PROJECT REPORT TO ESTABLISH AND OPERATE A FOREST TREE AND SHRUB NURSERY

PROJECT HOLDER: SHEN NGO

YEREVAN, 2005

TABLE OF CONTENTS

1 INTRODUCTION

This report describes the justification and objectives of the project (chapter 2), the main conditions of the nursery site (chapter 3), the necessary action to install a well functioning nursery (chapter 4), the nursery operations to produce high quality seedlings and other types of planting stock (chapter 5) and the costs to install and manage the nursery (chapter 6). The report mainly focuses on the nursery establishment and operations necessary to produce high quality seedlings for reforestation in the semi-arid and dry mountain steppe zones of Armenia. Readers interested more in the reforestation project should refer to the report "Action and Business Plan to Re-establish Jrvezh Arboretum".

2 JUSTIFICATION AND OBJECTIVES OF THE PROJECT

Armenia is covered today with approximately 8%[1] forest which is rapidly declining due to uncontrolled browsing and illegal cuttings. Fuelwood is still used in high quantities[2] in rural areas and in Yerevan (gas and electricity are too expensive for poor households and many households are not connected to the electricity net or to the gas pipeline). Moreover, there are "illegal" wood cutting enterprises, harvesting the beech and oak forests in an unsustainable, destructive manner. These wood logging enterprises are today the main agents of the destruction of Armenia's forest. Additionally, forests have not been well managed by the Armenian Forest Department due to the lack of funds. In the past 10 years, approximately 26.2% of beech (*Fagus orientalis*) forest became converted to coppice forest and currently only 10.3% of beech forest is reported to have high density, which is necessary to prevent natural hazards e.g. landslides, erosion and floods. Moreover, oak (*Quercus spp*.) forests are in very critical conditions, having 31.3% of mature and over-mature trees. The age structure of oak forests is not sustainable (average age being 90 years, pre-mature trees only having a share of 6.5%) and in the future will have a negative impact on forest resources (*State of the Environment Report for Armenia.2000. Environmental Conservation and Research Centre. American University of Armenia).* A large amount of Armenian forests were highly damaged, during the energy blockade after independence. Between 1992 and 1994 approximately 1 million m^3 of wood was cut annually (*Human Development Report Armenia 1999, UNDP*). Unfortunately, this mass destruction has not yet stopped. From 1996 to 2002, about 6 million m^3 of timber was cut, indicating an annual use of 1 million m^3 or 4'000 to 5'000 ha of clear cuttings per year (*National Councils for Sustainable Development*). Most of the negative impacts mentioned above continue in Armenia despite a new forest law. Some experts predict that Armenia will have no forests by 2025/30[3] if the current conditions persist. Due to unsustainable forest management, unfavourable topsoil (e.g. silt) and climate, the territory of the country has been subject to desertification. 26.8% of the country is extremely affected, 26.4% of the country's territory is strongly affected, average desertification covers 19.8% and weak desertification is 8.8% (*United Nations Common Country Assessment of Armenia*). Desertification will have a negative impact on Armenia's economy. It is acknowledged that not only do forests produce wood and non-timber-forest-products of economic value; forest services also include prevention against natural hazards (landslides, mudslides, stone fall,

[1] *Armenia Tree Project*
[2] 0.5 million m3/year is burnt in the country (*United Nations Common Country Assessment of Armenia*)
[3] *World Bank, Armenia Tree Project*

avalanches, torrent regulation, etc.) and the improvement of water household management and microclimate, though the precise economic value of these benefits has yet to be determined by scientists.

The objective of Shen NGO is to develop a 3 ha forest-tree and shrub nursery which, in the third year after establishment, will produce a large quantity of high quality plant stock. The demand of seedlings for reforestation and initialising the next generation of the mature/overmature forests is very high. Unfortunately, Armenia has only two acknowledged local NGO's involved in producing seedlings for reforestation (Armenian Forest NGO) and other uses (Armenian Tree Project[4]). A large number of governmental tree nurseries developed during the Soviet period are not functioning today or are in poor condition.

The selection of a central location for a tree nursery plays an integral role in fulfilling Shen's goals for reforestation. Approximately 65% of Armenian's forests are located in the North-East and 33% in the South of the country. Only 2% of Armenian's forest and shrub vegetation is located in Central Armenia. Due to this uneven forest distribution Shen has decided to develop a nursery in the Kotayk region, to supply the central dry parts of Armenia with forest trees and shrubs. One can argue now, that the operational costs of irrigation will be higher in the drier areas of Armenia, but on the other hand transportation costs and air pollution are reduced. Moreover, hardening and natural selection[5] of seedlings can be directly carried out in the nursery, increasing the success of future reforestation projects.

3 SITE CONDITIONS

The site is located in the Kotayk region approximately 4 km North-North-East of Abovian on the road heading to Jraber. The site can easily be reached by vehicles during the entire year (except winters with heavy snow), and there is plenty of labour force available in Abovian.

The average altitude of the site is 1'517 masl, and the average slope grade is 6.5% with a southern exposure. The area was used during the Soviet period as a tree nursery. Therefore, about 20'000 old seedlings of *Pyrus*, *Malus* and *Fraxinus* are scattered in the grass (alfalfa) vegetation. The site is surrounded to the North, East and West by trees, which have a positive effect on the microclimate (windbreak; weather extremes are more reduced than on the open bare surface). Agriculture is carried out in this area and there is an irrigation system supplying the area with water. The Armenian forest department declared that the water source supply is sufficient even during the main drought period from July - October. During the Soviet period water was provided from the 1st of April until the end of October. However, today the supply of water is shorter in duration, beginning at the end of May and ending earlier in mid October. Moreover, water is not everyday available. Water is pumped on to the top of the hill (1'563 masl) and distributed using gravity. There is still a network of old irrigation pipes. The main pipe line, which supplies Abovian with water, functions well. In contrast a high number of pipes, which were used to irrigate the reforested area, are damaged.

The site contains Quaternary and Miocene geological layers. According to the soil atlas from 1990, the nursery-site is located in the mountain-dark-chestnut soil area. Self conducted soil

[4] Since 2005, Armenian Tree Project is also involved in reforestation.
[5] Mainly only seeds adopted to the nursery site soil will germinate. This type of soil is widely found in the drier areas of Armenia.

analysis confirms this information. The soil contains a high amount of loam-clay and organic matter (mull-humus). The pH of the topsoil varies between 7.2-7.3. A sample 40cm lower has a pH of 7.22. Therefore, the soil is slightly alkaline. The optimum pH value for tree nurseries is 6. The deepness of soil is at least 50 cm. Clay and stone minerals have been highly weathered. Hardly any large stones were found and the topsoil contains less then 15% of stones. Basalt, Andezit, Dolerite, Obsidian and limestone are found on this site. Basalt has the highest share of rocks in the area. Since there is a high quantity of clay, soil-erosion caused by irrigation water should be less problematic. In contrast water-logging could cause problems, due to the high amount of clay. However, excess water can runoff (controlled), due to the slight slope. If water-logging highly affects the site, tilling the furrows and adding sand or shlugh (grained tuff stone) to the site soil can prevent this unfavourable condition. Biological activity in the soil is high. A high amount of earthworms (Lumbriciden) were identified. Earthworms have a positive effect on the soils structure. On the one hand they produce macro-pores, which are important for air and water exchange in clay-loamy soils and on the other hand they contribute to the "mixture" of soil (deposit of nutrients into lower soils horizons).

This site is located in the "moderate-warm-humid" agro-bio-climatic zone. Due to its close location to the "dry continental" agro-climatic zone, the values of annual precipitation are not very high and the absolute minimum temperature not very low as presented in the following table:

Agro-climatic zone	Average annual air temperature (^oC)	Average monthly air temperature in January (^oC)	Average monthly air temperature in July (^oC)	Absolute air temperature (^oC)		Annual sum of precipitation (mm)	Quantity of precipitation during the vegetation period (mm)
				max	min		
Moderate warm-humid	4-7	-5 to -10	15-19	37	-41	450-800	300-500
Dry continental	8-9	-5 to -7	21-23	38	-34	400-480	250-300

Table 1: Climate characteristics of the Abovian/Jraber site (*source: Soil Atlas of Armenia 1990)*

The annual sum of precipitation is about 450mm and the quantity of precipitation during the vegetation period is approximately 300mm. Rainfalls are mainly in spring and a few in autumn. Summers are very dry.

Unfortunately no exact graph describing evaporation could be obtained for the area. It is only known that the potential evaporation is approximately 960 mm/year and the effective evaporation 360mm/year. This site is located in the low frost risk region of Armenia and the absolute minimal air temperature is not very low as presented in table 1. Snow, which isolates the seedlings and the shelterbelt should produce a positive microclimate, reducing the risk of frost damage.

Based on the book "Dendroflora of Armenia", this site is located in the mountain steppe of the Areg-Kotayk region. This book describes the climate as follows:

Air temperature (^{o}C)				Frost free days	Precipitation (mm)	
Annual average	Absolute minimum	Absolute maximum	January average		average	period
8.2	-30	-----------	-5.7	187	498	115

Table 2: Climate characteristics of the nursery site (*source: Dendroflora of Armenia 1985)*

Main differences between the two climate tables are the absolute minimal air temperature. As mentioned above the site is located at 1'500 masl in the low frost risk zone and therefore, absolute minimal air temperatures are closer to –30^{o}C, than to –40^{o}C. Otherwise the tables are quite similar. Appendix 18 contains a report concerning how this nursery site was selected.

4 NURSERY ESTABLISHMENT

This chapter describes the layout of the nursery, followed by the necessary cultivation- and construction activities to establish a permanent forest tree and shrub nursery. It has to be mentioned that several activities such as fencing, terrain preparation and the partly installation of the irrigation system have been already carried out during the development of this report.

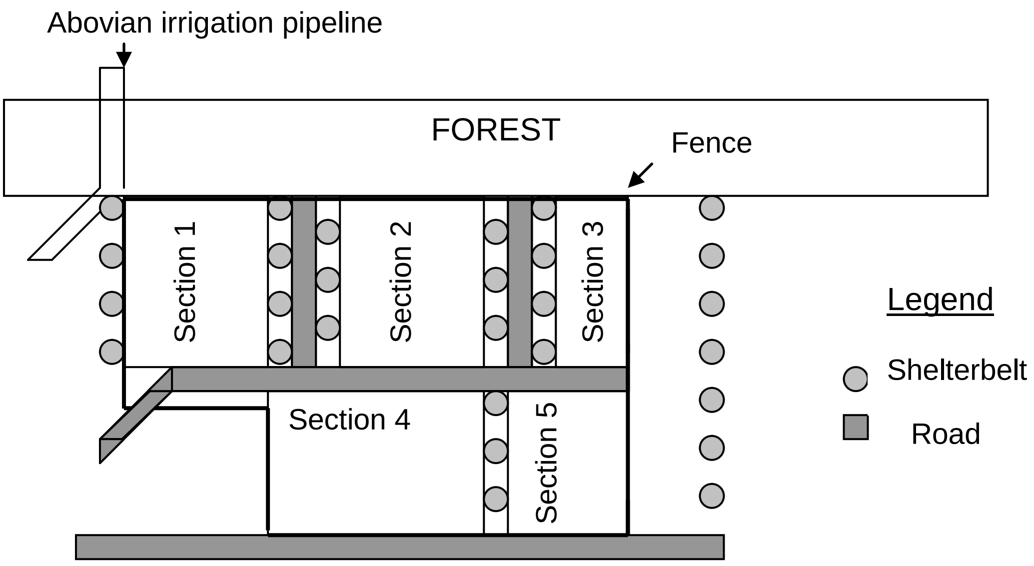
4.1 NURSERY LAYOUT

The total area allocated to Shen NGO for 10 years by the Forestry Department of the Ministry of Agriculture is 3 ha. This area was used during the Soviet period as a nursery site and therefore several conditions are given. The site is protected in the North by forest and in the East and West by shelterbelts. The 3 ha are already separated into 5 parts by shelterbelts and nursery management roads. Therefore, there are 5 main sections. Graph 1 illustrates the site at present time and the perimeter (fence) of the nursery. The average slope grade is 6.5 %[6]. The upper portions of the sections are steeper and the lower portions of the sections are almost flat.

Section 1 is 6'050 m^2, section 2 is 8'050 m^2, section 3 is 3'775 m^2, section 4 is 4'540 m^2 and section 5 is 2'215 m^2. Therefore, the nursery will have an entire propagation surface of 2.46 ha. Half a hectare will be used for infrastructure such as, tractor paths, shelterbelt, irrigation pipes, guard house, greenhouse, etc.

Sections one, four, and five will be used to sow seeds and plant cuttings. Section two will be used as sowing and transplanting beds, depending on the species propagated. Section three will be used as transplanting beds. Appendix 1 shows the topography of the site and appendix 2 shows the exact layout of the nursery including shelterbelts, roads, buildings, propagation units and the irrigation layout.

[6] Most of the nursery area is located on slopes less than 5%.



Graph 1: Perimeter of the Nursery

4.2 CLEARANCE AND CULTIVATION

The heavy soil which has not been cultivated for several years (about 15 years), should be cleared and cross-ploughed in the autumn, to allow the winter frosts to break up the clods. The site is covered by rough grass (alfalfa) and several perennial flowers such as *Tripholium*. Cross ploughing of a one ha surface in autumn 2004 showed that it is not sufficient to cross plough once. Therefore, the 2.5 ha of future seedbeds will have to be cross ploughed at least 3 times. All top growth, perennial roots and stones must be removed from the future seedbeds, otherwise the dense vegetation cover will re-sprout again. Undesirable small trees and shrubs, which are located on the future propagation area, can be removed entirely, using the Belarus tractor.

Before sowing the beds have to be well consolidated to allow the soil moisture to reach the surface layer by capillary activity, and to minimize loss of soil, due to erosion. Never cultivate the field by tractor when the soil is too wet, or the soil structure will be damaged. During a 10 year period Shen NGO will have to cultivate (cross plough) the 2.5 ha propagation area 7-9[7] times, depending on the growth rate of the seedlings.

4.3 BEDS, PATHS & ROADS

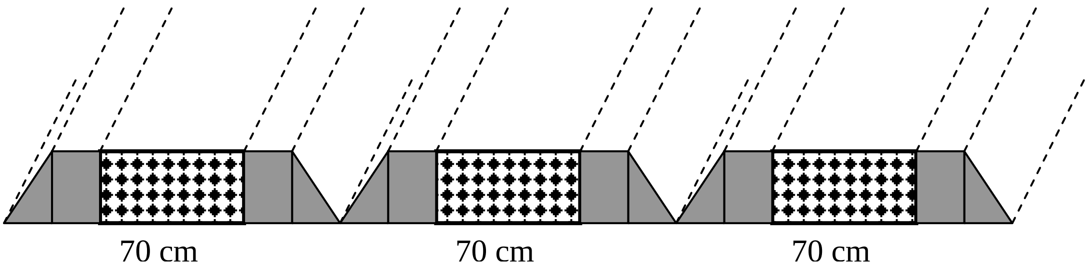
Seedbeds must be made afresh each time a new generation of seeds are sown or seedlings transplanted. Tractors with special cultivars are used to produce the seed beds due to the large size of the nursery. Each time beds are renewed the tractor cross ploughs the soil to loosen up the soil structure. Once the field has been ploughed the furrows can be made using a second set of special tractor cultivars. The “Belarus-furrow-cultivars” produce furrows 70 cm apart. The deepness and width of the furrows can be influenced depending on how deep the cultivars are pressed into the soil. An average, widely common depth of furrows is about 7cm (Table 3, page 8 contains detailed information about furrow shape, length, etc.). Raised beds are advantageous for propagation because they are well drained and warm more quickly, promoting germination and growth.

[7] To clear the vegetation cover, the area has to be cross ploughed 3 times before the seedbeds can be sown the first time. All 2-3 years the seedbeds need to be renewed, by cross ploughing the area two times. (1st year: 3 times, 3rd year: 2 times, 6th year: 2 times, 9th year: 2 times = 9 times/10 years)

Heavy rainfall and irrigation will cause soil erosion of the beds. Therefore, it is at the moment uncertain how close the seeds should be sown to the furrow. Literature recommends to leave a strip of 8-10 cm unsown. However, Armenian specialists argue that the seeds be far away from the water source. It is recommended to test out where exactly to sow the seeds. The heavy soil has the benefits of being more resistant to erosion and a more lateral infiltration movement than observed in light soils. If seeds are sown near to the furrow they should be sown deeper than usual to prevent them being washed out by heavy rainfall.

In general one seedbed (unit between two furrows) will contain two rows and the distance between the seedlings in the row will be 10[8] cm. However, the spacing between the rows is unknown, due to the problem described above. If the seeds are sown close to the furrows, the workers can walk easily between the two rows. Walking on the propagation area should be avoided during irrigation or rainfall because walking on wet soil compacts it, thus increasing the likelihood of the furrows and beds suffering damage. Every 7 meters a furrow should be filled with gravel and used as a main path (120cm wide path). Graph 2 shows the layout of the furrows, propagation area and paths.

This layout makes it possible to produce 700’000 plants in 3 years on a total propagation area of 2.5 ha. A spacing of 20cm would result in 350’000 trees.



Graph 2: Layout of propagation area, furrows and paths

- Propagation area (the closer to the furrow, the higher the risk of erosion and therefore, a higher risk of seeds getting washed out)
- Small paths (120cm wide paths are not shown in the graph)

The furrows are about 15-20cm wide on the upper open part and 7 cm deep. Due to the problem mentioned above (uncertainty where to sow exactly), the minimal size of the paths will be 30 cm wide and the maximum width 50 cm. It is very important that Shen NGO monitors the impact of soil erosion to adapt the seed/seedlings distance from the furrow (see appendix 7). Also the development of the seedlings in one row has to be monitored (densely planted seedlings do not grow very fast and are more prune to diseases).

The nursery will contain a network of a few large roads (4m wide) to allow small water trucks and tractors to service the nursery area. Large trucks will mainly be used every 2-3 years to transport planting stock to the reforestation site. The minimal radius of the turns should be 5 m

[8] If 10cm spacing is too close between the seedlings in one row, the seedlings can also be spaced at 15 or 20 cm. On the one hand, the larger the spacing, the less seedlings are produced and on the other hand, seedlings with more space are less vulnerable to diseases and have more space for growth development.

to allow vehicles to manoeuvre easily without damaging seedlings or infrastructure. Appendix 2 shows the machine-road network of the nursery. The machine-roads do not need to be of high quality, because they are not frequently used and if used, during dry days.

4.4 SOIL TREATMENT

The soil is heavy in the nursery area and therefore, water-logging could occur. However, the beds are on a slight slope allowing excess water to runoff and observations during the rainy season (April-May) indicate, that no water-logging affects the area. In contrast the heavy clay-loamy soil has a positive effect to withhold water longer than sandy soils. It should be noted, that the nursery is located at 1’500 masl. and the solar radiation is very high. Due to evaporation, the upper 1-2 cm of soil is dried out in 1-3 days after rainfall. The dried up crust protects the lower soil from drying out quickly and additionally produces macro pores which increase the infiltration of water.

The long term development of the soil structure is not easy to predict. However, it is assumed that erosion and soil compaction will occur on the long term, even though all precautionary measures to minimize this negative development will be carried out. Additionally, the soil will also lose valuable plant nutrients on the long term. Therefore, it is recommended to add fertilizers to the seed beds and if necessary to add humus and soil (turf, grained tuff (shlugh). Good-quality growing soil is essential to producing high quality planting stock. NPK (nitrate, phosphate, potassium) fertilizers are very useful to increasing the growth rate of seedlings. However, NPKs are very expensive. Therefore, organic fertilizers such as mulch and cow manure will be used.

According to local Armenian experts, soil born fungi should not be a problem in the area and therefore, no soil fumigation or soil acidification will be applied for the first sowing attempt. However, if damping off is significantly high in the nursery area, soil fumigation will be necessary (see chapter 5.8 and appendix 6).

4.5 FENCE AND PROTECTION

The nursery area must be protected against deer, cows and humans. The seed beds also need protection against birds and small animals. However, birds that eat small animals, such as mice are helpful. A fence to exclude big mammals and humans can be made from gauge mesh of 1.5 m height and barb wire. To assure the stability of the fence the poles are buried 50 cm in the ground and surrounded by holes (40cm in diameter) which are filled with concrete. A pole is placed every 3 m to assure stability. The nursery has at the moment one main entrance which is 6 m wide to allow big vehicles to enter the nursery. Additionally, the nursery will have 4 large doors (6m) to ease access to the sections.

There, are several methods to prevent small animals entering the nursery. Best, but also most expensive, is to burry 15cm of fine gauge mesh under the surface, to discourage burrowing and to place 35 cm above the surface to avoid mice enter the nursery. The portion of the fence which is buried must be treated with an anticorrosive coating because the zinc used in galvanisation eventually would make the soil toxic. An alternative, but less secure, would be to place stones at the bottom part of the fence. Additionally traps and poison can be used to reduce the damage by animals. If birds cause problems, poles with aluminium stripes can be used to deter them.

The shelterbelts in and around the nursery are not in perfect condition. Some trees in the shelterbelt have been harvested or died in the past. Therefore 280 trees (spacing 2m) have to be planted to produce a good shelterbelt, which protects the nursery from weather extremes. The young trees to produce the shelterbelt can be taken from the already existing 20’000 seedlings in the nursery area (section 3).

4.6 IRRIGATION SYSTEM

As Shen NGO has limited financial resources, the type of irrigation system will be developed on a step by step basis. The first stage of construction will be a furrow irrigation system consisting of a small amount of piping, many earth-channels, and requiring extensive labour. The second stage will improve the furrow irrigation system by adding more pipes and siphons/valves to ease the discharge of water from the main pipe line into the furrows. The 3rd stage will be to transform the furrow irrigation system into a sprinkler system. This report describes the second stage of establishing the furrow irrigation system.

As mentioned above in chapter 4.3, the furrows (small parallel channels) are constructed with a ridger-drawbar connected to a tractor, creating furrows 70 cm apart and about 7cm deep. Four furrows can be drawn simultaneously.

The seeds will be sown in the area, described in chapter 4.3 graph 2. They will not be planted in the middle of the ridge, even though lateral water movement and capillary rise will sufficiently supply the propagation area (rooting zone) with enough water. Spring 2005 was unusual rainy and no water-logging occurred in the nursery due to the slope allowing excess water runoff. The longest furrows in the nursery will be 125 m long.

The slope is uniform but exceeds the grade recommended by FAO. Therefore, in Section two, the furrows will be arranged almost perpendicularly to the slope grade to insure that the furrow grade does not exceed 0.5%. As mentioned above the soil crusts easily and therefore is especially suited to furrow irrigation because the water can infiltrate through the cracks. Additionally, the lower soil layers are protected from drying out quickly and erosion is less a problem for medium-heavy soils than for light soils. It should be mentioned that furrow irrigation was conducted here in the past in the line of the slope, with an average furrow garde of about 6.5%. Section one, three, four and five will also be irrigated in the line of the slope, because the slopes are not steep and section five is usually used as transplanting bed (2-3 year old seedlings prevent erosion).

The infiltration rate of the site soil is much lower than in sandy soils and therefore, furrows can be much longer. Additionally, there is much more lateral movement of water in clay soils than in sandy soils. Therefore, a wide, shallow furrow is desirable to obtain a large wetted area to encourage infiltration. Normally stream sizes up to 0.5 l/sec will provide an adequate irrigation, if furrows are not too long. When larger stream sizes are available, water will move rapidly down the furrows and so generally furrows can be longer. It is not recommended to use stream sizes larger than 3.0 l/sec.

It is important to maintain the furrows regularly in order to assure their well functioning (especially after heavy rainfall). Moreover, the stream size per furrow has to be tested out to minimize water loss and erosion due to excessively large stream sizes. On the other hand too small stream sizes result in inadequate watering of the propagation area and poor water distribution along the length of the furrows.

The following table only provides approximate values relating furrow slope, soil type, stream size and irrigation depth to furrow lengths (m).

Furrow slope (%)	Maximum stream size (l/s) per furrow	Clay		Loam		Sand	
		Net irrigation depth (mm)					
		50	75	50	75	50	75
0.0	3.0	100	150	60	90	30	45
0.1	3.0	120	170	90	125	45	60
0.2	2.5	130	180	110	150	60	95
0.3	2.0	150	200	130	170	75	110
0.5	1.2	150	200	130	170	75	110

Table 3: Values to design furrows (*source: FAO*)

To discharge water into the furrows, metal pipes and valves are used. Water is obtained from the existing main irrigation pipeline (Abovian pipeline), located 10m far from the nursery area. Additionally, water trucks and a 60 t reservoir are necessary, because water is only available from the end of May until mid October.

The main metal pipe (15 cm Ø, 160 m long), has been installed this summer (2005). However, 275 m of secondary pipes (5 cm Ø) still need to be installed and approximately 432 valves are necessary to discharge water into the furrows. Besides the pipes used to deliver water, 170 m of halved plastic pipes (10 cm diameter) are required to create a network that collects excess water runoff in a reservoir at the lowest point of the nursery. Appendix 2 shows the layout of the irrigation system and table 10, page 31 presents the costs to establish the irrigation system.

4.7 OTHER NECESSARY INFRASTRUCTURE AND TOOLS

A guardhouse, a 300m^2 greenhouse[9] and a heating/generator house will be constructed. The generator house is used to heat the greenhouse and supply the nursery area with electricity. The main reason to construct a greenhouse is to propagate *Junipers polycarpos* and *Juniperus foetidissima*. Both species are endemic, rare and very important tree species for reforestation in the dry mountain steppe and semi desert of Armenia. *Juniperus spp*. is very difficult to propagate from seeds and cuttings. Therefore, a greenhouse which is humid and containing heated seed beds will increase the success of propagating these valuable tree species.

4.7.1 Greenhouse

One of the most important factors (besides a good diseases management; see p. 26) for successful germination of seeds and the development of strong roots from stem cuttings is a moist environment maintained at a favourable temperature. Water loss is more dangerous for cuttings than for seedlings because they cannot take up water to replace the water lost through the leaves (transpiration) and will therefore, dry out if high rates of water loss occur. Temperature influences the physiological activity of plants. Temperatures between 21^{o}C to 27^{o}C stimulate optimum growth and development for most plants. 24^{o}C is usually recommended for most plants to produce roots from stem cuttings.

[9] The greenhouse will only be constructed, if it is impossible to propagate *Juniperus spp*. by conventional nursery operations.

Hydroponics, fog, mist and greenhouses are methods used in combination to propagate cuttings. However, neither hydroponics nor fog are widely used on large scale forestry (quite expensive). Mist is widely used in nurseries to propagate cuttings because it is an efficient system to produce large quantities of rooted cuttings. This method aids the rooting of difficult species and also helps to decrease the rooting time of “more easily” propagated species.

Intermittent or interrupted misting is superior to continually misting as this procedure causes cuttings to root faster and develop a better root system. Interrupted mist uses less water which keeps the propagation medium warmer and closer to the optimum conditions required for good root development.

Indoor misting is usually combined with bottom heating of the beds, to further decrease the amount of time required for rooting and enhance the quality of rooted cuttings. It is very important to maintain adequate ventilation with indoor misting. In general the rooting period is approximately 8 weeks. However, rooted cuttings should only be transplanted when they have developed a strong root system.

The greenhouse will be constructed with metal and glass. Plastic coverage is insufficient, due to snow in winter. Table 11, chapter 6 presents the costs to establish and manage a greenhouse. Appendix 16 shows the details of the greenhouse.

Commonly used rooting medium in greenhouses is a mixture of equal volumes of peat moss and coarse perlite. Combinations of other materials such as vermiculite, shredded sphagnum, and sand also prove satisfactory. It is important that the rooting zone is provided with sufficient oxygen and moisture. Therefore, the medium should drain freely and be free of pathogens and weed seeds. The air content of the media should be between 20 - 45 volume %.

The following factors are important to obtain a good propagation media:

- The media should be firm enough to hold the stem cuttings throughout their movement during rooting. The media should not shrink excessively after drying.
- The media should be able to hold moisture.
- The media should contain sufficient pores for drainage of excessive water and to supply the rooting zone with adequate oxygen.
- The media should not contain weeds, nematodes and other pathogens (e.g. soil borne fungi).
- The media should be capable of being sterilized with steam. However, other methods are also possible as mentioned below.
- The availability of plant nutrients should be adequate.

Besides chemical treatment of soil (e.g. soil fumigation), the media can be sterilized by placing a 5cm layer of moist medium on a tray in an oven at 104^{o}C for 1 hour. Be aware that the odour from heated moist media may be offensive. Soil is usually not recommended as a propagation medium in greenhouses, because it usually contains a variety of infectious organisms and can drain poorly if the amount of clay is to high. However, if soil is used it has to be sterilized as described above.

Root promoting hormones can be applied to the basal 1.2cm of cuttings before placement into the propagation medium to enhance root development of some plants. Root promoting chemicals are composed of the following auxins:

- Indole butyric acid (IBA) and/or
- Napthalene acetic acid (NAA)

4.7.2 Guardhouse (tool house) and equipment

The guardhouse and storage facility for tools is a mobile container hut which has to be renovated.

A number of tools are necessary to manage the nursery. Tools are mainly used to cultivate beds, transplant seedlings, and to collect, process and store seeds. Appendix 17 contains a list of specific tools and equipment.

5 NURSERY OPERATIONS

This chapter describes the operational activities necessary to produce high quality planting stock and to manage a permanent 3 ha forest tree and shrub nursery.

5.1 TREE SELECTION

One of the main factors affecting the success of reforestation projects and tree nurseries is the selection of suitable trees. Armenia is a highly complex country due to its geographical location in the South Caucasus. Armenia is the driest of the three Caucasian countries and solar radiation levels are amongst the highest worldwide and therefore high rates of evaporation intensely influence forestry and agriculture. Additionally, summer drought and frost complicate reforestation efforts in Armenia.

90% of Armenia's forests contain oak (*Quercus spp.*), beech (*Fagus orientalis*) and hornbeam (*Carpinus spp.*), and are mainly located in the North. The climate around Yerevan is much drier than in the Northern regions. One may argue to use intensive irrigation, but water is a valuable and scarce resource. Lake Sevan lost 40% of its water volume during the Soviet period. 54% of water loss was due to hydroelectric power stations and agriculture (irrigation). According to the forecast climate change[10], using forest trees and shrubs that are drought resistant can be beneficial. Drought resistant plants usually have extensive root systems (tap root e.g. *Pistacia spp*.), thick leaf waxes and bark (protects usually also against frost), good stomata control, and the capacity for leaf cells to function at low water contents. The following characteristics usually determine the suitability for drought resistance:

- Pioneer to mid-successional species versus climax species: The forests in the North of Armenia containing Oak, Beech and Hornbeam are Climax forests. In the South there are a few Relict Forests containing *Platanus* and *Juniperus spp*. These forest stands have a microclimate which has a positive effect on plant growth (weather extremes are smaller in the forest than on a bare surface). Therefore, pioneer and mid-succesional species should be used on bare reforestation sites. They usually use less water and are more tolerant against temperature extremes and soil site disturbance. (E.g. *Pinus spp., Robinia pseudoacacia, Betula spp.*)
- Multi-layer canopy versus single-layer canopy: Multi-layer[11] trees are usually used in reforestation in full sun because they are more water efficient than single layer trees. Monolayer[12] trees are usually used in partly shaded areas. (multilayer trees include *Quercus, Pinus, Carya,, Fraxinus, Juglans, Populus, Betula*; monolayer trees include *Fagus, Magnolia, Sassafras, Cercis*)

[10] Accepted climate scenario predicts that temperature will raise 2-3°C degrees and Armenia will have in future 10-15% less rainfall (for further detail see: *Vulnerability of natural ecosystems. A.L. Aghasyan et. al. Climate information centre of Armenia).*
[11] Multi-layer canopy contain many living branches with many leaf layers through out a deep crown.
[12] Single-layer canopy concentrates leaves in a single layer along the outside of the canopy area.

- Proper crown shape: In full light reforestation trees should ideally be tall with cylinder shaped crowns. (E.g. *Cupressus sempervirens, Juniperus spp.*)
- Proper leaf size and shape: Use small-leaved or small-deeply-lobed-leaved trees because they have better water use efficiency than larger leaves (transpiration). (E.g. *Ulmus, Juniperus)*
- Native versus exotics: Native trees are usually better adapted to local soil, climate and pathogens than exotics. Additionally, native trees have a much higher value in the ecosystem than exotics. However, Armenian forests have been highly destroyed and climate extremes (summer drought, frost and heat) make reforestation with native and exotic trees very difficult. Due to the long history of Armenia and the former Soviet Union, a high number of tree and shrub species have been introduced and successfully established.

Based on the criteria above to select suitable drought and frost resistant trees, literary research, and the phytogeographical analysis of Jrvezh arboretum, the following trees and shrubs have been selected to be propagated in the tree nursery:

Ailanthus altissima	*Hippophae rhamnoides**	*Pinus sylvestris*	*Robinia psuedoacacia*
Caragana arborescens	*Juglans regia**	*Pistacia mutica**	*Rosa canina**
Cedrus libani var. stenocoma	*Juniperus polycarpos**	*Platanus acerifolia*	*Sorbus graeca(*)*
*Celtis caucasica**	*Juniperus foetidissima**	*Platanus orientalis**	*Tamarix ramosissima**
*Celtis glabrata**	*Juniperus virginiana*	*Pyrus salicifolia**	*Ulmus elliptica**
*Crataegus orientalis**	*Malus orientalis**	*Quercus iberica**	*Ulmus pinnato-ramosa*
*Elaeagnus angustifolia**	*Pinus pallasiana*	*Quercus macranthera**	*Ulmus pupila*
Gleditischia triacanthos			

Table 4: Selected species to be propagated in the tree nursery, for the reforestation project of Jrvezh arboretum (*: endemic).

Appendix 3 (planting guide) contains detailed information about the species presented in table 4. The planting guides describe the growth requirement of the different species and how to propagate them.

5.2 SOURCE OF PLANTING MATERIAL

One of the most important factors is to obtain an adequate quantity of high-quality planting material (seeds, cuttings). It is not easy to obtain high-quality seeds in Armenia, since the break down of the forestry sector. Shen NGO ordered 300 kg of oak acorns from the Forest Department. Unfortunately, the acorns were of poor quality and approximately 2/3 had to be thrown away. Moreover, none of the sown acorns germinated leading to the assumption that the acorns were improperly stored (loss of humidity). Additionally, no information on the collection site was given. Therefore, Shen members will collect seeds themselves. The following factors are of essential importance to seed collection:

- Seeds should be collected in a mast year (e.g. oak usually produces good seed crops every 4 years. Many trees adapted to dry land climate produce good seed crops at intervals of 2, 3 or 4 years).
- Seeds and cuttings should be collected from plus candidate trees (plus candidate trees are the strongest individuals in a forest stand. The criteria for judging the quality of a tree are diameter, height, growth-form; neither biotic nor abiotic damage are important

criteria for identifying plus candidate trees. Planting material (seeds and cuttings) taken from strong healthy individuals, produces high quality seedlings (genetic fingerprint).

- Seeds should be collected from trees adapted to the site of the reforestation project. If possible collect seeds from trees growing near the reforestation project or from trees growing under the same conditions found at the reforestation site. Site conditions are defined by climate, topography and soil. Topography is an important issue in high mountain reforestation projects. If the reforestation site is located on a south-facing slope, seeds should only be collected from trees growing on south-facing slopes at the same altitude. Never plant seeds from the north slope on the south slope or vice versa. Altitude is also a very important factor. Never collect seeds from low levels for reforestation projects at high altitude. Swiss foresters recommend to collect seeds in a maximum altitudinal variation of ± 100m from the reforestation site and U.S. foresters recommend a maximum altitudinal variation of ± 150m.)

To analyse site conditions Atlases can be helpful. Additionally, field work and local knowledge are required as well as a data bank. Usually the development of a seed bank is conducted by the government, due to the large amount of information required. Appendix 8 shows a form to manage the seed data bank.

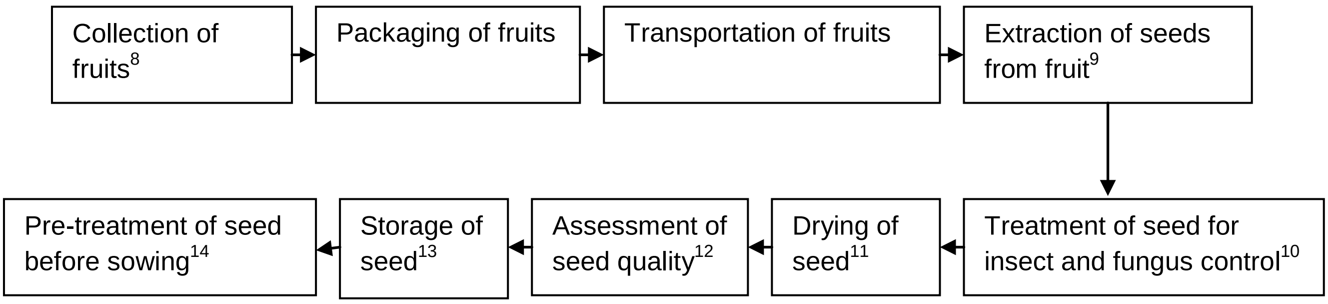
It is important to know from where the seeds come and which site conditions are found there. When seeds are stored the following information must be written on the package:

- Date of collection
- Tree or shrub species name (Latin and Armenian name)
- Site name
- Site conditions (soil pH, altitude, slope exposition, agro-bioclimatic zone of Armenia)

Appendices 8, 9, 10, and 11 contain detailed forms for the collection and management of fruits/seeds.

5.3 SEXUAL PROPAGATION (COLLECTION AND STORAGE OF SEEDS)

Seed handling includes a series of procedures beginning with the selection of the best quality seed source (see above chapter 5.2), through harvesting, processing, storage, pre-treatment to germination. The following graph shows which activities are frequently carried out between the collection and pre-treatment of seeds:



Graph 3: Sequence of seed handling (from collection of fruits to pre-treatment of seeds)

8 See chapter 5.3.1, 5.3.2, 5.3.3 and appendices 8, 10, 11.
9 See chapter 5.3.4
10 See chapter 5.8 and appendix 6.
11 Not all seeds need to be dried. As example oak and elm seeds should be sown as quickly as possible. Chapter 5.3.4 contains more details about seed drying.
12 See chapter 5.3.5
13 See chapter 5.3.6 and appendix 4
14 See chapter 5.3.7 and appendix 4

Before seed collection is carried out it is essential to know:

- Which species must be propagated (see chapter 5.1 and planting guide (appendix 3))
- Where to collect the seeds (see chapter 5.2 and appendix 11)
- How many seeds should be collected (see appendices 12 and 14)
- When to collect the seeds (see appendices 4 and 10)
- How to collect the seeds (see chapter 5.3.3)

5.3.1 When to collect seeds

When to collect seeds depends highly on the tree species, climate, and geographical location. Many trees adapted to dry climates usually don't produce a large quantity of seeds annually. They produce seeds in intervals such as every two, three or four years. The best seeds are produced in mast years (e.g. oak every 4 years). Collection should be planned according to these intervals, because in years with less seeds the quality is usually insufficient and the activity is combined with higher costs. The best time to collect seeds is when they are mature but before they are lost to predators, diseases or dispersed by wind or rain. There are several indicators to identify if fruits/seeds are mature. The most common indicators are:

- Size and colour of fruits/seeds
- Endosperm and embryo development of seeds (cutting test)
- Dehiscence and abscission (Fruit fall or opening of dehiscent fruits, shaking fruit-bearing branches, manual splitting of dehiscent fruits)
- Hardening of fruit/seed coat (mature seeds in dry areas usually have a hard seed coat e.g. *Juniperus spp., Robinia pseudoacacia, Gleditschia triacanthos*)

Stands growing at higher altitude normally flower and fruit later than stands of the same species growing at lower elevation. For example the seeds of *Ulmus spp*. were ripe in Yerevan (1'000 masl.) at the end of April 2005, whereas the seeds of *Ulmus* were ripe around the nursery site (1'500 masl.) at mid-end May 2005. Appendix 4 contains information when fruits/seeds are mature and the period of collecting them. However, these are average dates of the collecting period throughout the entire country and can vary depending on the altitude of the collecting area and the exact location. Appendix 4 can be used as a planning instrument, when to conduct seed collection. However, Shen should establish more detailed phonological tables, based on local observations, taking into account the climate (dry, average, wet year), altitude, slope position, and location (see appendix 10). Moreover, the intervals of seed production (mast year) have to be determined (e.g. 2004 was not a mast year for oaks).

5.3.2 Seed source

A seed source (e.g. forest stand) should yield a large quantity of high quality seeds which match reforestation habitat and purpose. In general the seed trees should be of good phenotype- neither juvenile nor over-mature and good seed producers. In other words, seed trees should have no sign of biotic and abiotic damage and be the strongest individuals in a stand with superior morphological characteristics (genetic fingerprint). Seeds should never be collected from inferior parent trees because this affects the performance of the reforestation project.

To estimate the potential quantity of seed crops available, preliminary assessment of flowers are carried out during the year. The more flowers a tree or forest stand contains, the more fruits can be expected.

It is important to develop working plans, which include the following factors:

- Calculation of seed quantity and labour demand (see appendices 12, 13 and 14)
- Preliminary assessment of flower and seed crop (see appendix 10)
- Identification of seed sources (see chapter 5.2, appendices 11 and 8)

- Updating of seed-source documentation (see appendix 8)
- Maintenance of seed sources[13]
- Training of staff[14], e.g. collection methods, processing, knowledge of trees and mature fruits/seeds.
- Preparation of seed processing and storage units[15].

5.3.3 Seed collection

Several methods have been developed to collect fruits and seeds. The methods range from simple collection from the ground after natural seed fall[16] to advanced methods, which are quite expensive (equipment) and need experienced staff (e.g. climbing trees). Tree climbing is not described in this report because nobody has been trained in tree climbing and the equipment does not exist in Armenia. As alternative to tree climbing, ladders which are well secured, can be used to get access to the crown.

Fruits from shrubs or small trees are usually quite easy to collect. The fruits can be directly picked form the branches or the fruit bearing branches can be shaken. Frequently tarpaulins, sheets, or nets are spread out below the seed bearing tree to ease the collection of seeds. Sometimes the collection of fruits/seeds can be quite difficult, involving specific equipment to detach the fruits from the branches. Specific equipment includes hocks, pruners, or saws with extending pools which can be operated from the ground. Also simple sticks can be used to beat the branches, if the fruits easily detach from the tree (e.g. *Ulmus spp*.) or a rope can be thrown over the seed bearing branches.

It has to be mentioned that fruit collection can be a dangerous operation. Fruits should never be collected on windy days, because branches could fall and most wind-dispersed-seeds are blown away. Additionally, the possibility of falling branches is increased due to the shaking of the tree or seed bearing branches. If ladders are used they have to be well secured and the person climbing the ladder should also be secured.

Never collect seeds from an inferior tree only because the collection of seeds is easy. Always keep in mind that plus candidate trees, from which high quality planting stock is produced, should come from tall, straight growing individuals.

The timing of seed collection is very important. Predation by insects and animals often causes major loss of seed crops just before and shortly after harvest. Therefore, appropriate timing of seed collection is the most effective preventive measure to avoid foraging and infestation.

5.3.4 Seed processing (seed cleaning)

Once fruits have been collected they should be processed as quickly as possible to minimize loss and deterioration. Damaged seeds can not be repaired. Processing includes several procedures depending upon fruit and seed type, condition of the fruits at collection time (immature), and potential storage period. Seed processing is necessary for most seeds to:

- Avoid/minimize the spread of pathogens, which result later on in damping-off disease in the seed bed (see chapter 5.8).
- Extract seeds from fruits for storage, pre-treatment and sowing.

---

[13] The primary aim of maintaining seed sources in Armenia is to protect the valuable plus candidate trees from being harvested or damaged. However, this is very difficult at the current circumstances. 5’000 ha are illegally clear-cut per year in Armenia.
[14] Workers will be trained by Mr. Valashak (Armenian nursery specialist).
[15] Will mainly be carried out at Shen office and homes of Shen members.
[16] Be aware, that fruits collected from the ground, have a higher risk of being affected by pathogens. A prevention in pest management is to collect the seeds just before natural seed fall or immediately after. The longer seeds are on the ground, the more prone they are to predators and diseases.

- Prevent the loss and deterioration of seeds.
- Regulate the seed moisture content during storage and pre-treatment.

Seeds processing can be grouped into the following procedures:

- Pre-cleaning, for fruit/seed lots containing larger debris, empty fruit parts, leaves, etc.
    - Pre-cleaning is carried out to ease further processing steps and to avoid the spread of pathogens. Soil debris can contain soil born fungi and leaves may carry fungal spores or other pathogens. Therefore, all non "fruit-material", such as soil, leaves branches, and damaged fruits have to be removed for all species.
- Pre-curing, for fruits that must be after-ripened, or where rapid desiccation hampers extraction (mainly for Conifers).
    - Pre-curing promotes after-ripening of immature fruits and eases the extraction of seeds. The duration of after-ripening varies between species and is mainly based on experience. A few species such as *Ginkgo biloba* and *Fraxinus spp.* always require after-repining because the embryo is not fully developed at the stage of dispersal. High moisture level (gradually declining), avoidance of drastic increase in temperature (normal air temperature) and ventilation are necessary conditions during after-ripening. Only immature fruits should be after-ripened.
    - To judge when maturity has been reached cutting test of the seed can be carried out.
    - Pre-curing of cones is sometimes necessary to ease the extraction of seeds (e.g. *Pinus spp*., *Cedrus spp*.). If cones are dried too quick or they don't have enough space to expand during drying "case hardening" can occur, resulting in difficulties to extract the seed. Re-moistening the fruits, and then slowly drying them a second time normally overcomes this problem. The cones can be dried indoor until they begin to open. Once the cones have opened they can be placed in a bag and shaken to release the seeds. Beating the bag with a stick also helps.
    - Pre-curing of fleshy fruits should always be carried out. Fruits should mainly be spread out in open trays to allow moisture from the fruit to drain off.
- Extraction of seeds.
    - The extraction method of seeds depends upon the species. The most common methods are described below.
    - Fleshy mature fruits like berries and drupes should have their fruit pulp fully or partly removed before drying. A common, easy way to do so is to soak the fruits in water overnight, macerate them e.g. on a wire mesh, and rinse them with water to remove as much pulp as possible. When the macerated fruits are left in water the seeds usually tend to stay at the bottom, while the soft fruit material and non-viable seeds tend to float and can be skimmed of.
    - Fleshy fruits should be collected as soon as they are fully ripe but before they fall or have been attacked by pathogens. Fleshy fruits should not be piled (in air tight bags) to avoid the chance of fermentation. Additionally, they should also not be soaked too long in water to avoid fermentation, indicated by bubbles and smell.
    - Air drying: Place fruits on a screen (e.g. white paper or line towel) in a single layer, making sure they don't touch each other. They should be air dried under shelter (e.g. office) to avoid climate influences e.g. direct strong sunlight or rain. Armenia's air humidity is dry and therefore air drying should be no problem. It is important that cones are not dried too fast. Otherwise cell collapse occurs, resulting in closed

cones. Air drying works well for., *Thuja spp. Biota spp. Sorbus aucuparia, most Pinus spp. Cedrus*[17] *spp. Abies spp. Elaegnus angustifolia, Picea spp. Viburnum spp.* and *Salix spp.*

- Oven drying: This method is used for serotinous cones and fruits. The cones only open when they have been exposed to high temperatures (in nature by fire). A normal convection oven can be used therefore. Be sure, that the cones are spread in a thin layer and avoid excessively high temperatures.
- Threshing: Spread fruit on a concrete floor and walk on them (don't stomp your feet). This method can be used for *Catalpa spp. Syringa vulgaris, Gleditischia traicanthos, Robinia pesudoacacia, Caragana spp., Juniperus spp.*. However, other mechanical treatments (beating with a stick, crushing them in a mortar) that will split the fruits without damaging the seeds are also suitable. Seeds from large fruits like *Gleditschia triacanthos* can be extracted by splitting each fruit by hand.
- Depulping: Remove the pulp of fruits by running them over a screen by hand or by placing them into a food chopper. The pulp is washed out with running water. However, for some fruits the sticky pulp remains attached to the seed. If this occurs, increase the pressure of running water or use a normal mixer. *Prunus virginiana* fruits are crushed and soaked in water before the seeds are separated from the pulp. Most fleshy fruits such as *Malus spp., Lonicera spp. Juniperus spp. Sorbus acucuparia, Pyrus, Viburnum spp* are extracted by depulping.
- Nuts (*Quercus spp*., *Castanea sativa*, *Fagus orientalis*): Acorns have to be removed from their cups, and chestnuts have to be removed from their husks. Acorns collected from the ground have to be checked carefully, as they are often partly chewed or affected by pathogens (fungi).
- For some fruits a combination of the different processing steps are carried out. As example for *Juniperus polycarpos* it is recommended to crush the fruit coat (threshing) first, then depulp them, followed by polishing/abrasion with a towel.

The following table shows the seed extraction procedure, depending on the fruit type:

Fruit type	Extraction procedure
Dry dehiscent fruits open at maturity to release their seeds, e.g. cones, pods, follicles. *Cedrus, Pinus, Biota*, most *Leguminosae*	Drying → shaking/tumbling
Dry indehiscent fruits, remain closed at maturity.	Drying → threshing
Fleshy fruits with very thin pulp, e.g. *Ziziphus spp.*	Drying Soaking → maceration → washing
Fleshy fruits with soft pulp, e.g. *Prunus, Ficus, Olea*	Soaking → fermentation → washing Soaking → maceration → washing
Fleshy fruits with soft, fibrous pulp	Soaking → maceration → washing → abrasion/polishing
Fleshy fruits with felty pulp	Soaking → abrasion/polishing

Table 5: Extraction procedure of seeds

- Dewinging involves the removal of any dry seed appendage, including wings, hairs, etc.

[17] Cedar and *Abies spp*. cones have to be collected before they are fully ripe, because the cones fall apart on the tree.

- Seeds distributed by wind contain wings. The winged seeds are rubbed between hands. A towel can also be used for this procedure. It is important that the seeds are not damaged during this process. Wings usually do not obstruct germination, but may be inconvenient in handling and in some instances, tend to collect moisture and promote fungal attack. Dewinging is mainly done for seeds that need to be stratified, while seeds sown immediately after collection (e.g. *Ulmus spp*.), rarely have the wings removed.
- Wings are typical for indehiscent dry fruits and conifers. Seeds of *Pinus*, *Abies*, *Cedrus*, *Betula*, *Ulmus*, *Ailanthus altissima*, *Acer spp*., *Salix spp*. *Populus spp*. and *Fraxinus spp*. have wings. It is not recommended to dewing the seeds of *Ulmus pumila*, *Fraxinus excelsior* and *Acer campestre* because the embryo is usually damaged.

- Cleaning of seed lots with impurities like fruit parts, leaves, twigs, empty seeds, etc.
  - Cleaning of the seeds can be done using several methods. It is important to store only healthy seeds to avoid the increase of fungi in the seed lot. A common method is to sieve a seed lot through a series of grids with decreasing mesh or hole size. Several types of screens are available. This method is mainly based on the size of the seed and the impurities.
  - Using a fan can also help to separate healthy seeds from empty seeds and other impurities. The method is mainly based on the weight and shape of seeds and impurities. For example dust and fungal spores are unwanted components of the seed lot which will be blown far away. Healthy, big, full seeds will land closer to the fan, than empty or less viable seeds. This technique is also used for grading[18].
  - Flotation: After the seeds have been extracted from the fruit and separated from pulp they can be placed in a jar of water or other liquids (for example 95% ethanol). If alcohols are used it is important that they do not negatively affect the germination of the seeds. Floating tests are usually carried out to separate sound seeds which sink from poor seeds and chaff which float.

5.3.5 Assessment of seed quality

One of the most frequent methods to assess seed lots is the cutting test. Cut seeds can be examined for insect attack, normal developed endosperm, and embryo. Insect attacks (e.g. holes) can sometimes be observed on immature fruits/cones. Cutting tests are time consuming, especially for small seeds. Alternatively the seeds can be exposed through the techniques described above to clean seeds (Floating test, Wind test).

Extracted seeds are dried (not too much, otherwise they will not germinate) and put into a liquid with a density ≥1 kg/dm^3 (e.g. water for oak acorns, 95% ethanol for *Pinus* spp.). Filled seeds will sink and the empty seeds, branches, leaves and pulp will float which can be skimmed off.

As mentioned above, a fan can be used to carry out the wind test.

Besides techniques to analyse the quality of seeds, Shen will need a labour force that frequently works with seeds and knows how to distinguish between healthy ripe seeds/fruits and bad quality seeds. It is very important only to collect healthy fruits and to store healthy seeds. This

[18] Grading is done for seed lots with large variation in seed size or weight. Grading usually separates the seed lot into several categories. As example oak acorns can be separated by hand into three groups according to their size. Usually small acorns (even though healthy) are not sown, because their endosperm contains less energy, and therefore germination and seedling development is not that good as seedlings germinating from large acorns.

is one of the main key-factors in implementing an integral pest management system where prevention is the key to success (see chapter 5.8 Integral pest management).

5.3.6 Storage of seeds

The storage of seeds depends on the species. Recalcitrant seeds such as oak, acorns, beech, and elm seeds can not be stored for a long time and are usually planted immediately after collection. Armenian nursery specialists recommend that *Ulmus spp*. seeds be sown within three days after collection. If they can not be sown immediately, due to rainy weather, they have to be immediately stratified, to prevent moisture loss. *Quercus spp*. and *Juglans spp*. can be stored in damp cold with plenty of air circulation. However, they can not be stored long and large storage facilities are necessary due to the size of the seeds. Other seeds can be stored for several years using an appropriate method. *Caragana arborescens*, *Pyrus spp*. and *Syringa vulgaris* are recommended to be stored at room temperature.

The seeds of most orthodox species can be safely dried for storage. However, excessive drying should be avoided or the seed will not germinate. Orthodox seeds are gently dried by spreading them out in a warm room. Clean, dry seeds are put into airtight containers or poly bags and labelled. The containers or bags can then be stored in a fridge at 2-5^{o}C, for several years. Equipment and containers should be clean and dry, to avoid the multiplication of fungi. Appendix 4 shows which seeds can be stored and the possible storage-duration before loosing viability.

Insects and fungi that seriously harm seeds and, as a result, reduce germination must be destroyed completely before the seeds are stored. Insecticidal dusts, for example Carbon Bisulfide or Methylbromide, can be used for treating seeds. Insecticide and seeds frequently are placed together in a sealed container for 24 hours, after which the seeds are aerated quickly and stored. Fumigation or fungicides can be used to treat pathogens. However, chemicals should only be used if really necessary. As mentioned above fruit collection, processing, quality analysis and correct storage are all preventive measurements to avoid having contaminated seed lots with fungi and insects (for more details see chapter 5.8).

5.3.7 Pre-treatment of seeds before sowing

Most seeds in Armenia enter a dormancy which must be overcome to allow the seed to germinate. Dormancy can be mechanical and caused by the seed-coat’s impermeability (*Gleditschia triacanthos*, *Robinia pseudoacacia)*; by physiological internal conditions in the seed, as in *Acer spp*. and *Betula spp*.; or by both factors.

Seeds must have overcome their dormancy and have the proper soil moisture, temperature and oxygen to germinate. Overcoming dormancy can be done mechanically/chemically or by using stratification. Seed moisture is highly influenced by the way seeds have been processed and stored (too dry seeds will not germinate and too moist seeds are highly prone to pathogens).

Concentrated sulphuric acid is commonly used to overcome seed-coat dormancy. However, the use of this acid is relatively dangerous and should only be carried out by trained persons, equipped with correct protective clothing. Other methods are to injure the seed-coat by rubbing the seeds between two pieces of sandpaper or to soak the seeds in hot water. The method selected depends on the species and the quantity of seeds.

Internal dormancy is usually overcome by cold stratification. Some species also need a warm treatment followed by a cold treatment. The most practical method of cold stratification is to store seeds in the refrigerator at temperatures between (0-5^{o}C). Appendix 3 and 4 contain the exact temperature and duration recommended for the different species. Seeds are usually mixed with three times their volume of moist sand or peatmoss in a polyethylene bag or in airtight containers.

5.4 ASEXUAL PROPAGTION OF PLANTS

Trees and shrubs can be propagated by sexual (seeds) and asexual (cuttings) means. The most common method to propagate plants asexually is from cuttings. Cuttings can be made from stems, roots, leaves, or combinations of plant parts such as stems with leaves. The four major categories of cuttings are:

- Stem cuttings
- Leaf cuttings
- Leaf-Bud cuttings
- Root cuttings

Reasons to carry out propagation by cuttings include because the species does not produce viable seeds, seeds are difficult to germinate, the collection and extraction process involves high costs, or a high amount of planting stock has to be produced in a short time.

The host trees from which cuttings are taken must be healthy and have the same desirable characteristics as plus candidate trees from which seeds are collected (see p. 12). Cuttings are placed in a warm humid environment to hasten root development and prevent them from drying. Cuttings are usually propagated in greenhouses (see p. 9).

This report only describes the technique of stem cuttings, because it is widely used in large scale propagation projects and easy to carry out. Root cuttings are also used, but involve usually a high amount of labour force and if not properly carried out can damage the tree.

Some plants root better from soft wood cuttings while others should be propagated from semi-hardwood or hardwood cuttings. The different types of cuttings are characterized as follows:

- Soft wood cuttings: Current season growth that is usually taken in Spring or early Summer during a growth flush when the tissue is relatively soft and succulent. They are called softwood because new growth is still flexible and non-woody. Although softwood cuttings usually root more easily and quickly than other cuttings they also require more labour and equipment. They must be handled more carefully than hardwood cuttings. The best material has some degree of flexibility, but should break if bent sharply.

- Semi-hardwood cuttings: Current season growth that is usually taken in late Summer after a growth flush has matured.

- Hardwood cuttings: Current season growth which are usually taken during the Winter months of November through February. These are dormant woody sections of young stems. Well ripened dormant shoots with nodes, which are the swellings that mark the position of buds, have to be selected. Cuttings should be at least as thick as a pen. Some plants root better if they are taken with a heel. The cuttings should be 15-30 cm long, with at least three buds. Some species root easily and are capable of standing inclement weather sometimes experienced in the spring months, and therefore can be propagated without additional heat. Other species that are sensitive to temperature should be propagated with aid of heat. The soil must be well drained to avoid rotting. If the conditions are not suitable to insert the cuttings into the soil they can be sealed in a plastic bag and stored at about 4.5^{o}C for a few weeks.

Stem cuttings are removed using a disinfected, sharp knife. Stem cuttings 10-15 cm (max 30 cm) in length are appropriate for most species. For several species a heel is recommended to enhance root development. The cut should be placed directly below a node to help callus the cut surface and reduce the entrance of pathogens. Leaves are removed from the bottom 2.5 cm of the stem cuttings, and then cuttings are stuck upright in a propagation substrate. Cuttings are usually inserted 1.2-2.5 cm into the propagation medium. Stem cuttings of *Salix* and *Populus* root very easily and are usually 30 cm long, of which 2/3 of the stem is inserted into the soil.

The following trees and shrubs are readily propagated from cuttings:

Abelia spp., Aucuba spp., Azalea spp., Berberis spp., Buxus spp., Buddleja spp., Cotoneaster spp., Elaeagnus spp., Euonymus spp., Forsythia spp., Gardenia spp., Hydrangea spp., Hypericum spp., Ilex spp., Juniperus spp[19]*., Ligustrum spp., Lonicera spp., Nerium spp., Pittosporum spp., Photinia spp., Populus spp., Pyracantha spp., Salix spp., several roses, Spiraea spp., Viburnum spp., Vitex spp., Weigelia sp..*

However, some trees and shrubs are difficult or impossible to propagate from cuttings. Among these are fir, pine (some exceptions), hemlock, locust, red cedar, mimosa, redbud, ginkgo, mountain laurel, goldenraintree, blue spruce, southern magnolia and dagwood. Most common forest trees, such as *Quercus spp., Castanea spp., Fraxinus spp., Juglans spp., Fagus spp., Ulmus spp.* and *Carya spp*. are difficult to propagate from cuttings. Most narrow leaf evergreens, such as the *Juniperus*, root best when cuttings are taken after the first frost of fall (early frost).

For more details about the propagation of stem cuttings please see chapter 4.7.1 “Greenhouse” and appendix 3 “Planting guide”).

5.5 PLANTING STOCK

This chapter describes which types of planting stock exist, the duration of seedlings in the nursery and the operational activities involving sowing, growing, and transplanting.

5.5.1 Types and age of planting stock

Seedlings usually stay for 2-4 years in the nursery. Optimum sizes depend largely upon the species and the characteristics of the planting site. Plants with well proportioned root : shoot ratios represent good stock. Other criteria to analyse the strength of seedlings are stem diameter, height, and woody root collar. Medium size stock, 15-40 cm in height, has a better survival rate than do smaller plants. Excessively tall plants are difficult to handle and can be loosened in the ground and blown over. Additionally, plants with a large top have high transpiration demands.

There are several kinds of seedlings such as bare-root stock, containerised stock, or ball-rooted stock. Bare rooted stock is usually dug up in late autumn. If bare rooted stock is properly protected in plastic bags, bare-root stock can last for some weeks out of the planting medium before being planted out in their final positions. However, transferring seedlings from the nursery to the reforestation site must be well planned and carried out quickly enough to minimize the loss of seedlings due to excessive transpiration.

Today most conifers, which resent root disturbance, are grown in containers. Seeds can be sown direct in containers or young seedlings can be transferred to containers later on. However, furrow irrigation is not practicable with containerised stock. Moreover, a high amount of labour force and additional soil and containers are necessary to produce containerised stock. Therefore, at the present Shen will mainly produce bare-rooted stock. In the long term, however, Shen should produce containerised stock for all conifers, because the survival rate in reforestation projects is higher.

Grading is done to eliminate seedlings that have damaged or diseased tops or roots and those seedlings below minimum standard of development, and to segregate seedlings that exceed

[19] Some Juniper species. are very difficult to propagate by cuttings, e.g. *Juniperus polycarpos*.

minimum standards into two or more quality classes. Inferior seedlings must not be used for reforestation.

5.5.2 Sowing and growing on

Outside sowing is mainly done in Spring (April-May). However, some species can also be sown in Autumn (e.g. oak). Appendix 5 shows, when seeds should be sown and at which depth. It is mainly recommended to sow in Spring, because the seeds can germinate and young seedlings can establish themselves. In Autumn the danger of pathogens for the seeds is higher because the seed is exposed from the soil for a longer time. However, some species have to be sown directly after collection (*Ulmus spp*. and *Quercus spp*.). Oak seeds which are ripe in Autumn can not be stored for a long time and usually do not require pre-treatment and are therefore sown directly.

Large seeds should be sown single. Acorns are spaced 5 cm apart, and ash and beech 2.5 cm apart. Seeds are usually sown twice the depth of their size, and covered with sieved soil or sand. Sowing in rows makes it easier to spot the seedlings when they emerge. Seeds can be sown in drills. Using the back of a rake or the edge of a board is useful to make the drill to the appropriate depth. The spacing of seeds/seedlings is described in chapter 4.3.

Seeds are broadcasted by hand, trying to get as even a coverage as possible. Appendix 5 gives the recommended sowing rates for different species. Very light seeds can be mixed with damp sand to try to get a more even coverage. Additionally, the coarse sand texture increases the success of germination (sand contributes to a better texture (more air) of the heavy soil). After sowing, a spade or a garden roller should be used to ensure good seed to soil contact.

Any weeds that appear in the seedbed are best removed by cutting through at just below ground level with a knife. Pulling them out may disturb the tree seeds and seedlings. It is important not to mistake germinating trees for weeds. Weeding must be done frequently, which means about every 2 weeks during the vegetation period.

Seedbeds need to be watered whenever the soil begins to dry beneath the surface. Watering should be done in the morning or evening. Avoid watering in bright sunlight. Moisture is essential for germination and seedlings development. The sprouting media has to be kept damp but never waterlogged or allowed to dry.

Seedlings of most species should be 10-30 cm tall at the end of the first year, when they are transplanted or lined out. The spacing between each seedling depends on the species. Conifers can be lined out closer together than leaved trees. It is important to give seedlings enough spacing to encourage a good root-shoot ratio. Therefore, seedlings have to be transplanted in the nursery because seeds are sown at a much higher abundance than the species can withstand later on (Intra-competition).

5.5.3 Transplanting (lining out)

The size of the seedlings depends on the time of sowing, germination period or growing conditions. If more than 50 % of the seedlings are less than 4cm tall, they should be left to grow on for another year. Besides the size of the seedlings, it also depends on the density of seedlings. Beds sown with small seeded species will usually be crowded after one year, and will need transplanting to give them more room to grow.

Besides giving more room to the seedlings, transplanting combined with root pruning as necessary, stimulates the plant to grow more side roots so that a fibrous, bushy root system results, rather than fewer, deeper roots. Moreover, species such as *Ulmus pumila* produce Tap-roots, which make transplanting or planting out very difficult if no root pruning has been carried out or left more than two years in the nursery. Fibrous, bushy roots allow to dig up the plant without damaging too many roots, and therefore increases the reforestation success.

Plants with damaged roots are prone to diseases and have more problems to take up water and nutrients. It is important to have a high ratio of roots to shoots. Additionally, the diameter of the stem should be enough thick.

It is important for nursery operations to describe seedlings by their age and time of transplanting. For example, 1 + (1) denotes one year's growth in the seedbed, followed by transplanting in the first winter, followed by a year's growth in the transplanted bed. In less favourable conditions, seedlings may require 2 years growth in the seedbed, followed by one year in the transplanted bed (2+(1)). Transplanting is normally done between October-December and March-April, depending on the season and location. Several factors have to be taken into account when to conduct transplanting. Seeds transplanted in late Autumn (November), will be usually significantly larger at the end of the following growing season than seedlings lined out in spring because each transplanting activity disturbs the root growth. On the other hand autumn transplanting may lead to transplants being lifted by frost action. Therefore, it is recommended to conduct a small experiment to identify the ideal transplanting time. A small amount of seedlings should be transplanted once in November and once in March/April.

Lifting, root pruning and transplanting should be done on the same day, as this lessens the chance of deterioration in storage. Still (windless), damp days are preferable for transplanting, as this will reduce the drying effect on exposed roots, and lessens the stress on the plants. Avoid transplanting in very wet conditions or when the soil is waterlogged, as root damage is likely if plants are lifted with sticky clods of soil attached. The procedure of transplanting is done as follows:

- Work from the outside of the bed and insert a fork vertically to its full depth and then ease it forward to loosen the soil.
- Grasp the seedlings close to the ground and lift them gently (the root hairs are very delicate), allowing excess soil to fall from the root system. The seedlings should not be shaken or knocked against the fork to remove the soil, because the soil prevents water loss and protects the root hairs. To prevent water loss seedlings should be placed immediately in a plastic bag, closed at the top and taken to a sheltered place, where separation, root pruning and sorting can be carried out.
- Any roots longer than 15-18cm should be cut off, using sharp secateurs. Additionally, any roots that are bent or twisted have to be pruned because such roots will stay this way and lessen the tree's chance of establishment.
- If there is a wide range in the height and diameter of the seedlings, they should be separated into different categories according to their strength, and transplanted into different beds (grading).
- It is very important to prevent the plants from drying out during the entire period of transplanting. Therefore, the plants must be placed into polyethylene bags and the top sealed. The bags have to be placed in a shady area, and the seedlings replanted as soon as possible on the same day.
- A trench can be dug to transplant the seedlings. The stems have to be planted upright, or "hockey stick" stems will develop, which results in a loss of quality. The roots need to be spread systematically downwards from the root collar. Never "corkscrew" or bend the roots into too shallow or narrow holes, as the roots will be permanently destroyed. This hard rule has to be obeyed for transplanting seedlings in the nursery as well as planting out plants at their final location in the reforestation project. It is better to cut off a long root, rather than bending it into a "j" shape.

The amount which seedlings grow is related to the amount of space they are given. The more space, the sturdier the plant. Root collar diameter is an important indicator to measure the strength (quality) of seedlings and is more significant than the height. The following table shows for some species the size of stock desired to produce for successful establishment later on.

Species	Seedlings height (cm)				
	20	30	40	50	60
Betula spp.	3mm	4mm	4.5mm	5.5mm	6.5mm
Fagus spp.	4mm	5mm	6mm	7.5mm	9mm
Quercus spp.	5mm	6.5mm	8mm	9.5mm	11mm
Fraxinus spp.	5mm	6.5mm	8mm	9.5mm	11mm
Prunus spp.	5mm	6.5mm	8mm	9.5mm	11mm
Tilia spp.	5mm	6.5mm	8mm	9.5mm	11mm

Table 6: Recommended minimum root collar diameter (mm) for broadleaved trees

However, growth rates will vary with species, genetic strains, soils, location, weather, fertilizer, management of diseases and irrigation.

5.5.4 Hardening

Hardening out is very important process to increasing the survival rate on the reforestation site. Young seedlings transplanted without a transition period into a dry, hot environment have poor survival rates. The environment in which seedlings are grown (greenhouse, nursery bed) should be adjusted gradually to the conditions found at the planting site. Therefore, watering and fertilizing should be decreased gradually. Hardening should be induced in stages, with the process usually taking about 8-10 weeks. Hardening out will minimize the physical damage of planting stock during handling, transport and planting at the reforestation site.

5.6 TIMETABLE OF NURSERY OPERATIONS

Spring and Autumn will be the main seasons of intensive nursery work and reforestation projects. Due to the limited financial resources of Shen to hire labour force work should be distributed evenly throughout the year. It is recommended that reforestation projects should be conducted in Autumn and main nursery activities in spring and autumn. An important reason to conduct reforestation in autumn is due to the climate conditions. Spring and Autumn are the rainy seasons in Armenia; however, spring storms with hail and late frost can devastate reforestation projects. Additionally, trees and shrubs planted in autumn can profit from additional snowmelt water in the Spring and most seeds are usually sown in Spring (spring sowing reduces the risk of seeds affected by pathogens experienced in Autumn).

Appendices 13 and 14 contain forms to plan monthly and yearly working activities in the nursery and to collect seeds. The main nursery operations are:

- Irrigate the seedbeds and control the furrows and wetting pattern.
- Sowing of seeds (Spring and autumn)
- Collection and processing of seeds and cuttings
- Weeding
- Transplanting of seedlings and root pruning
- Control of pests and disease and if necessary take action against
- Remake seedbeds

Besides the monthly activity plans, it is also important to plan annual main activities. For example, some trees only produce good seed crops every 4 years and therefore great attention should be given to seed collection of these species. Moreover, in 3 years a large amount of seedlings will be ready for transplanting to their final destination (Jrevzh arboretum), and therefore this activity has to be well organised several months in advance.

5.7 LABOUR FORCE, FUEL AND WATER

This chapter describes necessary resources (labour force, water, fuel, etc.) to manage the tree nursery.

5.7.1 Labour force

Five permanent workers, one nursery manager and one guard[20] are necessary to manage the 3 ha nursery (sowing, weeding, irrigating, transplanting and monitoring) and to prepare seeds and cuttings (collect seeds, processing of seeds, pre-treatment of seeds). Additionally, volunteers, soldiers and temporary workers are probably necessary in peak working months. The salary and taxes of workers are presented in chapter 6, table 8.

5.7.2 Water and fuel

Water is one of the most important factors in nursery operations and will be used in large quantities from April/May to November. Water will not be necessary from November/December until the end of March/beginning of April, because of the frozen soil and snow. The exact time of starting and stopping irrigation will change from year to year. In Spring and Autumn the most rainfall occurs and therefore irrigation has to be managed, depending on weather conditions, soil infiltration and percolation rate, and the size of seedlings. Seedbeds with young seedlings should always be moist (not wet, not saturated), and therefore frequent light watering carried out. As plantlets become older, the frequency of watering should be reduced to adapt seedlings to reforestation site conditions (hardening out). Evaporation reaches it's highest levels from June to September and therefore irrigation will be used in high amounts. As nursery site analysis shows, the potential evaporation is 960mm and the effective evaporation is 360 mm for an average year. Based on recommendations from FAO (1989), the following calculation is made to estimate the amount of water needed in 1 month:

Amount of Water= Water loss factor x Evapotranspiration x Area of seedbed

(Water loss factor values between 1.2 and 1.4)

Unfortunately the exact distribution of evaporated water per month is unknown and the transpiration of plant stock is unknown and will vary, depending on the plant species propagated. Therefore, estimations of necessary water are only made for one year. Water will mainly be needed in summer (remark: transpiration is not included and therefore the effective water use will be higher). The following input data is given:

Potential evaporation: 0.96 m /year
Area of seedbed: 25'000m^2
Water loss factor: 1.4

1.4 x 0.96 m/year x 25'000 m^2 = 33'600m^3/year ~ 35'000m^3/year

For the nursery with 2.5 ha of seedbeds, approximately 35'000 m3/year of water is needed. Most water will be used in summer and therefore it is very well possible that monthly water use will excide 2'000m^3/ha. Due to the insufficient information upon the distribution of water use, it is important to implement a monitoring system (appendix 7).

[20] The nursery manager and guard will also be involved in physical work to support the five workers.

Unfortunately, the water supply is not available during the entire vegetation period of the seedlings. As mentioned above, the water supply period is from mid/end May to mid October. Therefore, depending on the weather, Shen will need to supply the nursery in May and October with water trucks.

Fuel will mainly be used for the collection of seeds and transportation to the nursery site. Because there are hardly any forests around Yerevan, Shen will have to travel to the areas described in appendix 11 to identify plus candidate trees, from which seeds and cuttings can be collected. Therefore, Shen will consume about 250 l of fuel per month.

5.8 INTEGRATED PEST-MANAGEMENT (ENTMOLOGY AND PATHOGENS)

Integrated pest management contains three main parts as fallows: Prevention, combat and after care. Most important are preventive measurements to minimize the outbreak of diseases in the nursery. Combat usually involves the use of chemicals such as fumigants, fungicides and insecticides, and to eliminate affected seedlings. After care is the recovery of the nursery after a disease outbreak and should hopefully never be the case. This report mainly focuses on preventive measurements, most of which have already been presented in chapter 5 (mainly chapter 5.3).

5.8.1 Prevention

Preventive measures like early collection, processing, good hygiene and appropriate storage conditions are often sufficient to minimize the loss caused by pathogens and insects (see chapter 5.3). In cases where pesticide and other chemical treatment cannot be avoided the use should be limited and should be applied with due consideration of possible impairment of seed viability and seedling growth, risk of labours during handling, and danger to the environment (see chapter 5.8.3).

Seeds and seedlings in nurseries are prone to diseases caused by fungi, bacteria and viruses, because of their tender tissues and the establishment of themselves. However, many diseases can be avoided by selecting proper seed and propagation materials, creating good nursery beds, avoiding unnecessary wounding by transplanting seedlings, providing routine care (fertilization, watering, weeding), and using preventive measures as needed. Plants stressed by biotic and abiotic factors and human beings are often susceptible to diseases. Nurseries are especially vulnerable to damping-off diseases, mainly caused by soil and seed-born pathogens. Therefore, the following hygienic measures should be carried out in nursery operations:

- The planting material (seeds, cuttings) must not be infected with nematodes, bacteria, or highly soil-borne fungi such as *Phytophthora*, *Thielaviopsis*, or *Verticillium*. For example *C. deodara* and *C. libani* are vulnerable to damping-off diseases caused by *Fusarium*, *Rhizoctonia*, and *Pythium* species. Plants from which cuttings derive must be healthy, showing no symptoms of disease.
- Avoid introducing pathogens from one seedbed to the other. It is required that central cleaning areas should be established where soil is washed from the equipment. Tools can be placed on a bed of coarse rock or gravel. Boots, hand tools and mechanical equipment must be washed.
- Removed diseased plants and pruned limbs of diseased plants must be destroyed. This should happen outside the nursery area.
- Irrigation water can contain a high number of pests and pathogens. Therefore, surface water should be diverted into ditches to prevent infection from one nursery block to another. It is important that the source of irrigation water is not contaminated.

- To avoid disease in greenhouses footwear should be cleaned with a germicidal agent such as LF-10 or Amphyl.
- Tools have to be regularly disinfected whenever cuttings are collected or the pruning of infected plants is carried out. Denatured alcohol (7 alcohol:3 water) is effective in cleaning the cutting blades. Chlorine bleach diluted 1:5 with water is also effective. Wash the knifes in water at the end of the day to remove the alcohol.

A brief description of seed handling to prevent diseases is given. However, most of this information has already been described in greater detail in chapter 5.1-5.3. The time, location, and method of collection of cones, fruits or seeds, and their subsequent handling during transport, extraction, and processing, affects the development and spread of fungi on seeds. Other sources of contamination, besides fruits and cones already infected with fungi, arise during the processing and extraction of seeds. Washing water can also be an additional source of contamination. Therefore, the following measures should always be carried out:

- Collect seeds from healthy, disease free trees. Branch and root cuttings must be derived from healthy trees, having no symptoms of disease.
- Time of collection is an essential factor. Fruits, cones etc. should be collected directly from the tree and not from the forest ground. For example, the later oak acorns are collected from the field, the more infected they are with fungi. Most common fungi during acorn development are *Penicillium*, *Fusarium*, *Alternaria*, and *Trichothecium roseum*. During heavy rain *Cladosporium herbarum* can also affect acorns. If acorns are infected with *Ciboria batschiana,* the acorns can be soaked in hot water (44^{o}C for 8 hours).
- Cones, fruits, etc. should be transported in well aerated, clean, dry containers or bags.
- Seeds should be extracted from the cones immediately after harvest to minimize seed infection from the microbial population.
- Avoid damage and contamination of seeds during extraction and processing.
- Storage, Stratification: As mentioned above the quality of the seed lot must be controlled before storage or stratification. The seeds should be stored in airtight containers or polyethylene Zip bags and placed in a refrigerator. Be sure that the storage facilities are not already contaminated with pathogens. Additionally, sand used for stratification must be free of any fungi or insects. Some scientists recommend to treat seeds before stratification by some surface cleaning or sterilizing agent. However, surface treatment of seeds can also have a negative impact on seed viability and should only be applied if really necessary (application see chapter 5.8.3).
- Cultural practices: Losses due to fungi are expected to increase with earlier dates of sowing. Autumn sowing is most unreliable because the seeds are exposed a longer time to soil born fungi. Seeds sown in Spring germinate early and quickly escape damage, whereas in cold soil during Autumn they do not germinate until the following Spring, and can suffer maximum loss.
- Most soil mixes for containerised seedlings and seedlings grown in greenhouses contain perlite or vermiculite incorporated with sphagnum peat. This type of mix is usually well drained and acidic, the two factors that help reduce diseases. Major groups of pathogens associated with nursery diseases are species of *Fusarium* and watermolds, such as *Pythium* and *Phytophthora*, which are mainly introduced through irrigation.

5.8.2 Nursery diseases

The most common seedling diseases in nurseries are described in this chapter. It is important that people working in tree nurseries know the symptoms of seedling diseases and know how to manage them. Treatment of the seedlings can usually take place during weeding.

Damping-off (soil and seed born fungi)**:** This disease is caused by various fungi which attack seeds as germination starts, allowing other fungi to infect newly germinated seedlings. Affected seeds don't germinate and affected young seedlings topple over, as though broken at the ground line, or remain erect and dry up. A visible symptom of the disease is a watery-looking constriction of the stem at the ground line.

Besides the preventive measures described above, controls of damping off include reducing the sowing density, thinning seedlings to create better aeration at the ground line, and maintaining a dry soil surface through repeated cultivation. There are three main ways to control damping off when it occurs: soil acidification, soil sterilization, and the use of fungicides (see chapter 5.8.3). Established outbreaks cannot be controlled. As soon as damping off occurs, remove the affected seedlings and water the remainder with Chesnut Compound.

Grey mould: Seedlings in greenhouses may be affected by this disease. Infected parts die off. Increase ventilation in the greenhouse and apply Captan every 10 days until no mould is evident.

Mildew: This fungal disease can appear on two year old or older plants. It appears in warm dry weather, when newly emerged leaves may be affected by spores produced from buds in which the fungus has over-wintered. Diseased shoots should be cut off in the Autumn to prevent the spores from overwintering.

Melolantha spp. and cutworms: Besides the use of insecticides the control of both pests can usually be achieved by regularly cultivating the soil and removing the grubs or caterpillars by hand.

Stranglers: Stranglers are usually eliminated during weeding. However, they are presented in this chapter because strangler plants kill young seedlings. The strangler known by the Armenian name "Geillook" (small wolf, wild hop, *Humulus spp.*) was identified in the nursery and has to be carefully removed from young seedlings to avoid their death.

Ants: Ants may sometimes cause problems and therefore ant killer can be applied to the nests and runs. A biological measure is to plant lavender as a deterrent to ants.

5.8.3 Chemical pest management (combat)

The use of fungicides and bactericides should only be considered when the disease is a known threat. More important are the preventive operations mentioned above. If damping-off appears to be a problem, soil fumigation should be considered. Most common fumigants are chlorinated hydrocarbons, chloropicrin, fenamifos, methyl bromide, oxamyl and sodium methyldithicarbamate. There is a large variety of chemicals available to combat and prevent diseases, and there application varies highly, depending on tree species and disease. Therefore, appendix 6 explains the properties of nematicides, fungicides, insecticides, fumigants and their application. However, the application of these chemicals should only be carried out by experienced people equipped with protective clothing, because some are toxic to human beings.

A short description to combat damping-off diseases is given here. For more details about the different chemicals and their application see appendix 6.

- *Soil acidification* is carried out to reduce the pH of most alkaline soils found in dryland environments. Usually sulphuric acid is used. The equivalent of 200-400 m^3 of concentrated sulphuric acid is applied in dilute solution (2% per volume) per m^2 of soil surface.

- In *soil sterilization* formaldehyde and methyl bromide (available in Armenia) are used. Another possibility is to heat the soil in the oven during 1 hour at 104^oC.
- *Fungicides* are either applied to the soil or to the seeds before sowing. Some fungicides that have been used successfully in dry areas are Thiram and Captan. They can be applied as a dust or in water suspension to the soil, before or after seeding.

APPENDIX 3

Climatic characteristics of the different regions of Armenia

District/Region/ Sub-region	Air temperature (^oC)				Frost free days	Precipitation		Altitude (masl)	Floristic ecological groups of the region
	Annual average	Absolute minimum	Absolute maximum	Monthly average (January)		Annual average (mm)	Summer (mm)		
I: Shirak-Ashotsk district									
1. The mountain-meadow region of upper Ahurian	2.0	-46	28	-12.1	98	534	166	2’000-2’300	11-13
2. The mountain-prairie region of Hamasia	4.1	-32	31	-9.5	146	599	178	1’800-2’000	9-13
3. The prairie region of Shirak	5.9	-35	34	-9.6	146	459	144	1’500-1’900	7-13
3a. The prairie sub-region of middle-Ahurian	5.4	-30	36	-8.1	171	498	139	1’400-1’800	6-13
3b. The meadow-prairie sub-region of Western Aragats	3.8	-32	31	-8.4	164	514	180	1’900-2’250	11-13
II: Aparan-Hrazdan district									
4. The meadow-prairie region of Aparan-Hrazdan	5.0	-33	31	-8.8	164	612	136	1’800-2’250	10-13
5. Forest region of Southern flora	3.6	-33	28	-	-	700	-	1’800-2’250	9-13
III: Lori district									
6. The meadow-prairie region of Lori	6.1	-34	30	-4.4	131	692	265	1’600-2’000	11-13
7. The forest prairie region of Lori	6.7	-31	31	-3.9	153	630	219	1’500-1’800	5, 9, 10, 12, 13
8. The mountain-prairie region of Spitak-Pampak	7.1	-30	32	-4.9	167	475	161	1’500-1’700	8-13
IV: Ijevan district									
9. The subtropical region of Debed-Axstev									
9a. The lower, comparatively dry sub-region	11.8	-16	36	-0.3	227	468	164	400-700	1-13
9b. The upper, comparatively humid sub-region	10.8	-18	36	-0.6	223	541	190	700-1’000	2-13
10. The mesophyl-forest region of Debed-Axstev	8.8	-20	32	-2.1	180	572	204	900-1’300	5-7, 9-13
10a. The forest sub-region of Gugarq	7.5	-30	30	-4.8	139	540	240	1’300-2’500	5-7, 9-13
11. The mesophyl forest region of Marmarik	3.6	-31	30	-8.6	-	800	242	1’900-2’500	7-13
V: Sevan district									
12. The Broadleaved and conifer “thin” forest region of Areguni	6.4	-25	32	-4.2	183	390	132	1’900-2’000	6-13
13. The prairie region of Martuni	5.3	-25	30	-5.6	175	445	133	1’890-2’000	6-13
14. The prairie region of Sevan	4.4	-30	32	-7.1	161	549	183	1’770-2’050	7-13
14a. The meadow prairie sub-region of Dsnaget	3.1	-32	28	-7.7	131	613	184	2’000-2’300	11-13
15. The meadow prairie region of Gexam-Vardenis	4.1	-33	30	-8.5	123	420	140	1’940-2’300	11-13

District/Region/ Sub-region	Air temperature (^oC)				Frost free days	Precipitation		Altitude (masl)	Floristic / ecological groups of the region
	Annual average	Absolute minimum	Absolute maximum	Monthly average (January)		Annual average (mm)	Summer (mm)		
VI: Sisian district									
16. The meadow-prairie region of Sisian	2.6	-35	28	-9.5	108	524	111	1’900-2’300	11-13
17. The prairie region of Sisian	6.6	-30	33	-5.2	151	407	92	1’700-2’050	7-13
VII: Zangezur district									
18. The prairie region	8.5	-25	38	-	170	500	129	1’600-1’700	4, 6-13
19. The forest region of Vorotan	8.8	-20	34	-0.9	202	765	171	1’000-1’500	4-13
19a. The forest sub-region of Darabas	7.8	-28	34	-5.0	-	492	118	-	5-13
20. The forest region of Bargushat-Chustupi	9.1	-25	30	-1.3	180	646	150	1’200-1’800	5, 6, 11-13
20a. The dry subtropical sub-region of Ujania-Tsavi	12.0	-20	41	-0.4	222	531	180	700-1’200	3, 4, 6-13
21. The forest region of Vochji-Gechi	6.0	-30	28	-6.0	150	542	107	1’800-2’400	7-13
VIII: Yerevan district									
22. The prairie region of Areg-Kotayk	8.2	-30	-	-5.7	187	498	115	1’400-2’000	6, 12, 13
22a. The dry forest sub-region of Amberd (arid)	5.4	-32	-	-7.6	174	650	126	1’500-2’300	8, 13
23. The stony semi-desert region of Arteni-Ashtarak	9.6	-30	39	-5.5	211	391	95	1’100-1’400	6, 12, 13
24. The desert region of Arax	11.6	-28	41	-4.3	163	245	51	800-950	6-12, 13
25. The semi desert region of Yerevan-Echmiadzin Oshinder	11.4	-28	41	-4.7	217	315	73	850-1’100	4, 6, 12, 13
26. The dry “island” forest region (arid)	8.9	-30	34	-5.9	208	501	87	1’150-1’700	7, 10, 11, 13
27. The gipsofile semi-desert region of Eranos-Vrtsi	11.4	-30	41	-3.9	-	350	-	1’150-1’300	7, 8, 10-13
IX: Arpi district									
28. The semi-desert region of Echegnadzor	11.3	-25	41	-3.8	215	444	73	-	4, 6, 12, 13
29. The “island” forest region of Exhegis-Jermuk	4.8	-33	-	-8.1	-	707	113	1’650-2’300	9-13
30. The prairie region of Gnishik-Martiros	7.5	-32	32	-	-	550	-	1’500-2’000	6-13
X: Mejhuy district									
31. The middle-mountain Xyrophile forests of Meghri	9.0	-25	40	-	180	400	-	800-2’500	6, 7, 13
32. The dry subtropical region near Arax	14.5	-16	41	-0.3	253	293	48	500-800	1-4, 6-13

SEED HANDLING OF SPECIES PROPAGTED FOR JRVEZH DENDROPARK

(Time of collection, Specific weight of seeds, Germination rate, Storage duration, Pre-treatment of seeds)

Species	Time of mature seeds (month)	Time to collect the fruits (month)	Weight of 1'000 seeds in gram	Germination rate in %	Possible duration to store seeds (years)	Pre-treatment of seeds
Ailanthus altissima	IX-X	X-XII	30-35	80-90	4	Cold stratification (5^oC) during 70-80 days, or exactly 60 days and afterwards soaking in water during 10 days may aid germination.
Caragana arborescens	VII-VIII	VII-VIII	25-40	70-80	4	Treatment with H_2SO_4 for ?? hours
Cedrus libani var.stenocoma	Have to purchased from Turkey					No treatment necessary, or cold stratification ($3\text{-}5^oC$) during 14 days
Celtis caucasica	IX-X	IX-X	40-50	80-90	2	Cold stratification for 140-160 days
Celtis glabrata	IX-X	IX-X	35-40	70-80	2	Cold stratification for 130-140 days
Crataegus orientalis	IX-X	IX-XI	60-80	80-90	3	Cold stratification during 150-180 days
Elaeagnus angustifolia	IX-X	IX-X	0.2-0.3	80-90	3	Cold stratification for 60-80 days, or ($1\text{-}10^oC$) for 10-90 days, pre-treat with H_2SO_4 for ½ hour helpful
Gleditschia triacanthos	IX-X	X-XII	0.2-0.3	80-90	4	Treat with H_2SO_4 for ?? hours
Hippophae rhamnoides	IX-X	IX-XI	20-30	70-80	2	Cold stratification 40-50 days
Juglans regia	IX-X	IX-X	7-9 kg	80-90	1	Wetting 10 days and cold stratification for 40 days
Juniperus foetidissima	XI-XII	XI-XII	115-120	5-10	3	Cold stratification during 120-150 days
Juniperus polycarpos	XI-XII	X-XII	5-8	20-30	4	Cold stratification during 180-

						210 days
Juniperus virginiana L.	X-XI	X-XII	9-10	50-60	5	Cold stratification (5^{o}C) during 120 days
Malus orientalis	IX-X	IX-X	20-30	80-90	3	Cold stratification for 90-100 days
Pinus pallasiana Lamb.	XI-XII	XI-XII	22-27	90-100	4-5	Wetting, no pre-treatment necessary
Pinus silvestris L.	XI-XII	XI-XII	6-8	75-90	5	“”
Pistacia mutica	X-XI	X-XII	40-60	50-60	1	Cold stratification for 100-120 days
Platanus acerifolia	X-XI	XI-XII	4-6	40-50	2	Wetting
Platanus orientalis	X-XI	XI-XII	4-6	30-40	2	Wetting
Platycladus orientalis	X-XI	X-XI	25-26	80-90	5	Wetting, no pre-treatment necessary
Pyrus salicifolia	IX-X	IX-X	15-25	70-80	3	Cold stratification for 90-100 days
Quercus iberica	IX-X	IX-X	2.5-3 kr	80-90	0.5[21]	No pre-treatment[22]
Quercus macranthera	IX-X	IX-X	2.5-3 kr	80-90	0.5	No pre-treatment
Robinia pseudoacacia	IX-X	X-XII	15-20	70-80	4	10-20 min. of H_2SO_4
Rosa canina	X	X	?	?	?	Cold stratification 120-150 days
Sorbus graeca	IX-X	IX-XI	3-5	50-60	2	Cold stratification 130-150 days
Tamarix ramosisima	?	?	?	?	?	?
Ulmus pinnato-ramosa	IV-V	IV-V	5-6	60-70	-	No pre-treatment
Ulmus elliptica C. Koch	V	V	9-10	60-70	-	No pre-treatment
Ulmus pumila						No pre-treatment, no dormancy

[21] If stored: In damp cold with plenty of ventilation.
[22] With few exceptions acorns of white Oak group have little or no dormancy and will germinate immediately after falling. Acorns of black Oak group exhibit embryo dormancy and should be cold stratificated. A general rule is cold stratification for black Oak by (1-5^{o}C) for 30-60 days.

SEED HANDLING OF MOST FOREST AND SHRUB SPECIES OF THE REPUBLIC OF ARMENIA

Species	Time of mature seeds (month)	Time to collect the fruits (month)	Weight of 1'000 seeds in gram	Germination rate in %	Possible duration to store seeds (years)	Pre-treatment of seeds
Biota orientalis	X-XI	X-XI	25-26	80-90	5	Wetting, no pre-treatment necessary
Picea pungens v. glauca Belssn	X-XI	IX-X	6-8	50-60	5	“”or, cold stratification (5^oC) during 14-90 days
Picea abies Karst.	X-XI	IX-X	5-6	65-80	5	“”, no dormancy, germinates immediately
Cedrus deodara Loud.	IX-X	IX-X	120-130	55-65	3[23],	“”, or cold stratification (3-5^oC) during 14 days
Cupressus arizonica Greene	X-XI	X-XII	0.3-0.5	20-30	10	“”, or cold stratification (5^oC) during 30 days
Cupressus sempervirens L.	IX-X	X-XII	0.3-0.5	35-40	10	« «
Chamaecyparis lawsoniana	IX-X	IX-X	0.2-0.5	30-40	2	« «, or cold stratification (5^oC) during 30 days
Larix decidua	XI-XII	X-XI	5-7	20-30	2	« «, or cold stratification (5^oC) during 60 days
Larix leptolepis	X-XI	IX-X	4-5	25-50	2	“”, cold stratification would enhance germination rate.
Juniperus virginiana L.	X-XI	X-XII	9-10	50-60	5	Cold stratification (5^oC) during 120 days
Juniperus oblonga M.B.	X-XI	X-XII	8-10	30-40	4	Cold stratification during 150-200 days
Juniperus Sabina	XI-XII	X-XII	8-9	30-40	4	Cold stratification during 150-200 days
Juniperus polycarpos	XI-XII	X-XII	5-8	20-30	4	Cold stratification during 180-210 days
Juniperus depressa	X-XI	X-XII	6-8	30-40	4	Cold stratification during 150-180 days
Juniperus communis	XI-XII	X-XII	8-11	60-90	4	Cold stratification during 210-250 days
Juniperus foetidissima	XI-XII	XI-XII	115-120	5-10	3	Cold stratification during 120-150 days

[23] Seeds of all Cedrus are oily and do not keep well, all Cedrus seeds exhibit little or no dormancy.

Pinus excelsa	X-XI	X-XII	45-55	70-80	4	Wetting or no pre-treatment necessary
Pinus pallasiana Lamb.	XI-XII	XI-XII	22-27	90-100	4-5	Wetting, no pre-treatment necessary
Pinus silvestris L.	XI-XII	XI-XII	6-8	75-90	5	“”
Pinus sosowskyi Nakai (= P. hamata (Stev.) D. Sosn.)	XI-XII	XI-XII	9-11	80-90	5	“”
Pinus eldarica Medw.	X-XI	X-XII	50-55	80-90	4	“”
Thuja occidentalis L.	IX-X	IX-X	0.5-1	30-40	5	“”, Occasionally dormant seed lots are encountered
Armeniaca vulgaris	VI-VII	VI-VII	1.2-2 kr	90-100	2	Cold stratification (1-5^{o}C) during 60-80 days, other literature say 180 days
Cydonia oblonga	IX-X	IX-X	25-35	70-80	3	Cold stratification during 70-80 days
Ailanthus altissima	IX-X	X-XII	30-35	80-90	4	Cold stratification (5^{o}C) during 70-80 days, or exactly 60 days and afterwards soaking in water during 10 days may aid germination.
Robinia pseudoacacia	IX-X	X-XII	15-20	70-80	4	10-20 min. of H_2SO_4
Albizzia julibrissin	IX-X	IX-XI	50-52	60-80	3	Brief H_2SO_4 or mechanical treatment to overcome impermeable seed coat.
Amorpha fruticosa L.	IX-X	IX-XI	8-10	80-90	4	Wetting, No pre-treatment necessary
Berberis vulgaris	IX-X	X-XI	3-4	80-90	3	Cold stratification during 80-90days
Phellodendron amurense Rupr.	IX-X	IX-XI	10-20	80-90	2	Cold stratification during 90-100 days
Euonymus verrucosa	VIII-IX	VIII-IX	20-30	75-90	2	Cold stratification during 160-180 days
Euonymus latifolia Mill.	IX-X	IX-X	35-50	80-90	2	Cold stratification during 120-150 days
Betula verrucosa	VII-VIII	VII-VIII	0.2	40-50	1	No pre-treatment, cold stratification would enhance germination rate.
Betula litwinowii	VIII-IX	VIII-IX	0.2	40-60	0.5	“”
Ligustrum lucidum	IX-X	IX-XI	30-40	50-60	2	Cold stratification during 40-60 days
Ligustrum vulgare	IX-X	X-XII	20-30	70-85	2	Cold stratification (0-3oC)

						during 60-90 days
Laburnum anagyroides Medic.	VIII-IX	VIII-IX	20-30	50-60	2	Treatment with H_2SO_4
Crataegus orientalis	IX-X	IX-XI	60-80	80-90	3	Cold stratification during 150-180 days
Crataegus macrocantha	VIII-IX	IX-XI	70-90	80-90	3	Cold stratification during 120-150 days
Broussonetia papyrifera	VIII-IX	VIII-IX	3-4	50-60	1	Wetting, or no pre-treatment necessary
Sambucus racemosa	VI-VII	VI-VII	2-9	70-80	2	Cold stratification during 150-200 days
Sambucus nigra	VIII-IX	VIII-IX	3-4	60-70	2	Cold stratification during 150-180 days
Fagus orientalis	IX-X	IX-X	0.2-0.4 kr	70-80	0.5	No pre-treatment
Gymnocladus dioicus	IX-X	X-XII	1.5-2 kr	90-100	3	Treat with H_2SO_4 for 1-2 hours
Wisteria sinensis	X-XI	XI-XII	50-60	60-80	3	No pre-treatment
Cerasus vulgaris	VI-VII	VI-VII	0.2-0.4	80-95	2	Cold stratification for 150-180 days
Cerasus avium	V-VII	V-VII	0.3-0.5	90-100	2	Cold stratification for 120-150 days
Cerasus incana	VII-VIII	VII-VIII	0.1-0.2	50-60	3	Cold stratification for 90-120 days
Ulmus pinnato-ramosa	V	V	5-6	60-70	-	No pre-treatment
Ulmus elliptica C. Koch	V-VI	V-VI	9-10	60-70	-	No pre-treatment
Ulmus pumila						No pre-treatment, no dormancy
Hibiscus syriacus	IX-XI	IX-XII	15-20	70-80	2	No pre-treatment
Gleditschia triacanthos	IX-X	X-XII	0.2-0.3	80-90	4	Treat with H_2SO_4 for ?? hours
Carpinus orientalis	IX-X	IX-XII	20-30	60-80	1	Cold stratification for 90-120 days
Carpinus caucasica	IX-X	X-XII	30-40	60-80	1	Cold stratification for 90-120 days
Pyrus salicifolia	IX-X	IX-X	15-25	70-80	3	Cold stratification for 90-100 days
Pyrus caucasica	IX-X	IX-X	20-30	80-90	3	Cold stratification for 90-100 days
Pyrus syriaca	IX-X	IX-X	20-30	70-80	3	Cold stratification for 100-120 days

Parthenocissus quinquefolia	IX-X	IX-XII	20-30	80-90	2	Cold stratification for 60-70 days
Deutzia scabra	X-XI	XI-XII	0.3-0.5	50-60	1	No pre-treatment necessary
Cornus mas	VIII-IX	VIII-X	0.2-0.3 kr	70-80	4	Cold stratification (1-12oC) for 30-120 days, or cold stratification for 180-200 days
Cornus australis	VIII-IX	IX-X	40-50	80-90	2	Cold stratification for 90-120 days
Zelkowa carpinifolia	IX-X	X-XI	10-15	60-70	3	Cold stratification for 40-60 days
Quercus araxina (Trautv.)	IX-X	IX-X	2-2.5 kr	70-80	0.5	No pre-treatment [24]
Quercus iberica	IX-X	IX-X	2.5-3 kr	80-90	0.5	No pre-treatment
Quercus castaneifolia	IX-X	IX-X	2-2.5 kr	70-80	0.5	No pre-treatment
Quercus macranthera	IX-X	IX-X	2.5-3 kr	80-90	0.5	No pre-treatment
Quercus robur (W)	IX-X	IX-X	2.5-3 kr	80-90	0.5	No pre-treatment
Rubus caesius	VIII-IX	VIII-X	1-2	80-90	2	Cold stratification for 40-60 days
Jasminum fruticans	VIII-X	VIII-XI	9-11	80-90	1	Cold stratification for 40-60 days
Rhamnus pallasii	IX-X	IX-X	15-18	80-90	1	Cold stratification for 60-80 days
Rhamnus cathartica	VIII-X	VIII-X	15-20	80-90	1	Cold stratification for 60-80 days
Lonicera iberica	IX-X	IX-X	4-5	70-80	2	Cold stratification for 70-90 days
Lonicera caucasica	VIII-IX	VIII-IX	6-6.5	80-90	2	Cold stratification for 90-100 days
Lonicera maackii	IX-X	IX-XI	4-6	80-90	2	Cold stratification for 90-100 days
Lonicera tatarica	VII-VIII	VII-IX	3.5-4	60-70	2	Cold stratification (5^oC) for 30-40 days; up to 60 days will increase germination rate

[24] With few exceptions acorns of white Oak group have little or no dormancy and will germinate immediately after falling. Acorns of black Oak group exhibit embryo dormancy and should be cold stratificated. A general rule is cold stratification for black Oak by ($1\text{-}5^oC$) for 30-60 days.

Salix caprea	VII-VIII	VII-VIII	0.5-0.6	30-40	1	No pre-treatment,
Amelanchier rotundifolia	VIII-IX	VIII-IX	2-2.5	69-80	1	Cold stratification for 90-120 days
Viburnum lantana	VIII-IX	VIII-IX	35-45	60-70	4	Cold stratification for 90-100 days, or (1-5^{o}C) for 70 days
Viburnum opulus	VIII-IX	VIII-X	20-30	60-70	2	Cold stratification for 150-180 days, or (1-5^{o}C) for 30-60 days
Campsis padicans	XI-XII	XI-XII	4-6	60-70	1	No pre-treatment
Caragana arborescens	VII-VIII	VII-VIII	25-40	70-80	4	Treatment with H_2SO_4 for 2-3 hours
Celtis glabrata	IX-X	IX-X	35-40	70-80	2	Cold stratification for 130-140 days
Celtis caucasica	IX-X	IX-X	40-50	80-90	2	Cold stratification for 140-160 days
Catalpa bignonioides	X-XI	XI-XII	10-15	50-69	1	No pre-treatment
Catalpa ovata	X-XI	XI-XII	3-5	50-60	1	No pre-treatment
Castanea sativa	IX-X	IX-XI	8.4-9.5 kr	80-90	1	No pre-treatment
Koelreuteria paniculata	IX-X	IX-XI	0.9-1.5	70-80	2	Cold stratification (5^{o}C) for 90 days, Treat with H_2SO_4 for 1-2 hours, Russian literatures says only watering
Cotoneaster lucida	VIII-X	VIII-XI	20-30	80-90	4	Cold stratification 120-150 days
Cotoneaster horizontalis	IX-X	IX-XI	20-30	70-80	4	Cold stratification for 90-120 days, pretreat in H_2SO_4 for 2-3 hours
Cotoneaster racemiflora	IX-X	IX-XI	25-30	70-80	4	Cold stratification for 120-150 days[25]
Cotoneaster integerrima	IX-X	IX-XI	25-35	80-90	4	Cold stratification for 120-150 days
Cotoneaster melanocarpa	IX-X	I-XI	25-35	70-90	4	Cold stratification for 90-120 days
Staphylea pinnata	IX-X	IX-X	39-40	69-80	1	Cold stratification for 60-70

[25] It is assumed that most types of Contoneaster have to be pretreated with H_2SO_4

						days
Acer hyreanum	IX-X	IX-X	40-50	70-80	2	Cold stratification for 90-100 days
Acer iberica	VIII-IX	VIII-IX	30-40	20-30	1	Cold stratification for 30-40 days
Acer pseudoplatanus	IX-X	IX-X	100-140	70-80	1	Cold stratification for 80-100 days, (5^oC) for 90+days
Acer platanoides	IX-X	IX-XI	80-90	60-70	1	Cold stratification for 70-80 days, or cold stratification (5^oC) for 90-120 days
Acer campestre	IX-X	IX-XI	50-70	70-75	1	Cold stratification for 140-160 days, or cold stratification ($2\text{-}4^oC$) for 90-180 days
Acer saccharinum	V-VI	V-VI	70-75	80-90	1	No pre-treatment
Acer tataricum	VIII-IX	VIII-X	30-50	50-60	2	Cold stratification for 90-100 days
Acer trautvetteri	IX-X	IX-XI	50-60	80-90	2	Cold stratification for 120-150 days
Acer negundo	VIII-IX	VIII-XI	30-40	60-70	2	Cold stratification for 30-40 days, or (5^oC) for 60-90 days
Aesculus hippocastanum	IX-X	IX-XI	11-14Kr	90-95	0.5	No pre-treatment, or (5^oC) for 90+days
Frangulaan alnus	VII-IX	VIII-X	25-30	80-90	1	Cold stratification for 50-60 days
Grossularia reclinata	VII-VIII	VII-VIII	0.8-1.2kr	60-80	1	Cold stratification for 70-90 days
Corylus colurna	VIII-IX	VIII-X	1.2-1.5kr	60-70	1	Cold stratification for 120-150 days
Corylus avellana	VIII-IX	VIII-IX	0.9-2 kr	70-80	4	Cold stratification for 80-100 days
Tilia caucasica	IX-X	IX-IX	40-50	60-70	3	Cold stratification for 120-150 days
Tilia cordata	IX-X	IX-X	2-25	50-65	3	Cold stratification for 150-180 days
Elaeagnus angustifolia	IX-X	IX-X	0.2-0.3	80-90	3	Cold stratification for 60-80 days, or ($1\text{-}10^oC$) for 10-90 days, pretreat with H_2SO_4

						for ½ hour helpful
Mahonia aquifolium	VIII-IX	VIII-X	8-12	70-80	3	Wetting
						No pre-treatment
Spartium junceum	X-XI	X-XI	15-20	40-50	2	Pre-treatment with H_2SO_4
Amygdalus communis	VIII-IX	VIII-IX	1.5-3kr	20-90	2	Cold stratification 120-150 days
Amygdalus fenzliana	VIII-IX	VIII-IX	1-1.2kr	20-30	2	Cold stratification 120-150 days
Mespilus germanica	IX-XI	IX-XI	10-12	80-90	3	Cold stratification 90-120 days
Hippophae rhamnoides	IX-X	IX-XI	20-30	70-80	2	Cold stratification 40-50 days
Alnus incana	XI-XII	XI-XII	0.5-0.9	20-30	2	No pre-treatment
Juglans regia	IX-X	IX-X	7-9 kg	80-90	1	Wetting 10 days and cold stratification for 40 days
Juglans nigra	IX-X	IX-X	12-14 kg	89-90	2	Cold stratification during 180-200 days
Parrotia persica	VIII-IX	VIII-X	30-40	80-90	3	Cold stratification 40-50 days
Persica vulgaris	VIII-X	VIII-X	2-4 kr	70-90	2	Cold stratification 120-150 days
Platanus orientalis	X-XI	XI-XII	4-6	30-40	2	Wetting
Platanus acerifolia	X-XI	XI-XII	4-6	40-50	2	Wetting
Colutea orientalis	VIII-IX	VIII-IX	15-20	60-70	3	Treatment with H_2SO_4
Physocarpus opulifolia	IX-X	IX-X	0.9-1	80-60	3	Treatment with H_2SO_4
Sorbus hajastana	IX-X	IX-XI	3-5	50-60	2	Cold stratification 150-160 days
Sorbus torminalis	IX-X	IX-XI	4-5	60-80	2	Cold stratification 180-200 days
Sorbus dualis	IX-X	IX-XI	3-5	60-80	2	Cold stratification 150-160 days
Sorbus kuznetzovii	IX-X	IX-XI	3-5	50-60	2	Cold stratification 130-150 days
Sorbus aucuparia	IX-X	IX-XI	4-6	80-90	2	Cold stratification 120-130 days

Sorbaria sorbifolia	IX-X	IX-XI	0.2-0.5	50-60	2	-
Syringa vulgaris	IX-X	IX-XI	8-10	60-70	2	Cold stratification for 50-60 days
Cotinus coggygria	VII-VIII	VII-VIII	8-10	55-70	2	Cold stratification for 80-90 days
Prunus spinosa	IX-X	IX-XI	200-300	80-90	4	Cold stratification for 150-160 days
Prunus divaricata	VII-IX	VII-IX	0.6-1 kr	90-95	3	Cold stratification for 120-150 days
Sophora japonica	X-XI	XI-XII	100-200	60-80	3	No treatment
Rhus coriaria	IX-XI	IX-XI	4-6	80-90	2	Cold stratification for 120-130 days
Rhus typhina	IX-X	IX-XI	-	70-80	3	Cold stratification for 60-90 days
Zizyphus jujuba	IX-X	X-XI	200-300	60-70	2	Cold stratification for 120-150 days
Pistacia mutica	X-XI	X-XII	40-60	50-60	1	Cold stratification for 100-120 days
Forsythia intermedia	X-XI	X-XI	6-8	50-60	1	Wetting
Ephedra distachya	VII-IX	VII-IX	7-11	80-90	2	No treatment
Chaenomeles japonica	IX-X	IX-X	15-20	70-90	2	Cold stratification for 80-90 days
Diospyros canadensis	IX-X	X-XI	80-90	80-90	2	Cold stratification for 40-60 days
Cercis siliquastrum	IX-X	X-XII	25-30	60-70	4	Treatment with H_2SO_4
Padus mahaleb	VII-VIII	VII-VIII	100-200	80-90	3	Cold stratification for 120-150 days
Padus racemosa	VII-VIII	VII-VIII	40-50	70-85	1	Cold stratification for 180-240 days
Halimodendron halodendron	VIII-IX	VIII-IX	8-10	50-60	3	Treatment with H_2SO_4
Philadelphus caucasicus	IX-X	IX-XI	0.1-0.2	40-50	2	Wetting
Morus alba	VI-VII	VI-VII	1.5-2	90-95	1	Wetting, no other treatment
Malus orientalis	IX-X	IX-X	20-30	80-90	3	Cold stratification for 90-100 days
Fraxinus ornus	IX-X	X-XI	25-30	60-70	2	Cold stratification for 30-40 days

Fraxinus lanceolata	VIII-IX	IX-XII	30-50	70-90	2	Cold stratification for 30-40 days
Fraxinus excelsior	IX-X	IX-XII	70-90	70-80	2	Cold stratification for 150-180 days
Fraxinus oxycarpa	IX-X	IX-XII	50-70	70-80	2	Cold stratification for 120-150 days
Fraxinus pennsylvanica	VIII-IX	IX-XII	40-50	65-80	2	Cold stratification for 30-40 days

SOWING SEASON, SOWING DENSITY, SOWING DEPTH AND APPROXAMITE AMOUNT OF SEEDLINGS/HA (Species propagated for Jrvezh Dendropark)

Species	Sowing season		Seedlings used in gram/m’	Sowing deepens of seeds	Amount of seedlings per ha (measured in 1’000)	
	Fall	Spring			Young seedling s	Mature seedlings
Ailanthus altissima	X-XI	Early spring	5	2-3	500-600	-
Caragana arborescens	XI	Early spring	4	1-2	800-1000	-
Cedrus deodara Loud.	No	Early spring	12-15	2-3	400-500	250-300
Celtis caucasica	Beginning X	Early spring	2-3	2-3	720-800	250-300
Celtis glabrata	Beginning X	Early spring	2-3	2-3	720-800	250-300
Crataegus orientalis	Beginning X	Early spring	10-15	2-3	1400-1500	300-330
Elaeagnus angustifolia	Late fall	Early spring	10-20	2-4	-	300-330
Gleditschia triacanthos	Late fall	Early spring	40-50	2-3	450-550	-
Hippophae rhamnoides	X-XI	Early spring	2-3	1-2	720-800	300-350
Juglans regia	X-XI	Early spring	100-150	4-8	-	150-200
Juniperus polycarpos	Beginning of IX of the 2nd. year	Early spring	3	0.5-1	400-500	300-330
Juniperus foetidissima	Beginning of IX of the 2nd. year	Early spring	100	1-2	300-330	
Juniperus virginiana L.	Beginning of X	Early spring	2-3	0.5-1	400-500	300-330
Malus orientalis	Beginning X	Early spring	4-5	2-3	1150-1200	250-300
Pinus pallasiana Lamb.	No	Early spring	3	1-2	800-1000	300-330
Pinus silvestris L.	No	Early spring	2	1-2	1000-1200	300-330
Pistacia mutica	Beginning X	Early spring	4-6	2-3	720-800	200-250
Platanus acerifolia	Late fall	Early spring	2-3	0.5-1	250-400	200-250
Platanus orientalis	Late fall	Early spring	2-3	0.5-1	200-250	200-250
Platycladus orientalis	No	Early spring	6	1-2cm	400-500	300-350
Pyrus salicifolia	Beginning X	Early spring	4-5	2-3	1400-1500	250-300
Quercus iberica	X-XI	Early spring	110	4-6	450-600	200-250
Quercus macranthera	X-XI	Early spring	110	4-6	400-450	200-250

Robinia pseudoacacia	No	Early spring	3-4	1-2	400-500	150-200
Rosa canina	Late fall	Early spring	?	1-2	400-500	?
Sorbus graeca	IX-Beginning X	Early spring	0.5-0.6	0.5-1	400-500	200-250
Tamarix ramosisima						
Ulmus elliptica C. Koch	No	VI-VII	4-6	2-3	600-700	250-300
Ulmus pinnato-ramosa	No	VI-VII	4-6	2-3	600-700	250-300
Ulmus pumila						

SOWING SEASON, SOWING DENSITY, SOWING DEPTH AND APPROXAMITE AMOUNT OF SEEDLINGS/HA (For most species of Armenia)

Species	Sowing season		Seedlings used in gram	Sowing deepens of seeds	Amount of seedlings per ha (measured in 1'000)	
	Fall	Spring	On 1 linear m		Young seedlings	Mature seedlings
Biota orientalis	No	Early spring	6	1-2cm	400-500	300-350
Picea pungens v. glauca Belssn	No	Early spring	4	1-2	800-1000	300-350
Picea abies Karst.	No	Early spring	4	1-2	800-1000	300-350
Cedrus deodara Loud.	No	Early spring	12-15	2-3	400-500	250-300
Cupressus arizonica Greene	No	Early spring	0.2-0.3	0.5-1	400-500	250-300
Cupressus sempervirens L.	No	Early spring	0.2-0.3	0.5-1	350-400	200-250
Chamaecyparis lawsoniana	No	Early spring	0.1	0.5	600-800	300-330
Larix decidua	No	Early spring	4	0.5-1	400-500	250-400
Larix leptolepis	No	Early spring	4	0.5-1	400-500	250-300
Juniperus virginiana L.	Beginning of X	Early spring	2-3	0.5-1	400-500	300-330
Juniperus oblonga M.B.	Beginning of IX of the 2nd. year	Early spring	1.5-2	0.5-1	400-500	300-330
Juniperus Sabina	Beginning of IX of the 2nd. year	Early spring	1.5-2	0.5-1	400-500	300-330
Juniperus polycarpos	Beginning of IX of the 2nd. year	Early spring	3	0.5-1	400-500	300-330
Juniperus depressa	Beginning of X	Early spring	1.5-2	0.5-1	400-500	300-330
Juniperus communis	Beginning of X	Early spring	2-3	0.5-1	400-500	300-330

Juniperus foetidissima	Beginning of IX of the 2nd. year	Early spring	100	1-2	300-330	300-330
Pinus excelsa	No	Early spring	10-12	2-3	900-1200	300-330
Pinus pallasiana Lamb.	No	Early spring	3	1-2	800-1000	300-330
Pinus silvestris L.	No	Early spring	2	1-2	1000-1200	300-330
Pinus sosowskyi Nakai (= P. hamata (Stev.) D. Sosn.)	X-XI	Early spring	2-3	1-2	1000-1200	300-330
Pinus eldarica Medw.	X-XI	Early spring	10-12	2-3	800-900	300-330
Thuja occidentalis L.	No	Early spring	0.3-0.5	0.5-1	400-500	250-300
Armeniaca vulgaris	VII, beginning X	Early spring	60-80	3-4	280-300	?
Cydonia oblonga	Beginning X	Early spring	5-6	2-3	1400-1500	300-300
Ailanthus altissima	X-XI	Early spring	5	2-3	500-600	-
Robinia pseudoacacia	No	Early spring	3-4	1-2	400-500	150-200
Albizzia julibrissin	No	Early spring	10-15	1-2	400-500	250-300
Amorpha fruticosa L.	XI	Spring	2-3	2-3	500-750	-
Berberis vulgaris	Beginning X	Spring	1-2	0.5-1	1400-1500	300-350
Phellodendron amurense Rupr.	Beginning X	Spring	2-4	2-3	400-500	200-50
Euonymus verrucosa	Beginning X	Spring	3	1-2	400-500	-
Euonymus latifolia Mill.	Beginning X	Spring	5-6	1-2	400-500	200-250
Betula verrucosa	XI	Spring	0.1	Until 0.2	450-600	250-300
Betula litwinowii	XI	Early spring	0.1	Until 0.2	450-600	250-300
Ligustrum lucidum	X-XI	Early spring	3	2-3	700-800	300-330
Ligustrum vulgare	Beginning X	Early spring	3	2-3	1400-1500	-
Laburnum anagyroides Medic.	Late Fall	Early spring	4-6	1-2	450-500	200-250
Crataegus orientalis	Beginning X	Early spring	10-15	2-3	1400-1500	300-330
Crataegus macrocantha	Beginning X	Early spring	10-15	2-3	1400-1500	300-330
Broussonetia papyrifera	Late fall	Early spring	0.8-1	Until 0.5	500-600	250-300
Sambucus racemosa	Beginning X	Early spring	2	0.3-0.5	700-800	300-350
Sambucus nigra	Beginning X	Early spring	2	0.3-0.5	700-800	300-350
Fagus orientalis	Beginning XI	Early spring	25-30	3-4	400-500	400-500
Gymnocladus dioicus	Late fall	Early spring	30-40	3-4	300-400	-
Wisteria sinensis	Late fall	Early spring	3-4	2-3	400-500	-
Cerasus vulgaris	Beginning IX	Early spring	25-30	2-4	300-400	300-400
Cerasus avium	Beginning X	Early spring	25-30	3-4	-	300-400

Cerasus incana	Beginning X	Early spring	20-25	2-3	400-500	-
Ulmus pinnato-ramosa	No	VI-VII	4-6	2-3	600-700	250-300
Ulmus elliptica C. Koch	No	VI-VII	4-6	2-3	600-700	250-300
Ulmus pumila						
Hibiscus syriacus	Late fall	Early spring	1-1.2	0.5-1	400-500	-
Gleditschia triacanthos	Late fall	Early spring	40-50	2-3	450-550	-
Carpinus orientalis	Beginning X	Early spring	4-5	1-2	500-600	250-300
Carpinus caucasica	Beginning X	Early spring	4-5	1-2	400-500	250-300
Pyrus salicifolia	Beginning X	Early spring	4-5	2-3	1400-1500	250-300
Pyrus caucasica	Beginning X	Early spring	4-5	2-3	1400-1500	250-300
Pyrus syriaca	Beginning X	Early spring	4-5	2-3	1400-1500	250-300
Parthenocissus quinquefolia	Beginning X	Early spring	4-5	0.5-1	1000-1200	-
Deutzia scabra	No	Early spring	0.2-0.3	Until 0.5	800-1000	-
Cornus mas	Fall of the 2nd year	Early fall of the 2nd year	20-25	3-4	-	300-330
Cornus australis	Beginning X	Early spring	4	2-3	400-500	-
Zelkowa carpinifolia	Late fall	Early spring	1-1.2	1-2	400-500	200-250
Quercus araxina (Trautv.)	X-XI	Early spring	100	4-6	450-500	200-250
Quercus iberica	X-XI	Early spring	110	4-6	450-600	200-250
Quercus castaneifolia	X-XI	Early spring	100	4-6	450-500	200-250
Quercus macranthera	X-XI	Early spring	110	4-6	400-450	200-250
Quercus robur (W)	X-XI	Early spring	115	4-6	400-450	200-250
Rubus caesius	X-XI	Early spring	0.4-0.5	0.5-1	2000-2200	300-350
Jasminum fruticans	Late fall	Early spring	1-1.2	0.5-1	800-1000	-
Rhamnus pallasii	Late fall	Early spring	10-11	1-2	450-500	-
Rhamnus cathartica	Late fall	Early spring	10-11	1-2	450-500	-
Lonicera iberica	Beginning X	Early spring	1.5-2	0.5-1	700-800	-
Lonicera caucasica	Beginning X	Early spring	1.5-2	0.5-1	700-800	-
Lonicera maackii	Beginning X	Early spring	1.5-2	0.5-1	700-800	-
Lonicera tatarica	Late fall	Early spring	2.0-2.5	0.5-1	1000-1200	-
Salix caprea	Early fall	Early spring	0.5-1	Until 0.5	800-1000	-
Amelanchier rotundifolia	Beginning X	Early spring	0.4-0.5	0.5-1	1400-1500	300-350
Viburnum lantana	Beginning X	Early spring	8-10	1-2	450-500	-
Viburnum opulus	Beginning X	Early spring	10	1-2	400-500	250-300

Campsis padicans	No	Early spring	2-3	0.5-1	450-500	-
Caragana arborescens	XI	Early spring	4	1-2	800-1000	-
Celtis glabrata	Beginning X	Early spring	2-3	2-3	720-800	250-300
Celtis caucasica	Beginning X	Early spring	2-3	2-3	720-800	250-300
Catalpa bignonioides	Late fall	Early spring	1-1.5	1-2	300-400	200-250
Catalpa ovata	Late fall	Early spring	0.3-0.4	0.5-1	300-400	200-250
Castanea sativa	X-XI	Early spring	80-100	4-6	-	300-330
Koelreuteria paniculata	Late fall	Early spring	20-30	2-3	400-450	-
Cotoneaster lucida	Fall of the 2nd year	Early spring	4-6	1-2	500-600	300-330
Cotoneaster horizontalis	Fall of the 2nd year	Early spring	4-6	1-2	500-600	300-330
Cotoneaster racemiflora	Fall of the 2nd year	Early spring	4-6	1-2	500-600	300-330
Cotoneaster integerrima	Fall of the 2nd year	Early spring	5-7	1-2	500-600	-
Cotoneaster melanocarpa	Fall of the 2nd year	Early spring	5-7	1-2	500-600	-
Staphylea pinnata	X-XI	Early spring	5-6	2-3	900-950	300-330
Acer hyreanum	X-XI	Early spring	6-7	3-4	400-450	200-250
Acer iberica	Late fall	Early spring	5-6	2-3	400-450	-
Acer pseudoplatanus	Beginning X	Early spring	10-15	4-5	500-600	200-250
Acer platanoides	Beginning X	Early spring	8	3-4	400-500	200-250
Acer campestre	Beginning X	Early spring	7-8	3-4	300-400	200-250
Acer saccharinum	Late fall	Early spring	6-7	2-3	450-500	200-250
Acer tataricum	Beginning X	Early spring	5-7	3-4	400-450	200-250
Acer trautvetteri	Beginning X	Early spring	8-10	3-4	300-400	200-250
Acer negundo	Beginning X	Early spring	5-6	3-4	500-600	-
Aesculus hippocastanum	Beginning X	Early spring	150-200	4-8	400-500	200-250
Frangulaan alnus	Beginning X	Early spring	10-11	1-2	450-500	-
Grossularia reclinata	Beginning X	Early spring	0.3-0.5	0.5-0.6	1400-1500	300-350
Corylus colurna	Beginning X	Early spring	40-60	2-4	-	250-300
Corylus avellana	Beginnig X	Early spring	40-60	3-4	-	300-330
Tilia caucasica	Beginning X	Early spring	7-8	2-3	300-350	200-250
Tilia cordata	Beginning X	Early spring	6-7	1-2	300-350	-
Elaeagnus angustifolia	Late fall	Early spring	10-20	2-4	-	300-330
Mahonia aquifolium	Late fall	Early spring	2	0.5-1	600-800	-
Spartium junceum	Late fall	Early spring	0.8-1	0.5-1	600-800	-

Amygdalus communis	Beginning X	Early spring	60-80	3-4	-	300-330
Amygdalus fenzliana	Beginning X	Early spring	60-80	2-4	-	300-350
Mespilus germanica	Beginning X	Early spring	1.5-2.5	1-2	1100-1200	250-300
Hippophae rhamnoides	X-XI	Early spring	2-3	1-2	720-800	300-350
Alnus incana	No	Early spring	0.5	Until 0.2	400-500	200-250
Juglans regia	X-XI	Early spring	100-150	4-8	-	150-200
Juglans nigra	X-XI	Early spring	150-200	5-10	200-250	200-250
Parrotia persica	Late fall	Early spring	5-6	1-2	450-500	250-300
Persica vulgaris	Beginning X	Early spring	80-100	4-5	300-330	150-160
Platanus orientalis	Late fall	Early spring	2-3	0.5-1	200-250	200-250
Platanus acerifolia	Late fall	Early spring	2-3	0.5-1	250-400	200-250
Colutea orientalis	Late fall	Early spring	3-4	1-2	500-600	-
Physocarpus opulifolia	Late fall	Early spring	0.4-0.5	Until 0.5	600-800	-
Sorbus hajastana	IX-Beginning X	Early spring	0.5-0.6	0.5-1	400-500	200-250
Sorbus torminalis	IX-Beginning X	Early spring	0.5-0.6	0.5-1	400-500	200-250
Sorbus dualis	IX-Beginning X	Early spring	0.5-0.6	0.5-1	400-500	200-250
Sorbus kuznetzovii	IX-Beginning X	Early spring	0.5-0.6	0.5-1	400-500	200-250
Sorbus aucuparia	IX-Beginning X	Early spring	0.5-0.6	0.5-1	1400-1500	200-250
Sorbaria sorbifolia	No	Early spring	0.1-0.2	Until 0.5	800-1000	-
Syringa vulgaris	Late fall	Early spring	2-3	1-2	500-550	200-250
Cotinus coggygria	Late fall	Early spring	2	1-2	300-400	200-250
Prunus spinosa	Beginning X	Early spring	20-25	3-4	-	300-330
Prunus divaricata	Beginning X	Early spring	35-40	3-5	400-500	300-330
Sophora japonica	Late fall	Early spring	20-25	1-2	350-400	250-300
Rhus coriaria	Beginning X	Early spring	0.5-0.6	0.5-1	400-500	250
Rhus typhina	X	Early spring	-	-	400-500	-
Zizyphus jujuba	Beginning X	Early spring	10-20	2-4	-	300-330
Pistacia mutica	Beginning X	Early spring	4-6	2-3	720-800	200-250
Forsythia intermedia	Late fall	Early spring	1.5-2	0.5-1	500-600	-
Ephedra distachya	Late fall	Early spring	0.8-1	0.5-1	800-1000	-
Chaenomeles japonica	Beginning X	Early spring	5	1-2	400-500	300-330
Diospyros canadensis	X-XI	Early spring	4-5	1-2	580-650	200-250
Cercis siliquastrum	Late fall	Spring	5-6	1-2	450-500	200-250

Padus mahaleb	Beginning X	Early spring	20-25	3-4	720-800	200-250
Padus racemosa	End IX	Early spring	1.5-2.5	1-2	720-800	300-330
Halimodendron halodendron	No	Early spring	2-3	1-2	400-500	-
Philadelphus caucasicus	No	Early spring	0.1-0.2	Until 0.5	800-1000	-
Morus alba	No	Early spring	0.4	0.5-1	1700-2000	200-250
Malus orientalis	Beginning X	Early spring	4-5	2-3	1150-1200	250-300
Fraxinus ornus	Late fall	Early spring	6	1-2	400-500	200-250
Fraxinus lanceolata	Late fall	Early spring	7	2-3	350-400	-
Fraxinus excelsior	Beginning X	Early spring	8	3-4	400-500	200-250
Fraxinus oxycarpa	Beginning X	Early spring	7	3-4	400-500	200-250
Fraxinus pennsylvanica	Late fall	Early spring	7	2-3	350-400	-

SEEDBANK MANAGMENT FORM

LOCATION OF SEED COLLECTION

Local name:____

Coordinates:____

Altitude: ____

Slope exposition:____

STAND ANALYSE (IDENTIFICATION OF PLUS TREE CANDIDATES)

Man made forest ☐ natural ☐

Average age of the stand:____

Type of forest and main species[26]:____________________________________

Percentage of superior individuals in the stand[27]:___________________________

Scientific name of specie from which seeds are collected: _____________________

Seed lot code (use for databank and monitoring system)_______________________

SITE CONDITIONS

Soil type:

Light (sand) ☐ Medium (loam) ☐ heavy (clay) ☐

Soil pH:____

Percentage of stones in the soil profile:____________________________________

Soil deepness:____

Parental rock type:____

Name of soil type:____

Climate characteristics:

Annual precipitation:____

Precipitation during the vegetation period:_________________________________

Precipitation during the summer: _______________________________________

Annual average temperature:_______________________________________

Average temperature January:____

Average temperature July:____

[26] Texture and structure of the forest have to analysed. E.g. is it mainly a *Quercus, Fagus, Carpinus* or *Juniperus* forest? Is the forest homogenous or highly inhomogeneous?

[27] Superior individuals are the dominant trees in the forest stand. Therefore, height, diameter, quality of growth shape and no signs of biotic and abiotic damages have to be analysed. The higher the percentage of high quality trees, the lower the costs of collecting seeds because a high amount of seeds can be collected without displacement.

Absolute maximum temperature:____

Absolute minimum temperature:____

DEVELOPMENT OF SEEDLINGS IN THE NURSERY

Survival rate:

Percentage of germination:____

Percentage of survival rate of seedlings in the nursery:________________________

Growth rate:

Annual growth rate (Root collar diameter):_________________________________

Annual growth rate (Height):____

Height of seedlings before planting out at the reforestation site:__________________

Diameter of seedlings before planting out at the reforestation site:___________

Shoot to root ratio: ____

Growth form: Bushy ☐ Straight growing ☐

General quality: very good ☐ good ☐ average ☐ bad☐

DEVELOPMENT AT THE REFORESTATION SITE

Survival rate: ____

Growth development in height: ____

Growth development in diameter: ______________________________________

Percentage of trees affected by biotic factors: ______________________________

Percentage of trees affected by abiotic factors: _____________________________

Name(s) of biotic factor(s):____

Name(s) of abiotic factor(s):____

SITE CONDITIONS OF REFORESTATION SITE

Soil type:

Light (sand) ☐ Medium (loam) ☐ heavy (clay) ☐

Soil pH:____

Percentage of stones in the soil profile:___________________________________

Soil deepness:____

Parental rock type:____

Name of soil type:____

Climate characteristics:

Annual precipitation:____

Precipitation during the vegetation period:__________________________________

Precipitation during the summer: _______________________________________

Annual average temperature:______________________________________

Average temperature January:____

Average temperature July:____

Absolute maximum temperature:____

Absolute minimum temperature:____

Site preparation:

Type of water harvesting system:____

Irrigation: yes ☐ no ☐

Other measures carried out at the reforestation site:_______________________

Remark: All this information must be managed in an Access databank because the amount of information will continuously increase. Additionally, an ACCESS Databank will make it possible to analyse the information and therefore, determine which seed source is best suited for the different reforestation sites.

ESTIMATION OF AVAILABLE SEEDS

Year: ______________________________

Scientific name of specie: ______________________________

Phonological observations in Spring[28]: low blossom ☐ average blossom ☐

high blossom ☐

Estimation of seed crops (immature fruits): low quantity ☐ average quantity ☐

high quantity ☐

Location of seed collection:

Altitude:

Slope exposition:

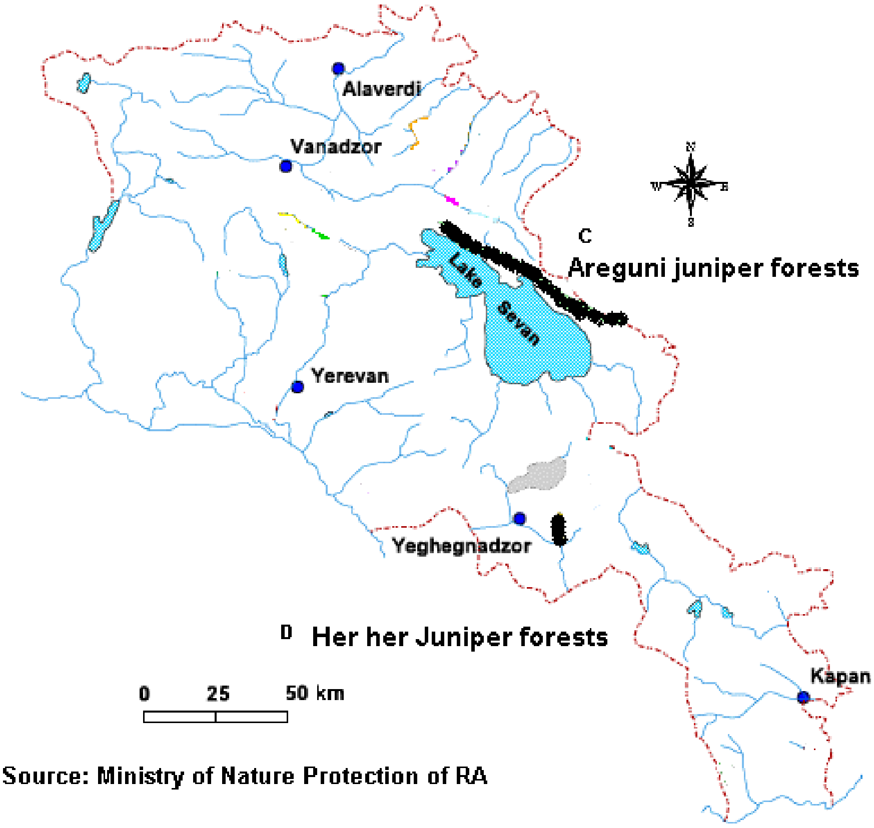
Proposed date to collect fruits:

Mast year: yes ☐ no ☐

Due to the complex topography of Armenia, trees will not blossom and produce fruits at the same time (the lower, the earlier). It is important to observe the development of fruits to collect them at the proper time, otherwise they will not be mature, dispersed by wind, rain or animals, or lost to pathogens. Shen NGO is involved in several other projects throughout the country. Therefore, Shen can collect this information from Shen members and other project partners. Certainly farmers going to the forest and the Armenian forest department, can be useful informants.

[28] Has to be observed from a specialist with several years of forestry experience in Armenia.

MAP 6: LOCATION OF JUNIPER FORESTS



Source: Ministry of Nature Protection of RA

NECESSRAY TOOLS AND EQUIPMENT TO MANAGE A TREE NURSERY, INCLUDING THE COLLECTION AND PROCESSING OF SEEDS

Tools for planting and early care:

Subject	Quantity
Spades	5 pieces
Forks	5 pieces
Rakes	5 pieces
Wheelbarrow	2 pieces
Bags to protect seedlings during transplanting	20 pieces
Knifes for root pruning	5 pieces
Water canes	5 pieces
Total	

Clearing tools:

Subjects	Quantity
Grass hock, for cutting herbaceous material	2 pieces
Long handled scythe for cutting grassy rides and glades	2 pieces
Total	

Equipment to collect seeds and cuttings:

Subject	Amount
Bags	5 pieces
Tarpaulin	5 pieces
Ladder	1 piece
Pruning saw	2 pieces
Extension poles	2 pieces
Bypass action type secateurs	2 pieces
Total	

Equipment to handle and store seeds:

Subject	Quantity
Fridge	1 piece
Airtight containers	10 pieces
Sand (stratification)	5 m3

IBA	5 kg
Sulphuric acid	10 l
Sieves (series of grids)	10 pieces
Wire mesh	1 piece
Mortar	1 piece
Food chopper/mixer	1 piece
Seed fumigation	100 kg
Total	