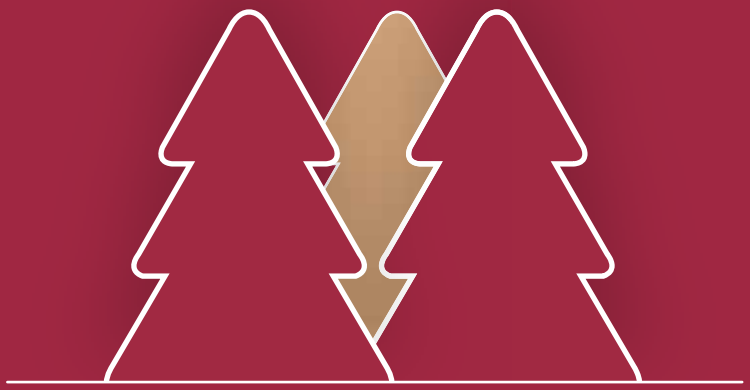

Forest and Landscape Restoration Guidelines

Shouf Biosphere Reserve

2019 Shouf Biosphere Reserve

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"The contents of this publication are the sole responsibility of the Shouf Biosphere Reserve and can in no way be taken to reflect the views of the European Union."

This document is the new addition to a series of publications developed by the Shouf Biosphere Reserve with the aim of sharing know-how, best practices, and lessons learned with other practitioners and other protected areas.

Forest Landscape Restoration has been adopted by the Shouf Biosphere Reserve as a comprehensive ongoing process aiming at recovering the landscape after the disturbances that have affected it due to series of ecological, socioeconomic, and cultural modifications, combined with water deficit, extreme weather events, and large-scale disturbances due to climate change and causing irreversible shifts towards undesirable conditions, all affecting human well-being.
The Shouf Biosphere Reserve unremittingly strives to remain a learning site for sustainable development, restoring the ecological functionality of the landscape, building the capacities and enhancing the welfare of the surrounding communities.

Finally, I take this opportunity to thank every member of the team who has been involved in this endeavor and also to extend our gratitude to the EU for this project, to the Italian Agency for Development Cooperation, MAVA, World Food Programme, and many other donors, for their support, always looking forward to more opportunities of cooperation.

Al Shouf Cedar Society Advisor Nora Joumblatt

Halting deforestation has to be a priority for us – Lebanese and Europeans. Not only because it is the “right” and “ethical” thing to do, but because it is in our “self-interest”, given how critical forests are to the well-being of the planet and to ourselves.
Forests matter to the EU. And this is why we have been supporting the Shouf Biosphere Reserve, Lebanon’s largest nature reserve (=5% of Lebanese territory), together with other European Member States such as Italy and France. We believe in the necessity of acting collectively to halt Lebanon’s loss of biodiversity. We believe that in the world we live in today – characterised by its interdependencies – threats have to be addressed jointly. And this is why, we – as Europeans – have been funding so many environmental interventions in Lebanon, from promoting a clean air, to protecting Lebanon’s marine and coastal biodiversity, to afforestation activities.
Forests matter to Lebanon too. And we want to highlight the incredible commitment and work of so many Lebanese actors active in forestry activities, starting with the Shouf Biosphere Reserve.

EU Ambassador Christina Lassen

Contents

About this Publication

This publication which is funded by the European Union is the result of an enormous effort undertaken by the Shouf Biosphere Reserve, with the engagement of its management team, international providers of technical assistance, and local stakeholders (authorities, private and public sectors, and communities) to design, plan, and implement a comprehensive and participatory forest landscape restoration programme in one of the most valuable and well known protected areas in the Middle East, the Shouf Biosphere Reserve.

Six years of hard work, test and trial, lessons learned and field practice – from the inception of the current FLR cycle to today - are distilled in these guidelines, which are meant as a contribution to the efforts of the Lebanese and international community of practitioners, not only in the in the field of forest protection, management and restoration, but also in those of biodiversity conservation, sustainable rural development, protected area management, and in the increasingly important challenge to achieve resilience and adaptation to the threats posed by climate change.

The first part of the publication introduces the concept of Forest Landscape Restoration and provides a global review of the latest thinking, practices and the international policies driving the FLR effort worldwide. This includes the concepts of Land Degradation and Land Degradation Neutrality, which inspire the latest policies such as the Bonn Challenge, and drive investments in the FLR field from global donors such as international agencies and the Global Environment Facility (GEF).

The second part of the publication shifts its focus from global to local, analizing the landscape of the Shouf Biosphere Reserve from all its different angles –geographic, physical and climatic features, biological diversity, social, economic, and cultural aspects. This analysis provides the basis and rationale to understand the choices made and strategies followed in shaping the FLR strategy in the protected area.

The third part of the publication reviews the seven principles of Forest Landscape Restoration and provides a detailed technical review of how each principle was applied and translated into practice in the landscape of the Shouf Biosphere Reserve, during the last six years. This part analyses the root, intermediate, and ultimate causes of land and forest degradation in the project area, enphasizing the interaction between “traditional” degradation and the impact of climate change, and focusing on the adaptation measures applied to enhance the resilience of the forest landscapes to the new threat. Each FLR practice is described in full detail, including the link between FLR interventions and the need to support/strengthen the local economy – with a special reference to agro-silvo-pastoral practices, the introduction of renewable sources of energy, and tourism.

Finally, the document provides a long list of bibliographic references and technical annexes, including the criteria for species selection and the nursery production protocols, that can guide and inspire institutions, organisations and private citizens who wish to engage in the challenging but fascinating endeavour of Forest Landscape Restoration.

Background

Although Lebanon is well known in the Middle East as a land of forests and the home of the world-famous Cedars, the country - with its mountain terrain, steep slopes and high population density- is particularly vulnerable to the impact of deforestation, land degradation, and desertification. All these threats will be increasingly exacerbated by the impact of climate change. The Second National Communication of the Lebanese Government to the UNFCCC calls for the implementation of experiences of forestation/ restoration that can maximise the resilience of the ecosystem to the foreseen impacts, including forest fires.

Al-Shouf Cedar Society (ACS) was established in 1994 with the specific objective of leading the management of the Shouf Biosphere Reserve (SBR). The core mission of ACS is the conservation of the natural and cultural heritage of the SBR, in cooperation with the local institutions and communities, through environmental, awareness and rural development activities.

In 2012 ACS joined an innovative international project known as “Mediterranean Mosaics” project, whose goal was to build the resilience of Mediterranean rural biodiversity-rich landscapes to global change, through the identification and implementation of adaptation measures influencing land management, markets and policy/governance frameworks. The project, supported by the Swiss-based MAVA Foundation, was designed considering the policy, governance, and socio-economic context of Lebanon, and the need to develop innovative forestation and restoration work that would increase the resilience of Lebanese forest ecosystems to the challenges posed by the impact of human action and climate change.

In the framework of Mediterranean Mosaics, ACS developed its first Forest Landscape Restoration (FLR) plan, covering an ecological corridor connecting the Beqaa Valley and the Ammiq wetland in the east to the western slopes of the Shouf Biosphere Reserve mountain range. The plan was designed and implemented under the guidance of a team international experts. Overall, production protocols for high quality plants of approx. 30 native tree and shrub species were developed, and approx. 50 hectares of land were restored, using a mix of innovative techniques and a rigorous protocol that took care of all the aspects of the work – from seedling production all the way to the monitoring of the result. The FLR programme involved since its very start all the main stakeholder groups, including local municipalities, community members, especially farmers and small-medium size business in the agro-forestry sector, and other concerned institutional and non-institutional stakeholders.

The results of the adaptive forest restoration work in the ecological corridor of the Shouf Biosphere Reserve were monitored and evaluated. The data collected yielded excellent results, with a survival rate of seedlings and seeds that has no precedent in the history of forestation in Lebanon.

The remarkable success of this initiative paved the way for a new partnership with the Lebanese Ministry of Agriculture, with funds from EU/ENPI. The new project titled “Environmentally-sound and Socially-beneficial Forestation in the Shouf Biosphere Reserve” started in 2014, with a duration of four years. The action was built around four interconnected results. The first result consisted of the mapping of forestation/restoration sites, and the implementation of the forestation/restoration work, monitoring and management, on a total of 25 hectares belonging to four municipalities. The second result focused on the empowerment of the target municipalities on forestation/restoration forest management and monitoring. The third result aimed at building the capacity of beneficiaries at the community level to create small businesses related to sustainable forest exploitation (non-timber forest products, handicraft, tourism-related services, biomass energy production), through farmers-to-farmer training. The beneficiaries were also able to tap a specific small credits scheme - the “Cedar Loans” - made available by ACS for the launch of new enterprises. The fourth result focused on awareness raising, communication, and the production of technical guidelines to upscale and disseminate the result of the FLR work.

The satisfactory results of the FLR work developed since 2012 encouraged ACS to widen the scope of its restoration program, extending it to other important habitats of the Shouf Biosphere Reserve and its buffer zone, such as abandoned and degraded stone terraces and other agricultural lands subject to traditional farming practices. In 2017- 2018 a new ambitious program was launched, with the financial support of the MAVA Foundation and AICS, the Development Agency of the Italian Government. This new action places special focus on the empowerment of the weakest sectors of the rural society, namely women and young unemployed, and applies the lessons learned and practices of the previous FLR work in the restoration of extensive agro-forestry systems, promoting value chains of high-quality products, the conservation and monitoring of the rich biodiversity associated to these habitats, and specific tourist measures for the valorisation of the natural and cultural heritage.

Nowadays, the restoration of forest and agro-silvo-pastoral landscapes is solidly embedded in the strategic guidelines of ACS. The Society is firmly committed to keep working in this domain, further refine its technical practices, and disseminate the lessons learned from the FLR and the related fields of biodiversity conservation, climate change adaptation, rural development and poverty alleviation throughout Lebanon and at the global level.

A. Forest and Landscape Restoration – The Context

A.1. The Need to Restore Degraded Forests and Landscapes

A.1.1. Land Degradation Worldwide

Over the last several centuries, about 30 percent of global forest cover has been completely cleared and a further 20 percent has been degraded[1] due to the growth of human populations and the consequent conversion of forestland into agriculture, pastures, mines and urban areas. In the case of the Middle East region, deforestation started thousands of years ago and continued until the last century. The Lebanese forests were already greatly reduced and fragmented in the seventeenth century, and continued unregulated cutting of cedars for construction, furniture and fuel took place during the Ottoman rule of the country until the end of the First World War in the 20th century[2] . The area covered by cedar forests still declined throughout the 20th century as a result of housing developments, uncontrolled touristic developments and over-grazing. In 1965 the total area covered by cedar forest in Lebanon was 2,593 ha and by 1988 it was reduced to 2,323 ha, a loss of 270 ha (10.5%) in 23 years[3].

Despite the fact that deforestation has been reduced in the last decades, some 129 million hectares – an area equal to the size of France, Germany and Italy together – have been lost since 1990[4], mainly in Latin America, Sub-Saharan Africa, North Africa and West Asia. Between 1960 and 1998, forestland decreased 32.5% in Lebanon (mainly in the Beqaa region) and the area covered by wooded crops decreased significantly (e.g. about 31% reduction of olives, 72% reduction of fruit trees and 82% reduction of vineyards), with the consequent increase of barren and desertified land[5]. Since 2000 and until 2015, according to FAO (FRA 2015)[6], the total forest area of the country has increased about 6,300 ha covering a total area of 137,600 ha. On the contrary, other wooded land has decreased 11,000 ha since 2005, covering a total area of 106,000 ha in 2015.

Today, degradation is already impacting the well-being of at least 3.2 billion people, with about 20% of the vegetated land surface showing declining trends in productivity and costing more than 10% of the annual global gross product in loss of biodiversity and ecosystem services[7]. The main direct drivers of land degradation and associated biodiversity loss are expansion of crop and grazing lands into native vegetation, unsustainable agricultural and forestry practices, climate change, and, in specific areas, urban expansion, infrastructure development and extractive industry. Forest landscapes in Lebanon are mainly threatened the extractive industry (quarries), urbanization, improper management of forest and grazing resources, and an outdated legal framework matched with poor law enforcement.

Like in other Mediterranean countries, fires have been especially damaging to Lebanon's forests in recent years, representing one of the most important elements that destroy Lebanon's natural resources.

There is a positive feedback between land degradation and climate change. Land degradation is a major contributor to climate change, while climate change can exacerbate the impacts of land degradation and reduce the viability of some options for avoiding, reducing and reversing land degradation. For instance, between 2000 and 2009, land degradation was responsible for annual global emissions of approximately 3.6–4.4 billion tonnes of CO_2 due to deforestation and forest degradation, forest fires, and the decline of carbon content in many cultivated soils and rangelands under maladaptive management practices[8]. In Lebanon, a net decrease of 12% in CO_2 removals from the forests was recorded between 1994 and 2012, mainly due to the conversion of vegetated lands into settlements and forest fires. By 2050, with a projected global warming of at least 1.5 °C, the combined effect of human-induced land degradation and climate change could reduce crop yields by 10 per cent globally and by up to 50 per cent in certain regions, and significantly increase the likelihood of wildfires, pest and disease outbreaks in scenarios where droughts and heat waves are projected to be more frequent[9].

The Mediterranean region is one of the areas in the world where a greater impact of climate change is foreseen. In the region, average annual temperatures are now 1.4 °C higher than during the pre-industrial area, well above (0.4 °C more) than the global warming average. Being part of the region, climate change is expected to have major implications for Lebanon's environment, economy, and social structure. According to the Third National Communication (TNC) of Lebanon to the United Nations Convention on Climate Change (UNFCCC)[10], it is projected a temperature increase between 1.2°C and 1.7°C by mid-century and up to 3.2°C by 2100, and a decrease in precipitation of 4 to 11% with drier conditions by the end of the century, compared to the baseline period of 1986-2005. Higher temperatures, together with less water availability and an extended dry summer season, will result in a hotter and drier climate.

[1]Minnemeyer, S. et al (2010) A world of opportunity for forest and landscape restoration. WRI.
[2]Khuri, S. et al (2000). Conservation of the Cedrus libani populations in Lebanon: history, current status and experimental application of somatic embryogenesis. Biodiversity and Conservation N° 9.
[3]Khouzami M (1994) The Lebanese cedar forests. In: Proceedings of the First National Conference on the Cedar of Lebanon, Present and Future. American University of Beirut, Lebanon.
[4]Food and Agriculture Organization of the United Nations, 2016. Global Forest Resources Assessment 2015. How are the world's forests changing?
[5]Masri, T. et all (2002) Land cover change over the last 40 years in Lebanon. Lebanese Science Journal, Vol. 3, N° 2.
[6]Global Forest Resources Assessment 2015 (http://www.fao.org/forest-resources-assessment/past-assessments/fra-2015/en/)
[7]IPBES (2018): Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. R. Scholes, R. et al (eds.). IPBES secretariat, Bonn, Germany. 44 pages.
[8]Ibid.

The extreme weather events will also intensify, with more frequent, intense and extended drought periods and heat waves. We can highlight the following on-going and projected impacts for Lebanon and the Mediterranean region as a whole[11]:

Climate feature	Lebanon	Mediterranean region
	40% reduction of snow cover with an increase of 2°C. Snow residence time reduction from 110 days to 45 days. Shift of snow fall from 1,500 m altitude to 1,900 by 2090.	Many mountain regions are experiencing reduced snow cover, and loss of glacier mass in the Alps, Pyrenees, Turkish and Balkan mountains since 1980s, with dramatic downstream effects as melt water contributes up to 60–70 % to annual river flows.
	Earlier snow melt with reduced water availability in the soil, rivers and springs during summer.	90 mm reduction in annual precipitation and 20 mm reduction in summer precipitation in some parts of the Mediterranean region.
	Drought periods 9 days longer by 2040 and 18 days longer by 2090. The dry summer season will extend in length.	Droughts are projected to increase in frequency, duration and severity: 7% more drought period with a 1.5 °C of global warming, and 11% more drought period with a 2 °C.
	Soil moisture reduction.	Soil moisture has significantly decreased since 1950, and summer soil moisture content is projected to significantly decrease for the coming decades.
	43 additional days with maximum daily temperature higher than 35°C.	Number of warm days almost doubled since 1960. Very extreme heat waves every two years are projected in the 2nd half of 21st century.
	Higher risk of forest fires.	Annually burned area by forest fires is expected to increase by a factor of 3 to 5 by 2100.
	40% reduction of maize production by 2040 and 64% by 2080. 16% reduction of wheat production by 2040 and 30% reduction by 2080.	25% reduction of crop yields by 2080 under a 5.4 °C warming, with an estimated loss of 1% gross domestic product (GDP).

[9]Ibid.
[10]MoE/UNDP/GEF (2016). Lebanon's third national communication to the UNFCCC. Beirut, Lebanon.
[11]European Environment Agency (2017) Climate change, impacts and vulnerability in Europe 2016. An indicator-based report.
[12]Info extracted from: MoE/UNDP/GEF (2016). Lebanon's third national communication to the UNFCCC. Beirut, Lebanon.
[13]Info extracted from: (i) Kovats, R.S., et al. (2014) Europe. In: Barros, V.R. et al (eds.) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1267-1326.; (ii) European Environment Agency (2017) Climate change, impacts and vulnerability in Europe 2016. An indicator-based report. EEA Report N°1/2017.

A.1.2. The Global Benefits of Restoration

The restoration of healthy conditions, functions and services provided by the ecological systems – including forests, scrubland, pastures, freshwater systems, and agriculture systems – is recognized by the international community as a key element to meet the 2030 Agenda for Sustainable Development, and the global commitments under the three Rio Conventions on Biodiversity Conservation (Aichi Target 15), Climate Change and Combat Desertification (Land Degradation Neutrality Goal).

The Intergovernmental Science-Policy Platform and Ecosystem Services (IPBES), which provides scientifically credible and independent assessments to better inform decision makers – governments, private sector and civil society - highlighted among the most cost-effective climate change mitigation options the restoration and sustainable management of forests, and the restoration of organic soils in sustainably managed agriculture and pasture lands[14]. IPBES estimates that Restoration actions to avoid, reduce and reverse land degradation can provide more than one third of the most cost-effective climate mitigation needed to keep global warming under 2°C by 2030.

World leaders recognized the need to intensify restoration efforts and launched in 2011 the Bonn Challenge, a global effort to bring 150 million hectares of deforested and degraded landscapes into restoration by 2020, including eliminating deforestation due to land conversion into agriculture and pastures, and strengthening forest governance[15]. In 2014, leaders meeting in New York called for the restoration of an additional 200 million hectares by 2030, a target incorporated into the Bonn Challenge. Underlying the Bonn Challenge is the forest and landscape restoration approach (FLR), which aims to restore ecological integrity at the same time as improving human well-being through multifunctional landscapes.

The restoration of 350 million hectare will generate about USD170 billion per year in net benefits from watershed protection, improved crop yields and forest products, and could sequester up to 1.7 gigatons of carbon dioxide equivalent annually[16]. About 90 per cent of this value is potentially tradable, meaning that it encompasses market-related benefits and direct additional income opportunities for rural communities.

The Economics of Ecosystems and Biodiversity (TEEB) global initiative estimated in 2009[17] the costs and benefits of restoration projects in different ecosystem types. As we can see in the table below, the value for restoration projects can be tremendous. However, the restoration costs are also quite high, hence it is much better to conserve and sustainably manage these ecosystems rather than letting them degrade. To have the best chance of success, such restoration projects should be implemented using a landscape-related holistic approach to ensure long-term pay-offs.

Estimated costs and benefits of restoration projects in different biomes[18]

Biome/ Ecosystem	Typical cost of restoration (USD/ha)	Estimated annual benefits from restoration (USD/ha)	Net present value of benefits over 40 years (USD/ha)	Internal rate of return (%)	Benefit/cost ratio
Lakes/Rivers	4,000	3,800	69,700	27	15.5
Tropical forests	3,450	7,000	148,700	50	37.3
Other forests	2,390	1,620	26,300	20	10.3
Woodlands/ Scrublands	990	1,571	32,180	42	28.4
Grasslands	260	1,010	22,600	79	75.1

[14]IPBES (2018): Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. R. Scholes, R. et al (eds.). IPBES secretariat, Bonn, Germany. 44 pages.
[15]http://www.bonnchallenge.org/content/challenge
[16]Ibid.
[17]TEEB (2009) TEEB Climate Issues Update. September 2009
[18]Modified version from TEEB 2009.

A.1.3. Restoration under the Lebanese Commitments to the Rio Conventions

Forest restoration is also considered by the Lebanese government as a critical action to respond to the national commitments on biodiversity conservation, climate change and combat desertification. During the past decade, Lebanon has initiated a number of programs/initiatives to restore forested lands: (i) the development of the National Reforestation Plan (NRP) by the MoE in 2001; (ii) the development of the National Action Plan to Combat Desertification by the MoA in 2003, (iii) the development of the project "Safeguarding and Restoring Lebanon's Woodland Resources" to complement what has been started under the NRP in 2009, (iv) the launching of the Lebanese Reforestation Initiative (LRI) in 2012 with the support of the International Program of the US Forest Service, (v) the launching of the 40 million forest trees by the MoA in 2012; and (vi) the implementation of forest restoration initiatives by the civil society, with the financial and technical support of international organizations such as IUCN, WWF, FAO, UNDP, EU-ENPI Programme and The GEF.

The National Afforestation and Reforestation Programme in Lebanon: The 40 Million Trees Initiative

This governmental initiative, launched by the Ministry of Agriculture in partnership with the FAO in 2012, aims at increasing forests from 13% of Lebanon's total area (currently) to 20% over a period of 20 years. By increasing the green cover, this program aims at both increasing the resilience of forests to the impacts of climate change and reducing national GHG emissions by creating additional carbon sinks. The program maintains two integrated phases:

1- Elaboration of a master plan for reforestation in Lebanon able to respond to the local needs through the development of scientific based tools for identifying the proper site selection, the assessment of the field conditions, the selection of suitable native species, the elaboration on the suitable planting techniques, the development of adapted maintenance, follow up and evaluation practices for the successful implementation of any reforestation activities. All of these are based on the expected function attributed to the Lebanese forests.
2- Implementation of the master plan for reforestation in Lebanon at the national level in partnership with the national stakeholders of public and private sector from ministries, NGOs, private banks, private investors, local community members etc. This approach is expected to merge all efforts of stakeholders towards contributing to the utmost goal of planting 40 million forest trees in 70,000 hectares of public land in the coming 20 years.

The national afforestation and reforestation programme (The 40 million forest trees initiative), the Intended Nationally Determined Contribution (INDC) under the UNFCCC, and the national biodiversity strategy and action plan have set the stage for improving resilience of forest resources and biodiversity. The aim is to increase forests from 13% of Lebanon's total area to 20% over a period of 20 years, and to develop and implement adaptation plans to reduce the vulnerability of natural and agriculture ecosystems' and the rural society to climate change.

Potential adaptation and mitigation options to increase climate resilience in forest landscapes that are mentioned in the governmental commitments to the three Rio conventions, include:

- Protection measures: protecting natural ecosystems and traditional agriculture systems from irrational uses, pollution and land conversion, to help maintain the existing carbon reservoirs, the ecosystem services, and the biological diversity linked to the genetic reservoirs, the species and habitats that characterize the forests, pastures and agriculture systems.
- Management measures: developing and adopting sustainable management guidelines in forestry, agriculture production and livestock grazing to improve the capacity of the ecosystems to increase their ecosystem services (e.g. water regulation and soil water storage; increase of soil nutrients; capture carbon in soil and plants; facilitate pollination and pest control; increase the provision of non-timber forest products), reduce water stress and prevent the excessive accumulation of dry biomass, with the consequent prevention of major risks such as fires, forest dieback, carbon emissions, and soil erosion.

- Restoration measures: Restoring forestland and the production capacity of degraded agriculture lands, with positive benefits in terms of increasing the ecosystem services (e.g. carbon sequestration; diversification of species and habitats; soil conservation; water regulation; the provision of agriculture, wood and non-timber products; the facilitation of flora and fauna species to respond to climate change impacts).

A.2. What is Forest and Landscape Restoration

A.2.1. The Concept of Forest and Landscape Restoration

Forest and Landscape Restoration (FLR) is defined as a planned process to restore ecological integrity and enhance human well-being in degraded forest landscapes so that their ecological and social resilience is strengthened and their ecosystem services are enhanced to support the societal needs.

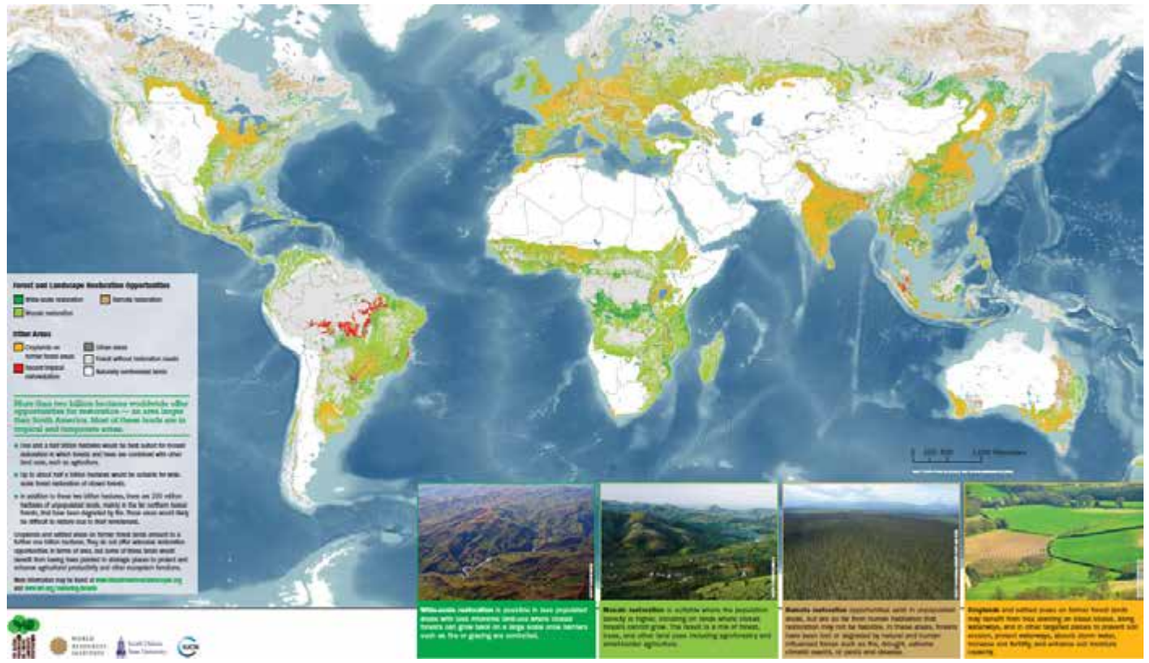
Deforested land and degraded forests can be brought back to a healthy state by means of forest and landscape restoration, regaining their ecological functions and enhancing human well-being.

An assessment by the Global Partnership on Forest and Landscape Restoration (GPFLR) identified approximately 2 billion hectares of the world's deforested and degraded forest lands where opportunities for restoration may be found – an area larger than South America. This represents a vast opportunity to reduce poverty, improve food security, mitigate climate change impact, and conserve biodiversity.
Deforested and degraded forest lands were divided into four categories, resulting in a map of restoration opportunity areas and other former forest lands (with resolution of 1 km2):

- Wide-scale restoration – Less than 10 people/km2 with less intensive land-use where closed forests can grow back on a large scale, once barriers such as fire or grazing are controlled.
- Mosaic restoration – Moderate human pressure (between 10 and 100 people/km2) and potential to restore a mix of forest, trees, and other land uses including agroforestry and small-holder agriculture.
- Remote restoration – Very low human pressure (density of less than one person/km2 within a 500km radius) but too far from human habitation, which can make it impossible to do restoration.
- Croplands and pastures on former forest areas – Areas with intensive human pressure (over 100 people/km2) and heavily modified landscape, that may benefit from soft restoration interventions in targeted places to prevent soil erosion, protect waterways, absorb storm water, increase soil fertility, and enhance soil moisture capacity.

[19]https://infoflr.org/what-flr (IUCN).
[20]Minnemeyer, S. et al. (2011) A World of Opportunity: Bonn Challenge on forest, climate change and biodiversity 2011. The Global Partnership on Forest Landscape Restoration (More information may be found at www.ideastransformlandscapes.org and www.wri.org/restoring-forests
[21]Figure from Minnemeyer, S. et al. (2011)

Worldwide Forest and Landscape Restoration Opportunities



Most deforested and degraded land – one and a half billion hectares - offers opportunities for "mosaic restoration". Most degraded areas in the Mediterranean region are suitable for "mosaic restoration", mainly in mountain areas. This may consist in a combination of active and passive restoration interventions to regain a diverse landscape pattern with a mix of land uses including forests and open wooded areas, agroforestry systems, pastureland, and small-holder agriculture land, such as agriculture terraces in mountain slopes.

Maintaining and restoring Mediterranean mosaic-like landscapes with a high diversity of land uses, habitat types, and wild and cultivated species and varieties, is also critical to increase resilience against climate change. In general terms, higher diversity implies a wider range of opportunities and options to cope with environmental, social and economic change:

- Natural habitats and agricultural systems with a greater diversity of species and varieties, are more resilient against climate variability and change because each species and variety has a different genetic pool that gives them different attributes in relation to different temperature and humidity conditions. For instance, planting different species and varieties of the same species at the farmland and landscape levels reduces the risk of

losing the entire crop if an exceptional climatic event occurs (it may affect less well-adapted species variety but be overcome by those with adaptive characters) and increases opportunities for economic diversification and the lengthening of the production period (earlier and later varieties).

• Species-rich habitats and culture-rich societies can perform many different functions that result in higher number of adaptation options to cope with climate changes and risks. For instance, forest habitats with species with different life forms (e.g. species that re-sprout after fire, browsing and cutting; nitrogen-fixing species; species attracting seed-dispersal fauna; pioneer species rapidly colonizing forest gaps) are more resilient to climate risks, such as wildfires.

• Mosaic landscapes with high diversity of habitats and land uses are more resilient to climate risks, while offering a wider range of economic opportunities to rural societies habitat types, land use options and ecosystem services with.
A variety of passive or active forest management and restoration techniques have been successfully used to stop and reverse land degradation and conserve biodiversity, while yielding multiple economic, social and environmental benefits. A considerable amount of information on forest landscape restoration is available to practitioners, through global networks set up by national and international institutions in the past decades, which capture the approaches, methodologies, and best practices developed and successfully applied in many regions. The following is a non-comprehensive list of well-known and reputed networks:

The Global Partnership on Forest and Landscape Restoration (GPFLR)
(http://www.forestlandscaperestoration.org)
The Forest and Landscape Restoration Mechanism
(http://www.fao.org/in-action/forest-landscape-restoration-mechanism/en/)
Global Guidelines for the restoration of degraded forests and landscapes in drylands (http://www.fao.org/dryland-forestry/dryland-restoration-initiative/en/)
Restoration of Natural Capital Alliance (RNC)
(http://www.rncalliance.org)
The Ecosystem Services Partnership (ESP)
(https://www.es-partnership.org/)

While drawing from existing knowledge, FLR projects should make sure that their own experience and achievements are fed into existing reservoirs of know-how for the benefit of future practitioners. In this sense, the FLR initiative in the SBR Landscape followed the FLR planning methodology proposed by the Global Guidelines for the Restoration of Degraded Forests and Landscapes in Drylands, is part of the FAO Forest and Landscape Restoration Mechanism, and builds on innovative science and technologies developed and successfully tested in Mediterranean-wide regional projects.

A.2.2. FLR Guiding Principles

I. FOCUSES ON THE ENTIRE LANDSCAPE

It entails balancing a mosaic of interdependent sustainable land uses and management practices, and ensures the maintenance of functional ecosystems and viable species populations over a large territory - in this case the 50,000 ha of the Shouf Biosphere Reserve mountain range.

II. ADDRESSES THE ROOT-CAUSES OF LANDSCAPE DEGRADATION

Effective restoration interventions in the long-term require a good understanding of the anthropogenic and climate change drivers of degradation and the implementation of reduction measures.

III. ENGAGES ALL CONCERNED ACTORS AND SUPPORTS PARTICIPATORY GOVERNANCE

FLR actively engages stakeholders at different scales, including vulnerable groups, in planning, decisión making, and direct involvement in the implementation, monitoring and benefit sharing from restoration actions.

IV. RESTORES MULTIPLE FUNCTIONS FOR MULTIPLE BENEFITS

FLR interventions aim to restore multiple ecological, social and economic functions across the landscape, generate a range of ecosystem goods and services that benefit multiple stakeholder groups, and help conciliate the different actors' interests, including biodiversity conservation needs.

V. INVESTS IN 360 DEGREE CAPACITY BUILDING AND KNOWLEDGE GENERATION

FLR supports knowledge generation incorporating scientific innovation and local know-how to adapt restoration to the local context, and continuous training for transferring cutting edge FLR knowledge to national and local learning platforms.

VI. CONSIDERS A WIDE RANGE OF IMPLEMENTATION OPTIONS WITH A COST-BENEFIT VIEW

FLR uses a variety of approaches that are adapted to the local social, cultural, economic and ecological context, and ensure short- to mid-term economic benefits: (i) policy improvement; (ii) protection, measures; (iii) sustainable management of natural resources; and (iv) active restoration interventions.

VII. MAINTAINS AND ENHANCES NATURAL ECOSYSTEMS WITHIN THE LANDSCAPE

FLR enhances the conservation, recovery, and sustainable management of natural ecosystems and traditional management practices that are linked to the cultural identity of the landscape, following the "ecological restoration principles" - an intentional activity that initiates or accelerates the recovery of ecosystems with respect to their functions, structure, species composition and resilience to environmental risks.

VIII. MANAGES ADAPTIVELY FOR LONG-TERM RESILIENCE

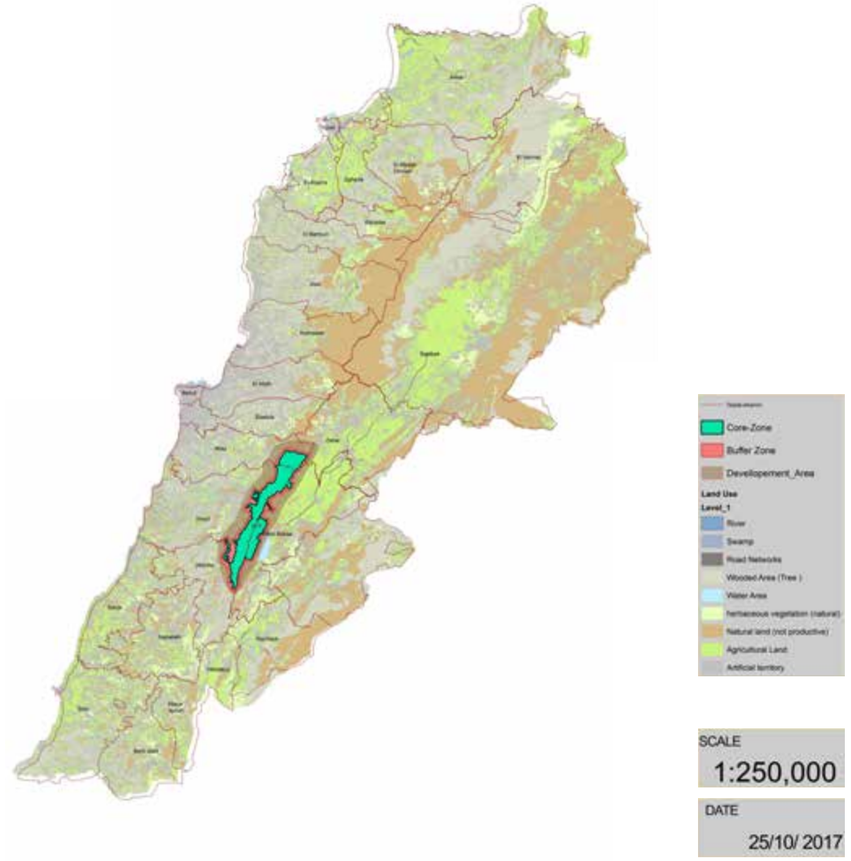
FLR seeks to enhance the resilience of the landscape and its stakeholders over the long-term. Restoration approaches should be adjusted over, being flexible and responsive to social, economic and environmental changes time. As restoration progresses, information from monitoring activities, should be integrated into management plans and transferred into learning process.

B. FLR in the Shouf Biosphere Reserve Landscape

FLR Principle I: Focuses on the Entire Landscape

I.1. The Shouf Biosphere Reserve Landscape

The Shouf Biosphere Reserve (SBR) is a mountainous landscape that lies between longitude 35° 28' – 35° 47' East, and Latitude 33° 32' – 35° 48' North and extends along an altitudinal gradient ranging from about 1100 to 1900 meters in the southern extension of Mount Lebanon range. The landscape extends along a north-south axis, with the western slopes facing the Mediterranean sea in the Shouf district and the eastern slopes facing the Anti-Lebanon range and connect with the Beqaa valley in the district of West Beqaa. The northern border is defined by the Beirut-Damascus highway, while the southern border is defined by the municipality of Jezzine in the south-western side, and Lake Qaraoun in the south-eastern side of West Beqaa.



Bioclimatic zones in the Shouf Biosphere Reserve Landscape

The SBR landscape is a large mosaic-like mountainous territory of 550 km2 characterized by a gradient of ecological, geomorphological and climatic features supporting a wide range of habitats, species and rural populations which have interacted throughout millennia. Traditional cultural practices linked to agricultural, pastoral and forestry systems helped shape this mosaic-like landscape, as a result of the efforts made by rural communities to adapt to its environmental constraints and make an efficient use of its natural resources.

More than anywhere else, large territorial units or landscapes are required to maintain the functionality and sustainability of the Mediterranean agro-silvo-pastoral systems both in ecological and socio-economic terms. The SBR landscape is a good example of this:

- The SBR herders and livestock need to undertake upland-lowland transhumant movements in time and space to fulfil their nutritional needs, based on the seasonal abundance or scarcity of fodder and water in the upper and lower parts of the mountain landscape. Through these movements herders and livestock have influenced the structure, composition, distribution and dynamics of natural habitats in this large territory and contributed to the creation of a very unique landscape.
- The high mountain cedar and oak forests in the SBR landscape play an important role in regulating the flow of water and soil nutrients along the altitudinal gradient which represent key ecosystem services for agriculture development at lower altitudes. The terraced landscape of the low mountain areas also contributes to soil water infiltration and underground water recharge - with a positive effect on other land uses and human needs.

I.1.1. Physical Environment

Climate: The SBR landscape is characterize by a bio-climatic gradient from the Supra-Mediterranean type at the lower altitudes, characterized by fresh to cold temperatures and sub-humid conditions (annual rainfall between 600 and 1,300 mm), to the Oro-Mediterranean type at higher altitudes, characterized by sub-humid to humid conditions (annual rainfall between 1,000 and 1,600 mm) and cold to very cold temperatures. In the eastern slopes of West Beqaa there are drier condition with annual rainfall lower than 600mm.

The average annual precipitation of 1,000 mm, with significant inter-annual differences (from 593 mm up to 1,555 mm in the period 2010-2015). Rainfall mainly occurs in winter with an average precipitation of 422 mm, about half of it in the form of snow (225-250 mm is the average annual snow coverage over a period of 3 months). Rainfall is also abundant in late autumn (about 100 mm/month) and early spring (about 80 mm/month).

The maximum rainfall recorded in 24 hours is 156-214 mm. The drought period extends over 4 to 6 months (between May and September/October) with no precipitation in July and August, insignificant quantities of less than 10 mm in June and September, and limited amount (between 30 mm and 40 mm) in May and October.

Cedar tree crown snow load

Fog is common in the western side of the SBR

Average annual temperature is 13.6°C, with the highest average monthly temperature during July and August (between 21-22°C) and the lowest average monthly temperature lower than 7°C between December and February. Climate change has become evident in recent years, with an increase of 0.7 °C of the average annual temperature, and a longer summer drought period extending towards the end of October or beginning of November. Lower annual rainfall, higher temperature and a longer drought period have already become a major challenge for the survival of the planted seeds and seedlings in the forest restoration interventions, and need to be considered into the planning and implementation of future restoration works.

Geomorphology: The SBR landscape is mainly formed by dolomite and limestone rocks from the Jurassic and Cretaceous geologic periods. The main mountain massif above the surrounding towns up to the mountain summit is formed by an extremely thick Jurassic limestone layer with very superficial soils with a little or no organic horizon and abundant

presence of large to small fragments of rocks in depth and in the soil surface. Only in the few old-growth forest stands soils are deeper and rich in organic matter. Numerous rocky outcrops in the convex shoulders of the slopes alternate with concave zones that have deeper soils and are the areas where the runoff water is concentrated. In the summit of the mountain range the landscape takes the shape of an egg box, with a series of small depressions or dolines where moisture is concentrated and soil is clayed and deeper.
At a lower altitude, mainly in the western slopes of the Shouf district, the landscape is formed by an alternation of different types of rocks from the Cretaceous period, including: (i) different types of sandstone - ferruginous reddish brown to white sandstone - with intercalations of clays, marls, lignite beds, and localized basalt flows and ash deposits; (ii) sand; (iii) different types of limestone rocks, sometimes interbedded with grey and blue marls and clay. The sandstone substrates are the most distinctive ones, often covered by stone pine (Pinus pinea) forest stands, a tree species that is well adapted to acid, loose sandy soils throughout the Mediterranean Region. Soils are deeper, mainly due to the human-made terraced system, and have fewer large fragments of deep rocks. The sandstone and sandy substrates are very friable with soils prone to erosion and occasional landslides under normal climatic conditions. This is especially evident in areas where quarries have been opened and abandoned, where there are obvious signs of erosion. This problem will become more serious with increased temperatures and heavier concentrated precipitations as a result of climate change.

Old cedar tree in between limestone outcrops

Stone pines growing on sandstone substrate

Awali river, a perennial river flowing in Southern Lebanon, originating from the Barouk mountain at a height of 1,492 metres and the Niha mountain.

Ammiq wetland in the West Beqaa side

Hydrology: The SBR is mainly composed of karstic limestone aquifers feeding over 200 springs in the area that supply water needs in 21 villages and towns. They also feed several perennial rivers: Beirut, Damour and Awali rivers in the western sea-side, and the Litani river in the eastern Beqaa-side. The summit of the range is considered as a divide between the western and eastern hydrological systems. Some of the springs are tapped and some flow freely and supply the downstream ecosystems, the agriculture fields nearby rivers and water sources, and domestic use. It is also the main source of water for the Ammiq Swamp in the Beqaa Valley and Quorum dam. This swamp is of high ecological importance as it is listed on the Ramsar list.

I.1.2. Natural environment

Vegetation: The SBR has a high diversity of vegetation types due to the altitudinal gradient, continentality gradient, lithological variability, and the historical interactions between people and nature.

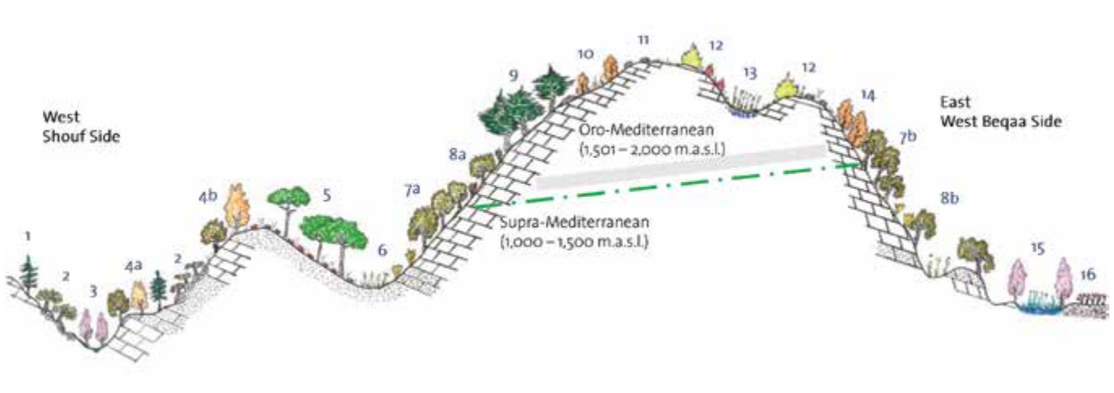
Along the altitudinal gradient of the SBR mountainous landscape a series of bioclimatic zones follow one another, mainly defined by the temperature changes from the warmest basal zone to the coldest zone at the mountain summit. The bio-climatic zones[22] are delimited according to the temperatures, the rainfall and the distribution of both climatic features throughout the year. Each bioclimatic zone corresponds to a series of plant communities.

Supra-Mediterranean bio-climatic zone: This zone corresponds to the development area where rural settlements and agriculture activities occur. It is extended along an altitudinal range between 1000 and 1500 m that has more favourable climate conditions for human activities and a diversity of lithologies and soils that favour agricultural development.

The vegetation that characterizes the later successional stages consist of forest habitats in which the dominant tree species are the evergreen oak *Quercus calliprinos*, the deciduous oak *Quercus infectoria*, the Stone pine *Pinus pinea* and the Calabrian pine *Pinus brutia*. The forest canopy can be dominated by one or several species as a function of edaphic factors and the response to disturbances and anthropic uses. Acid, friable and deeper soils in sandstone and sand substrates are mainly occupied by *Pinus pinea* and *Quercus infectoria* forests, mainly in the western side of the mountain, becoming predominant in the northern part of the landscape in Ain Zhalta and Barouk municipalities. Basic, more compact and superficial soils mainly occur in the limestone substrates throughout the landscape, being occupied by *Quercus calliprinos* and *Q. infectoria* forests, and at lower altitudes in the south-western part of the landscape by forests dominated by Brutia pine forests or mixed oak-pine forests. Brutia pine and *Quercus infectoria* often form secondary forests as a result of the colonization of abandoned agriculture terraces.

[22]The publication follows the classification of Rivas-Martínez, S. (1983) Pisos Bioclimáticos de España. Lazaroa 5: 33-43.

Bioclimatic zones in the Shouf Biosphere Reserve Landscape



Supra-Mediterranean Bioclimatic Zone

1 - Brutia pine (Pinus brutia) forest
2 – Oilve & fruit tree plantation in agricultural terraces
3 - Riparian forest (Alnus orientalis, Platanus orientalis, Populus alba, Salix spp)
4a – Mixed forest (Quercus calliprinos, Q. Infectoria, P. Brutia)
4b – Mixed oak forest (Quercus calliprinos & Q. Infectoria)
5 – Stone pine (Pinus pinea) forest
6 – Low mountain pastures and shrubland (Sarcopoterium spinosum & Calycotome villosa)
7a – Dense oak (Quercus calliprinos) forest in the more humid Shouf side
7b – Dense oak (Quercus calliprinos) forest in the more dry and continental Beqaa side
8b – Open oak (Quercus calliprinos) forest in the more dry and continental Beqaa side
15 – Ammiq wetland with Fraxinus syriaca and Ulmus minor forest
16 – Vineyards in the flatland area of Beqaa valley

Oro-Mediterranean Bioclimatic Zone

8a – Open oak (Quercus calliprinos Woodland and high mountain shrubland (Spartium junceum, Styrax officinalis, Colutea cilicica)
9– Cedar (Cedrus libani) forest
10 – Open oak (Quercus brantii subsp. look) forest and copses of Rosaceae tree species (Sorbus torminalis, S flavellifolia, Pyrus syriaca, Prunus ursina, Crataegus azarolus)
11 – Mountain Summit throny cushion shrubland (Astragalus spp., Onobrychis cornuta, Acantholimon ulicinum, Berberis libanotica, Prunus prostrata)
12 – High mountain juniper Woodland (Juniperus excelsa)
13 – Doline depression humid pastureland (Hordeum bulbosum, Blysmus compressus, Alepecurus arundinaceus)
14 – Dense oak (Quercus brantii subsp. look) forest and Quercus Calliprinos 7b – Dense oak (Quercus calliprinos) forest in the more dry and continental Beqaa side

Companion species change according to the type of substrate. In the forests occurring in limestone substrates companion species include fruit trees of small size, such as the wild pear *(Pyrus syriaca)*, the wild plum *(Prunus ursina)*, the azerole *(Crataegus azarolus)*, the wild pistachio *(Pistacia palaestina)*, the Syrian maple *(Acer obtusifolium),* and the oriental strawberry tree *(Arbutus andrachne)*; climbing shrubs such as *Clematis vitalba, Lonicera etrusca, Tamus communis, Smilax aspera*; shrubs such as *Rhamnus punctata*, the wild rose *(Rosa canina)*, the Spanish broom *(Spartium junceum)*; aromatic plants such as *Origanum syriacum, Stachys distans and Teucrium divaricatum*; grass species such as *Dactylis glomerata, Brachypodium pinnatum, and Melica angustifolia*.

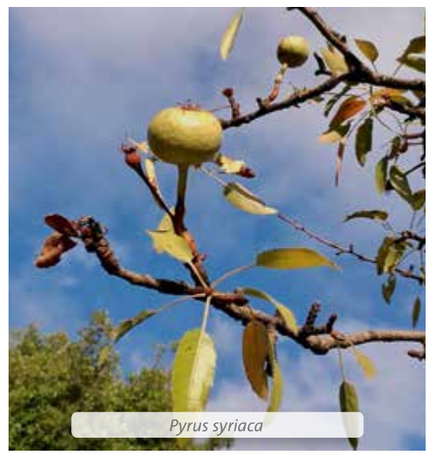

Acer obtusifolium


Prunus ursina


Arbutus andrachne


Pistacia palaestina

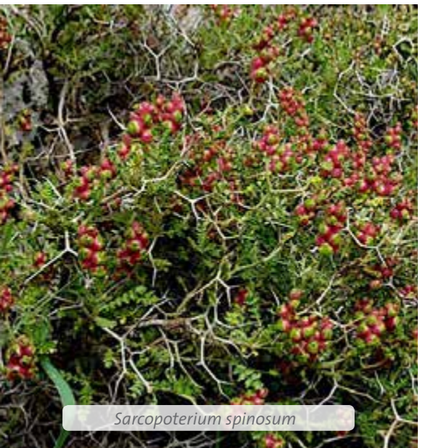

Crataegus monogyna

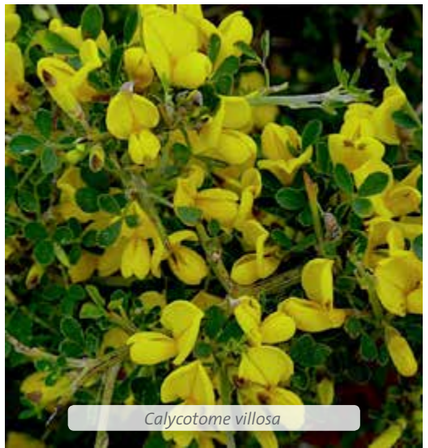

Pyrus syriaca

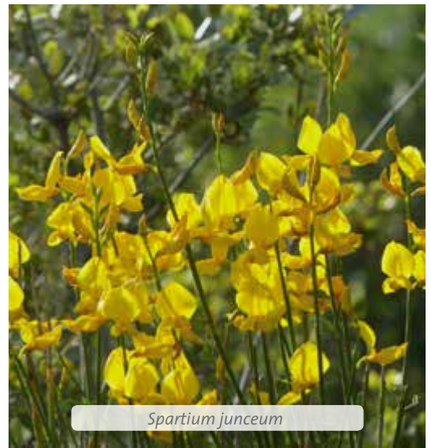

Quercus calliprinos


Pinus brutia


Quercus infectoria


Sarcopoterium spinosum


Calycotome villosa


Spartium junceum


Pinus pinea forest in degraded sandstone slopes near Ain Zhalta, with Rhododendron ponticum


Quercus infectoria and Q. calliprinos mixed forests near Maasser, in the Shouf side of the SBRL


Pinus brutia secondary forest near Kreibe, with Quercus calliprinos and Pistacia palaestina


Quercus calliprimos forest near Aitanit in the Beqaa side of the SBRL

In the forests occurring in sandstone substrates, companion species include calcifuge plants such as the pink rockrose (*Cistus creticus*), the white rockrose (*Cistus salvifolius*), *Halimium umbellatum, Origanum ehrenbergii,* and the lavender (*Lavandula stoechas*); Prickly juniper (*Juniperus oxycedrus*) although indifferent to substrate composition, becomes abundant in stone pine forests under sandstone.

Calcicole-Calcifuge plant species

Calcareous soils are characterized by the presence of calcium carbonate ($CaCO_3$) in the parental material (limestone substrate), with high pH (7-8) due to the weak acidity of the carbonic acid. Acid soils are characterized by the presence of silica (SiO_2) in the parental material (sandstone substrate), with low pH (5-6.5). Plant species can be classified as calcicole and calcifuge depending on their tolerance or not to high carbonate content in the soil conditions respectively. It is not the presence in the soil of carbonate per se that calcifuge plants cannot tolerate, but the fact that high carbonate conditions makes iron (Fe) to become less soluble and therefore less absorbable by the roots of the plants. Consequently, calcifuge plants often develop iron deficiency symptoms in calcareous soils, a plant disorder also known as "lime-induce chlorosis"[23]. Calcicole plants can experience a variety of stresses in acid soils, such as nutrient deficiencies of calcium (Ca) and magnesium (Mg), and the toxic effect of high levels of aluminium[24] (Al) and manganese[25] (Mn) that become increasingly soluble as pH drops.

Plant species can be classified as[26]:

• Strict calcifuge species that only occur in siliceous or completely decarbonated soils, such as *Lavandula stoechas, Cistus creticus, and Cistus salvifolius* in the sandstone substrates where Stone pine forests naturally occur;
• Non-strict calcifuge species that clearly prefer siliceous soils, but tolerate calcareous soils, such as stone pine (*Pinus pinea*);
• Indifferent species with no clear preference for siliceous or calcareous soils, such *as Juniperus oxycedrus, Quercus calliprinos and Quercus infectoria*;
• Non-strict calcicole species that clearly prefer calcareous soils, but tolerate siliceous soils, such as *Spartium junceum* and *Rosmarinus officinalis*;
• Strict calcicole species that only occur in calcareous soils.


Cistus creticus, strict calcifuge species


Rosmarinus officinalis, non-strict calcicole species

Seral plant communities characterize forest areas that have suffered environmental disturbances (e.g. forest fires) or areas that were converted into agricultural and pastoral land that have been abandoned in the last decades and recolonized by the natural vegetation:

• Recently abandoned agriculture terraces in limestone substrates are colonized by species-rich communities of herbaceous plants, including several orchids (e.g. *Orchis anatolica, O. italica, O. galilaea, Neotinea tridentata, Anacamptis papilionaceae, A. morio subsp. syriaca*), legume species (e.g. *Trifolium stellatum, T. campestre, Ononis natrix, Medicago sativa, Ononis adenotricha*); aromatic plants such as *Helichrysum sanguineum, Origanum syriacum*; grass species, such as *Hordeum bulbosum, Avena barbata, Dactylis glomerata*; Edible herbs such as *Scorzonera cana and Eryngium glomeratum, and Gundelia tournefortii*; other species such as *Nigella ciliaris, Linum pubescens, Allium ampeloprasum, Allium descendens, Pallenis spinosa*.
• Mid-term abandoned agriculture/pasture land with grass species in limestone substrates is colonized by small thorny shrubs – *Sarcopoterium spinosum, Calycotome villosa, Rhamnus punctata*) that become dominant – specially *Sarcopoterium* - with a very high plant cover of 50-80%.
• Long abandoned agriculture/pasture land with thorny shrubs in limestone substrates are colonized by wild fruit trees and high shrubs (e.g. *Spartium junceum, Styrax officinalis, Juniperus oxycedrus*).
• Degraded stone pine forestland after fire and/or overuse of plant resources are colonized by seral shrub communities dominated by *Cistus* species.

The rivers in the western side of the landscape are characterized by oriental alder (*Alnus orientalis*), oriental plane tree (*Platanus orientalis*), the white poplar (*Populus alba*), and several willow species (*Salix libani, Salix alba*). Companion species are *Mentha aquatica, Eupatorium cannabium, Scrophularia umbrosa, Stachys hydrophila, Dryopteris pallida*, and under acid substrates the fern species *Osmunda regalis*. Ammiq wetland in the eastern side is characterized by the Syrian ash tree (Fraxinus angustifolia subsp. syriacus), elm (*Ulmus minor*) and the Lebanese willow (*Salix libani*), the companion species marco-herbs Phragmites australis and Thypha latifolia, and other freshwater plants such as *Iris pseudacorus, Nasturtium officinale, Alisma plantago-aquatica, Sparganium neglectum, Cyperus longus, Juncus inflexus*, among others.

[23]Symptoms include leaves turning yellow or brown in the margins between the veins which may remain green, while young leaves may appear to be bleached. Fruit would be of poor quality and quantity. (https://en.wikipedia.org/wiki/Iron_deficiency_(plant_disorder)).
[24] Aluminium is not a plant nutrient, and as such, is not actively taken up by the plants, but enters plant roots passively through osmosis. Aluminium inhibits root growth, interfering with many physiological processes including the uptake and transport of calcium and other essential nutrients, cell division, cell wall formation, and enzyme activity. (https://en.wikipedia.org/wiki/Soil_pH).
[25]Classic symptoms of Mn toxicity are crinkling or cupping of leaves. (https://en.wikipedia.org/wiki/Soil_pH).
[26]PDF: Lithologic data improve plant species distribution models based on coarse-grained ocurrence data. Available from: https://www.researchgate.net/publication/28266620_Lithologic_data_improve_plant_species_distribution_models_based_on_coarse-grained_ocurrence_data.

Alnus orientalis, dominant riparian tree in the Shouf side of SBRL

Rhododendron ponticum, relic species that grows in riverine zones in the Shouf side

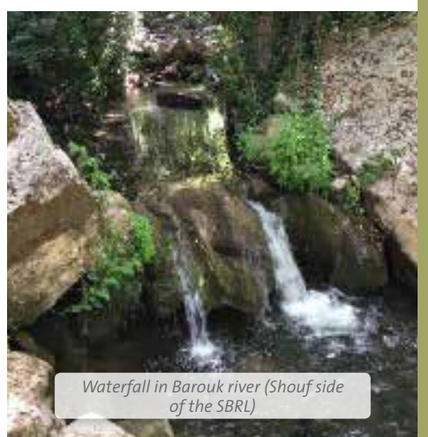
Fraxinus syriaca, common tree in Ammiq wetland

Ammiq wetland (West Beqaa valley)

Arum hygrophilum

Iris pseudacorus

Quorum dam in te Litany river (West Beqaa Valley)



Waterfall in Barouk river (Shouf side of the SBRL)

Oro-Mediterranean bio-climatic zone: This zone extends along an altitudinal range between 1500 and 1900 m, almost up to the mountain summit. It is characterized by a compact limestone substrate from the Jurassic period, which forms a montane axis with very steep slopes and poorly developed soils. There are no human settlements in this area with a very extreme climate and in some places, as in the municipality of Mrusti, there are vestiges of abandoned terraces. The main human activities in the past have been summer grazing, collection of wood and the harvesting of useful wild plants. Currently this is the area of the SBR under strict protection where most human activities are banned (e.g. grazing, wood collection).

The vegetation of the later successional stages is characterized by forest habitats in which the dominant tree species are the cedar tree (*Cedrus libani*) only in the western sea-facing slopes, and by the high mountain oak species *Quercus brantii* on both mountain sides. In the lower parts of this bio-climatic zone, *Quercus calliprinos* can be abundant. The forest canopy is usually dominated by one species, although mixed forest stands are also found with an upper tree layer dominated by cedar trees and a lower tree layer dominated by oaks and scattered fruit trees (*Sorbus flabellifolia, Sorbus torminalis, Malus trilobata*) and *Acer hyrcanum sbsp. tauricolum*.

History of Cedar Forests in Lebanon

Cedrus species have fossil records from the Oligocene (33.7-23.8 M[27] years) of western Kazakhstan, the Miocene (23.8-5.3 M years) of southwestern Europe, the Pliocene (5.3-1.8 M years) from southeastern Europe, and the early Pleistocene (1.8-0.01 M years) in the Ahhagar Massif in the central Sahara. Currently, only three cedar species exist: Cedrus deodara in the Himalaya, *C. libani* in the Middle East, and *C. atlantica* in the Atlas mountains of Morocco and Algeria. The highly disjunct distribution of apparently very closely related Cedrus species could come from contraction and isolation of a

formerly more extensive range of possibly one or two species, during Tertiary mountain uplifts, a geologic period lasting from approximately 66 million to 2.6 million years ago. *Cedrus deodara* constitutes a separate gene pool from the Mediterranean cedars. Although *Cedrus atlantica* and *Cedrus libani* are clearly independent species, natural hybrids between both species are fertile, indicating that they are not separate species from a reproductive point of view. *Cedrus libani* is composed of highly differentiated population groups, including *C. libani* variety brevifolia from Cyprus, possibly as a result of fragmentation.

Cedrus libani A. Rich. is a tree species distributed in Turkey, Cyprus, Syria and Lebanon. The species dominates the forest canopy of monospecific or mixed forests, which have a total extension of about 1,025 km2. The species is considered as Vulnerable in the IUCN Red List of Threatened Species. Cedar forests are severely fragmented, particularly the relic Black Sea subpopulation in Turkey, and the Syrian and Lebanese subpopulations. As a result of centuries of over-exploitation, the tree now covers only 5% of its estimated ancient range in Lebanon, with an actual size of about 22 km2, scattered in fifteen fragmented relic stands. Six of these stands are located in the SBR landscape: 104 hectares in Bmohrai and Ain Zhalta, 185 ha in Barouk, 16 ha in Maasser al Shouf, 4 ha in Dhahr al Azr, 2 ha in Jiwar al Abhal, and 1 ha in Jabal Niha, that combined are home to about 25 % of the remaining cedar forests in Lebanon. This makes the SBR a critically important site for the long-term conservation and natural propagation of the cedar tree.

The cedar forests of Lebanon enjoy the unique distinction as the oldest documented forests in history. The cedars were featured prominently in the earliest written records of the Sumerians dating from the third millennium BC. The Epic of Gilgamesh describes the cedar forests of the Levant as being “one thousand leagues long and one thousand leagues wide”. However, it was the Phoenicians from the ancient cities of Byblos, Tyre and Sidon, who developed their famous sea-going merchant boats and became the principal dealers of cedar wood. Because of its durability cedar wood was highly regarded, especially in Egypt, by the builders of sarcophagi and other burial appurtenances, while its resin was used in mummification. The ship of Cheops (2600 B.C.), discovered beneath the Great Pyramid at Giza, was made predominantly of *Cedrus libani* timber. Numerous later texts of the Middle and New Kingdoms detail the felling of Lebanese trees in the course of Egyptian military campaigns and collected as a tribute from Byblos, the main center for shipment of the lumber to Egypt. The Bible records in some detail how King Solomon, King of Israel, asked King Hiram of Tyre to cut and transport vast quantities of cedar wood for building his temple and palace in Jerusalem. The expansion of the Roman Empire into Syria and Lebanon had a detrimental effect on the cedars until the Emperor Hadrian installed markers around the boundary of the remaining forests and declared them as Imperial Domain. Cedar wood from the early Arab period was found in several sites, most prominently in the roof of el-Aqsa Mosque in Jerusalem. The Crusaders also used this wood in their buildings and logs of cedar were found in the Castle Pilgrim at Atlit. Centuries later, during the early years of the twentieth century, the Ottoman Turks deforested major cedar growing areas to provide fuel for their wood-burning railway engines. Only the highest and most remote groves escaped damage.

Abu-Izzeddin, Faisal (2013) . Memoirs of a Cedar. A history of deforestation, a future of conservation. Shouf Biosphere Reserve.

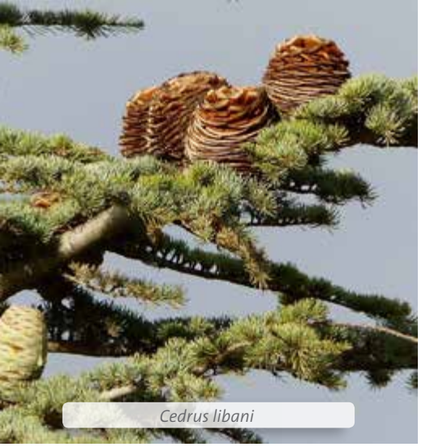
Companion species include fruit trees of small size, such as the wild pear *(Pyrus syriaca)*, the wild plum *(Prunus ursina)*, the azerole *(Crataegus azarolus)*, the common hawthorn *(Crataegus monogyna)*, scattered fruit trees *(Sorbus flabellifolia, Sorbus torminalis, Malus trilobata)*, and *Acer hyrcanum sbsp. tauricolum*; shrubs such as *Colutea cilicica, Styrax officinalis, Berberis libanotica, Cotoneaster nummularius*, and the Spanish broom *(Spartium junceum)*; grass species such as *Dactylis glomerata, Poa diversifolia, Stipa barbata* and *Agropyron panormitanum*; herbal species such as *Geranium libani, Lathyrus libani, Corydalis solida, Rubia aucheri, Doronicum caucasicum*.

Mixed cedar and Brantii oak forest in Maasser

Mixed oak (Quercus calliprinos and Q. Brantii) woodland in high mountain slopes in Mrusti (Shouf side of the SBRL)

Mixed oak (Quercus calliprinos, Q. brantii) woodlands in Kefraya (Beqaa side of the SBRL)

[27] M: million.


Cedrus libani


Quercus brantii subsp. look


Old-growth cedar stand


Cedar plantation


Sorbus flabellifolia


Sorbus torminalis


Crataegus azarolus


Lonicera nummulariifolia


Styrax officinalis


Colutea cilicica


Geranium libanoticum


Phlomis brevilabris

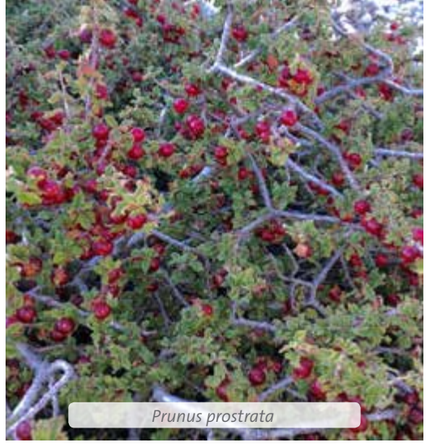
In the upper part of the bio-climatic zone, the SBR mountain summits at about 1,900m are exposed to extreme weather conditions, with strong cold winds in winter and abundant snowfall. Under these conditions, the few trees that occur show very limited growth in height, with a characteristic flag-shape, scattered and distributed in small troughs and slopes protected from the dominant winds. The vegetation is dominated by species-rich pasture communities and thorny cushion shrubs, such as *Astragalus echinus, A. gummifer, Acantholimon ulicinum* and *Onobrychis cornuta*. In the summit areas there is a karstic relief with abundant small depressions or dolines characterized by a dense cover of *Hordeum bulbosum*, and other hygrophilous grass species such as *Blysmus compressus* and *Alopecurus arundinaceus*.


Juniperus excelsa in the SBR mountain summit


Higrophyllous pasture in the doline depressions that characterize the SBR summit


Daphne oleoides

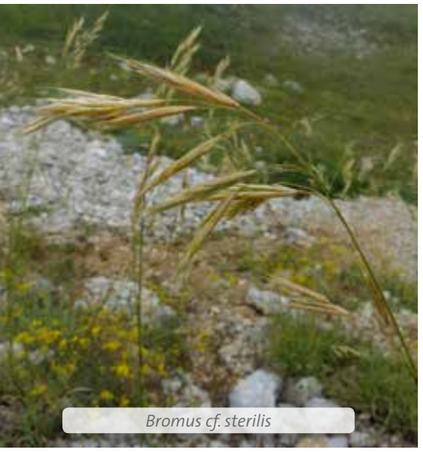

Berberis libanotica

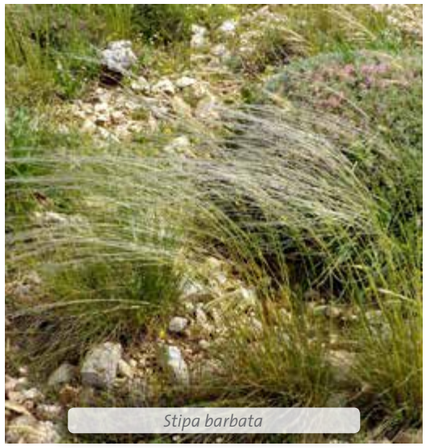

Prunus prostrata


Astragalus cruentiflorus


Onobrychis cornuta


Atraphaxis billardieri


Bromus cf. sterilis


Stipa barbata


Hordeum bulbosum and goat livestock


Alopecurus arundinaceus


Blysmus compressus


Tanacetum aucheri

The greater aridity and continentality (wide thermal variations between day and night, and between the yearly seasons) influences the bioclimatic levels of the mountain slopes on the eastern side over-looking to the Beqaa valley. *Quercus calliprinos* forests extends along a wider altitudinal gradient, reaching approximately 1700 meters of altitude, and giving way to the *Q. brantii* forest that extends up to the mountain summit. Cedar forests are absent, and the high mountain steppe juniper woodlands (*Juniperus excelsa*) appears in few areas, becoming more widespread in the central and northern part of the Mount Lebanon range.

Flora: So far, about 1,070 vascular plant species are known in the SBR landscape. However, research is still needed to have a complete picture of its plant diversity. The landscape is rich in medicinal, edible and aromatic plants (e.g. *Gundelia tournefortii, Crataegus azarolus, Scorzonera mollis, Thymus syriacus, Origanum syriacum, Rhus coriaria*[28]) very much harvested and used by local inhabitants. It is also home to 25 internationally and nationally threatened species, 48 endemic to Lebanon or to the Syria/Lebanon/Turkey area, and 14 rare species, whilst 214 species are restricted to the Eastern Mediterranean or Middle East area. Venerable trees and old-growth forest stands are linked to sacred places and village histories, becoming the representation of the collective memory. The cedar tree is a religious symbol, a national emblem and an icon spearheading 21st nature conservation in Lebanon.


Tulipa montana


Sternbergia clusiana


Salvia multicaulis


Cyclamen persicum


Helichrysum sanguineum


Michauxia campanuloides


Anacamptis morio subsp. syriaca


Ophrys holosericea


Thymbra spicata


Orchis galilaea


Micromeria myrtifolia


Eremostachys laciniata

Fauna: The SBR landscape is home to 32 species of mammals, being one of the last remaining areas in Lebanon where large mammals that once roamed the region can still be found. Mammals have increased in number since the SBR was established, with stable populations of several large species, such as the wolf *(Canis lupus)* in the mountain landscape, being monitored with camera traps. Striped hyenas *(Hyaena hyaena)* are found on the borders of the Reserve and feed on the garbage dumps and dead animal carcasses. Wild boar *(Sus scrofa)* is very abundant and easily observable in the mountain ecosystems. An abundant stable population of Cape hyrax *(Procavia capensis)* is located in the southwestern part of the landscape, near the archeological site of Niha fortress. At night, the howls of the golden jackal *(Canis aureus)* fill the valleys with sound. Other important species are the Red fox *(Vulpes vulpes)*, Indian porcupine *(Hystrix indica)*, Beech marten *(Martes foina)*, European badger *(Meles meles)*, Cape hare *(Lepus capensis)*, Caucasian Squirrel *(Sciurus anomalus)*, Palestine Mole Rat *(Nannospalax ehrenbergi)*, and Wild cat *(Felis silvestris)*. Recently, the Al-Shouf Cedar Society (ACS), with financial support from MAVA Foundation and the Italian Embassy, started the process for the reintroduction of the Nubian ibex *(Capra nubiana)*, an iconic large herbivore that disappeared in Lebanon at the beginning of the 20th century.

Over 275 bird species have been recorded in the Shouf Biosphere Reserve and the Ammiq Wetland. The birdlife of the SBR landscape includes rare or threatened species such as the Syrian serin *(Serinus syriacus)*, Eagle owl *(Bubo bubo)*, Chukar partridge *(Alectoris chukar)*, Long-legged buzzard *(Buteo rufinus)*, among others. The whole area, strategically placed between Europe, Africa, and West Asia is very important for bird migration, with over 240 different bird species using this flyway. Each year countless storks *(Ciconia ciconia)*, pelicans *(Pelecanus onocrotalus)*, cranes *(Grus grus)*, birds of prey *(e.g. Milvus migrans, Pernis apivorus, Hieraaetus pennatus)*, and other migrants pass over the reserve and use it as a resting, feeding and roosting site.

The SBR also includes 31 species of reptiles and amphibians including the chameleon (*Chamaeleo chamaeleon*), the endemic lizards *Phoenicolacerta laevis*, *Lacerta media* and *Lacerta kulzeri*, the high mountain snakes which live in several habitats including cedar and Brantii oak forests *(Coluber najadum and the rare Elaphe quatuorlineata)*, the high mountain vipera *(Vipera bornmuelleri)* the amphibian species related to aquatic habitats tree frog *(Hyla savignyi)*, green frog *(Rana levantina)* and fire salamander *(Salamandra infraimmaculata)*, the Greek tortoise *(Testudo graeca)*, the agama *(Laudakia stellio stellio)* that appears frequecuently on the dry stone walls of the agriculture terraces, among others.

[28]: A Survey of Economic Plants for Arid and Semi-Arid Lands (SEPASAL) found 224 plants of economic importance distributed in Lebanon (SEPASAL, 1999).

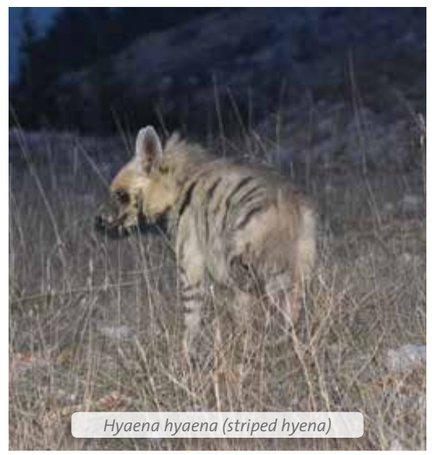

Capra nubiana (Nubian ibex)


Meles meles (Eurasian badger)


Procabia capensis (Rock hyrax)


Canis lupus (Wolf)


Hystrix indica (Indian Crested Porcupine)


Hyaena hyaena (striped hyena)

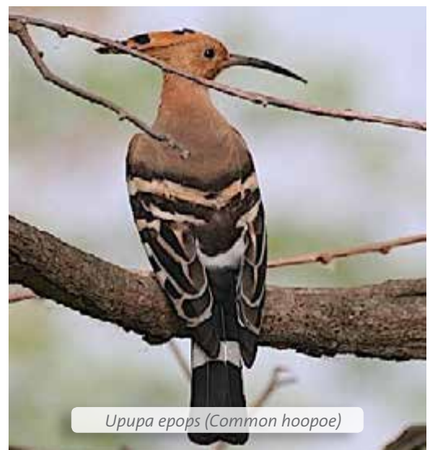

Mauremys cf. rivulata (Western Caspian turtle)


Hyla savignyi (Common tree frog)


Testudo graeca (Greek tortoise)


Stellagama stellio (Starred agama)


Serinus syriacus (Syrian serin)


Upupa epops (Common hoopoe)

I.1.3. Land Use

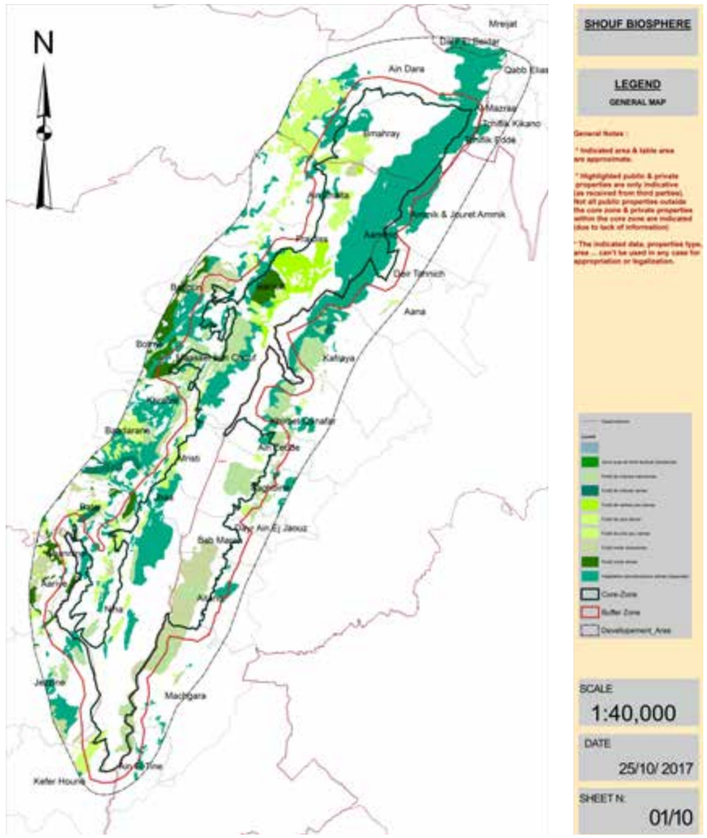
Land use/land cover in the SBR Landscape is the result of past and present changes in the application of traditional cultural practices, the intensification or abandonment of such practices, and in the case of cedar forests, the exploitation of its timber since ancient times. As a result, the current landscape is composed of a series of land cover types and subtypes linked to different uses and their degree of use or abandonment in different areas.

Based on Google Earth image and data collection in the field, the following land use types were identified and mapped:

Land Use/Land Cover Type	SBR Core Zone (hectares)	SBR Buffer & Development Zone (hectares)	Total (hectares)
Olive crops	731.0	3,781.4	4,512.4
Fruit tree crops	192.6	1,914.6	2,107.2
Vineyard	-	194.0	194.0
Small Agriculture terraces	458.6	1,158.4	1,617.0
Large agriculture land	-	8,652.0	8,652.0
Abandoned agriculture land	3,494.7	616.0	4,110.7
Pasture land	6,075.1	3,799.0	9,874.1
Shrubland	371.0	463.0	834.0
Shrubland with scattered trees	3,978.8	6,200.8	10,179.6
Cedar forest	400.8	2.8	403.6
Dense oak forest	124.0	77.1	201.1
Open oak woodland	224.8	2,066.5	2,291.3
Dense pine forest	629.5	954.6	1,584.1
Open pine forest	1,816.0	1,692.6	3,608.6
Dense mixed forest	35.8	1,917.3	1,953.1
Open mixed forest	218.0	1,261.3	1,479.3
Riparian area	-	1.5	1.5
Mountain lakes	433.9	12.4	446.3
Rocky outcrops	535.5	12,719.8	13,255.3
Quarries	576.7	1,091.0	1,667.7
Burned land	1.5	1.6	3.1
Urban	374.1	1,225.0	1,599.1
Industrial area	-	324.3	324.3
Total Land Area	20,672.4	50,127	70,799.4

The part of the landscape most modified by human intervention corresponds to the mountain foothills at the Supra-Mediterranean level, due to the milder climate conditions and the complex geological features favouring the presence of deeper soils and higher soil water content and freshwater availability. The landscape is characterized by a mosaic of agricultural land, agro-forestry, semi-natural woodlands and pastures. Agriculture is the main land use in the SBR landscape, covering 30% of the territory, from which 19.4% (4,111 ha) is currently abandoned.

Forests cover 16.1% of the landscape. Most forest ecosystems are characterized by oak and pine species, traditionally used for wood collection, honey production, and the collection of wild edible and medicinal plants. In many cases, secondary oak forests – mainly *Quercus infectoria*, mixed with *Pinus brutia* at lower areas in the south-western side of the landscape – have colonized abandoned agriculture terraces, becoming very dense stands with high accumulation of dry biomass. According to the satellite analysis, cedar forests cover 403.6 hectares (about 25% of the total cedar forests in Lebanon), distributed in 6 relic stands located in the core zone.



Pastureland occupies 14% of the SBR, from which 61.5% are high mountain grasslands located in the core zone, and 38.5% are low mountain pastures where livestock grazing is allowed. Part of low mountain pasture land are developed in abandoned terraces at the bottom of narrow valleys between the main mountainous massif and the hills that run parallel to it. They host a rich flora, with numerous orchid species. Livestock grazing – mainly goats and few sheep - follows a short-distance transhumant system, with daily movements from the surrounding villages – or from livestock farms nearby the villages and small towns - up to the mountain slopes and back between spring and autumn. So far, grazing management does not follow any organized rotation system, but shepherds decide everyday where to graze, mainly in function of the availability of water. This means that in some seasons of the year the livestock is taken to areas with worse pasture quality (e.g. shepherds in Ain Zhalta choose for summer grazing the pastures in the lower hills with drier grass and no woody species instead of the greener pastures higher up on the slopes of the main massif) but with greater availability of water. The stone pine forests at the lower elevations are also important for grazing, being *Cistus spp.* shrubs very appreciated by livestock. Autumn grazing mainly takes place in the slopes of the main massif below the strict protected zone, due to the availability of *oak acorns* which are the most appreciated resource by livestock due to its high energy and protein value. Other important fodder species – leaves and fruits - are small fruit trees from the Rosaceae family, such as Crataegus sp*p., Prunus ursina, and Pyrus syriaca*. During winter, shepherds move livestock at lower altitudes closer to the coast with milder climate.

Shrublands cover 15.5% of the total surface of the SBR landscape. They represent secondary vegetation that grows on abandoned agriculture terraces and degraded forest land. Shrublands are very important for livestock grazing too, with numerous highly palatable legume species, such as the Spanish broom (*Spartium junceum*), *Calycotome villosa, Astragalus spp.*, and other shrubs such as *Rhamnus punctatus, Sarcopoterium spinosum, and Cistus spp.*

Rocky outcrops occupies numerous mountain slopes and hills, covering 18.7% of the SBR territory. They are important habitats for *chasmophytic*[29] plant species and for the recently introduced Nubian ibex.

Quarries for the extraction of limestone stone and sand are scattered distributed throughout the SBR, covering 2.4% of the SBR landscape. They are already abandoned in many places, although without the implementation of restoration measures, causing a great aesthetic and landscape impact. They are specially active in the northern border of the SBR landscape, causing significant problems for livestock grazing, soil erosion, habitat destruction, landscape degradation, and environmental pollution with negative effects on water and the health of surrounding local population.

The FLR initiative in the SBR has implemented a pilot intervention for the restoration of an abandoned limestone quarry at the park entrance of Mrusti, providing best practices on how to restore quarries in Mount Lebanon.

The SBR landscape is mostly characterized by the Jurassic karst aquifer, referred to as the *Barouk-Niha Aquifer*, one of the major aquifers in Lebanon. About 200 springs supply the 28 towns and villages that surround the main mountain massif, and the perennial river Litani in the West Beqaa side, and the Damour and Awali rivers in the western side. Some of the springs are tapped and others flow freely supplying the downstream ecosystems and agriculture. There are four well-known and licensed water bottling industries in the western side of the SBR. The Reserve management unit is involved in the protection of the quality and quantity of these springs and related aquifers by protecting the recharge area, as well as testing and investigating the bacteriological quality of all the springs.

I.1.4. Social Context

The SBR is home to more than 170,057 inhabitants, spread over 28 municipalities, which are located in the transition zone of the reserve around the core and buffer areas. Despite the historical feuds between Christian Maronites and Druze, the Shouf district is one of the most religiously diverse regions in Lebanon. The Druze, Maronite Catholics and Sunni Muslims are the largest religious groups in addition to a Greek Catholic population and a smaller Shi'a Muslim population.

[29]: Plants specially adapted to survive in rocky habitats with restrictions in the availability of water and nutrients, whose roots are installed in small fissures or cracks in the walls, where fine particles accumulated by the wind accumulate, forming an incipient soil.

Municipalities in the SBR Landscape		
Municipality	Location	Population
Inner municipalities overlapping the buffer zone		
Aana	West Beqaa (central part of SBR)	2,400
Ammiq	West Beqaa (northern part of SBR)	800 in summer (400 in winter)
Ain Dara	Aley (northern part of SBR)	3,000 in summer (1,250 in winter)
Ain Zebde	West Beqaa (southern part of SBR)	2,500
Ain Zhalta	Shouf (northern part of SBR)	7,000
Aitanit	West Beqaa (southern part of SBR)	2,500
Bab Maraa	West Beqaa (southern part of SBR)	1,000
Barouk/Fraidiss	Shouf (central part of SBR)	12,000
Batloun	Shouf (central part of SBR)	3,500
Bmahray	Aley (northern part of SBR)	2,400
Jbaa	Shouf (southern part of SBR)	2,000
Kafraya	West Beqaa (central part of SBR)	1,600
Khraibe	Shouf (central part of SBR)	4,400
Maasser el Shouf	Shouf (central part of SBR)	5,500
Mristi	Shouf (southern part of SBR)	2,300
Niha	Shouf (southern part of SBR)	7,000
Saghbine	West Beqaa (southern part of SBR)	7,000
Exterior municipalities not overlapping the buffer zone		
Aariye	Jezzine (southern part of SBR)	300
Baadarane	Shouf (southern part of SBR)	4,000
Bater	Shouf (southern part of SBR)	2,500
Bhannine	Shouf (southern part of SBR)	50
Botme	Shouf (central part of SBR)	1,800
Deir Tachnich	West Beqaa (central part of SBR)	7
Jezzine Gaza	Jezzine (southern part of SBR)	8,000
Kefer Houné	Jezzine (southern part of SBR)	5,000
Khirbet Qanafar	West Beqaa (southern part of SBR)	3,500
Machgara	West Beqaa (southern part of SBR)	25,000
Qabb Elias	Zahle (northern part of SBR)	53,000
Total Population		170,057

On average 30% of the population in the SBR municipalities are civil servants, 20% are engaged in agriculture activities (although the annual income of less than half of them comes predominantly from this sector), 15% in private businesses, and 15% are unemployed. In the region there are two offices of the Ministry of Agriculture (extension and forest guard centres in Deir el Kamar), one police station to support the protection of the Reserve, 6 civil defence centres with a key role in forest fire fighting and other emergencies, the Red Cross centre helping in the visitors safety.

Farmers' landholdings range between 500 to 300,000 m2, with a mean of 25,891 m2. The largest landholdings are in the Beqaa-side, while the smallest are in the Shouf-side. The majority of farmers are engaged in horticulture and tree crops (apples, olives, cherries, peaches, pears), in addition to apiculture (cedar and oak honey, and mutifloral honey), floriculture, and the harvesting of wild plants (Oryganum, sumac, dandelion greens, akkoub, among others). Many agriculture products are processed which reduces its perishability and increases its diversification and benefits. Main processed products are: olive oil, apple-based products (e.g. apple cider, jam, juice, and molasses), grape molasses, tomato paste, pomegranate juice and molasses, mixed of herbs, dried fruits, herbal infussions, mouneh, and dairy products.

Grazing activities in the SBR are undertaken by 18 shepherds, from which 6 operate in the Beqaa-side, 11 operate in the Shouf-side and 1 operates in both sides of the mountain. The total number of heads of goats is 9,905 (4,575 in the Beqaa-side, and 5,330 in the Shouf-side). Seven shepherds from the Shouf-side undertake short-transhumance movements, bring livestock to grazing zones outside the SBR, at lower altitudes in mountain hills closer to the coast. The rest of shepherds keep grazing in some of the DGZs located at lower altitudes or keep the animals in their farms to be fed with purchased feed.

A large number of the population who live in the municipalities around the SBR depend on agricultural activities as an additional income to have a decent living. However, an increasing number of them are leaving their villages to become construction workers, government or private sector employees, and small business entrepreneurs. The trend is towards a downscaling traditional agricultural activity as a result of an aging population, poor marketing strategies, soil degradation, and high production costs (e.g. excessive use of pesticides and fertilizers). Security issues and political instability have also had a marked impact on people's livelihoods. The 2006 war, in particular, was a breaking point, and economic activity has not yet returned to pre-war status. The lack of employment opportunities has led to increased migration and local residents are heavily dependent on remittances from Lebanese who live and work abroad. Numerous problems related to the chaotic and uncontrolled construction of houses that affect both the core and the buffer zones are due by the investment of these remittances in new houses.

The SBR hosts a small number of the 1.1+ million Syrian refugees registered by the UNHCR in Lebanon. In the western side of the reserve 7,000 to 8,000 refugees and in the eastern 50,000 refugees, mainly in Qabb Elias municipality. Refugees are reliant on humanitarian aid, which is presently insufficient to keep up with the growing needs. Only around half the Syrian refugees in Lebanon are economically active while one third of them work in low-skilled jobs in an unorganized economy. On average, about half of the refugees' household members are engaged in some form of agricultural activity, which was the predominant employment sector most of them were previously engaged in Syria.

I.1.5. Cultural Context

The SBR landscape is one of the best-preserved areas in Lebanon, with very unique cultural identity. The scenery is breathtaking – picturesque villages dot the mountain foothills and historical monuments are found at every turn of the road. Rich in history, having been the centre of the Emirate of Mount Lebanon, there is a wide choice of heritage sites, from archaeological places, to historical palaces, to religious sites. The Shouf Built Heritage Conservation Project (SBHCP) and the archaeological mission of Qasr el Swayjani allowed the confirmation of the ancient history of the region with the discovery of numerous archaeological sites and features such as funeral chambers, agricultural installations (namely grape and olive presses), and large structures that belong to temples or forts. The chronology of these monuments dates back to the middle Bronze Age, the Iron Age, the Hellenistic period, the Roman and proto-Byzantine periods as well as early Islamic eras and medieval crusader and Mameluke period.

The SBR is a multicultural region with a mosaic of religious communities: it is the home of the Druze, settled since the Middle Ages and remained under the authority of their emirs; numerous Maronite Christians and Greek Catholics are mixed with Druze population; the Iqlim el Kharroub district is mainly inhabited by Sunni Muslims.

Cultural practices linked to forest, livestock management and agriculture occurred since ancient times and they have imprinted their own identity to the SBR landscape.

The Cedars of Lebanon are an important part of the cultural heritage of the people of Lebanon. The cedar tree is featured on the national flag, the national airline, Government logos, the Lebanese currency and innumerable commercial logos. The Lebanese cedar is cited numerous times in religion and mythology – seen as a "world tree" in several mythological passages, the cutting of the cedar is seen as the destruction of world-empires, really as the end of history. The religious and mythological recordings and the wood and medicinal employment reflect the importance of the cedars of Lebanon historically, and have contributed to making it one of the most significant tree species in world history. Its leaves and wood are traditional uses as antiseptic and expectorant, the essential oil from the wood is used in perfumery and cedar seed oil is highly repellent of adult mosquitoes and has the potency to control mosquito larvae.

Beekeeping is an ancient industry dating back thousands of years, that currently remains an important part of the local culture and its economy in the SBR landscape. Clay hives still containing residues of honey have been found in Phoenician and Roman archeological sites. Cedar honey is produced mainly by the Lebanese bee strain called *Apis mellifera syriaca*.

This is the only type of bee that can withstand the vast fluctuations in climate and temperature that are found in the high altitudes of the Lebanese mountains, where the weather can be very hot during the day and very cold at night. The Lebanese bee consumes the honeydew released from the aphids in the cedar trunks to produce honey. Although their production in terms of quantity is relatively lower than that of other strains of bees, they are still the most efficient in such an environment. Cedar honey is used as food, as well as in folk medicine as an unguent and is attributed with wound healing properties.

Major Cultural Landmarks in the SBR Landscape

The setting of the Shouf Biosphere Reserve Landscape is a nexus of many cultures, religions, and historical events all of which have left an imprint which makes the area's cultural heritage as rich as its ecosystems. The following are some major landmarks:

- Qab Elias Castle- an old powerful Druze fortress served as a guardian outpost controlling the road that linked Beirut to Damascus, and a marching post for the Druze and Chehab rulers of Wadi al-Taym; (South Beqaa)
- Deir el Qamar and Beit Eddine- are historic villages with palaces and monumental buildings such as the Palaces of Emir Fakhreddine and of Emir Bechir ;
- Moukhtara Palace - home and headquarters of the Joumblatt family since the 17th century;
- Tyron Niha - a cave castle dating to the rule of Prince Fakhreddin II's epic history which was successively used by the Arabs, Crusaders, and princes of Mount Lebanon;
- El Nabi Ayoub – (Arabic name of the prophet Job) a shrine built on the hill above the village of Niha to honour Job's memory and hold his relics.
- Bmohray - contains the remains of Roman monuments and rock sarcophagi. Most probably its first inhabitants were engaged in the trade of cedar wood which is still abundant in the area.
- Maasser el Shouf - Recent archaeological studies revealed that Maasser was inhabited since the 4th century BC. The El Hosn ruins date back to the Roman era as evidenced by tombs cut in the rock.
- Aitanit village - A main water source is located in the center of Aitanit village surrounded by a large rock with Roman inscriptions. One of the most important sites is the Roman cave which is a hypogeum or underground chamber. An archaeological site "Jwar el Khan" is located near Aitanit and has around 40 sarcophagi and cisterns.
- Kefraya village - has a Romano-Byzantine grape mill located among the agricultural terraces outside the center of the village. The Dahr el Moghor hypogea (underground dwellings) from the Roman and Byzantine era (near the Boustros palace) are dug into the rock of a small hill in the middle of the Kefraya vineyards.
- Botmeh - is on the Barouk River Valley Trail and is famous for its old stone houses, its old churches, and an ancient grape press. Visitors interested in archaeology can visit the ruins of the ancient village of Fornaya which dates to the Roman period.

- Baadarane is known for its Ottoman houses and monuments particularly the palace of Sheikh Ali Joumblatt, as well as the Tajeldin and Abou Chakra gates. Recent excavations revealed Roman ruins that include grape presses, tombs cut into the rock, and sarcophagi. Hundreds of ceramic shards from the Phoenician, Hellenistic, Roman, and Byzantine eras have been found between Khreibeh and Baadarane villages.

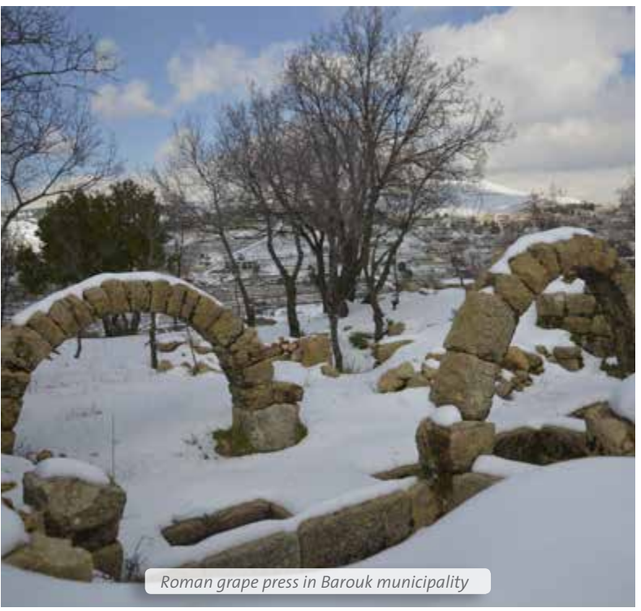
Tree worship is a traditional cultural practice in the SBR landscape. Kissing trees and worshipping them is more common among the Druze community[30]. There are four very old oak (*Quercus calliprinos*) trees linked to sacred ceremonies that have become part of the collective memory of the region: in Barouk in Delboun forest, in Botme, in Khraibe, and in the Druze sanctuary hosting the tomb of El Nabi Ayyoub (the prophet Job) in Niha municipality. To the rear of Darih El Nabi Ayyoub shrine there is a tree said to be miraculous, and, behind the sanctuary, a forest with old-growth oaks and a century-old arbutus tree, known to be miraculous and full of benedictions and graces. Local tradition says that this tree cured Job of skin disease. Devotees practice a variety of rituals around the tree, like hanging string and cloth in its branches. They also take fragments of the bark home for good fortune.

From the cultural point of view, oak forests play a very important role in the provision of ecosystem services supporting local livelihoods. In the same way as cedars, oak forests are an important resource for the production of high quality oak honey – produced in the same way as cedar honey - highly appreciated nationally and with a high market value. Oak forests are also a basic source of food for livestock in the autumn-winter period, due to the highly energetic and nutritive value of their acorns, especially of the high mountain oak *Quercus brantii subsp.* look, whose acorns are very large. Moreover, the oak forests are an important source of firewood to heat the houses in winter, whose use has now been improved by the project, for the production of briquettes.

[30]: Dafnit, A. (2007) Rituals, ceremonies and customs related to sacred trees with a special reference to the Middle East. Journal of Ethnobiology and Ethnomedicine

Darih El Nabi Ayyoub shrine in the municipality of Niha

Miracolous old strawberry tree (Arbutus andrachne) at Darih El Nabi Ayyoub shrine



Roman grape press in Barouk municipality

Baadaran palace of Sheikh Ali Joumblatt

Niha fortress

Moukhtara Palace

Terraced landscapes represent a very ancient cultural practice that goes back to the Bronze age (about 3,700 years ago), in steep hilly or mid-mountainous areas throughout the Mediterranean region to create arable land opportunities in steep mountain areas. The terraces provide a wide range of ecosystem services: they create fertile soil and favourable microclimate conditions for crops; slow down the water runoff to irrigate the crops and fill local reservoirs for irrigation during dry spells; support biodiversity in the microhabitats provided by the stone walls; act as firebreaks in forested mountain landscapes. UNESCO has recently inscribed "The art of drystone walls" in the list of intangible elements declared as World Heritage Sites, as they represent "a harmonious relationship between man and nature". The slopes around the municipalities in the SBR landscape were intensively terraced and cultivated since very old times for the production of vines, olives, mulberries, walnut and almond trees in addition to figs and grains. The presence of several grape and olive presses from the Roman times is an indicator of the ancient culture of terraced crops in the region. Olives are still cultivated in terraces, as well as a number of fruit trees. While the production of wine and arak is a major economic activity in the West Beqaa side, most terraces dedicated to vine crops are currently abandoned in the Shouf side.

Agriculture terraces were very much used in the past for the production of mulberry trees for the silk industry. It is worth noting that the silk industry was a very flourishing one in the region in the 19th century until the middle of the 20th century when the activity of sericulture declined in Lebanon. Fakhr ad Din II Maan (1572 - 1635), the agronomist prince, developed silk related agriculture and established an industry based on the production of silk. This would ensure economic autonomy to the emirate of Mount Lebanon, thanks to its commercial exchanges with Tuscany and Modena. The silk bundles were grouped in the Kaissariyye of Deir el Qamar in the Shouf where local weavers would get their silk supply. This particular kind of silk was called baladi (local), and was famed for its beautiful yellow color. The first Kerkhana (silk factory in Persian) for the reeling of cocoons was built in Btater in the Shouf region. Teams of spinners were brought from France to train young women, who for the first time, were encouraged to leave their households, to go out to work. This was a real social revolution in this rural and traditional part of the country.

Traditional food reflects the cultural identity, history and lifestyle of the local communities in the SBR landscape. Numerous wild herbs - such as *Origanum syriacum, Thymbra spicata, Asparagus acutifolius, Eryngium glomeratum, Scolymus maculatus, Scorzonera mollis, Centaurea iberica, Cichorium intybus, Pyrus syriaca* - are traditionally collected by local people, especially women, and used for own consumption and marketing, as part of a very rich gastronomic culture. An example is the spiny thistle-like *Gundelia tournefortii*, known as akkoub, traditionally harvested and used in the region for food and healing (diuretic) purposes. Local women spend hours shaving the vegetable, that are eaten fresh or kept under vacuum in glass jars in order and store the plant in large quantities. In the SBR, the price of one freshly collected peeled kilogram of Gundelia is about USD 8. Farmers collect an average of 70 Kg daily for 60 continuous days during the period in late spring/early summer. Similar amount is collected for the case of *Scorzonera mollis* whereof the root is sold for almost USD 6 per kilogram[31].


Gundelia tournefortii


Scorzonera cf. mollis


Eryngium falcatum


Centaurea cf. iberica


Beekeepers


Oak honey and other local products


Preservation of Ambarees in the Beqaa


Production of pine nuts in Ain Zhalta

Livestock production is also an important component of the cultural identity and food heritage of the local communities in the SBR landscape. Livestock is mainly composed of goat herds from shepherds in neighbouring villages that graze in designated areas following a traditional short transhumance system (spring to autumn in the mountains and winter at lower areas outside the SBR landscape). Milk production is mainly used for processing traditional dairy products, including cheese, labneh and kishk, which are sold locally and at national level.

- Kishk, a fermented product prepared with bulgur (dry cracked wheat) and yogurt, is a traditional product from both the West Beqaa and the Shouf sides of the landscape. It is an old Lebanese tradition since the 10th century. It is exclusively produced in rural areas during summer to serve as a provision for winter time. Consumption is common all over the country and constitutes an important part of the winter diet when consumed as a thick soup containing qawarma (preserved lamb meat), as well as in pizza or man'ousheh. Goat milk gives it a typical acidic (pungent) taste. Kishk production involves 3 to 5 people during 20 days with an average production of 50 kg per household, with a profit of about USD 14/kg (selling price is about USD 20/kg), generating a revenue per household/season of about USD 700[32].

- Both in the Beqaa and the Shouf sides of the SBR landscape there is old tradition to produce labneh from baladi and shami goats' milk in clay jars, known as sirdeleh in the Shouf and ambarees in the Beqaa[33]. Labneh is produced in this way from late March until end September, when goat milk is abundant. This traditional food is the result of an old and wise local knowledge of food production and a preservation technique that has proven successful over the centuries. During the goat-milking season in June, the process starts by filtering and pouring raw goat milk and coarse salt into the clay jars that are porous, with a hole in the base for draining purposes. The mixture is left to ferment at room temperature until the curd separates from the whey water, at which time the liquid is drained through the jar's opening. Over the span of the summer, the process of adding milk, coarse salt, fermenting, and draining is repeated until each jar is filled with curd. The curd is then left in closed jars for four months to complete its fermentation process, at which stage ambarees develops into a type of labneh, yellowish in colour and sour in taste. Throughout the fermentation process the product acidity rises, thus eliminating microorganisms that would otherwise be harmful. It is then sold either tightly packed in a jar or in the form of small balls conserved in olive oil. In this form, this kind of labneh, highly dense in milk solids, can be preserved for a whole year.

[31]: Fadel, D. et al (2016) Screening of threatened economically important Gundelia tournefortii and Scorzonera mollis species in Shouf Biosphere Reserve, Lebanon. International Journal of Plant, Animal, and Environmental Sceinces, Vol. 6, Issue 3
[32]: Chedid, M. et al (2018) The Lebanese Kishk: a traditional dairy product in a changing local food system. Journal of Food Research Vol. 7, N°5
[33]: https://365daysoflebanon.com/2016/04/03/the-art-of-ambarees/

I.1.6. Protection Status

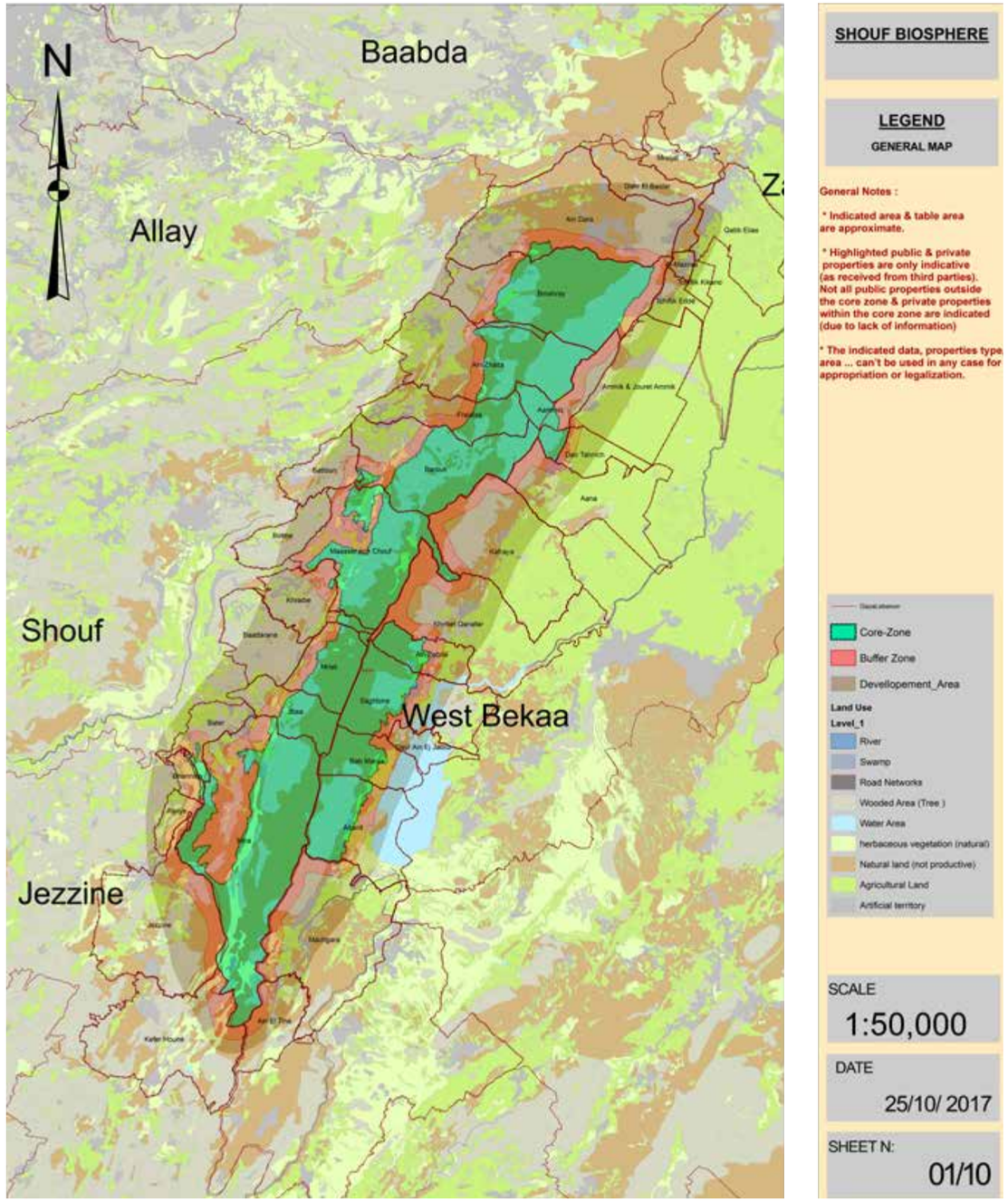
1.5.1 Law No. 532: Government legislation, Law No. 532 of 24 July 1996 declared "The communal lands of Niha, Jbeih, Mreste, Khraibe, Maasser, Barouk, Bmohreh, Ain Dara, Ain Zhalta villages, in addition to the Government owned lands on the eastern side of Barouk Mountain" as the Al-Shouf Cedar Nature Reserve.

The Shouf Cedar Nature Reserve is under the authority of the Lebanese Ministry of Environment (MoE), which manages it through the Appointed Protected Area Committee (APAC) that includes among its members the Al-Shouf Cedar Society (ACS), the Mayors of the larger villages, and independent environment experts. APAC liaises with the Reserve' Management Team, which deals with the day-to-day management and planning.

Shouf Biosphere Reserve (SBR): In July 2005, UNESCO declared the Shouf Cedar Nature Reserve and the villages surrounding it as the Shouf Biosphere Reserve with an area of approximately 539 km equal to 5% of the total area of Lebanon. The SBR is divided into three zones:

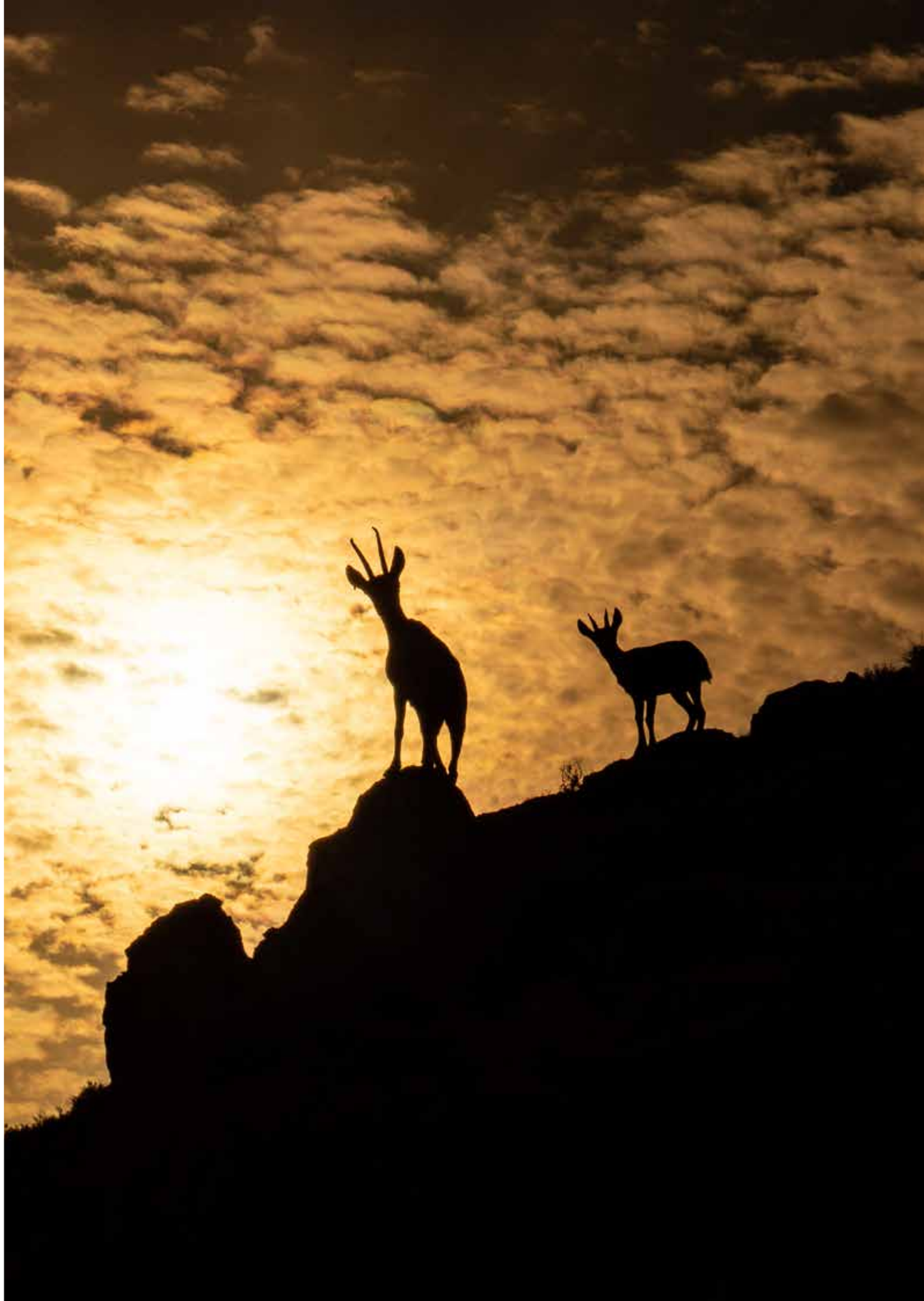
- **Core zone:** the core zone covers an area of about 115.5 km. and its main objectives are the protection and rehabilitation of the SBR's natural and cultural values. It includes all the area designated as Nature Reserve.
- **Buffer Zone:** the buffer zone covers an area of about 64.5 km. surrounding the core zone and where activities compatible with the conservation objectives can take place (such as ecotourism or agriculture).
- **Transition zone:** the transition zone covers an area of about 359 km. and includes all the villages surrounding the SBR where sustainable resource management practices are promoted.

The SBR also includes Ammiq wetland (outside the core zone), an area of 280 ha in the mountain foothills of the West Beqaa side of the Reserve, about 7 km south of the city of Qab Elias. Ammiq was designated by BirdLife International as an Important Bird Area in 1994, and was declared Ramsar Convention Site Number 978 in 1999.
In addition to the Ministry of Environment, the following government agencies have roles and responsibilities that impact on the environment and the Shouf Biosphere Reserve:
- The Ministry of Public Works is responsible for the Kefraya-Maasser Shouf road which passes through the reserve.
- The Department of Antiquities has jurisdiction over the antiquities and ancient ruins.
- The Ministry of Information and the Maasser Municipality have authority over the T.V. transmitters in the reserve.
- The Barouk Water Office has authority over water rights, especially the Barouk watershed.



The FLR initiative is implemented in the framework of the Lebanon's National Biodiversity Strategy and Action Plan (2016), which incorporates the lessons learned in the implementation of the different FLR initiatives in the SBR landscape. It also contributes to the National Strategy for Forest Fire Management in Lebanon, with special focus on reducing the risk of fire through the management of forest biomass and livestock grazing. and the use of livestock grazing to maintain fire-break areas. FLR in the SBR is a direct contribution to the 40 Million Trees Forestation Program, and its objectives completely coincide with those of the Lebanon National Forest Program 2015-2025:

- NFP Objective on ecosystem functioning: (i) Restore the ecosystem functioning of all type of forests and other woodlands in Lebanon; (ii) Manage forest ecosystems to be resilient and adapt better to climate change and all other changing conditions including the rapid economic growth; (iii) Adopt ecosystem-based management to maintain ecological integrity, enhance biodiversity and protect forest health.
- NFP Objective on Ecosystem services: (i) Establish value chains concepts for the goods extracted from all forest types in Lebanon; (ii) Initiate and promote private investment and partnership between public and private sectors in the development of forests, OWL and rangelands; (iii) Support the socio-economic development of low income villagers and communities, while empowering the role of women for a more balanced gender approach in all sectors of forestry.



FLR Principle II: Addresses the Root-causes of Landscape Degradation

II.1 The Root-causes of Landscape Degradation in the SBR

Traditional in-situ restoration approaches that focus on local level problems are necessary but insufficient to address the magnitude of forest and landscape degradation. The logical strategy will be to understand and remove the underlying socio-economic and political causes that truly drive the degradation of natural resources, which means "scaling up" the restoration objectives and actions and strengthening the sustainability of restoration actions in the field through macro-level measures such as:

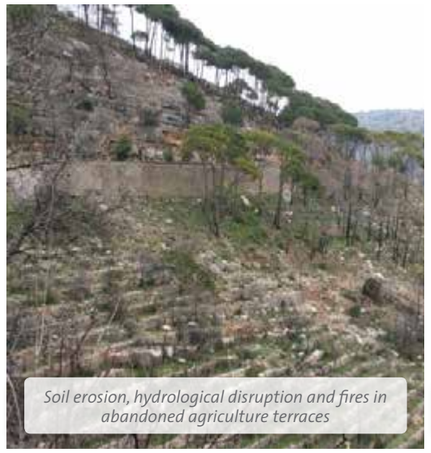
- **Policy reforms allowing for:** good governance mechanisms with fair involvement of local community groups; the regulation of sustainable land management practices preventing unsustainable exploitation of vegetation cover, soil and water and the conversion of valuable natural and semi-natural ecosystems; policy incentives to create employment opportunities and economically support and compensate farmers for the implementation and maintenance of sustainable uses;
- **Market incentives** to increase the market value and open new market opportunities for the products of the numerous valued and undervalued plant species existing in the SBR landscape;
- **Certification of goods and services** from the SBR landscape by using consumer pressure on the business sector (pharmaceutical companies, NWFP-related companies, tourism companies) to push land owners/governments to end destructive practices and implement ecologically sound, socially responsible and economically viable use of natural resources.

Only by exploring, understanding and addressing the root causes of natural resources degradation and loss at various local, regional, national and international levels can the SBR landscape restoration project create conditions (supportive policy frameworks, good governance and economic incentives) for more sustainable activities that promote the long-term success of restoration actions.

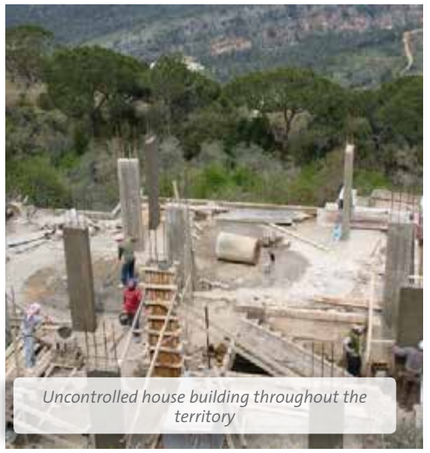
Threats to landscape values: habitat alteration is the primary cause of biodiversity loss world-wide. The forest ecosystems in mount Lebanon have been intensively exploited since millennia, resulting in a significant reduction of the extension and quality of forest cover, what is especially evident in the case of cedar forests that currently occupy few isolated relic stands. The alternation of periods of overexploitation of natural resources and abandonment has given rise to a landscape with visible problems of soil loss, limited capacity for water retention, pollution, and highly exposed to forest fires. Animal and plant populations have been reduced due to the degradation and loss of habitats.

Proximate causes of landscape degradation: the loss of the traditional cultural practices that allowed an efficient use of the natural resources as the best historical adaptation to the environmental constraints of the SBR landscape have resulted in the mismanagement and overexploitation of forests, pastures and wildlife. The abandonment of the traditional terraced farming systems throughout the territory has caused soil degradation and water retention problems. The intensification of apple tree production, mainly in the humid banks of Awali river in Barouk and Damour river near Ain Zhalta, have caused significant soil and water pollution problems.

Uncontrolled land uses, such as the opening of quarries and house building throughout the territory not only have reduced the aesthetic values of the landscape, but are creating serious problems of air, water and soil pollution, soil erosion, habitat fragmentation and higher fire risk (presence of houses in the middle of the forest).

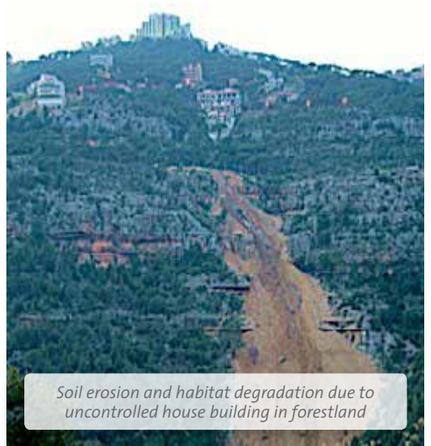


Soil erosion, hydrological disruption and fires in abandoned agriculture terraces



Uncontrolled house building throughout the territory

Higher occurrence of large scale fires due to the combined effect of maladaptive agricultural practices (burning of waste) and climate change



Soil erosion and habitat degradation due to uncontrolled house building in forestland

Opening of quarries for stone and sand extraction without impact evaluation, planning or post-extraction restoration plan

Uncontrolled hunting is the largest threat to migratory birds

On-going and future changes in climate conditions are already causing serious problems due to water deficit and the higher frequency and intensity of extreme weather events (heat waves, droughts). There is a positive feedback between land degradation and climate change: on the one hand carbon emissions from fires and soil degradation increase the concentration of green-house gases in the atmosphere and the consequent global warming trend; on the other hand, the higher temperatures and drought events derived from climate change negatively affect the landscape uses, with a higher risk of agricultural production losses, and decrease in the quality and availability of pastures, forest products and water.

Climate Change impact in Mount Lebanon

The Mediterranean region is one of the areas of the planet most affected by climate change. According to experts, in the Mediterranean region, average annual temperatures are now 1.4 °C higher than during the period 1880-1899, well above current global warming trends[34]. Depending on the climate scenario and the season, a rise in temperature from 2 °C to 6 °C by 2100 is expected in the region. Annual precipitation has decreased up to 90 mm per decade and summer precipitation up to 20 mm per decade since 1960. It is projected further reduction of 20% to 40% in annual precipitation and 30% to 50% in summer precipitation by 2011 in the southern parts of the region. High temperature events are likely to become more frequent and intense with a projected heat wave every two years by mid-century[35]. Higher frequency of intense heat waves and drought conditions will significantly increase the risk of large scale fires, with a projected increase in the burned are of 3 to 5 fold by the end of the century. The severity and frequency of droughts have increased in large parts of the region, and future projections would increase competition between different water users, such as agriculture, industry, tourism and households. Changes in temperature as well as precipitation patterns and intensity will affect evapotranspiration and infiltration rates, and thus soil moisture. Significant trends in the reduction of summer (June to August) soil moisture content already occurred in certain parts of the region, with up to -8 litres per m3 every 10 years for the period 1951-2012[36].
Analysis of historical climatic records in Lebanon since the early 20th century and projected climate scenarios indicates that the warming trend in Lebanon has no precedent[37]. Average annual temperature is projected to increase between 1.2 °C and 1.7 °C by mid-century and up to 3.2 °C by the end of the 21st century, compared to the baseline period of 1986-2005. A decrease in annual precipitation of 4 to 11% is also projected by the end of the century. Snow precipitation, which is a basic water resource in mount Lebanon, is projected to decrease by 40% with a 2 °C warming and up to 70% with a 4 °C warming. By the end of the century snow precipitation will shift from 1,500 m altitude up to 1,900 m, which means that it would hardly snow in the SBR. Early snow melting will reduce the recharge of most springs and the availability of water for irrigation during summer. Extreme weather events are also projected to increase in frequency and intensity: longer and more frequent drought events and earlier and 9 to 18 days longer summer drought period, and heat waves with up to 43 additional days with maximum daily temperature higher than 35 °C. Direct damage costs from climate-related changes in agriculture productivity, human health, properties and ecosystem services is estimated of about USD 320 million by 2020, which will cause Lebanon's GDP reduction of 3%, and an average cost per household of USD 1,500. These numbers will significantly increase 9 fold by mid-century.

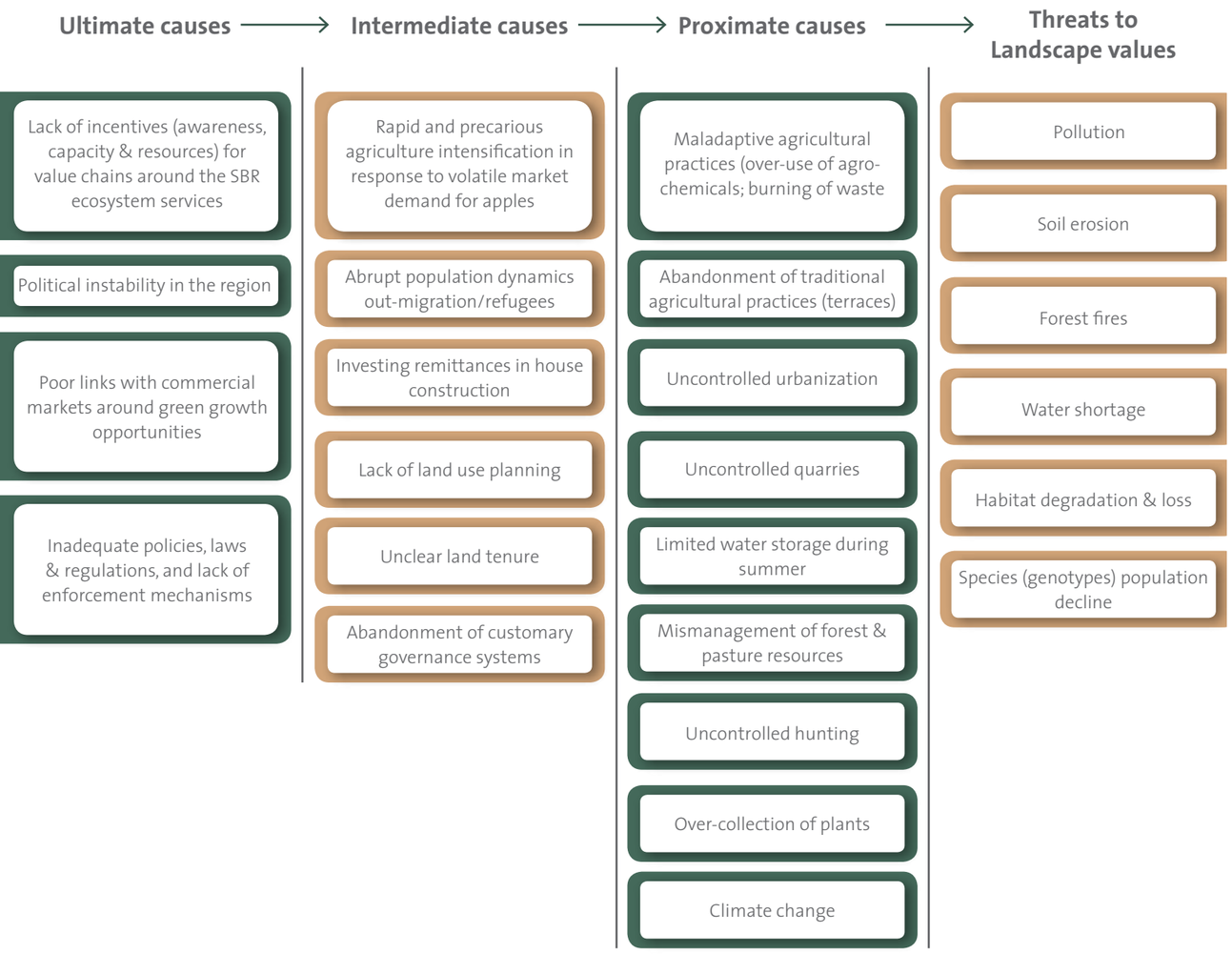
Intermediate causes: the unclear delimitation of land tenure, together with the absence of land use planning in the SBR landscape are behind uncontrolled urbanization and mining activities in the buffer zone of the Biosphere Reserve as well as in some parts of the core zone. The accelerated process of urbanization is also due to the remittances sent by Lebanese emigrants who live abroad but want a home in Lebanon.

The abandonment of the customary governance systems that regulated the management of natural resources in communal and public lands has led to conflicts among land users and the overexploitation of the natural ecosystems and wildlife. Abrupt population dynamics are also behind the degradation of the landscape. The migration of a large part of the population during and after the war caused the abandonment of many cultivated lands with the consequent destruction of the ancient agricultural terraces, soil erosion processes and the reduction of the capacity of terraced soils to regulate water flow and storage. In the best of cases, the terraces were colonized by secondary vegetation (stages of plant succession from pastures, to thickets and forests, according to the time of abandonment) that today accumulates a lot of dry biomass and carries a high risk of fire. The war in Syria has led to a major process of population displacement and the settlement of refugees in the region, which has increased the pressure on the SBR landscape, with more urbanization and uncontrolled over-use of natural resources. The uncontrolled entrance of livestock from Syria presents an important sanitary risk for the local cattle resource, the human population and the wild fauna.

The lack of planning for the agricultural sector in the region, and the presence of a limited number of real farmers whose main livelihood is agriculture, makes it difficult to understand the region's agricultural potential and access to markets. As a consequence, local farmers respond to ephemeral booms, such as the cultivation of apples, which are subject to a very volatile market, with high price and sales drops, and a strong environmental impact (excessive use of agrochemicals and water).

[34]: http://www.medecc.org
[35]: European Environment Agency (2017) Climate Change, impacts and vulnerability in Europe 2016. An indicator-based report.
[36]: Ibid.
[37]: Ministry of Environment (2016) Lebanon's Third National Communication to the UNFCCC.

Conceptual model for assessing root causes of landscape degradation in the SBR Landscape



Ultimate causes: Political instability in the region, represents a major cause preventing sustainable development in the region and in Lebanon as a whole. Current policies, legislation and regulations are in some cases weak and require improvements to support sustainable management practices and land uses. Moreover, the lack of sufficient enforcement mechanisms prevents the effective control of illegal actions. There are limited governmental resources to undertake spatial planning processes and cadastral survey and mapping, an issue that is especially relevant in the case of protected areas.

The absence of governmental incentives to support land users in the adoption of sustainable production systems makes it difficult to revitalize and improve the economic sectors that depend on the natural resources of the landscape. To this, we must add the lack of local knowledge and external support to develop value chains around the SBR ecosystem services and to access international markets for high value products, such as organic food, medicinal and aromatic plants.

FLR in the SBR has addressed the root causes of landscape degradation through the selection of priority actions at various levels:

	Priority actions
Proximate causes behind direct threats	• Ecological restoration interventions to increase the extension and improve the quality of natural habitats and the natural populations of rare and/or threatened flora and fauna species. • The development of production protocols and ensure the availability of plant material in local tree nurseries from a wide range of native plant species and genotypes of local crops and wild relatives. • The reduction of fire risk through the management of forest biomass and agriculture waste. • The reduction of water shortage through the improvement and establishment of water harvesting structures in the landscape, the reduction of soil water evaporation in forest planting and agriculture production, and the increase in the availability of water in the soil through water capture and storage systems, such as the construction of micro-catchments in planting holes. • The reduction of soil erosion through the restoration of agriculture terraces and forestland, and the improvement of soil cover in agriculture production. • The reduction of pollution through the promotion of organic agriculture, the management of solid waste for briquettes production and compost, and the development of municipal plans to prevent and regulate polluting uses in the core and buffer zones of the SBR landscape. • The incorporation of climate change adaptation measures in the selected methods and technologies for the restoration of agriculture land and natural ecosystems, and the management of natural resources.
Intermediate causes	• The revitalization of traditional customary governance systems, mainly linked to the organization and regulation of short-distance transhumance grazing systems. • The establishment of local governance mechanisms (municipal forest committees; Shouf Alliance) to facilitate FLR planning and implementation. • The clarification and cadastral mapping of land tenure in the municipalities of the SBR, and the promotion of participatory planning processes to regulate land uses and prohibit urbanization, mining, hunting and unsustainable management of natural resources in the core and buffer zones of the SBR. • Support farmers affected by the collapse of the apple market to convert their lands into organic farming of high value local crops and wild edible plants. • Support unemployed local young people and refugees to develop their professional skills and find job opportunities linked to the management of natural resources.
Ultimate causes	• Demonstrate best practices through pilot interventions on spatial planning, effective governance systems, and sustainable management of forests, pastures and agriculture to influence policy making and legislation/regulations improvement. • Build the institutional and technical capacity of all concerned actors on FLR • Raise awareness and education of local stakeholders and visitors, with special attention to the new generations. • Enhance green growth in the SBR landscape through the promotion of small local business that respond to climate change, and value chain development around goods and services from the landscape ecosystems.

In the next chapters we will discuss in detail the different priority measures mentioned in the table.

FLR Principle III: Engages All Concerned Actors and Supports Participatory Governance

III.1 The Involvement of All Concerned Stakeholders in FLR Planning and Implementation

III.1.1 Stakeholders' Participation in the SBR Landscape

FLR is a multi-stakeholder, collaborative endeavour that requires discussion and consultation with stakeholders and partners throughout the planning, implementation and monitoring process. It needs a good knowledge of the different actors in the landscape to understand how they interact among them and make use of natural resources, and realize the existence of conflicts and problems that may jeopardize the sustainability of natural resources management. Unclear tenure rights, the absence of adequate legislation and regulations and enforcement mechanisms, the lack of respect of land use limitations in the different zones of the biosphere reserve, the presence of incompatible uses in the same areas, the adoption of maladaptive management practices and overuse of some resources, and the existence of humanitarian emergencies, can have a negative impact on the long-term conservation of natural resources if they are not adequately addressed and solved.

Stakeholder participation includes the following steps:

Stakeholders' assessment and mapping: it involved the identification of people, groups, and institutions that have some interest in FLR or will be affected by FLR interventions. ACS has identified those groups that will be directly or indirectly affected by the project's actions: neutral, in favour of or opposed actors to FLR; actors who may consider that FLR interventions could positively or adversely affect their interests. A stakeholder table was produced to: (i) visualize the relative influence and level of interest — either positive or negative — of each of the stakeholder groups; (ii) assist the project team in understanding which stakeholders share similar goals or have similar interests; (iii) identify potential alliances, that is, groups that do not regularly share an interest, but which may join efforts to advocate for actions (e.g. policy improvement, effective governance systems, green growth opportunities; sustainable NRM) supporting FLR.

Stakeholders involved in FLR planning and implementation in the SBR landscape			
Level	Interest in FLR	Level of support/ opposition to FLR	Strategy for getting support or reducing obstacles
Local	24 municipalities of the SBR; Federation of Municipalities of the Higher Shouf (Moukhtara)		
	• Improved conditions in municipal and private lands, mainly for human benefits	• Variable: mainly in favour (fear of land use restrictions may generate little interest or initial rejection)	• Awareness raising, visits to successful pilot experiences • Setup of FMC for FLR planning and implementation • Capacity development (CD)
	Deir el Kamar Forestry branch-offices, Ministry of Agriculture		
	• Best practices on forest management issues	• In favour	• Awareness raising, CD, and best practices
	Al-Shouf Cedar Society (ACS)		
	• In charge of the management of the SBR, leading FLR	• In favour (leader organization)	• Internal CD of staff (technical, participation, gender)
	The SBR Appointed Protected Area Committee (APAC)		
	• Same as previous	• Same as previous	• Strong focus on awareness raising of committee members
	Local NGOs: Green Orient, Friends of Green Environment, and Lebanese Home for Environment		
	• Improved conditions for biodiversity conservation, NRM and livelihoods	• In favour	• Identification of synergies and collaboration for FLR implementation
	Land users: beekeepers, farmers, shepherds, and plant collectors		
	• Improved conditions for higher quantity and quality of natural resources	• Variable, depending on whether they sense risk to their interests or support for their activities	• Support green value chain development through grants • Agreements on NRM regulations and effective governance
	FLR-related enterprises: "Native Nurseries"; AFDC tree nursery; Kfarfakoud briquettes plant; women cooperatives		
	• Emerged from FLR actions, and fundamental for the sustainability of FLR in the SBR landscape	• In favour	• Support green value chain development through grants • Strong efforts on CD • Leading role in FLR implementation
	Tourism operators, restaurants, guesthouses, hotel and hostel, local guides, and shops		
	• Improvement of SBRL values to attract investment and visitors	• In favour	• Marketing SBRL values & identity • Support sust. tourism businesses
	Large agriculture-related enterprises, such as the Kefraya winery		
	• Improved ecosystem services from SBR landscape, with high interest for CC adaptation	• In favour or neutral	• FLR as an opportunity for CC adaptation (e.g. moving vineyards at higher altitude) • Potential for upscaling pilot interventions (e.g. bio-energy)
	Land owners and citizens		
	• Improvement of SBR landscape values to attract investment and visitors	• Variable, depending on whether they sense risk to their interests (e.g. house building) or support for their activities	• Spatial planning/cadastral to define tenure rights and regulate land uses • Marketing of landscape values and identity • Support green growth through job creation and grants

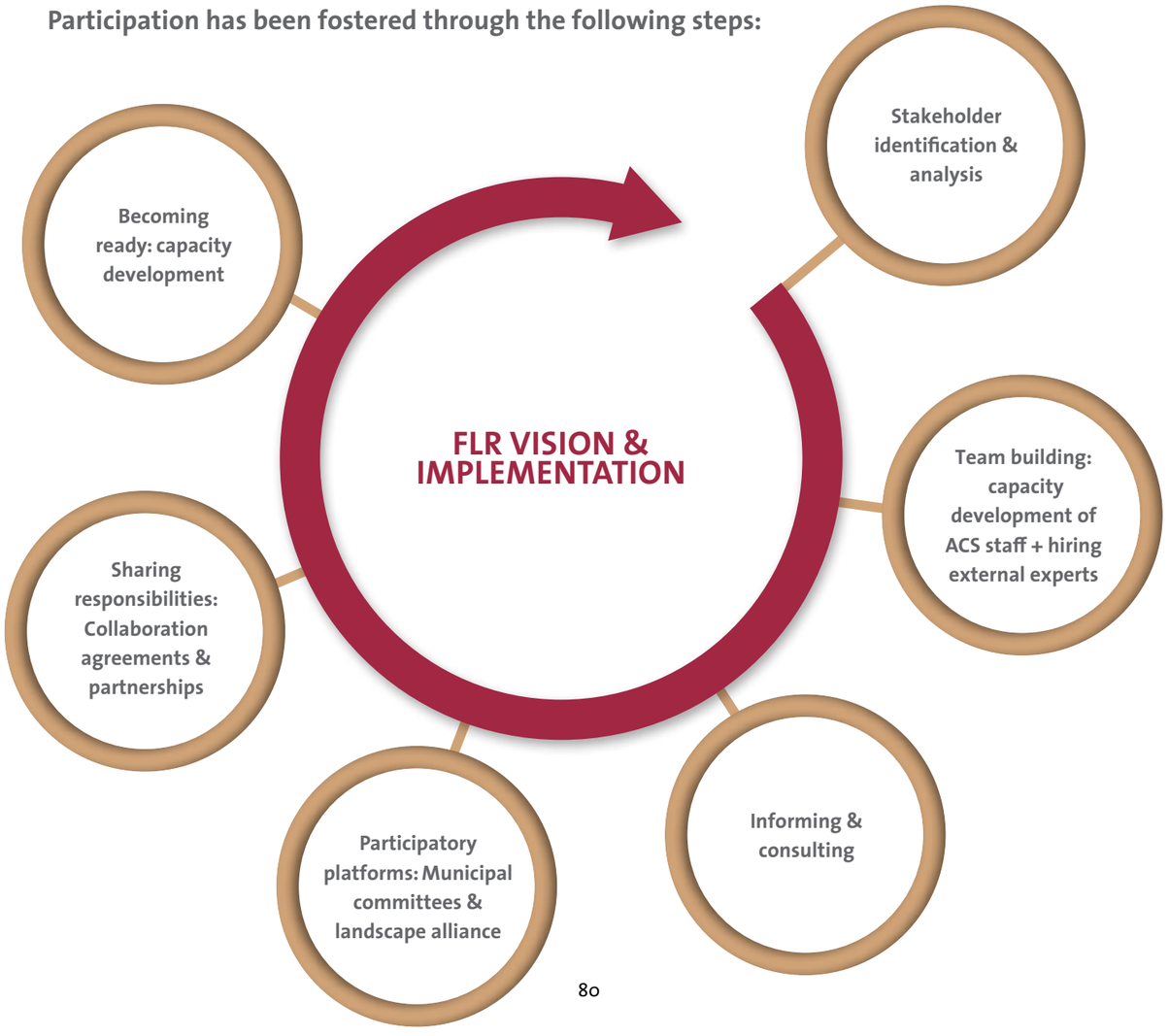
Stakeholders involved in FLR planning and implementation in the SBR landscape			
Level	Interest in FLR	Level of support/ opposition to FLR	Strategy for getting support or reducing obstacles
Local	Syrian refugees		
	• FLR as an opportunity for social integration within SBR hosting communities	• "Hidden stakeholder" with no role in decision-making	• Social integration through capacity development and green jobs around FLR implementation
	Public and private schools and education associations		
	• FLR as an opportunity to introduce environmental issues to new generations	• In favour	• Strong focus on awareness raising and education on FLR implementation
National	Ministry of Environment; Ministry of Agriculture		
	• FLR best practices in the SBR to guide the national response to commitments to Rio conventions	• In favour: support FLR implementation at the national level	• FLR in the SBRL: pilot for replication and upscaling at national level • Fundraising opportunities • Advocacy for policy improvement
	Ministry of Finance; M. Interior & Municipalities; M. Energy & Water; M. Public Works & Transport		
	• Improvement of SBRL values for development opportunities	• Variable, depending on FLR alignment with cross-sectoral policies	• Spatial planning/cadastral to define tenure rights and regulate land uses • FLR mainstreaming in policy dev.
	Souk El Tayeb		
	• Improvement of SBRL values to attract investment and visitors	• In favour	• Support green growth through FLR • Active involvement in green value chain development
	American University of Beirut; Lebanese University		
	• Improvement of SBRL values & biodiversity conservation	• In favour	• Active involvement in biodiversity monitoring and research on ecosystem management
	NGOs: SPNL, AFDC, A Rocha Lebanon, Arcenciel, the Lebanon Mountain Trail Association		
	• Improvement of SBR biodiversity and socio-economic values	• In favour	• Identification of synergies and collaboration for FLR implementation
	MORES s.a.r.l. consultancy firm		
	• Improvement of SBR biodiversity and socio-economic values	• In favour	•Collaboration for FLR implementation
	Eco-tour operators Responsible Mobilities, Lebanese Adventure, Esprit Nomade, Liban Trek		
	• Improvement of SBRL values to attract investment and visitors	• In favour	• Marketing of SBRL values & identity • Support sustainable tourism businesses
	Visitors to the SBR		
	• Improvement of SBR ecological, and socio-cultural values	• In favour	• Strong focus on awareness and education
	Lebanese Media (TV, radio, press)		
	• Improvement of SBRL values	• In favour	• Strong focus on awareness raising

Stakeholders involved in FLR planning and implementation in the SBR landscape			
Level	Interest in FLR	Level of support/ opposition to FLR	Strategy for getting support or reducing obstacles
International	IUCN Regional Office for West Asia; IUCN Centre for Mediterranean Cooperation		
	• Improvement of SBRL values	• In favour: leader on FLR worldwide	• Best practices to be shared and transferred worldwide
	Private foundations MAVA Foundation pour la Nature, Ford Foundation, and Rotary Club		
	• Mediterranean-wide interest on cultural landscapes and biodiversity conservation	• In favour: FLR funders in the SBR landscape	• Positioning SBR as a best-practice landscape to be shared with other Mediterranean biodiversity and cultural hotspots • Fundraising opportunities
	Italian NGOs: LIPU/BirdLife Italy and the Istituto OIKOS; Italian company ILEX		
	• Improvement of SBRL values	• In favour: FLR partners	• Sharing know-how and experiences on FLR in the Mediterranean region
	The Royal Society for the Conservation of Nature of Jordan		
	• Regional cooperation on Biodiversity conservation	• In favour or Neutral	• Cooperation on Nubian ibex reintroduction
	Mediterranean Centre for Environmental Studies (CEAM, Spain)		
	• Cooperation on FLR-related issues	• In favour	• Replication of best practices on FLR in other Mediterranean countries
	International experts on FLR, mainly from Spain		
	• Sharing knowledge on FLR-related issues	• In favour: direct contributors	• Provide technical support and guidance on FLR
	UN organizations: FAO, UNDP and UNESCO		
	• Improvement of SBRL values	• In favour: FAO is leading FLR worldwide	• Best practices to be shared and transferred worldwide
	International aid agencies: the European Commission, the Italian Cooperation, GIZ, USAID, SDC, AFD, WB and the embassies of donor countries such as Japan, USA, Finland, and Canada		
	• Improvement of SBRL values	• In favour: FLR funders	• Fundraising opportunities
	Private companies: Middle East Airlines, Byblos Bank, Porches Club Lebanon, Khalil Fatal and Sons, Advanced cars, Lycee National Schools, Four Seasons Hotel, HSBC Bank, Patchi, Nestle		
	• Improvement of SBRL ecological and socio-cultural values	• In favour: FLR funders	• Contribute to the environmental & social corporate responsibility • Potential for PES schemes
	Visitors to the SBR		
	• Improvement of SBR ecological, and socio-cultural values	• In favour	• Strong focus on awareness and education

Stakeholders' engagement: Lasting solutions for FLR in the SBR landscape rely on participation by key stakeholders—from local people who live off the land, to the civil society that value the benefits of the biodiversity and cultural values of the landscape, to the government, corporations, and donor institutions whose attitudes and behaviours will shape the development landscape. Although the processes for engagement and participation will vary from one landscape to the next, FLR is a multi-stakeholder, collaborative endeavour that requires discussion and consultation with stakeholders and partners throughout the process.

ACS has involved and gathered support from numerous actors at the local, national, and international levels, who have directly and indirectly contributed to FLR planning, implementation and monitoring in the SBR:

Participation has been fostered through the following steps:



A) Team building: FLR became the overall framework for several ACS-led projects on climate-smart landscape restoration, NRM, biodiversity conservation and rural development in the SBR landscape[38]. ACS has established an FLR team, including a field restoration, capacity development and gender coordinator, a value chain and monitoring coordinator, two project assistants, a technical expert in field implementation works, a monitoring & evaluation expert, an engineer in charge of the development of green infrastructures, and administration and procurement staff. The reserve rangers, daily paid workers, and volunteers have guaranteed the necessary human resources for the implementation of the field interventions.

ACS has hired international assistance to provide advice, scientific guidance, training and technical support on FLR programme development and implementation. Annual training courses targeting the project staff on different FLR-related subjects (e.g. ecological restoration techniques, adaptive management of natural resources, development of value chains, lobby and advocacy for policy improvement, programme development and implementation) was provided through the regional networking.

Additionally, the services of two national organizations were hired to assist in the assessment of water resources and climate change impact in the SBR landscape (*MORES* consultancy firm), and in the assessment of forest and agriculture restoration needs (*Native Nurseries sarl*), identifying measures to improve the water resources and agroforestry of the reserve and technically supporting its implementation.

B) Information and consultation, wherein ACS team introduced the FLR rationale, objectives, and methodologies to all the identified stakeholders, and sought information regarding their views, concerns, needs, and interest to be part of the FLR process in the SBR landscape. Consultation followed a gender- and age-sensitive approach, targeting separately women and men, and understanding the different realities of young and older population to better target FLR interventions.
The project has devoted special attention to the opportunities that can derive from FLR actions to improve the living conditions of the most vulnerable population. However, vulnerable people are hardly reachable (e.g. refugees who do not have a permanent address and move throughout the territory; local families on the edge of poverty) without intense direct action of identification, search and contact.
In this sense, the project team made use of the UNHCR registration and records regarding Syrian refugees in the SBR municipalities and paid visits to verify whether they still live there, and inform them directly about the opportunities for participation, learning and employment that they might have in the framework of the FLR initiative.

The National Poverty Targeting Programme (NPTP) was also used to identify families receiving food assistance, who could also benefit from FLR.

ACS has developed informational brochures and videos that were used in different communication events, including: public events organized in the townhall of the SBR municipalities; field awareness sessions targeting land users, as well as primary and secondary students from the schools; local festivals; annual forest restoration campaigns involving the general public; meetings with ministerial staff, research organizations and NGOs about the National reforestation Plan; meetings with aid agencies and corporate sector interested in FLR. Through this communication events, stakeholders learned about the SBR FLR initiative, and remain informed about planned interventions, achieved results, and other issues of interest to highlight. Communication events were also important to acknowledge successful experiences from *landscape champions* in FLR implementation, demonstrating the value of FLR to improve the environmental, social and economic conditions in the SBR landscape, and in this way encourage other people to follow suit.

C) Engagement, which allowed ACS to foster personal relationships with key stakeholders, organize participatory processes for the planning, implementation and monitoring of FLR interventions, and secure commitments for FLR implementation through informal agreements, MoUs and contracts. Chapter 2.4 will describe the governance mechanism developed by the project to facilitate participation and agree on workplans, expected outputs, implementation schedules, and stakeholders' roles and responsibilities

D) Partnerships and networking: FLR in the SBR landscape has been designed and implemented in the framework of the Global Partnership on Forest and Landscape Restoration (GPFLR). It followed the FLR principles and FAO guidelines for FLR in Drylands, and became one of the FLR pilot sites of the Mediterranean Initiative under the FAO Forest and Landscape Restoration Mechanism (FLRM). Moreover, ACS has established partnerships with the Italian organizations Lipu (BirdLife representative in Italy) and Ilex (Italian Landscapes Exploration) in the framework of the Mediterranean Mosaics Project, which has been fundamental for the exchange of know-how and experiences on FLR planning and implementation under a climate change scenario in two high ecological value landscapes: The Shouf Biosphere Reserve and the Sirente-Vellino Natural Park in the Abruzzo mountains in Italy.

[38]: Mediterranean Mosaics project: www.mediterraneanmosaics.org; : ; ENPI/2010/021-837, EuropeAid/135-358/M/ACT/LB "Environmentally-sound and Socially-beneficial Forestation in the Shouf Biosphere Reserve"; MAVA Funded project "Building the ecologic and socio-economic resilience of the SBR Mountain Landscape by restoring and strengthening the socio-cultural fabric which sustains its biodiversity and cultural values (M6)"; Italian Government funded project "STONE - restauro e valorizzazione di Sistemi agricoli Tradizionali per lo sviluppO economico e la coNservazione ambiEntale della Riserva dello Shouf".

The SBR landscape has also become a member of MEDFORVAL, a regional network including 20 high ecological value forest landscapes throughout the Mediterranean region. MEDFORVAL has provided a platform to give visibility and support international actions in favour of the conservation and sustainable management of high ecological value forests in the region. The collaboration between the members of the network has resulted in: training opportunities to learn about innovative protection, management and restoration methods; learning visits for representatives of stakeholders with a fundamental role in the management and conservation of some network sites, to hosting sites where best practices have been developed; the provision of grant funding to provide rapid response to urgent conservation problems in the network sites; the provision of financial support for the development of joint project proposals among network members.

E) Empowerment, to ensure the necessary understanding and skills of all concerned actors to make decisions and become active on FLR implementation, the project has invested significant efforts in capacity development actions, addressing all concerned actors, from local unemployed young people, to land users, extension agents, NGO staff, researchers, civil servants, local entrepreneurs, and school teachers. Poverty alleviation and gender balance have been major criteria for the selection of candidates, with the main objective to become highly qualified on specific issues (e.g. qualified workers on biomass management, plant production, forestation, agriculture stonewall restoration, tourist guide) and increase their chances to find jobs.

III.2 Effective Governance Mechanisms

Lessons learnt on natural resource-based community development show that ecosystem degradation trend can be reversed by: (i) establishing and enforcing appropriate policy and legal frameworks that regulate the sustainable use of resources and prevent conflicts between competing development sectors, and (ii) involving local communities through legitimate decentralized institutional arrangements. FLR in the Shouf Biosphere Reserve has addressed both these governance problems to improve natural resources management and restore natural and semi-natural ecosystem health and services.

III.2.1 Decentralized Governance Arrangements

AGSBR - Alliance for the Green Shouf Biosphere Reserve: With the aim of developing effective local governance mechanisms for the planning, implementation and monitoring of FLR interventions in the SBR landscape, the president of the ACS formulated the decision to establish the Alliance for the Green Shouf Biosphere Reserve (AGSBR) - an informal network including all main partners and stakeholders interested in FLR. The goal of the AGSBR is to focus the partners' and stakeholders' work around a common FLR vision, with the multiple objective of empowering all concerned actors on FLR planning and implementation, reducing trade-offs to maximize the environmental and socio-economic benefits while minimizing potential threats, and leveraging resources for the achievement of the FLR long-term goals.

The Alliance is composed of about 18 members, including representatives of the municipalities (through the FMCs), in addition to representatives of the MoE, MoA and some independent experts. AGSBR was instrumental in bringing municipalities together and facilitating coordinated actions and cooperation among them on FLR-related activities (e.g. the organization of awareness raising events such as tree planting days and information events about FLR results during regional festivals). The Alliance was also important to speed up administrative matters in the presentation of project proposals by ACS to raise funds for FLR implementation, such as the processing of letters of support from the municipalities.

FMCs - Municipal Forest Management Committees: FMCs were established in sixteen municipalities from the western and eastern sides of the SBR, namely: Aana, Kefraya, Kherbet, Kanafar, Ain Zebdeh, Aaitanit, Jbaa, Niha, Batloun, Maaser, Barouk, Mrusti, Saghbine, Baadaran, AinZhalta and QebElias. The aim is to have credible grass-root structures with legitimacy and recognition from local stakeholders and respect from the communities of the SBR. FMCs are small bodies formed by 7 to 12 members representing the municipality Council, community organizations, women groups, NGOs and local schools. FMCs facilitated the development of action plans for FLR interventions at the municipality level, and catalysed the participation of the population of the municipality in the planning and implementation of different FLR interventions, such as forestation, forest thinning and pruning, cleaning and demarcation of nature trails, etc. Some committees have been very active and their example has had a snowball effect in other municipalities that, impressed by the results achieved, have promoted and activated their FMCs. The FMC in Baadaran has also promoted cooperation among several FMCs to support the implementation of FLR interventions that concern several municipalities, such as the establishment of nature trails or the collection of agriculture and forest biomass for the production of briquettes. ACS has been very active in fundraising to cover the financial costs of the activities implemented by the FMCs.

In order to empower the FMC members, the project team has implemented a capacity development plan in agreement with the recipients that includes: (i) field training sessions following a "learning-by-doing" approach to acquire knowledge on native species plant production protocols, field restoration techniques, the sustainable management of forest biomass, and FLR monitoring; (ii) field visits to learn about best practices. The project has also facilitated the exchange of information and know-how among FMC with the objective to develop a network of committees of mutual support in the SBR.

Pilot Municipalities: A more detailed collaboration protocol was signed between the ACS and the four municipalities of Barouk, Maasser, Mrusti and Aitanit for the development of *municipal forest restoration plans* (MFRPs) and the implementation of concrete pilot FLR interventions. MFRPs were developed with the participation of different stakeholders from the municipalities, and following the FLR planning tool developed in the framework of the FAO *Global guidelines for the restoration of degraded forests and landscapes in drylands*[39]. Learning visits were organized for FMC members and other interested neighbours of the municipality to the tree nursery "Native Nurseries sarl" in Ramlieh and the Kfarfakoud briquettes production plant - both enterprises supported by the project - to learn about the production of high quality plant material from native tree and shrub species, as well as the production of briquettes for house heating, making use of biomass from forest and agriculture waste, including olive pomace and chipped wood from the pruning of oak and pine trees, olives and fruit trees. FMC members participated in several "learning-by-doing" training sessions to acquire the necessary skills on adaptive forest management, fire prevention, forest restoration, agriculture stonewall restoration, organic agriculture production, and soil compost production, construction of green infrastructures for water harvesting, and establishment of nature trains, among others.

The governance bodies established by the project – AGSBR and FMC - proved to be very useful decentralized governance arrangements to convey the FLR objectives and positive impact for the sustainable development of the SBR to its primary beneficiaries – the rural communities of the SBR municipalities. ACS is currently helping both bodies to plan future activities and develop a long-term action plan beyond the completion of the ENPI/ARDP project.

[39]: www.fao.org/dryland-forestry/dryland-restoration-initiative/en/

III.2.2 Policy and Legal Frameworks

Increasing land users' knowledge about forest-related legislation and promoting the use of existing public incentives: The FLR initiative in the SBR has assessed gaps and opportunities within the existing Lebanese policies regulating natural resources management, and providing economic incentives to help municipalities, private land owners, and users to improve management and the environmental conditions of their lands. User-friendly materials were produced and disseminated among land owners and users through information events and learning workshops. The aim was to increase the users' knowledge about existing legislation, rules and regulations about forest conservation, management and restoration, to make accessible and understandable the legal texts, and to facilitate the access to the existing public financial aid for landowners to improve the conditions of their land and the natural resources.

Advocacy for policy improvement through mainstreaming climate change adaptation into forest restoration and management: The project has demonstrated how to adapt to climate change in forest restoration and management through effective pilot interventions that have positively influenced national policies on forest management and environmental risk reduction. This included the demonstration of: (i) innovative nursery techniques for the production of high quality seedlings of about 45 native species; (ii) effective forest planting techniques to improve soil water harvesting and storage in the planting sites to help compensate the growing trend of water deficit during summer and increase the survival rate of seedlings; (iii) sustainable options for the management of forest and agriculture biomass with the multiple objective to reduce climate-related risks (e.g. forest fires) while creating economic opportunities (e.g. briquettes production for house heating). Pilot interventions were implemented in close cooperation with the MoA and MoE. In the special case of forest thinning and pruning, staff from the two regional offices of the Ministry of Agriculture at Deir el Kamar (extension and forest guard centres), supervised the works. Pilot demonstrations played a key role in changing the old-fashion way of addressing forestation and forest management in Lebanon, by mainstreaming climate change adaptation techniques that helped reduce climate-related risks such as the higher frequency and intensity of forest fires and the increase of water deficit and drought. Successful results have deeply inspired larger forest restoration and management interventions in Lebanon, with UNDP, USAID and WFP funding support.

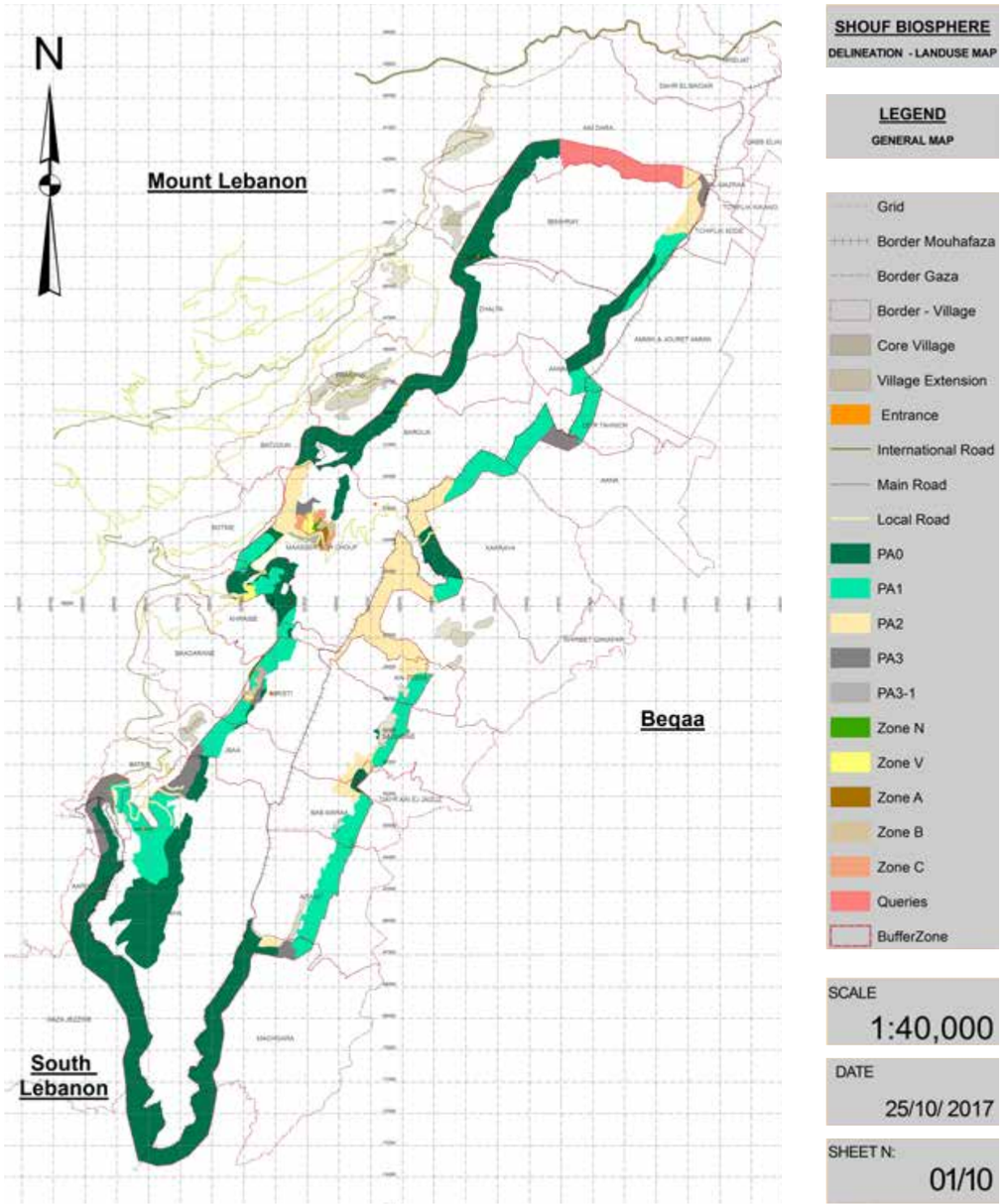
Delineation of the boundaries and clarification of tenure rights and land use restrictions in the different zones of the SBR landscape: For both the International Union of Conservation of Nature (IUCN) the world's oldest and largest global environmental network, and the Convention on Biological Diversity (CBD), protected areas require delineation of boundaries. Delineation, which is now mandatory for the establishment of protected areas in Lebanon, refers to the definition of protected areas' boundaries that includes the geo-referencing of border; and establishing clear, enforceable guidelines on permissible land-uses within (i) a 500-m buffer zone surrounding the protected area (PA) and (ii) parcels of private and communal land inside the PA.

The Ministry of Finance (MoF) is the authority responsible for defining the boundaries of governmental land, while for communal and private land, it is the joint responsibility of the MoF and the Ministry of Interior and Municipalities (MoIM). Law No. 532 of 24 July 1996 declared "The communal lands of Ain Dara, Bmohray, Ain Zhalta, Barouk, Maasser, Khraibeh, Mrousti, Jbaa, Niha villages, in addition to the Government owned lands on the eastern side of the Mountain" as a Nature Reserve. A pending issue after that designation and the subsequent establishment of the Shouf Biosphere Reserve in 2005 was the clear delineation between publicly owned lands and privately-owned lands, and the regulation of land uses in the different zones of the reserve.

The delineation process of the SBR was implemented under the European Union funded project *"Support to Reforms - Environmental Governance"*[40]. The project, implemented in the framework of the Ministry of Environment component "Strengthening Environmental Inspection and Enforcement", was commissioned to five experts (Land-use expert, Topography expert, Environmental expert, GIS expert, and Legal expert) who worked for two years and delivered the delineation of the boundaries of the SBR zones. The delineation was based on the principles: (i) preserving the integrity of the core zone; (ii) public good supersedes private interest; (iii) the interest of small owners is taken into account more considerably than that of big owners and developers; (iv) developing an action plan to deal with unclear issues; (v) available detailed urban plans constitute the basis for land-use planning and zoning in surrounding town with no plans.

[40]: GFA Consulting Group (2017) Design Proposal of the general guidelines and detailed system for the Shou biosphere reserve in the towns of Ain Dara, Bmohray, Ain Zahlta, Al-Faridis, Al-Barouk, Maaser Al-Shouf, Al-Khraibeh, Mrosty, Jbaa and Niha. European Union Funded Project.

Land tenure delineation and land-use regulation in the SBR



Legend:

- The Old Center (A)
- Dense residential areas and trade (B)
- Medium residential and Trading Areas (C)
- Natural Area (N)
- Residential Zone for villas (V)
- PA0 (Construction allowed in 1% of land property)
- PA1(Construction allowed in 2% of land property)
- PA2 (Construction allowed in 5% of land property)
- PA3 (Construction allowed in 10% of land property if bigger than2500 m2)
- PA3-1 (Construction allowed in 5% of land property if bigger than2500 m2)

The team of experts reported back to all concerned stakeholders on the findings as well as the course and the decisions followed in the delineation process. The process to develop maps and guidelines for permissible land-uses followed a participatory process, involving: (i) negotiations and conflict resolution, supported by the identification of suitable compensation and appropriation modalities for the private lands annexed to the core zone; (ii) economic valuation of opportunities for sustainable uses to convince land owners to adopt them; (iii) propose incentives such as taxes reduction and other tactics, to push land owners towards sustainable uses in the buffer zone; (iv) improvements in the existing Detailed Urban Plans; (v) development of Strategic Environmental Assessment (SEA) for the guidelines proposed for the buffer zone.

The maps and guidelines were submitted through MoE to DGUP in order to issue a decree through the council of ministers to ratify delineation. Awaiting final approval, any development proposal in the core and buffer zones should go to the board of the Urban Planning Establishment in Beirut, which means that no permission will be given without detail assessment of potential impacts. This represents a major step to improve the governance of the SBR, and to prevent land degradation problems from unsustainable land uses in the landscape.

FLR Principle IV: Restores Multiple Functions for Multiple Benefits

IV.1. Identify FLR Goals to Ensure the Ecological, Socio-economic, and Cultural Resilience of the SBR Landscape

IV.1.1. The SBR Landscape Resilience

The SBR landscape is a good example of the coevolution and coadaptation between ecosystems and social systems, which has resulted in multiple benefits for nature and people. On the one hand, the SBR mountain landscape is characterized by a great variety of environmental conditions, a rich flora and fauna, and a high diversity of habitats that have allowed the settlement and development of rural communities. A wide range of ecosystem services have supported the development of diverse production systems and cultural practices that gives its own identity to the communities that live in the SBR landscape. On the other hand, local people in the SBR have contributed to the ecological diversity through the development and use of cultural practices, enriching the natural landscape with a greater diversity in terms of habitats and species.

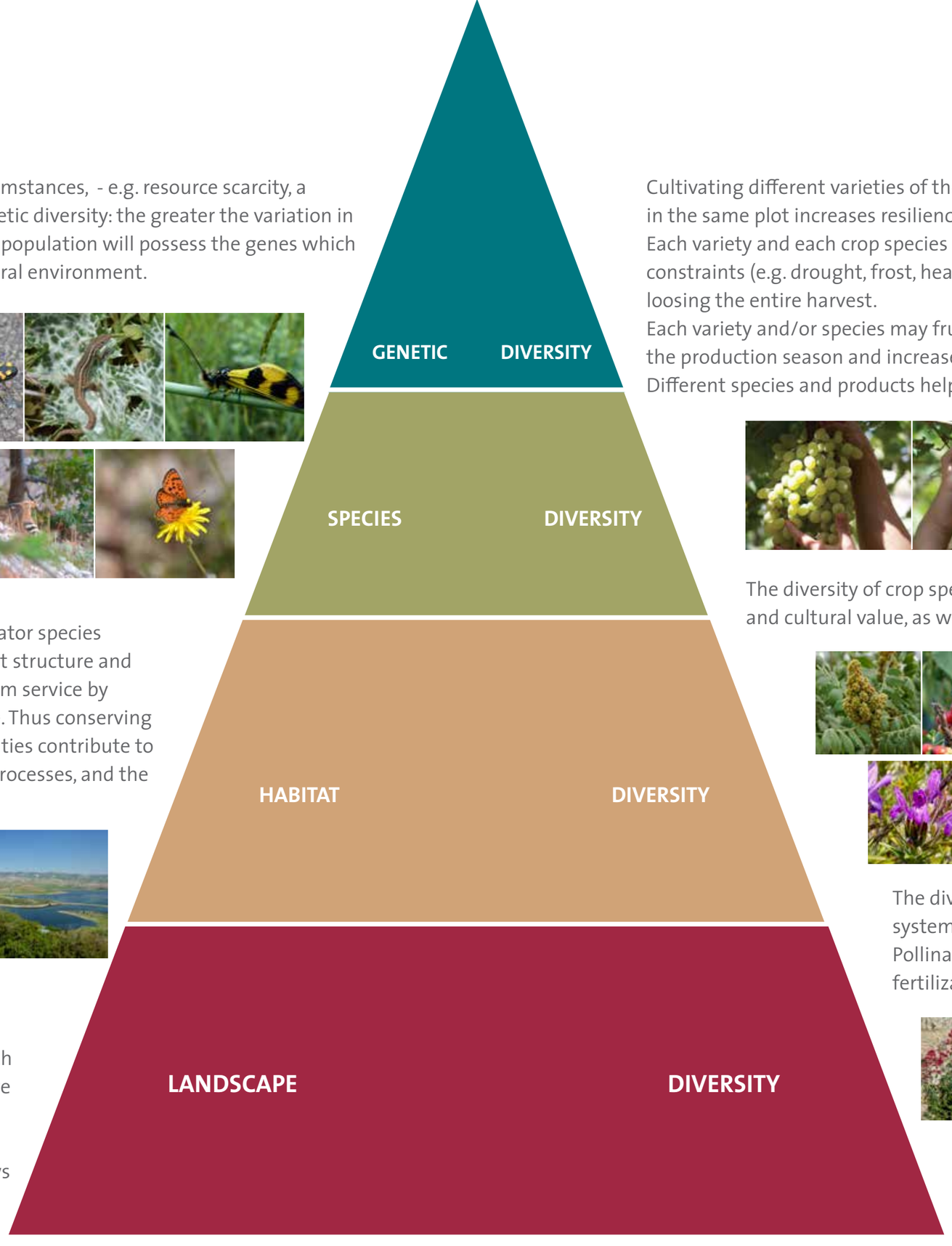
An example is the transhumant grazing system through which shepherds and livestock adapt to the seasonal availability of food and water throughout the landscape. This cultural practice helped enrich the landscape with a greater number of habitats and species that were developed thanks to the movement of the animals that acted as dispersal-vectors and the herbivorous action contributed to create new habitats with a composition of selected species.

Another example are the semi-domesticated forests that characterize the SBR landscape, which are the product of planned farming and are attached to the local economy. The mosaic-like coexistence in the rural areas of the SBR landscape (mid mountain and foothills) of small forest patches of several oak species (*Quercus calliprinos, Q. infectoria, Q. brantii subsp. look*), stone pine trees, semi-domesticated ash tree, poplar, wild pear, wild plum, wild pistachio, wild almond and azerole, and domesticated varieties of olive trees, figs, mulberry, pomegranate, and vines, differing their growth capacity, their temperature and rainfall tolerance, has resulted in a high level of biodiversity and high socio-economic and ecological resilience to climatic change. Semi-domesticated oak and stone pine forests have evolved from long-standing and complex domestication processes targeting highly valuable tree species (e.g.; pruning, breeding, grafting) that nowadays represent cultural legacies from the past. For most semi-domesticated tree species domestication remains more or less invisible, involving the selection of individual trees with special attributes in untouched forests for later planting, and the intentionally designing of a high variety of shapes and architecture of tree crowns by local people through several management practices, such as coppicing, tree-crown pruning and pollarding, the clearing of forestland maintaining scattered large trees or planting selected individuals in land with rotational pastures and rainfed or irrigated cultivated land, etc. It does not focus on the selection of single-purpose genotypes but targets increased production (e.g. acorns, pine nuts, honeydew, fruits) and the maintenance of a high level of genetic diversity. Venerable trees and forest stands are given names, and family or village histories are linked to them, becoming the representations of their collective memory.

The capacity of species to adapt to new circumstances, - e.g. resource scarcity, a changing environment - depends on its genetic diversity: the greater the variation in genes, the more likely is that individuals in a population will possess the genes which are needed to adapt to changes in their natural environment.

Plant diversity increases the stability of predator species richness, possibly as a result of higher habitat structure and herbivore diversity. It provides a key ecosystem service by reducing insect outbreak potential over time. Thus conserving and and restoring diversified plant communities contribute to the maintenance of biodiversity, ecological processes, and the stability of entire food-webs.

Biodiversity plays an essential role for the functioning of extensive natural landscapes, that consist of different ecosystem types such as forests, pastures, scrubland and agriculture land.
Landscapes with a greater biodiversity are more productive and their productivity shows lower year-to-year variation under climate-driven environmental changes.



Cultivating different varieties of the same crop species and different crop types in the same plot increases resilience:
Each variety and each crop species tolerates different environmental constraints (e.g. drought, frost, heat, pests) and all together reduce the risk of loosing the entire harvest.
Each variety and/or species may fructify in a different period, which lengthens the production season and increases market opportunities.
Different species and products helps diversify market opportunities.

The diversity of crop species and varieties increases the aesthetic and cultural value, as well as the tourist potential of the landscape.

The diversity of habitats linked to farming systems increases the ecosystem services (e.g. Pollination, presence of insects that fight pests, soil fertilization, wáter conservation, edible species).

Resilience in the SBR Landscape

Resilience can be defined as "the capacity of a social and/or ecological system to absorb disturbances and re-organize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks"[41]. Social resilience is an important component of the circumstances under which individuals and social groups adapt to environmental change. Ecological and social resilience may be linked through the dependence on ecosystems of communities and their economic activities, and the dependence on sustainable cultural practices of long-ago modified ecosystems.

Socio-Economic Resilience

Highly diverse traditional production systems:
- Terraced crops for olive and fruit trees, vineyards, cereals and vegetables
- Transhumant livestock management for milk products, leather and meat
- Harvesting of firewood, honey, edible plants, pine nuts and fruits.

Shouf Landscape Resilience

Ecological Resilience

Highly diverse agro-silvo-pastoral mosaic landscape:
- Spring-summer mountain pastures
- High mountain cedar and oak forests
- Semi-domesticated low mountain oak and pine woodlands
- Highly diverse habitats and crop species & varieties linked to the agriculture terraces

Cultural Resilience

Strong regional Identity around the production of high value products (e.g. olive oil, wine, labneh, oak & cedar honey and pine nuts), and strong historical cultural influences directing farmers towards their production.

More resilient social-ecological systems are able to respond to shocks without changing in fundamental ways. In other words, they can cope, adapt, or reorganize without sacrificing the provision of ecosystem services[42]. Resilience is often associated with diversity at different levels: ecological diversity in terms of habitats, species and gens; socio-cultural diversity in terms of the use of large number of crop and animal species and genetic varieties, and diversification of cultural practices, production and market opportunities.

Building social-ecological resilience requires understanding the complex connections between people and nature, incorporating the knowledge of local users, and creating opportunities for technological innovations and supportive economic incentives and policies.

[41]: Walker et al, 2004.
[42]: Folke, C. Et al (2002) Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. Ambio Vol. 31, N° 5.

The excessive exploitation of natural resources and the abandonment of cultural practices are the cause of degradation and loss of natural habitats and species, rendering ecosystems unable to provide many ecosystem services.

Mainstreaming climate change impacts on forest ecosystems into forest restoration:
Climate change compounded by maladaptive anthropogenic processes (e.g. unsustainable rapid land-use changes, rural abandonment and overexploitation of land resources) are likely to increase the frequency and intensity of pathogen outbreaks, uncontrolled fires and other large-scale disturbances[43]. All this may contribute to:

- Diminishing forested areas, which will be replaced by fire-prone shrub communities.
- Increasing landscape fragmentation, which will consequently hinder migration/ dispersal opportunities for a number of species at risk of extinction.
- Decreasing annual tree growth increments and the subsequent income from forests.

In general terms, species responses to climate change impacts will consist of:

- Tolerance to new climate conditions and in-situ persistence, thanks to its genetic plasticity, its presence in refugial areas protected from the general climate disturbances, and / or the maintenance of well-preserved habitat conditions that creates a particular micro-climate and helps buffer the effect of changes in climate.
- In-situ adaptation of species with high genetic plasticity, which can evolve and genetically adapt to new conditions.
- More or less extended ecosystem shifts, with the movement of species ranging northwards and upwards in elevation, following changes in bio-climate conditions suitable for them.
- Reduced growth rate and regeneration success, which finally can lead to extinction due to the lack of ability to cope with changes in climate.

Analyses of past climate changes provide valuable information about the ability demonstrated by certain Mediterranean species to migrate, in-situ persist or become extinct under sharpe changes in climate conditions. This enhances our understanding of forest ecosystems' dynamics and allows to define more clearly and with greater certainty suitable adaptation strategies in the face of future climate conditions.

A study lead by IDAF[44] has analyzed the projected changes by 2050 under B1 and A2 IPCC scenarios in the distribution range of 20 native forest species. Based on this study, we have prepared the following table including 15 analyzed species that are common in the different bio-climatic zones of the SBRL:

Species	Current & future potential distribution range						CC Impact and FLR recommendation
	Shouf side (SS)			W. Beqaa (WB)			
	MM	SM	OM[45]	MM	SM	OM	
Acer obtusatum	↓	↑		↓	↑		• Upwards migration • Seedling planting (current distribution range & above)
Acer tauricolum			↓			↓	• SBRL: area with highest future potentiality in Lebanon • Narrowing distribution range in WB • Seedling planting (current distribution range)
Arbutus andrachne	↓	↑↑			↑		• Upwards species migration •Seedling planting (current distribution range & above)
Cedrus libani		⊘	↓				• SBRL: area with highest future potentiality in Lebanon • Narrowing distribution range • Seedling planting (current distribution range), avoiding sites affected by strong wind
Crataegus spp.	⊘	↑↑	↓↓	⊘	↓	↓	• SBRL: area with highest future potentiality in Lebanon • Upwards species migration • Narrowing distribution range in WB •Seedling planting (current distribution range & above)
Juniperus drupacea		⊘	↓		⊘	↓	• SBRL: area with highest future potentiality in Lebanon • Narrowing distribution range • Seedling planting (current O. distribution)
Juniperus excelsa							• Narrowing distribution range in WB • Seedling planting (current distribution range)
Juniperus oxycedrus		↓	↑	⊘	↓	↓	• SBRL: area with highest future potentiality in Lebanon • Upwards species migration • Narrowing distribution range in WB •Seedling planting (current distribution range & above)
Pinus brutia	↓	↓	↑	(S[46]) ↓	(S)	↑	• Upwards species migration • Northwards species migration in the WB •Seedling planting (current distribution range & above)
Pistacia spp.	↓	↓	↑	(S) ↓	(S)	↑	• Upwards species migration • Northwards species migration in the WB •Seedling planting (current distribution range & above)
Prunus ursina		↓↓	↓		(S) ↓↓	(S) ↓	• SBRL: area with highest future potentiality in Lebanon • Upwards species migration • Narrowing distribution range in WB •Seedling planting (current distribution range & above)
Pyrus syriaca	↓↓	↓↓	↑	(S) ⊘	(S) ⊘	↑	• SBRL: area with highest future potentiality in Lebanon • Upwards species migration • Narrowing distribution range in WB •Seedling planting (current distribution range & above)
Quercus calliprinos	↓	↓	↑		↓	↑	• Upwards species migration • Narrowing distribution range in WB •Seedling planting (current distribution range & above)
Quercus infectoria		↓↓	↑	⊘	↓↓	↑	• SBRL: area with highest future potentiality in Lebanon • Upwards species migration • Narrowing distribution range in WB •Seedling planting (current distribution range & above)
Styrax officinalis	↓↓	↓↓	↑	↓↓	↓↓	↑	• Upwards species migration • Narrowing distribution range in WB •Seedling planting (current distribution range & above)

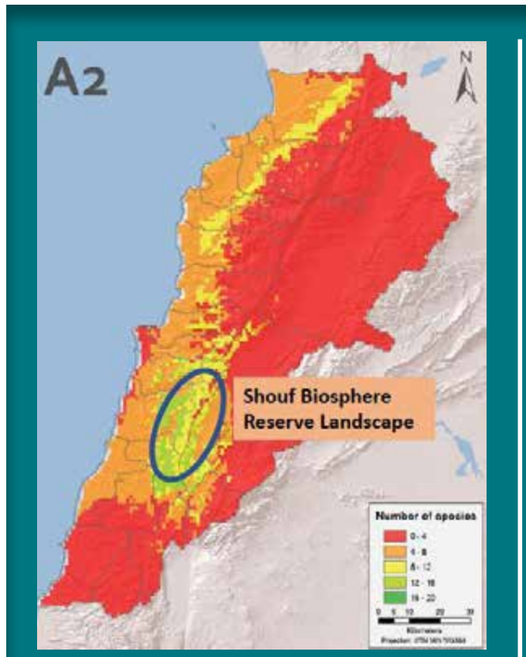
Symbols:

- Current high distribution range potentiality
- Current medium to low potentiality
- Future medium to low potentiality
- Future high potentiality
- ↑ Low to mid future potentiality increase
- ↑↑ High future potentiality increase
- ↓ Low to mid future potentiality decrease
- ↓↓ High future potentiality decrease
- ⊘ No future potentiality

According to IDAF study (based on the 20-native species analyzed), in 2050 the SBRL will have the highest potential species richness (A2 scenario) in Lebanon. It looks like the SBRL will act as a refugee for numerous tree species, which increases the importance of having established this protected area, and of strengthening the conservation actions in this biosphere reserve in the future. A number of areas in the Mediterranean region (e.g. The southern extremes of the three peninsulas, Iberia, Italy and Greece) acted as refugia for tree taxa during the changes in climate conditions over the last full glacial (ca. 100,000 – 16,000 years ago), role that the SBRL could fulfill in the future.

[43]: Regato, Pedro. 2008. Adapting to Global Change: Mediterranean Forests. Malaga, Spain: IUCN Centre for Mediterranean Cooperation. ii+254 pp.
[44]: Navarrete Poyatos, M.A. et al (2014) Climate change impacts on native tree species distribution in Lebanon : Potentiality projections to 2050. IDAF.
[45]: MM: Meso-Mediterranean Bio-climatic Level (> 1,000 m a.s.l. in the SBRL); SM: Supra_mediterranean BL (1,000-1,500 m a.s.l.); OM: Oro-Mediterranean BL (1,501-1950 m a.s.l. in the SBRL).
[46]: S: Southern half of the West Bekaa

Potential species richness in 2050 in Lebanon and the SBRL, according to A2 scenario [47]



Old-growth cedar forest stand in Barouk

Other conclusions that we can extract from the climate change modeling and field observations regarding forest ecosystems in the SBRL are:

- According to modeling results, it is projected that few analyzed species (e.g. *Juniperus excelsa, Acer tauricolum, Prunus ursina*) remain quite stable in terms of potential distribution area. In fact, current tree flora in the Mediterranean region flora is made up of very resilient old taxa that have already experienced many abrupt and intense climate changes in the past, being able to maintain quite stable populations through periods where climate conditions have changed[48]. These types of species may be quite resilient to future changes in climate.
- Tree and shrub species with southern range margins in the Mediterranean basin have the bulk of their genetic diversity in their so-called *rear-edge* populations, although these represent a small fraction of their distribution range. Mount Lebanon, and more specifically the Shouf region, hosts rear-edge populations of a number of tree species, such as *Ostrya carpinifola and Abies cilicica* in the northern half of the range, and *Cedrus libani, Acer tauricolum and Juniperus* excelsa in the SBRL.

[47]: Figure from Navarrete Poyatos, J.M. et al (2014), modified with the inclusion of the SBRL location.
[48]: Petit JP, Hampe A, Cheddadi R. (2005) Climate changes and tree phylogeography in the Mediterranean. TAXON, 54(4): 877-885.

Under a climate change scenario, the great stability and genetic diversity of the numerous "rear-edge" tree relic populations scattered along the Mediterranean mountain landscapes – such as the SBR landscape - are extremely important for in-situ conservation strategies as the best climate change adaptation measure.

- Shifts in species distribution ranges in respose to changes in respose to warming have been described in palaeo-historical climate changes and are already observed in a number of Mediterranean mountain regions due to current climate change trends (e.g. the shiftinh of *Pinus halepensis* 200m upslope in the mountains of southern France, occupying the lower altitudinal range of *Pinus sylvestris*[49]; the shifting of *Fagus sylvatica* 70 m upwards with its replacement by the evergreen oak *Quercus ilex* in the Montseny BR in NE Spain[50]). In the case of the SBRL, it is projected that a number of species from the Meso-Mediterranean bioclimatic level, such as *Acer obtusatum* and *Arbutus andrachne*, will shift upwards into the Supra-Mediterranean level, and species from the Supra-Mediterranean level, such as *Crataegus azarolus, C. monogyna, Pyrus syriaca, Quercus calliprinos, Q. infectoria and Styrax officinalis*, will shift upwards into the Oro-Mediterranean level. Migration capability is dependent on each species' seed production and dispersal strategies, which may be limited. Thus, a good adaptation measure would be to facilitate the upwards movement of these species by planting seedlings in a range of about 200 meters above their current distribution limit, or by planting scattered patches of seedlings from these species at higher altitude, from where they can accelerate their future dispersion needs.
- In the case of species with a distribution range at the highest bio-climatic level (Oro-Mediterranean) in the SBRL, such as *Cedrus libani* and *Juniperus excelsa,* the lack of space for upwards migration will lead to the marrowing of their distribution range. A good adaptation strategy in this case would be that of increasing the conservation efforts of the existing well-preserve species populations and habitats, and seedling planting in degraded areas to expand/enrich the habitat and facilitate connectivity among isolated populations.

The FLR implications for climate change adaptation arising from this analysis may be summarized as follows:

a) As an important refugial area with high potentiality for future distribution range of a high number of species, the increase and strengthening of biodiversity conservation efforts in the SBRL becomes a must. The SBRL could become a national observatory to monitor global warming, with the establishment of a permanent system for monitoring the effect of climate change on biodiversity, as part of a Mediterranean-wide regional network. The knowledge and capacity of ACS staff about the conservation status and monitoring of rare species populations should be built in cooperation with national research centres and as part of a regional network efforts.

b) Conservation efforts in the buffer zone of the SBRL should match sustainable, adaptive management measures – forest and agriculture biomass management and fire prevention - to reduce anthropogenic drivers of biodiversity loss, and increase resilience against climate risks, mainly heat waves/forest fires and drought/forest dieback.

c) Seedlings and seeds from species whose distribution range is projected to shift upwards should be part of the target species for planting interventions in areas about 200 m above current distribution area, mixed with other species whose current distribution coincides with the plantation site. In this way, the future need for species migration at high altitudes is accelerated, without drastically altering the floristic composition of the current ecosystem in the intervention site (precautionary approach, as it is not known one hundred percent what the future response of the species will be to the changes in the weather).

d) It is recommended to perform seedling/seed planting, from species whose distribution range is projected to shift upwards, in vast pasture areas without woody vegetation, by creating small patches, temporarily fenced, scatterly distributed in the landscape, becoming seed dispersion islets that will facilitate the future migration needs at higher altitude areas. This also responds to an urgent need to improve pasture management, with the increase of woody species - especially oaks - that provide high quality food (e.g. acorns and leaves) and shelter for livestock in the summer-autumn period.

e) In the case of species that inhabit the upper altitudinal limit and that cannot migrate at higher elevations, whose distribution area will narrow due to climate change – as is the case of *Cedrus libani* and *Juniperus excelsa* – it is advisable to plant seedlings making a good selection of the planting sites, to avoid extreme environmental conditions (e.g. very poor soils; exposure to strong winds) that question the future survival of the plants. It is also recommended to enrich degraded habitats with seedling/seed planting and promote connectivity among isolated relic populations.

IV.1.2. Multi-purpose FLR Goal to Build SBR Landscape Resilience

Building landscape resilience to climate and anthropogenic disturbances through FLR in the SBR landscape involves interventions at different levels that are interdependent with the multi-purpose goal of increasing ecological, social and cultural resilience and promoting sustainable development.

[49]: Vennetier M, Vila B, Liang EY, Guibal F, Ripert C, Chandioux O. (2005) Impacts du changement climatique sur la productivité forestière et le déplacement d'une limite bioclimatique en région méditerranéenne française. Ingénieries, 44, 49-61.
[50]: Peñuelas P, Boada M. (2003) A global change-induced biome shift in the Montseny mountains (NE Spain). Global Change Biology, 9(2), 131-140.

FLR Objectives in the SBR Landscape		
Objective 1	Enhance the ecosystem services provided by ecosystems in the SBR Landscape through the setting and consolidation of best practices on ecosystems' restoration, management and conservation that incorporate innovation and climate adaptation	
	Ecological Resilience	• Adaptive management of forest biomass reduces the risk of climate-related risks (e.g. forest fires, pest and death of trees). • Innovative plant production and field restoration techniques reduce water stress and increase soil water storage. • Restoring abandoned terraces improves landscape water regulation and reduces soil erosion. • Diversified restored ecosystems increase genetic diversity and trophic interactions, becoming more resilient to climate and human disturbances
	Socio-economic Resilience	• Adaptive management of forest biomass and agriculture waste create opportunities for green local businesses and employment. • The restoration of diversified natural ecosystems and agriculture terraces increases the economic opportunities linked to firewood, wild edible/medicinal/cosmetic plants, and organic agriculture value chains.
	Cultural Resilience	• Restoring ecosystem services through innovation helps adapt traditional cultural practices to the modern context and revive the cultural identity. • Restoring flagship species populations (e.g. cedars, Nubian ibex) enhance the cultural heritage and identity of the SBR communities.
Objective 2	Empower institutional and grassroots actors in the SBR landscape to sustainably manage, conserve and restore natural and semi-natural ecosystems	
	Ecological Resilience	• Sensitized, skilled and strong organizations and individuals, with good knowledge on sustainable management and green growth, are basic to stop and reverse ecosystem degradation and biodiversity loss.
	Socio-economic Resilience	• Skilled organizations and individuals will develop green businesses for high quality products (briquettes plant; tourism enterprises; NTFP cooperatives; livestock and agriculture producers) with a gender focus. • Forest restoration and management provide new job opportunities for young unemployed and Syrian refugees.
	Cultural Resilience	• Strengthening the capacity of local people to innovate and adapt traditional cultural practices to modern conditions, enhances the local identity as a quality brand in front of consumers. • Cross-fertilization through exchanges with other actors in the Mediterranean region with knowledge and experience in reviving similar cultural practices.
Objective 3	Promote green growth through economic diversification and development of value chains for organic agriculture, livestock and forest products, based on the appeal of the local identity	
	Ecological Resilience	• Green growth based on the sustainable use of natural and semi-natural ecosystems prevents landscape degradation and biodiversity loss. • Transforming waste into economically valuable products increases the resilience of natural and semi-natural ecosystems to climate-risks.
	Socio-economic Resilience	• Restored and sustainably managed ecosystems provide more goods and services for developing higher quality value chains. • Supporting small local businesses for the marketing of briquettes reduces households' energy costs, pollution and health problems by substituting fossil fuel energy sources. • A diversified economy around the goods & services provided by the ecosystems increases the adaptive capacity of local communities to climate-risks.
	Cultural Resilience	• Green growth around traditional cultural practices and eco-tourism raise awareness and value the cultural heritage and identity of the SBR landscape.
Objective 4	Mainstream FLR best practices into policies and regulations concerning natural resources management and spatial planning in the SBR landscape, through policy dialogue	
	Ecological Resilience	• Improved policies and regulations and enforced implementation will increase the sustainable management of natural resources.
	Socio-economic Resilience	• An effective policy framework incorporating FLR knowhow will provide economic incentives for land users to shift from maladaptive to sustainable practices and to restore degraded systems.
	Cultural Resilience	• Legal support to the traditional cultural practices and governance systems helps value the cultural identity at the national level.

FLR vision for a resilient SBR Landscape:

"A highly diverse and functional SBR landscape that is internationally recognized as the repository of a rich cultural heritage linked to its natural resources and emblematic species - especially the national symbol *Cedrus libani*... that sustains healthy ecosystems and viable populations of biological species resilient to environmental risks ... and whose restored ecosystem services support the economic, cultural, and spiritual needs of local communities"

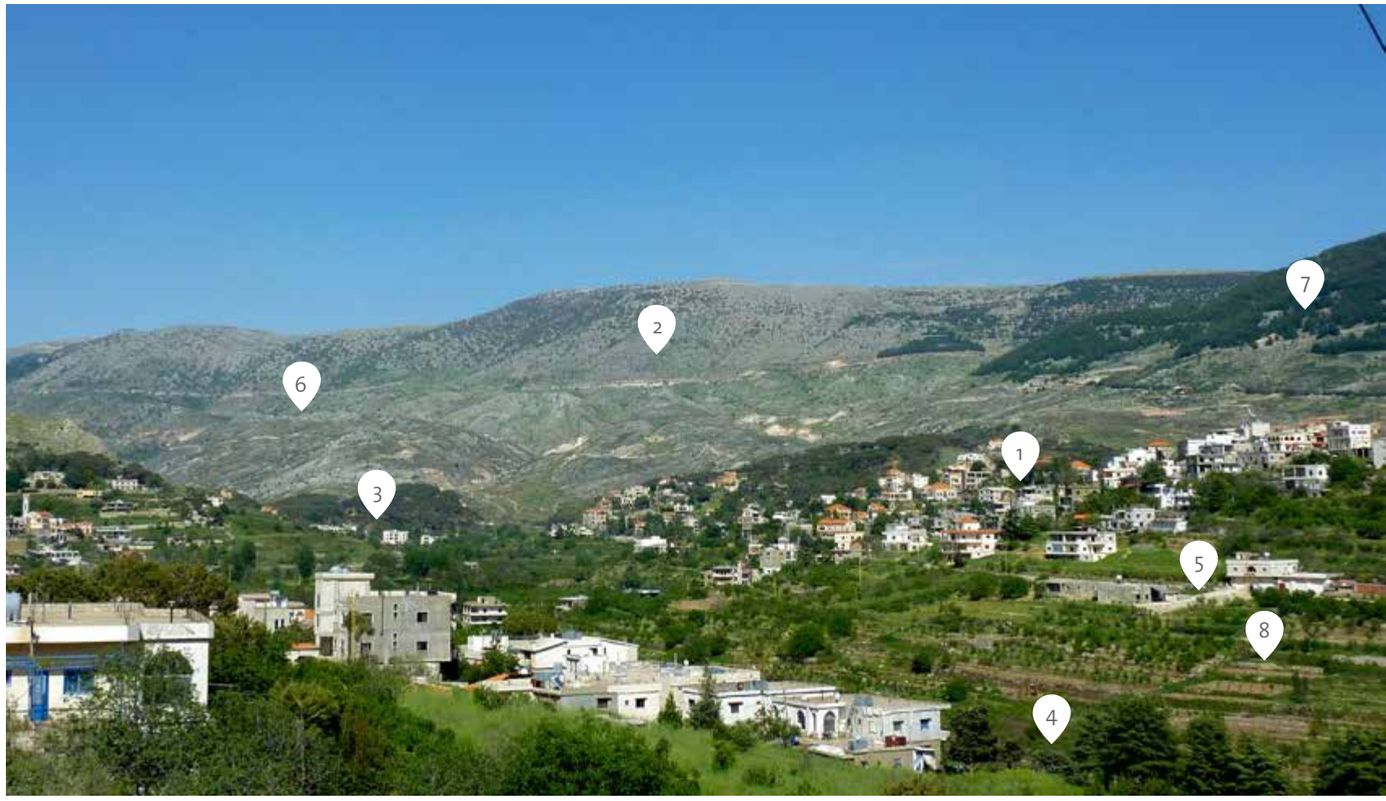
- ✓ The connectivity, functionality and diversity of the SBR mountain ecosystems is restored, building resilience against climate change impacts, and supporting the species adaptation needs.
- ✓ The large herbivore population (Nubian ibex) of the SBR landscape is restored, resulting in a balanced predator (*wolf, caracal, hyena*) - prey (*Nubian ibex, wild boar*) food web, which has a profound positive effect on the surrounding plant, bird, and mammal communities throughout the landscape.
- ✓ The governance of short-distance transhumance system is restored and adapted to current socio-political context, with an harmonic human-wildlife interaction, improved pastureland and water availability, and an effective rotation-resting livestock management.
- ✓ Oak and pine forests are adaptively managed with the conversion of excesive biomass into bioenergy (briquettes), the improvement of forest growth and carbon storage, and the consequent reduction of fire risk and death of trees due to water stress and diseases.
- ✓ Traditional agriculture terraces systems and related semi-natural habitats are restored, supporting critical ecosystem services – hydrologic regulation, soil fertility, micro-climate, pest-control, fire-break - recycling agriculture waste for bioenergy and compost production, and producing high-value, diversified crops of wild culinary plants and local fruit varieties with a crop-livestock intergrated management approach.
- ✓ The local economy is enhanced and diversified – local businesses and employment creation with a gender and youth focus – based on green value chains of forest, agriculture, livestock and tourism-related products resulting from FLR interventions, targeting the local, national and international markets.

1- Supporting effective governance & participation

2- Restoring ecosystem services

3- Adaptive management for climate-risk reduction

4- Improving water conservation & harvesting



5- Transforming waste into a good & reduce pollution

6- Managing human-wildlife interactions

7- Enhancing biodiversity & cultural values

8- Green Growth & economic diversification based on local identity

FLR Principle V: Invests in 360º Capacity Development and Knowledge Generation

V.1 Capacity Development

V.1.1. Building the Capacity of All Concerned Actors

FLR is a new concept with very limited experience in terms of implementation. Modern approaches on forest and landscape restoration are very recent and much work is needed to build the capacity of all practitioners (Govt, NGOs, land users and managers, private enterprises) to acquire the necessary skills to implement best restoration practices in drylands. The FLR work in the SBR has adopted a "continuous" training strategy that integrates knowhow on FLR from other Mediterranean regions with comparable socio-economic contexts and landscape degradation problems, as well as the best practices developed in the SBR.

Training of Trainers: Key issues for the training programmes were identified in a participatory way with the representatives of the FMCs in the early stage of the project, including the following topics: FLR principles, components and methodologies; forest biomass management; creation of nurseries for seedlings of plants with high economic value; field restoration techniques; the development of forest management plans; fire prevention and management issues; land use planning linked to the biosphere reserve zones; hunting and the new hunting law; organic agriculture production in terraces with special focus on aromatic plants, fruit trees and vegetables, and addressing soil preparation, irrigation, fertilization, integrated pest management; honey and wild edible plants harvesting, processing and marketing. The international and national experts hired by ACS developed training materials and provided training to ACS staff, FMCs members, farmers, forest managers, members of women cooperatives and other local organizations. Training tools were later used by ACS project staff to provide continuous training to all users involved in the FLR restoration, management and value chain development actions.


Training on forest biomass management


Training on forest biomass management


Training on apiculture


Training on aromatic plant processing


Syrian refugee woman trained on forest restoration


Training on dry stone wall terraces restoration


Training on sustainable agriculture production


Training on aromatic plant cultivation

Capacity development and employment opportunities for vulnerable population: The project has invested significant resources to create employment opportunities for young unemployed, with a special focus on vulnerable local families receiving food assistance and Syrian refugees. The project has applied a "learning-by-doing" approach, combining theoretical sessions given in the Park Office, with practical field training sessions. Farmers, unemployed young and Syrian refugees – both women and men – were professionally trained on forest thinning, forest restoration planting techniques, dry stone wall construction, compost production, charcoal production, rehabilitation of water reservoirs, and the construction and conditioning of nature trails and other ecotourism-related infrastructures. Field training has been supported a foreman - well trained and with good knowledge on the subject - who has guided the practical work carried out by the participants.

Thanks to a partnership with the WFP, funded by BMZ, ACS was able to upscale this work. Through this joint venture, the WFP "cash for food e-cards" programme was applied for the first time to the training of skilled workers among vulnerable population groups – Syrian refugees and local families receiving food assistance - in areas of employment related to FLR priorities to build landscape resilience to climate change in the SBR.
The training programme had a major gender- and poverty alleviation focus: in 2018, it involved 88 women (23.4% of the total participants), of which 69 were Syrian refugees. The total number of participants was 376 people, from which 67.5% were Syrian refugees. The training was organized in cycles with periodic sessions over several months. The people who received training got a certificate that shows that she/he has acquired good knowledge and qualified in the specified profession.

Cash for food e-cards training and employment programme in the SBR Landscape (2018 data about participants)			
	Lebanese	Syrian refugees	All
Number of male (Shouf side)	60	112	172
N° male (West Beqaa side)	43	73	116
N° female (Shouf side)	15	49	64
N° female (West Beqaa side)	4	20	24
Total N° participants	122	254	376
% female	15.6	27.2	23.4
% male	84.4	72.8	76.6

As a result of the learning-by-doing training programme, 16 ha of forests were thinned, 20 tons of briquettes were produced, 420 m2 of drystone walls were restored, 10 km of nature trails were established, 69,000 tree seedlings where planted, and agriculture production in the restored terraced was initiated. A number of trained people were able to find jobs beyond the project's interventions. From the evaluation of the capacity development programme, it appeared that the women interviewed have acquired self-confidence and are happy to generate income to support the family needs. Some refugees mentioned that the acquired qualifications will be very useful when they return to their country. An important positive effect of the mixed training cycles involving both men and women is that men were more motivated and worked more efficiently.

Strengthening the capacity of the SBR managers through regional networking: ACS staff and the national and international experts that collaborated in the implementation of FLR in the SBR landscape, have benefited from annual training courses in the framework of several Mediterranean-wide networking initiatives. Within the framework of the Mediterranean Mosaics project, two annual training courses were organized, one in 2016 (hosted by the partner organization ILEX in the Sirente-Velino Natural Park) and another one in 2017 hosted by ACS in the SBR landscape.

These 3-days learning courses had a very practical approach and training was provided by: (i) managers of the Regional Natural Park of Luberon in France, with best practices in natural resource management and climate risk reduction, especially the use of grazing to reduce the risk of fire; (ii) agricultural entrepreneurs from Spain and Italy with experience in innovation and development around green value chains and economic diversification combining eco-tourism and the marketing of food products, approaching producers and consumers, and increasing the economic benefit of the goods and services provided by the enterprise; (iii) Experts from *Altro Mercato* (Italy) involved in fair trade linking environmentally-sound and social-beneficial projects that support vulnerable local communities in the production of goods and services oriented to an international market ; (iv) researchers from Italy with high experience in watershed restoration and integrated management, and from Spain (CEAM Research Institute) on fog water harvesting, and ecosystem restoration in drylands; (iv) BirdLife experience in the modelling of climate change impacts and identification of adaptation options for mountain and wetland ecosystems and bird species.

Further training opportunities took place in the framework of the MEDFORVAL network, involving 18 high ecological value forest landscapes throughout the Mediterranean region. Three annual training courses took place from 2015 to 2017, with network members providing best practices on several FLR-related issues.

V.1.2. Knowledge Generation

The project has produced a number of printed materials and videos providing guidelines for the planning and implementation of several-FLR related issues:

- **Sustainable Forest Management Trail Book:** This trail aims to guide visitors throughout important areas in the SBR landscape where sustainable forest management and livestock grazing activities occur. The trail links the village of Batloun, Barouk-Fraidis, Maasser el-Shouf and Botmeh.
- **Water and Climate Change Assessment of the SBR landscape:** this booklet is an assessment of the water needs and gaps in the SBR landscape, that provides guidelines on water management and conservation – not just for human consumption, but also for ecosystem restoration, wildlife, agriculture, and firefighting. It was started by ANTEA Group and completed by MORES s.a.r.l., in collaboration with local stakeholders, under the supervision of ACS team. Nestle Waters, supported the whole process.
- **SBR Management Plan**, including the vision and objectives for the management of the reserve.
- **Restoration Plan – Mediterranean Mosaics Project SBR:** It provides guidelines for the planning and implementation of different forest restoration interventions in the SBR landscape, and the production of high-quality seedlings.
- **Thermal Biomass for Lebanon:** it provides information about innovative methods to improve the use of forest biomass and agriculture waste in a sustainable way, with a major focus on climate change mitigation and adaptation, and supporting the development of local enterprises and employment opportunities.
- **The Economic Value of the SBR Landscape:** this is the first economic valuation of ecosystem services in Lebanon, under the leadership of ACS and the support of IUCN.
- **Ecotourism Strategy for the SBR.**
- **Marketing and Business Plan for Rural Products.**

Short tutorial videos were produced to guide practitioners in the implementation of field restoration works, seedling production in the nurseries, climate-adaptive forest thinning operations, and the production of briquettes from forest biomass and agriculture waste. All publications and videos are available in the web page of the SBR: *http://shoufcedar.org/front-page/publications-2-2/*

The results of the FLR initiative in the SBRL have been introduced in different international forums, such as the IUCN World Congress (Hawaii, September 2016), the XV OPTIMA MEDITERRANEA Meeting (Montpellier, June 2016), the 5th Mediterranean Forest Week under the Collaborative Partnership on Mediterranean Forests (Agadir, March 2017), and the CBD COP 14 (Egypt, November 2018). A paper with preliminary FLR results was published in the international journal Plant Sociology[51] , and relevant information on FLR in the SBRL has been included in the FAO publications *The State of Mediterranean Forest 2018* and *Unasylva Vol 66 (2015)*.

[51]:Hani, N. Et al (2017) Adaptive forest landscape restoration as a contribution to more resilient ecosystems in the Shouf Biosphere Reserve (Lebanon). Plant Sociology, Vol 54. Suppl 1.

V.2. Environmental Education

Education and youth engagement are essential for the long-term sustainability of FLR implementation. Environmental education is an ice-breaking tool, and effective way to bring people together and discover common goals for the conservation and sustainable use of natural resources. Environmental education activities with children generate interest in their parents, who indirectly participate and become proud of their children's work. This has a catalytic effect, making adults aware, through their children, and more active in improving the use of natural resources.

ACS team has undertaken a number of environmental education activities, involving teachers and students from several public and private schools in the SBR municipalities. The education activities provided training to school teachers on key environmental issues related to the SBR and the FLR-related initiatives, and supported them in the organization of classes and field visits to the SBR to learn about different environmental issues. We can highlight the following two initiatives:

The Green Passport Environmental Journey : ACS and the USAID-funded Lebanon Reforestation Initiative (LRI) organized a four-day Green Passport activity that started on August 2017 in the SBR landscape. Fifty children including Lebanese, Syrian refugee and children with special needs from different SBR municipalities visited important natural and cultural sites in the four municipalities - Barouk, Ain Zhalta, Niha and Maaser El Shouf (where the 4 entrances to the SBR are located). They learned about the importance of preserving forests, water and wildlife, the cultural heritage and the economic uses of forests such as biomass production, beekeeping and the harvesting and use of wild plants. In addition to the knowledge they acquired, participating children expressed in several live testimonials their happiness in meeting other children from neighboring towns as well as children of Syrian refugees. Parents also expressed appreciation for the activity in building linkages among diverse communities and in increasing their children's environmental awareness. Moreover, the children played a catalytic role in positively influencing the attitudes of their parents, relatives and communities regarding the importance of nature conservation and the sustainable use of natural resources.

Raising awareness on endangered species (caracal)


Learning about native plant species

Rally for Nature event in the Shouf cedar forest


Children planting oak seedling

Rally for Nature: An annual awareness activity entitled 'Rally for Nature' is conducted by ACS with the objectives of: (i) familiarizing the students and building up their knowledge on the importance of forests and biodiversity; (ii) reconnecting the young generation with nature; and (iii) exploring the trails of the reserve. For instance in 2018, ACS and the USAID-funded Lebanon Reforestation Initiative (LRI) organized environmental education sessions in nine public schools in the SBR region, involving 105 students. The sessions' themes were Biodiversity, Solid Waste Management, Water Conservation and Management, and Forest and Agriculture Biomass Management and Use for Bio-energy. Students attended the "Rally for Nature" activity, a one-day event that allowed an examination of how much knowledge the students had assimilated.

The rally was organized in the municipality of Ain Zhalta on April 21, involving 20 volunteers from 9 schools. The results of a written quiz game were reviewed and the results announced. Each student in the winning group won a 3D puzzle as a gift. Certificates of participation were distributed to all students and volunteers.

FLR Principle VI: Considers a Wide Range of Implementation Options with a Cost-benefit Approach

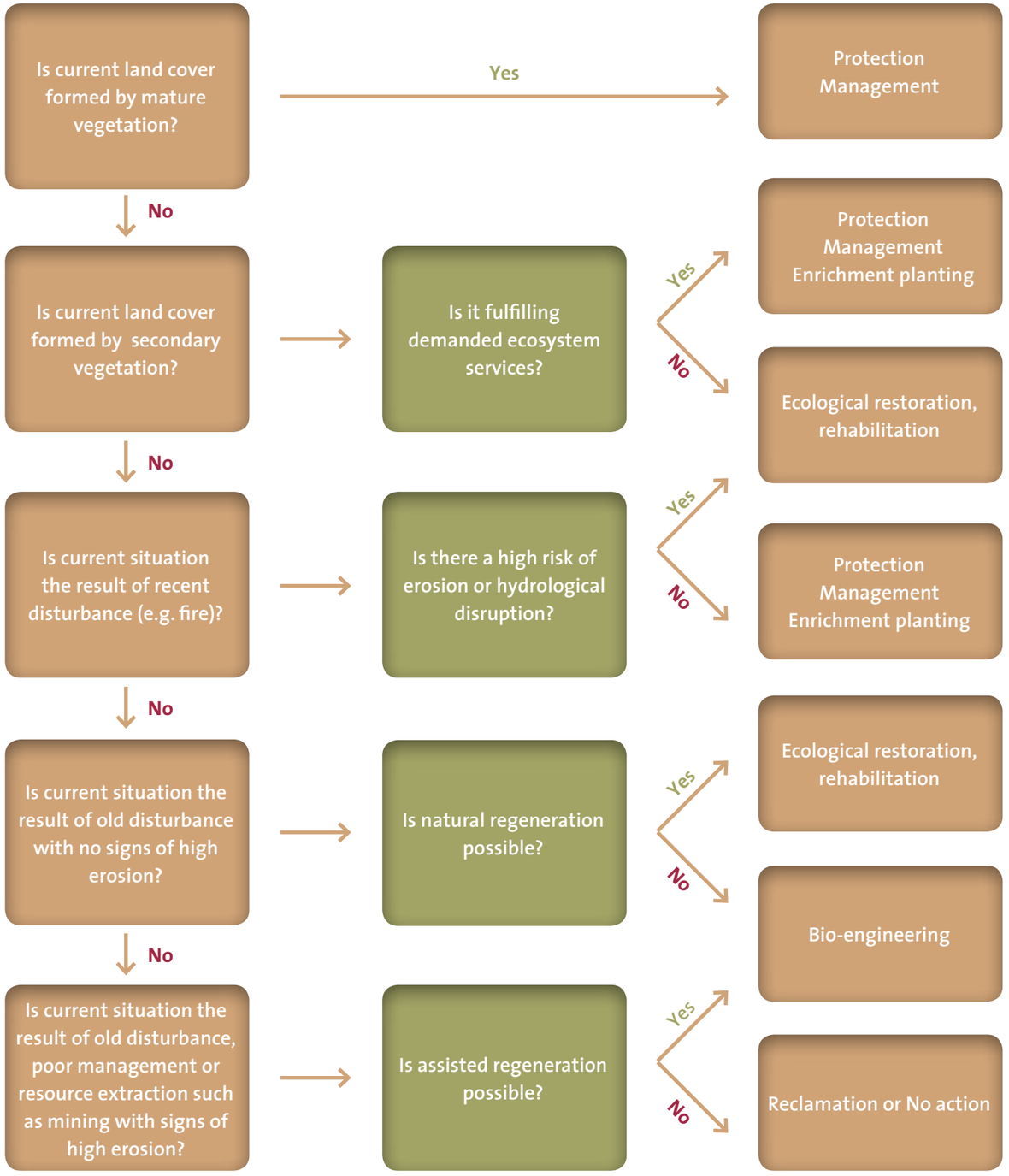
VI.1 Select the Type of Restoration Interventions

VI.1.1. Carefully Assess Active Restoration Needs

In most cases forest landscape restoration consists of a combination of protection, management and active planting measures within the landscape. Protection and management interventions may be very effective in the early stages of landscape degradation and very often are very affordable actions in terms of costs. Active restoration interventions, such as seedling planting, may be required when natural ecosystems require support to enhance regeneration and species diversification in degraded areas. A cost-benefit analysis must precede the decision to adopt this costlier measure. In fact, the need for active restoration should be carefully assessed at the site level, and, if land degradation risks do not require urgent seeding/plantation actions, it may be desirable to first monitor the results of protection/management interventions before deciding what will be needed. It may result that no active restoration is needed rather enriching planting activities may be all that is required. This will result in a substantial reduction of costs and site alteration. In highly degraded areas with evident signs of soil erosion direct restoration interventions may be extremely costly and become unaffordable. In such cases the company that exploits/destroys the territory must be required to finance its restoration – as it is the case of the quarries and sand extraction companies in the SBR.

Bio- engineering: Restoration techniques that rely on biological knowledge to build geotechnical and hydraulic structures and to secure unstable slopes and banks. Whole plants or their parts are used as construction materials to secure unstable sites, in combination with other (dead) construction material.
Ecological Restoration: The process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed (SER 2004).
Enrichment planting[52]**:** The planting of desired tree species in a modified natural habitat or secondary vegetation type with the objective of creating a vegetation unit with higher species diversity and/or dominated by desirable species.
Forest restoration: To restore a degraded forest to its original state – that is, to re-establish the presumed structure, productivity and species diversity of the forest originally present at a site.
Reclamation: Generally, reclamation aims at converting land damaged through resource extraction, such as sand or stone quarries, or poor management, to a productive use. Using native plants for revegetation and mimicking naturally occurring plant communities help to achieve these goals and brings the damaged land back to a stable condition.
Rehabilitation: To restore the capacity of degraded forest land to deliver forest products and services. Forest rehabilitation re-establishes the original productivity of the forest and some, but not necessarily all, of the plant and animal species thought to be originally present at a site.
Secondary vegetation: herbaceous or woody vegetation re-growing on land than was previously disturbed (e.g. burned land) or largely cleared of its original vegetation cover. Secondary Pinus brutia and Quercus spp forests and scrubland commonly developed naturally on abandoned agriculture terraced land.
[52]:Rietbenger-McCracken, J. et al. (Eds) (2007) The Forest Landscape Restoration Handbook. Earthscan. London.

Carefully assess active restoration (direct planting of seedlings, cuttings and/or seeds) needs, and, if not clearly required, implement and monitor the results of less-costly protection and management interventions, or combine the three type of interventions.



VI.1.2. Defining FLR Priority Interventions for the SBR Landscape

Based on the mapping exercise, field assessments and consultation with experts and project partners, the following FLR priorities were identified for the different land use/land cover types:

Land Use/Land Cover Type	FLR Priority Intervention
Agriculture land	
Dry stone wall agriculture terraces under production (e.g. olive trees, fruit trees)	• Ecologically sound crop production techniques to improve soil and water conservation and prevent pollution (e.g. compost soil fertilization, integrated pest management, minimum till, soil mulching).
	• Integrated crop-livestock farming to improve soil nutrient cycling, avoid the use of herbicides and diversify production.
	• Diversify existing crops with a mixture of drought-resistant trees, shrubs and herbal species from edible wild species and local crop varieties, to improve soil fertility, reduce pests and diversify production.
	• Gather the remains of olive/fruit tree pruning and olive pomace for the production of briquettes and compost. No waste burning must occur.
	• Enhance marginal habitats linked to the terraces, which harbours numerous species that are beneficial for farming production, such as spiders, wild bees, reptiles and amphibians, micro-mammals and birds.
Recently to mid-term abandoned agriculture terraces	• Restore degraded stone walls, making use of sound construction techniques and support its role as habitat for flora and fauna species.
	• Cultivate the restored terraces with climate-adapted native edible/aromatic/medicinal plants and local crop varieties, applying ecologically sound production techniques (e.g. compost soil fertilization, integrated pest management, minimum till, soil mulching), multi-crop production, and crop-livestock integration.
	• Preserve natural habitats in/around the restored terraces under production: (i) maintain patches of herbaceous communities in the cultivated area, especially those spots with high presence of orchid species; (ii) maintain ruderal vegetation in the borders of the terraces; (iii) maintain scattered native trees growing in the fields and the border of the terraces, specially the old-growth ones which represent "habitat trees", very important for bird and insect species that also act as natural enemies of crop and forest pests; (iv) while restoring the dry stone walls, incorporate seeds, rhizomes, bulbs, and other plant material of chasmophytic plant species – e.g. *Cyclamen persicum, Capparis spinosa, Asplenium spp.* - to enrich this habitat type; (v) while restoring water reservoirs, springs and river canals crossing the terraces, preserve the natural habitats and undertake enrichment planting if needed.
Long ago abandoned terraces colonized by tree/shrub shelterbelts, copses and open woodlands	• Avoid the conversion of already established forests into agriculture land.
	• Undertake thinning and pruning operations to clear too dense Brutia pine and oak wooded land with the multi-purpose objective to enhance the growth of remaining stems, reduce water competition among the stem that leads to dry biomass accumulation and increases fire risk, and create job employment and business development opportunities around bioenergy. Goat grazing should be combined with thinning/pruning to prevent the growth of the new shootings, also acting as a fire prevention measure. This type of management should be prioritized in high fire risk areas of the landscape, such as along the road network.
	• Assess the availability and economic value of non-timber forest products (e.g. edible, medicinal and cosmetic herbs, edible mushrooms, bee colonies), which are favoured by the thinning/pruning operations, and organize sustainable harvesting.

Agriculture terraces restored and under production

Recently abandoned agriculture terraces with shrubs

Old abandoned agriculture terraces with secondary pine and oak forest

Land Use/Land Cover Type	FLR Priority Intervention
	Shrubland
Shrubland in high mountain slopes	• Main area designated to forest restoration with the planting of seeds and seedlings (oak acorns) of a mixture of species of the reference ecosystems[53] - Cedar forest, *Quercus brantii* forest, Mixed cedar and *Quercus brantii subsp.* look forest, and copses of fruit trees *(Malus trilobata) and Acer hyrcanum sbsp. tauricolum.* • Main area designated to forest restoration with the planting of seeds and seedlings (oak acorns) of a mixture of species of the reference ecosystems - Cedar forest, *Quercus brantii* forest, Mixed cedar and *Quercus brantii subsp.* look forest, and copses of fruit trees (*Malus trilobata*) and *Acer hyrcanum sbsp. tauricolum.* • Restoration interventions should be prioritized in: (i) the concave zones of the northeast-facing slopes that are more protected to the effect of the dominant winds, have deeper soils and concentrate runoff water; (ii) the shrubland areas in between relic cedar stands to increase connectivity among them. • No interventions are recommended in the southwest-facing slopes, although the planting of wind-resistant species, such as *Juniperus excelsa, J. oxycedrus, Prunus prostrata, Berberis libanotica*, can be proposed for soil protection needs. • Restoration interventions with *Juniperus excelsa, J. oxycedrus, Prunus prostrata, Berberis libanotica* in the convex shoulders of the slopes with rocky outcrops and more superficial soils.
Cushion shrubland in low mountain slopes and hills	• Main area designated to forest restoration with the planting of seeds and seedlings (oak acorns) of a mixture of species of the reference ecosystems[54]- *Quercus calliprinos forest, Mixed Q. calliprinos and Q. infectoria* forest, *Pinus pinea* forests. • Establish small fenced plots of 0.25 to 0.5 for the planting activities in areas where livestock grazing occurs.

[53]:Reference ecosystems are sites with more or less evolved successional stages of the potential habitat type that we expect to emulate in the restoration site. The biophysical site conditions of the reference site closely match those of the restoration site. The species composition and structure of the reference sites can guide our decisions when selecting the species and methods used in our restoration sites.
[54]:Reference ecosystems are sites with more or less evolved successional stages of the potential habitat type that we expect to emulate in the restoration site. The biophysical site conditions of the reference site closely match those of the restoration site. The species composition and structure of the reference sites can guide our decisions when selecting the species and methods used in our restoration sites.


Low mountain cushion shrubland dominated by Sarcopoterium spinosum


High mountain shrubland with Styrax officinalis, Rosa sp., and Spartium junceum


Mountain summit cushion thorny shrubland

Land Use/Land Cover Type	FLR Priority Intervention
Pastureland	
Open pasture land at lower altitudes outside the core area	• Planting of oak acorns and seedlings - predominantly oak species together with azerole, wild pear, wild apple, stone pine, among other wild fruit trees – in small fenced areas of 0.25 to 0.5 ha if livestock grazing occurs, scattered throughout the pasture land, to increase food availability (especially acorns) when the grass is dry (late summer and autumn) and provide shelter to livestock during summer. • Create shelters by planting trees (same as previous) and shrubs (*Spartium junceum, Cistus spp.* In acid soils) in strategic places of open pastures (e.g. division between land users' pasture grounds; along ravines and roads) to increase food availability, shelter and soil water retention. • Enrich grass cover by seed sowing of highly palatable species proposed by shepherds (e.g. *Trifolium spp.*) as an important food for livestock to improve the production of milk. • Restore and/or construct small water reservoirs in critical areas to overcome water shortage and ensure water needs for livestock, and in this way avoid shepherd's temptation to illegally surpass the limits of the core zone in search of water.
High mountain open pastures with thorny cushion shrubs at higher altitudes inside the core area	• Prevent the entrance of shepherds with livestock to avoid conflicts with the reintroduced wild herbivore (Nubian ibex) due to competition for feeding resources. This implies the enforcement of zoning regulations preventing grazing near the border of the core zone, and negotiations with shepherds to facilitate grazing in the designated areas. • Enrichment planting: increase the diversity of palatable woody species for Nubian ibex, by planting seedlings (*Quercus spp, Rosaceae tree species, Rhamnus punctatus*) and oak acorns to increase food availability in open areas.
High mountain hygrophilous pastures in doline depressions	• Prevent the conversion of doline pastures into forest or other uses, as they represent a very unique habitat type, highly valuable for the refill of the underground water table.

Low mountain pasture, including abandoned agricultures

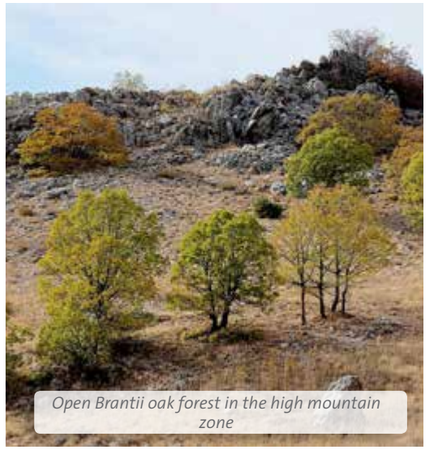
High mountain pasture with cedar seedling

High mountain hygrophilous pasture in doline depression

Land Use/Land Cover Type	FLR Priority Intervention
Forestland	
Scattered forest patches of *Sorbus spp. and Acer hyrcanum sbsp. tauricolum* in concave areas of high mountain summit and slopes	• Enrichment planting in concave areas, using a mixture of seedlings from Rosaceae tree species and maple to increase the presence of copses throughout the landscape.
Open *Quercus brantii* woodlands in high mountain slopes	• Enrichment planting using a mixture of Brantii oak seeds and seedlings of Rosaceae tree species and maple. Cedar seedlings can be planted under existing brantii oaks, which provides a nursery-effect facilitating seedling growth.
Dense *Quercus brantii* forests	• Cedar seedlings can be planted under existing brantii oaks, which provides a nursery-effect facilitating seedling growth. This is especially recommended in the oak forest patches in between the isolated cedar stands of Ain Zhalta and Barouk.
Old-growth cedar forests	• Full protection, with establishment and maintenance of trails for visitors, avoiding free walking through the forest understory to preserve mature soil conditions and biodiversity.
Cedar plantations with terraces (1960s and 1970s)	• Enrichment planting, using a mixture of brantii oak seeds, and seedlings from Rosaceae tree species and maple to increase diversity in mono-specific plantations. • Plan thinning operations in too dense almost mature plantations, to avoid future water stress and death of trees due to climate change trends. Discuss the potential risk of forest dieback with MoA if no thinning takes place in the mid-term.
Open *Quercus calliprinos* woodlands in mid mountain slopes	•Enrichment planting using a mixture of calliprinos oak seeds and seedlings from Rosaceae tree species (*Pyrus syriaca, Prunus ursina, Malus trilobata, Crataegus monogyna, C. azarolus*) and maple (*Acer obtusatum*).
Open stone pine woodlands in the sandstone hills and valleys at the foot of the main mountain massif in the west-facing side	• Enrichment planting using a mixture of stone pine and infectoria oak seedlings. • Avoid the burning of the forest understory to prevent soil erosion, and substitute with regulated grazing to control the growth of the forest understory.
Dense secondary coppice woodlands of *Quercus calliprinos and Q. infectoria*, mixed with Brutia pine at lower altitudes	• Undertake thinning operations to reduce fire risk and water stress among tree stems. • Regulate post-thinning Livestock grazing to avoid the growth of oak shootings in the thinned areas. • Discuss with MoA the possibility to compensate shepherds to undertake a fire prevention role in high fire risk areas (natural fire cuts maintained by grazing). • Assess the availability and economic value of non-timber forest products (e.g. edible, medicinal and cosmetic herbs, edible mushrooms, bee colonies), which are favored by the thinning/pruning operations, and organize sustainable harvesting.
Landscape Level	
Landscape connectivity	• Plan planting interventions in key areas of the landscape that enhance vertical connectivity – e.g. connecting forest habitat types along the altitudinal gradient, from Ammiq wetland in the Beqaa valley to the top of the mountain and the mosaic of agriculture terraces and forest patches in the Shouf side of the SBR landscape. • Establish and condition nature trails connecting the different restored cultural practices –traditional agriculture in terraces, adaptively managed forest stands and grazing areas - biodiversity hotspots and cultural sites in the SBR landscape.
Species migration needs	• Planting of small patches of oak acorns and seedlings of target plant species in small fenced areas of 0.25 to 0.5 ha if livestock grazing occurs, scattered throughout large barren areas in the SBR landscape to create “woodland islets” to enhance natural seed dispersal. The species will be selected based on the climate change projections, promoting their presence in future suitable areas.


Scattered patches of Sorbus spp. Prunus ursina, Acer hyrcanum sbsp. tauricolum in concave areas of high mountain summit and slopes

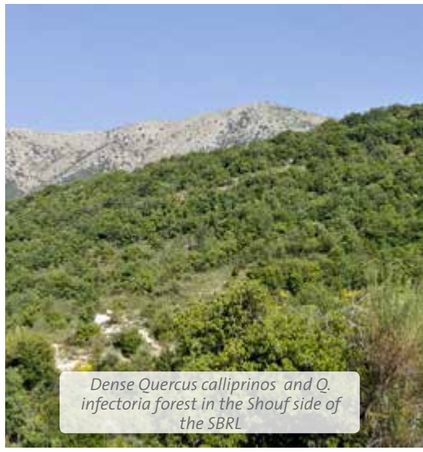

Dense brantii oak forest in the Beqaa side of the SBRL

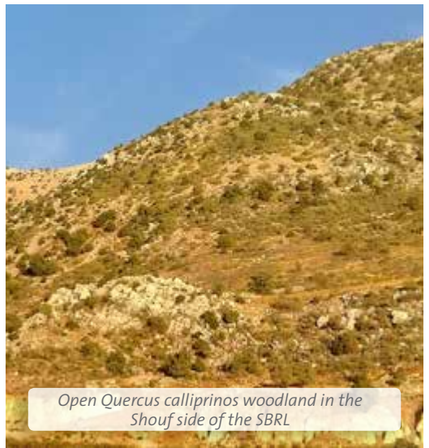

Open Brantii oak forest in the high mountain zone


Cedar and Brantii oak forests in the Shouf side of the SBRL


Scattered cedar forest stands


Cedar plantation


Dense Quercus calliprinos and Q. infectoria forest in the Shouf side of the SBRL


Open Quercus calliprinos woodland in the Shouf side of the SBRL


Open Pinus pinea forest near Ain Zhalta


Dense secondary Pinus brutia forest on abandoned agriculture land near Khreibe

Land Use/Land Cover Type	FLR Priority Intervention
	Freshwater areas
Riparian forests	•Prevent the construction of houses and recreational areas in the flooding area where riparian forests (alder, plane, willow, poplar, tamarisk, ash tree) occur.
Ammiq wetland	• Enrichment planting using a mixture of seedlings and cuttings from freshwater tree species, such as *Fraxinus angustifolia subsp. syriaca, Ulmus minor, Populus alba and Salix spp.* Tree planting has a double aim: (i) establish forest patches in several places of the wetland to create habitat conditions – shelter, nesting and observation place - for birds and other fauna; (ii) establish green barriers between Ammiq lake, the nearby main road and the agriculture land surrounding the lake. • Public-partnership agreement between ACS and land owners to promote organic agriculture in surrounding agriculture land – vineyards – as a way to prevent contamination of surface and groundwater with agrochemicals and health problems to fauna and the whole trophic chain.
Water springs	• Protect natural habitats around water springs. • Conduct water with pipes from some springs to downstream water reservoirs that are key as drinking troughs for livestock and to feed toilets in the entrances of the SBR.
Water reservoirs	•Restore abandoned reservoirs for the collection of runoff water and piped water from springs, as green infrastructures well integrated in the surrounding landscape.
	Barren land
Abandoned quarries	• Planting oak acorns – *Quercus calliprinos and Q. infectoria* - and seedlings from fast-growing species well-adapted to grow in loose, removed soils – e.g. *Rhus coriaria, Pinus pinea, Spartium junceum, Styrax officinalis, Capparis spinosa* – in in areas with slag heaps. • Planting fast growing tree species – e.g. *Pinus pinea, Cupressus sempervirens, Populus alba, Fraxinus syriaca* – as green barriers at the foot of the quarry cliffs. • Planting of seeds of chasmophytic plants – e.g. *Putoria calabrica* - in rock fissures and rough wall surfaces, to facilitate the creation of a new habitat in the denuded cliffs.


Water harvesting in water spring


Barouk small pond


Check dam to reduce water flow velocity and increase soil water infiltration


Ash tree forest in Ammiq lake


Limestone quarry


Sandstone quarry

VI.1.3 Developing the FLR Plan

A detailed restoration plan identifies the broad steps and list of actions needed to achieve successful restoration results, covering both the selection of specific restoration measures and the approaches and technologies used to implement them[55]. The development of the plan should involve all concerned stakeholders, defining their roles and responsibilities in its implementation and monitoring work.

The project has applied the *FAO's Monitoring and Reporting Tool for Forest and Landscape Restoration* in Drylands that was tested in 22 case studies worldwide, and reviewed and validated at two international workshops – Konya (Turkey) in 2012; Dakar (Senegal) in 2013. This comprehensive tool aims to guide project leaders in designing their projects, and implementers in reporting on and tracking the progress of restoration, analysing the elements of success and failure, and compiling the lessons learned for adaptive management and corrective actions.

The tool consists of an easy-to-complete form to be filled out by practitioners. The form is built around seven categories of information, described below. The tool can be used for reporting and monitoring on restoration initiatives at the country level. FAO is working to make it available as a web-based tool to be filled in online on a voluntary basis by practitioners and managers of restoration initiatives. Over time, this will enable the development of a database linking and supporting networking and lessons learned among a community of restoration practitioners and enablers worldwide.

Forest Landscape Restoration Plan Components[56]	
General information	User provide a one-stop summary of the restoration initiative's main attributes, such as its location, geographic extent. The involved stakeholders are identified, along with the nature of their contributions.
Area description	Users characterize the restoration area according to 5 criteria: 1) Climatic conditions and climate-related risks 2) Geomorphological, hydrological and pedological properties 3) Ecological properties (flora, fauna, fungi and trophic interactions; description of reference ecosystem in surrounding areas; description of vegetation cover in the restoration area). 4) Socio-economic context (e.g. land uses, land rights, income-generating activities) 5) Causes of degradation (historic and current; direct and root-causes)
Problem statement	Users explain what is needed and why, ideally with reference to similar projects carried out elsewhere with lessons learned.
Restoration objectives	Users state the multipurpose restoration objectives (ecological, economic, social, cultural) and related specific outcomes, outputs, actions and timeframe. The scope of the intervention as well as its contribution to broader initiatives is also described.
Supportive governance framework	Users assess the level of support for restoration provided by the governance framework. Stakeholder involvement should be detailed in a table showing roles and responsibilities. Information on local actors and providers of specific actions in capacity development, research, awareness raising and institutional development can be listed in this section.
Restoration strategy adopted	Users provide details about planned interventions, and proposed implementation measures: • stakeholders' the roles and responsibilities • work to be carried out • Location • timing, with a very detailed schedule of activities, considering the needs of each activity in relation to the weather conditions throughout the year • budget • materials required • workforce needed • onsite supervision • permits and safety issues • logistics. Special attention is given to facilitate natural regeneration, soil and water management measures, the selection of adequate plant material, as well as planting- and post-planting/maintenance related activities.
Awareness raising and knowledge management	Users describe the planned awareness raising activities to get the buying, consult, inform and disseminate results. A specific plan regarding data gathering, analysis and processing to share know-how from the FLR intervention with practitioners from the project area, the national and international arena, should be developed
Monitoring	Users specify the proposed monitoring plan, including timeframe, baseline, performance & impact indicators (e.g. ecological, social, economic, political and technical indicators), means of verification, measurement methods, stakeholder's roles and responsibilities, and other aspects.
Results and sustainability	This section is part of the implementation of monitoring activities after first restoration interventions are implemented. Users provide an indication of the degree of success of the restoration initiative, based on the measurement of processes and activities, with a focus on the following points: • Restoration objectives and outcomes: users are invited to provide an appreciation of the participation, relevance, effectiveness and adequacy of the FLR intervention. • Capacity development: N° of people trained; N° of participating stakeholders; cost; etc. • Field restoration ecological results/impacts: survival rate; plant growth; increase in vegetation cover; changes in degradation drivers, cost/ha, etc. • Filed restoration contribution to human well-being. • Impacts on policies (e.g. contribution to policy improvement) • Environmental impact of restoration interventions. • Sustainability (e.g. in terms of scaling up, ownership by local actors, the institutionalization of results in the long term, funding and capacities). • Identification of problems and measures to overcome them in future interventions. • Listing and describing key impacts and achievements.
Further sources of information	Users provide sources of information and references of relevant supporting documents (e.g. maps, papers, web pages, pictures, videos).

[55]:Keenleyside, K., N. Dudley, S. Cairns, C. Hall & S. Stolton (2012) Ecological restoration for Protected Areas: principles, guidelines and best practices. IUCN.

[56]:Based on the FAO's Monitoring and Reporting Tool for Forest and Landscape Restoration in Drylands: FAO. 2015. Global guidelines for the restoration of degraded forests and landscapes in drylands: building resilience and benefiting livelihoods, by Berrahmouni, N., Regato, P. & Parfondry, M . Forestry Paper No. 175. Rome, Food and Agriculture Organization of the United Nations.

FLR Principle VII: Maintains and Enhances Natural Ecosystems within the Landscape

VII.1. The Production of High Quality Plant Material

VII.1.1 Species Selection Criteria

A/ Environmental criteria

Increasing landscape resilience: In general terms, diversity implies a wider range of opportunities and options to cope with environmental changes, and thus increases landscape resilience to human- and climate change-induced disturbances[57]. It is recommended to combine different species performing different functions in the same restoration site.

Being part of the reference ecosystem: Reference ecosystems are sites with more or less evolved successional stages of the potential habitat type that we expect to emulate in the restoration site. This implies that: (i) The reference site has more intact, autogenic ecological processes, higher functionality, more complex structure, and greater diversity than the site to be restored; (ii) The biophysical conditions of the reference site closely match those of the restoration site.

Providing soil protection/improvement benefits: In landscapes with specific environmental risks (e.g. soil erosion; soil salinization; soil pollution) it is important to select species well adapted to such limiting conditions that also improve soil conditions – soil architecture, fertility, and infiltration capacity – or help re-establish the hydrologic regimes.

Drought resistant: In landscapes with major water constraints it is important to select species well adapted to capture rain/fog water, to retain runoff water, and facilitate water infiltration.

Biodiversity conservation: Endemic species whose populations exist in few sites, or threatened species populations from the SBR that have been dramatically reduced due to overuse or habitat degradation, may require urgent in-situ and/or ex-situ protection and restoration measures.

[57]:Regato, P. (2008) Adapting to global change, Mediterranean Forests. IUCN Centre for Mediterranean Cooperation

B/ Economic, social and cultural criteria

Economic production: Restoration actions often have a productive purpose and thus gain the support of local communities while amortizing the cost of plantation. The economic value of the native plant species in each landscape should be assessed and discussed among stakeholders.

Social preference: Local people often prefer species that are part of their traditional culture that have well-defined end uses and good marketing opportunities at local level.

Cultural keystone species: A number of plant species (e.g. the Lebanese cedar tree) are a fundamental component of the contextual underpinnings of the local and/or national identity, as reflected in their roles in language, ceremonies, diet, and medicine[58].

Annex 3 provides a table with the plant species selected for the SBR FLR interventions, indicating their ecological, social and economic values.

Native versus exotic species

Native species are always a better choice as they have evolved in the area and are better adapted to its environmental conditions. Moreover, the species genetic diversity and the genetic pools of the different species populations in their distributional range allows them to react to a wide range of environmental conditions and climate change.

A precautionary principle should be adopted when using exotic species, as available knowledge of the potential risks and long-term negative effects of using this type of species may not be good enough. Therefore, the combined use of native and exotic species in restoration projects should be well justified, based on well-known exotic species with no negative effect on the natural ecosystems.

In some cases, FLR may have as part of its objectives the control or eradication of those exotic species which are or have the risk to become invasive, competing with and replacing native species, and causing major environmental disruptions (e.g. the hydrologic disruption and supply water reduction caused by Eucalyptus species in the Mediterranean region)[59]. Care should be taken to cause the least possible disturbance to indigenous species and soils as exotics are removed.

VII.1.2 Selecting High Quality Plant Material

Plant reproductive material for ecological restoration activities includes seeds, whole plants, and cuttings for vegetative propagation. Plant reproductive material is gathered in the field preferably in areas near the site to be restored and with similar ecological conditions. In the Shouf Biosphere Reserve seeds from about 40 native species were gathered in areas with similar ecological conditions to the areas being restored.

High quality seeds require:

- Authenticity through good identification of the "mother plants"
- High genetic diversity by collecting seeds from high quality plants that are far from each other to ensure higher genetic diversity
- Proper quality seed testing after harvesting
- Adequate cleaning, storing and germination methodologies

Good knowledge of the target species: Information on target species should be collected and filed. Information sources include published literature, reports and web info, consultation with specialists, and interviews with people living in the areas where the species occur. At least make sure you know what to look for, when to collect reproductive material and where to go.

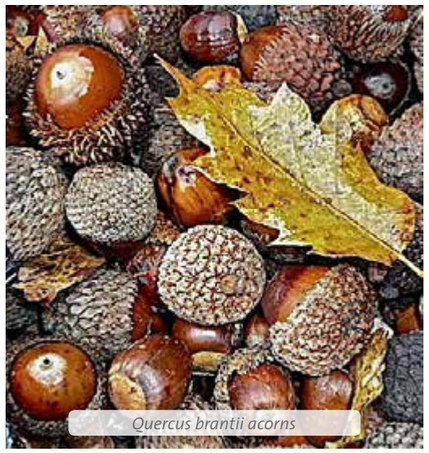
A number of relevant documents on Lebanese flora are published or accessible through the web:

- Tohme, G. & H. Tohme (2007) Illustrated Flora of Lebanon. CNRS.
- Lebanon e-flora (http://www.lebanon-flora.org) that provides easy access to species information for amateurs, botanists, ecologists and plant geneticists.
- The IUCN Red List of Threated Species (http://www.iucnredlist.org/search) provides information about the conservation status and threats of the world vascular plants.
- Web sites on the accepted names of the SBR plant species: (i) www.theplantlist.org; (ii) http://ww2.bgbm.org/EuroPlusMed; (iii) The international Plant Names Index http://www.ipni.org.


Collecting fruits in the wild


Juniperus drupacea seeds


Sorbus torminalis fruit collection

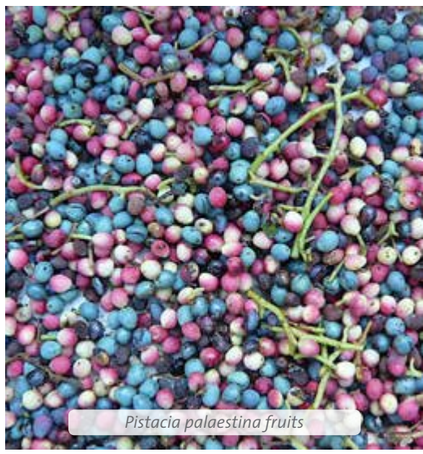

Quercus brantii acorns


Quercus infectoria acorns


Crataegus azarolus fruits


Cedrus libani seeds


Laurus nobilis fruits


Pistacia palaestina fruits


Stratified seeds

Stratified seeds

Germination of Acer obtusatum seeds

[58]: Jackson R. & N. Jain (2006) Mountain Cultures, Keystone Species: Exploring the Role of Cultural Keystone Species in Central Asia. Final Report submitted to The Christensen Fund by SLC/ Cat Action Treasury, Sonoma, California.
[59]: Binns, J.A., P.M. Illgner & E.L. Nel (2001) Water shortage, deforestation and development: South Africa's Working for Water Programme. Land Degrad. Develop. 12: 341-355.

Region of provenance: The region of provenance where reproductive material comes from should be clearly delineated and mapped. In the specific case of the project the region of provenance was the Shouf Biosphere Reserve itself. Within the region of provenance collection sites should be selected where healthy plant populations and individuals with remarkable features occur such as sites with plants with abundant well-developed seeds; sites with individuals with more tasty fruits; sites with individuals having desired morphological features such as single-stemmed or multi-stemmed individuals.

Candidate mother trees or shrubs for regular seed collection should be selected and marked within collection sites before beginning regular seed collection every year. It is important to select mother trees that: (i) will provide a reliable source of plant reproductive material, (ii) exhibit the morphological characteristics that are typical of the species, and (iii) are found across a range of different locations to maximize the genetic diversity of the seeds you are collecting.

Record information for each mother: (i) species and family, (ii) height, diameter at breast height and canopy diameter, (iii) special features justifying its selection, (iv) forest layer (e.g. understory, canopy, emergent, isolated in forest gap), (v) area of origin and a GPS reference.

Climate change considerations may influence decisions about the provenance of the plant material. If for example, we consider the climate predicted for 2040, we can decide to gather seeds from collection sites where current climate conditions are similar to the predicted ones. In this way, practitioners try to ensure that planted seedlings will be better adapted to the climate conditions in which they will live as adults. However, a precautionary approach must be followed since modelled predictions of changes in future climate have a certain margin of uncertainty.

Genetic diversity: The selection of plant reproductive material to be collected should be based not only on the morphological quality features – easily evaluated by practitioners - but also on the genetic characteristics and variability of the species that contribute to increase the ecological resilience of the restored habitats. For example, the collection of seeds from individuals living in water-restricted or warmer areas may help increase the adaptive capacity for future climate constraints of the seedlings after their germination.

For each species we should aim to collect from as many different populations and locations where mother trees or shrubs are adapted to a wide climate range (e.g. populations of the same species living at different altitudinal range that support different temperature and precipitation conditions). It is recommended to avoid in-breeding by collecting from mother trees or shrubs that are distant from each other and from different populations.

When to collect: Develop a seed collection calendar to plan trips to the field. Include information on the species phenology: when your species is expected to (a) produce buds and flowers, (b) produce immature fruits and (c) when these fruits are likely to mature. You might find it helpful to include notes on how to identify flowers, immature or mature fruits in the field. Monitor the phenology of the target species during several consecutive years, as it may vary (a) from year to year or (b) between populations found in different locations/altitudes due to the species physiology itself or to climatic fluctuations.

Take photographs of different reproductive stages of the target species in the collection sites, and record the location (GPS data) and date they were taken, to guide future field collection trips. Be aware that not all species produce seeds or sufficient seeds every year (e.g. Pinus pinea has a cycle of cone production every 2 to 6 years): the collection of reproductive material should take place in optimal years when higher production of well-developed seed, fruits and cuttings occurs.

Make sure that fruit ripening has taken place in the field: an unripe fruit will not allow the production of high-quality seedlings. Be aware that certain species, such as Juniperus excelsa, usually produce high percentages of seedless fruits.

VII.1.3. Managing Plant Material

How to manage collected material: Good management of collected reproductive material is required from the collection site prior to its use in the tree nursery or to its direct use in the restoration sites. Protocols for each species should be developed, in terms of collection tools, duration and conditions of transport from the field to nursery, storing, packaging, temperature, humidity, shadow conditions and stratification.

Crataegus fruits

Cedrus Libani

Macerating Arbutus andrachne fruits to remove the fleshy coat covering the seeds

Juniperus drupacea fruits

Laboratory analysis of seed quality

In the case of fruits, it is very important to follow cleaning-extraction-processing protocols specific for each species, to avoid damaging the seeds, and extract the maximum number of seeds, select viable seeds, and check seed quality.

Dry fruits:

- Fruits that open themselves or able to fly (e.g. conifer species, species from the families of *Fabaceae, Brassicaceae, Asteraceae, Betulaceae*). They should be collected before they become ripe, and dried in shade/sunny places or in ovens (e.g. Pine nuts).
- Fruits that do not open themselves (e.g. species from Lamiaceae family such as *Rosmarinus, Lavandula, Thymus, Origanum, Poaceae, Asteraceae*). They should be crushed by hand or feet, or making use of roller or mortar.
- Final separation of seeds from the inert residues is done by blowing, vibration or sieving.

Fleshy fruits:

- Species from genus *Arbutus, Juniperus, Pistacea, Rhamnus,* and from the *Rosaceae* family.
- Drying the fruits, storing them and sowing with the fleshy seed coat.
- Removing the fleshy coat covering the seeds by macerating the fruits in water (1-2 days). Fruits are crushed by hand or using an electric mixer. Seeds are separated from the fruit residues by “floating” and “sieving under a jet of water”.

Selection and calibration: quality seed implies having homogeneous seeds within a seed batch in terms of their external appearance (shape, size, weight). There are several seed quality testing procedures, such as:

- *Purity analysis test:* it verifies that seeds are from the desired species, and identifies the presence of inert particles (e.g. sand, insects, seed fragments).
- Weight determination
- *Determination of moisture content:* this is an essential test in case seeds are stored.
- *Biochemical test for seed viability:* Tetrazolium test to check whether seeds are alive or not. Tetrazolium is a redox indicator that stains metabolically active tissues. It is a very effective and fast method. It is highly recommended in the case of seeds with difficult germination, such as dormant seeds.
- *Germination test:* This method consists of placing some seeds in containers with substrate and humidity to activate germination. It provides conclusive results on seed viability and vigour, but it is very time-consuming especially in the case of dormant seeds that are difficult to germinate.
- *Seed health test* to assess pest and diseases.

Seed Conservation: It is crucial to develop short- and long-term conservation measures. In many cases a high-quality seed can be stored for several years maintaining its quality-relevant to climate change scenarios. Dry seeds require cold and dry storage. For most dry seeds it is recommended a temperature of 2-4 ºC, and a moisture content of 4-8%. After drying the seeds at a suitable moisture content, store them in sealed moisture-proof containers, such as plastic bags or glass bottles.

Seed treatment and dormancy: Seed treatment technologies are developed to facilitate uniform germination and improved plant production. Some of the benefits provided by seed treatment are[60]: (i) improve germination/seedling growth through manipulation of seed vigour or physiological status; (ii) facilitate seed planting (pelleting, coating, encrusting); (iii) deliver materials (other than pesticides) needed at sowing (e.g. nutrients, inoculants); (iv) remove weak or dead seeds using non- traditional 'upgrading' techniques (density, colour, x-ray); (v) covering seeds with visible pigments or other materials/markers for traceability and identity preservation.

Dormancy is a mechanism to prevent germination during unsuitable ecological conditions, when the probability of seedling survival is low. Often seed dormancy is divided into two broad categories based on what part of the seed produces dormancy: exogenous (external dormancy) and endogenous (internal dormancy). Treatments for breaking seed dormancy can be used to stimulate germination:

Treatments for breaking the external dormancy:

- Seeds with hard and waterproof seed coat (e.g. species from the genus *Ceratonia, Rhus, Colutea, Cercis, Juniperus, Genista, Crataegus, Malus, Prunus*...): (i) scarification; (ii) boiling; (iii) warm stratification; (iv) use of acids (sulphuric acid).
- Seeds with chemical inhibitors in the fleshy cover that prevent germination (e.g. species from the genus *Crataegus, Sorbus, Ilex, Rosa*): (i) removal of the fleshy cover; (ii) early collection.

Treatments for breaking the internal dormancy:

- Species from the genus *Fraxinus, Juniperus, Rosa, Acer, Cedrus, Laurus, Juglans, Malus, Prunus, Celtis, and Crataegus*. They have seeds with chemical inhibitor next to the embryo.
- Embryo needs cold temperature and humidity to germinate, so it is recommended cold stratification (store seeds into wet sand in the fridge at 2-4 ºC, for 3-4 months), and the use of gibberellic acid.

Cold stratification: Cold stratification: consists of subjecting seeds to both cold and moist conditions. Seed of many trees, shrubs and perennials require these conditions before germination will ensue. The substrate to mix with the seeds could be peat, sand or vermiculite. We recommend vermiculite.
Place the seeds in sealed plastic bags with moistened vermiculite to be refrigerated. The substrate will have a humidity of about 60%. It is important to only slightly dampen the vermiculite, as excessive moisture can cause the seeds to mold in the bag.

If necessary, sieve the substrate before mixing with the seeds, to ensure that the substrate particles and the seeds have different size to facilitate separation from each other before sowing.
Soaking the seeds in water for about 24 hours immediately before placing them in cold stratification can cut down on the amount of time needed for stratification, as the seed needs to absorb some moisture to enable the chemical changes that take place. Some species usually germinate during the cold stratification, inside the fridge. In these cases check the seeds regularly and remove them from the fridge when at least 10% of the seeds have germinated.

Warm stratification: Any seeds requiring warm stratification will be subject to the same measures. it requires temperatures of 15-20 ºC, and it will be important that the temperature of the room remains as constant and stable as possible.

Certification of plant material: International certification schemes, such as the EU or OECD scheme on marketing of forest reproductive material establish rules that are applied to a number of forest species. For example, the EU certification scheme defines the types of basic material accepted for producing forest reproductive material from the different categories of 47 forest species, although the principles of such scheme are valid for other species relevant in restoration programmes. It would be desirable to precisely define the selection purpose, the type and characteristics of the basic material from which the reproductive material must be collected.

[60]: www.seedconsortium.org/

VII.1.4. Production of Plant Material in the Tree Nursery

The technologies used in the tree-nursery will determine the quality of the plant material and lead to a better performance in the field. It is necessary to fine tune the cultural practices in the nursery to improve the morphological and physiological quality of the produced plants to be adapted to current and future limiting climate conditions. Optimizing the seedling potential for establishment in harsh field conditions depend on the following factors[61]:

Establishing a local tree nursery: The FLR project in the SBR has supported the production of high-quality plant materials in local tree nurseries, such as *Native Nurseries sarl.*, located in the municipality of Ramlieh. The advantages of working with a local nursery are: (i) better acclimatization of the seedlings that are produced under climate conditions close to those of the restoration sites; (ii) easier and cheaper transport of the seedlings from the nursery to the restoration sites.

Requirements in selecting the location of a native tree nursery

- Climate and altitude: they should be compatible with the bio-climatic conditions that characterize the natural distribution areas of the species under production
- Soil quality: an essential feature in the case of bare root plants which are grown without containers. Good quality features are a minimum depth of 50 cm, free of stones, good drainage (e.g. less than 15-20% clay), minimum fertile conditions, pH between 5.5 and 8, and no alkaline and salty conditions.
- Availability and quality of water: this is a key factor for the establishment of the nursery. pH above 8-9 should be avoided.
- Landform: it is preferable to be located in flatland areas, or in terraces in the case of steep areas.
- Easy accessibility: the location should be suitable for the transport of materials supply and seedling delivery.

The nursery should include the following infrastructure and production areas

- Office, store for materials and machinery, small laboratory, working areas.
- Greenhouse infrastructure providing protection against cold and frost; seed-beds for seed sowing; small/soft seedlings very sensitive to wind, heavy rains and frost; the production of cuttings. The greenhouse should include raised supports to carry the trays and seedling containers, irrigation equipment, and heating system. It should be organized in a way that facilitates the passage of workers.

- Irrigation system: It should be adapted to the water requirements of the different species, in terms of water quality, watering frequency and dosage, type of watering (e.g. drop size/pressure), indoor/outdoor location.
- Sun-shading structures providing protection from heat for seedlings very sensitive to summer heat. Shading mesh is usually black plastic with about 40% light transmission. Shading mesh with aluminium fiber that reflects the sunlight provides cooler environment than the usual black plastic mess. Shading mesh also promotes faster growth if needed, and always should be followed by seedling hardening outside the mesh before planting.
- Outdoors growing/hardening areas for seedlings in containers. The use of gravel or a permeable mesh on the soil ensures good drainage while preventing the growing of seeds.
- Outdoors growing areas for bare root production.
- Outdoors growing areas for “mother plants” as a source of seeds and cuttings.
- Fences and paths.

Use of adequate containers: The selection of a container must be in accordance with the morpho-functional characteristics of the plant species, its development patterns and the environmental conditions where it will be planted. Under Mediterranean climate conditions with strong water restrictions during summer drought period a poorly developed seedling root system will lead to high mortality. As a consequence, it is necessary to produce seedlings with an appropriate biomass distribution, and an optimum root/shoot ratio with a robust root system longer than the aerial part, capable of reaching quickly the deeper soil horizons where some moisture could be available during the summer drought period.

Appropriate root/shoot ratio for seedlings	
Aerial part	Root system
It should be short and hardened to: • withstand the dormant period during winter. • allow the plant to invest its scarce energies in developing a good root system. • avoid excessive water transpiration during the first summer after planting. It should have well lignified woody tissues. The height of the aerial part should be proportional to the size of the container and the root collar diameter: • Between 15-40 cm for 1-2 year seedlings. • The maximum height should be equal to the container size. • The minimum height should be half the container size.	It should be a long, straight, with a well-developed secondary root system, able to rapidly reach the deeper soil horizons, where soil moisture is still available during the summer drought. In the case of tap roots, they should be straight, not spiralled/rolled or growing out from the bottom of the container. The minimum container volume is of 200 cm3 for 1-year seedlings, and 300 cm3 for 2-year seedlings. In the case of tap-root species such as Quercus, Fraxinus, and Ceratonia, it is recommended container of 300 cm3 and more than 15 cm long.

[61]: Most information extracted from: Chirino E. et al (2009). Ecological restoration in degraded drylands: the need to improve seedling quality and site conditions in the field. Chapter 4 in: S.P. Grossberg Ed. Forest management. Nova Science Publishers, Inc.

Currently, there are a wide variety of containers in the market defined in terms of their material, shape, size, depth, the opening of bottom cells to prevent the growth of the root outside of the container, the presence of vertical ribs in the inside part of the container to prevent root spiralling, etc. Containers should provide a minimum volume of soil to ensure: (i) an equilibrated growth of the seedling; (ii) an adequate plant production density, depending on the species (number of plants per m2); (iii) the prevention of possible deformations in the root growth , and root spiralling problems; (iv) facilitation of handling and transportation; (v) capacity of re-using or recycling; (vi) adapted to the *Line Production Machinery,* if needed; (vii) cost-effectiveness in relation to quality/price and market availability.

The FLR project in the SBR Landscape has used forest trays between 200 and 350 cm3, 15-18 cm depth, with vertical ribs inside to prevent root spiralling, and bottom cells to prevent the growth of the root outside the container (this system requires that trays are placed in an elevated structure that prevents the bottom of the tray from touching the ground). These containers are easily handled and transported both inside the nursery and to the field, allowing more than one use.

Container capacity for the plant species produced in the SBR FLR initiative		
Species (1-2 year seedlings)	Container capacity (cm3)	Minimum root collar diameter (mm)
Acer tauricolum, Celtis australis, Ulmus minor	300-350	3
Fraxinus syriaca	300-350	4
Rosa canina, Rosa glutinosa	250-300	2
Prunus dulcis, Prunus ursina, Pyrus syriaca, Sorbus flabellifolia, Sorbus torminalis	250-300	3
Crataegus azarolus, Crategus monogyna, Quercus brantii, Quercus calliprinos, Quercus infectoria	250-300	4
Juniperus drupacea, Juniperus excelsa, Juniperus oxycedrus	200-250	2
Cedrus libani, Pinus brutia	200-250	2.5
Pinus pinea	200-250	3.5

Culture substrates[62]: Soil substrates must allow the optimum oxygenation of the plant root system[63]present, good water holding capacity and water availability to help reduce the post-transplant shock, and facilitate a better water status for the seedlings to reduce water stress conditions during the first months after out-planting. Among the features that characterize good substrates are:

- Good aeriation (porosity between 60-80% of the total volume).
- Absence of seeds, insects, fungi, and toxic substances
- Ph between 5 and 8
- Minimum 20% water retention capacity
- Facility to absorb water after drying up
- Low weight
- Available in the market
- Good value for money

Substrates can be:

- Chemically inactive (e.g. sand, perlite, vermiculite, porespan, volcanic grit) that provide good aeration and water holding but lack nutrients - making it necessary to fertilize.
- Chemically active (e.g. compost and loam, black or brown peat, composted woody leftovers, wood fibbers, clay) that provide some nutrients to the seedlings. Peat substrates may have problems in the water transferring to the seedling during the summer drought period.

The high demand of substrates for the production of ornamental and forest plants in nurseries, and the ecological problems related to the over-exploitation of peat and forest organic soil sold as substrates in the market, makes it more necessary to produce compost in the same nurseries from sewage sludge. Several studies[64] [65]showed that shrubs and trees from Mediterranean drylands (e.g. *Pistacia lentiscus; Pinus halepensis; Quercus ilex*) cultivated in compost-based substrates presented better growth and nutrition, especially those in sewage sludge-based compost. However, this substrate type presented disadvantages in its handling (very heavy).

[62]: Chirino, E., A. Vilagrosa, J. Cortina, A. Valdecantos, D. Fuentes, R. Trubat, V.C. Luis, J. Puertolas, S. Bautista, M.J. Baeza, J.L. Peñuelas & V.R. Vallejo (2009) Ecological restoration in degraded drylands: the need to improve the seedling quality and site conditions in the field. In: Forest Management, Steven P. Grossberg Ed. Nova Science Publishers, Inc.
[63]:Tsakaldimi, M. (2006). Kenaf (Hibiscus cannabinus L.) core and rice hulls as components of container media for growing Pinus halepensis M. seedlings. Bioresource Technology, 97, 1631-1639.
[64]:Ostos, J.C., López-Garrido, R. Murillo. J.M., López, R. (2008). Substitution of peat for municipal solid waste- and sewage sludge-based composts in nursery growing media: Effects on growth and nutrition of the native shrub Pistacia lentiscus L. Bioresource Tecnology, 99, 1793-1800.
[65]:Ingelmo, F., Albaich, R., Ortiz, F., Escarre, A., Lledó, M.J. (2002). Producción de planta forestal con un substrato derivado de lodos de depuradora; una alternativa para viveristas. Lodos, 67, 1-7.


Quercus infectoria seedlings


Cedrus libani seedlings


Abies cilicica seedlings

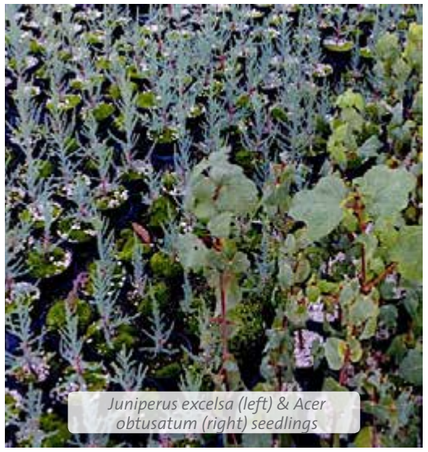

Pinus brutia seedlings


Celtis australis seedlings


Crataegus sp. seedlings


Pyrus syriaca seedlings

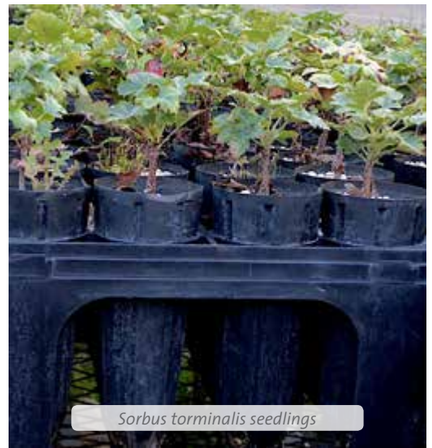

Arbutus andrachne seedlings


Juniperus excelsa (left) & Acer obtusatum (right) seedlings


Rhus coriaria seedlings


Lonicera nummulariifolia seedlings


Prunus dulcis seedlings


Sorbus torminalis seedlings

Watering for nursery production[66] [67]**:** Water quality should be a primary consideration when establishing a nursery as this is a critical factor for plant production. A water sample should be collected and sent to a laboratory to test its quality (e.g. presence of soluble salts that can harm plants; presence of pathogenic fungi, weed seeds, algae, possible pesticide contamination and pH). Good water management requires an efficient use of water, reliable sources of water, high uniformity of water distribution, and a flexible approach to the changing needs of species grown during germination and early growth.
Hand-watering requires simple and inexpensive equipment and is often the most practical irrigation strategy for small native plant nurseries, especially in the start-up phase. After the specific watering requirements for each plant species are understood the nursery owner could establish automated micro-pressurized irrigation systems to meet the plant's needs.

Watering recommendations from the FLR initiative in the SBR landscape:

- up to 85% of substrate moisture during germination process (March)
- 70-75% moisture while seedlings are growing (April to August)
- Decreasing to 50-60% moisture in September-October, before planting in the field (End October up to early December) to ensure good hardening of the seedlings.

Composting: Composting is a biological process by which microorganisms decompose organic matter. Compost can be produced in two ways: aerobic composting involves organisms that need oxygen for their living, while the anaerobic composting involves organisms that can live in the absence of oxygen. The production system adopted by the project was the aerobic composting. The raw material used is a combination of the shredded material from the pruning of trees, cow manure from a farm in Maaser, and chicken manure from farms in Baadarane.

Compost production aimed to find alternative sources of organic fertilizer for local farmers. It involved: (i) the development of a composting unit in a central area of the SBR (Maaser), that will supply the restored agricultural terraces where FLR interventions will take place; (ii) training landowners a to develop a composting unit in their farms, following the model developed by the project in Maaser, where learning-by-doing workshops on compost production were conducted; (iii) the development of educational materials to outreach other farmers beyond the project framework.
The compost produced from the decomposition of carbon and nitrogen can be ready for its use as soil fertilization after 3 to 6 months.

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[66]: Landis, T.D. & K.M. Wilkinson (2009) 10: Water quality and irrigation. In: Dumroese, R.K., T. Luna, T.D. Landis Eds. Nursery manual for native plants: A guide for tribal nurseries - Volume 1: Nursery management. Agriculture Handbook 730. Washington, D.C.: U.S. Department of Agriculture, Forest Service. p. 177-199.
[67]:Chirino, E., A. Vilagrosa, J. Cortina, A. Valdecantos, D. Fuentes, R. Trubat, V.C. Luis, J. Puertolas, S. Bautista, M.J. Baeza, J.L. Peñuelas & V.R. Vallejo (2009) Ecological restoration in degraded drylands: the need to improve the seedling quality and site conditions in the field. In: Forest Management, Steven P. Grossberg Ed. Nova Science Publishers, Inc.

Maaser composting unit is composed of the following sections:

• Pre-storage area: it is used to store the shredded material, and should have enough space to collect one day's collected material.

• Shredding machine:

- Location: It should be located at the entrance of the composting unit, with road access, with enough space in front of the machine for the shredded material to be downloaded and mixed.
- Size: It depends on the size of the raw material.
- Power supply: diesel or electricity (the machine available at the SBR works with diesel).

• Mixing area:

- Size: Should be enough to receive waste collected during 3 working days plus extra space for the bobcat to work easily.
- Ground: preferably concrete without loose gravel to avoid being mixed with the compost.
- Shape: round or square.

• Composting area:

Size: Width should be enough to receive waste collected during 3 working days; length should be enough for 6 turning piles including 2 meters between each pile.

- Access: road access to the storage room.

• Storage room: Not needed if compost is directly distributed to farmers.

- Size: enough to receive all year round production.
- Shape: rectangular, open roof, and slanted side walls.
- Location: at the end of the composting unit.

• Bobcat:

- Size: regular
- Additional equipment: shovel

• Water source: water should be accessible every day to spray the compost each time it should be mixed or turned over.

- Equipment: hose or sprinkler.

• Working plan:

- Make a preliminary testing for the C/N ratio in each type of waste discharge.
- Decide the quantities of each part of the mixture needed to reach a C/N ratio between 25 and 50.
- Shred all the materials other than animal waste.
- Mix with the bobcat.
- Turn the first pile to the next piling space and fill the previous piling place with the following mixing pile.
- Move the turned pile to the following piling place until passing it through the 6 piling sites, always filling the previous site with the next pile.
- Move the resulting compost from the last piling place to the storage room. Interested farmers will come and transfer compost to their farmland plots.

Fertilization geared to target seedlings[68]: Nitrogen (N), phosphorus (P) and potassium (K) form 75% of the nutrient concentrations in plant tissues, and thus are the most important nutrients in nursery culture techniques. Diverse studies have indicated that fertilization may increase drought tolerance for several reasons. For example, N and P availability increases root growth potential and root hydraulic conductance[69 70] thereby enhancing the ability of fertilized seedlings to capture soil water[71]. This can be crucial in degraded areas where nutrients may be limited[72].

Fertilizers can be:

• *Organic fertilizers* (e.g. compost/loam, earthworm humus, cow/sheep/goat manure that increase soil nutrients and improve microbial life.

• *Inorganic fertilizers*, composed by Nitrogen-Phosphorus-Potassium that is mixed directly with the substrate, or provided through the irrigation system (ferti-irrigation). They usually act quickly for a short period of time. The recommended dosage is: (i) 15-45-15 for the germination period (March to May); (ii) 30-30-30 for the growth period (May to mid August); (iii) 5-30-45 for the hardening period (Mid August to November). There are slow release fertilizers (e.g. Basacote Plus-6M, with NPK composition of 16-8-12, and a recommended dosage of 4 gr/litre of substrate) that liberate nutrients when temperature increases, having a longer-term availability, but with the risk of over-liberation during summer.

Applying plant growth regulators (PGRs)[73]: Growth regulators (PGRs) are synthetic chemical compounds that induce hormone-like responses in plants, promoting, inhibiting or modifying plant behaviour. The effect of PGRs to regulate growth and to improve drought tolerance in plants has been widely described and studied. However, its use in forestry practices has to date been scarce.

[68]:Ibid.
[69]:Singh, D.K. and Sale, P.W.G. (2000). Growth and potential conductivity of white clove roots in dry soil with increasing phosphorus supply and defoliation frequency. Agronomy Journal, 92, 868-874.
[70]:Trubat R., Cortina J. and Vilagrosa A. (2006). Plant morphology and root hydraulics are altered by nutrient deficiency in P. lentiscus (L.). Trees: Structure and Function, 20, 334- 339.
[71]:Reinbott, T.M and Blevins, D.G. (1999). Phosphorus nutritional effects on root hydraulic conductance, xylem water flow and flux of magnesium and calcium in squash plants. Plant and Soil, 209, 263-273.
[72]:Valdecantos, A., Cortina, J. and Vallejo, V.R. 2006. Nutrient status and field performance of tree seedlings planted in Mediterranean degraded areas. Annals of Forest Science, 63, 249-256.

The forestry use of PGRs has focused on growth inhibitors or retardants in aboveground biomass development that promote higher allocation to the root system[74], although too high doses may have negative effects on the root development[75]. The results obtained in different research studies are promising but it is necessary to contrast these results with research in the field.

Mycorrhizal treatment[76]: Plants that receive proper nutrition are more able to resist disease and this is one way that mycorrhizae help plants resist soil borne diseases. Mycorrhizae create a barrier when they coat the outside of the root, and compete with pathogenic microorganisms and may actually exude toxins and antibiotics to protect the plant. Moreover, root-feeding nematodes are less likely to attack mycorrhizal plants.

Applying mycorrhizal inoculants, is becoming an increasingly common practice in the nursery sector. Whether nurseries are producing native, ornamental, or agricultural plants, adding mycorrhizae to seedling production can lower mortality rates and reduce water and fertilizer consumption. It increases the surface area of a plant's root system and, as a result, the plant is able to absorb more water. This increase in water uptake increases the survival of transplants and facilitates drought resistance. In some cases mycorrhizae increase a plant's access to nutrients (e.g. phosphorus and zinc) which can be important in tropical soils where phosphorus availability is low, and can increase nitrogen fixation for nodule-forming plants. Other benefits include improved soil structure due to the mycorrhizae binding soil particles into aggregates— allowing water to infiltrate and increasing oxygen in the rhizosphere.
However, there is much uncertainty concerning where to obtain the fungi, what types to use, the quality of commercially available products and the most effective application methods.

Phyto-sanitary treatments: Phytosanitary treatments are required to prevent and/or fight pests and diseases affecting the plant reproduction material. Treatments can be based on the use of agrochemical pesticides, or organic pest management measures.

[73]: Chirino, E., A. Vilagrosa, J. Cortina, A. Valdecantos, D. Fuentes, R. Trubat, V.C. Luis, J. Puertolas, S. Bautista, M.J. Baeza, J.L. Peñuelas & V.R. Vallejo (2009) Ecological restoration in degraded drylands: the need to improve the seedling quality and site conditions in the field. In: Forest Management, Steven P. Grossberg Ed. Nova Science Publishers, Inc.
[74]:Aphalo, P.J., Rikala, R and Sánchez, R.A. (1997) Effect of CCC on the morphology and growth potential of containerised silver birch seedlings. New Forests, 14, 167-177.
[75]:Ibid.
[76]:Brooks, L., D. Brown, S. Smith & S. Sprenger (2006) The use of mycorrhizae in native plant production. Native Plant Production, University of Washington.

The FLR work in the SBR landscape has supported biological phytosanitary treatments that are more environmentally-sound and prevent water/soil pollution and workers' health problems. Some examples of organic treatments are:
- Fungicides: Equisetum arvense, Sulphur; copper ("Caldo bordelés": sulphate of copper)
- Insecticides: oil of Tree of Neem (*Azadirachta indica*); soap of potassium; *Bacillus thuringensis*; extract of "pelitre" (*piretrine from Chrisantemum*); rotenone (extract of Tephrosia, Derris and other tropical legumes); traps with pheromones; colored traps with pheromones; colored traps with gums; biological (natural predators and parasites); and plants to control insect attacks.

Weed management: Since weeds reduce the growth and quality of nursery plants by competing for nutrients, water and light, nursery growers must plan an effective weed control program:

- Prevent the addition of weed seeds in the soil substrate used for plant production.
- Use cover crops that compete effectively with weeds and prevent erosion, or cover the soil with mulches preventing the growth of weeds.
- Cover the ground along growing lines with water permeable, black plastic mesh to prevent the growth of weeds
- Undertake hand weeding of weeds growing around the nursery.
- Harden the plants of the nursery with biological treatments. The use of inorganic herbicides was not supported by the FLR project in the SBR landscape due to the negative health and environmental effects. Moreover, the repeated use of one herbicide, or herbicides with a similar mode of action will gradually produce a shift in the weed population to those that are tolerant, or it could lead to the development of an herbicide resistant biotype.

Propagation from seeds: this propagation system enhances genetic diversity, improving the capacity of the planted seedlings and restored habitats to cope with climate variability and change, and makes them more resistant to diseases and insect pests. During seed germination, both outside and inside the greenhouse, a high degree of moisture in the substrate should be maintained (about 85%).

Deciduous trees and shrub species for the production of bare root plants:
- Species from the genus *Ulmus, Platanus, Acer, Berberis, Sambucus, Rosa, Crataegus, Celtis, and Juglans*:
- Direct seed sowing in the ground during spring or autumn without containers.
- Removal during subsequent winter (seedling with no leaves) and transplanting to field.

Evergreen or deciduous plants produced in containers:

• *Plants with small seeds*, such as *Alnus orientalis, Arbutus andrachne, Myrtus communis, Rhus coriaria,* species from the *Lamiaceae* family (e.g. *Thymus spp., Origanum spp., Lavandula spp., Salvia spp.*), from the *Cistaceae* family (e.g. *Cistus spp., Halimium spp., Helianthemum spp.*), from the *Asteraceae* family (e.g. *Artemisia spp., Santolina spp.*).
- Controlled sowing in seed trays under plastic protection.
- Pick out seedlings and transplanting them into containers (forest trays or pots).

• Plants with medium to big seeds with germination problems (e.g. dormancy, low viability), such as from the genus *Laurus, Malus, Prunus, Juniperus, Jasminum, and Viburnum*.
- Controlled sowing in under plastic protection.
- Pick out seedlings and transplanting them into final containers.

• Plants with medium to big seeds with good germination capacity, such as species from the genus *Quercus, Pinus, Cedrus, Abies, Ceratonia, Atriplex, Stipa, Lygeum, Retama, Cytisus, Genista, Spartium, and Pistacia*.
- Direct sowing in final containers, under plastic protection until May in the case of *Cedrus, Abies, Pistacia, and Atriplex*, or outside without plastic protection in the case of *Quercus, Pinus, Ceratonia, Stipa, Lygeum, Retama, Cytisus, Genista, and Spartium*. In the case of *Quercus spp. and Pinus pinea*, the containers should be outside and covered with a plastic mesh after sowing until germination, to prevent the attack of rodents/birds and frost damage.

Cuttings: Vegetative propagation is used for species that are difficult to reproduce from seeds by means of promoting the development of roots from cut stems. Growing plants from stem cuttings is the most popular method of vegetative propagation. Seedlings from cuttings have identical genetic makeup (clones), which reduces the genetic diversity of the plant populations that they produce. This makes them less resistant to pests and diseases, as well as to climate variability and change. In ecological restoration cutting techniques are only recommended for those species with very difficult germination, such as *Buxus spp., Ligustrum spp., F icus carica, Olea europaea, Tamarix spp., Polupus spp., Salix spp., and Platanus orientalis.*

• **Autumn cuttings** of evergreen species, such as *Buxus spp., Ligustrum spp., Olea europaea*:
- Spring shoots almost woody collected in autumn.
- Production under plastic protection.
- High water control is required to avoid transpiration water loss.

• **Winter cuttings of deciduous species,** such as *Populus spp., Salix spp., Platanus orientalis, and F icus carica:*
- Woody stems of 1-2-3 years old, collected in winter.
- Production in the outside directly in the soil without any protection.

The method for the production of cuttings is as follows: first cut the stems making sure they have 3 to 4 healthy buds on them; do not let them dry out. Then, reduce the number/size of leaves, either by removing part of the leaves or cutting them in half. If needed put the cut stems in a hormone solution[77]. Insert the cut stems in the moist soil (peat moss – perlite mixture, 50% - 50%). Place the containers over the heat source (the heat should not exceed 35 °C). Turn on the mist system for several seconds every few minutes so that the leaves remain wet, this is to ensure they don't lose water. Monitor the cuttings until they produce roots then move them into larger containers or plant them in the soil outside the greenhouse.

Rooting hormones can be used to encourage basal roots in the cuttings. The most usual rooting hormone is the Indolyc Butyric Acid (IBA). It can be used by mixing with water or with talcum/ashes.

Hardening treatments[78]:

Drought preconditioning: Drought preconditioning consists of reducing the watering regime in the tree-nursery by submitting the seedlings to progressive drought conditions to enhance the plant's physiological attributes (e.g. better stomatal control for drought stress resistance, better root/shoot ratio, and higher root growth capacity after out-planting) that increase the survival and growth of seedlings under field condition. The intensity of drought preconditioning should be adjusted to the plant species and the seedling characteristics, taking into consideration the species-specific limits of water-stress resistance. Several studies have observed that applying mild or moderate drought preconditioning levels perform better than applying very intense drought conditions[79] [80]. In general, it has been observed that long preconditioning periods of about 3 to 6 months produce better results than short periods, although this seems to be species-specific related. In experimental plots in eastern Spain, only when the onset of the dry period is close to the planting date, as occurs in the most arid areas of the Mediterranean basin, is it more likely to observe a significant effect of some physiological adaptations on the survival of certain species.

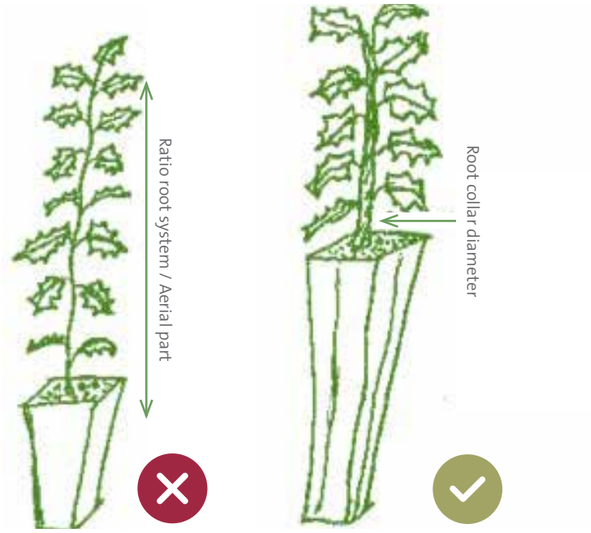
The FLR initiative in the SBR applied the following hardening measures to enhance drought resistance: When seedlings were transferred to grow outside the greenhouse, after the germination phase, watering was reduced from 85% to 70-75%. At the end of the production process, and especially 1-1.5 months before planting, watering must decrease to 50-60% in order to guarantee a good hardening. Right before planting, seedlings will be heavily irrigated in the nursery and carefully transported to the restoration sites to avoid any possible damages.

Nutritional hardening: Nutritional hardening implies the reduction of nitrogen supply to control seedling growing, promote reserve accumulation, and increase K supply to prevent transpiration water loss and to face low temperatures[81]. It has received less attention than water stress preconditioning.

Some studies from CEAM[82]demonstrated that the short-term reduction of N availability prior to planting could be a promising technique to improve the establishment of woody species in semi-arid environments. On this subject the bibliography shows contrasting results, showing positive results in the field from both methods of fertilization - on the one hand, maintaining optimum nutrition and, on the other hand, nutritional hardening. Thus, it should be concluded that the effects of different N fertilization regimes are highly dependent on the specific behaviour of each species, and that other factors must also be considered. It is obvious that more research is needed in the areas of seedling quality enhancement and gearing the fertilization to the attributes of the target seedlings and the characteristics of the planting sites.

[77]: Optional hormones are: IAA (indole-3-acitic acid), IBA (indole-3-buteric acid); IPA (indole-3-proioninc acid); PAA (phenyl-acetic acid); 4-Chloroindole-3-acetic acid (4-Cl-IAA)
[78]:Chirino, E., A. Vilagrosa, J. Cortina, A. Valdecantos, D. Fuentes, R. Trubat, V.C. Luis, J. Puertolas, S. Bautista, M.J. Baeza, J.L. Peñuelas & V.R. Vallejo (2009) Ecological restoration in degraded drylands: the need to improve the seedling quality and site conditions in the field. In: Forest Management, Steven P. Grossberg Ed. Nova Science Publishers, Inc.
[79]:Villar-Salvador P., Ocaña L., Peñuelas J.L. and Carrasco I. 1999. Effect of water stress conditioning on the water relations, root growth capacity, and the nitrogen and non- structural carbohydrate concentration of Pinus halepensis Mill (Aleppo pine) seedlings. Annals of Forest Science, 56, 459-465.
[80]:Villar-Salvador P., Planelles R., Oliet J., Peñuelas-Rubira J.L., Jacobs, D.F. and González M. (2004). Drought tolerance and transplanting performance of holm oak (Quercus ilex L.) seedlings after drought hardening in the nursery. Tree Physiology, 24, 1147-1155.
[81]: Chirino, E., A. Vilagrosa, J. Cortina, A. Valdecantos, D. Fuentes, R. Trubat, V.C. Luis, J. Puertolas, S. Bautista, M.J. Baeza, J.L. Peñuelas & V.R. Vallejo (2009) Ecological restoration in degraded drylands: the need to improve the seedling quality and site conditions in the field. In: Forest Management, Steven P. Grossberg Ed. Nova Science Publishers, Inc.
[82]: Ibid.

Cedrus libani high quality seedling



Good and bad example of root/aerial ratio and root collar diameter

Annex 4 includes the production protocols and other relevant information regarding the target species used in the SBR FLR interventions.

VII.2 Effective Field Restoration Interventions to Increase Water Availability and Seedling Survival

VII.2.1 Forest Restoration Techniques in the Field

Water and Drought: Landscape restoration in Mediterranean areas with summer drought conditions will require addressing the question of how to establish efficient arrangements for water supply and water use to ensure both ecological and socio-economic sustainability. There are several complementary approaches that should be applied in any restoration project to improve the water availability for seedlings, especially in the first years after being transferred to the field:

1) The selection of drought-tolerant species and ecotypes which may be better adapted to face summer drought conditions.
2) The use of water and nutrient hardening treatments to the seedlings produced in the tree nursery to induce mechanisms for drought resistance.
3) The increase of water availability in the restoration sites through proper location of the planting hole (micro-relief with higher humidity), soil preparation techniques (e.g. planting hole with greater depth; adjustment of planting period to rainfall; construction of micro-catchment and dry well; use of air humidity collectors).
4) The reduction of water losses (e.g. location of the planting hole in micro-relief areas with higher protection from the sun; the use of mulching and shelters; the use of nurse-plants as facilitators).

Restoration techniques to address water requirements[83]	
Aim	Technique
Improve water use	• Selection of drought-tolerant species and ecotypes
Increase water use efficiency	• Seedling preconditioning • Improvement of nutritional status
Increase water supply	• Soil preparation and amendments • Irrigation • The use of air humidity collectors • Micro-site selection • Adjustment of planting period to rainfall
Reduce water losses	• The use of shelters • Mulching • Micro-site selection • Control of competing species • The use of nurse-plants as facilitators (micro-climate)

Unlike other arid and semi-arid areas[84]irrigation has seldom been used in large forestation projects in the Mediterranean region. On one hand, it is expected that seeds, seedlings and cuttings from native plants are well adapted to their environment and should be able to grow without irrigation, just as they do from natural regeneration. On the other hand, it is economically unfeasible (moving water containers and installing irrigation systems in remote areas) and socially questionable (water is very scarce and much needed for human use).

Assisted watering should not be necessary, or at least should be limited to very specific moments of water stress in the first two years after planting if the following three premises are met:
- **Use of high-quality seeds, seedlings and cuttings**, well hardened to face field conditions;
- **Adequate preparation of soil conditions** with effective techniques to help store the maximum quantity of water;
- **Selection of the right time for planting** at the beginning of the rainy season when the soil is well moistened in those regions where a predictable rainy season occur.

Restoration projects are increasingly including emergency watering in their plans mainly due to climate change predictions of higher water shortage, longer drought periods and less predictable rainy patterns. For example, in the Mediterranean region it has been determined that periods of 70-120 consecutive days without any significant rainfall event higher than 5 mm result in high mortality rates of seedlings during their first summer in the field[85].

A large number of irrigation systems are available to deliver water to planted seedlings in an efficient way, but scientific literature and innovation on this topic is scarce. The FLR initiative in the SBR considered the following systems:

- **Small water inputs applied by drip irrigation or hand hose:** this irrigation system may be sufficient to split the drought period into several less stressful intervals and dramatically decrease seedling mortality . This is an interesting option for restoring burned and degraded areas more efficiently. It is expected that the more stressful the environmental conditions he more effective the provision of small water pulses will be.

[83]: Vallejo et al (2012) Chapter 11: Restoration of Mediterranean-type woodlands and shrublands. In: Van Andel, J. & J. Aronson (2012) Restoration Ecology. The New Frontier. Wiley-Blackwell.
[84]: Bainbridge, D.A. (2002). Alternative irrigation systems for arid land restoration. Ecological Restoration, 20, 23-30.
[85]:Valiente, J.A., M.J. Estrela, D. Corell, D. Fuentes, A. Valdecantos & M.J. Baeza (2011) Fog water collection and reforestation at a mountain location in a western Mediterranean Basin region: air-mass origins and synoptic analysis. Erdkunde Vol. 65, N° 3: 277-290

• **Fog water collection:** Evaluations of fog fluxes using fog water collection devices have shown in an experimental study in the region of Valencia (Spain) very promising results with a collected volume of fog water as high as 100 liter/m2. This met the watering requirements of 10 to 20 litres per seedling for a standard forest plantation of 800-1000 pine seedlings/ha[87]. The capacity to collect fog water, following CEAM equipment and technical support, has been tested in the SBR. So far no significant results were obtained with very limited amount of fog water collected. However, the experimental plots are still on-going which may provide more promising results in the near future.

The FLR planting interventions in the SBR were designed with the exclusion of assisted watering. However, the project undertook assisted watering in a number of sites (e.g. Aitanit restoration site at lower altitude with higher arid conditions) when summer drought was more intense. In this case irrigation of 10 litters per day per seedling was implemented for 15 days during the first drought season. In the second year an irrigation of 20 litters per season was implemented 4 times throughout the year. In the third year an irrigation of 20 litters per season was implemented 3 times throughout the year. In some sites a number of seedlings nearby the road where irrigated while the most distant ones were not irrigated. Interestingly the survival rate of irrigated seedlings did not increase in comparison with the rest.

Treatment of Existing Vegetation: The FLR initiative in the SBR has followed the rationale that the use of shrubs as a nurse plant is an alternative technique for reforestation with higher success than the traditional techniques in which pre-existing vegetation was considered a source of competition. A number of applied research projects in the Mediterranean region have demonstrated a much higher seedling survival when planted under/nearby individuals of pioneer shrubs acting as nurse plants, when compared to seedlings planted in open areas where the vegetation cover had been previously cleared[88][89][90]. The rationale for this is that in environments with a dry season and pre-existing vegetation buffers summer drought stress, ameliorates the water status of seedlings and thus usually increases seedling survival.

[86]: Sánchez-Blanco, M.J., Ferrández, T., Navarro, A., Bañon, S. and Alarcón, J.J. (2004) Effects of irrigation and air humidity preconditioning on water relations, growth and survival of Rosmarinus officinalis plants during and after transplanting. Journal of Plant Physiology, 161, 1133-1142.
[87]:Valiente, J.A., M.J. Estrela, D. Corell, D. Fuentes, A. Valdecantos & M.J. Baeza (2011) Fog water collection and reforestation at a mountain location in a western Mediterranean Basin region: air-mass origins and synoptic analysis. Erdkunde Vol. 65, N° 3: 277-290.
[88]:Castro, J.; Zamora, R.; Hódar, J.A.; Gómez, J.M., 2002. The use of shrubs as nurse plants: a new technique for reforestation in Mediterranean mountains. Restoration Ecology, 10, 297-305.
[89]:Castro, J., R. Zamora, J. Hódar, J.M. Gómez, L. Gómez-Aparicio (2004) Benefits of Using Shrubs as Nurse Plants for Reforestation in Mediterranean Mountains: A 4-Year Study. Res- toration Ecology Vol. 12 No. 3
[90]:Ouahmane, L., R. Duponnois, M. Hafidi, M. Kisa, A. Boumezouch, J. Thioulouse and C. Plenchette (2006) Some Mediterranean plant species (Lavandula spp. and Thymus satureioides) act as potential 'plant nurses' for the early growth of Cupressus atlantica. Plant Ecology (2006). Springer

The FLR planting interventions in the SBR maintained the vegetation cover in the restored sites, and made use of the positive nursery role played by a number of legume and thorny shrubs that provide shelter and favourable micro-climate conditions for the planted seeds and seedlings during drought periods.

Transferring Plant Material: Before transporting the seedlings to the field, they should be irrigated thoroughly - better few hours or a day before shipping them. The seedlings could be delivered with their containers or removed from the containers and packaged in nylon bags after which they are packaged in boxes or crates. The transportation vehicle should be equipped with cover to protect the seedlings from direct wind. The seedlings should be delivered the same day of planting to the reforestation site. Delays in unpacking the seedlings may hurt them especially if they are stored in a sunny place.

Soil Preparation Techniques: The main challenge faced by practitioners when planting seedlings, cuttings and sowing seeds in restoration projects is to overcome water stress after planting, especially during the summer drought period of the first year after planting. Degraded land is less capable of retaining and storing water, and often shows low levels of fertility thereby limiting plant performance. Moreover, the elevated radiation that characterises the Mediterranean climate enhances the intensity of drought. Key obstacles to plantation success are the post-planting shock experienced by seedlings and the intensity and length of summer drought[91][92][93]. Thus, one of the main priorities of restoration in drylands is to reduce water stress – increase water harvesting in the planting site and conserve soil water during the drought period[94]. Innovative soil and water conservation technologies, as well as planting techniques that mimics ecological interactions to foster seedling establishment, have significantly improved plantation success in drylands[95]:

• **Increasing the planting hole depth:** Soil preparation improves soil physical properties and enhances deep rooting for seedlings allowing them to reach deep soil horizons and increase their capability of withstanding seasonal droughts. Researchers demonstrated that increasing the depth of the planting hole from 40 to 60 cm may increase seedling performance by 15% in the case of some Mediterranean tree and shrub seedlings[96].

[91]: Chirino, E., A. Vilagrosa, J. Cortina, A. Valdecantos, D. Fuentes, R. Trubat, V.C. Luis, J. Puertolas, S. Bautista, M.J. Baeza, J.L. Peñuelas & V.R. Vallejo (2009) Ecological restoration in degraded drylands: the need to improve the seedling quality and site conditions in the field. In: Forest Management, Steven P. Grossberg Ed. Nova Science Publishers, Inc.
[92]:Vallejo, R. (2008) Rural landscape and water: the role of forests. Water Tribune, 2008 International Exposition of Zaragoza.
[93]:Burdett, A.N. 1990. Physiological processes in plantation establishment and the development of specifications for forest planting stock. Canadian Journal of Forest Research 20: 415-427.
[94]:Vallejo, R. (2008) Rural landscape and water: the role of forests. Water Tribune, 2008 International Exposition of Zaragoza.
[95]:Chirino, E., A. Vilagrosa, J. Cortina, A. Valdecantos, D. Fuentes, R. Trubat, V.C. Luis, J. Puertolas, S. Bautista, M.J. Baeza, J.L. Peñuelas & V.R. Vallejo (2009) Ecological restoration in degraded drylands: the need to improve the seedling quality and site conditions in the field. In: Forest Management, Steven P. Grossberg Ed. Nova Science Publishers, Inc.
[96]:Alloza, J.M. (2003) Análisis de repoblaciones forestales en la comunidad valenciana. Desarrollo de criterios y procedimientos de evaluación. Ph.D. Thesis. Departamento de Producción Vegetal. Universidad Politécnica de Valencia.

FLR pilot restoration in the SBR Landscape applied a minimum depth of 40 cm to open the planting holes (40x40x40 cm), although lately a minimum of 60 cm was recommended. Planting holes are opened with augers. Holes are refilled with extracted soil in its lower 30-40 cm, then the seedling is installed and the rest of the hole is covered with soil, pressing it lightly with the foot. In the case of acorns, the same procedure is followed, except for the depth in which they are placed - about 5 cm from the surface of the hole - covering them later with the rest of the extracted soil.

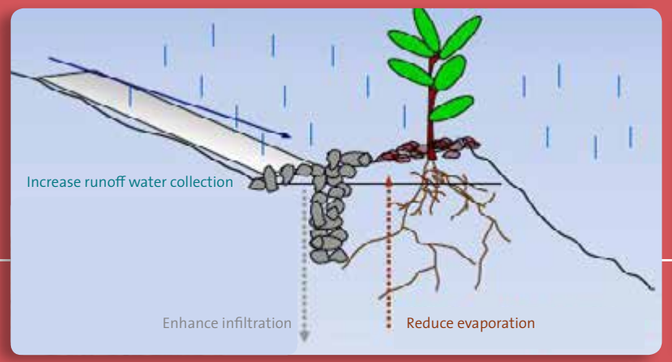
- **Applying soil mulching:** Site preparation also exposes the soil surface to raindrop impact, which may promote soil surface sealing and crusting, thus reducing water infiltration in the planting hole. This favours overflow and damage the planting pits through rilling[97]. The application of plastic sheets, chopped plant debris and other types of mulch is an effective measure successfully used in areas prone to drought[98]as a way to reduce the impact of raindrops, avoid soil crusting and promote water infiltration. In addition, mulches reduce evaporation and contribute to controlling plant competition by hampering the establishment of neighbouring vegetation, and buffers freezing temperatures during winter[99].

- **Constructing micro-catchments for runoff harvesting:** Planting holes with their associated micro-catchments act as "micro-dams" allowing runoff capture and a higher water storage capacity to improve plant growth and survival. In addition, the surplus water may help to reduce saline stress when soils are rich in soluble salts from natural or anthropogenic origin[100]. Moreover, the micro-catchments reduce runoff erosion by creating sinks along the slope.

Micro-catchments are technically feasible and economically affordable, and have been used for centuries in agricultural and agro-forestry systems in arid regions worldwide. It basically consists of digging two 1.5 m long, 0.20 m high ridges forming an oblique angle upslope from the planting hole[101]. Different modifications on the same principle are developed, adapting the technique to different factors, such as the amount and distribution of rainfall events, the soil properties and the topography. The over-costs from establishing micro-catchments may be balanced by the fact that seedling survival increases, and the costs for replacing dead seedlings in the planting site may not be necessary.
In the SBR FLR initiative the combined use of micro-catchments and the setting of stones covering the hole around the planted seedlings for soil mulching have provided very satisfactory results promoting runoff harvesting, reducing soil water evaporation, and preventing the growth of weeds. It is critical to keep the stones during the post-planting maintenance works and beyond, as soil mulching is the most effective way to improve and maintain soil moisture during summer drought periods.

Field restoration techniques aiming at optimizing water availability to planted seedlings [102 103]

Little attention has been paid to the use of inexpensive agricultural techniques in dry Mediterranean land restoration, such as the combined use of micro-catchment, plastic mulches and dry wells. When using micro-catchments implemented with a 300 cm2 plastic sheet upstream the planting hole (improved micro-catchment) the amount and durability of water pulses in relation to traditional planting benches increased, even in late spring and summer months when water stress is exacerbated. A dry well filled with stones, 20–25 cm deep, added in the upper part of the planting hole, and close to the planted seedling promoted infiltration around the root system before collected water evaporates.
When considering only the rainfall events below 10 mm, the average runoff from improved micro-catchment was more than twice than that of the controls (10, 13, and 25 L from the Control, Micro-catchment, and Improved Micro-catchment holes, respectively). The implementation of a micro-catchment alone did not significantly increase runoff interception (run-on water) at any rainfall intensity, but the improved micro-catchment multiplied run-on by 2 and 5 times in the high- and low-intensity events, respectively, as compared with the control planting holes. The dry well treatment combined with improved micro-catchment and stone mulch on the surface treatments added two vertical water pathways in depth, thus contributing to increase both the water inputs from runoff and water infiltration and conservation in the planting hole. By enhancing this type of source-sink dynamic, the dry well combined treatment helped overcome the water scarcity at the driest site and increased water availability at the planting hole, thus benefiting seedling establishment and growth.
It is important to assess the cost of establishing dry well + improved micro-catchment to understand the unit cost per planted seedling in the FLR work of the SBR. Costs will be related to the extra-time field workers may need to prepare the hole and the cost of plastic sheet (the other materials are small stones that will be available in the field).
Soil preparation technique in the planting hole, incorporating: (i) a dry well (DW) filled with stones, 20–25 cm deep, in the upper part of the planting hole; (ii) stone mulching covering the soil of the planting hole; and (iii) improved micro-catchment by shaping small channels at both sides of the hole that direct collect runoff to it and a plastic sheet upstream of the planting hole that reduces the interception of runoff by micro-topography (stones and plants) and generates runoff even for very light rain events.



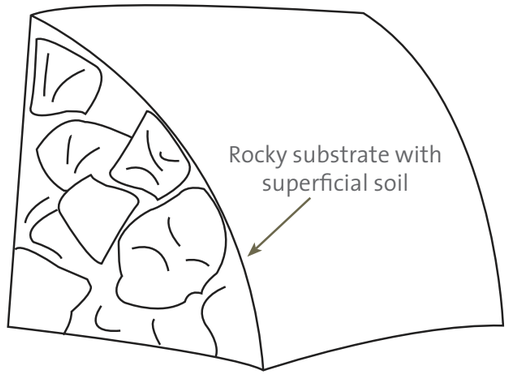
Field restoration techniques aiming at optimizing water availability to planted seedlings

Best Planting Period: The best period for planting is the one in which the soil has the necessary water for the establishment of the seedlings to meet their water needs during the first months on the ground. This basically corresponds with the starting phase of the longer rainy period, which in the case of the SBR Landscape corresponds with end October/early November. However, inter-annual climate variability and climate change trends are significantly affecting both the total amount annual rainfall (which is being reduced) and the starting of the rainy period (which may be postponed until mid-November). This prevents establishing a specific starting date for the plantations and makes it necessary to monitor the rains to ensure that the soil is sufficiently wet to start planting. Likewise, the delay of rains significantly reduces the period of time available for planting which could be limited by the intense cold in late Autumn/early winter.

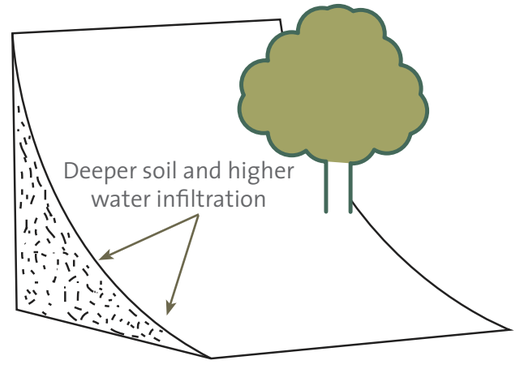
Adjusting the planting density and seedlings' distribution: The number of seedlings per hectare is a very controversial issue and depends on several factors: (i) the environmental conditions of the site or the landscape unit; (ii) the ecosystem management purpose; (iii) the economic purpose; (iv) the social demands. However, in the Mediterranean climate the main factor influencing the planting density is the seedlings' competition for the scarce water resources. Moreover, Mediterranean mountain landscapes are quite heterogeneous in terms of landform patterns with multiple habitat types and environmental units. Planting densities should be adjusted to the carrying capacity of the habitat types in the SBR landscape in terms of soil conditions and water availability and to the species used.

It is a common mistake to use planting densities substantially higher than the maximum density attainable by these species in natural landscapes. The FLR work in the SBR applied planting densities between 500-800 seedlings of trees/ha, and between 1500-1750 seedlings of shrubs/ha. Planting densities were modified based on the landform units: lower densities were allocated to hill summit units and convex slope units with superficial soils, while higher densities were allocated to concave slopes with deeper soils.

[97]: Ries, J.B. and Hirt, U. (2008). Permanence of soil surface crusts on abandoned farmland in the Central Ebro Basin/Spain. Catena, 72, 282-296.
[98]:Valdecantos A., Baeza M.J. and Vallejo V.R. (2008). Vegetation management for promoting ecosystem resilience in fire-prone Mediterranean shrublands. Restoration Ecology (doi: 10.1111/j.1526-100X.2008.00401.x).
[99]:Ibid.
[100]:Bainbridge, D.A. (2002). Alternative irrigation systems for arid land restoration. Ecological Restoration, 20, 23-30.
[101]:Chirino, E., A. Vilagrosa, J. Cortina, A. Valdecantos, D. Fuentes, R. Trubat, V.C. Luis, J. Puertolas, S. Bautista, M.J. Baeza, J.L. Peñuelas & V.R. Vallejo (2009) Ecological restoration in degraded drylands: the need to improve the seedling quality and site conditions in the field. In: Forest Management, Steven P. Grossberg Ed. Nova Science Publishers, Inc.
[102]:Valdecantos, A, D. Fuentes, A. Smanis, J. Llovet, L. Morcillo & S. Bautista (2014) Effectiveness of Low-Cost Planting Techniques for Improving Water Availability to Olea europaea Seedlings in Degraded Drylands. Restoration Ecology Vol. 22, No. 3, pp. 327–335.
[103]:Vallejo, V.R, A. Smanis, E. Chirino, D. Fuentes, A. Valdecantos & A. Vilagrosa (2012) Perspectives in dryland restoration: approaches for climate change adaptation. New Forests (2012) 43:561–579.



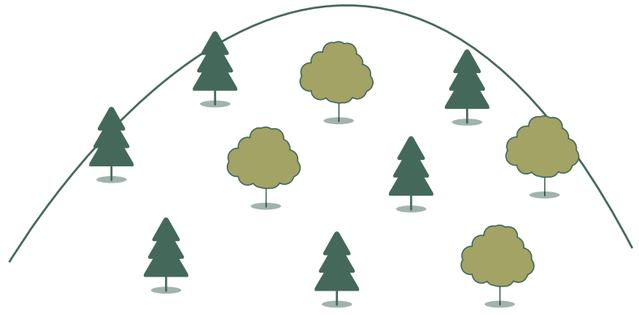
Concave Topography



Convex Topography

Planting density was also correlated to the seedling distribution in the planting sites: rocky outcrops usually occur in convex slopes and hill summits. This forces us to adopt a more or less heterogeneous distribution of the seedlings avoiding areas with high rockiness.

Seedlings were planted following a "quincunx" pattern or staggered arrangement, as a way to get the most of the runoff water.

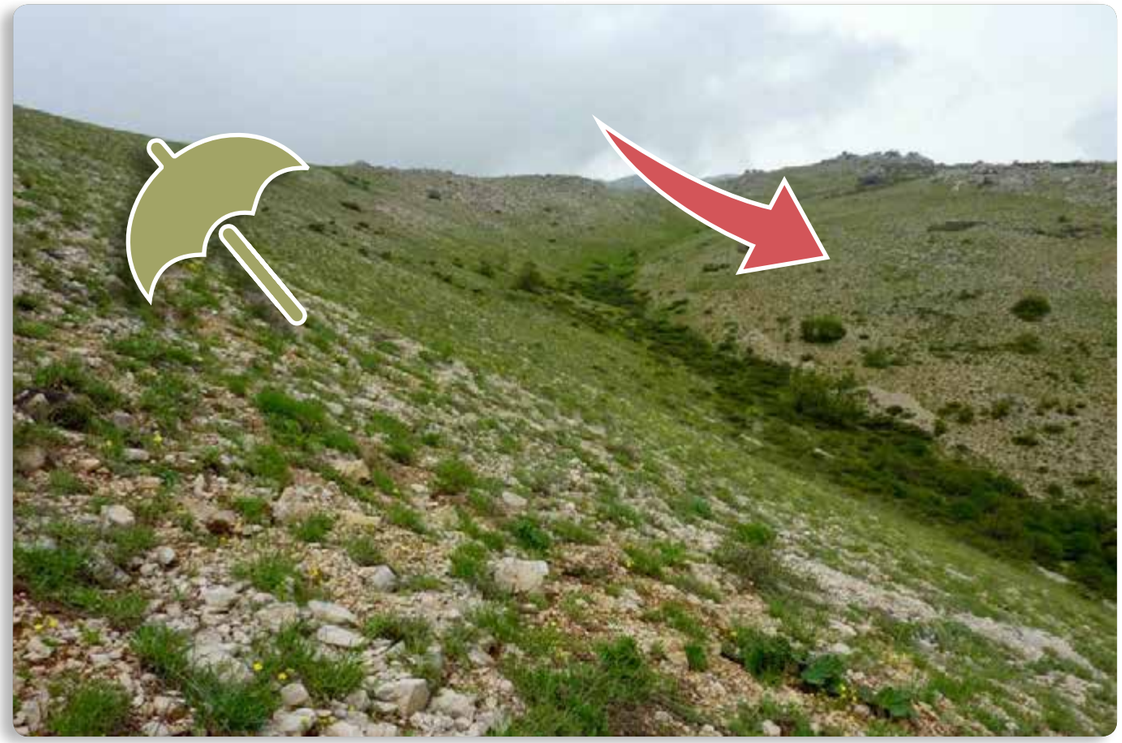


Quincunx pattern

Site selection: A careful selection of the restoration site is required to achieve the expected results. Very windy sites or very rocky areas are more suitable for the planting of shrub seedlings.

NE-facing slope protected from the strong winds
• Planting of seedlings of tree and shrub species characterizing oak and cedar forests.

SW-facing slope affected by strong winds
• Planting of seedlings of small trees and shrub species characterizing open juniper woodlands.



Prunus ursina small tree with flag-shape growth due to the effect of strong winds

• In the case of the eastern Beqaa-side of the SBR landscape with drier and more continental climate conditions, it is recommended to give priority for tree planting to the NE exposures well protected from the dominant winds.

Combining Different Species: Forest Landscape Restoration planting interventions in the SBR Landscape aim to enhance habitat functionality and species diversity with the multipurpose objective to: (i) accelerate the process to restore the natural habitats by incorporating species that play an important role in facilitating recruitment (e.g. fruit trees and shrubs attracting seed-dispersal fauna), species that improve conditions for the regeneration and growth of other species (e.g. nitrogen-fixing species) and species providing a nursery effect for the growth of other species; (ii) to increase the presence of species populations in the landscape that may act as stepping stones to facilitate the species altitudinal and latitudinal migration needs responding to the shifting of climate conditions due to climate change; (iii) to increase the presence of plant populations from species with high socio-economic value related to the ethno-cultural local knowledge.

The project has supported the planting of seeds (mainly oak acorns and cedar seeds) and seedlings from about 40 native species representing the "reference ecosystems" of the different habitat types under restoration. Generally speaking, between 9 to 12 different species where planted in the same restoration site including dominant tree species (representing the majority of seedlings) and companion tree and shrub species. In the riparian forest restoration in Ammiq wetland four dominant tree species were used and in pilot sites where different methods of direct sowing of oak acorns were tested only two species were used.

Most Suitable Plant Material for Each Site: Very often restoration projects in drylands just focus on the use of seedlings (and/or cuttings in riparian restoration) in planting operations. However, a preferential use of seeds or the combined use of seeds, seedlings and cuttings may be desirable depending on the environmental conditions of the different landscape units.

Direct sowing has advantages over the planting of seedlings and cuttings[104]. As in natural regeneration plants growing from seeds are better adapted to the environmental conditions of the area and usually develop a better root system/aerial ratio. Sowing requires little soil preparation minimizing damages to the soil and to the existing vegetation cover. Moreover, sowing has much lower costs (no need for nursery production, transportation and soil preparation costs) and can include a large number of species in the restoration work by mixing seeds from different species.

Direct sowing can also be implemented in inaccessible sites (e.g. sowing seeds from helicopters) and over wider landscape areas[105]. However, sowing seeds requires a much higher amount of seeds to be collected than those required for nursery production - an issue that implies much more labour and a large and well-organized network of workers within the landscape to collect seeds in the right period. It may also have a negative impact on the natural regeneration of the collection sites when seeds are collected intensively.
Sowing seeds has a number of risks to be assessed in experimental plots to avoid future failures: predators (rodents, mammals, and birds) are attracted by certain seeds and may significantly reduce sowing success; small seeds are carried by water runoff and may significantly reduce the percentage of seeds in the sowed restoration area; and intense radiation and water limitation may prevent seed germination.

Sowing of Branti oak acorns with protector to prevent rodent predation

Rodent activity in the soil of restoration sites

Sowing seeds from herbaceous species seems to be the best option to restore grasslands, in combination with other protection and management measures. Common methods of grasslands restoration include transferring soil seed banks, direct sowing with seed mixtures, transferring seeds contained in hay, and transplanting seedlings[106]. Sowing indigenous herbaceous species facilitates the recruitment of species, controls weeds, and accelerates plant succession, which is essential in ecosystem restoration[107]. Furthermore, this technique is more sustainable compared to the financial and energy cost of other restoration techniques.

[104]: Schmitt, J. (2012) Communication at the 1st International Experts Workshop on Drylands Restoration (Konya, Turkey). FAO
[105]: Lemenih, M. (2004) Effects of Land Use Changes on Soil Quality and Native Flora Degradation and Restoration in the Highlands of Ethiopia Implications for sustainable land management. Doctoral Thesis, Swedish University of Agricultural Sciences Uppsala.

Broadcast seeding of *Cedrus libani* in the bare karstic mountains of southern Turkey showed very successful results, restoring 40,457 ha of forestland between 1984-2005. An average of 9,000 seedlings/ha (from 6,000/ha in sunny slopes up to 14,000/ha in shady slopes) were obtained[108]. Rapid shoot growth and height differentiation began when seedlings were 4-6 years old, although soil compaction and bedrock crack systems could limit growth. Results suggested that about 250 kg/ha and 500 kg/ha seeds with cone scales are needed for broadcast seeding in bare karstic land (double number of seeds on sunny exposures compared to shady ones). Some recommendations when applying broadcast seeding under these conditions are: (i) the area to be restored must be fenced before seeding to protect against grazing; (ii) surface soil treatment (deep soil treatment in abandoned agriculture land) must be applied by a ripper, mounted on an agriculture tractor or crawler tractor in compact soils or densely weed covered areas; (iii) seeding should be applied just before or during snow season to reduce seed predation by insects and birds; (iv) stones and boulders on the soil surface should not be removed as they reduce evapo-transpiration and increase seedling survival; (v) seeds should be collected from surrounding forest stands at similar altitude and ecological conditions.

Seed sowing under the snow

Cedar seeds

Cedar regeneration

[106]: Buisson E., Dutoit T., Torre F., Römermann C. & Poschlod P. (2006). The implications of seed rain and seed bank patterns for plant succession at the edges of abandoned fields in Mediterranean landscapes. Agriculture, Ecosystems and Environment 115, 6-14.
[107]: Prach K. & Pysek P. (2001) Using spontaneous succession for restoration of human-disturbed habitats: Experience from Central Europe. Ecological Engineering 17, 55-62.
[108]: Boydak. M. (XXX) Reforestation of Lebanon cedar (Cedrus libani A. Rich.) in bare karstic lands by broadcast seeding in Turkey.

The FLR initiative has tested direct sowing of acorns from the three oak species of the SBR landscape (*Quercus calliprinos, Q. infectoria, and Q. brantii*) combined with the use of tube protectors (plastic tubes made with a rigid plastic tube with about 4 mm hole size) of 0.5 meter height that were buried 15 cm at the bottom and closed with a strip at the top to prevent the entrance of rodents. In the second year, the strip at the top was opened to facilitate the vertical growth of seedlings. Results are very promising, with about 70-80% survival rate which showed good protection against rodents.

Post-planting interventions:

Replacing dead seedlings: Dead seedlings should be replaced early in the next planting season (just after the first rain in October-November) with high quality seedlings of the same species that died, to maintain the same restoration objective originally planned. In the framework of the project in the SBR, 2,000 seedlings were replanted in 2015 to replace dead seedlings planted in 2014, and 500 seedlings more in the fenced plots. Seedlings from coniferous species (e.g. cedar, pine and juniper) and Quercus species were the most sensitive and affected by the severe drought conditions in 2015. In the case of Quercus, predation of a large number of sown acorns caused high mortality in a number of sites. In order to overcome this problem, the acorns were planted with protectors the following year which increased their survival significantly.

Assuming that there will be a mortality rate (e.g. an average of around 30% in the SBR) two strategies can be followed:

- increase the number of seedlings per hectare to absorb the possible mortality and avoid a new planting the following year with the consequent increase in cost per hectare;
- replace the dead plants the following year with the consequent cost of a new planting campaign. Any of the two strategies is right and the decision to follow is up to the restoration team.

Supplemental irrigation in the restored sites: active planting interventions in the SBR FLR initiative do not consider irrigation as a usual practice to be promoted due to social-responsibility and cost reduction reasons. The project considers that high quality seedlings planted at the right period of the year and making use of effective soil preparation techniques should not require irrigation to ensure their survival. However, climate change and variability trends have already exacerbated drought conditions during the summer period – more extended and intense drought - so in years with more severe drought conditions it may be indicated to apply one or two supporting irrigations during the summer period in the first two years after planting, whenever possible in terms of access and costs. It is important to monitor the healthy status of the planted seedlings to understand if it is critical to irrigate or not.

Taking advantage of the positive plant interactions: Research suggests that, in stress-prone dry environments, keystone plant species – trees, shrubs and mega-herbs - can have a net positive effect on the recruitment and growth of other species. Research results in southern Spain demonstrated that the facilitated effect occurred in all the studied landscape units - low and high altitudes; sunny, drier slopes, and shady, wetter slopes – but significant differences in plant interactions were reported depending on the seedling species planted as well as the nurse shrub species involved[109]. Facilitator plants or "nurse plants" had a stronger facilitative effect on seedling survival and growth in the drier and sunny areas where water scarcity was a limiting factor during the growing season, and thus can positively affect restoration success.

The use of nurse-plants in restoration efforts in stressful environments such as drylands accelerates the recovery of healthy ecosystem dynamics in two ways[110]: (i) Increasing the population of facilitator species through the planting of seedlings, cuttings and seeding can locally ameliorate abiotic conditions (e.g. improved soil structure, organic matter and nutrient cycling; increased water infiltration providing hydraulic lift; creation of micro-climate conditions of shadow and air humidity) and biotic conditions (e.g. increased mycorrhyzal abundance, plant diversity and soil seed bank), providing habitat requirements for other plant species and for seed dispersers, therefore accelerating the natural recovery of vegetation; (ii) Planting seedlings from desirable species under or nearby nurse-plants benefit from more favourable abiotic and biotic conditions, accelerating and improving plant growth and survival. The selection and use of multipurpose nurse-plants becomes an ecologically sound, socially acceptable and economically beneficial restoration strategy to be adopted and supported by landowners and users.

The FLR initiative has tested the use of nurse-plants in restoration work in two ways:

• Increasing the population of facilitator species through seed sowing or seedling planting (e.g. the sowing of oak acorns) that locally ameliorate abiotic conditions (e.g. improved soil structure, organic matter and nutrient cycling; increased water infiltration; microclimate conditions of shadow and air humidity) and biotic conditions (e.g. increased mycorrhyzal abundance, plant diversity and soil seed bank), providing habitat requirements for other plant species and for seed dispersers therefore accelerating the natural recovery of vegetation.
• Testing the "nursery effect" of thorny shrubs (e.g. *Juniperus oxycedrus, Onobrychis cornuta, Astragalus spp.*) to demonstrate an effective facilitation role supporting the survival and growth of seedlings and seeds planted in the adjacent part above the nurse plants under the critical dry conditions of most of the growing season, thus positively influencing restoration success.

The nursery effect of thorny cushion legumes (*Onobrychis cornuta*) facilitating the growth of Prunus ursina seedling

The nursery effect of *Quercus brantii* facilitating the growth of cedars

[109]: Gómez-Aparicio, L., R. Zamora, J.M. Gómez, J.A. Hódar, J. Castro & E. Baraza (2004) Applying plant facilitation to forest restoration: a meta-analysis of the use of shrubs as nurse plants. Ecological Applications, 14(4), 2004, pp. 1128–1138. Ecological Society of America.
[110]:Castro, J.; Zamora, R.; Hódar, J.A.; Gómez, J.M., 2002. The use of shrubs as nurse plants: a new technique for reforestation in Mediterranean mountains. Restoration Ecology, 10, 297-305.

Forest restoration in degraded secondary shrubland and pastureland				
Aim	To enhance ecosystem functionality and species diversity in degraded forestland. Planting seedlings of a wide range of trees and shrubs representing the mountain forest habitats will help restore natural environmental conditions, the ecological processes and the species diversity.			
What	Restoring degraded high mountain slopes covered with secondary scrub vegetation, with seedlings of species characterizing mixed cedar forest ecosystems in the more humid Shouf-side and Brantii oak forests in the drier and more continental Beqaa-side.	Restoring the culminating mountain areas with skeletal soils and the SW slopes affected by strong winds, with seedlings of tree and shrub species characterizing open juniper woodlands.	Restoring degraded low mountain limestone slopes covered with secondary scrub vegetation, with seedlings of tree and shrub species characterizing mixed oak forests.	Restoring degraded low mountain sandstone slopes covered with secondary scrub vegetation, with seedlings of tree and shrub species characterizing stone pine forests and mixed infectoria oak and stone pine forests.
Location	1500-1900 m NE-facing slopes	1500-1900 m summit and SW-facing slopes	1000-1500 m limestone slopes	1000-1500 m sandstone slopes
Planting density	800 seedlings/ha	500 seedlings/ha	800 seedlings/ha	800 seedlings/ha
Planting framework (Quincunx pattern)	Every 2.5 meters in lines separated 5 m each	4.5x4.5 meters between holes	Every 2.5 meters in lines separated 5 m each	Every 2.5 meters in lines separated 5 m each
	Irregular, avoiding rocky outcrops and convex sites	Irregular, avoiding rocky outcrops and convex sites	Irregular, avoiding rocky outcrops and convex sites	Irregular, avoiding rocky outcrops and convex sites

Forest restoration in degraded secondary shrubland and pastureland				
Plant species	N° seedlings per each species/Total N° seedlings per hectare			
Cedrus libani	400/800 (Shouf Side) 100/800 (Beqaa side)			
Quercus brantii (a + s[111])	100/800 (Shouf side) 400/800 (Beqaa side)	50/500		
Quercus calliprinos (a + s)	80/800		250/800	
Quercus infectoria			150/800	200/800
Juniperus excelsa		100/500		
Juniperus oxycedrus		20/500		
Pinus pinea				400/800
Sorbus flabellifolia	50/800	40/500		
Sorbus torminalis	50/800		50/800	
Acer tauricolum	50/800	40/500		
Acer obtusatum			50/800	50/800
Malus trilobata	20/400		60/800	
Prunus ursina	20/400	50/500	40/800	
Crataegus azarolus	20/400		30/800	50/800
Crataegus monogyna			30/800	40/800
Pyrus syriaca			40/800	40/800
Arbutus andrachne			20/800	20/800
Styrax officinalis	10/400		50/800	
Rosa glutinosa			10/800	
Rosa canina			10/800	
Lonicera nummulariifolia		50/500		
Cotoneaster nummularius		50/500		
Colutea cilicica		50/500	10/800	
Berberis libanotica		50/500		

[111]: a: acorns; s: seedling.

field restoration information panel


Workers digging holes with auger


Restoration site in Maasser municipality


The planting hole has to be 60 cm deep


Restoration site in Aitanit municipality


Stone mulching


Cedrus libani seedling


Restoration site in Mrusti municipality


Quercus brantii seedling


Crataegus monogyna seedling


Prunus dulcis seedling


Sorbus flabellifolia seedling


Sorbus torminalis seedling


Acer tauricolum seedling

Enrichment planting in degraded forest- and pastureland				
Aim	• To increase species diversity in simplified forest stands, contributing to higher ecosystem services (e.g. ecological processes, pollination, pest control, habitat for fauna species), improved natural regeneration (e.g. increasing the presence of wild fruit tree/shrub species attracting seed-dispersal fauna), and forest resilience against climate risks (e.g. increasing the presence of re-sprouting species that regenerate after fire). • To create "woodland islets" with a major climate change adaptation focus: - creating stepping stone areas to facilitate future species migration needs in response to the upwards shifting of bio-climate conditions due to climate change) - providing favourable environmental conditions for livestock to stand future higher heat stress thanks to the shadow and higher humidity under the tree thickets) - enhancing ecosystem services (e.g. source of propagules, which greatly accelerates woodland development in the surrounding denuded areas; improvement of soil fertility and microclimate conditions; attraction of seed dispersal fauna that plays a major role in natural forest regeneration). • To increase forest connectivity, benefiting from the nursery-effect of some species that facilitate the growth of the planted seedlings.			
What	Providing connectivity between relic cedar stands, by planting cedar seedlings in Q. brantii forest patches, taking advantage of the oaks' nursery-effect.	Diversifying mono-specific pine and oak stands, and old cedar plantations, by planting acorns and seedlings of re-sprouting broadleaf tree species	Creation of scattered small forest patches in large pastureland without woody vegetation, by planting acorns and seedlings of fruit-tree species in small areas (fenced or not)	Creation of small forest patches in/ around the lake and green barriers on the edge with road and crops, by planting seedlings and cuttings of freshwater tree species
Location	High mountain NE-facing slopes	Low mountain slopes	High and Low mountain slopes	Ammiq wetland
Planting density	150 seedlings/ha	200 seedlings/ha	500 seedlings/ha	500 seedlings/ha
Planting framework	Nearby existing oak trees	In small forest gaps	5x5 meters (Quincunx pattern)	5x5 meters (Quincunx pattern)
Plant species	N° seedlings per each species/Total N° seedlings per hectare			
Cedrus libani	150/150			
Quercus brantii (a + s)			250/500 (HM[112])	
Quercus calliprinos (a + s)			150/500 (LM[113]) 50/500 (HM)	
Quercus infectoria			100/500 (LM)	
Pinus pinea			50/500 (LM)	
Acer tauricolum			50/500 (HM)	
Sorbus flabellifolia			50/500 (HM)	
Sorbus torminalis		30/200	50/500 (HM)	
Malus trilobata		30/200	50/500 (LM)	
Prunus ursina		20/500	20/500 (LM)	
Crataegus azarolus		30/200	30/500 (LM)	
Crataegus monogina		30/200	40/500 (LM)	
Pyrus syriaca		20/200	50/500 (HM)	
Prunus dulcis			40/500 (LM)	
Arbutus andrachne		20/200	20/500 (LM)	
Celtis australis				50/500
Fraxinus syriaca				200/500
Ulmus minor				100/500
Populus alba				100/500
Salix libani				50/500

[112]: HM: high mountain.
[113]: LM: Low mountain.


Enrichment planting with cedar seedlings in the brantii oak woodland in between the relic cedar stands of Ain Zhalta (left) and Barouk (right)


Planting cedar seedlings taking advantage of the facilitation effect of oak stands in high mountain sites


Establishing small 2 m height fenced plots in pasture land to restore "woodland islets"


Quercus calliprinos seedlings in fenced area


Planting of tree seedlings in scattered fenced sites within large pasture zone without woody vegetation, increases food for livestock (acorns and leaves) while facilitating species migration needs due to climate change.


Crataegus sp. Seedling in fenced plot


Quercus infectoria seedling in fenced plot

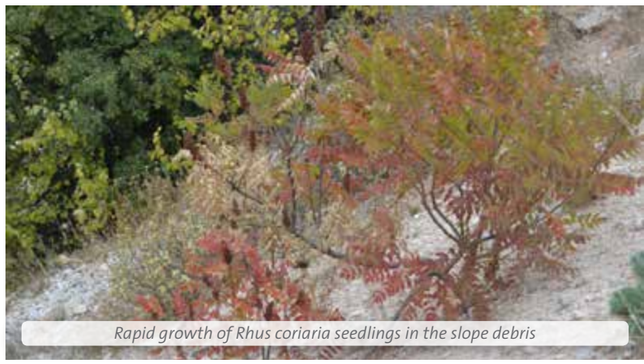
Interventions for quarry restoration			
Aim	• Stabilize the unstable soils of the slag heaps and avoid erosion problems, by recovering a natural vegetation cover. • Create a green barrier in front of the cliff of the quarry to reduce its visual and landscape impact. • Facilitate the creation of a rupicolous habitat in the cracks of the quarry wall.		
Location	Abandoned quarry at the SBR entrance in Mrusti		
What	Planting seedlings and acorns in the slag heaps	Planting seedlings and cuttings in front of the cliff	Seed sowing of rupiculous plant species in fissures
Planting density	500 seedlings/ha	80 seedlings/100 meters	Variable, depending on the availability of fissures
Plant species	N° seedlings per each species/Total N° seedlings per hectare		
Rhus coriaria	70/500		
Styrax officinalis	50/500		
Quercus calliprinos (a+s)	80/500		
Quercus infectoria (a+s)	60/500		
Pinus pinea	30/500		
Cupressus sempervirens	20/500		
Sorbus flabellifolia	50/500		
Sorbus torminalis	50/500		
Crataegus azarolus	30/500		
Acer obtusatum			
Arbutus andrachne	20/500		
Celtis australis	40/500	20/100m	
Salix alba		30/100m	
Populus alba		30/100m	
Putoria calabrica			+
Capparis spinosa			+


Seedling planting and seed sowing in the talus debris of the abandoned quarry in Mrusti.


Seedling planting in the talus debris inside the quarry in Mrusti.


Rapid growth of Pinus pinea in the loose soil at the foot of the quarry slope


Successful growth of Arbutus andrachne seedlings


Rapid growth of Rhus coriaria seedlings in the slope debris


Quercus calliprinos seedling


Seedling planting and seed sowing in the talus debris of the abandoned quarry in Mrusti.


Quercus infectoria seedling


Sorbus flabellifolia seedling

Equipment Used in Field Restoration Works: Field planting operations were undertaken with the Earth Auger STIHL Model BT 121, which is a comfortable one-man earth auger with vibration-reducing handles, particularly suitable for drilling holes. It includes Quick-Stop drill brake, which brings to a halt as soon as the drill jams in the ground. Other planting equipment are pick axe, forked hoe and shovel hoe used in inaccessible places where the earth auger cannot be used.
Forest thinning and pruning equipment included: (i) MS 261 high performance chain saw (bar length 40-45 cm; 2.8 kW power output) for the cutting of shoots and branches; (ii) Jensen Woodchipper machine type A231 Di V-3600 TDR 80 km/h; (iii) Pick-up with 3 tons capacity to load shredded wood in the field (the daily rent cost is USD 50); (iv) bigger truck with the capacity to carry 12 to 14 tons of biomass to be transported to the briquettes plant (USD 100 renting cost per trip); (v) Cut-resistant foot wear EN ISO 17249 (cut-resistance class 1, equal to 20 m/s); (vi) Face and ear protector with nylon mesh, double headband and ear defenders; (vii) Chain saw leather gloves with cut protection 5-Finger (protection class 1, equal to 20 m/s), with cut resistant inlay in the back of both gloves; (viii) chain saw trousers with cut protection.

Equipment used in field FLR interventions in the SBR landscape:

Face and ear protector

Woodchipper Machine

Chain saw leather gloves

Cut resistant foot wear

Auger Machine

chain saw trousers

MS 261 high performance chain saw

Human resources for field restoration work: Daily-paid workers were hired among the young unemployed local population and Syrian refugees thus providing much needed income and contributing to their social and economic integration. These daily workers attended awareness raising events to learn about FLR and the employment opportunities related to the project interventions. The project applied "learning-by-doing" techniques through continuous training implemented before and during the implementation work. The workers who showed more interest and better skills in the application of the acquired techniques were assigned as foremen and as trainers of the less qualified workers and the newcomers. About 22 € was given to the workers per day, and 30 € to the more specialized ones.

Hole opening performance was as follows:
• Opening of holes with hoes and picks in rocky places where auger machine could not be used: 7-8 holes/worker/hour, representing a higher performance than envisaged in the Forest Restoration Plan (6/worker/hour).
• Opening of holes with augers: 14-16 holes/worker/hour (12/worker/hour was envisaged in the Forest Restoration Plan).
• The working rate per person per day for the planting operations was also higher than expected:

Active planting costs in the SBR: Considering work performance and the cost of the produced seedlings (USD 1), the cost of the field restoration work in the SBR was about USD 3-3.5 per planted seedling, including:
- seedling production cost,
- the cost of seedling transferring to the field,
- the cost of soil preparation, and
- the cost of seedling plantation.

For an average plantation density of 700 seedlings per hectare the cost per hectare was between USD 1,750 and USD 2,100 depending on the degree of difficulty of each restoration site (e.g. the accessibility depending on mountain steepness and the distance to the nearest road; the necessary effort to dig a hole depending on the hardness and rockiness of the soil). It is expected that higher work performance and lower cost of seedlings will decrease restoration costs per hectare in the short- to medium term up to USD 1.5-2 per planted seedling. The cost per hectare is more difficult to assess depending on the planting density and the need to replace dead seedlings. In the case of fenced restoration sites (about 25 x 25 m) the cost of establishing the fence (USD 12/m2) must be added to the total costs.

The forest restoration cost was significantly reduced compared to average costs in Lebanon:

- The Project managed to decrease the forest restoration cost from USD10 per each planted seedling to USD 2.5 - USD 3.
- The reduction of costs was due to: (i) an accurate plant production protocol avoiding the excessive consumption of water and other inputs; (ii) the equipment used for soil preparation (auger machine); (iii) the professionalization of the staff involved in plant production and field planting; (iv) the exclusion of watering in the maintenance of the restored sites.
- Supplemental irrigation in the restored sites not only increases the cost of forest restoration but also is socially questionable - water is a very scarce commodity much needed for human development in dry regions. In the case of six supplemental irrigations provided to seedlings in a restored site the forestation cost/ha would increase more than 100%.

The project has demonstrated the possibility of implementing forest restoration without additional water supply to the planted seedlings, which represents a great success in reducing the restoration costs and is a major contribution to the forestation guidelines defined by the Lebanese government in its National Forestation Programme.

VII.2.2 Restoring Dry Stone Walls in Abandoned Agriculture Terraces

Although agricultural terraces have gone through periods of expansion, consolidation and decline the remarkable fact is that some of the oldest continue to have an impact on the landscape[114]. A key to such resilience was probably due to the strong cultural identity linked to the mountainous agriculture terraced systems, such as in the SBR landscape. These systems have reduced the likelihood of abrupt changes in the ecological capital of the landscape, namely the loss of ecosystem services – soil erosion prevention, increase soil fertility, hydrological regulation, create micro-climate conditions for agriculture production.

The study and conservation of agriculture terraced landscapes has become an important topic for sustainable development since the Rio Earth Summit in 1992. Terraces became an important concern of the CBD activities concerning indigenous knowledge, the UNESCO-CBD Joint Program on the Linkages between Cultural and Biological Diversity, and the FAO GIAHS program[115]. In Europe for instance, the cultural practice to construct agricultural terraces with dry stone walls in rural areas of Croatia, Cyprus, France, Greece, Italy, Slovenia, Spain and Switzerland was inscribed in 2018 by UNESCO in its Representative List of the Intangible Cultural Heritage of Humanity.

Abandoned terraces used to grow olives, various fruit trees, vineyards and cereals and some are still used in the SBR landscape. However, even these cultivations are not regularly taken care of and no repairs of the old stone walls are done resulting in their collapse and subsequent washing downslope of the terraced soil. The main use of these terraces is for grazing by livestock that is a part of the grazing zoning system of the SBR.

The restoration of abandoned terraces plays a critical role in terms of enhancing ecosystem services to sustain both biodiversity and human well-being. The project activities will demonstrate best practices in terms of: (i) restoring the ecological functionality of the terrace systems to avoid environmental risks, regain biodiversity values and enhance their integration in the eco-cultural landscape; (ii) supporting green economic opportunities to enhance people's livelihoods, jobs generation and market links between producers and consumers, through the production and marketing of aromatic/medicinal/edible plants positively impacting the socio-economic situation in the region.

The process of agricultural terrace collapse[116]

The abandonment of agricultural terrace systems generates several environmental issues the most important of which is renewed erosion. The following types of collapse can be identified: (i) collapse of the wall summit elements; (ii) partial collapse of the wall; (iii) translation of the wall base; (iv) total collapse of the wall.

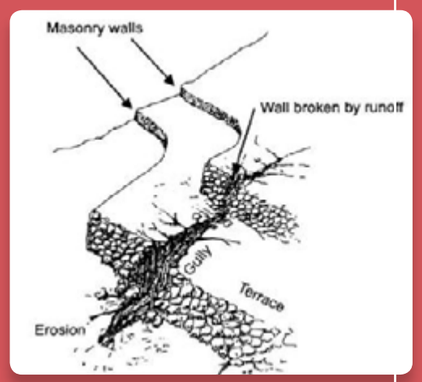
It is worth noting how more causes can act simultaneously and lead to more complex collapse forms. The collapse of the wall summit elements can be due to surface water runoff (when the wall head is made up of small sized elements) but it can be helped by an excess of vegetation that grows between the cracks of the wall itself. Collapses can be preceded by a localized or widespread degradation of the top (left and central figure) and for the manager this is the right moment to intervene to stop the degradation phenomenon, before a collapse occurs (right figure). The collapse of summit elements due to water runoff begins with the excess water - not absorbed by the ground - which leaping from terrace bed to terrace bed can cause the fall of small lithic elements at the top of a terrace wall.

Localized degradation of wall top

Widespread degradation

Wall portions collapse

The depression left by the fall of one or more lithic elements can become a runoff concentration point accelerating soil and stone elements removal. The water collection funnel can grow until it involves downstream terraces in the degradation process, and it can become a gully of a considerable size and impossible to recover. The partial collapse of the wall for stability loss is due to the deformations a wall can suffer as a result of ground thrust. Because of this thrust part of the structure deforms with respect to its original geometry that leads to a progressive deformation.



The term “dry stone” indicates how the stone elements constituting the terrace retaining wall are placed near one another without the use of binders. The walls made in this way can have variable height as a function of slope gradient, and length equally variable as a function[117]. This type of dry wall can be further divided into two subtypes: the walls whose head is at the same level of the terrace bed (which is the case of the two project areas) and those whose head is higher than the terrace bed level. The raised head is, moreover, a wind protection for some types of crop and serves as a passageway for farmers along the strip. Another important function that the raising of the wall performs is to interrupt the water runoff flow that otherwise would jump from one terrace to another damaging crops. The raising of the wall has a barrier effect which favours water accumulation and infiltration in the soil.

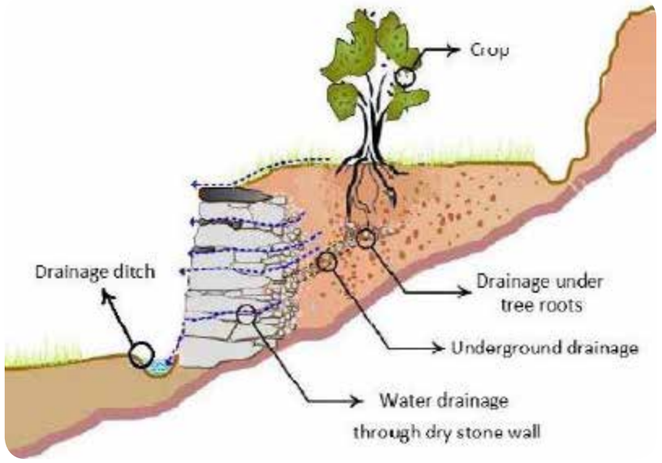
Behind the wall a mass of minute material is set to promote drainage. The bedrock and the excavation represent the walls foundation, which have a varying width, depending on the height of the terrace. The wall is raised with a slope towards the interior of approximately 15%.

[114]: Du Guerny, J. & Lee-Nah Hsu (2010) Meeting the challenges to sustainability: A northern Mediterranean Agriculture Perspective. First Terraced Landscape Conference, Honghe, China, 11-15 November 2010. UNESCO/FAO/Ramsar.
[115]: Agnoletti, M. et al (2015) Territorial analysis of the agricultural terraced landscapes of Tuscany (Italy): preliminary results. Sustainability2015, 7
[116]:Sangiorgi et al., (2006) Muri a secco e terrazzamenti nel Parco dell’Adamello; linee guida per il recupero, University of Milano.
[117]:Parco Nazionale Delle Cinque Terre (2004) Manuale per la costruzione dei muri a secco. Linee guida per la manutenzione dei terrazzamenti delle Cinque Terre. LIFE 00 ENV/IT/000191 PROSIT.

The construction is done in courses, trying to bind the stones of the facade with those positioned against the ground, inserting stone elements with the long side placed orthogonally to the wall axis. The stones are laid significantly inward tilted, to minimize the risk of slipping, and holes between one stone and the other are filled with stone chips or small stones for binding to prevent the stones of larger size from moving. The use of these small stones is therefore very important for the stability of the wall because they serve to increase the support points between one stone and another, thus eliminating possible situations of precarious balance.

Dry walls themselves are self-draining but when the terrace wall is constructed with mortar weep holes or drainage pipes have to be necessarily added. In a terrace the drainage function can be increased by improving the backfilling with coarse gravel. Drainage pipes placed through the wall several cm above ground level can be added also in normal dry-stone walls, to favor drainage in case of clayey soil that are difficult to drain by themselves.

General model of terrace system[118]



In general, dry stone walls, while having the same basic rules of construction, show differences due to the lithic material type and to construction rules of limited spatial extent such as the use of soil to regularize the stone laying beds[119]. An important characteristic of a terrace wall is its slight inclination towards uphill to counteract the ground thrust.

Two layers of stones are placed in vertical, then behind the new masonry smaller stones are placed to form a drainage layer, which is then covered with soil. The lower part up to 1,5-2 m is occupied by soil rich in stones then the rest of the terrace bed is filled with good soil for plant roots.

The FLR initiative provided training to farmers, young unemployed and Syrian refugees on good practices for restoring dry stone walls in abandoned or degraded terraces (see FLR Principle V). Through learning-by-doing training sessions on terraces of farmers interested in putting them back into production are restored, while a certificate of qualification in this matter is given to successful participants.


Abandoned terraces


Degraded dry stone walls


Water pond in abandoned agriculture terrace, fed by underground water from an excavated tunnel in the mountain slope


Abandoned terrace with access steps


Restoring abandoned terraces


Dry stone wall restoration


Dry stone wall restoration

The restoration of dry stone wall terraces in the SBR also includes interventions for the maintenance and recovery of marginal habitats linked to the agriculture terraces, such as hedges, tree and shrub shelters, isolated trees, ruderal vegetation along roads, the stone walls, etc. Installation and preservation usually require low-cost techniques and minimal labour. Preserving and restoring small strips of land left unploughed have major environmental benefits:

- Species diversity in marginal agricultural habitats is significantly high including insects that play a major role in crop pollination and pest control.
- Marginal habitats act as barriers to slow runoff water, improve water infiltration, prevent wind desiccation and erosion, prevent loss of soil nutrients, and create microclimate conditions in croplands.
- Natural vegetation strips (NVS) have little competition with crops for space and can play an important role for fodder provision.

Economically valuable wild trees or shrubs can be planted in the border of stone walls, providing additional source of income, as for instance oak honey or edible fruits and nuts. While restoring dry stone walls, seeds, rhizomes and bulbs of wild plants, such as species from the genus *Cyclamen, Capparis spinosa, Sedum spp, ferns,* can be incorporated in the crevices between the stones to enrich the habitat type.

[118]: Contessa V. (2014) Terraced landscapes in Italy: state of the art and future challenges. Corso di laurea magistrale in Scienze Forestali e Ambientali. U.S.Padova. Dip. Territorio E Sistemi Agro-Forestali
[119]:Ibid.


Dry stone wall habitat: Dryopteris pallida


Dry stone wall habitat: Ceterach officinarum (right) and Umbilicus cf. intermedius (left)


Dry stone wall habitat: Rosularia libanotica


Dry stone wall habitat: Capparis spinosa

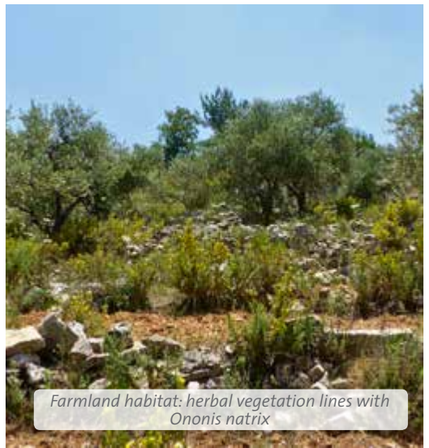

Dry stone wall habitat: Cyclamen persicum


Dry stone wall habitat Aristolochia sempervirens


Farmland habitat: Underground water collection and water pond linked to traditional terraces


Farmland habitat: hedges with mixed shrubs (e.g. Origanum syriacum, Pistacia palaestina) and herbs (Hordeum bulbosum)


Farmland habitat: Old ash tree acting as an "habitat trees" providing micro-habitats (e.g. cavities, bark pockets, large dead branches) for numerous flora, fauna and fungi species.


Farmland habitat: herbal vegetation lines with Ononis natrix


Farmland habitat: grassland with abundance of orchid species, such as Anacamptis sancta, in agriculture terraces


Farmland habitat: nitrophilous vegetation with the thistle species Notobasis syriaca

VII.3 Adaptive Management Interventions to Increase Resilience Against Climate Risks

VII.3.1 Thinning and Pruning

Climate change is increasing the landscape vulnerability to unsustainable fire regimes and forest dieback, especially when maladaptive human practices or land abandonment promote the accumulation of dry biomass in forests, woodlands and scrublands, and the burning of agriculture waste. This is especially evident in the case of the SBR landscape, where forest fires occur mainly in autumn - outside the period of greatest risk in summer - due to the burning of pruned branches and stubble by farmers. In this context, the SBR FLR initiative has incorporated management and economic development objectives for climate change adaptation through the collection and economic use of forest and agriculture waste. It has helped transform dense forest stands into a more resilient forest structures that positively contribute to the ecological resilience of the SBR landscape (prevention of forest fires and forest dieback events; enhancement of ecosystem services), while supporting new economic development and employment opportunities.

In abandoned coppiced forests and too dense secondary pine/oak forests thinning and pruning operations helped speed up the growth of the best selected stems, increased carbon storage in more mature forest stands, reduced water stress and competition in dense vegetation stands, and increased the ecosystem services provided by forests (e.g. higher diversity and abundance of plants providing non-timber forest products). Moreover, the collection of pruned branches from olives and fruit trees and other residues (e.g. olive pomace) helpd reduce the risk of fire (burning agricultural waste in autumn is a common practice in the SBR Landscape and the main cause of forest fires) while creating economic opportunities through its use as bioenergy and compost production.

Forest management interventions consisted in the thinning and pruning of dense oak coppice stands, mainly along the roads, with the intension of keeping about 1-3 stems per individual (those with healthier conditions and with better diameter and height). These interventions provided very good results:

• The growth and health conditions of the thinned oak and pine trees have significantly improved. In the first year after thinning operations the oak trees grew 50-70 cm in height compared with control trees that grew only 8-20 cm. In the second year after thinning operations the thinned oak trees grew 30-50 cm in height compared with the control trees that grew only 5-10 cm.

• The good results from the thinning and pruning operations had a very positive effect in raising the awareness of all concerned stakeholders (e.g. the forest administration from the Ministry of Agriculture, the local municipalities, private landowners, local consumers willing to buy briquettes instead of fuel) about the climate-risk reduction and socio-economic opportunities.

• This activity had an important upscaling effect wherein the MoA forest administration became more willing to support thinning and pruning operations that were previously very limited, or even banned in the case of pine forests. Moreover, Aitanit municipality has taken the decision to use suitable agriculture waste for bioenergy production and prohibit its burning.

• The risk of fire has significantly decreased thanks to the collection of agriculture waste (wood waste from pruning and olive pomace) that is not burned – main cause of forest fires in the region – and to thinning and pruning operations in forest strips along roads.

• The wood products resulting from the thinning and pruning operations were used in the following way: (i) the thicker branches were distributed to the local population for direct heating; (ii) the thinner ones were shredded to provide raw material to for the manufacturing of briquettes; (iii) very thin branches were used for reviving the traditional knowledge of charcoal production.

Thinned forest land in the SBR Landscape					
Municipality	N° hectares	Year	Land Ownership	Forest type	Location
Batloun / dalboun	0.1	2013	public land	Oak	20m along the road side
Batloun / dalboun	0.2	2014	public land	Oak	100m along the road side
Batloun / dalboun	5	2014	public land	Oak	1500m strip on road side
Batloun / dalboun	30	2015	public land	Oak	Inside the forest
Batloun / dalboun	1	2015	public land	Oak	300m along the road side
Batloun / dalboun	9	2017	public land	Oak	750m along the road side
Masser	0.23	2018	Private Land	Mix	Inside the forest
Botmih	5	2017	Public and Private lands	Pine	2000m along the road side
Masser	5	2017	Public and Private lands	Oak	1000m along the road side
Masser	6.2	2015	Public and Private lands	Oak / pine	3200m along the road side
Khraibeh	5	2015	Public and Private lands	Oak / pine	1200 along the road side
Khraibeh	1.1	2015	public land	Oak	450m along the road side
Baadaran	7.2	2018	Public and Private lands	Pine	1500m along the road side
Jbaa	0.29	2017	Private Land	Mix	Inside the forest
Niha	6.2	2018	Public and Private lands	Pine	1400m along the road side
Barouk	1.5	2018	Private Land	Mix	Inside the forest
Batloun	4	2018	Private Land	Oak	Inside the forest
Batloun	3	2018	Private Land	Oak	Inside the forest
Maaser	0.07	2018	Private Land	Oak	Inside the forest
Total	90.09				

The wood collection season extends from 15th September till 15th April of the following year. Each 1,000 m2 of dense oak forest generates in average 2,000-2,500 kg of wood logs, and 600-800 kg of smaller biomass. In the case of dense Brutia pine forest, thinning and pruning operations generate 1,000-1,500 kg of wood logs and 400-600 kg of smaller biomass. After 3 years of thinning and pruning in Dalboun oak (*Quercus calliprinos*) forest generated 1,600 kg of biomass from the new shoots and the shrub layer.

Oak forest thinning site


Equiped workers cutting oak stems and branches


Oak thinning


Oak forest thinning operations


Brutia pine forest management


Brutia pine pruning and shredding machine

Cut wood is organized by diameter for different uses:

- Large wood logs from private land are provided to the land owners.
- Large wood logs from public land are distributed to the poorest families in the concerned municipality. The FMC made a survey of the financial status of the families in the municipality to identify potential beneficiaries.
- Medium wood is chipped to be used for briquettes production, composting and soil mulching.
- Small and thin branches were traditionally used for charcoal. Since charcoal production is currently forbidden by the MoA they are now distributed to poor families and used to start the fire in the stoves of houses.

Innovative kiln for charcoal production

Feeding the charcoal kiln

Transporting the charcoal kiln

Charcoal production

Other wild fruit tree species from the forest ecosystem – e.g. *Arbutus andrachne, Prunus ursina, Pyrus syriaca* – are pruned and maintained so as to preserve the species diversity. In addition to the thinning and pruning operations, the shrub layer is cleared and the biomass is also used for the production of briquettes, composting, and soil mulching.

The project has begun to collect data to measure the impact of the activity on the forest ecosystem and its biodiversity. Although there is still no precise data, initial observations show an increase in the population of some edible plant species such as *Asparagus acutifolius*, and a higher presence in thinned forests of the Syrian serin, one of the most important bird species in the SBR.

VII.3.2 Sustainable Grazing

After the initial protection of grasslands (e.g. temporary enclosures) and the thinning and pruning operations in forests, it is necessary to implement good grazing management practices. This requires rotating systems with periodic resting periods to allow the re-growth of healthy pastures. Livestock grazing in thinned and pruned forest land prevents the regrowth of the cut stems and controls the growth of understory vegetation, especially in areas with high fire risk (e.g. along the roads) which makes it one of the best fire prevention practices.

In the case of the pilot restoration interventions of the FLR initiative in the SBR Landscape, the municipal forest committees, the SBR staff, local farmers and shepherds agreed on land management practices supporting a successful combination of protection (e.g. enclosure to protect against livestock and bushfire), management (e.g. thinning operations to select the best stems; rotating management in a division of forest parcels; controlled grazing/fuelwood collection during rainy season and grazing restrictions for at least 18 months in logged forests; banning the lopping of fodder trees), and active restoration (e.g. enrichment by direct seeding using local farmer's techniques for cereal sowing). This resulted in a high increase of regeneration (1,600-3,600 stems/ha from seeding and re-sprouting), and the identification of the top ten tree species responding better to logging. Nevertheless, fire control was a difficult task due to the coincidence of intensive labour demand for crops during high fire risk season and the difficulty of dividing the work between both needs and to find enough volunteers to help.

The principles of rotation and resting: Adjusting the utilisation needs according to climate conditions and type of grasslands is a relevant measure in most grassland. Grassland productivity and species diversity is dependent on the mobility of livestock, the length of continuous grazing on the same parcel, the frequency with which the patch is re-grazed, dispersion of animals and herds around the site, and the interval during which the patch is rested. Unmanaged grazing or complete exclusion from grazing often will lead to ageing grasses that cease to grow productively causing land degradation and loss of biodiversity[120]. Controlled grazing allows for more even distribution of dung and urine that can enhance soil organic matter and nutrients for plant productivity thus regenerating grasslands and improving livestock production simultaneously.

Temporary exclusion of animal grazing in degraded landscapes: This represents a very successful approach in FLR projects resulting in a very fast recovery of the former vegetation and the quality of soil. SPNL, partner of ACS in the West Beqaa area of the SBR, is promoting the re-establishment of the customary governance system known as *Hima*. It consists of a set of rules for livestock grazing in a territory utilised by several users.

The *hima* rules bind all the members of the community and specify areas where grazing is allowed all year around, areas where grazing is only allowed under exceptional conditions (e.g. drought periods), areas reserved for beekeeping and areas reserved for the protection of forest which are held under common property[121]. All those committing offense against the *hima* rules have to pay a fine and receive social sanctions.

The use of enclosures to improve pastures: The Shouf FLR initiative has implemented enclosure measures for the temporary exclusion of grazing in small land plots to protect planted seedlings from grazing. The establishment of enclosures require a number of prerequisites to be effective:

- Understanding ownership rights in the targeted degraded pastures and setting clear agreements with the municipal forest committees and local shepherds for the protection of the enclosure areas.
- Involving all concerned local people – namely shepherds using the targeted pastures and the municipal forest committees - in the planning, implementation, and monitoring of the enclosures.
- Raising awareness and know-how of local shepherds on the value of the tempory exclusion areas from grazing to improve the productivity and quality of pastures as well as the value of scattered tree thickets as a key adaptation measures to help livestock face current and future climate shocks.
- Enabling local shepherds to benefit from the established enclosures through trade-offs, such as the provision of the mown grass that is annually cut inside the enclosure to facilitate the growth of the planted seedlings. Differences in the growth of grass inside the enclosure (much higher) and outside the enclosure also help raise the awareness of local shepherds about the benefits of temporary exclusion of grazing as part of a rotation system.
- Integrating enclosure management into agriculture, livestock grazing and forest management.

The environmental benefits provided by enclosure measures[122] are:

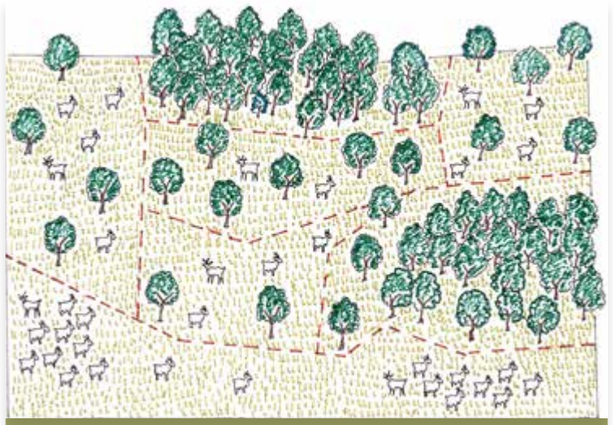
- Water conservation: significantly lower runoff coefficients, higher infiltration and increased soil moisture availability are demonstrated in enclosure sites as compared to degraded grazing land creating more favourable conditions for plant growth.
- Erosion reduction: on a larger scale, the recovery of grass cover in temporary enclosures help prevent soil erosion and increases soil fertility.

- Higher diversity of palatable grass species, pasture quality and productivity: after one year major improvement of pasture conditions occurs, and in few years species diversity and the quality of pastures is significantly improved.
- When seedling planting takes place in the fence plots, the higher availability of woody species, such as oaks, azaroles, hawthorns, and wild pears, play a major role in increasing the presence of highly valuable palatable species to feed the animals while creating shelter areas with microclimate conditions for the grass to remain green over a longer period, and as a protection against high insolation.

Temporary enclosures have the additional value of lowering funding requirements for the restoration of grasslands which is a critical issue in most FLR projects.

Livestock grazing as a fire prevention technique: Livestock grazing is considered a valid technique to maintain fuel-break areas with a minimum amount of biomass. This helps to reduce the capacity of the fire to increase its intensity and spread quickly through the territory, as well as facilitate the access and movements of the fire extinguishing services in the eventual case of fire. The object is to create larger areas that maintain a vegetative cover with little biomass – grazed pastures with scattered trees - thanks to a planned and directed grazing intervention in these critical areas, rather than opening firebreak strips with bare soil that have proven to be ineffective in the past.

[120]: Neely, C., S. Bunning & A. Wilkes (2009) Review of evidence on drylands pastoral systems and climate change. Land and Water Discussion Paper 8. FAO.
[121]:www.spnl.org/hima
[122]:Descheemaeker, K., J. Nyssen, J. Poesen, M. Haile, B. Muys, D. Raes, J. Moeyersons & J. Deckers (2006) Soil and water conservation through forest restoration in exclosures of the Tigray highlands. Journal of the Drylands 1(2): 118-133.



"Strategic zones for fire-fighting with livestock control of herbaceous and shrub layers"

Fire-break are managed by hired shepherds implementing controlled livestock grazing

The integrated livestock grazing and fire prevention programme in southern France establishes the so-called "strategic zones" or fire-fighting areas, in which there is a strong control of the herbaceous and shrub layers by livestock, with the aim to support the work of the extinguishing services (in the eventual case of a fire) to directly combat the fire front. These zones are divided in "key areas", where livestock should limit the shrub biomass to 500 m3/ha, and "support areas", where it is intended to reduce both the strength of an eventual fire (before it reaches the key areas) and the risks of secondary foci, and in which livestock should limit woody biomass up to 2,000-2,500 m3/ha[123]. The use of livestock grazing to maintain larger fire-break areas better integrated in the landscape is been used in several Mediterranean countries nowadays. It produces several positive externalities on rural life and the environment, contributing to a sustainable rural development[124]. Shepherds are specifically trained in schools to learn about the management of livestock and grazing in critical fire-risk areas, and they have become professionalized and performing a job that is paid by the public administration. The maintenance cost of a network of shepherds that keep clean fire-break areas is significantly less than the cost of maintaining the traditional fire areas.

The FLR initiative in the SBR has supported livestock grazing as a complementary activity of the thinning and pruning management interventions in forest land. Local shepherds were involved in goat grazing interventions in the years following thinning operations as a way to prevent the regrowth of the cut stems and control the growth of the forest understory in high fire-risk areas, such as along the road network.

Thinned forest site maintained with goat grazing

Livestock grazing in abandoned terraces

Goats controlling the growth of new shootings in thinned forest sites

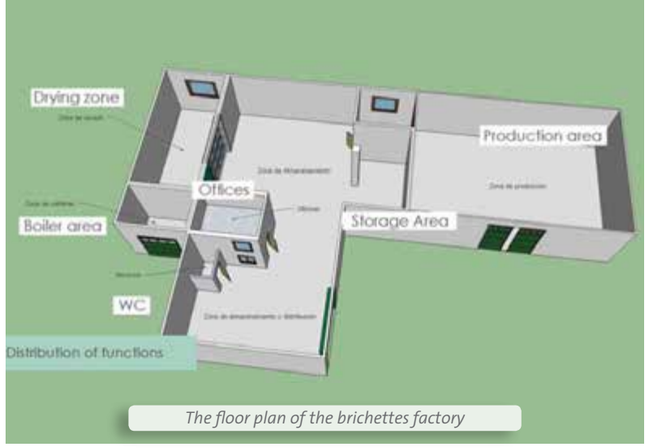
[123]: González Rebollar J.L. et al (2011) Ganadería extensiva y silvicultura preventiva: algo más que una mirada al pasado. Ambienta, Vol. 97: 22-45. MMAMRM.
[124]: Rúiz Mirazo, J, A.B. Robles and J.L. González-Rebollar (2009) Pastoralism in Natural Parks of Andalusia (Spain): A tool for fire prevention and the naturalization of ecosystems. Options Méditerranéennes, A no. 91, 2009 – Changes in sheep and goat farming systems at the beginning of the 21st century.

VII.4 Economic Development through FLR Implementation

VII.4.1 Creating Local Businesses for Briquettes Production

The project supported the establishment of a local bioenergy plant for the production of briquettes for cooking and heating from local waste materials – the olive pomace that result from olive oil pressing, and the wood waste from the pruning of olives and fruit trees, as well as the thinning and pruning of oak and pine forests. The plant is located near Kfarfakoud village and consists of one building with two areas, one for production and another one for storage, sale and distribution. It includes the following equipment:

- Concrete storage areas for olive pomace, sawdust and the mixture of both.
- Hoppers or silos.
- Micro-sprinkler system to humidify the mixture
- Briquette production machines.
- Drying facility consisting of a stove fuelled by its own briquettes and the use of fans.
- Metal structures for drying the briquettes.
- Briquettes moving equipment including a loader and conveyor belts.
- Bobcat for moving briquettes on pallets in the storage area.
- Weighing scale and packaging bags.
- Tractor with shovels and chippers.
- Saw mill.
- Roll-off truck carrying pallets.
- Mobile pyrolytic furnace.
- Offices, exhibition room and services.



The floor plan of the brichettes factory


Briquettes factory


Mixture of wood chips and olive pomace


Briquettes production machines


Cutting the briquettes


The drying of the briquettes


The packaging of the briquettes

Briquettes box

As a first step, the intervention (project) assessed the potential of available biomass resources (both from forest and agriculture land) in the SBR Landscape to meet local energy consumption needs and planning for the establishment of *biomass management zones* in high fire-risk areas, where the collection of forest biomass is a priority (e.g. along roads, near urban areas, landform units where the risk of fire is higher). Additionally, the project assessed the availability of agriculture waste, which represents the higher component of the briquettes. According to estimates, the quantity of olive pomace (olive pressing residue) that is produced every year in the area, as well as the quantity wood resulting from the fruit tree pruning is much higher than what the bioenergy plant could absorb.

Forest and agriculture waste were used to feed a new briquette production plant targeting the traditional wood stoves used by the inhabitants of the region. The three components used in producing the briquettes are: (i) woodchips from the forest (45% moisture content at origin); (ii) woodchips from the pruning of olives and fruit trees (45% moisture content at origin); (iii) olive pomace (30% moisture content at origin). The briquettes are composed of 40% olive pomace and 60% wood.

Around 100 daily-paid workers (USD 20/day) are involved in the gathering of biomass (forest wood cutting and shredding; gathering agriculture wood waste and olive pomace) from October to April. Five workers (2 permanent, one a woman; 3 seasonal for a period of 8 months/yr), with an average salary of USD 600/month, manage the factory. The factory produces about 6,000 briquettes per day (6 working hours), with the plan to increase production from 1 million briquettes in 2013 up to 5.6 million in 2021.

Business plan for the production of briquettes (2013-2021)

Year	Briquettes t/yr (17% MC)	Briquettes N°/year	Forest woodchips (t/yr) (45% MC)	Fruit tree woodchips (t/yr) (45% MC)	Olive Pomace (t/yr) (30% MC)	Total raw material (30%-45% MC)	Expected net benefit (USD 50/t)
2013	1,200	1,000,000	357	238	800	1,394	60,000
2014	1,489	1,241,000	443	295	993	1,731	74,450
2015	1,848	1,540,081	513	403	1,232	2,148	92,400
2016	2,293	1,911,241	591	546	1,529	2,666	133,300
2017	2,846	2,371,849	677	734	1,898	3,309	142,300
2018	3,532	2,943,465	771	981	2,354	4,106	176,600
2019	4,383	3,652,840	869	1,303	2,923	5,095	219,150
2020	5,440	4,533,175	971	1,726	3,627	6,323	272,000
2021	6,751	5,625,670	1,071	2,276	4,501	7,847	337,550

The Lower Calorific Value (LCV) of the briquettes compared with other wood is as follows:
- 1 kg of briquettes provides 4.65 kWh/kg, the same heat that 1.25 kg of oak wood (oak wood consumed is about 30%-35% moisture), or 1.5 kg of olive wood (olive wood consumed is about 35% -40% moisture).
- Each 2 kg of briquettes has the same lower calorific value (LCV) as a liter of diesel. The retail price for 2 kg of briquettes is about USD 0.33 and the price of a liter of diesel is about USD 1.00. Thus, the briquette costs USD 0.035/kWh, whereas diesel costs USD 0.11/kWh for the same heat generation.

For the same heat generation, the cost of energy has been reduced by more than two thirds in comparison with fuel – the main energy source in the local households - with a positive effect on the consumption and savings of the local population, as well as in the reduction of pollution and health problems due to the use of diesel.
The total investment for establishing the factory was USD 200,000. The net profit is 25% of sales (profit of USD 50/t of briquettes with a sale price of USD 200/t), part of which reverts to the improvement of the management of the SBR and FLR implementation. In the first years part of the briquettes were distributed free of charge to promote its use and gain acceptance by the local communities.

The production of briquettes has a climate change mitigation and adaptation focus:
- To promote climate-resilient and economically viable use of forest/agriculture waste whose burning increases forest fires that devastate large areas of Lebanon every year.
- To contribute to the reduction of CO_2 emissions from fossil energy consumption (e.g. diesel for house heating) and the burning of forests and agriculture waste.
- To increase the capacity of forests to adapt to climate change with a reduced competition for the scarce water resources in the thinned forest stands.
- To reduce the cost of energy for local communities and increase local employment and local business around energy production.

The Project also supported the revival of traditional knowledge to produce charcoal from small tree branches commercialized for the local tradition of smoking waterpipe or shisha. This FLR intervention contributes to the implementation of the National Bioenergy Strategy for Lebanon that considers the residues from forest thinning and pruning as one of the ten most promising bioenergy options for the country, and the Lebanon National Forest Program 2015-2025 objectives on ecosystem functioning and ecosystem services. The publication “Thermal Biomass for Lebanon Mediterranean Mosaics Project (MM) Shouf Biosphere Reserve (SBR), 2015”, which is available online[125] or printed at the SBR headquarters in Maaser, provides further detailed information on the management and use of forest and agriculture biomass for bioenergy production.

VII.4.2 Establishing a Solid Waste Treatment and Composting Unit

The Baadarane waste treatment and composting factory (BWTC) operates according to the following steps: (i) collection and transport; (ii) waste reception; (iii) manual and mechanical sorting, (iv) recycling, baling and selling; and (iv) composting. The unit produces recyclable materials and compost and discards inert material. The factory is managed by 18 permanent staff (including 2 Syrian refugees), plus 9 workers (6 permanent and 3 seasonal) whose task is to collect the waste from the villages. The total investment was USD 500,000.

The domestic waste generated by the municipalities of Higher Chouf (Moukhtara, AinQani, Ammatour, Haret Jandal, Bater, Niha, Jbaa, Khreibeh, Baadarane, Boutmeh, Maasser) is collected from the waste bins distributed along the main, secondary and tertiary roads, and transported to the BWTC. The unit receives around 15 tons on a daily basis, 7 days per week. It operates 8 hours a day, from 7:00 to 15:00. The trucks transporting waste stop at the weighbridge for weighing before and after the drop-off of waste inside the sorting facility (Picture 1). When the trucks reach the sorting facility, the waste bags are unloaded on the floor in front of the loading hopper (Picture 2). The bags are opened manually by the workers to remove bulky items and unsuitable materials before feeding the waste into the process line. From the hopper, waste reaches the manual bag opening conveyor (Picture 3), designed to transport the waste upward to the trommel screen, while workers, standing on its platform stairs on both sides, open and remove the bags manually. The trommel screen is mainly used after the bag opening to mechanically separate most of the wet organic fraction from the dry fraction of waste. The organic wet waste having a diameter less than 80 mm - the size of the screen holes - falls directly into the cell beneath the screen and is conveyed through the wall of the sorting facility into the composting facility. The oversized materials continue their way to the manual sorting belt. The coarse grit waste material (diameters > 80 mm) move on to the manual sorting conveyor where hand-pickers on both sides select the valuable recyclables from the waste and drop them into their respective recyclable material outlet chute beneath (Picture 4).


Weighbridge and control room for weighing of trucks transporting waste to facility


Loading hopper


Manual bag opening conveyor


Recyclable material outlet chute and storage container beneath manual sorting conveyor


Recyclables stored on-site


Baling unit for PET and cardboard


Baled cardboard stacked outside

Compost production

[125]: http://shoufcedar.org/wp/wp-content/uploads/2017/05/Biomass_plan_Shouf_Biosphere_Reserve_Final_low_res_3227033_201554000_

There are several outlet chutes assigned for the different types of recyclable material: plastic, glass, aluminium cans, paper and cardboard, among others. Recyclables are stored temporarily onsite (Picture 5) before being sold to recycling industries. Cardboard and polyethylene terephthalate (PET) plastics are picked up from the containers afterwards to be baled (Picture 6) and temporarily stored before being sold to recycling companies. After the manual sorting station, an over band magnetic separator is installed to separate ferrous metals from the refuse waste. The ferrous material is collected in a separate bin and stored as recyclables. The final residual inert material or refuse waste is collected at the end of the sorting conveyor, just behind the over-band magnet, before being transported for storage outside the facility.

The production of organic compost is being improved with shreds from the thining and pruning of pine and oak forests. In 2018, 400 tons of high-quality compost were produced to be used in the restored agriculture lands.

VII.4.3 Sustainable Agriculture Production in Restored Terraces

Abandoned terraces used to grow olives, different fruit trees, vineyards and cereals. Some terraces are still used for vineyards, olives and fruit trees. However, even these cultivations are not regularly taken care of, and no repairs for the old stone walls are done, resulting in their collapse and subsequent erosion of the terraced soil. The main use of these terraces is free grazing by livestock, and that is a part of the grazing zone system of the SBR.

The restoration of abandoned terraces plays a critical role in terms of enhancing ecosystem services to sustain both biodiversity and human well-being. The project activities will demonstrate best practices in terms of: (i) restoring the ecological functionality of the terrace systems to avoid environmental risks, regain biodiversity values and enhance their integration in the eco-cultural landscape; (ii) supporting green economic opportunities to enhance people's livelihoods, jobs generation and market links between producers and consumers, through the production and marketing of aromatic/medicinal/edible plants, positively impacting the socio-economic situation in the region. Besides, the proposed restoration activities support land use management based on the sustainable use of natural resources, increase people's awareness about the ecosystem services provided by the Lebanese mountain landscape, and enhances its eco-tourism attractions.


Tawlet Ammiq


Food products

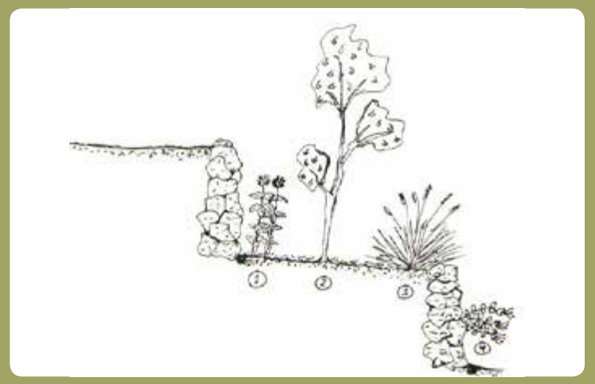

Selling food


Women and soap products


Restored agriculture terraces under production with oregano, lavender, olives and wild fruit trees (Maasser Al Shouf)

The proposed planting design options for revitalizing the agricultural use of the restored terraces include the selection, production and planting of suitable native tree, shrub and herbal species with economic interest.
Three different options with different species and different spatial distribution on the terraces (A, B, C) are explained in the following figures of a replicable module of 100 m2 (20 m long x 5 m wide).

Agriculture Production in Restored Terraces - Option A



Morus nigra

Rosmarinus officinalis

Capparis spinosa

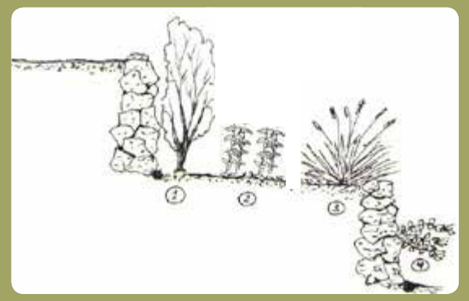
1) Inner planting line, at the foot of the upper terrace wall, with 1 to 3 staggered lines of small shrubs and/or herbaceous plants, or 1 line of large shrubs
• **Potential species:**
a) Small shrubs and/or herbaceous plants: *Oryganum syriacum, Thymbra spicata, Gundelia tournefortii, Tragopogon longirostris, Allium ampeloprasum, Hypericum perforatum, Matricaria chamomilla*
b) Larger shrubs: *Rhus coriaria, Rosa canina, Zizyphus jujuba, Myrtus communis*

2) Middle line with fruit trees
• **Potential species:** *Pyrus spp., Malus spp., Crataegus azarolus, Crataegus monogyna, Juglas regia, Prunus dulcis, Prunus ursina, F icus carica, Morus spp, Olea europaea, Pinus pinea, Pistacia vera, Laurus nobilis*

3) External line of plants on the upper edge of the terrace wall., with medium-size aromatic shrubs
• **Potential species:** *Lavandula officinalis, Salvia urticifolia, Salvia fruticosa, Rosmarinus officinalis*

4) Plant species increasing the biodiversity value of the stone wall habitat
• **Potential species:** *Capparis spinosa, Cyclamen persicum, Putoria calabrica, Rosularia libanotica*

Agriculture Production in Restored Terraces - Option B



Rhus coriaria

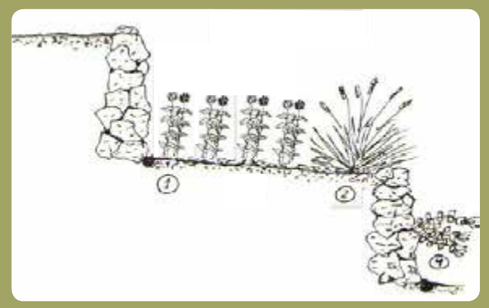
Lavandula officinalis

Origanum syriacum

Cyclamen persicum

1) Inner planting line, at the foot of the upper terrace wall:
• Large shrubs
• **Potential species:** *Rhus coriaria, Rosa canina, Zizyphus jujuba, Myrtus communis*
2) Middle area with 2 to 3 lines of small shrubs and/or herbs:
• **Potential species:** *Oryganum syriacum, Thymbra spicata, Gundelia tournefortii, Tragopogon longirostris, Allium ampeloprasum, Hypericum perforatum, Matricaria chamomilla, Ceratonia siliqua*
3) External line of plants on the upper edge of the terrace wall:
• Medium-size aromatic shrubs
• Potential species: *Lavandula officinalis, Salvia urticifolia, Salvia fruticosa, Rosmarinus officinalis*
4) Plant species into increase the biodiversity value of the stone wall habitat
• **Potential species:** *Capparis spinosa, Cyclamen persicum, Putoria calabrica, Rosularia libanotica*

Agriculture Production in Restored Terraces - Option C



Thymbra spicata

Rosmarinus officinalis

Centranthus ruber

1) Main cropping area:
• 3 to 4 staggered lines of small shrubs and/or herbaceous plants, or 1 line of large shrubs
• **Potential species:** *Oryganum syriacum, Thymbra spicata, Gundelia tournefortii, Tragopogon longirostris, Allium ampeloprasum, Hypericum perforatum, Matricaria chamomilla.*

2) External line of plants on the upper edge of the terrace wall:
• 1 line with medium-size aromatic shrubs
• **Potential species:** *Lavandula officinalis, Salvia urticifolia, Salvia fruticosa, Rosmarinus officinalis*

4) Plant species to increase the biodiversity value of the dry stone wall habitat.
• **Potential species:** *Capparis spinosa, Cyclamen persicum, Putoria calabrica, Rosularia libanotica, Centranthus ruber.*

The following table provides information about the number of seedlings per surface unit to be planted in the restored terraces, depending on the plant size (e.g. small aromatic shrub, medium shrub, large shrub and/or tree). The total number of seedlings per hectare goes from 12,400 to 45,000, corresponding the largest number to a plantation with only small aromatic plants, and the smallest number with a mixed plantation including seedlings of all sizes.

Number of Seedlings for the 3 Agriculture Production Options									
Plant species	Option A Seedlings/100 m²			Option B Seedlings/1000 m²			Option C Seedlings/ha		
Origanum syriacum or other small shrubs and/or herbs	80-240	250	450	800-2400	2500	4500	8000-24000	25000	45000
Medium shrubs	20-40	20-40		200-400	200-400		2000-4000	2000-4000	
Large shrubs	20	20		200	200		2000	2000	
Tree species	4			40			400		
TOTAL	124-304	290-310	450	1240-3040	2900-3100	4500	12400-30400	29000-31000	45000

If we take into account the high number of seedlings needed to put an hectare of terraces into production, and their cost (from USD 0.14 - USD 0.17[126] per small aromatic plant seedling up to USD 0.45[127] – USD 1 per large seedling), it would be important to train farmers so that, at least, they can produce their own aromatic shrub cuttings.

The expected yields per hectare of different plant species are:

- 2-3 tonnes of Origanum/ha two years after planting anf over a period of 7 years.
- 1 tonne of dry flowers/leaves/ha and 18-22 kg/ha of essential oil of lavender two years after planting and over a period of 10 years.
- 1.5 tones/ha of dry leaves of mint one year after planting anf over a period of 3 years.
- 1-2 kg/Pistachio tree (275 trees/ha) 5 years after planting, 4-6 kg/tree after 7 years, 10kg/tree after 10 years, and an additional 1 kg/tree/year after 11 years.

The initial investment depends on whether the production is under rainfed (USD 7,500 – 9,000/ha) or under irrigation (USD 20,000-30,000/ha). There is a net profit of about USD 4,000/ha after 7 years for pistacchio, USD 2,900/ha after 4 years for wild fruit trees (e.g. Crataegus spp, Ziziphus jujuba), and USD 8,670/ha after 2 years for Origanum.

VII.4.4 Increasing tourism-related natural infrastructure in the SBR landscape

ACS, in collaboration with the local municipalities and FMCs and the financial support of private foundations, has established more than 250 km of hiking trails throughout the SBR landscape. These trails connect sites of high ecological value in which the different ecosystems and natural values of the landscape are represented, as well as sites of high cultural value where historical monuments and traditional cultural practices are maintained. The creation of the trail network has been part of the capacity building and employment generation activities of the FLR program.

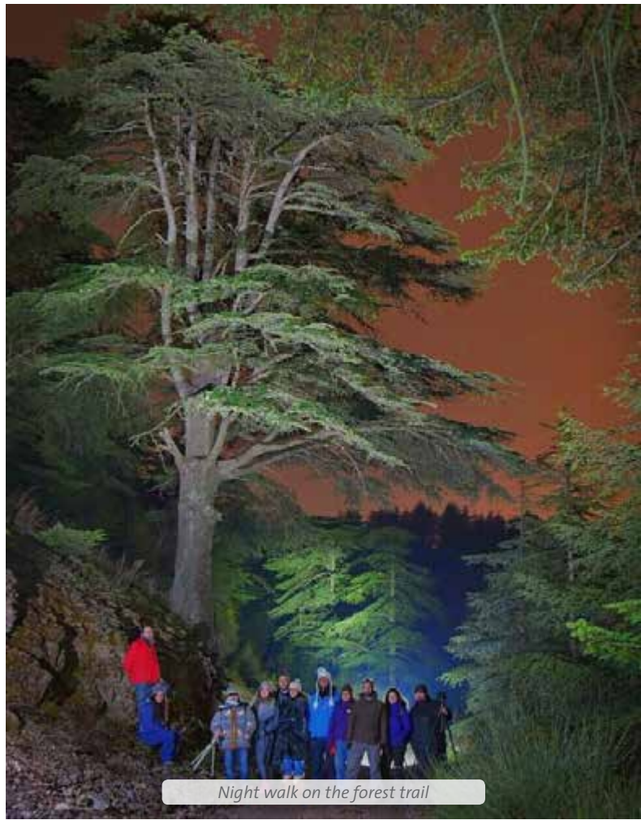
The trails are equipped with observation points, signs and panels on the eco-cultural values observed. In addition, pedestrian crossing signs have been established in areas that cross local roads, to avoid possible accidents. In the case of trails that cross important areas, such as the centenary cedar stands in the Barouk Cedar Forest Trail, they are equipped to facilitate the access of the disabled – e.g. ramps and guide bars for the elderly, wheelchair users, and the visually impaired.
The network of trails includes short, medium and long walks that link the villages surrounding the natural reserve in order to satisfy the needs of a wide range of visitors. Visitors can hike alone or in small groups with a guide, along the designated trails. The trails are thematic, and named according to the special features they exhibit.
ACS has produced and printed a number of publications and videos for visitors to learn about what they can find in the trails and use them as a guide (see www.shoufcedar.org). Awareness raising and communication about the trail network is part of AGSBR's tasks to bring municipalities together and facilitate coordinated action and cooperation among them on FLR-related activities. Between June and September, a list of tourism-related events (e.g. farmers' markets, music festivals, handicrafts, paintings, planting days, organized visits to trails) are organized together with the municipalities and advertised with the name of the trails – e.g. the *Ain Zhalta Trail of the Moon, the Barouk Sunset Trail, the Mrusti Old Oak Trail, the Kraibe Spanish Broom Trail*, etc. These events are promoted, with special offers for those who register early, and contribute substantially to the local economy of the SBR landscape municipalities, especially between mid spring and mid autumn.


Nature trail conditioning


Nature trail conditioned for disable visitors


Workers opening a nature trail


Visitors walking in a nature trail


Night walk on the forest trail

[126]: Price in Spain of small aromatic plant seedlings sold in forest tray with alveoli.
[126]:Price in Spain.

FLR Principle VIII: Manages Adaptively for Long Term Resilience

VIII.1 Monitoring the Impact of Field Restoration Interventions

Effective monitoring is an essential element of adaptive management because it provides a reliable feedback on the effects of project actions. Monitoring involves the repeated measurement of variables over time to determine if actions have caused changes or trends, either expected or unexpected. As opposed to casual observation monitoring is designed to help us identify what changes are occurring in the system and whether or not these changes are due to our actions. The project team managing the FLR pilot restoration interventions has developed different monitor protocols to be used in the pilot restored sites depending on the site features and type of restoration interventions:

Planting sites:

Monitoring target: at least 10% of each restoration site, depending on the heterogeneity of the site, related to altitude, exposure, soil, etc, defining representative and permanent monitoring plots of 1,250 m2 (18 m x 70 m), with a total of 100 seedlings each.

Method:

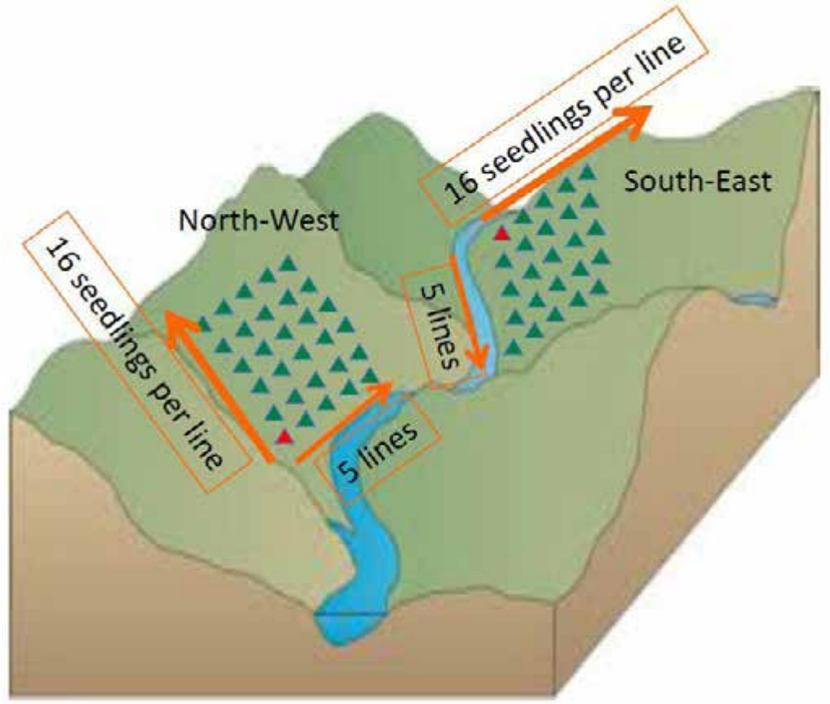
- Defining monitoring plots of 5 planting lines according to altitudinal gradients and mountain aspect (e.g. north-west exposure; south-east exposure).

- Marking the location of the first seedling (down-left, looking upwards) e.g. painting a rocky outcrop with colour.
- Counting 20 seedlings per each line along an altitudinal gradient indicating: (i) alive healthy; (ii) dead; (iii) alive with problems (see excel file), and providing comments regarding health problems.
- Taking pictures of the restoration site as well as close-up pictures from the different species, showing alive healthy, dead and alive with problems whenever it is the case.

Tools:

- Excel document
- Photo camera

Designing of data collection in the monitoring plots



Forest Restoration Enclosures:
Monitoring target: 50% of fenced plots.

Method:

- Counting all seedlings per each species inside the selected enclosures, indicating: (i) alive healthy; (ii) dead; (iii) alive with health problems (see excel file), and providing comments regarding health problems.
- Taking pictures of the restoration site as well as close-up pictures from the different species showing their health status.

Tools:

- Excel document
- Photo camera

Abandoned quarry:
Monitoring target: 100% of the 2 restored debris slopes.

Location:
- Mrusti municipality

Method:
- Taking pictures in the two talus debris and selecting the best position(s) with a complete view of the slopes. Taking close-up pictures from the different species showing alive healthy, dead and alive with problems whenever it is the case.
- Desk work: counting all seedlings per each species on the printed pictures or directly in the computer screen, indicating: (i) alive healthy; (ii) dead; (iii) alive with problems (see excel file), and providing comments regarding health problems.

Tools:
- Excel document
- Photo camera

Monitoring Calendar:
a) In May to assess winter mortality due to bad seedling quality, poor planting or harsh winter conditions.
b) In October to evaluate the effect of summer drought on the survival rate of the seedlings.

From May to October some tracking walks can be done in those areas where irrigation support could be considered in years with exceptional summer drought intensity.

VIII.2 Adaptive Management Approach for FLR Monitoring & Evaluation

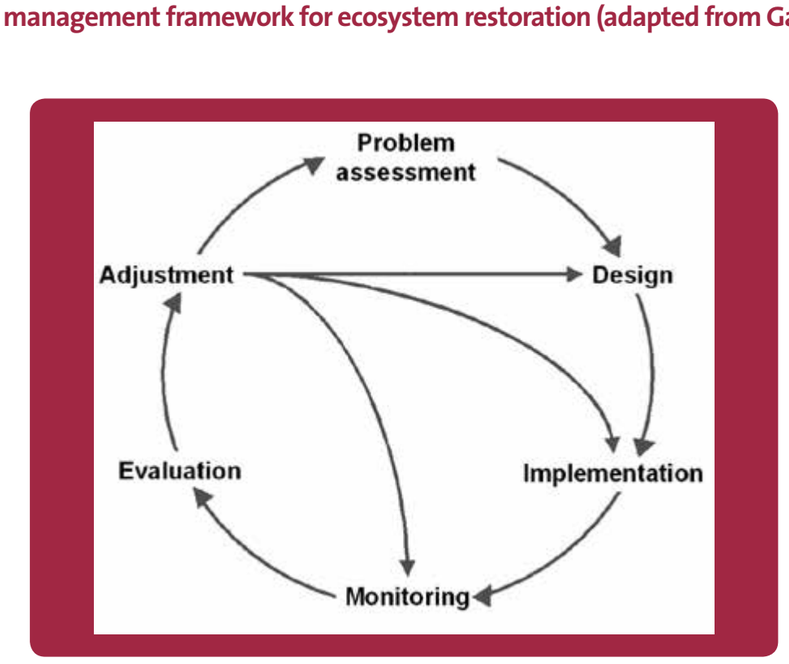
Adaptive management is the integration of design, management, and monitoring to systematically test assumptions in order to adapt and learn[128].

Testing assumptions is about thinking about the situation at your project site, developing a specific set of assumptions about what is occurring and what actions you might be able to use to affect these events, systematically trying different actions to achieve a desired outcome, and develop an understanding of not only which actions work and which do not, but also why.

Adaptation is about taking action to improve your project based on the results of your monitoring, and, if needed, changing your assumptions and your interventions to respond to the new information obtained through monitoring efforts (e.g. verify whether your assumptions were correct or wrong, whether your actions were poorly executed, or whether the conditions at the project site have changed).

Learning is about systematically documenting the process that your team has gone through and the results you have achieved to enable other people in the broader conservation community to benefit from your experiences, including information about successes or lessons learned, as well as about the difficulties you have encountered and the adopted measures to overcome them.

An adaptive management framework for ecosystem restoration (adapted from Gayton, 2001)[129]



Monitoring goals will determine: (i) whether the FLR project has helped achieve its stated desired future ecological condition in the project area; and (ii) whether it has helped achieve its stated social and economic goals or social and economic conditions necessary to the project. Once the FLR implementation team has identified the goals that it wants to monitor it must select one or more indicators that can be used to measure change in that goal.

Monitoring groups are faced with the challenge of choosing the indicators of change that they will monitor. They need to consider limitations, such as time- and money-constraints, when carefully selecting which indicators will provide them with the most useful information. When selecting indicators monitoring groups will want to ask themselves whether a proposed indicator is:

- **Relevant** for the site and treatment?
- ***Sensitive*** to change so that it can detect change within the monitoring timeframe?
- **Measurable** with available methods that multi-party groups can use to generate accurate, standardized data?
- **Defensible** and not subject to individual or organizational bias?
- **Able to be measured** by methods that are professionally accepted and understood?
- **Integrated** so that the whole suite of indicators provides a reasonable picture of ecological change?

[128]: Salafsky, N., R. Margoluis, and K. Redford. 2001. Adaptive management: A tool for conservation practitioners. Washington, D.C.: Biodiversity Support Program.
[129]: In Bautista et al Eds. (2009) (39)


Biodiversity monitoring in abandoned agriculture terraces


Monitoring the reintroduced Nubian ibex population


Installing traps to capture and monitor herpetofauna


Observing and counting tarantula nests

Monitoring seedling growth and survival


Monitoring seedling growth and survival

FAO has recently developed a comprehensive Landscape Restoration Monitoring and Reporting Tool[130] for FLR projects/programs in drylands to guide project implementers in the design and implementation of projects, the assessment of project performance and impacts, the compilation of lessons learnt and the sharing of know-how. The FLR initiative in the SBR landscape has adopted the FAO Monitoring and Reporting Tool that was used for designing and assessing the performance and impact of the four FLR pilot interventions in the municipalities of Aitanit, Barouk, Maaser and Mrusti.

VIII.3 Cost-Benefit Analysis

VIII.3.1 Cost-benefit Analysis of FLR Initiatives

There is a need to identify where FLR projects will incur net benefits for biodiversity conservation and human wellbeing so that efforts can be effectively targeted. Even in locations where restoration is likely to be cost-effective financial incentives may need to be provided to support restoration actions. The costs of active restoration interventions can be substantial varying widely among different countries and depending on various factors (e.g. amount of in-kind contribution by partners; labour costs that the restoration initiative should pay; amount of equipment shared for free or paid by the initiative; the need to produce plant material or pay external services for plant supply; the need to pay for external services for the protection and maintenance of the restored areas; the use or not of supplementary irrigation).

An FAO assessment of restoration costs in 22 dryland regions worldwide provided an estimate of costs ranging between USD 200/ha up to USD 17,000/ha, with maintenance costs ranging between no cost up to USD 300/ha/yr. While these data tell us much about the major differences that exist between the various initiatives of restoration in drylands, it is also true that in some cases indirect costs may have been included in the overall estimate of costs per hectare (e.g. awareness raising and training costs).

Billions of dollars are currently being spent across the globe on ecological restoration projects (136). Funding requirements for FLR depend on the targets and time frames. Based on a conservative hypothesis of USD 2,390 per hectare (following TEEB, 2009), the yearly budget required to meet internationally agreed restoration targets may range from USD 36 billion to USD 49 billion (Table 20) – a relatively reasonable amount. Although these figures may be controversial, the high benefit-cost ratio of ecosystem restoration measures suggest that FLR is cost efficient from a sustainable development perspective.

VIII.3.2 Sustainable Financing for FLR in the SBR Landscape

A/ Promoting Corporate Social responsibility (CSR)
Private companies are willing to support environmental and social projects in the framework of their corporate social responsibility (CSR) strategies. ACS has taken advantage of such initiatives by partnering with a number of private companies, such as Middle East Airlines, Byblos Bank, Porches Club Lebanon, Khalil Fatal and Sons, Advanced cars, Lycee National Schools, Four Seasons Hotel, HSBC Bank, and Patchi. These companies have supported FLR activities in the SBR landscape with the aim to contribute to the social and environmental sustainability in Lebanon and enhance collaboration with other organizations.

B/ Cedars Forever Program
The Cedars Forever program was developed to promote the survival of the Lebanese cedar tree – a species in danger of extinction. In order to restore Lebanon's mountains to their original state, *Cedars Forever* is supporting the plantation of cedar seedlings in Lebanon, primarily in the Barouk cedar forest which constitutes the major part of the cedar stands in the Shouf Nature Reserve. As a first step Cedars Forever plans to plant hundreds of thousands of cedar trees over a period of 10 years in a completely deforested 14 million m2. In the future it hopes to expand to other areas in Lebanon.

Individuals and organizations wishing to contribute to the program may do so by adopting a Cedar. For USD150 a cedar seedling will be planted bearing the name of the person who adopted it as well as a serial number. By adopting a Cedar, you are not just planting a tree, you are investing in the future of a beautiful country, encouraging ecotourism and leaving a far greater inheritance behind.

C/ Cedar Loan Program
The SBR setup the *Cedar Loan Program* to facilitate micro-loan access to local villagers and residents. As of June 2014, the SBR had received hundreds of applications and approved 51 loans worth USD 1000 - 3000 each. The total value of approved loans has reached USD 122,000, an indication of the program's appeal which is inspired by the management of the SBR and the patrimonial value of the iconic *Cedrus libani*. Consistent with the vision of the SBR each loan must have an ecological/environmental benefit. For example, the program was used to fund projects establishing or expanding plant nurseries, rehabilitating lands and stone terraces, and propagating aromatic and medicinal plants, as well as ecotourism services.

[130]: http://www.fao.org/dryland-forestry/monitoring-and-assessment/global-drylands-assessment/en/

"Adopt a cedar" initiative

"Adopt a cedar" initiative

D/ The National Afforestation / Reforestation Program (NARP)

NARP, also known as the *40 million trees program* aims at increasing the forest cover (of 70,000 hectares) from the current 13% to 20% by 2030, adapting the natural ecosystems to the climate change which is already negatively affecting the country. NARP includes planting activities all over the country by the MoA but is designed from the angle of shared responsibilities between stakeholders and the MoA. The NARP is closely aligned with the FAO Country Programming Framework (CPF) which attempts to address the agriculture sector, including forests, from a sector-wide and integrated perspective since all subsectors are mutually dependent.

Several projects were implemented for fund raising for FLR in Lebanon like the SALMA project whose main objective was to expand the area under reforestation and afforestation, thus contributing to climate change adaptation and mitigation measures in targeted project areas. The project also assisted municipalities (local communities) to form reforestation consortiums (RCs). It provided reforestation and livelihood support grants to RCs based on participatory reforestation plans prepared by the RCs with assistance from the project. Under SALMA project much greater emphasis was given to the need for the development of an implementation modality for large-scale sustainable reforestation activities, as a means to help the Government of Lebanon (GoL), including municipalities and RPs, to move beyond the SALMA project and achieve the goal of NARP. The SALMA project aimed to reforest only 2,000 ha out of the 70,000 ha NARP target.

E/ The Forest and Landscape Restoration Mechanism in Lebanon

The FLR Mechanism aims to support countries in the planning and implementation of forest and landscape restoration (FLR) as a contribution to achieving the Bonn Challenge - the restoration of 150 million hectares of deforested and degraded lands by 2020. FAO's Forest and Landscape Restoration Mechanism (FLRM) will contribute to the implementation of restoration initiatives and programs in Lebanon by promoting an integrated approach of landscape management, with the aim to restore a well-balanced package of goods and services provided by the landscapes.

Increasing the forest area and reducing the degradation of other forested landscapes are not the only issues. FLR principles need to involve all the relevant stakeholders and build on multiple economic options in order to create jobs, reduce the rural exodus and keep a good standard of living based on a sustainable use of all the goods and services provided by Lebanese landscapes.

The work plan 2016-2018 of the Forest and Landscape Restoration Mechanism in Lebanon were focused on three outputs and 12 activities:

The three outputs focused on:

A. Governance, institutional support to the Ministry of Agriculture and enabling environment of forest and landscape restoration with actions focused on intersectoral coordination, compared legislative analysis, knowledge dissemination and identification / mapping of restorations options.

B. Facilitate the access of national institutions to sustainable financing for Forest and Landscape Restoration.

C. Pilot actions focused on the implementation of innovative models potentially replicable in other Lebanese regions with a focus on: restoration of abandoned terraces (Kadisha Valley and Shouf Biosphere Reserve) and restoration of landscapes affected by erosion in the bio-corridor of Bkassine iconic pine forest and Mhaidseh. This work plan 2016–2018 is implemented with a strong leadership of the Rural Development and Natural Resources Directorate (RDNRD) of the Ministry of Agriculture.

In the framework of the FLRM, the Al-Shouf Cedar Society ACS received funding from FAO and the MAVA Foundation for a pilot action to restore the traditional landscape of agriculture terraces in the SBR and the World Heritage site of Qadisha valley in north-western Mount Lebanon that hosts an outstanding number of monasteries and hermitages with nearby terraces. The initiative implemented field restoration work in several pilot terraces, as well as capacity building and awareness raising activities targeting local communities about sound restoration methodologies and the socio-economic and environmental values of traditional terraced landscapes.

REFERENCES

- Abu-Izzeddin, Faisal (2013) . Memoirs of a Cedar. A history of deforestation, a future of conservation. Shouf Biosphere Reserve.
- Agnoletti, M. et al (2015) Territorial analysis of the agricultural terraced landscapes of Tuscany (Italy): preliminary results. Sustainability2015, 7.
- Bautista, S., J. Aronson & V.R. Vallejo Eds. (2009) Land Restoration to Combat Desertification. Innovative Approaches, Quality Control and Project Evaluation. CEAM.
- Allen, E. (1995): Restoration ecology: limits and possibilities in arid and semiarid lands. In: Proceedings of the Wildland Shrub and Arid Land Restoration Symposium, A. Forest Service INT-GTR-315. Washington DC, 7–15.
- Alloza, J.M. (2003) Análisis de repoblaciones forestales en la comunidad valenciana. Desarrollo de criterios y procedimientos de evaluación. Ph.D. Thesis. Departamento de Producción Vegetal. Universidad Politécnica de Valencia.
- Antea Group (2017) Groundwater resources sustainable assessment of the western slope of the Shouf Biosphere Reserve. Report prepared for Nestlé Waters Lebanon.
- Aphalo, P.J., Rikala, R and Sánchez, R.A. (1997) Effect of CCC on the morphology and growth potential of containerised silver birch seedlings. New Forests, 14, 167-177.
- Bainbridge, D.A. (2002). Alternative irrigation systems for arid land restoration. Ecological Restoration, 20, 23-30.
- Bautista et al Eds. (2005) Land Restoration to Combat Desertification. Innovative approaches, quality control and project evaluation (www.ceam.es/reaction/book01.htm).
- Bautista, S., J. Aronson & V.R. Vallejo Eds. (2009) Land Restoration to Combat Desertification. Innovative Approaches, Quality Control and Project Evaluation. CEAM
- Binns, J.A., P.M. Illgner & E.L. Nel (2001) Water shortage, deforestation and development: South Africa's Working for Water Programme. Land Degrad. Develop. 12: 341-355.
- Birchler T., Rose R., Royo A. and Pardos M., 1998. La planta ideal: revisión del concepto parámetros definitorios e implantación práctica. Investigación Agraria: Sistemas y Recursos Forestales, 7, 109-121.
- Boydak. M. (2007) Reforestation of Lebanon cedar (Cedrus libani A. Rich.) in bare karstic lands by broadcast seeding in Turkey.
- Brooks, L., D. Brown, S. Smith & S. Sprenger (2006) The use of mycorrhizae in native plant production. Native Plant Production, University of Washington.
- Bugalho, M.L. & L.N. Silva (2014) Case Study: Promoting sustainable management of cork oak landscapes through payments for ecosystem services: the WWF Green Heart of Cork project Unasylva 242, Vol. 65, 2014/1
- Buisson E., Dutoit T., Torre F., Römermann C. & Poschlod P. (2006). The implications of seed rain and seed bank patterns for plant succession at the edges of abandoned fields in Mediterranean landscapes. Agriculture, Ecosystems and Environment 115, 6-14.
- Burdett, A.N. 1990. Physiological processes in plantation establishment and the development of specifications for forest planting stock. Canadian Journal of Forest Research 20: 415-427.
- Castro, J.; Zamora, R.; Hódar, J.A.; Gómez, J.M., 2002. The use of shrubs as nurse plants: a new technique for reforestation in Mediterranean mountains. Restoration Ecology, 10, 297-305.
- Castro, J., R. Zamora, J. Hódar, J.M. Gómez, L. Gómez-Aparicio (2004) Benefits of Using Shrubs as Nurse Plants for Reforestation in Mediterranean Mountains: A 4-Year Study. Restoration Ecology Vol. 12 No. 3
- Chirino, E., A. Vilagrosa, J. Cortina, A. Valdecantos, D. Fuentes, R. Trubat, V.C. Luis, J. Puertolas, S. Bautista, M.J. Baeza, J.L. Peñuelas & V.R. Vallejo (2009) Ecological restoration in degraded drylands: the need to improve the seedling quality and site conditions in the field. In: Forest Management, Steven P. Grossberg Ed. Nova Science Publishers, Inc.
- Contessa V. (2014)Terraced landscapes in Italy: state of the art and future challenges. Corso di laurea magistrale in Scienze Forestali e Ambientali. U.S.Padova. Dip. Territorio E Sistemi Agro-Forestali.
- Cortina, J., Bellot, J., Vilagrosa, A., Caturla, R., Maestre, F., Rubio, E., Martínez, J.M., Bonet, A., 2004. Restauración en semiárido. In: Vallejo, V.R., Alloza, A. (Eds.), Avances en el Estudio de la Gestión del Monte Mediterráneo. Fundación CEAM, Valencia, pp. 345e406.
- Cortina, J., B. Amat, V. Castillo, D. Fuentes, F.T. Maestre, F.M. Padilla, L. Rojo (2011) The restoration of vegetation cover in the semi-arid Iberian southeast. Journal of Arid Environments 75: 1377-1384.
- de Groot, R.S., J. Blignaut, S.van der Ploeg, J. Aronson, T. Elmqvist, and J. Farley. 2012. Investing in Ecosystem Restoration Pays: Evidence from the F ield (fothcoming) based on data from Neßhöver, C., J. Aronson, J.N. Blignaut, D. Lehr, A. Vakrou & H. Wittmer 2011. Investing in Ecological Infrastructure. In: The Economics of Ecosystems and Biodiversity in National and International Policy Making. edited by Patrick ten Brink. Earthscan, London and Washington. Pp. 401-448.
- Descheemaeker, K., J. Nyssen, J. Poesen, M. Haile, B. Muys, D. Raes, J. Moeyersons & J. Deckers (2006) Soil and water conservation through forest restoration in exclosures of the Tigray highlands. Journal of the Drylands 1(2): 118-133.
- u Guerny, J. & Lee-Nah Hsu (2010) Meeting the challenges to sustainability: A northern Mediterranean Agriculture Perspective. F irst Terraced Landscape Conference, Honghe, China, 11-15 November 2010. UNESCO/FAO/Ramsar.
- FAO. 2015. Global guidelines for the restoration of degraded forests and landscapes in drylands: building resilience and benefiting livelihoods, by Berrahmouni, N., Regato, P. & Parfondry, M . Forestry Paper No. 175. Rome, Food and Agriculture Organization of the United Nations.
- Folke, C. Et al (2002) Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. Ambio Vol. 31, Nº 5.
28. Gómez-Aparicio, L., R. Zamora, J.M. Gómez, J.A. Hódar, J. Castro & E. Baraza (2004) Applying plant facilitation to forest restoration: a meta-analysis of the use of shrubs as nurse plants. Ecological Applications, 14(4), 2004, pp. 1128–1138. Ecological Society of America.

- Hani, N. Et al (2017) Adaptive forest landscape restoration as a contribution to more resilient ecosystems in the Shouf Biosphere Reserve (Lebanon). Plant Sociology, Vol 54. Suppl 1.
- Ingelmo, F., Albaich, R., Ortiz, F., Escarre, A., Lledó, M.J. (2002). Producción de planta forestal con un substrato derivado de lodos de depuradora; una alternativa para viveristas. Lodos, 67, 1-7.
- IUCN. 2012. Enhancement of natural capital through forest and landscape restoration (FLR). Policy brief. Available at: https://cmsdata.iucn.org/downloads/policy_brief_on_forest_restoration_2.pdf.
- Jackson R. & N. Jain (2006) Mountain Cultures, Keystone Species: Exploring the Role of Cultural Keystone Species in Central Asia. F inal Report submitted to The Christensen Fund by SLC/ Cat Action Treasury, Sonoma, California.
- Landis, T.D. & K.M. Wilkinson (2009) 10: Water quality and irrigation. In: Dumroese, R.K., T. Luna, T.D. Landis Eds. Nursery manual for native plants: A guide for tribal nurseries - Volume 1: Nursery management. Agriculture Handbook 730. Washington, D.C.: U.S. Department of Agriculture, Forest Service. p. 177-199.
- Lefevre, M. Et al (2012) The influence of the Common Agriculture Policy on agricultural landscapes. JRC Scientific and Policy Reports. European Commission.
- Lemenih, M. (2004) Effects of Land Use Changes on Soil Quality and Native Flora Degradation and Restoration in the Highlands of Ethiopia Implications for sustainable land management. Doctoral Thesis, Swedish University of Agricultural Sciences Uppsala.
- Liagre, L. Et al (2015). Sustainable financing for forest and landscape restoration. The role of public policy makers. FAO and UNCCD.
- Maestre, F.T., Cortina, J., Bautista, S., Bellot, J. and Vallejo, V.R. (2003). Small scale environmental heterogeneity and spatio-temporal dynamics of seedling survival in a degraded semiarid ecosystem. Ecosystems, 6, 630-643.
- Mansourian S. (2005) Overview of forest restoration strategies and terms. In: Mansourian, S et al Eds. (2005) Forest Restoration in Landscapes: Beyond Planting Trees. Springer, New York.
- Millán, M.M., Estrela, M.J., Sanz, M.J., Mantilla, E., Martin, M., Pastor, F., Salvador, R., Vallejo, V.R., Alonso, L., Gangoiti, G., Ilardia, J.L., Navazo, M., Albizuri, A., Artiñano, B., Ciccioli, P., Kallos, G., Carvalho, R.A., Andrés, D., Hoff, A., Werhahn, J., Seufert, G., and Versino, B. 2005. Climatic feedbacks and desertification: The Mediterranean model. Journal of Climate 18: 684-701.
- Minnemeyer, S et al. (2011) A World of Opportunity: Bonn Challenge on forest, climate change and biodiversity 2011. The Global Partnership on Forest Landscape Restoration (More information may be found at www.ideastransformlandscapes.org and www.wri.org/restoring-forests).
- Navarrete Poyatos, M.A. et al (2014) Climate change impacts on native tree species distribution in Lebanon : Potentiality projections to 2050. IDAF.
- Neely, C., S. Bunning & A. Wilkes (2009) Review of evidence on drylands pastoral systems and climate change. Land and Water Discussion Paper 8. FAO.
- OECD (2001) Sustainable development strategies. What are they and how can development cooperation agencies support them? www.oecd.org/publications/pol_brief/
- Oliet, J., Valdecantos, A., Puértolas, J. and Trubat, R. (2006). Influencia del estado nutricional y el contenido en carbohidratos en el establecimiento de las plantaciones: In Calidad de planta forestal para la restauración en ambientes Mediterráneos. Estado actual de conocimientos. (pp. 109-111). Madrid, Spain: Ministerio de Medio Ambiente.
- Ostos, J.C., López-Garrido, R. Murillo. J.M., López, R. (2008). Substitution of peat for municipal solid waste- and sewage sludge-based composts in nursery growing media: Effects on growth and nutrition of the native shrub Pistacia lentiscus L. Bioresource Tecnology, 99, 1793-1800.
- Ouahmane, L., R. Duponnois, M. Hafidi, M. Kisa, A. Boumezouch, J. Thioulouse and C. Plenchette (2006) Some Mediterranean plant species (Lavandula spp. and Thymus satureioides) act as potential 'plant nurses' for the early growth of Cupressus atlantica. Plant Ecology (2006). Springer
- Parco Nazionale Delle Cinque Terre (2004) Manuale per la costruzione dei muri a secco. Linee guida per la manutenzione dei terrazzamenti delle Cinque Terre. LIFE 00 ENV/IT/000191 PROSIT.
- Pausas, J. G., C. Blade, A. Valdecantos, J.P. Seva, D. Fuentes, J.A. Alloza, A. Vilagrosa, S. Bautista, J. Cortina & R. Vallejo (2004) Pines and oaks in the restoration of Mediterranean landscapes of Spain: New perspectives for an old practice - a review. Plant Ecology, 209: 209-220.
- Peñuelas P, Boada M. (2003) A global change-induced biome shift in the Montseny mountains (NE Spain). Global Change Biology, 9(2), 131-140.
- Petit JP, Hampe A, Cheddadi R. (2005) Climate changes and tree phylogeography in the Mediterranean. TAXON, 54(4): 877-885.
- Poorter H. and Nagel O. (2000). The role of biomass allocation in the growth response of plants to different levels of light, CO2, nutrients and water: a quantitative review. Australian Journal of Plant Physiology, 27, 595-607.
- Prach K. & Pysek P. (2001) Using spontaneous succession for restoration of human-disturbed habitats: Experience from Central Europe. Ecological Engineering 17, 55-62.
- RCC, 2006. Dispositif agroenvironnemental appliqué à la prévention des incendies de forêt en région méditerranéenne. Résultats de 20 ans de réalisations et propositions pour l'avenir. Document de synthèse. Éditions La Cardère - l'Éphémère, Laudun (France).
- Regato, P. (2008) Adapting to global change, Mediterranean Forests. IUCN Centre for Mediterranean Cooperation.
- Reinbott, T.M and Blevins, D.G. (1999). Phosphorus nutritional effects on root hydraulic conductance, xylem water flow and flux of magnesium and calcium in squash plants. Plant and Soil, 209, 263-273.
- Ries, J.B. and Hirt, U. (2008). Permanence of soil surface crusts on abandoned farmland in the Central Ebro Basin/Spain. Catena, 72, 282-296.
- Rietbenger-McCracken, J. et al. (Eds) (2007) The Forest Landscape Restoration Handbook. Earthscan. London.
- Rúiz Mirazo, J, A.B. Robles and J.L. González-Rebollar (2009) Pastoralism in Natural Parks of Andalusia (Spain): A tool for fire prevention and the naturalization of ecosystems. Options Méditerranéennes, A no. 91, 2009 – Changes in sheep and goat farming systems at the beginning of the 21st century.

- *Salafsky, N., R. Margoluis, and K. Redford. 2001. Adaptive management: A tool for conservation practitioners. Washington, D.C.: Biodiversity Support Program.*
- *Sánchez-Blanco, M.J., Ferrández, T., Navarro, A., Bañon, S. and Alarcón, J.J. (2004) Effects of irrigation and air humidity preconditioning on water relations, growth and survival of Rosmarinus officinalis plants during and after transplanting. Journal of Plant Physiology, 161, 1133-1142.*
- *Sangiorgi et al., (2006) Muri a secco e terrazzamenti nel Parco dell'Adamello; linee guida per il recupero, University of Milano.*
- *Schmitt, J. (2012) Communication at the 1st International Experts Workshop on Drylands Restoration (Konya, Turkey). FAO*
- *SER International Primer on Ecological restoration (2004).*
- *Singh, D.K. and Sale, P.W.G. (2000). Growth and potential conductivity of white clove roots in dry soil with increasing phosphorus supply and defoliation frequency. Agronomy Journal, 92, 868-874.*
- *Stedman-Edwards, P. (1997) Socio-economic root-causes of biodiversity loss: an analytical approach paper. WWF*
- *TEEB. 2009. TEEB climate issues update . The Economics of Ecosystems and Biodiversity.*
- *Trubat R., Cortina J. and Vilagrosa A. (2006). Plant morphology and root hydraulics are altered by nutrient deficiency in P. lentiscus (L.). Trees: Structure and Function, 20, 334- 339.*
- *Tsakaldimi, M. (2006). Kenaf (Hibiscus cannabinus L.) core and rice hulls as components of container media for growing Pinus halepensis M. seedlings. Bioresource Technology, 97, 1631-1639.*
- *Valiente, J.A., M.J. Estrela, D. Corell, D. Fuentes, A. Valdecantos & M.J. Baeza (2011) Fog water collection and reforestation at a mountain location in a western Mediterranean Basin region: air-mass origins and synoptic analysis. Erdkunde Vol. 65, Nº 3: 277-290.*
- *Valdecantos, A., Cortina, J. and Vallejo, V.R. 2006. Nutrient status and field performance of tree seedlings planted in Mediterranean degraded areas. Annals of Forest Science, 63, 249-256.*
- *Valdecantos A., Baeza M.J. and Vallejo V.R. (2008). Vegetation management for promoting ecosystem resilience in fire-prone Mediterranean shrublands. Restoration Ecology (doi: 10.1111/j.1526-100X.2008.00401.x).*
- *Valdecantos, A, D. Fuentes, A. Smanis, J. Llovet, L. Morcillo & S. Bautista (2014) Effectiveness of Low-Cost Planting Techniques for Improving Water Availability to Olea europaea Seedlings in Degraded Drylands. Restoration Ecology Vol. 22, No. 3, pp. 327–335.*
- *Vallejo, R. (Ed) (2006) Common methodologies and tools for restoring burned areas. http://www.eufirelab.org/prive/directory/units_section_4/D-04-08/D-04-08-v.pdf*
- *Vallejo, R. (2008) Rural landscape and water: the role of forests. Water Tribune, 2008 International Exposition of Zaragoza.*
- *Vallejo, V.R, A. Smanis, E. Chirino, D. Fuentes, A. Valdecantos & A. Vilagrosa (2012) Perspectives in dryland restoration: approaches for climate change adaptation. New Forests (2012) 43:561–579.*
- *Vallejo et al (2012) Chapter 11: Restoration of Mediterranean-type woodlands and shrublands. In: Van Andel, J. & J. Aronson (2012) Restoration Ecology. The New Frontier. Wiley-Blackwell.*
- *Vennetier M, Vila B, Liang EY, Guibal F, Ripert C, Chandioux O. (2005) Impacts du changement climatique sur la productivité forestière et le déplacement d'une limite bioclimatique en région méditerranéenne française. Ingénieries, 44, 49-61.*
- *Vilagrosa, A., Seva, J.P., Valdecantos, A., Hernández, N., Cortina, J.A., Bellot, J., Vallejo, V.R., 1997. Una nueva técnica viverística para la introducción de plantones de Quercus sp. en clima seco y semiárido. In: Vega, G., Almeida, M.H. (Eds.), Montes de futuro: respuestas ante un mundo en cambio. SECF, Pam- plona, pp. 667e672.*
- *Villar-Salvador P., Ocaña L., Peñuelas J.L. and Carrasco I. 1999. Effect of water stress conditioning on the water relations, root growth capacity, and the nitrogen and non- structural carbohydrate concentration of Pinus halepensis Mill (Aleppo pine) seedlings. Annals of Forest Science, 56, 459-465.*
- *Villar-Salvador P., Planelles R., Oliet J., Peñuelas-Rubira J.L., Jacobs, D.F. and González M. (2004). Drought tolerance and transplanting performance of holm oak (Quercus ilex L.) seedlings after drought hardening in the nursery. Tree Physiology, 24, 1147-1155.*

List of Acronyms

ACS	Al-Shouf Cedar Society
AFD	French Development Agency's
AFDC	Association for Forests, Development and Conservation
AGSBR	Alliance for the Green Shouf Biosphere Reserve
APAC	Appointed Protected Area Committee
ARDP	EU Agriculture and Rural Development Programme
BC	Before Current Era
BWTC	Baadarane Waste Treatment and Composting Unit
CBD	United Nations Convention on Biological Diversity
CEAM	Centro de Estudios Ambientales del Mediterráneo
C/N	Carbo/Nitrogen Rate
CPF	FAO Country Programme Framework
CSR	Corporate Social Responsibility
DGUP	General Direction of Urban Planning
ENPI	European Neighbourhood and Partnership Instrument
ESP	Ecosystem Services Partnership
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FLR	Forest and Landscape Restoration
FLRM	FAO Forest and Landscape Restoration Mechanism
FMC	Municipal Forest Management Committee
FRA	FAO Forest Resources Assessment
GDP	Gross Domestic Product
GEF	Global Environment Facility
GIAHS	FAO Globally Important Agriculture Heritage
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoL	Government of Lebanon
GPFLR	Global Parnership for Forest and Landascape restoration
Ha	Hectare
ILEX	Italian Landscape Exploration
IBA	Indolyc Butyric Acid
INDC	Intended Nationally Determined Contribution t the UNFCCC
IPBES	Intergovernmental Science Policy Platform and Ecosystem Services
IUCN	International Union for the Conservation of Nature
K	Potassium
L	liter
LMTA	Lebanon Mountain Trail Association
LRI	Lebanon Reforestation Initiative
M	Meter
M	Million
MEDFORVAL	Mediterranean Forests of High Ecological Value
MFRP	Municipal Forest Restoration Plan
MM	Mediterranean Mosaics Project
MoA	Ministry of Agriculture
MoE	Ministry of Environment
MoEW	Ministry of Energy and Water
MoF	Ministry of Finance
MoIM	Ministry of Interior and Municipalities
MoPWT	Ministry of Public Works and Transport
N	Nitrogen
NARP	National Afforestation and Reforestation Programme
NPK	Nitrogen, Phosporus, Potassium
NPTP	National Poverty Targeting Programme
NRM	Natural Resources Management
NRP	National reforestation Plan
NVS	Natural Vegetation Strips
NWFP	Non-Wood Forest Products
OECD	Organisation for Economic Co-operation and Development
OWL	Other Wooded Land
P	Phosphorus
PGR	Plant Growth Regulator
RC	Reforestation Consortium
RDNRD	Rural Development and Natural Resources Directorate
RNC	Restoration of Natural Capital Alliance
SBHCP	Shouf Built Heritage Conservation Project
SBR	Shouf Biosphere Reserve
SDC	Swiss Agency for Development Cooperation
SEA	Strategic Environmental Assessment
SPNL	Society for the Protection of Nature in Lebanon
TEEB	The Economics of Ecosystems and Biodiversity
TNC	Third National Communication to the UNFCCC
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
USAID	United States Agency for International Development
USD	United States of America Dollar
WB	World Bank
WFP	World Food Programme
WWF	World Wildlife Fund

ANNEXES

ANNEX 1: Accepted Latin Names and Synonyms for the Plant Species Mentioned in this Publication

Accepted Latin Names and Synonyms of the Plant Species Mentioned in this Publication[131]

Accepted Name	Synonym Commonly Used	English name	French name	Arabic name
Acantholimon ulicinum (Willd. ex Schult.) Boiss.	Same name	vjh gorse prickly thrift	Acantholmon faux ajonc	غملول جوقلي
Acer hyrcanum sbsp. tauricolum (Boiss. & Balansa) Yalt.	Acer tauricolum Boiss. & Balansa	Taurus maple	Erable du taurus	قيقب طوروس
Acer monspessulanum subsp. microphyllum (Boiss.) Bornm.	Acer hermoneum (Bornm.) Bornm. & Schwer.	Hermon maple	Érable de l'hermon	قيقب حرمون
Acer obtusifolium Sm.	Acer syriacum Boiss. & Gaill.	Syrian maple	Érable de Syrie	قيقب سوري
Allium ampeloprasum L.	Same name	Wild leek	Poireau d'ete	كرّات بري ابيض
Allium rotundum L.	Allium descendens Pall. ex Schult. & Schult. f., des. inval.	Round garlic	Ail rond	ثوم مستدير
Alnus orientalis Decne.	Same name	Oriental alder	Aulne oriental	مغت
Anacamptis morio subsp. syriaca (E.G.Camus) H.Kretzschmar, Eccarius & H.Dietr.	Same name	Pyramidal orchid	Orchis pyramidal	سحلب هرمي
Anacamptis papilionacea (L.) R.M.Bateman, Pridgeon & M.W.Chase	Same name	Pyramidal orchid	Orchis pyramidal	سحلب هرمي
Arbutus andrachne L.	Same name.	Oriental strawberry tree	Arbousier d'orient	قطلب الشرق
Astracantha echinus (DC.) Podlech	Astragalus echinus DC.	Hedgehog milk vetch	astragale herisson	قتاد كباية شوك
Astracantha gummifera (Labill.) Podlech	Astragalus gummifer Labill.	Gum dragon	Gomme adragante	كثيراء كبيكج
Avena barbata Link	Same name	Common bearded oat	Avoine barbue	شعيرة
Berberis libanotica C. K. Schneid.	Same name	Lebanon baberry	Berberis du Liban	بربارىس لبنان
Blysmus compressus (L.) Link	Same name	Compressed blysmus	Blysmus comprime	نبعيّة
Brachypodium phoenicoides (L.) Roem. & Schult.	Brachypodium pinnatum Font Quer [non (L.) P. Beauv.]	Pinnate false- brome	Brachypode penné	قطبان ريشي
Calicotome villosa (Poir.) Link	Same name	Furrowed thorny broom	Calictome velu	قندول مقلم الساق

Accepted Latin Names and Synonyms of the Plant Species Mentioned in this Publication[131]

Accepted Name	Synonym Commonly Used	English name	French name	Arabic name
Capparis spinosa L.	Same name	Spiny caper	Capier epineux	كبر وبر
Cedrus libani A.Rich	Same name	Cedar of Lebanon	Cedre du Liban	ارز لبنان
Celtis australis L.	Same name	European nettle tree	Micocoulier austral	ميس
Cistus creticus L.	Same name	Cretan cistus	Ciste de crête	لاذن احمر
Cistus salviifolius L.	Same name	Sage-leaved cistus	Ciste a feuilles de sage	لاذن ابيض
Clematis vitalba L.	Same name	Traveller's joy	Vigne- blanche	ياسمين البر
Colutea cilicica Boiss. & Balansa	Same name	Cilician bladder-senna	Baguenaudier de cilicie	سنا قيليقية
Corydalis solida (L.) Clairv.	Same name	Short- lobbed corydalis	Corydale À lobes courts	قبرية قصيرة
Cotoneaster nummularius Fisch. & C. A. Mey.	Same name	Nummular cotoneaster	Cotoneaster nummulaire	سفرجلية
Crataegus azarolus L.	Same name	Azarole	Azerolier	زعرور اصفر
Crataegus monogyna Jacq.	Same name	Whitehorn	Aubépine fruit rougeÀtre	زعرور احمر
Cyclamen persicum Mill.	Same name	Persian cyclamen	Cyclamen de perse	بخور مريم
Dactylis glomerata L.	Same name	Orchard- grass	Dactyle aggloméré	قدم الديك
Dioscorea communis (L.) Caddick & Wilkin	Tamus communis L.	Common black bryony	Tamier commun trilobé	كرمة سوداء
Doronicum orientale Hoffm.	Doronicum caucasicum M.Bieb.	Oriental leopard's- bane	Doronic d'orient	درونق شرقي
Elymus panormitanus (Parl.) Tzvelev	Agropyron panormitanum Parl.	Palermo couch- grass	Agropyre de palerme	سيفون
Elytrigia libanotica (Hack.) Holub	Agropyron libanoticum Hack.	Lebanon couch- grass	Agropyre du Liban	سيفون لبنان
Eryngium glomeratum Lam.	Same name			
Fraxinus angustifolia subsp. syriaca (Boiss.) Yalt.	Fraxinus syriaca Boiss.	Syrian ash	Frêne de Syrie	دردار، مرّان سوري
Geranium libani P. H. Davis	Same name	Lebanon geranium	Geranium du Liban	غرنوقي لبنان
Gundelia tournefortii L.	Same name	Tournefort's gundelia	Gundélie de tournefort	عكوب
Halimium umbellatum (L.) Spach	Same name	Syrian halimium	Halimium Syrien	حلميوم سوري
Helichrysum sanguineum (L.) Kostel.	Same name	Blood-red everlasting	Immortelle sanguine	خالدة حمراء

[131]: This is based in the web pages: (a) Euro+Med Plantbase (http://ww2.bgbm.org/EuroPlusMed/query.asp) that integrates and critically evaluates information from Flora Europaea, Med-Checklist, the Flora of Macaronesia, and from regional and national floras and checklists from the area as well as additional taxonomic and floristic literature. This is complemented by the European taxa of several families taken from the World Checklist of Selected Plant Families and of the Leguminosae from the International Legume Database and Information Service ILDIS. By 1st of February 2018 it provides access to the total European flora of vascular plants; (b) The Plant List (www.theplantlist.org) Collaboration between the Royal Botanic Gardens, Kew and Missouri Botanical Garden enabled the creation of The Plant List by combining multiple checklist datasets held by these institutions and other collaborators. The Plant List provides the ACCEPTED Latin name for most species, with links to all synonyms by which that species has been known. It also includes unresolved names for which the contributing data sources did not contain sufficient evidence to decide whether they were Accepted or Synonyms, or where there were conflicting opinions that could not be readily resolved.

Accepted Latin Names and Synonyms of the Plant Species Mentioned in this Publication[131]

Accepted Name	Synonym Commonly Used	English name	French name	Arabic name
Hordeum bulbosum L.	Same name	Bulbous barley	Orge bulbeuse	شعير بصلي
Jasminum fruticans L.	Same name	Yellow jasmine	Jasmine jaune	ياسمين بري
Juniperus drupacea Labill.	Arceuthos drupacea (Labill.) Antoine & Kotschy	Drupe bearing arceuthos	Genévrier À fruits charnus	دفران
Juniperus excelsa M.Bieb.	Same name	Grecian juniper	Genévrier élevé	لزّاب
Juniperus oxycedrus L.	Same name	Prickly juniper	Genévrier oxycédre	عرعر عادي
Lathyrus libani Fritsch	Unresolved name	Lebanon vetchling	Gesse du Liban	جلبان لبنان
Lavandula angustifolia Mill. ssp. angustifolia	Lavandula officinalis Chaix			
Lavandula stoechas L.	Same name	Fresh lavender	Lavande stéchade	لاوند
Linum pubescens Banks & Sol.	Same name	Pink flax	Lin pubescent	كتّان ازغب
Lonicera etrusca Santi	Same name	Etruscan honeysuckle	Chévrefeuille d'étrurie	سلطان الجبل
Lonicera nummulariifolia Jaub. & Spach	Same name	Nummular-leaved honeysuckle	Chévrefeuille À feuilles nummulaires	زهر العسل مخملي
Melica minuta subsp. angustifolia (Boiss. & C. I. Blanche) W. Hempel	Melica angustifolia Boiss. & C. I. Blanche	Narrow-leaved melick	Mélique À feuilles étroites	مليقة ضيقة الورق
Michauxia campanuloides L'Hér.	Same name	Rough- leaved michauxia	Michauxie fausse-campanule	ميشكسية جريسية
Medicago sativa L.	Same name	alfalafa	Luzerne	فصة مزروعة
Neotinea tridentata (Scop.) R. M. Bateman, Pridgeon & M. W. Chase	Same name	Dense flowered- orchid	Neotienée	نيوتينية
Nerium oleander L.	Same name	Oleander	Laurier - rose	دفلى
Nigella ciliaris DC.	Same name	Ciliate nigella	Nigella ciliée	حبة البركة
Onobrychis cornuta (L.) Desv.	Same name	Horned sainfoin	Sainfoin cornu	عرن قرني
Ononis adenotricha Boiss.	Same name	Glandular- downy restharrow	Bugrane poilue – glanduleuse	شبرق اصفر – زهر
Ononis natrix L.	Same name	Shrubby rest harrow	Bugrane natrix	شبرق ثعباني
Gundelia tournefortii L.	Same name	Tournefort's gundelia	Gundélie de tournefort	عكوب
Halimium umbellatum (L.) Spach	Same name	Syrian halimium	Halimium Syrien	حلميوم سوري
Helichrysum sanguineum (L.) Kostel.	Same name	Blood-red everlasting	Immortelle sanguine	خالدة حمراء
Orchis anatolica Boiss.	Same name	Anatolian orchid	Orchis d'anatoilie	سحلب الاناضول
Orchis galilaea (Bornm. & M. Schulze) Schltr.	Same name			
Orchis italica Poir.	Same name	Italian orchid	Orchis d'italie	سحلب ايطالي
Origanum ehrenbergii Boiss.	Same name	Ehrenberg's marjoram	Origan d'ehrirenberg	زعتر هجين
Origanum syriacum L.	Same name	Syrian marjoram	Origan de Syrie	زعتر المناقيش اللبنانية

Accepted Latin Names and Synonyms of the Plant Species Mentioned in this Publication[131]

Accepted Name	Synonym Commonly Used	English name	French name	Arabic name
Pallenis spinosa (L.) Cass.	Same name	Spiny pallenis	Pallénide épineuse	زباد شانك
Pinus brutia Tenore	Same name	Calabrian pine	Pin de calibre	صنوبر بري
Pistacia palaestina Boiss.	Unresolved name	Palestine pistachio	Pistachier de Palestine	بطم
Platanus orientalis L.	Same name	Oriental plane	Plantane d'orient	دلب
Poa diversifolia (Boiss. & Balansa) Boiss.	Same name	Diversely leaved-meadow- grass	Paturin À feuilles différentes	تف مختلف الورق
Podospermum canum C. A. Mey.	Scorzonera cana (C. A. Mey.) Griseb.	Alpine viper's- grass	Scorzonére alpine	دبح جبلي
Populus alba L.	Populus bolleana Lauche	Trembling poplar	Tremble	حور ابيض
Prunus argentea (Lam.) Rehder	Amygdalus orientalis Mill.	Field almond	Amandier agreste	لوز حقول لبنان
Prunus dulcis (Mill.) D.A.Webb	Prunus amygdalus Batsch; Amygdalus korshinskyi (Hand.-Mazz.) Bornm.; Amygdalus communis L.	Common almond	Amandier	لوز مر او حلو
Prunus ursina Ky	Same name	Bear plum	Prunier des ours	برقروق، خوخ الدب
Putoria calabrica (L. f.) DC.	Same name	Putoria Calabria	Putoria de calabre	منتنة كلبريا
Pyrus syriaca Boiss.	Same name	Syrian peer	Poirier de Syrie	نجاص بري
Quercus coccifera L.	Quercus calliprinos Webb	Kermes oak	Chêne des cédres	سنديان
Quercus infectoria G. Olivier	Same name	Cyprus oak	Chêne tinctorial	ملول، عفص
Quercus ithaburensis Decne. subsp. Ithaburensis	Quercus brantii ssp. look (Ky) Mouterde	Tabor oak	Chêne du thabor	بلوط طابور
Rhamnus punctata Boiss.	Same name	Dotted buckthorn	Nerprun ponctué	عجرم
Rhododendron ponticum L.	Same name	Short- fruit rhododendron	Rhododendron a fruits courts	البقّيل
Rhus coriaria L.	Same name	Tanner's sumac	Sumac des corroyeures	السماق
Rosa canina L.	Same name	Dog rose	Églantier	نسرين
Rubia rotundifolia Banks & Sol.	Rubia aucheri Boiss.	Aucher's madder	Garance d'aucher	فوة اوشيه
Salix alba L.	Same name	White willow	Saule blanc	صفصاف ابيض
Salix pedicellata Desf.	Salix libanii Bornm.	Lebanon willow	Saule du Liban	صفصاف لبنان
Salvia fruticosa Mill.	Same name	Lebanon shrubby sage	Sauge ligneuse du Liban	قصعين لبنان
Sarcopoterium spinosum (L.) Spach	Same name			
Smilax aspera L.	Same name	Rough smilax	Salsepareille	فشاغ
Sorbus torminalis (L.) Crantz	Same name	Wild service tree	Alisier terminal	غبيراء المغص

Accepted Latin Names and Synonyms of the Plant Species Mentioned in this Publication[131]				
Accepted Name	Synonym Commonly Used	English name	French name	Arabic name
Sorbus umbellata (Desf.) R. M. Fritsch	Sorbus flabellifolia (Spach) C.K.Schneider.	Fan leaved service tree	Sorbier en éventail	غبيراء مروحية الورق
Spartium junceum L.	Same name	Spanish broom	Genet d'espagne	وزّال
Stachys cretica L.	Same name	Cretan woundwort	Épiare de créte	قرطوم متهدّل
Stachys distans Benth.	Same name	Distant woundwort	Épiare distant	قرطوم متباعد
Stipa barbata Desf.	Same name	Bearded feather-grass	Stipe barbue	حلفاء شامية
Styrax officinalis L.	Same name	Storax	Aliboufier officinal	حور
Teucrium divaricatum Sieber ex Heldr.	Same name	Shaggy germander	germandrée	جعدة وبرة
Thymbra spicata L.	Same name	Spiked thymbra	Thymbre en épi	زعتر دق
Trifolium campestre Schreb.	Same name	Hop trefoil	Tréfle des champs	نفل اصفر
Trifolium stellatum L.	Same name	Stellate clover	Tréfle étoilé	نفل نجمي
Ulmus minor Mill.	Same name	Lesser elm	Orme mineur	دردار
Ziziphus jujuba Mill.	Same name	Common jujube	Jujubier commun	عناب

ANNEX 2: Bio-climatic Zones in the Shouf Biosphere Reserve Landscape

Bio-climatic Zones in the Shouf Biosphere Reserve					
Bio-climate	Lithology	Forest Habitat Type	Dominant tree species	Companion tree/ shrub	Herbal/small shrub species
I. Western side of the mountain range influenced by the milder and wetter conditions of the Mediterranean Sea.					
Supra-Med. (1000-1500 m)	Limestone (calcareous soil)	Evergreen oak forests	*Quercus calliprinos*	• *Crataegus azarolus* • *Pyrus syriaca* • *Prunus ursina* • *Acer syriacum* • *Lonicera etrusca* • *Clematis vitalba* • *Spartium junceum* • *Origanum syriacum* • *Jasminum fruticans*	• *Brachypodium pinnatum* • *Melica angustifolia* • *Poa bulbosa* • *Teucrium divaricatum* • *Hordeum bulbosum* • *Asparagus acutifolius*
		Mixed oak and pine forests	*Q. calliprinos* *Q. infectoria* *Pinus brutia*		
		Mixed oak forests	*Q. infectoria* *Q. calliprinos*		
	Sandstone (Acid soil)	Stone pine forests	*Pinus pinea* *Q. infectoria*	•*Juniperus oxycedrus* • *Cistus creticus* • *Cistus salvifolius* • *Lavandula stoechas* • *Halimium umbellatum* • *Rhododendron ponticum*	• *Tuberaria guttata* • *Aira elegans* • *Briza maxima* •*Origanum ehrenbergii*
Mountain-Med (1501-1900 m)	Limestone (Calcareous soil)	Cedar forests	*Cedrus libani*	• *Sorbus flabellifolia* • *Sorbus torminalis* • *Malus trilobata* • *Acer hyrcanum subp. hermoneum* • *Cotoneaster nummularius* • *Lonicera nummulariifolia* • *Colutea cilicica* • *Styrax officinalis* • *Juniperus oxycedrus*	
		Mixed cedar/oak forests	*Cedrus libani* *Q. brantii look*		
		Oak forests	*Q. brantii look*		
Oro-Med (>1900 m)	Limestone (Calcareous soil)	Pastures & cushion thorny shrubs		• *Berberis libanotica* • *Prunus prostrata* • *Pyrus syriaca* • *Cotoneaster nummularius*	• *Onobrychis cornuta* • *Agropyron libanoticum* • *Astragalus spp* • *Acantholimon libanoticum*
II. Eastern side of the mountain range influenced by the more continental and dry conditions of the inner Beqaa Valley					
Steppe-Med (900-1500 m)	Limestone (Calcareous soil)	Evergreen oak forests	*Q. calliprinos* *Q. infectoria*	• *Amygdalus korschinskii* • *Jasminum fruticans* • *Spartium junceum* • *Rhamnus punctata* • *Crataegus azarolus*	• *Stachys cretica* • *Phlomis sp.* • *Michauxia campanuloides*

Bio-climatic Zones in the Shouf Biosphere Reserve					
Bio-climate	Lithology	Forest Habitat Type	Dominant tree species	Companion tree/ shrub	Herbal/small shrub species
II. Eastern side of the mountain range influenced by the more continental and dry conditions of the inner Beqaa Valley					
Steppe-Supra-Med (1500-1800 m)	Limestone (Calcareous soil)	Mixed oak forests	*Q. calliprinos* *Q. brantii*	• *Acer hyrcanum subp. hermoneum* • *Cotoneaster nummularius* • *Lonicera nummulariifolia* • *Amygdalus korschinskii* • *A. Orientalis* • *Jasminum fruticans* • *Pyrus syriaca* • *Berberis libanotica*	• *Ziziphora capitate* • *Thelegonum cynocrambe* • *Ononis pusilla* • *Trigonella monantha*
Steppe-Mountain-Med (1800-2400 m)	Limestone (Calcareous soil)	Juniper forests	*Juniperus excelsa*	• *Berberis libanotica* • *Astralagus spp*	• *Onobrychis cornuta* • *Agropyron libanoticum*
III. Riparian Forests					
Riparian forests	Limestone (Calcareous soil)	Lowland wetland forest in Ammiq	*Fraxynus syriaca* *Salix spp.* *Ulmus minor*	• *Rubus spp.* • *Rosa spp.* • *Crataegus monogyna*	• *Alisma plantago-aquatica* • *Epilobium sp.*
		Plane tree and alder forests	*Platanus orientalis Alnus orientalis Salix libani*	• *Nerium oleander*	• *Hypericum hircinum* • *Pteris vitata*
	Sandstone (Acid and calcareous soil)	Alder forests	*Alnus orientalis Salix libani*	• *Rhododendron ponticum* • *Arbutus andrachne*	• *Osmunda regalis* • *Equisetum telmateia* • *Blechnum spicant*

ANNEX 3: Multipurpose Criteria for the Selection of Native Species in the SBR Landscape

Multipurpose criteria for the selection of native species in the SBR Landscape		
Species	Environmental value	Socio-economic value
Acer syriacum	• Small re-sprouting tree after fire and cutting.	• Ornamental and gardening.
Acer tauricolum	• Re-sprouting tree after fire and cutting.	• Ornamental and gardening.
Arbutus andrachne	• High shrub or small tree re-sprouting after fire and cutting. • Fruit tree attracting seed-dispersal fauna.	• Potential for jam and liquor production • Ornamental and gardening (flowers; stems with intense red colour).
Berberis libanotica	• Fruit shrub attracting seed-dispersal birds.	• Ornamental and gardening.
Capparis spinosa	• Drought-resistant. • Valuable species for soil erosion prevention.	• Edible. • Ornamental in dry stone wall terraces. • Shelter shrub protecting agriculture land.
Cedrus libani	• Dominant tree of the cedar forest habitat type that harbours numerous flora and fauna species. • Hydrologic regulation (capturing fog water and facilitating soil water infiltration).	• National identity value (symbol of Lebanon). • Cedar honey. • Medicinal (fever, infant insomnia and agitation, wounds)
Celtis australis	• Tree re-sprouting after fire and cutting. • Fruit tree attracting seed-dispersal fauna.	• Ornamental and gardening. • The fruit of this tree is sweet and edible, and can be eaten raw or cooked.
Cotoneaster nummularius	• Fruit shrub attracting seed-dispersal birds.	•Ornamental and gardening
Crataegus azarolus	• Tree re-sprouting after fire and cutting. • Fruit tree attracting seed-dispersal fauna. • Fodder for wild fauna.	• Medicinal (diarrea, insomnia, palpitation, hypertension and heart diseases, diabetes, cáncer).. • Edible with high potential for organic food marketing. • Fodder for livestock. • Ornamental and gardening.
Crataegus monogyna	• Tree re-sprouting after fire and cutting. • Fruit tree attracting seed-dispersal fauna. • Fodder for wild fauna.	• Medicinal. • Edible. • Fodder for livestock. • Ornamental and gardening.
Cupressus sempervirens	• Drought-resistant species.	• Wind-barrier in agriculture land and urban/ roads. • Wood provision. • Ornamental and gardening.
Cyclamen persicum	• Threatened species.	• Ornamental in dry stone wall terraces. • Edible leaves and poisonous bulbs • Ethno-botanical element of local culture.
Fraxinus syriaca	• Freshwater ecosystem	• Windbreak • Fodder tree with palatable leaves for livestock • The phloem sap can be extracted by incising the bark, and dried in the air obtaining edible flakes called manna, appreciated for its bitter-sweet taste and for its mild osmotic laxative and diuretic properties, more recently used in cosmetics and pharmaceuticals.
Gundelia tournefortii	• Threatened species.	• Edible. • Medicinal (cold, fever, diabetes, kidney pains, constipation...). • Ethno-botanical element of the local culture.

Multipurpose criteria for the selection of native species in the SBR Landscape		
Species	Environmental value	Socio-economic value
Juglans regia	•Fruit tree attracting seed-dispersal birds.	• Edible
Juniperus drupacea	•Fruit tree attracting seed-dispersal birds. •Threatened species.	• Ornamental and gardening.
Juniperus excelsa	•Fruit tree attracting seed-dispersal birds. • Rare species in the SBR. • Wind- and drought-resistant.	• Linked to livestock grazing systems (fodder, wood, micro-climate for pastures). • Ornamental and gardening.
Juniperus oxycedrus	• Fruit shrub/small tree attracting seed-dispersal birds. • Nursery effect facilitating the growth of other species (e.g. planted seedlings).	• Essential oil from its wood, used in cosmetics, skin treatment and incense.
Laurus nobilis	• Relic tree species.	• High economic potential (herbal for tea and culinary uses; essences; ornamental; medicinal bays used as astringent and salve for open wounds)
Lavandula officinalis	• Drought-resistant shrub.	• High economic potential (herbal for tea and culinary uses; essences)
Lonicera nummulariifolia	• Shrub resistant to high mountain cold winds.	• Ornamental plant. • Toxic.
Malus trilobata	• Tree re-sprouting after fire and cutting. • Fruit tree attracting seed-dispersal fauna.	• Ornamental and gardening. • Grafting of apple species and varieties.
Myrtus communis	• Shrub re-sprouting after fire and cutting. • Fruit shrub attracting seed-dispersal fauna.	• Medicinal. • Cosmetic. • Edible (liquor and condiment for cooking).
Origanum syriacum	• Drought-resistant shrub.	• High economic potential (herbal for tea and culinary uses; essences)
Pinus brutia,	• High regeneration after fire and land abandonment. • Fast growing species colonizing poor soils. • Drought-resistant.	• Wood for bioenergy and construction. • potential edible use of pine seeds.
Pinus pinea	• Fast growing species colonizing poor soils. • Drought-resistant.	• High economic value for pine nuts. • Bioenergy and compost use of pruned branches, cones and nut shells.
Pistacia palaestina	• Re-sprouting shrub after fire and cutting • Drought-resistant shrub. • Valuable species to restore poor, degraded soils.	• Oil essence with high economic potential. • Grafting of pistachio commercial varieties.
Populus bolleana	• Freshwater ecosystems	• Wind breaks • Wood.
Prunus dulcis	• Re-sprouting tree after fire and cutting • Drought-resistant tree.	• Edible. • Grafting of almond commercial varieties. • Medicinal (hipercolesterolemia).
Prunus prostrata	• Re-sprouting shrub after fire and cutting. • Fruit shrub attracting seed-dispersal fauna. • Wind- and drought-resistant.	• Ornamental and gardening. • Edible fruits. • Medicinal (constipation).
Prunus ursina	• Re-sprouting small tree after fire. • Fruit tree attracting seed-dispersal fauna.	• Grafting of plum commercial varieties.
Putoria calabrica	• Threatened species adapted to grow in rocks.	• Quarry restoration (limestone walls).
Pyrus syriaca	• Re-sprouting small tree after fire and cutting. • Fruit tree attracting seed-dispersal fauna.	• Grafting of pear commercial varieties. • Medicinal (cough, stomach ache).

Multipurpose criteria for the selection of native species in the SBR Landscape		
Species	Environmental value	Socio-economic value
Q. brantii ssp. Look	• Re-sprouting species after fire and cutting; • Facilitation role as nursery-species for cedars' recruitment. • Narrow endemic species.	• Fodder and firewood.
Quercus calliprinos	• Re-sprouting species from fire and cutting	• High value of honey and fuel-wood from sustainable tree pruning. • High cultural value of old individuals, as sacred venerated trees in Druze religion.
Q. infectoria	• Re-sprouting species from fire and cutting	• High value of honey and fuel-wood from sustainable tree pruning. • The galls of Q. infectoria have been pharmacologically documented to possess astringent, antidiabetic, local anaesthetic, antiviral, antibacterial, antifungal, larvicidal and anti-inflammatory activities.
Rhus coriaria	• Fruit shrub • Shrub well-adapted to grow on unstable stony soils in steep slopes.	• High economic value for sumac as a culinary spice (dried and crushed fruits). The sap and the fruit contain toxins that can cause irritation in people who are sensitive to these compounds • Medicinal (diarrhea; lipid lowering effect). • The leaves and the bark were traditionally used in tanning (dyes of various colours, red, black and brown).
Rosa canina	• Fruit species attracting seed-dispersal fauna	• Edible: syrup, tea, marmalade, sweet wine. • Cosmetic. • Medicinal: the plant is high in certain antioxidants; the fruit is noted for its high level of vitamin C; it is also used against diarrhea, kidney stones, intestinal worms, and scurvy.
Rosa glutinosa	• Fruit species attracting seed-dispersal fauna	• Edible. • Cosmetic.
Salix alba	• Freshwater ecosystems.	• Wind breaks • Wood
Salvia fruticosa	• Drought-resistant shrub	• High economic potential (herbal for tea and culinary uses; essences)
Sorbus flabellifolia	• Re-sprouting shrub after fire and cutting. • Fruit shrub attracting seed-dispersal fauna.	• Ornamental and gardening.
Sorbus torminalis	• Re-sprouting shrub after fire and cutting. • Fruit shrub attracting seed-dispersal fauna.	• Ornamental and gardening. • Fruits are edible (over-ripe and bletted ones) and taste similar to dates, although they are now rarely collected for food. Before the introduction of hops, the fruit were used to flavor the beer. • Medicinal: traditionally known as a herbal remedy for colic (the tree's Latin name torminalis means "good for colic").
Spartium junceum	• Nitrogen-fixing species. • Fodder for wild fauna.	• Fodder for livestock • Ornamental and gardening value.
Styrax officinalis	• Fruit shrub attracting seed-dispersal fauna. • Shrub well-adapted to grow on instable stony soils in steep slopes.	• Ornamental plant. • Fragrant resin that can be tapped from this tree and used as incense or for medicinal uses.
Thymbra spicata	• Drought-resistant shrub	• High economic potential (herbal for tea and culinary uses; essences)
Thymus syriacus	• Drought-resistant shrub	• High economic potential (herbal for tea and culinary uses; essences)
Ulmus minor	• Freshwater ecosystems.	• Edible fruits. • Ornamental and gardening.

ANNEX 4: Nursery Production Protocols for the Target Species

Maple tree species

Acer syriacum Boiss. & Gaill.
(Synonym of ***Acer obtusifolium Sm***.[132])

Family: Sapindaceae

قيقب سوري

Distribution map[134]

General information: *Acer obtusifolium* is an evergreen small maple tree to a height of about up to 5 m. It has leathery foliage varying from un-lobed to tri-lobed. The leaves are normally gray-green.
It mainly occurs in the Supra-Mediterranean bioclimate, as a companion species in the oak (*Quercus calliprinos, Q. infectoria), pine (Pinus pinea, P. brutia*) and mixed oak/pine forests.

Acer tauricolum Boiss. & Balansa
(Synonym of ***Acer hyrcanum sbsp. tauricolum (Boiss. & Balansa) Yalt***[133] .

Family: Sapindaceae

قيقب طوروس

Distribution map[135]

General information: *Acer hyrcanum* is a deciduous tree up to 15 meters tall. Leaves are up to 4 cm (1.6 inches) across, usually 5-lobed but occasionally with only 3 lobes, dark green on top, lighter green underneath because of a layer of wax. It mainly occurs in the Mountain-Mediterranean bio-climate, as a companion tree species in the Cedar forests, and oak (*Quercus brantii, Q. calliprinos, Q. infectoria*) forests.

Collection period: October-November when the fruits become brown and before they fly away from the trees.
Cleaning operations: Dry the fruits on paper. Do not remove the wings.
Storing measures: Dried fruits (with the wings) can be stored for some years in the fridge at 1-3 °C, in plastic bags or glass bottles.
Seed Pre-treatment to activate germination: Cold stratification in humid peat (one part of seeds per one part of peat), with some fungicide, for about 2 months (January and February), in the fridge at 2-4 °C. Seeds germinate at low temperature, so it will be important to check periodically and remove them from cold stratification when about 10% of the seeds have just germinated (don't remove before).

Seed sowing in the nursery: Sowing after pre-treatment in March, in seed trays (inside the greenhouse) or directly in forest trays with alveoli of 300-350 cc for outside putting 2 seeds (make sure seeds are not empty) in each alveolus. In both cases use peat substrate and sow the seeds at a depth of 0,5 cm. In the case of sowing in seed trays, when the seedlings appear and they are large enough to be handled, transplant them into forest trays (300-350 cc) using peat substrate, and making sure that the roots do not break. Place the forest trays outside.
Growing in the nursery: The seedlings can grow outside the greenhouse during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Seedling hardening: Remove the shade (if present) from over the plants in September, at least 1 month before transplanting them to the field to ensure a good hardening.

Oriental strawberry tree

Arbutus andrachne L.

Family: Ericaceae

قطلب الشرق

Distribution map[136]

Green: Countries where the species is naturally distributed; **Yellow:** in large cultivation.

General information: *Arbutus andrachne* is a shrub or small tree that can reach a height of about 12 metres. The smooth ferruginous-colour bark exfoliates during the summer, leaving a layer with a pistachio light-green colour, which changes gradually to a beautiful orange brown. The flowers bloom in spring and are white or yellowish green. Its fruits ripen in autumn, and when left to dry in a cool place are eaten as sweet chewy candy.
It mainly occurs in the Supra-Mediterranean bioclimate, as a companion species with the oak (*Quercus calliprinos, Q. infectoria), pine (Pinus pinea, P. brutia*) and mixed oak/pine forests.

[132]: Accepted name according to theplantlist.org
[133]:Ibid.
[134]:Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).
[135]:Ibid.
[136]:Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Collection period: November to December when the fruits become red in colour and they are soft.
Cleaning operations: They are fleshy fruits with numerous small seeds inside mixed with the pulp. To separate the fleshy pulp from the seeds, fruits should be macerated in water for 2-3 days. Then extract the seeds crushing the fruits in sieves (with holes smaller than the seeds) under a jet of water. Extracted seeds always remain mixed with some pulp. In any case, this mixture can be stored after drying, or can be directly sowed.
Storing measures: Dry the seeds up to about 6-8% of humidity before storing. Store them in a dry and fresh room, or in the fridge at 2-4 °C, using plastic bags or glass bottles. Store them for no more than 3 months.
Seed pre-treatment: Cold stratification in humid peat (one part of seeds per one part of peat), with some fungicide, for 1 to 1,5 months in the fridge at 2-4 °C, before sowing the seeds in March. Before making the stratification, sieve the peat to facilitate the extraction of seeds at the end of the treatment. Check periodically and remove them from the cold stratification when about 10% of the seeds have germinated (do not remove before).
Seed sowing in the nursery: Sowing after pre-treatment takes place in February before temperature increases in late winter/early spring (seeds need less than 20°C to germinate). Use seed trays, with fine peat substrate. Place the seeds very superficially at about 1-2 mm depth. Protect the seed trays on the production tables under plastic or inside the greenhouse. Make sure seed trays are watered enough by spraying until germination begins. If the surface of the seedbed dries, seeds can fall into a secondary dormancy and germinate later (during the following autumn). Prevent fungi attacks by applying fungicides after sowing and later on every 10-15 days. When seedlings appear and they are large enough to be handled, transplant them into "small forest trays with alveoli", or in the final forest trays (250-300 cc), with peat substrate, and keep them inside the greenhouse. After 1 month, more or less, seedlings can be placed in the outside.
Seedling growing in the nursery: During summer protect the seedlings with a shade mesh.
Planting in the field: October to February. Remove the shade from over the plants in September, at least 1 month before transplanting. The young seedlings are very sensitive to frost.

Lebanese cedar

Cedrus libani A.Rich

Family: Pinaceae

ارز لبنان

Distribution map[137]

Green: Countries where the species is naturally distributed

General information: *Cedrus libani* is an evergreen coniferous tree that can reach 40 m in height with a massive columnar trunk up to 2.5 m in diameter. The trunks of old trees ordinarily fork into several large, erect branches. The crown is conical when young, becoming broadly tabular with age with fairly level branches. The leaves, 5 to 35 mm, are needle-like arranged in spirals and concentrated at the proximal end of the long shoots, and in clusters of 15–35 on the short shoots. *Cedrus libani* produces cones at around the age of 40.
C. libani var. brevifolia grows in the Troodos mountains in Cyprus, and characterized by its shorter grayish needles and its higher tolerance to drought and aphids.
Cedrus libani grows in the Mountain-Mediterranean bioclimatic zone, in the west-facing slopes of the SBR, exposed to the wet winds from the sea, in well-drained calcareous soils.

Collecting period: November-December, when cones become brown colour.
Cleaning operations: Put the cones under the sun or in a warm room to dry them and facilitate the extraction of seeds. Soaking the cones in warm water (about 40°C) for 2 days before drying can facilitate its opening. After drying extract the seeds by rubbing the cones on a sieve.
Storing measures: Dry the seeds to about 10-12% of humidity before storing. Store them in a dry and fresh room, or in the fridge at 2-4 °C, using plastic bags or glass bottles.
Seed pre-treatment: Cold stratification in the fridge at 2-4 °C for 1 to 1,5 months, in humid peat (one part of seeds per one part of peat) with some fungicide, before seed sowing in March. Seeds germinate at low temperature, so it will be important to check periodically and remove them from the cold stratification when about 10% of the seeds have just germinated (do not remove before).
Seed sowing in the nursery: sowing after pre-treatment takes place in March, directly in forest trays with alveoli (200-250 cm3 for 1 year-seedlings, and 300-350 cm3 for 2 year-seedlings) with peat, placing 2 seeds per alveolus at 0.5 cm deep. Greenhouse is not needed so that forest trays should be located outside. If both sowed seeds germinate, one of the seedlings should be removed from the alveolus, taking care not to break the root, and transplanted in another one.
Growing in the nursery: Seedlings will grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Hardening before transferring to the field: If shade is used during summer remove it in September at least 1 month before transplanting to ensure a good hardening.
Planting in the field: During the first autumn-winter season (October to February) after germination if the final size of seedling is at least 10 cm heigth.

[137]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Mediterranean hackberry

Celtis australis L.

Family: Ulmaceae

ميس

Distribution map[138]

Green: Countries where the species is naturally distributed; **Orange:** naturalized in the wild; **Yellow:** large-scale cultivation.

General information: *Celtis australis* is supposed to have been the Lotus of the ancients, whose fruits Theophrastus, Herodotus, Discorides describe as sweet, pleasant, and wholesome.
Celtis can grow to 25 m in height. The bark is smooth and grey, almost elephantine. The alternate leaves are narrow and sharp-toothed, rugose above and tomentose below, 5–15 cm long and dark grey/green throughout the year, fading to a pale yellow before falling in autumn. The fruit is a small, dark-purple berry-like drupe, 1 cm wide, hanging in short clusters, and are extremely popular with birds and other wildlife.
This tree usually grows isolated and/or in small groups in wooded mountain slopes or nearby river beds taking advantage of fresh and humid conditions. It is often planted as an ornamental as it is resistant to air pollution and long-living.
Collection period: October-December.
Cleaning operations: Remove the fleshy seed-coat macerating the fruits in water for 1-2 days. After that, mix with a liquidizer (very slowly) and sieve under a jet of water.
Storing measures: Dried seeds (fruits without pulp) can be stored for some years in the fridge at 2-4 °C in plastic bags or glass bottles.
Seed pre-treatment: Cold stratification in the fridge at 2-4 °C in humid peat (one part of seeds per one part of peat), for 3 months, before seed sowing in March. Fungicide is not needed.
Seed sowing in the nursery: Sowing after pre-treatment in March in seed trays with peat at 1 cm deep. Put the trays inside the greenhouse. When seedlings appear and are large enough to be handled transplant them into forest trays with alveoli (300-350 cm3) using peat and taking care that roots do not break. Place the forest trays in the outside.
Growing in the nursery: Seedlings will grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Hardening before transferring to the field: If shade is used in summer, remove it from over the plants in September, at least 1 month before transplanting to ensure good hardening.
Planting in the field: From October to February.

[138]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Azarole

Crataegus azarolus L.

Family: Rosaceae

زعرور اصفر

Distribution map[139]

Dark green: Countries where the species is naturally distributed; **Orange:** Countries where the species is naturalized in the wild and/or cultivated; **Light green:** Doubtfully native.

General information: The azerole small tree reaches 3 to 5 meters height. It has tomentose and thorny branches in the wild, although without thorns in the cultivated trees. Leaves are bright green and grayish on the underside, deeply divided into three or five dentate lobes with short and pubescent petioles. The flowers are white, arranged in corymbs from 3 to 18 florets. The blooming season is in April and May. The fruit is globose of about 2 cm, red or yellow when ripe, and contains a fleshy edible pulp with a bitter-sweet flavour. Maturation occurs in September.
Collecting period: October-November when the fruits become soft and yellow or red in colour. They have 2-3-4 hard seeds inside. Fruits are bigger than those from *Crataegus monogyna* species, the latter with only one seed inside.
Cleaning operations: The fleshy pulp should be removed immediately after the collection of the fruits because it contains chemical inhibitors that obstruct the germination. Macerate the fruits in water for 1-2 days after collection. Then mix with a liquidizer and extract the seeds by sieving under a jet of water. Remove the floating pulp and floating empty seeds. Finally, dry the seeds that will be stored, or sow them after pre-treatment.
Storing measures: Dried seeds (6-8 % of humidity) in plastic bags or glass bottles in the fridge (2-4 °C).
Seed Pre-treatment: Put the fruits in a plastic bag with humid peat (one part of peat per one part of seeds) in a warm place at 20-25 °C (warm stratification) for 1-2 months and then place the bag into the fridge at 2-4°C (cold stratification) for 3-4 months, until at least 10% of the seeds have germinated (never before, as it could promote dormancy again). Fungicide is not necessary.
Seed sowing in the nursery: Sowing in spring inside the greenhouse after pre-treatment in seed trays with peat at 0,5 cm depth. When seedlings appear and are large enough to be handled, transplant them immediately into forest trays with alveoli (250-300 cm3) using peat substrate and taking care that roots do not break.
Growing in the nursery: seedlings can grow during summer in the outside, without any protection. If the sun is too harsh protect them with a shade mesh.
Hardening before transferring to the field: If shade is used in summer remove it from over the plants in September, at least 1 month before transplanting them to ensure a good hardening.
Planting in the field: From October to February.

[139]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Common hawthorn

Crataegus monogyna Jacq.

Family: Rosaceae

زعرور احمر

Distribution map[140]

General information: The common hawthorn is small tree of 5–14 metres tall, with a dense crown. The younger stems bear sharp thorns. The leaves are 20 to 40mm long, obovate and deeply lobed, sometimes almost to the midrib, with the lobes spreading at a wide angle. The upper surface is dark green above and paler underneath. The flowers are produced in late spring (May to early June) in corymbs of 5-25 together, with five white petals, numerous red stamens, and a single style; they are moderately fragrant. Fruits of about 10mm long are small, fleshy, oval dark red, containing a single seed. Fruits are important for wildlife in winter, including seed dispersal birds who disperse the seeds in their droppings.
Collecting period: September-October when the fruits become soft and red in colour. They have just one hard seed inside.
Cleaning operations: The fruits have a fleshy pulp that has to be removed immediately after being collected because it contains chemical inhibitors that obstruct the germination. Macerate the fruits in water for 1-2 days after collection. Then mix with a liquidizer and extract the seeds by sieving under a jet of water. Remove the floating pulp and empty seeds. Finally dry the seeds that will be stored or sow them after pre-treatment.
Storing measures: Dried seeds (6-8 % of humidity) in plastic bags or glass bottles, in the fridge (2-4 °C).
Seed pre-treatment: Put the fruits in a plastic bag with humid peat (one part of peat per one part of seeds). Fungicide is not necessary. Follow the sequence bellow:

- Two weeks in a warm place at 20-25 °C (warm stratification).
- Six weeks into the fridge at 2-4°C (cold stratification).
- Two weeks in a warm place at 20-25 °C (warm stratification).
- Two weeks into the fridge at 2-4°C (cold stratification).
- Two weeks in a warm place at 20-25 °C (warm stratification).
- About ten weeks into the fridge at 2-4°C (cold stratification), until at least 10% of the seeds have germinated (never before, as it could promote dormancy again).

Seed germination in the nursery: Sow the seeds inside the greenhouse in spring, after pre-treatment, in seed trays with peat at 0,5 cm depth. When the seedlings appear and they are large enough to be handled transplant them immediately into forest trays with alveoli (250-300 cc) using peat substrate, and making sure that the roots do not break.
Seedling growing in the nursery: Seedlings can grow outside during summer without any protection. If the sun is too harsh protect them with a shade mesh.
Hardening before transferring to the field: If shade is used in summer remove it from over the plants in September at least 1 month before transplanting them to ensure a good hardening.
Planting in the field: From October to February.

[140]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Syrian ash tree

Fraxinus syriaca Boiss.
(Synonym of ***Fraxinus angustifolia subsp. syriaca (Boiss.) Yalt.)***

Family: Oleaceae

دردار، مرّان سوري

Distribution map[141]

General information: The Syrian ash tree is a medium-sized deciduous tree, growing 40-45 m in height and up to 1.5 m in diameter. The crown is dense, irregular and dome shaped, with short and pendulous shoots. Its bark is grey and becomes finely and deeply reticulate-fissured. The leaves are compound, arranged in groups of 7-13, odd pinnate, and are slender, 3-8 cm long and 1-1.5 cm broad, shiny green and hairless. Flowers are wind pollinated, developing in early spring or even in autumn, without petals, green with dark purple stigmas and anthers. The fruit is a samara 3-4 cm long, flattened, with a distal wing, ripening at the end of the summer. It grows well on moist soils, in temporary flooded lowlands, but also on well-drained slopes.
Collecting period: October-November when the fruits are brown and before they fly from the trees.
Cleaning operations: Put the fruits to dry on paper. Do not remove the wings.
Storing measures: Dried fruits with the wings can be stored for some years in the fridge at 2-4 °C in plastic bags or glass bottles.
Seed pre-treatment: Cold stratification in the fridge at 2-4 °C, in humid peat (one part of seeds per one part of peat), with some fungicide for 2-3 months before sowing. Check periodically and remove them from the stratification when about 10% of the seeds have just germinated.
Seed Sowing in the nursery: After pre-treatment seeds are sown in March, in seed trays or directly in forest trays with alveoli (300-350 cc; and 2-3 seeds per alveolus), with peat substrate at 0,5 cm depth. Put the trays inside the greenhouse. When the seedlings appear in the seed trays and they are large enough to be handled, transplant them into forest trays (300-350 cc) using peat substrate and taking care that the roots do not break. Place the forest trays outside. Because this species has a pivoting root forest trays with alveoli help avoid spiralling of the root and promote the growth of secondary roots.
Seedling growing in the nursery: seedlings can grow during spring and summer outside without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Hardening before transferring to the field: Remove the shade (if present) from over the plants in September at least 1 month before transplanting them to the field to ensure a good hardening.
Planting in the field: From October to February.

[141]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Syrian juniper

Juniperus drupacea Labill.

Family: Cupressaceae

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Distribution map[142]

General information: Alt is a 10–25 m tall tree, with a trunk up to 1–2 m thick. It has needle-like leaves in whorls of three, that are green, 5–25 mm long and 2–3 mm broad, with a double white stomatal band on the inner surface. It is usually dioecious with separate male and female plants. The seed cones are the largest of any juniper, berry-like but hard and dry, green ripening in about 25 months to dark purple-brown with a pale blue waxy coating; they are ovoid to spherical, 20–27 mm long and 20–25 mm diameter, and have six or nine fused scales in 2-3 whorls, each scale with a slightly raised apex.

This species occurs in Syria, Lebanon, Israel, Southern Turkey and two locations in Greece (Peloponnese). The most widespread subpopulation occurs in Turkey, in the Taurus Mountains through to Hatay and into Syria. It should be considered as threatened in Lebanon where it has a very fragmented distribution.

This tree grows in montane oak, pine and cedar forests. It grows on of shallow, rocky soils, usually on calcareous rocks. It has an altitude range of between 600-1,800 m and occurs in small groups or solitary mixed with other conifer species.

Limited use although its decay-resistant wood has made the larger trees valuable for timber. The cones, which have high levels of sugar have been used in Turkey for marmalade or as dried fruit.

Collecting period: November-December. The flowers are dioecious so some trees are only female (producing seeds) and the others only male. The fruits take 2 years to mature.

Cleaning operations: The fruits are fleshy but they have a very hard stone-like layer inside with 3 very protected seeds. The fruit needs a lot of time to break and to allow the embryo to germinate. Moreover, the seeds have internal dormancy. An interesting option to keep in mind is the possibility of harvesting the fruit “green”- when the embryo has fully formed but before the seed coat is hardened. The fleshy seed coat can be removed by macerating the fruits in water (with 1% of bleach to eliminate resins), for 1-2 days after collection. Then mix with a liquidizer and extract the seeds by sieving under a jet of water. Remove the floating pulp.

Storing measures: Dried fruits (6-8% of humidity) with or without the external seed coat can be stored in plastic bags or glass bottles in a dry and fresh room or in the fridge at 2-4 °C.

Seed pre-treatment: There is no available information about a good and quick germination pre-treatment for this species. Natural germination can take 2 or more years. The proposed, but not conclusive, method to speed up the germination process is the following (further researching is needed to improve the final results):

- After removing the fleshy seed coat soak the fruits into boiling water for 5-6 seconds and then remove from the heat and keep in the water for 48 hours. Then put the fruits in a plastic bag with humid peat (one part of peat per one part of seeds) and fungicide, into the fridge at 2-4 °C (cold stratification) for 3 months, then put the bag in a warm place at 20-25 °C (warm stratification) for 2 months and finally put it again in the fridge for 3 months (cold stratification). After this long pre-treatment (from the autumn when fruits are harvested till the following one), the fruits can be sown and could germinate in the next spring.

Seed sowing in the nursery: sowing in autumn after pre-treatment in a cold frame or in seed trays with peat, at 1-2 cm depth. The first seedlings could appear during the next spring. Remove weeds and avoid animal attacks when necessary. When the seedlings appear and they are large enough to be handled, transplant them immediately into forest trays with alveoli (200-250 cc) using peat substrate and making sure that the roots do not break.

Seedling growing in the nursery: The young plants can grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh. The young plants grow very slowly and can take more than one year to be large enough to be transplanted into the field.

Hardening before transferring to the field: Remove the shade from over the plants in September, at least 1 month before transplanting, to ensure a good hardening.

Planting in the field: From October to February.

Greek Juniper

Juniperus excelsa M.Bieb.

Family: Cupressaceae

لزّاب- قطران

[142]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Distribution map[143]

General information: This juniper tree is found in the cold and dry high mountain areas and high plateaus (Mountain-Mediterranean and Oro-Mediterranean bio-climatic zones) from the Eastern Mediterranean region. It occurs from north-eastern Greece and southern Bulgaria across Turkey to Syria and Lebanon, and the Caucasus mountains. *J. excelsa subsp. polycarpos*, known as the Persian juniper, occurs in the Alborz and other mountains of Iran to northwestern Pakistan. It often occurs together with mountain deciduous oaks, pines, and Juniperus foetidissima, being distinguished from it by its slenderer shoots 0.7-1.3 mm diameter (1.2–2 mm diameter in J. foetidissima), and grey-green, rather than mid green, leaves.
It is a large tree reaching 6–20 m tall. It has a trunk up to 2 m in diameter, and a broadly conical to rounded or irregular crown. It is dioecious with separate male and female plants, but some individual plants produce both sexes. The cones are berry-like, 6–11 mm in diameter, blue-black with a whitish waxy bloom, and contain 3-6 seeds.
Collecting period: November-December. The flowers are dioecious so some trees are only female (fruit-producing individuals) and the others only male. The fruits take 18 months to mature and become blue-black in colour. Every fruit have 3-6 seeds.
Cleaning operations: Remove the external fleshy seed coat macerating the fruits in water (with 1% of bleach to eliminate resins), for 1-2 days after being collected. Then mix with a liquidizer and extract the seeds by sieving them under a jet of water. Remove the floating pulp. Use the floating method to test seed vitality in concentrated 10% saltwater- the empty seeds and debris will float while only the filled seeds sink to the bottom of the container. Discard the floating material. Collect the sunken seeds and use these seeds for planting.
Storing measures: Dried fruits without the external seed-coat can be stored in a dry and fresh room or in the fridge at 1-3 °C, in plastic bags or glass bottles.
Seed pre-treatment: Put the fruits in a plastic bag with humid peat (one part of peat per one part of seeds) and fungicide into the fridge at 2-4°C (cold stratification) for 4-5 months before sowing (December to March). Another pre-treatment system used in the FLR work in the SBR is the following : Once the sunken seeds are collected soak them in oak ash water (10% ash) for three days. Remove from the ash and rinse thoroughly with water. Soak the seeds for 24 hours in citric acid solution (10%). Remove the seeds and rinse thoroughly with water. Cold stratify them for 5 months.
Seed sowing in the nursery: Sowing in spring, after pre-treatment in a cold frame or in seed trays with peat at 0,5 cm depth. Germination can take many months or even one year after sowing. The first seedlings will appear during the next autumn up to next spring. Remove weeds and avoid animal attacks when necessary. When the seedlings appear and they are large enough to be handled transplant them immediately into forest trays with alveoli (200-250 cm3) using peat substrate, and making sure that the roots do not break.
Seedling growing in the nursery: Seedlings can grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh. Seedlings grow very slowly and may need one year after germination to be large enough to be planted in the field.
Hardening before transferring to the field: Remove the shade from over the plants in September, at least 1 month before transplanting, to ensure a good hardening.
Planting in the field: From October to February

[143]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Prickly Juniper

Juniperus oxycedrus L.

Family: Cupressaceae

عرعر عادي

Distribution map[144]

General information: The species has a Pan-Mediterranean distribution, very widespread and locally common. As a whole it is assessed as Least Concern by the IUCN Red List of Threatened Species. It is a common shrub or small tree that grows over all kinds of rock from limestone to sandstone and metamorphic lithologies.
The ecology of the species shows certain differences between the populations from the western half and the eastern half of the Mediterranean region: while in the west it usually occurs at lower altitudes in drier and thermal zones (Meso-Mediterranean bio-climatic level), as a companion species in the holm oak and cork oak woodlands and the Aleppo pine and Maritime pine forests, in the east it has a broader distribution area, rising higher in altitude at the Supra-Med and Mountain-Med bio-climatic levels, where it occurs in scrubland, as well as in forests and woodlands dominated by Pinus brutia, P. pinea, Quercus calliprinos, Q. Infectoria, Cedrus libani, and *J. excelsa*.
Prickly Juniper is suitable for cultivation as an ornamental in southern Europe where a number of cultivars, especially with more pendulous foliage, are commonly planted in gardens and parks. Essential oils are extracted from the branches and leaves especially in France and Turkey. This 'oil of cade' is used for medicinal purposes .
Collecting period: November-December. The flowers are dioecious, so some trees are only female (producing seeds) and the others only male. The fruits take 2 years to mature and become reddish brown in colour with 2-3 seeds each.
Cleaning operations: Remove the external fleshy seed coat macerating the fruits in water (with 1% of bleach to eliminate resins), for 1-2 days after being collected. Then mix with a liquidizer and extract the seeds by sieving them under a jet of water. Remove the floating pulp.
Storing measures: Dried fruits (6-8% of humidity) without the external seed-coat can be stored, for several years, in a dry and fresh room or in the fridge at 2-4 °C, in plastic bags or glass bottles.
Seed pre-treatment: Put the fruits in a plastic bag with humid peat (one part of peat per one part of seeds) and fungicide in a warm place at 20-25 °C (warm stratification) for 2 months and then place the bag into the fridge at 2-4°C (cold stratification) for 3-4 months before sowing.
Seed sowing in the nursery: Sow the seeds in spring, after pre-treatment, in a cold frame or in seed trays with peat substrate at 0,5 cm depth. Germination can take many months or even one year, after sowing. The first seedlings will appear during the next autumn until next spring.

[144]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).
[145]:Info from iucnredlist.org

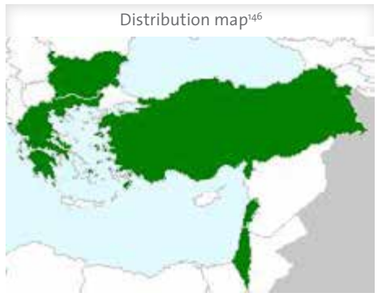
Remove weeds and avoid animal attacks when necessary. When the seedlings appear and they are large enough to be handled transplant them immediately into forest trays with alveoli (200-250 cm3) using peat substrate, and taking care that the roots do not break.
Seedling growing in the nursery: Seedlings can grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh. Seedlings grow very slowly and may need one year after germination to be large enough to be planted in the field.
Hardening before transferring to the field: Remove the shade from over the plants in September, at least 1 month before transplanting, to ensure a good hardening.
Planting in the field: From October to February.

Lebanese Wild Apple

Malus trilobata (Poir.) C. K. Schneid.

Family: Rosaceae

Distribution map[146]



General information: *Malus trilobata* is relatively widespread in the Eastern Mediterranean Basin. However, subpopulations are made of scarce trees, and are highly fragmented and isolated within their area of occupancy (AOO), which is relatively low (49 points recorded, mostly in Lebanon and Turkey). The AOO is thought to approach 2,550 km2. There is continuing decline in habitat is due to change of land use, cutting, grazing, fires, but mostly intrinsic factors such as the limited recruitment capacity of the species to conquer new habitats, or to recover after threats. The species is listed as Near Threatened, as the species is severely fragmented, and there is continuing decline in habitat quality and extent, also the AOO nearly approaches the threshold for Vulnerable (2,000 km2).
Collecting period: September-October.
Cleaning operations: Macerate the fruits in water for 1-2 days after being collected. Then mix with a liquidizer (very slowly because the seeds are soft and could break), and extract the seeds by sieving them under a jet of water. Remove the floating pulp and floating empty seeds. Finally, dry the seeds for storage or sow them after pre-treatment.
Storing measures: Dried seeds (8-10% of humidity) can be stored in the fridge at 2-4 °C, in plastic bags or glass bottles.
Seed pre-treatment: Cold stratification in humid peat (one part of seeds per one part of peat), with some fungicide, in the fridge at 2-4 °C, for 3 to 4 months, until at least 10% of the seeds have germinated (never before as it could promote dormancy again).

Seed sowing in the nursery: Sowing after pre-treatment in March, in seed trays, with peat substrate at 1 cm depth. Put the trays inside the greenhouse. When the seedlings appear in the seed trays and they are large enough to be handled transplant them into forest trays with alveoli (250-300 cm3), using peat substrate, and taking care the roots do not break. Place the forest trays in the outside.
Seedling growing in the nursery: Seedlings can grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Planting in the field: October to February. If shade mesh is used remove it from over the plants in September, at least 1 month before transplanting, to ensure a good hardening.

Turkish pine

Pinus brutia Tenore

Family: Pinaceae

صنوبر بري

Distribution map[147]

Dark green: Countries where the species is naturally distributed; **Orange:** Possibly naturalized.

General information: *Pinus brutia* is a medium-size tree, reaching 20–35 m tall and with a trunk diameter of up to 1 m, exceptionally 2 m. The bark is orange-red, thick and deeply fissured at the base of the trunk, and thin and flaky in the upper crown. The leaves (needles) are in pairs, slender, mostly 10–16 cm long, bright green to slightly yellowish green.
The cones are sessile, heavy and hard, 6–11 cm long and 4–5 cm broad at the base when closed, green at first, ripening glossy red-brown when 24 months old. It is closely related to *Pinus halepensis,* although it is easily differentiated by their cones (pedunculated in P. halepensis, sessile in *P. brutia*), their bark (gray in *P. halepensis,* orange-red in *P. brutia*), and their leaves (larger and more rigid in *P. brutia*)
Forests dominated by this species cover extensive areas mainly on the eastern part of the Mediterranean where the tree is an economically important conifer species. Its wood is used for several purposes, including in the carpentry industry and for pulp and paper production, as well as for firewood. The seeds of the tree are also used in pastry-making. From the 1930s - 1970s, the species was widely planted in coastal areas of the Mediterranean for soil protection and windbreaks.
Brutia pine grows on all substrates and in most bioclimates of the Mediterranean region. It is drought-tolerant with fire resistant cones allowing it to successfully colonize dry, abandoned and burnt areas.
Collecting period: September-November, when cones become brown.

[146-147]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Cleaning operations: Put the cones under the sun or in a warm room to dry them and facilitate their opening for the extraction of seeds. After drying, extract the seeds by rubbing the cones on a sieve.
Storing measures: Dry the seeds to about 6-8% of humidity before storing. Store in plastic bags or glass bottles in a dry and fresh room or in the fridge at 2-4 °C.
Seed pre-treatment: Cold stratification in the fridge at 2-4 °C, in humid peat (one part of seeds per one part of peat), with some fungicide, for 1 to 2 months, before sowing the seeds in March. Check periodically and remove the seeds from stratification when about 10% of the seeds have just germinated (do not remove before).
Seed sowing in the nursery: Sowing after pre-treatment takes place in March directly in 200-250 cm3 forest trays with alveoli with peat substrate at 0.5 cm depth (2 seeds per alveolus). Place the forest trays outside (greenhouse is not needed). If the two sowed seeds germinate, one of the seedlings should be removed and transplanted in another alveolus, taking care not to break the root.
Seedling growing in the nursery: Seedlings can grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Hardening before transferring to the field: If shade is used during summer remove it from over the plants in September at least 1 month before transplanting to ensure a good hardening.
Planting in the field: During the next autumn-winter (October to February) if the final size of the seedlings is high enough.

White Poplar

Populus bolleana Lauche
(Synonymous of ***Populus alba L.)***

Family: Salicaceae

حور ابيض

Distribution map[148]

General information: The white poplar is native to most countries in the Mediterranean region, Central and Eastern Europe, to Central Asia. It grows in moist sites, often as a riparian tree, in regions with hot summers and cold to mild winters.
It is a medium-sized deciduous tree, 16–27 m tall, with a trunk up to 2 m in diameter and a broad rounded crown. The bark is smooth and greenish-white to greyish-white with characteristic diamond-shaped dark marks on young trees, becoming blackish and fissured at the base of old trees. The leaves are 4–15 cm long, five-lobed, with a thick covering of white scurfy down on both sides but thicker underneath. Its green-and-white leaves makes it an interesting ornamental tree, but the abundant root suckers may cause problems in some situations.

[148]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Seeds: The seeds of this species are viable for a very short time and they can only be stored after drying into plastic/glass bottles in a freezer. Sowing the seeds and management of the seedlings are very difficult because of the small size. For these reasons production from cuttings is more common than production by seeds. Winter cuttings from 1-2 year old branches are very successful.
Cutting collecting period: At the end of winter (early February) when the buds are ready to open. Cut very straight branches 1-2year old. Prepare cuttings of 20-30 cm long and 0,6-0,12 cm wide making a cut just above the proposed top bud and another cut 15-20 cm below the top cut and below a bud. Poplar cuttings need a lot of water to produce roots, so soak them in water (e.g. in boxes inside a plastic pool) for 10-15 days before planting them in the soil.
Installing the cuttings in the ground: In February-March after being soaked in water. Dig the soil very well. Plant the cuttings vertically, leaving exposed about 2,5 cm and at least 2 buds. The cuttings will be installed in lines separated at least 0,5 m – 1 m. In each line the distance between cuttings can be about 15 cm. If the soil is very heavy or poor, the addition of some sand and/or compost will be useful. Root growth from the cuttings will need a very soft and rich soil. Water abundantly the cuttings after planting, and every time the soil becomes dry. Remove the weeds when necessary. The cuttings can also be placed in forest trays with alveoli (300-400 cm3) with peat substrate.
Seedling growing in the nursery: The cuttings will root during February-March and after that they will produce the first branches. The growth will continue during the summer until the autumn when the leaves fall. No protection will be needed. Watering periodically.
Planting in the field: During the following winter (November- February), after leaves fall, the rooted cuttings can be transplanted to the field. After removing from the nursery they have to be transferred to the field as soon as possible avoiding root desiccation. They can be stored some days before planting, if necessary, protecting the roots with soil or sand.

Almond tree

Prunus dulcis (Mill.) D.A.Webb

Family: Rosaceae

لوز

Distribution map[149]

General information: The almond is a species of tree native to the Middle East, from Turkey to India and Pakistan, although it has been introduced elsewhere. It was spread by humans in ancient times along the shores of the Mediterranean into northern Africa and southern Europe, and more recently transported as a cultivated fruit tree to other parts of the world, notably California, United States. It grows under Mediterranean climate with warm, dry summers and mild, wet winters. The tree buds have a chilling requirement of 300 to 600 hours below 7.2 °C to break dormancy. Cultivated trees reach full bearing five to six years after planting. The fruit matures in the autumn, 7–8 months after flowering.

The almond is a deciduous tree, growing 4–10 m in height, with a trunk of up to 30 cm in diameter. The leaves are 8–13 cm long with a serrated margin. The flowers are white to pale pink, 3–5 cm diameter with five petals, produced singly or in pairs and appearing before the leaves in early spring.
Seed collecting period: September-October when the external fleshy seed coat becomes dry and open.
Cleaning operations: Remove the external fleshy seed coat by hand or using a "cement mixer" to separate from the internal stone. Do not dry the seeds below 10-12% of humidity.
Storing measures: Seeds can be stored for no more than 3-4 months before sowing into non hermetic sacks, in a fresh place, at a temperature less than 15°C, and avoiding the humidity of the seeds to be less than 10-12%.
Seed pre-treatment: Cold stratification in the fridge at 2-4 °C, in humid peat (one part of seeds per one part of peat), for 2 months before sowing operations. Fungicide is not necessary.
Seed sowing in the nursery: Sowing after pre-treatment in March, directly in forest trays with Alveoli (250-300 cm3), with peat substrate, at 2 cm depth (one seed per alveolus). Trays can be placed outside (greenhouse is not needed).
Seedling growing in the nursery: The young plants can grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Planting in the field: From October to February.

Bear plum

Prunus ursina Ky

Family: Rosaceae

برقروق، خوخ الدب

Distribution map[150]

General information: This is a native species from the Supra-Mediterranean and Mountain-Mediterranean forests (oak, pine, fir and cedar forests) of the Eastern Mediterranean, from Italy to Jordan.
Prunus ursina is a deciduous shrub to a small tree, reaching 4 to 8 meters in height; it is highly branched and the branches sometimes bear thorns. The twigs are velvety and the leaves are ovate to oblong. It produces white hermaphrodite flowers in pairs during the spring. Its 2-to-3 cm fruit is globose and turns yellow to dark orange when ripe; it has no food interest and may be toxic if consumed excessively.

[149-150]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Collecting period: September-October when the fruits become yellow-orange in colour. They have a hard stone inside.
Cleaning operations: The fruits have a fleshy pulp that has to be removed immediately after being harvested because it contains chemical inhibitors that obstruct the germination. Macerate the fruits in water for 1-2 days after collection. Then mix with a liquidizer and extract the seeds sieving them under a jet of water. Remove the floating pulp and floating empty seeds. Finally, dry the seeds.
Storing measures: Dried seeds (10-12 % of humidity) in the fridge (2-4 °C), in plastic bags or glass bottles.
Seed pre-treatment: Put the fruits in a plastic bag with humid peat (one part of peat per one part of seeds) in a warm place at 20-25 °C (warm stratification) for 1 month and then place the bag into the fridge at 2-4°C (cold stratification) for 3-4 months, until at least 10% of the seeds have germinated (never before as it could promote dormancy again). Fungicide is not necessary.
Seed sowing in the nursery: Sowing in spring, after pre-treatment inside the greenhouse in seed trays with peat substrate, at 1 cm depth. When the seedlings appear and they are large enough to be handled, transplant them immediately into forest trays with alveoli (250-300 cm3) using peat substrate, and taking care that the roots do not break.
Seeding growing in the nursery: The young plants can grow during summer without any protection. If the sun is too harsh protect them with a shade mesh.
Planting in the field: October to February. If shade mesh is used remove it from over the plants in September at least 1 month before transplanting to ensure a good hardening.

Syrian pear

Pyrus syriaca Boiss.

Family: Rosaceae

نجاص بري

Distribution map[151]

General information: This is a native species from the Supra-Mediterranean and Mountain-Mediterranean forests (oak, pine, fir and cedar forests) of the Middle East from Turkey to Jordan. In the months of March and April the tree blossoms with white flowers. The fruit ripen in the autumn in the months of September and October. The fruit is edible although not very tasty mostly because of hard stone like objects found in the skin. The ripe fruit falls to the ground and when it starts to rot the smell attracts wild boars. The boars eat the fruit and distribute the seeds.
Collecting period: September-October.
Cleaning operations: Macerate the fruits in water for 1-2 days after being collected. Then mix with a liquidizer (very slowly because the seeds are soft and could break), and extract the seeds by sieving them under a jet of water. Remove the floating pulp and floating empty seeds. Finally, dry the seeds for storage or sow them after pre-treatment.

[151]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Storing measures: Dried seeds (8-10% of humidity) can be stored in the fridge at 2-4 °C, in plastic bags or glass bottles.
Seed pre-treatment: Cold stratification in humid peat (one part of seeds per one part of peat), with some fungicide, in the fridge at 2-4 °C, for 3 to 4 months, until at least 10% of the seeds have germinated (never before as it could promote dormancy again).
Seed sowing in the nursery: Sowing after pre-treatment in March, in seed trays, with peat substrate at 1 cm depth. Put the trays inside the greenhouse. When the seedlings appear in the seed trays and they are large enough to be handled transplant them into forest trays with alveoli (250-300 cm3), using peat substrate, and taking care the roots do not break. Place the forest trays in the outside.
Seedling growing in the nursery: Seedlings can grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Planting in the field: October to February. If shade mesh is used remove it from over the plants in September, at least 1 month before transplanting, to ensure a good hardening.

OAKS

Quercus calliprinos Webb
(Syn. of ***Quercus coccifera L.)***

Quercus infectoria G. Olivier

Quercus brantii ssp. look (Ky) Mouterde
(Syn. of ***Quercus ithaburensis Decne. subsp. Ithaburensis)***

Family: Fagaceae

سنديان

Distribution map[152]

General information: evergreen oak widely distributed all around the Mediterranean region. There are ecological differences between the originally considered Q. coccifera (western half of the Mediterranean region) has a marked thermal and xerophilic character, while *Q. Calliprinos* (eastern half of the region) has a wider distribution area, rising in altitude where it is exposed to colder and wetter climate conditions, even heavy snowfalls in winter.

ملّول، عفص

Distribution map[153]

General information: This deciduous oak species is distributed in the Eastern Mediterranean region, from Greece to Jordan. It usually occurs in the Meso-Mediterranean and Supra-Mediterranean bio-climatic levels, in all types of substrates, as a dominant canopy species or co-dominant species together with *Quercus calliprinos, Pinus pinea and P. brutia*.

بلوط طابور

Distribution map[154]

General information: This deciduous oak species is distributed in the Eastern Mediterranean region, from Turkey to Jordan. It mainly occurs in the high mountain areas (Mountain-Mediterranean bio-climate zone) as a dominant canopy species or as a lower tree layer in the cedar forests. In the Shouf region it usually grows as a shrub or small tree.

Collecting period: October-December. Gather the acorns when they turn brown. It is better collecting them from the branches rather than from the soil. If collected from the soil, make sure you select good quality acorns without attacks from insects or fungi.
Cleaning operations: No cleaning is needed.
Storing measures: Fleshy fruits that cannot be totally dried as it will kill the embryo. They can be stored with a humidity over 40% and for no more than 1-3 months, keeping them in boxes into humid peat, in a fridge at 0-3 °C. With higher temperatures they germinate.
Seed pre-treatment: Separate low quality acorns by flotation in water (unsuitable acorns will float). In the case of low humidity (seed-coat very separated from embryo), keep the seeds in water for up to 12 hours prior to sowing as a way to ensure rehydration (never below 35%).
Seed sowing in the nursery: Sowing in November-December after the harvesting of acorns (or in February-March with stored seeds). Do not use very small seeds: "the bigger the seed, the higher nutrient reserves and capacity to survive after sowing". To prevent root spiralling and to promote a good root growth, sow the acorns in forest trays with alveoli of 250-350 cm3 volume and more than 15 cm long, with vertical ribs in the inside walls. Place the forest trays separated from the ground to stop the growth of the main root and secondary roots once they reach the bottom of the alveoli. Use peat as the main substrate component. Put one acorn in each alveolus, at 1-2 cm depth, in horizontal position. Water the alveoli plentifully and place them in the outside, in a structure that separates them from the ground. Greenhouse is not needed and could prevent a good hardening of the seedlings. During winter, sowed acorns can be protected (until germination) with a mesh cover to avoid frost damage and mice attacks. Until spring roots will be developed and later on the first stems will spring out of the alveolus.
Seedling growing in the nursery: Seedlings can grow during spring and summer without any protection.
Planting in the field: During the next autumn-winter (October to February).

[152]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).
[153]:Ibid.
[154]:Ibid.

Sumach

Rhus coriaria L.

Family: Anacardiaceae

السماق

Distribution map[155]

Dark green: Countries where the species is naturally distributed; **Orange:** Status unknown.

General information: Sumach is a deciduous shrub or small tree that widely distributed in the Eastern and Northern Mediterranean countries. In North Africa it is only native of Algeria. However, in some countries the species was very much planted in the past for the production of dyes. In the Shouf Biosphere Reserve it grows as a companion shrub and small tree in oak and pine woodlands and scrubland in the Supra-Mediterranean bio-climate zone.
Collecting period: September-October.
Cleaning operations: Remove the seed-coat macerating the fruits in water for 1-2 days. Then mix with a liquidizer (very slowly) and sieve under a jet of water. Remove the floating pulp and floating empty seeds. Finally, dry the seeds for storage or sowing after pre-treatment.
Storing measures: Dried seeds (6-8% of humidity) can be stored in the fridge at 2-4 °C in plastic bags or glass bottles.
Seed pre-treatment: After removing the fleshy seed-coat, soak the fruits in boiling water for 5 minutes and then remove from the heat and keep them in the water for 48 hours (these seeds have an endocarp that is very hard and impermeable to water). Then put the fruits in a plastic bag with humid peat (one part of fine sieved peat per one part of seeds) into the fridge at 2-4 °C (cold stratification) for 2 months. Fungicide is not necessary. After pre-treatment only few seeds germinate. Further research is needed.
Seed sowing in the nursery: Sowing after pre-treatment in March in seed trays with peat substrate at 0,5 cm depth. Put the trays inside the greenhouse. When the seedlings appear in the seed trays and are large enough to be handled, transplant them into forest trays with alveoli (200-250 cm3) using peat substrate, and taking care that the roots do not break. Place the forest trays in the outside.
Seedling growing in the nursery: Seedlings can grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Planting in the field: October to February. If shade mesh is used remove it from over the plants in September at least 1 month before transplanting to ensure a good hardening.

[155]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Dog rose

Rosa canina L.

Family: Rosaceae

نسرين

Distribution map[156]

General information: Dog rose is widely distributed in Europe the Middle East countries and in the western part of North Africa. It is a deciduous shrub about 1–5 m tall, though sometimes it can scramble higher into the crowns of taller trees. Its stems are covered with small, sharp, hooked prickles, which aid it in climbing. The leaves are pinnate, with 5–7 leaflets. The flowers, 4-6 cm in diameter with five petals, are usually pale pink, but can vary between a deep pink and white.
The species grows in the border of forests and woodlands, scrubland, and it rapidly colonizes abandoned agriculture and pasture land. It is a companion species of all types of forests (oak, pine, and cedar forests in the Shouf BR). It has been planted or encouraged in the wild for the production of vitamin C from its fruit (often as rose-hip syrup), especially during conditions of scarcity or during wartime. It is also used in forest restoration for stabilizing unstable soils, and in gardening. Numerous cultivars have been named, though few are common in cultivation. The cultivar *Rosa canina* 'Assisiensis' is the only dog rose without prickles.
Collecting period: October-November when the fruits become soft and red in colour. They have many seeds inside provided with a very hard seed-coat.
Cleaning operations: The fruits have a fleshy pulp that has to be removed immediately after harvesting because it contains chemical inhibitors that obstruct the germination. Macerate the fruits in water for 1-2 days. Then mix with a liquidizer, and extract the seeds by sieving them under a jet of water. Remove the floating pulp and floating empty seeds. Finally dry the seeds for storage or sow them directly after pre-treatment.
Storing measures: Dried seeds (6-8% of humidity) in plastic bags or glass bottles in the fridge (2-4 °C).
Seed pre-treatment: Put the fruits in a plastic bag with humid peat (one part of peat per one part of seeds) in a warm place at 20-25 °C (warm stratification) for 2 months and then place the bag into the fridge at 2-4°C (cold stratification) for 3-4 months until at least 10% of the seeds have germinated (never before, as it could promote dormancy again). Fungicide is not necessary.
Seed sowing in the nursery: Sowing in spring inside the greenhouse, after pre-treatment, in seed trays with peat substrate at 0,5 cm depth. When the seedlings appear and they are large enough to be handled transplant them immediately into forest trays with alveoli (200-250 cm3) using peat substrate, and taking care that the roots do not break.
Seedling growing in the nursery: The young plants can grow during summer without any protection. If the sun is too harsh protect them with a shade mesh.
Planting in the field: October to February. If shade is used remove it from over the plants in September at least 1 month before transplanting, to ensure a good hardening.

[156]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

White willow

Salix alba L.

Family: Salicaceae

صفصاف ابيض

Distribution map[157]

General information: White willow is widely distributed in freshwater ecosystems of Europe and the Mediterranean region. It is a medium-sized to large deciduous tree growing up to 10–30 m tall, with a trunk up to 1 m diameter and an irregular, often-leaning crown. The bark is grey-brown and deeply fissured in older trees. The leaves are paler than most other willows due to a covering of very fine silky white hairs, in particular on the underside; When mature in midsummer, the female catkins comprise numerous small (4 mm) capsules each containing numerous minute seeds embedded in white down which aids wind dispersal.
Seeds: The seeds of this species are viable for a very short time and they cannot be stored. Seed sowing is very difficult due to its small size. For this reason production by cuttings is more common. Winter cuttings from 1-2 year old branches are very successful.
Cutting collecting period: December-January when the buds in the branches are still dormant. Cut very straight branches, 1-2 years old. Prepare cuttings of 15-20 cm long and 0,6-0,12 cm wide, making a cut just above the proposed top bud and another cut 15-20 cm below the top cut, and below a bud.
Storing measures: If the weather is too cold, the prepared cuttings can be stored before planting, for 1-3 weeks, in plastic boxes, top down. Water them just a bit for maintaining them humid enough. Put the boxes in a dark, fresh and humid storing place. If some roots appear transplant the cutting to the soil immediately.
Installing the cuttings in the ground: In January dig the soil very well. Plant the cuttings vertically, leaving exposed about 2,5 cm with at least 2 buds. The cuttings will be planted in lines separated at least 0,5m - 1m. In each line the distance between cuttings can be about 15 cm. If the soil is very heavy or poor the addition of some sand and/or compost will be useful. Root growth from the cuttings will need a very soft and rich soil. Water abundantly the planted cuttings and every time the soil becomes dry. Remove the weeds when necessary. The cuttings can also be placed in forest trays with alveoli (300-400 cm3) with peat substrate.
Seedling growing in the nursery: The cuttings will root during February-March, and after that they will produce the first branches. Growth will continue during the summer until the autumn when the leaves fall. No protection will be needed. Water the plants periodically.
Planting in the field: During the following winter (November- February), after leaves fall, the rooted cuttings can be transplanted to the field. After removing them from the nursery they have to be transferred to the field as soon as possible to avoid root desiccation. They can be stored some days before planting, if necessary, by protecting the roots with soil or sand.

[157]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Fan-leaved service tree (Sorbus flabellifolia) and checker tree (Sorbus torminalis)

Sorbus flabellifolia (Spach) C.K.Schneider.
(Syn. of ***Sorbus umbellata (Desf.) R. M. Fritsch)***

Family: Rosaceae

غبيراء مروحية الورق

Distribution map[158]

General information: *Sorbus umbellata* is a small tree found across a large range of southeastern Europe and the Middle East. It is a medium-size tree 5-15 m tall, generally found in the mountain slopes of the Mountain-Mediterranean bio-climatic zone, in open cedar and oak woodlands, forest edges, or as small copses in concave micro-relief with wetter soil conditions. The fruits are eaten by many birds and a few mammals making the tree ecologically important.

Sorbus torminalis (L.) Crantz

Family: Rosaceae

غبيراء المغص

Distribution map[159]

General information: *Sorbus torminalis* is widely distributed in Europe, the Middle East and the western part of North Africa. It is a medium-sized deciduous tree 15–25 m tall, with a trunk up to 1.3 m in diameter. The fruits are eaten by many birds and a few mammals, making the tree ecologically important.

Collecting period : September-October.
Cleaning operations: The fruits have a fleshy pulp that has to be removed immediately after harvesting because it contains chemical inhibitors that obstruct the germination. Macerate the fruits in water for 1-2 days after collecting. Then mix with a liquidizer (very slowly because the seeds are soft and could break) and extract the seeds by sieving them under a jet of water. Remove the floating pulp and floating empty seeds. Finally dry the seeds for storage or sow them directly after pre-treatment.
Storing measures: Dried seeds (8-10% of humidity) can be stored in the fridge at 2-4 °C, into plastic bags or glass bottles.

[158]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).
[159]: Ibid.

Seed pre-treatment: Cold stratification in the fridge at 2-4 °C in humid peat (one part of seeds per one part of peat), with some fungicide for about 3 months in the case of Sorbus flabellifolia, and 3-4 months in the case of Sorbus torminalis, until at least 10% of the seeds have germinated (never before as it could promote dormancy again).
Seed sowing in the nursery: Sowing after pre-treatment in March, in seed trays, with peat substrate at 0,5 cm depth. Put the trays inside the greenhouse. When the seedlings appear and they are large enough to be handled, transplant them into forest trays with alveoli (250-300 cm3) using peat substrate and taking care that the roots do not break. Place the forest trays outside.
Seedling growing in the nursery: Seedlings can grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Planting in the field: October to February. If shade mesh is used remove it from over the plants in September, at least 1 month before transplanting, to ensure a good hardening.

Storax

Styrax officinalis L.

Family: Styracaceae

حوز

Distribution map[160]

Dark green: Countries where the species is naturally distributed; **Orange:** Status unknown.

General information: *Styrax officinalis* is distributed in the Eastern Mediterranean region from Italy to Jordan. It is a deciduous shrub reaching a height of 2–5 m. It has very thin elliptical leaves 5–10 cm long and 3.5–5.5 cm wide, alternate and widely spaced on thin, reddish stems, with a tight, dark bark on basal stems. It has white flowers. This deciduous shrub species prefers open areas in dry rocky slopes or slope sections with accumulation of loose stones in the Supra-Mediterranean and Mountain-Mediterranean bio-climatic zones. It also occurs as a companion species in scrubland and open cedar, pine and oak forests.
Genuine Styrax resin, probably from *Styrax officinalis*, was imported in quantity from the Near East by Phoenician merchants, and Herodotus in the 5th century BC indicated that different kinds of "storax" were traded (included the Styrax resin, and the resin from the Turkish sweetgum, Liquidambar orientalis).
Collecting period: November-December, when the fruits become brown.
Cleaning operations: The fruits have a fleshy pulp that has to be removed. Macerate the fruits in water for 1-2 days after harvesting. Then mix with a liquidizer (very slowly because the seeds are soft and could break) and extract the seeds by sieving them under a jet of water. Remove the floating pulp and floating empty seeds. Finally dry the seeds for storage or sow them directly after pre-treatment.

[160]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Storing measures: Dried seeds can be stored in the fridge at 2-4 °C into plastic bags or glass bottles.
Seed pre-treatment: Cold stratification in the fridge at 2-4 °C in humid peat (one part of seeds per one part of peat), with some fungicide, for 2 to 4 months. After pre-treatment only few seeds germinate. Further research is needed.
Seed sowing in the nursery: Sowing after pre-treatment in March, in seed trays, with peat substrate, at 0,5 cm depth. Put the trays inside the greenhouse. When the seedlings appear in the seed trays and they are large enough to be handled, transplant them into forest trays with alveoli (250-300 cm3) using peat substrate, and taking care that the roots do not break. Place the forest trays in the outside.
Seedling growing in the nursery: Seedlings can grow during spring and summer without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Planting in the field: October to February. If shade mesh is used remove it from over the plants in September, at least 1 month before transplanting, to ensure a good hardening.

Field elm

Ulmus minor Mill.

Family: Ulmaceae

دردار

Distribution map[161]

Dark green: Countries where the species is naturally distributed; **Orange:** Status unknown.

General information: *Ulmus minor* is freshwater tree species widely distributed in Southern Europe and the Middle East. It also occurs in the Maghreb countries although it seems to be absent as a native species in Morocco. The tree can reach 30 m tall. Young branchlets occasionally have corky wings. The leaves are smaller than those of the other European elm species, hence the specific epithet minor, however they can vary greatly according to the maturity of the tree. Leaves on juvenile growth (suckers, seedlings etc.) are coarse and pubescent, whereas those on mature growth are generally smooth, though remaining highly variable in form. A common characteristic is the presence of minute black glands along the leaf veins. The fruits (samara) are typically ovate and notched, the notch extending to the central seed. The species readily produces suckers from roots and stumps.
Collecting period: March-April when the fruits are brown and before they fly from the trees.
Cleaning operations: It is not necessary.
Storing measures: The seeds of this species are viable for a very short time (1-2 months) so they cannot be stored and have to be sown immediately after collection.

[161]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Seed pre-treatment: No pre-treatment is needed.
Seed sowing in the nursery: Sowing just after collection in March-April, in seed trays (inside the greenhouse) or directly in forest trays with alveoli (300-350 cm3) outside, putting 2-3 seeds (make sure that seeds are not empty) in each alveolus. In both ways use peat substrate and sow at a depth of 0,5 cm. When the seedlings appear in the seed trays and they are large enough to be handled, transplant them into forest trays (300-350 cm3) using peat substrate and taking care that the roots do not break. Place the forest trays outside.
Seedling growing in the nursery: Seedlings can grow during spring and summer outside without any protection. If the sun is too harsh in summer protect them with a shade mesh.
Planting in the field: October to February.

Jujube

Ziziphus jujuba Mill.

Family: Rhamnaceae

عناب

Distribution map[162]

Dark green: Countries where the species is naturally distributed; **Orange:** Status unknown; Lime yellow: Naturalized; **Yellow:** Largely planted.

General information: *Ziziphus jujuba* precise natural distribution is uncertain due to extensive cultivation. It seems to be native to the Caucasus countries of Georgia and Armenia. It also occurs in most Mediterranean countries, like Lebanon, being planted and/or naturalized in the wild. It is well adapted to arid conditions and poor soils. It is a small deciduous shrub or small tree 5-12 m tall, usually with thorny branches, the branches have a characteristic zigzag shape. The leaves are shiny-green, ovate-acute, 2–7 cm long and 1–3 cm wide, with three conspicuous veins at the base, and a finely toothed margin. The flowers are small, with five inconspicuous yellowish-green petals. The fruit is an edible oval, maturing brown to purplish-black, looking like a small date.
Collecting period: October-November when the fruits become brown in colour. They have a hard stone inside.
Cleaning operations: The fruits have a fleshy pulp that has to be removed after harvesting. Macerate the fruits in water for 1-2 days after being collected. Then mix with a liquidizer and extract the seeds by sieving them under a jet of water. Remove the floating pulp and floating empty seeds. Finally, dry the seeds for storage or sow them directly after pre-treatment.
Storing measures: Dried seeds (8-10 % of humidity) in plastic bags or glass bottles in the fridge (2-4 °C).

[162]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).

Seed pre-treatment: Put the fruits in a plastic bag with humid peat (one part of peat per one part of seeds) into the fridge at 2-4°C (cold stratification) for 2-4 months. It is advisable to scarify the seeds before stratification by soaking them in Sulphuric Acid (96-98%) for 2 hours. Fungicide is not necessary.
Seed sowing in the nursery: Sowing in spring after pre-treatment, inside the greenhouse, in seed trays with peat substrate, at 1 cm depth. When the seedlings appear and they are large enough to be handled transplant them immediately into forest trays with alveoli (250-300 cm3) using peat substrate, and taking care that the roots do not break.
Seedling growing in the nursery: Seedlings can grow during summer without any protection. If the sun is too harsh protect them with a shade mesh.
Planting in the field: October to February. If shade mesh is used remove it from over the plants in September, at least 1 month before transplanting, to ensure a good hardening.

Fan-leaved service tree (*Sorbus flabellifolia*) and checker tree (*Sorbus torminalis*)

Lavandula officinalis Chaix (Synonym of ***Lavandula angustifolia Mill. ssp. angustifolia)***

Origanum syriacum L.

Salvia fruticosa Mill.

Thymbra spicata L.

Family: Lamiaceae

لاوند

Distribution map[163]

زعتر

Distribution map[164]

قصعين لبنان

Distribution map[165]

زعتر دق

Distribution map[166]

General information: Aromatic shrubs from the Lamiaceae family are very common in the scrublands of the Meso-Mediterranean and Supra-Mediterranean bio-climatic zones throughout the Mediterranean region. They are part of the degradation stages of oak and pine woodlands, colonizing rocky areas, abandoned agriculture and pasture land, and degraded forestland. They are well adapted to drought conditions and poor soils.
Lamiaceae family shrubs from many different genera (e.g. *Lavandula, Mentha, Nepeta, Origanum, Rosmarinus, Salvia, Teucrium, Thymus, Thymbra*) are important ornamental, medicinal, and aromatic plants, many of which produce essential oils that are used in traditional and modern medicine, in the food, cosmetics and pharmaceutical industry. Except for Lavandula angustifolia, which was introduced in Lebanon, the other three mentioned species are native to the country.
Collecting Period: June to September depending on the species. Take the fruits when they are mature and before they open and seeds fall.

Cleaning operations: Dry the fruits on paper. They will open and the seeds drop out. Crushing on a suitable sieve to separate the seeds. Extract the seeds from the other parts of the fruit by sieving.
Storing measures: Dried seeds can be stored for some years. Store in the fridge at 2-4 °C in plastic bags or glass bottles.
Seed pre-treatment: No pre-treatment is needed. However, in the case of Lavandula officinalis the germination rate improve significantly by soaking the seeds in Giberelic Acid (500 mg/liter) for 24 hours before sowing.
Seed sowing in the nursery: Sowing in March in seed trays with peat substrate and scattering the seeds very superficially (less than 1 mm depth in Thymbra and Origanum; 1 mm depth in Lavandula; 2 mm depth in Salvia). The seeds can be covered by using a fine sieve to spread the peat over. Before sowing them it is very important that the peat of the seedbed is plentifully watered. Place the trays inside the greenhouse. After sowing, every time the seedbed needs water, just spray it to prevent the seeds from moving. Water periodically until germination starts, preventing the surface of the seedbed from drying out. Protect the seedbeds against fungi attacks applying some fungicide just after sowing and later on every 10-15 days. When the seedlings appear and they are large enough to be handled transplant them into "small alveolus trays", with peat substrate and keep them inside the greenhouse. After 1 month more or less, the root system will fill the small-alveolus and seedlings will be transplanted into forest trays with alveoli (200-250 cm3) and can be located in the outside.
Seed sowing can be also done directly in the forest trays inside the greenhouse, putting 5-10 seeds in each alveolus. Besides, the seedlings could be directly transplanted from the seedbeds to the final forest trays avoiding the use of "small-alveolus trays".
Seedling growing in the nursery: Seedlings can grow during the summer without any protection.
Planting in the field: October to February.

[163]: Botanical Museum, Helsinki, Finland 2018. Data from BGBM, Berlin-Dahlem, Germany (in: The Euro+Med Plantbase, http://ww2.bgbm.org/EuroPlusMed/results.asp).
[164]:Ibid.
[165]:Ibid.
[166]:Ibid.

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