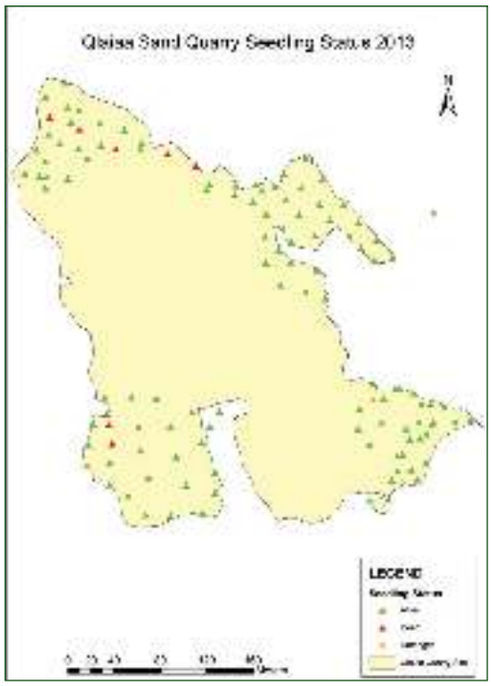


Figure 7-10. Seedling status map of Qlaiaa sand quarry reforestation site based on yearly monitoring data - summer 2013

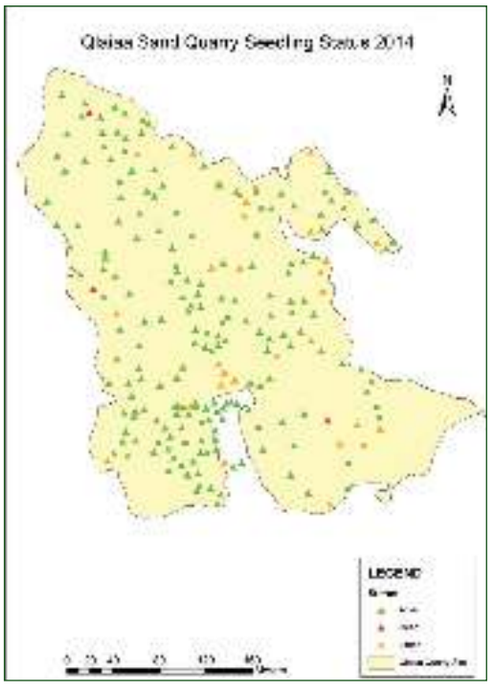


Figure 7-11. Seedling status map of Qlaiaa sand quarry reforestation site based on yearly monitoring data - summer 2014

8. RACHAYA REFORESTATION SITE

8.1. SITE FACTS

Mouhafaza: Bekaa- West

Caza: Rachaya

Partners: • Municipality of Rachaya el Wadi

• Association for Forests, Development and Conservation (AFDC)

GPS coordinates of entrance: 33°29'06.54''N 35°51'24.74''E

Elevation: 1,200 - 1,500 m

Slope: Medium – different aspects

Rockiness: Medium to high

Soil type: Limestone

8.2. SITE DESCRIPTION

The reforestation site in Rachaya is composed of a series of hills, separated by roads and valleys that used to be occupied by the Syrians during the war. It is a very rocky site, where cutting during the war and subsequent grazing inhibited regeneration of several species and kept some, like oaks and crataegus, at ground level. Weed biodiversity is high and was only well-assessed after a year of prohibited grazing.

The site has several important characteristics:

1) It is a large, barren site that has the potential for expansion into neighboring municipality lands.

2) Rachaya has an established forest planted long ago by the Green Plan and several small successful planting initiatives.

3) Part of the site was used as a military base during the Syrian occupation and severely degraded. Reforesting the site holds an emotional interest for the local community.

8.3. OUTPLANTING SPECIFICATIONS

A total of 79,523 seedlings of 16 species were planted in Rachaya over a total area of 94.19 ha. Details on planting of the Rachaya site are provided in Table 8-1 below.

Table 8-1. Outplanting information for Rachaya reforestation site

Year	Nb of seedlings planted	Nb of hectares planted	Species planted	Planting start date	Planting end date
1	27,000	22.31	*Acer monspessulanum, Amygdalus sp., Arbutus andrachne, Cedrus libani, Celtis australis, Cercis siliquastrum, Fraxinus ornus, Laurus nobilis, Pinus pinea, Pistacia terebinthus spp. Palaestina, Prunus ursina, Pyrus syriaca, Quercus calliprinos, Quercus infectoria*	29 Nov 2011	15 Mar 2012

2	45,823	71.88	*Amygdalus sp., Cedrus libani, Pinus brutia, Pinus halepensis, Pinus pinea, Pistacia terebinthus spp. Palaestina, Pyrus syriaca, Quercus calliprinos, Quercus cerris pseudocerris, Quercus infectoria*	29 Oct 2012	27 Jan 2013
3	6700	In same area	*Amygdalus sp., Pinus brutia, Pinus pinea, Quercus calliprinos*	30 Nov 2013	14 Feb 2014
Total	79,523	94.19			

8.4. MONITORING AND INSPECTION RESULTS

Rachaya is the largest LRI site in terms of number of seedlings and the second largest after Kfardebiane in surface area. The topography of the site created serious challenges both for planting speed as well as for the design and installation of the irrigation system. Despite those challenges, Rachaya's monitoring results were quite satisfactory, with almost 60% survival the first year and 68 - 73 % in 2013 and 2014 (see Table 8-2).

Table 8-2. Monitoring results summary for Rachaya Reforestation site - 2012, 2013 and 2014

Monitoring Results	Year 2012	Year 2013	Year 2013
Yearly monitoring dates	09/15/2012- 09/27/2012	09/13/2013 - 09/20/2013	07/02/2014 - 08/08/2014
Number of days	11	5	6
Monitoring protocol used	1	1	2
Number of plots	361	826	1713
Number of seedlings monitored	273	491	3463
Survival rate	58.00%	68.68%	73.20%
Percentage of damaged seedlings out of total survival	51.72%	27.12%	4.65%

Planting inspections were introduced to Rachaya in the planting season of 2012-2013 (results shown in Table 8-3 below). Rachaya had a larger crew size than most of the other sites. Worker productivity was average compared to most other sites with 38 seedlings planted per worker per day. Planting quality was among the highest across all sites, with ~88% seedlings well-planted above ground and over 90% well-planted below ground. However, planting density was too high compared to the LRI's average of 500-600 seedlings/ha. Workers' motivation to restore their old forests and see this area green again made it hard to convince them to plant with larger spacing.

In the fall of 2013, planting was done only to replace dead seedlings across the site and with the help of volunteers. Training and follow-up by LRI staff was done during volunteering days but no inspection data was recorded.

Table 8-3. Inspection results summary for Rachaya reforestation site - planting season of 2012-2013

Inspection Metric	Result Value
Number of seedlings planted	45,823
Number of inspection days	54
Average number of workers per day	22
Average worker productivity	38
Average planting quality above-ground	87.82%
Average planting quality below-ground	90.57%
Average seedlings density per ha	934

8.5. INTERPRETATION OF MONITORING AND INSPECTION RESULTS

The improvement in seedling survival rates and the decrease in the proportion of damaged seedlings seen between 2012 and 2014 can be linked to some of the following factors:

a. Seedling quality:

Seedlings planted at the Rachaya site in 2011 lacked good hardening although their growth parameters were good. The advantage of Rachaya over other sites planted that same season was that seedlings were delivered in their containers, almost on a daily basis since AFDC, LRI's partner on Rachaya site, was at the same time providing seedlings and supervising planting.

During the planting seasons of 2012 and 2013, seedlings were grown in deepots (D40 for pine seedlings) and were transported in their containers to the planting site in a covered truck with shelves. Seedlings were hardened better than in 2011 and their growth parameters were also improved.

b. Planting quality

Worker productivity fluctuated around the same average for all of the planting season of 2012 and 2013 (Fig. 8-1). The major reasons for the low average were two fold: the topography of the site required a considerable amount of effort for workers to navigate and plant the site; and workers in Rachaya were experienced farmers who took special care of every seedling planted, resulting in high planting quality at the expense of productivity (Fig. 8-2).

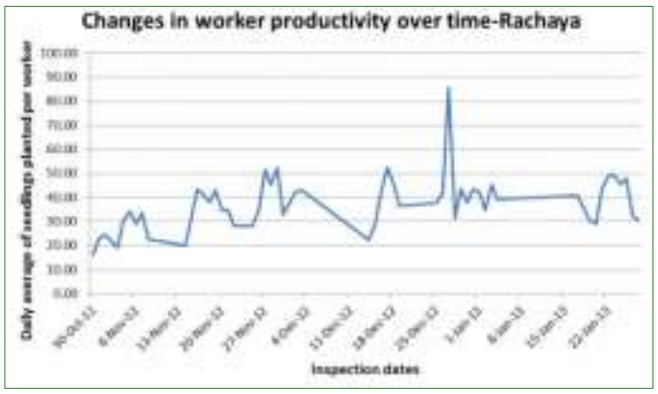


Figure 8-1. Changes in worker productivity in Rachaya during the planting season of 2012-2013 based on inspection data

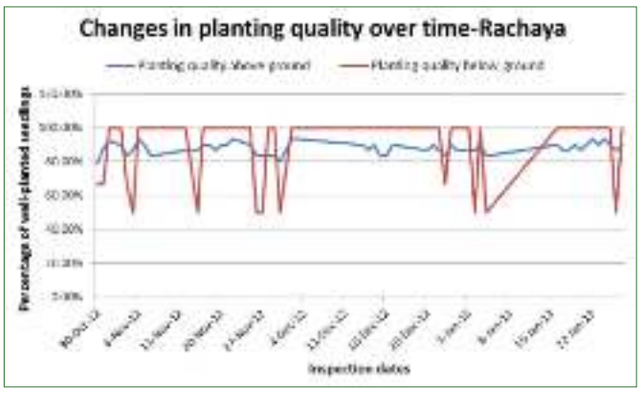


Figure 8-2.Changes in planting quality above- and below-ground in Rachaya during the planting season of 2012-2013 based on inspection data

c. Weed management and moisture availability

In Rachaya, weeds constituted a serious issue. Rachaya is also classified as a high risk fire area on the Lebanese fire risk map (AFDC, 2014)2. Scalping was performed in Rachaya since the first year (Fig 8-3). Trials on using different types of mulching were also done in several plots in the site over the three years (Fig. 8-4).

As in all LRI sites for the first year of planting, installing the irrigation system was delayed. In fact, Rachaya was the last site to have its irrigation system installed. The site was irrigated almost all summer with water trucks. Delays in irrigation and the known inefficacy of irrigating with water trucks that could not access the whole site could have contributed significantly to the amount of mortality observed in summer 2012 (see Fig. 8-5).

Figure 8-3. Complete scalping around pine seedling planted in Rachaya reforestation site

[2] *AFDC (Association for Forests, Development and Conservation). 2014. Fire Risk Map.*

Figure 8-4. Different mulching options tried in Rachaya in 2012. From left to right: stone mulching, plastic mulch mat, and fabric mulch mat

In 2013, all the area planted in 2011 had a drip irrigation system set. However, the extension of the site planted in fall 2012 did not get a drip irrigation system and was irrigated manually or with water trucks. The concentration of high mortality in those specific areas (see Fig. 8-6) that received less irrigation reinforces the hypothesis that irrigation played a primary role in the mortality rates observed in Rachaya. That area was replanted in fall 2013.

d. Other site-specific factors and incidents

On September 20, 2013, the LAF organized a drill adjacent to the LRI reforestation site in Rachaya, leading to an accidental fire that extended to a total of 5 ha, most of which was planted. Based on a sub-sample count, an estimated 20% of total seedlings planted survived and the estimated lost seedlings amounted to approximately 3,000. A second fire followed a month later, causing less damage than the first one since it was farther from the planted area. In fall 2013, LAF officers planted more than 3,000 seedlings in the burned area to compensate for the loss.

8.6. MONITORING MAPS OF RACHAYA SITE

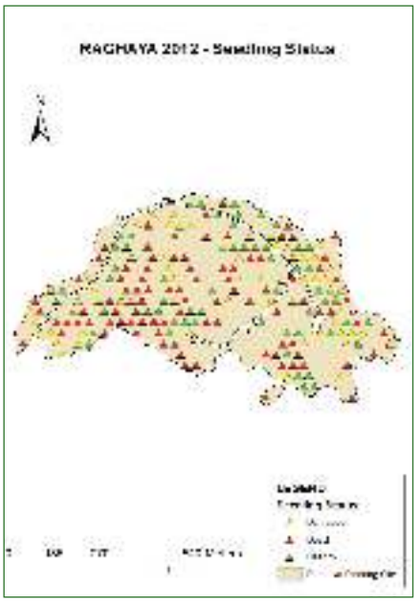


Figure 8-5. Seedling status map of Rachaya reforestation site based on yearly monitoring data - summer 2012

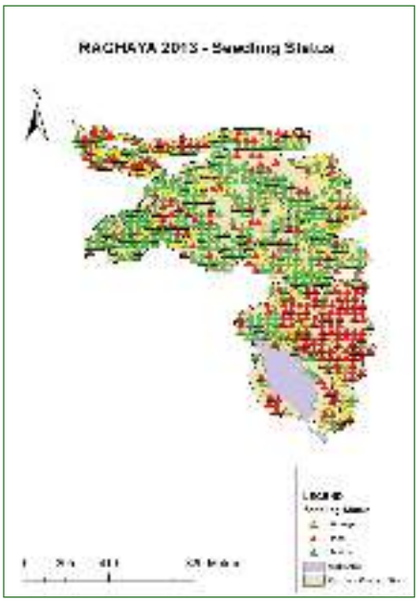


Figure 8-6. Seedling status map of Rachaya reforestation site based on yearly monitoring data - summer 2013

Figure 8-7. Seedling status map of Rachaya reforestation site based on yearly monitoring data - summer 2014

9. RMADIYE REFORESTATION SITE

9.1. SITE FACTS

Mouhafaza: South Lebanon

Caza: Tyr

Partners: Municipality of Rmadiye

GPS coordinates of entrance: 33°11'14.77''N 35°16'27.46''E

Elevation: 200 - 300 m

Slope: Medium-to-high

Rockiness: Medium-to-high

Soil type: Chromic Luvisols (LVcr), with possible Ferric Luvisols (LVfr) and Calcic Luvisols (LVcc)

9.2. SITE DESCRIPTION

Reforestation in Rmadiye was done in one large area divided into several sections by a labyrinth of valleys. The hills are all rocky with rich soil in some places, and more shallow, degraded soil in others.

The characteristics of this site include:

1) Rich soil.
2) Suitable planting site for Carobs.
3) Large area for reforestation on the edges of a highly urbanized area.
4) High interest of local population in the reforestation project.

9.3. OUTPLANTING SPECIFICATIONS

A total of 43,618 seedlings of 10 species were planted in Rmadiye over a total area of 80.14 ha. Details on planting of the Rmadiye site are provided in Table 9-1 below.

Table 9-1. Outplanting information for Rmadiye reforestation site

Year	Nb of seedlings planted	Nb of hectares planted	Species planted	Planting start date	Planting end date
1	32,118	63.87	*Acer tauricolum, Ceratonia siliqua, Cupressus sempervirens, Fraxinus angustifolia, Pinus brutia, Pinus halepensis, Pinus pinea, Quercus infectoria*	14 Nov 2012	30 Jan 2013
2	11,500		*Ceratonia siliqua, Crataegus spp.,Laurus nobilis, Pinus brutia, Pinus halepensis, Pinus pinea, Quercus calliprinos*	18 Dec 2013	06 Mar 2014
Total	43,618				

9.4. MONITORING AND INSPECTION RESULTS

LRI started planting in Rmadiye in fall 2012. The results of the first year of planting were average, with a 51% survival rate. In 2014, survival rates increased slightly to reach 63% (Table 9-2).

Table 9-2. Monitoring results summary for Rmadiye reforestation site – 2013 and 2014

Monitoring Results	Year 2013	Year 2014
Yearly monitoring dates	10/02/2013 - 10/08/2013	08/24/2014 - 08/27/2014
Number of days	4	4
Monitoring protocol used	1	2
Number of plots	119	464
Number of seedlings monitored	569	1372
Survival rate	51.32%	62.68%
Percentage of damaged seedlings out of total survival	16.09%	13.99%

Planting inspections were conducted in Rmadiye both in 2012 and 2013 (results shown in Table 9-3 below).

Rmadiye average worker productivity was low for both seasons. The reason was mostly the time required for workers to move around the site and that worker tasks were interchanged between workers during the same day, which precluded determining planting worker productivity.

Planting quality was also moderate the first year. In 2013, planting quality improved considerably from 65% to 72% for above-ground and 64% to 86% below-ground.

Table 9-3. Inspection results summary for Rmadiye reforestation site - planting season of 2012-2013

Inspection Metric	Result Value 2012	Result Value 2013
Number of seedlings planted	32,118	11,500
Number of inspection days	51	13
Average number of workers per day	18	15
Average worker productivity	29	21
Average planting quality above-ground	65.28%	72.34%
Average planting quality below-ground	64.38%	86.11%
Average seedlings density per ha	613	545

9.5. INTERPRETATION OF MONITORING AND INSPECTION RESULTS

The moderate survival rate of seedlings planted in Rmadiye can be linked to several factors. Those factors are detailed and analyzed below.

a. Seedling quality

During the planting season of 2012, seedlings provided to the Rmadiye site conformed to LRI protocols and standards, except for one batch of carob seedlings for which the shoots were highly underdeveloped, resulting in a very low shoot-to-root ratio.

In 2013, seedlings were of better quality than 2012 due to increased experience of seedling producers.

Seedling storage was also improved from 2012 to 2013. In 2012, seedlings were stored in a shaded location but were exposed to wind. In 2013, seedlings were stored in a more closed location.

The quality of the carobs received in 2012 could have accounted for part of the mortality. The improvement in seedling quality could have contributed to the improvement in survival rates observed in summer 2014.

b. Planting quality

Unlike other sites where worker productivity increased through the season, inspection of planting quality in the fall seasons of 2012-2013 and 2013-2014 showed a rather stagnant or even slightly decreasing worker productivity average over time (Fig. 9-1 and 9-2). This was due mostly to the quick turnover of workers for both seasons and to the hard topography and limited access to the site that required walking for long distances to reach the planting area.

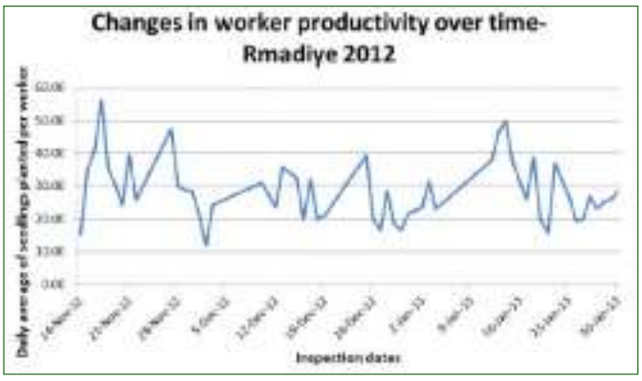


Figure 9-1. Changes in worker productivity in Rmadiye during the planting season of 2012-2013 based on inspection data

Figure 9-2. Changes in worker productivity in Rmadiye during the planting season of 2013-2014 based on inspection data

In the first planting season, planting quality was variable day-to-day in Rmadiye, but fluctuating around the same average (Fig. 9-3). Rocks in the planting hole and J-rooting were among the most common planting mistakes done. Shallow planting was also common.

In the planting season of 2013-2014, planting quality was constantly high with a slightly increasing trend for below-ground planting, reaching 100% well-planted seedlings most of the time (Fig. 9-4).

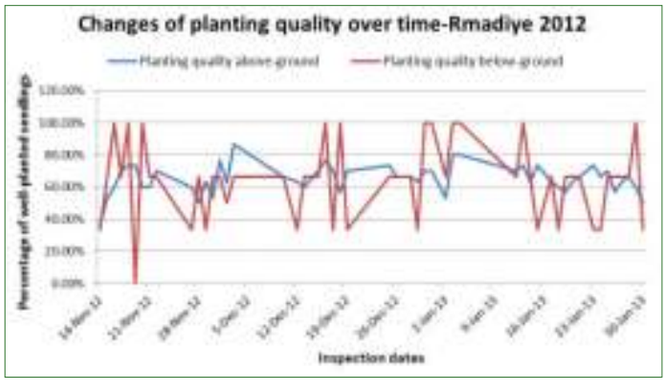


Figure 9-3. Changes in planting quality above and below-ground in Rmadiye during the planting season of 2012-2013 based on inspection data

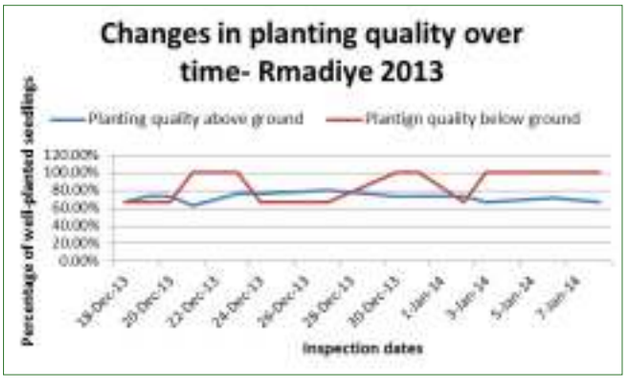


Figure 9-4. Changes in planting quality above and below-ground in Rmadiye during the planting season of 2013-2014 based on inspection data

c. Weed management and moisture availability

In Rmadiye, weed management procedures included scalping and mulching (see examples in Fig. 9-5 below).

Figure 9-5. Weed management procedures used in Rmadiye including scalping (left) and mulching (right)

A hand irrigation system was installed on most of the site in the summer of 2013 and was improved later in the fall of 2013. Delays in irrigation and lack of irrigation access to all the sections of the site had a serious impact on mortality. Figure 9-6 shows the distribution of mortality over the site. The area with the highest concentration of green (healthy) seedlings is in fact the one that had the irrigation system installed first and that was irrigated more than once during the summer of 2013.

d. Other site-specific factors and incidents

On June 19, 2013, 4 ha of land were burned in Rmadiye in a fire started most probably by workers at a stone factory adjacent to the planting site. Some 1,600 seedlings were in the area of the fire, with about 20% of those surviving the fire. Local people and Civil Defense were able to stop the fire from spreading further. Again, LRI technical staff noted that seedlings with good scalping survived, while those with plastic mulching burned faster because the mulching caught fire (Fig. 9-6).

Figure 9-6. Photos taken in Rmadiye on July 9th, 2013 showing the contrast in the effect of fire on a seedling surrounded by a plastic mulch mat (left) with a seedling around which weeds were scalped (right)

In summary, poor seedling quality of carobs delivered to the Rmadiye site, the average planting quality, and mostly the delays in irrigation and lack of moisture contributed to reducing the seedling survival rate of that site. The fire added to the level of mortality by burning some seedlings. The observed improvements in seedling quality, planting quality and irrigation led to an improvement in seedling survival at the end of 2014.

9.6. MONITORING MAPS OF RMADIYE SITE

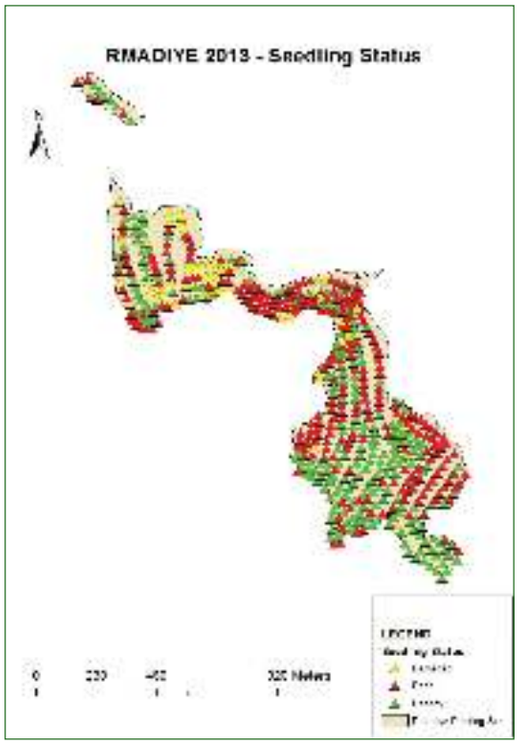


Figure 9-7. Seedling status map of Rmadiye reforestation site based on the yearly monitoring data - summer 2013

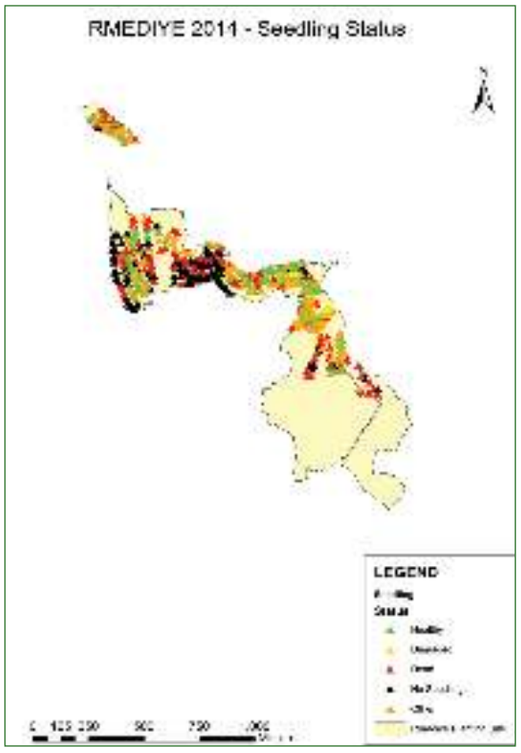


Figure 9-8. Seedling status map of Rmadiye reforestation site based on the yearly monitoring data - summer 2014

10. TANNOURINE REFORESTATION SITE

10.1. SITE FACTS

Mouhafaza: North Lebanon

Caza: Batroun

Partners: • Municipality of Tannourine

• Tannourine Cedar Forest Nature Reserve Committee

GPS coordinates of entrance: 34°12'28.06''N 35°56'20.67''E

Elevation: 1750 - 1800 m

Slope: Medium

Rockiness: Medium-to-high

Soil type: Ferric and Calcic luvisols

10.2. SITE DESCRIPTION

In Tannourine, North Lebanon, two sites were chosen, a small one adjacent to the Tannourine Cedar Nature Reserve that extends the current forest toward the north, and fits well with the objective of ultimately linking this forest with the cedars of Bcharre; and a second site is situated on top of the mountain range running between Tannourine and Bcharre.

The site near the entrance to the reserve has a section that is easy to access with a small excavator and another that is steeper and rockier which was dug by hand.

The site has the following characteristics:

1) It is an extension to the existing cedar forest.

2) It was previously agricultural land, with good, deep soil and accessible terraces on the top part.

3) Challenging weed management issues with tall and dense weed population.

4) Potential for expansion into a biocorridor restoration project between Tannourine and Bcharre.

The higher elevation site is located in an area where natural regeneration of junipers is occuring. Planting was introduced as an incentive for the municipality to discontinue their grazing contracts on that section to allow for the regenerating junipers to grow above grazing line and to create a denser juniper forest by adding seedlings.

10.3. OUTPLANTING SPECIFICATIONS

A total of 11,564 seedlings of 11 species were planted in 2 locations in Tannourine over a total area of 22.40 ha. Details on planting of the Tannourine site are provided in Table 10-1 below.

Table 10-1. Outplanting Information for Tannourine reforestation site

Year	Nb of seedlings planted	Nb of hectares planted	Species planted	Planting start date	Planting end date
1	3,680	5.00	*Acer hyrcanum, Amygdalus sp., Cedrus libani, Celtis australis, Pyrus syriaca, Sorbus torminalis, Sorbus flabellifolia*	26 Nov 2011	20 Dec 2011
2	4,009	6.90	*Acer spp., Cedrus libani, Juniperus excelsa, Pyrus syriaca, Quercus brantii, Quercus calliprinos, Quercus cerris, Sorbus torminalis*	22 Oct 2012	21 Nov 2012
3	3,875	10.5	*Juniperus excelsa on the new site, Cedrus libani on the old site*	28 Nov 2013	06 Dec 2013
Total	11,564	22.4			

10.4. MONITORING AND INSPECTION RESULTS

Monitoring results in Tannourine were remarkably low for 2012 and 2013 and showed a slight improvement in 2014 (Table 10-2).

Table 10-2. Monitoring results summary for Tannourine reforestation site- 2012, 2013 and 2014

Monitoring Results	Year 2012	Year 2013	Year 2014
Yearly monitoring dates	07/24/2012	09/23/2013	25/08/2014
Number of days	1	1	1
Monitoring protocol used	1	2	2
Number of plots	**8**	**221**	**348**
Number of seedlings monitored	**10**	**253**	**479**
Survival rate	30%	47.83%	61.17%
Percentage of damaged seedlings out of total survival	66.67%	11.56%	15.03%

Planting inspections were conducted in 2012 on the Tannourine site (results shown in Table 10-3 below). Planting quality was good for that year and density fell within the range required by LRI (500-600 seedlings/ha).

Table 10-3. Inspection results summary for Tannourine reforestation site - planting season of 2012-2013

Inspection Metric	Result Value
Number of seedlings planted	4,009
Number of inspection days	15
Average number of workers per day	7
Average worker productivity	38
Average planting quality above-ground	83.54%
Average planting quality below-ground	85.33%
Average seedlings density per ha	552

Planting quality improved from the previous year. Although inspection data were not available, seedlings dug out in summer 2012 showed signs of J-rooting or roots that never grew from their initial size. Besides seedling quality and the level of hardening, lack of root growth could be due to

air pruning caused by severe cracking in the soil surface (Fig. 10-1) as an effect of the combination of excavation of a relatively large surface area by machinery when the soil was wet, freezing of soil surface in the winter, and severe drought in the summer months.

Figure 10-1. Photo taken in Tannourine planting site - May 15th, 2012 - showing a dead seedling and deep cracking of the soil around it

10.5. INTERPRETATION OF MONITORING AND INSPECTION RESULTS

The low seedling survival rate found in Tannourine in 2012 and 2013 is analyzed below based on the four factors: seedling quality, planting quality, weed management and moisture availability, and other site specific factors.

a. Seedling quality

As for other sites, seedling quality improved tremendously from 2011 to 2012 since the nine LRI-supported nurseries started adopting LRI protocols for seedling production.

Seedlings planted in Tannourine were mostly produced by the Tannourine nursery. Hence, transportation, storage and change of climatic conditions between the nursery and the site were not considered as significant issues in this case.

Seedling hardening, however, can play a major role in a site like Tannourine due to the harsh winter conditions. Inadequate seedling hardening could lead to seedling mortality in this site. Seedlings planted in 2011 were not well-hardened, while those planted in 2012 and 2013 went through the process of hardening and were ready to tolerate the hard winters of Tannourine.

b. Planting quality

Worker productivity in Tannourine increased remarkably during the planting season (Fig 10-2) and planting quality averages were quite high (Fig. 10-3 and Table 10-3), which suggests that the mortality observed in 2013 on the site is not directly linked to planting quality.

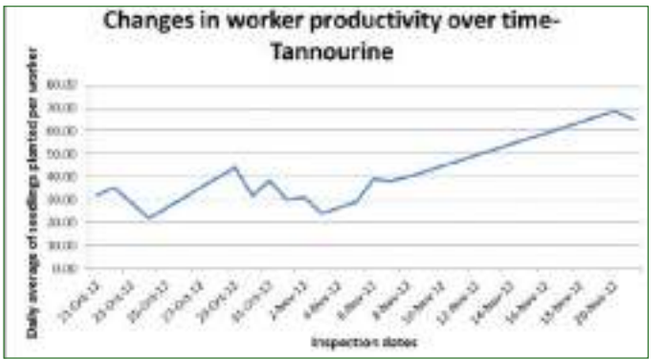


Figure 10-2. Changes in worker productivity in Tannourine during the planting season of 2012-2013 based on inspection data

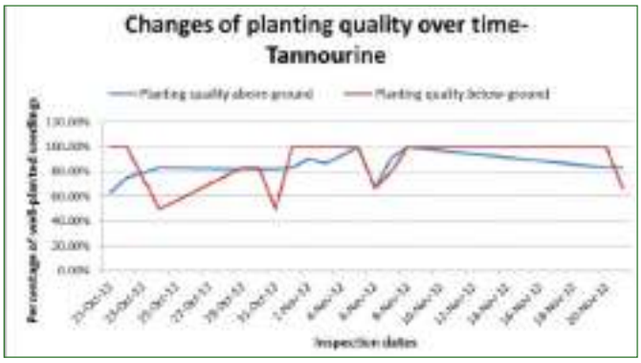


Figure 10-3. Changes in planting quality above- and below-ground in Tannourine during the planting season of 2012-2013 based on inspection data

c. Weed management and moisture availability

In the site near the cedar forest of Tannourine, weed population is the highest and densest across all LRI sites. The site being protected from grazing for several years and receiving yearly high levels of moisture offers a perfect environment for a diversity of wild plants and tall grasses.

Both in 2012 and 2013, unfortunately, scalping was not done as proposed and mulch mats provided were not applied on time. In addition, although an irrigation system was set on the whole site, water was not supplied regularly and irrigation was performed fewer times than needed.

d. Other site-specific factors and incidents

No specific events or incidents were recorded for the Tannourine site.

With the information summarized above, improvement in seedling quality and the addition of planting inspection could have contributed to the improvement in survival rate observed between 2012 and 2013. However, the lack of good weed and irrigation management kept survival rates in both years below average.

10.6. MONITORING MAPS OF TANNOURINE SITE

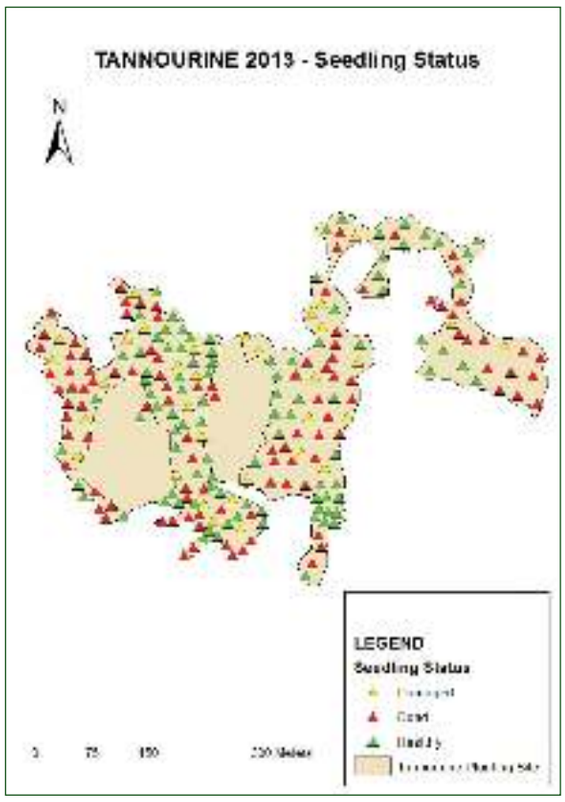


Figure 10-4. Seedling status map of Tannourine reforestation site based on the yearly monitoring data - summer 2013

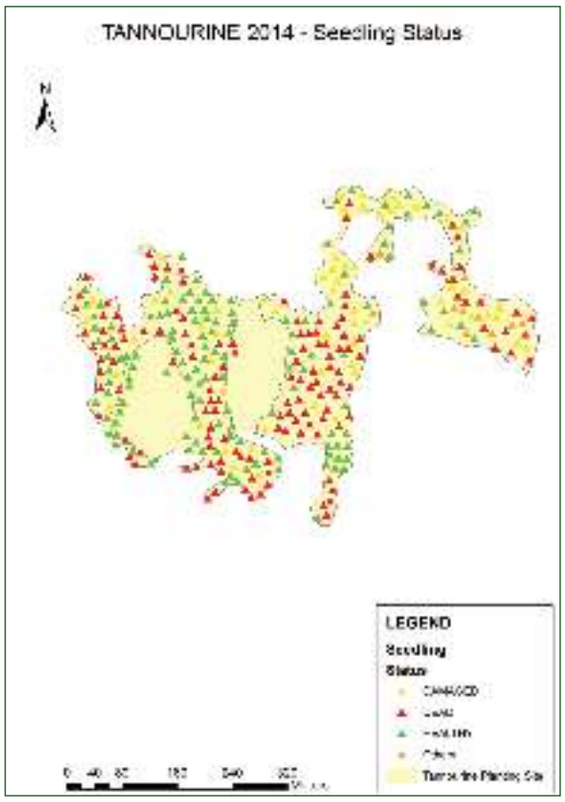


Figure 10-5. Seedling status map of Tannourine reforestation site based on the yearly monitoring data - summer 2014

III. LEBANON REFORESTATION INITIATIVE:
SMALL REFORESTATION SITES

III. LRI SMALL-SCALE REFORESTATION SITES

In addition to the ten large LRI reforestation sites, smaller-scale sites have been supported by LRI both in 2012 and 2013 following different approaches.

While the LRI sites discussed in Section II above were fully supported by LRI, financially and technically, with minor contributions from partners, including water for irrigation and site supervision, the sites that will be discussed in this chapter were based on a more balanced cost-sharing methodology where partners' contributions were relatively high.

Those sites can be classified into the following groups:

1. SITES PLANTED IN PARTNERSHIP WITH THE LEBANESE ARMED FORCES AND LOCAL MUNICIPALITIES

This group includes four sites planted in the week of February 25th, 2013 and ten sites planted in the week of February 10th, 2014, both during Lebanese Armed Forces (LAF) campaigns organized by the CIMIC section under the patronage of General Kahwaji and in collaboration with LRI. The purpose of the two campaigns and of LRI's involvement in this group of sites was two-fold:

1. Increase the surface area planted with high quality seedlings produced with advanced nursery production techniques, following LRI outplanting best practices.
2. Increase awareness on both nursery and outplanting best practices introduced and promoted by LRI with a higher number of municipalities and most importantly with LAF officers who are generally involved in several reforestation activities across the country.

For all 14 sites, LRI provided the seedlings and technical assistance during planting, as well as follow up and monitoring; LAF officers contributed their time to plant all seedlings provided for each site during the specified dates; and the local municipalities prepared the land for planting, assisted with local workers during the planting campaign and committed to irrigation and maintenance for a minimum of three years. LRI's technical assistance included the presence of one LRI outplanting staff or inspector on each site for the duration of the planting to provide training to daily planting teams and to check on mistakes and fix them on the spot. Out of the ten sites planted with LAF in 2014, five were LRI large sites where additional support was needed to replace dead seedlings or continue planting. Table III-1 below enumerates all 14 sites with the surface area planted in each site, number of seedlings and species planted, and monitoring results for those planted in 2013.

Table III-1. Outplanting and Monitoring information of all sites planted in partnership with LAF and local municipalities

Site location	Mouhafaza	Surface area planted	Number of seedlings planted	Species planted	Survival rate (%)/ monitoring date
Sites planted in February 2013					
Fiaa	North Lebanon	0.81 ha	2,000	*Pinus brutia*	100.00% / Sep 2013
Souk el Gharb	Mount Lebanon	0.085 ha + small plots	2,000	*Cupressus sempervіens, Pinus brutia, Pinus pinea*	90.00% / Sep 2013
Qaitouly	South Lebanon	2.2 ha	2,000	*Pinus pinea*	91.30% / Sep 2013
Habboush	Nabatiyeh	1 ha	2,000	*Cupressus sempervіens, Pinus brutia, Pinus pinea*	90.00% / Sep 2013
Sites planted in February 2014					
Fneidik	Akkar	6 ha	3,000	*Cedrus libani, Abies cilicia*	Monitoring delayed due to security
Maqne	Baalbeck-Hermel	0.5 ha + Replacing dead seedlings on site	2,500	*Pinus pinea*	84.74%
Majdel Baana	Mount Lebanon	2.23 ha	2,000	*Crataegus sp., Pinus pinea, Pistacia sp., Quercus calliprinos*	89.87%
Qobaiaa	Mount Lebanon	2.75 ha	2,000	*Crataegus sp., Pinus pinea, Pistacia sp., Quercus calliprinos, Malus trilobata*	88.51%
Aanjar	Bekaa	0.5 ha + Replacing dead seedlings on site	2,000	*Quercus calliprinos, Pinus brutia*	91.47%
Rachaya	Bekaa	5 ha	2,000	*Quercus calliprinos, Pinus brutia*	73.20%
Qlaiaa	Nabatiyeh	Replacing dead seedlings on site	2,300	*Pinus pinea*	94.60%
Tebnine	Nabatiyeh	0.7 ha	500	*Pinus pinea*	100%
Qrayeh	South Lebanon	1 ha	2,200	*Ceratonia siliqua, Pinus halepensis*	59.46%
Rmadiye	South Lebanon	Replacing dead seedlings on site	2,500	*Pinus brutia*	62.68%

2. SITES PLANTED BY LOCAL PARTNER NGOS AND MUNICIPALITIES WITH A DEFINED CONTRIBUTION FROM LRI

LRI also assisted sites identified and coordinated by local partner NGOs who requested seedling contribution and technical assistance from LRI. In such cases, the NGO had established an agreement with the local municipalities to plant and maintain a certain number of seedlings. LRI coordinated solely with the NGO and provided good quality seedlings along with technical assistance as needed.

Prior to approval, LRI checked that the sites being planted conformed to LRI's criteria for site selection and ensured that adequate maintenance would be provided to support good seedling survival. In this category, LRI worked with four partner NGOs: Jouzour Loubnan, Rene Moawad Foundation, Green Hand, and Save Energy Plant Trees (S.E.P.T); and directly with three municipalities, Maknounyeh, Dahr el Ahmar, and Ras Baalbeck. The sites planted along with their outplanting information are presented in Table III-2 below.

Table III-2. List and details of sites planted by local partner NGOs and municipalities with a defined contribution from LRI

Site Location	NGO Partner	Surface area	Number of seedlings provided by LRI	Species	Planting dates	Survival rate / Monitoring date
Ehmej	Jouzour Loubnan	15 ha	4,851	*Cedrus libani, Juniperus excelsa, Quercus cerris*	Dec. 2012 & Oct. 2013	~50%
Ibl Es Saki	Jouzour Loubnan	40 ha	3,400	*Pinus pinea, P. brutia, P. halepensis, Ostrya carpinifolia, Cupressus semperviens*	Mar. 2013 & Jan. 2014	400 dead in Nov. 2013 (mole damage)
Zaarour	Jouzour Loubnan	3 ha	1,400	*Cedrus libani*	Oct. 2013	N/A
Bteday	Jouzour Loubnan	35 ha	6,100	*Cedrus libani, Quercus calliprinos, Quercus infectoria, pinus, pirus, amygdalus*	Jan. 2014	N/A
Aytat	Green Hand	0.8 ha	500	*Pinus pinea, Crataegus sp., Ceratonia siliqua*	Mar. 2014	77.59%
Barouk	SEPT	0.1 ha	62	*Pinus pinea, Laurus nobilis, Celtis australis*	Feb. 2014	N/A
Kfardebiane-Nabaa el Aasal	SEPT and Women for Development of Kfardebiane	3 ha	1,000	*Pinus pinea, Cedrus libani*	Mar. 2014	N/A
Sawiri	Association for working women in Lebanon	4 ha	2,000	*Laurus nobilis, Pinus brutia, Pinus pinea, Pistacia sp, Quercus calliprinos*	Feb. 2014	N/A
Bmarian	LAF	1 ha	1,000	*Pinus pinea, Laurus nobilis*	500 in Mar. 2013 and 500 in Mar. 2014	85% / Sep. 2013
Maknounyeh	N/A	2.2 ha	2,000	*Pinus pinea*	Mar. 2012	100.00% / Sep. 2013
Dahr el Ahmar	N/A	3.5 ha	4,000	*Pinus pinea, P. brutia, Cedrus libani*	Mar. 2013	54.78% / Sep. 2013

Ras Baalbeck	N/A	1.5 ha	700	*Pinus pinea*	Dec. 2013	N/A
Akroum	Rene Moawad Foundation	2 ha	1,000	*Pinus pinea, Pinus brutia, Salix alba*	May 2014	N/A

3. SITES PLANTED BY LOCAL PARTNER NGO AND LOCAL MUNICIPALITIES AND FUNDED BY PRIVATE SECTOR DONORS WITH WHOM THE LINK WAS FACILITATED BY LRI

LRI also played a major role as a convener in bringing private sector companies to support reforestation activities. In collaboration with local NGO partners and municipalities that had sites assessed by LRI to be suitable for reforestation, LRI staff developed reforestation packages that were proposed to several major companies as part of their social corporate responsibility. As a result, four reforestation projects were realized in 2013-2014 and two are being prepared for planting in fall 2014-2015. Details of those projects are provided in Table III-3 below. Field visits were done during the planting season to insure good planting quality. Monitoring of those sites was done by LRI in collaboration with the implementing partner NGO at the end of summer 2014 (results shown in Table III-3 below).

Table III-3. Sites planted in fall 2013-2014 through a partnership between the private sector, local NGOs and municipalities, through the facilitation efforts of LRI

Site location	Private sector donor	NGO partner	Municipality	Number of seedlings planted	Species planted	Survival rate 2014
Mrusti (old stone quarry)	Tinol	Chouf Cedar Reserve	Mrusti	3,000	*Pinus pinea, Pinus brutia, Quercus spp., Amygdalus, Malus trilobata, Rosa canina,etc*	93.50%
Deir Ammar (abandoned quarrying and dump area)	La Phoenicienne	AFDC	Deir Ammar	1,000	*Ceratonia siliqua, Amygdalus sp., Laurus nobilis, Pinus pinea, Quercus infectoria*	90.00%
Hadchit (Barren hill)	Holcim	Friends of the Cedar Forests-Bcharre	Hadchit	1,300	*Cedrus libani*	92.30%
Kfardebiane	Dar Al Handasa	Jouzour Loubnan	Kfardebiane	3,000	*Juniperus excelsa, Cedrus libani*	45.00%

4. PILOT SITES PLANTED ON RELIGIOUS ENDOWMENT LANDS IN PARTNERSHIP WITH A LOCAL NGO AND/OR MUNICIPALITY

In 2014, LRI also planted two pilot sites on religious endowment land. Religious endowments present the advantage of being sustainable despite the fact that they could be private. To test the possibility of working with such entities, LRI launched in 2014 two small-scale reforestation projects, one including 700 stone pine seedlings planted on land owned by the Monastery of the Holy Savior in Joun (April 6, 2014) and one including 3,000 stone pine, carob and laurel seedlings planted on land owned by the Dar El Awkaf of Hasbaya and Marjayoun, located in the town of Kfar Hamam (April 4th, 2014).

The process included a first field visit to assess the potential reforestation area and to gauge the interest of the management board in each location. The approach used for these two sites is quite different from the ten large LRI sites. The model is based on a full cost share. Species provided were mostly economic species to create an incentive for the private landowner to ensure the survival of the seedlings planted. Seedlings were provided by LRI from LRI-supported nursery members of the Cooperative of Native Tree Producers in Lebanon. Soil preparation and later scalping and irrigation were provided by the landowners under the signed agreement. Planting itself was done through volunteers provided by the third signatory party on the agreement, SEPT NGO in the case of Joun, and the municipality of Kfar Hamam in the case of Dar el Awkaf. Planting was done after training and under the supervision of LRI outplanting technical team. At the end of summer 2014, all seedlings planted in Joun and more than 60% of those in Kfarhamam were still alive.

a. Monitoring and inspection protocols for small scale sites

Unlike for larger sites where a sub-sample of total seedlings planted is inspected during planting and monitored afterwards for survival, small scale sites present the advantage of allowing full assessment of seedlings planted.

In small scale sites, inspection can be done above ground for each seedling planted and below ground for around 10% of total seedlings planted. Precentage of below-ground planting inspection can vary based on the reforestation manager's decision and planting crew performance. Monitoring in small scale sites can also be done on 50-100% of seedlings planted, based on the total number, time of monitoring team, and decision of the reforestation manager.

In both cases, information are collected on a per-seedling basis instead of the plot system used for larger sites but the procedure for data collection and the quality of information collected remains the same.

b. No irrigation trials

LRI also tried planting without irrigation in 2012 on small sections of 4 sites across the country, namely Aanjar, Kfarzabad, Ainata and Qlaiaa. In Aanjar and Ainata, all seedlings left without irrigation died. In Kfarzabad, about half of the seedlings planted survived, but the security situation on site prohibited the LRI team from getting more accurate data. In Qlaiaa, in the new section of the rocky site with soils rich in organic matter and a medium north-facing slope, all seedlings left without irrigation survived and only 1.25% of them showed signs of stress. It is worth noting here that both Aanjar and Ainata non-irrigated areas were planted towards the end of the planting season. In Ainata, they were located on the top hill that is highly exposed to direct sunlight. In Aanjar, the section of the site was very rocky and scalping was not performed early enough to ensure good weed management.

In a different experiment started in 2012, LRI tested the effect of three different types of mulching and irrigation on seedling survival and growth. The experiment was set in four sites, Aanjar and Maqne with pine seedlings and Bcharre and Tannourine with cedar seedlings. In each of the 4 sites, 288 seedlings were planted in the experimental plots, half of which were left without irrigation as a control. Although the data did not show clear differences among mulching types (stone, fabric and plastic mulching), differences in mortality between irrigated and non-irrigated seedlings were greater in some sites than in others. Average seedling mortality rates for all four sites are presented in Table IV-3 below. The rates were quite variable among sites, ranging from ~29% in Bcharre, to more than 86% in Aanjar. The results in Bcharre were considered particularly promising for the potential of successful reforestation without irrigation in that area. Results for Tannourine were not too high and were almost double in mortality than Bcharre, suggesting that soil types, exposure and maybe planting quality could have a greater effect on the success of no-irrigation than altitude and yearly precipitation. In Maqne, the results were quite promising, considering how arid the area is. In Aanjar, on the other hand, the results are very similar to those obtained for the non-irrigated site section left in 2012-2013, suggesting that the success of reforestation in a site like Aanjar is tightly linked to irrigation.

Table III-4. Average mortality rates of irrigated and non-irrigated seedlings in experimental plots set in four LRI

reforestation sites

Site	Average mortality rate for non-irrigated seedlings	Average mortality rate for irrigated seedlings
Tannourine	46.28%	8.01%
Bcharre	28.67%	21.54%
Aanjar	86.77%	50.32%
Maqne	44.96%	53.78%

More irrigation trials will be conducted in 2013-2014 in several new sites to compare results.

IV. LEBANON REFORESTATION INITIATIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

IV. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The Lebanon Reforestation Initiative has planted (and facilitated the planting of) more than 516,000 seedlings on more than 731 ha of land across more than 30 sites distributed throughout the country, in collaboration with local municipalities and NGO partners (see Table IV-1 for a summary of seedlings planted and surface areas across sites and site categories). Throughout the process, LRI has worked on improving outplanting best practices and setting new approaches to reforestation that could lead to improved survival rates and reduced reforestation costs.

Table IV-1. Total number of seedlings and surface area planted under the LRI project

	2011-2012		2012-2013		2013-2014		Total	
Site	**Number of seedlings planted**	**Surface area planted (ha)**	**Number of seedlings planted**	**Surface area planted (ha)**	**Number of seedlings planted**	**Surface area planted (ha)**	**Number of seedlings planted**	**Surface area planted (ha)**
Aanjar	16,500	35.40	21,940	9.30	7,500	0.50	45,940	45.20
Ainata	0	0.00	22,811	22.31	11,250	0.60	34,061	22.91
Bcharre	0	0.00	25,286	56.00	12,920	30.39	38,206	86.39
Kfardebiane	0	0.00	41,350	117.00	22,100	13.00	63,450	130.00
Kfarzabad	16,500	22.82	21,540	8.88	0	0.00	38,040	31.70
Maqne	0	0.00	22,430	28.02	15,400	0.50	37,830	28.52
Qlaiaa Waer	27,000	24.66	30,015	7.52	4,800	0.00	61,815	32.18
Rachaya	27,000	22.31	45,823	71.88	6,700	0.00	79,523	94.19
Rmadiye	0	0.00	32,118	63.87	11,500	16.27	43,618	80.14
Tannourine	3,680	5.00	4,009	6.90	3,875	10.5	11,564	22.40
Akroum	0	0.00	0	0.00	1,000	2.00	1,000	2.00
LAF sites	0	0.00	8,000	4.09	9,700	12.68	17,700	16.77
Small-scale sites	2,000	2.20	10,501	44.00	15,112	62.90	27,613	109.10
Private donor sites	0	0.00	0	0.00	8,300	15.00	8,300	15.00
Religious endowments	0	0.00	0	0.00	3,700	7.00	3,700	7.00
Totals	**92,680**	**112**	**285,823**	**440**	**133,857**	**171.27**	**512,360**	**723.27**

Planting quality inspection and monitoring of seedling survival were not conventionally used in reforested areas across Lebanon. The purpose of this document was to share the protocols used by LRI for these two practices with reforestation stakeholders and to show the importance of the data collected through both processes for drawing lessons learned and improving the decision-making process for future projects. Planting quality inspection was found in most sites to have the additional advantage of influencing planting quality within the same planting season and consequently improving seedling survival rates. In fact, across all LRI sites, a clear relationship was observed between below-ground planting quality and seedling survival whereby sites with better planting quality at the root level exhibited higher survival rates (Fig. IV-1).

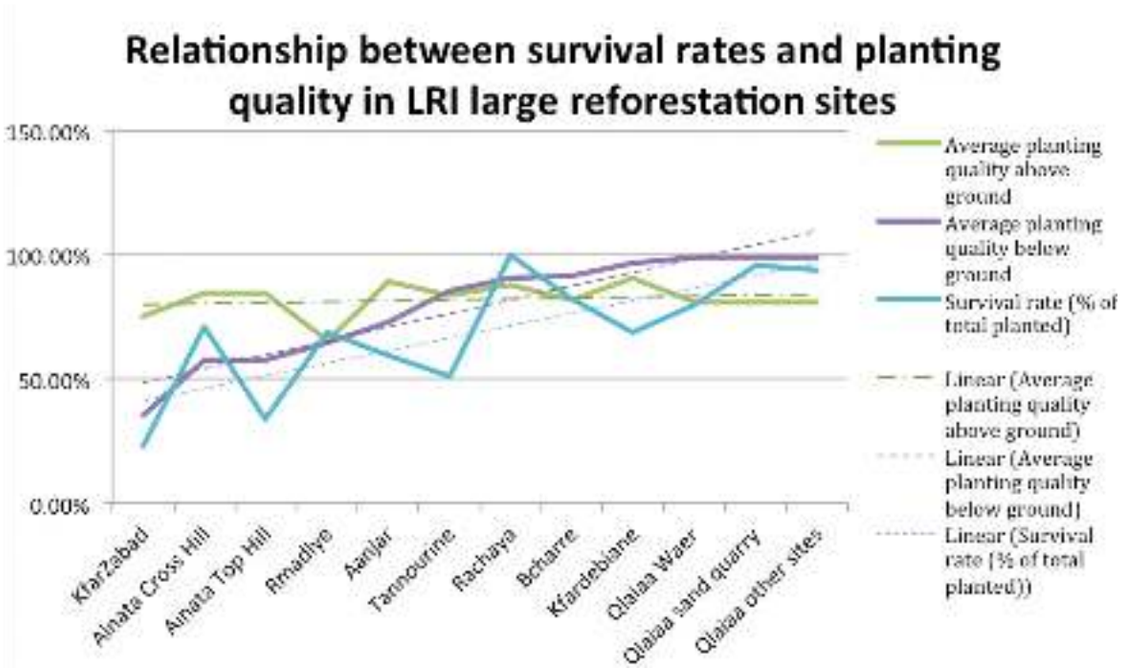


Figure IV-1. Graph showing relationship between survival rates and planting quality results in LRI large reforestation sites for the planting season of 2012-2013

The average seedling survival rates improved from approximately 37% at the end of summer 2012 to over 67% in 2013 (Table IV-2), compared to the historical national average of 25%. This improvement in survival was related in all sites to three major factors:

1. The improvement in seedling quality achieved by LRI-supported nurseries upon adoption of LRI container tree seedling production best practices;
2. The improvement in planting quality with additional worker training and on-site planting quality inspection during the field season; and
3. Moisture conservation through good weed management and irrigation.

Table IV-2. Yearly and cumulative survival rate information for the ten large LRI reforestation sites

	2011-2012			2012-2013			2013-2014		
Site	**Number of seedlings planted**	**Survival rate (% of total planted)**	**Number of surviving seedlings**	**Number of seedlings planted**	**Survival rate (% of total planted)**	**Number of surviving seedlings**	**Number of seedlings planted**	**Survival rate (% of total planted)**	**Number of surviving seedlings**
Aanjar	16,500	18.00%	2,970	21,940	59.49%	13,052	7,500	91.47%	21,516
Ainata Cross Hill	0	N/A	0	8,000	70.93%	5,674	11,250	95.00%	16,078
Ainata Top Hill	0	N/A	0	14,811	49.20%	7,287	0	66.36%	4,836
Bcharre	0	N/A	0	25,286	82.04%	20,745	12,920	90.64%	30,514
Kfardebiane	0	N/A	0	41,350	68.65%	28,387	22,100	68.65%	34,659
Kfarzabad	16,500	16.00%	2,640	21,540	22.97%	4,948	0	2.00%	152
Maqne	0	N/A	0	22,430	79.80%	17,899	15,400	84.74%	28,218
Qlaiaa Waer	15,000	42.00%	6,300	28,000	95.62%	26,774	4,800	83.80%	31,738
Qlaiaa sand quarry	9,000	84.00%	7,560	0	93.85%	0	0	95.00%	7,182
Qlaiaa other sites	3,000	10%	300	2,015	100.00%	2,015	0	95.00%	2,199
Rachaya	27,000	58.00%	15,660	45,823	68.68%	31,471	6,700	73.20%	39,404
Rmadiye	0	N/A	0	32,118	51.32%	16,483	11,500	62.68%	17,540
Tannourine	3,680	30.00%	1,104	4,009	47.83%	1,918	3,875	61.17%	4,219
Totals	**90,680**	**36.86%**	**36,534**	**267,322**	**68.49%**	**176,652**	**96,045**	**74.59%**	**238,254**

Data collected through the process of inspection of planting quality has also helped understand better the competence of Lebanese planting workers in reforestation. Although experienced in agriculture in general, Lebanese workers still need to build experience and skills in reforestation practices to achieve better productivity and efficacy. Average worker productivity ranged across sites between 27 and 57 for Lebanese labor, while it reached 93 to 115 when non-Lebanese crews were employed (Table IV-4). Bringing reforestation to the next level in Lebanon is going to require extensive training of planting crews with a special focus on improving worker productivity through the improvement of seedling transportation in the field (using more planting bags), adaptation of existing tools to maximize time and energy efficiency (such as using the combination tool), and creating incentives for workers to plant faster and better quality.

The future of reforestation in Lebanon relies mostly on the implementation of best practices both at the nursery and the outplanting levels, and most importantly on good data collection and record keeping that allow reforestation managers to learn from previous mistakes and tackle problematic issues with an informed mindset. Monitoring and inspection are simple additions that would bring reforestation to the next level.

Table IV-3. Inspection results for the ten large LRI reforestation sites

Site	Number of seedlings planted	Number of Inspection days	Average number of workers per day	Average worker productivity	Average planting quality above ground	Average planting quality below ground	Average seedling density per ha
Aanjar	21,940	38	15	27	89.20%	72.70%	685
Ainata	22,811	22	18	57	84.37%	57.58%	1,076
Bcharre	25,286	18	11	115	81.79%	91.61%	384
Kfardebiane	41,350	33	20	93	90.61%	96.61%	423
KfarZabad	21,540	27	15	36	75.13%	35.36%	725
Qlaiaa	30,015	58	6	37	80.59%	98.99%	582
Rachaya	45,823	54	22	38	87.82%	90.57%	934
Rmadiye	32,118	51	18	29	65.28%	64.38%	613
Tannourine	4,009	15	7	38	83.54%	85.33%	552

**Numbers highlighted are either the lowest or highest among all sites*

ANNEXES

ANNEX 1. INSPECTION FORMS

LRI Planting Inspection Form[version 1.4]						Page ___ of __ [(d)]	
Planting Site[a]: _____					Inspector[f]: _____		
Date[b]: _____ DateC: _____		Time[c]: _____					
	Seedlings in Plot				# "Good" trees		% Plant[l]
Pl. #[g]	1[h]	2[h]	3[h]	Total[i]	Above[j]	Below[k]	
	above:						
	below:						
	Photos/Remarks[m]:						
	above:						
	above:						
	above:						
	above:						
	below:						
	above:						
	above:						
	above:						
	above:						
	below:						
			Totals:	n above	p	q	
				o below			
% "Good" (above)[r]:_____				% "Good" (below)[s]: _____			

Planting Inspection Form Instructions
These instructions refer to the superscript letters in the form. (VERSION 1.4)

Letter	Explanation
A	The name of the planting site (e.g. Rachaya)
B	Today's date
C	The time of inspection
D	The number of pages of each inspection (e.g. Page 1 of 2). There can be multiple inspections in a given day. Each inspection should be done on separate forms.
F	The name of the planting inspector
G	Plot number (1,2,3..)
H	Seedling inspection code. For each seedling, enter the code that describes its condition (e.g. "1" = satisfactory planted seedling) (see table of codes). If the seedling was not planted satisfactory, enter the code that describes the problem. You can have more than one code if there is more than one problem. Enter the codes for the above ground inspection in the top cell, and the code for below ground inspection of this same seedling in the bottom cell.
I	The total number of trees inspected on the plot. Enter the total of all the "Above" ground inspected seedlings in top cell and the "Below" ground total in the bottom cell.
J	The total number of satisfactory planted ("Good") trees on the plot from the "Above" ground inspection. Add all the seedlings coded "1".
K	The total number of satisfactory planted ("Good") trees on the plot from the below ground inspection. Add all the seedlings coded "1".
L	The estimated percent of the plot that is plantable (sufficiently free of rocks or other obstacles to allow planting a seedling).
M	Enter the photo number for any problems with planting identified that the inspector wishes to document to show the planting crew. Describe any of the identified problems in this cell.
N	The total # of trees inspected for all plots. Add all the numbers in Column i that apply to the above ground inspection only.
O	The total trees inspected for below ground quality for all plots. Add all numbers in Column i that apply to the below ground inspection only.
P	The total number of satisfactory planted ("Good") trees on all all plots from the above ground inspection. Add all values from Column J.
Q	The total number of satisfactory planted ("Good") trees on all plots from the below ground inspection. Add all values from Column K.
R	The percent of seedlings on all plots planted to a satisfactory level (i.e. those trees coded "1") based on the above ground inspection). Divide cell P by cell N.
S	The percent of seedlings on all plots planted to a satisfactory level (i.e. those trees coded "1") based on the below ground inspection. Divide cell Q by cell O.

Seedling Inspection Codes (Above Ground)		
#:	Code:	Definition:
1	Good	Seedling satisfactorily planted
2	Too Deep	Seedling was planted too deep (branches buried)
3	Too Shallow	Seeding was planted too shallow (the plug is above the dirt level)
4	Angled	Seedling was planted > 20 degrees from vertical
5	Loosely Planted	Seedling can be easily lifted from the ground by pulling on the tree using thumb and forefinger
6	Poor Hole Location	Seedling was planted too close to a large rock, preventing mulch mat placement

Seedling Inspection Codes (Below Ground)		
#:	Code:	Definition:
1	Good	Seedling satisfactorily planted
2	J or L Rooted	Seedling root system is bent and/or turned up at bottom
3	Air pockets	Air pockets occur around the roots
4	Rocks in hole	The dirt used to fill the hole was not cleaned of rocks

LRI Daily Planting Report version 1.4						
Planting Site[a]: _____						Crew Size[e]: ____ # Hrs[g]:
Inspector[b]: _____						Weather[f]:
Date[c]: _____						
GPS "Track" Name[d]:_____						
Seedling Inventory		Species[h]				
		1-	2-	3-	4-	5-
Nursery[i]						
# Trees Delivered[j]						
# Trees Carryover[k]						
# Trees Remaining[l]						
# Trees Planted[m]						
# Trees Rejected[n]						
Roots moist? (Pre-plant)[o]		Yes No	Yes No	Yes No	Yes No	Yes No
	(Post-plant)[p]					
Remarks[q]:						
Inspection Summary			Remarks[r]			
Above	# "Good" Trees[s]					
	# Inspected[t]					
	Quality %[u]					
Below	# "Good" Trees[v]					
	# Inspected[w]					
	Quality %[x]					
Density	# Planted[y]					
	Area Planted (ha)[z]					
	Seedlings per ha[aa]					
	Average Spacing[ab]					
Narrative[ac]:						
Issues to Resolve[ad]:						
Supplies/Equipment Needs[ae]:						

Daily Planting Report Instructions (VERSION 1.4)	
Letter	Explanation
A	The name of the planting site (e.g. Rachaya)
B	The name of the planting inspector.
C	Today's date
D	The name of the "track" used in the Garmin GPS to delineate the planting area completed today.
E	The number of people in the planting crew today.
F	A description of the weather today.
G	The total number of hours worked collectively today by the planting crew.
H	The species of the seedling being inventoried (e.g. Pinus pinea=PIPI)
I	The nursery where the seedlings were grown.
J	The # of seedlings delivered today for each species.
K	The # of seedlings for each species delivered in previous days but not planted.
L	The number of trees for each species remaining after today's planting.
M	The number of trees planted for each species today. Add Cell J and K and subtract Cell L.
N	The # of seedlings rejected for planting and to be returned to nursery.
O	Were the seedlings which arrived from the nursery each day moist?
P	Check box to confirm that the seedlings remaining after today's planting have been moistened if needed.
Q	Describe any important details about the condition of the seedlings.
R	Describe any important details about the quality of planting today.
S	The total number of satisfactory planted trees on all plots from all "Above" ground inspections completed today. Add all values from Cell P of the Planting Inspection Forms.
T	The total number of seedlings "Above" ground inspected today. Add all values from Cell N of the Planting Inspection Forms.
U	The percent of seedlings planted today to a satisfactory level based on the "Above" ground inspection). Divide cell R by cell S.
V	The total number of satisfactory planted trees on all plots from all "Below" ground inspections completed today. Add all values from Cell Q of the Planting Inspection Forms.
W	The total number of seedlings "Below" ground inspected today. Add all values from Cell O of the Planting Inspection Forms.
X	The percent of seedlings planted today to a satisfactory level based on the "Below" ground inspection). Divide cell U by cell V.
Y	The total number of trees planted today. Add all values in Row M.
Z	The area planted today in hectares (from Garmin GPS)
AA	The # of seedlings per hectare planted today (Cell X divided by Cell Y).
AB	The average spacing in meters of trees (all species combined) planted today [take the square root of (10,0000 divided by Cell Z)].
AC	Provide a summary of the important events of the day regarding planting and inspection.
AD	Describe any issues that need to be discussed with LRI staff and/or the planting crew.
AE	Describe any supplies or equipment needed.

ANNEX 2. SAMPLE MONITORING DATA COLLECTION SHEET

ID	DATE	Plot Quality (Plantable or not)	HEALTHY	DAMAGED	DEAD	NOTES
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
Total						

ANNEX 2. SAMPLE MONITORING DATA COLLECTION SHEET

ID	DATE	Plot Quality (Plantable or not)	HEALTHY	DAMAGED	DEAD	NOTES
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
Total						

(Footnotes)

1 Inspections were not carried out during weekends and therefore the number of inspection days is lower than the actual number of planting days.

2 Average productivity is calculated based on daily productivity recorded for each inspection day. Worker productivity on a given day = number of seedlings planted / total crew size. Ideally, only workers who are planting should be counted, but because workers often mixed roles (not all were always planting trees) the entire crew was included in the calculation.

*3 Percentage of planting quality above ground = number of seedlings showing good quality planting seen above-ground / total number of seedlings inspected *100.*

*4 Percentage of planting quality below ground = number of seedlings showing good quality planting when roots underground are exposed / total number of seedlings inspected below-ground *100*