DOCTOR OF PHILOSOPHY

Exploring payments for ecosystem services in the context of native tree planting in Lebanon

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Award date:
2015

Awarding institution:
Bangor University

Exploring Payments for Ecosystem Services in the Context of Native Tree Planting in Lebanon

A thesis submitted for the degree of Doctor of Philosophy

to Bangor University

PRIFYSGOL BANGOR UNIVERSITY

by

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March 2015

Acknowledgements

First and foremost, I would like to dedicate this thesis to my family and to thank them for being patient and having faith in me; to my mother Odette for helping me believe in myself and shoot for the stars; my father V. Narbi for inspiring me to work hard and conserve resources; my sister Nyrie for reminding me to breathe, sit up straight and eat more salads; and to my Oma for her unconditional love.

This thesis would not have been possible without financial contributions from Sheikh Khaldoun, and I am honoured to be the first recipient of the Khaldoun Barakat Research Fund. I am also indebted to my dear friend Basma Barakat for additional financial, technical and emotional support, and to another to my 'brother-from-another-mother' Jackson Allers for encouraging and enabling me to seek an early career path in Lebanon.

I am intellectually indebted to my mentors who moulded me as a researcher. I owe a sincere thanks to Salma Talhouk for guiding me into the path of research after investing in so many years of my career at AUB-NCC (a.k.a. Ibsar); to Amin Kamete for his contributions on the complexities of governance; to Rob Brook for his sagely wisdom and impeccable support in reviewing my sloppy drafts and encouragement in so many aspects of thesis; and finally my main supervisor Neal Hockley for his guidance and teachings in helping me build my own intellectual zeal and refining those sloppy drafts into comprehensive chapters of this thesis – Thank you.

I would like to acknowledge and thank the talented individual who contributed to my research and thesis; first and foremost to my field assistants Edward Antoun, Marie-Ange Saady, and Hussam Hawwa for their magnificent efforts in the field, as well as dealing with my anxiety and stress at various times. I owe a special thanks to Jean Stephan, Aaed Ghanem, Charbel Tawk, Anthony Tarabay, Fadi Dinno, and Nada Farah for assisting me in various aspects of my research in Lebanon. Equally, I owe a major thank you to all those who took time out of their busy schedules to participate in my research.

I owe a big thanks my colleagues and peers at AUB – Marianne Yazbek and Mohammed el-Zein for their taxonomic and ecological expertise as well as helping me contact participants for the stakeholder survey; Ali Chalak and for his environmental economics expertise and suggestions on research design. I also owe a special thanks to my former colleagues who were always more like family at the AUB-NCC – Khaled Slim for his expertise on native forest trees, their production and ecology; Dima Ousta for her help with Arabic translations and reviewing of surveys and consent forms; Wassim Kays and Lama Talk for assisting me in various aspects of fieldwork; and finally to Najat Saliba for always inquiring about my progress and reassuring me in my work. Last but not least, I would like to thank all my friends at Bangor for all your kindness and support especially through the last stretch of stress-filled insanity!

Executive Summary

From local governance regimes to policies and markets, diverse institutions are crucial for ensuring effective natural resource management. Payments for Ecosystems Services (PES) are being adopted globally as a potential strategy for protecting and increasing forests by paying for environmental goods and services not captured in the market. Large-scale reforestation efforts have also increased globally, but are mostly aimed at increasing forest cover rather than ensuring resilient ecosystems. Many have argued that such incentivised reforestation schemes could lead to plantations of limited species diversity. Enhancing tree species diversity simultaneously with other forest ecosystem services (e.g. carbon sequestration) in reforestation therefore remains a challenge. Since many land managers are reluctant to voluntarily plant trees of little market or use value, PES may offer a strategy for enhancing tree diversity if stakeholders' perceptions were understood. I therefore explored *how PES should be designed to deliver biodiversity-enhancing reforestation*. Empirical research was carried out in mountainous villages within Lebanon's newly designated Important Plant Areas (IPAs). Semi-structured interviews were conducted with local authorities and key informants in 48 villages within nine IPAs exposing numerous socio-institutional and biophysical constraints to reforestation on municipal lands. I then set out to gauge landowners' perceptions of PES schemes with varying levels of conditionality. In this mixed-methods study, I found that private landowners are very diverse in their preferences and attitudes towards PES schemes expressed through their discussions about risks and reward. I later surveyed national stakeholders' preferences for native species to be used in reforestation. Similarly, these stakeholders (and potential PES buyers) also exhibit preference heterogeneity when prioritising native species for reforestation. Finally, I estimate a production possibility frontier from a choice experiment conducted with landowners in the Bcharre-Ehden IPA. My results indicated that real trade-offs do exist between the extent of forest cover and diversity of species used in reforestation. However, while limited in scope, it is possible for reforesting private lands with diverse native forest species cost-effectively through identifying and targeting willing suppliers (i.e. landowners). Increasing participation requires further research to investigate whether absentee residents, with landholdings not tied to commercial farming, would be willing to accept low-cost payments for biodiversity-enhancing reforestation. My thesis provides insights from empirical studies that will contribute to both research and policy in designing PES for achieving multiple objectives cost-effectively.

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1 Introduction

1.1 The Dynamics of Land-Use and Land-Cover

There are approximately 3.8 billion hectares of forests worldwide, accounting for roughly 30% of total terrestrial land-cover (FAO 2011). While forests have provided humans with a wide range of goods and services, they continue to decline globally (Hansen et al. 2010). The net loss of global forests was estimated at 66.5 million hectares from 1990-2005, the majority of which took place in the tropics (Lindquist et al. 2012). Given that global forests are natural habitats to nearly two-thirds of Earth's terrestrial biodiversity (MEA 2005a), these losses can have significant impacts on plant and animal species. Biodiversity loss is also expected to accelerate as a result of both deforestation and climate change, potentially impacting poorer and marginalised communities around the world (Butchart et al. 2010; Pereira et al. 2010)

Over 40% of the Earth's ice-free land surface has been converted to agriculture, urban development and other land-uses to meet human needs (Barnosky et al. 2012). Croplands (1.53 billion hectares) and pastures (3.38 billion hectares) account for around 38% of those landscapes, and are increasing (Foley et al. 2011). Large-scale conversion of primary forests – predominantly for agricultural purposes – has led to forest loss and degradation in the tropics, contributing directly or indirectly to biodiversity loss and climate change (Thompson et al. 2009). Agricultural expansion, driven by global demands of food production as the main competing land-use, is therefore expected to lead to more deforestation in the future, particularly in less developed countries in the tropical south (Goudie 2007). There is, however, a different trend taking place in many countries in the northern hemisphere. Recent studies have found that there have been marginal gains in forest area from natural expansion and tree planting in temperate and boreal zones (Achard et al. 2002; Gibbs et al. 2010).

Forest transitions, or the declines or expansions of forest cover changes, are driven by social, economic and political factors (Lambin and Meyfroidt 2011). For example, labour scarcities resulting from off-farm jobs and scarcities in forest products have led to 'new forests' in some countries, largely as a result of natural regeneration after land abandonment, but also active restoration in some cases (Rudel et al. 2005). Economic development in the tropics, however, does not necessarily reduce deforestation. For example, despite economic growth in Indonesia, its forests have declined considerably due to illegal logging and fires, followed by their opportunistic conversion to agriculture (Abood et al. 2015). Institutional factors influencing land-use and land cover change are therefore important for examining the complexities involved in forest restoration and related natural resource management practices.

1.1.1 Definition of Forests and Woodlands

Understanding of the varying definitions of forests is essential for examining forest-related land-use/land-cover change (Watson 2000). Unfortunately, there is no universally accepted classification system for forest land cover. The FAO, for example, defines a ‘forest’ as any land with trees over 5 meters tall with at least 10% canopy cover, or capable of reaching that threshold *in situ* (FAO 2010). In the Marrakesh Accords (2001) of the UN Framework Convention on Climate Change, ‘forests’ were defined as an area greater than 0.5-1.0 hectare having trees with a minimum crown cover of 10-30% and define trees as woody plants capable of growing more than 2-5 meters tall (UNFCCC 2002, cited from Sasaki and Putz 2009). These definition can be problematic since planted trees capable of reaching those thresholds can be defined as forests, whereas native vegetation having some trees or recovery (e.g. after fire) may not. Other definitions exist within specific countries (but may change over time), and I discuss Lebanese forest statistics and definitions below.

Differences also exist in forestry-related activities pertaining to land-use. Rudel et al. (2005), for instance, define ‘deforestation’ as the clearing of forests by people with no natural regrowth of trees; ‘reforestation’ as the spontaneous regeneration of previously forested land, and ‘afforestation’ as the planting of trees on land that was not previously forested (plantations are an example of the latter). Evans (1992), on the other hand, emphasises that most plantations are ‘man-made forests’ and “distinct from rainforest or savannahs because their orderliness and uniformity show they are artificial” (3). This is further elaborated to differentiate between afforestation, reforestation, and natural regeneration (ibid: 8):

1. Afforestation: bare land that has not had trees in the last 50 years, e.g. grasslands, sand-dunes, arid/semi-arid rangelands.
2. Reforestation (a): land that was previously forested in the last 50 years, but which had been cleared and replanted with a single species (sometimes introduced), e.g. most timber or pulp-producing plantations.
3. Reforestation (b): land that was previously forested in the last 50 years, but renewed (replanted) with the same crop (or native species) as before, e.g. timber plantations, but much less common than previous.

4. Natural regeneration (a): human-assisted forests established through deliberate silvicultural interventions and manipulations, e.g. ‘enrichment planting’.
5. Natural regeneration (b): forests (re)established without any human interventions.

Although quite precise, these definitions may not be well suited to the specific Lebanese context (in particular the 50 year cut-off may be very arbitrary in a region with such a long history of land use change). The reforestation considered in the empirical chapters of this thesis falls into several of the categories above, including afforestation, reforestation and human assisted natural regeneration, since it may take place on land which has been treeless for fewer or more than 50 years, and may use single or multiple species (though these have usually been native). In this thesis I use reforestation as an umbrella term for these processes, taking care to be specific about the species planted and the land use and cover which is replaced.

Emphasis on mixed cropping and forestry systems with productive trees (i.e. agroforestry) had made some important social, economic and environmental contributions globally (Tougiani et al. 2009; Hall et al. 2011a; George et al. 2012). Some have also shown that sustainable intensification of agro-ecosystems with commercial trees, e.g. coffee plantations, contributes to reducing greenhouse gas emissions in the tropics (Noponen et al. 2013). The majority of forest plantations, however, often consist of introduced/exotic species of improved varieties for higher yield in either fibre, fruit or other tree parts. Plantations also tend to replace natural forests in many tropical countries, largely for the purpose of timber and other forests products, but increasingly for storing carbon. Recently, some have argued against plantations attaining the same definition and status as natural forests, particularly in light of emerging ‘carbon markets’ (e.g. Sasaki et al. 2011). Most plantations are unlikely to maintain similar levels of biodiversity to more diverse forests if they consist of monocultures, exotic species, or both (see Figure 1.1). They may also do more harm than good to biodiversity if there is the additional element of agrichemical inputs, e.g. pesticides (Kanowski et al. 2005).

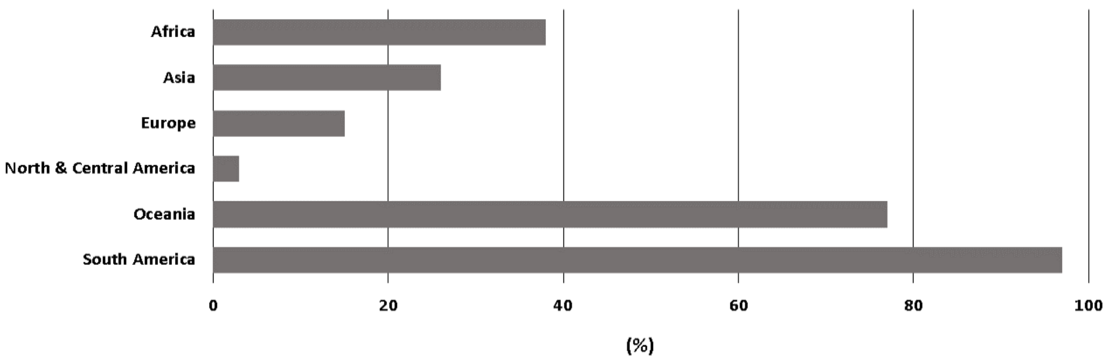

Figure 1.1. Percentage of introduced species in planted forests (Source: FAO 2010, p. 5).

In general, homogenous forest plantations managed for producing agricultural commodities (including timber) provide fewer ecosystem services and have less biodiversity than more diverse forests, whether planted or natural (Carnus et al. 2006; Brockerhoff et al. 2008). Some have hypothesised that monoculture plantations can also facilitate successive species to emerge within the understory but dependent on particular outputs desired and types of land-cover/land-use, such as rehabilitation of degraded lands or timber production (Lugo 1997; Sayer et al. 2004). Bremer & Farley (2010) conducted a review of papers on re/afforestation and found a considerable variability of biodiversity in plantations, but argue that natural systems should not be converted and that indigenous species should be used in place of exotics. While re/afforestation practices are not always detrimental to biodiversity (Hartley 2002), habitat loss often is. Certain institutional measures, such as appropriate species selection on deforested or degraded lands, and knowledge of local ecology and soil conditions, should therefore be considered (Lamb 1998; Chazdon 2008; Bullock et al. 2011; Hall et al. 2011b).

1.1.2 Characteristics of Forest Ecosystems (Biomes)

Biophysical and ecological aspects of forests are defined under broad categories or ‘biomes’ and subcategories of each, including tropical moist forests, temperate broadleaved forests, Mediterranean forests, etc. Olsen et al. (2001) mapped and categorised 14 terrestrial biomes containing 867 ‘ecoregions’ within 8 biogeographic realms (see Figure 1.2). Seven of those biomes include ‘forests’ and five contain savannahs (or grassy woodlands with sparse trees forming an open canopy) and/or shrubland[1]. While there is no single typology to describe land-cover types in the Mediterranean basin, the biome is characterised as forests bundled

[1] Landscapes dominated by woody, multi-branched plants of less than eight metres height.

together with woodlands and scrub[2]. There are also subcategories (or ecoregions), such as *maquis* and *garrigue* shrub- or scrublands (Blondel and Aronson 1999; Palahi et al. 2008).

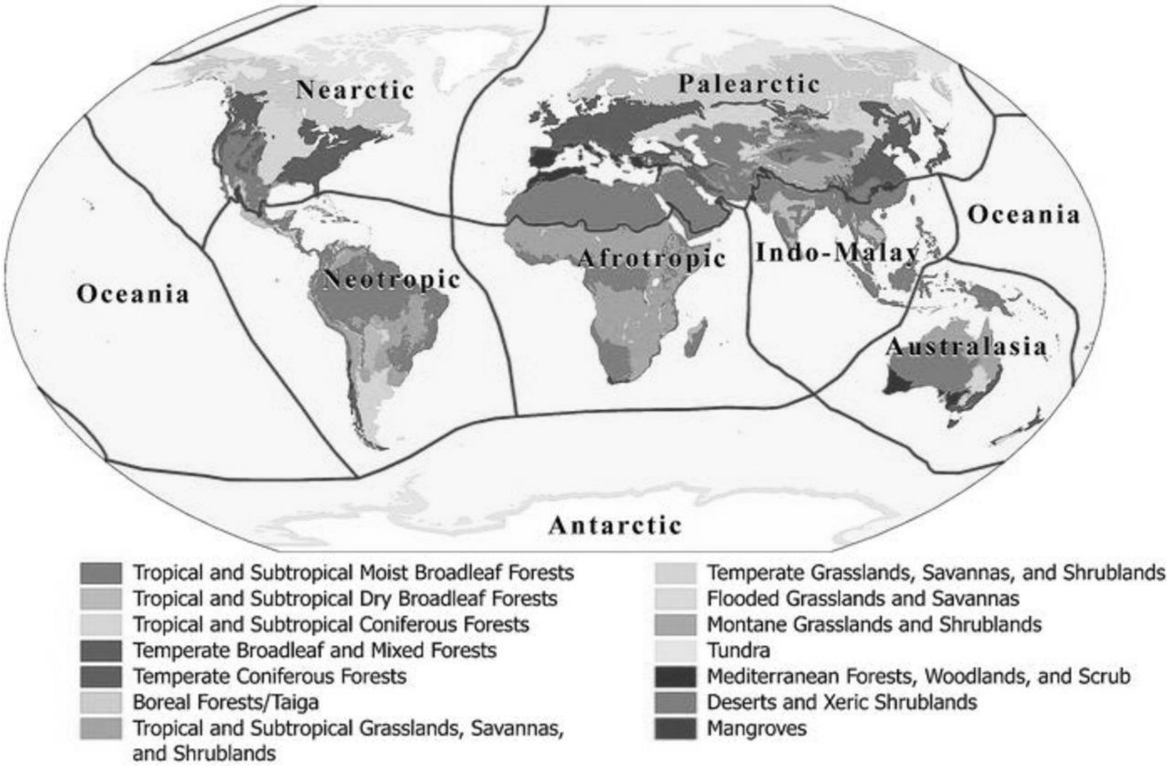

Figure 1.2. Global biomes (14) within eight biogeographic realms (Source: Olson et al. 2001).

The importance of understanding the characteristics and types of forests and biomes in the context of my research required its extensive presentation here. For the purpose of maintaining consistency and clarity, I use the FAO definition of forests (presented above in section 1.1.1) since it is also adopted in the context of Lebanon's forestry sector (Section 5.4 below). I refer to 'woodlands' based on FAO's proposed definition: land having trees capable of reaching a minimum height of 2 metres at maturity *in situ* and defined by ecoregion, with a canopy cover of more than 5 percent (as opposed to 10% that would define 'forests') on a minimum area of 0.5 hectares (FAO 2010)[3]. I also refer to FAO definitions of 'afforestation'

[2] Other Mediterranean-climate regions with similar forest, woodland and scrub features include the US (California), Chile, South Africa, and Australia (Cowling et al. 1996).

[3] 'Other wooded land' often used by FAO as land-use/land-cover class for open woodland and scrub communities.

and ‘reforestation’[4], which are based on the Marrakech Accords (2001) under the Kyoto Protocol (FAO 2006):

1. <u>Afforestation</u>: *“the direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources;”*
2. <u>Reforestation</u>: *“the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land.”*

1.1.3 Definition of Biodiversity

Biodiversity is the overall variety of life on Earth, or as defined by the United Nations Convention on Biological Diversity (UN-CBD): “the variability among living organisms from all sources, including, *inter alia*, terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems” (UNCBD 1992, cited in Heywood 1995).

Natural ecosystems are characterized as having (multi)functional attributes, where various biotic and abiotic processes contribute to complex ecological functions for maintaining the systems’ resilience (Hector and Bagchi 2007; Gamfeldt et al. 2008). Many authors point to the functional effects biodiversity has at various levels of ecosystem services to sustain productive and resilient ecosystems (Elmqvist et al. 2003; Folke et al. 2004; Balvanera et al. 2006; Gamfeldt et al. 2008). Without functional ecosystems, important services for ensuring the renewal and maintenance of natural resources, such as wood and non-wood forest products, steady flows of clean water, carbon sequestration, soil amelioration, and biodiversity, would diminish over time (de Groot et al. 2002). In a review of the projected consequences that biodiversity loss would have on ecosystems, Chapin et al. (2000:234-235) explain:

> *Species diversity has functional consequences because the number and kinds of species present determine the organismal traits that influence ecosystem processes. Species traits may mediate energy and material fluxes directly or may alter abiotic conditions (for example, limiting resources, disturbance and climate) that regulate process rates. The components of species diversity that determine this expression of traits include the number of species present (species richness), their relative abundances (species evenness), the particular species present (species composition), the interactions among*

[4] Since both types are likely to be used in different contexts, e.g. afforestation in rangelands and reforestation on abandoned cropland that was previously forest, I will often refer to them together i.e. re/afforestation.

species (non-additive effects), and the temporal and spatial variation in these properties. In addition to its effects on current functioning of ecosystems, species diversity influences the resilience and resistance of ecosystems to environmental change.

The composition, number and abundance of species are also influenced by environmental factors such as climate (e.g. precipitation, evapotranspiration) soil types and social factors such as land-use/land-cover dynamics. The reduction of biodiversity, therefore, reduces the ability of an ecosystem, ecoregion, or even biome, to deal with change (Cardinale et al. 2012).

1.1.4 Definition of Ecosystem Services

'Ecosystem services' (ES) have been defined as "the benefits that people obtain from nature" (MEA 2005b: v), although many definitions have been proposed (Boyd and Banzhaf 2007). For example, Daily (1997:3) defines ecosystem services as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life" (Daily 1997). The Millennium Ecosystem Assessment (MEA 2005b) provides a framework which classifies ecosystem services under four main categories:

- *Provisioning services*: e.g. food, water, timber and fibre
- *Regulating* services: e.g. climate, floods, diseases, wastes, and water quality
- *Cultural* services: e.g. recreational, aesthetic, and spiritual benefits
- *Supporting* services: e.g. soil formation, photosynthesis, and nutrient cycling

Although biodiversity is considered to be important in all four categories of ecosystem services described above, in many cases its importance stems from the role it plays in the complex and ambiguous *supporting services*. Chapin et al. (2009) describe supporting services as "the fundamental ecological processes that control the structure and functioning of ecosystems" (31). In addition, social systems, particularly institutions, also play a vital role in supporting ecosystem service delivery and maintenance (Figure 1.3).

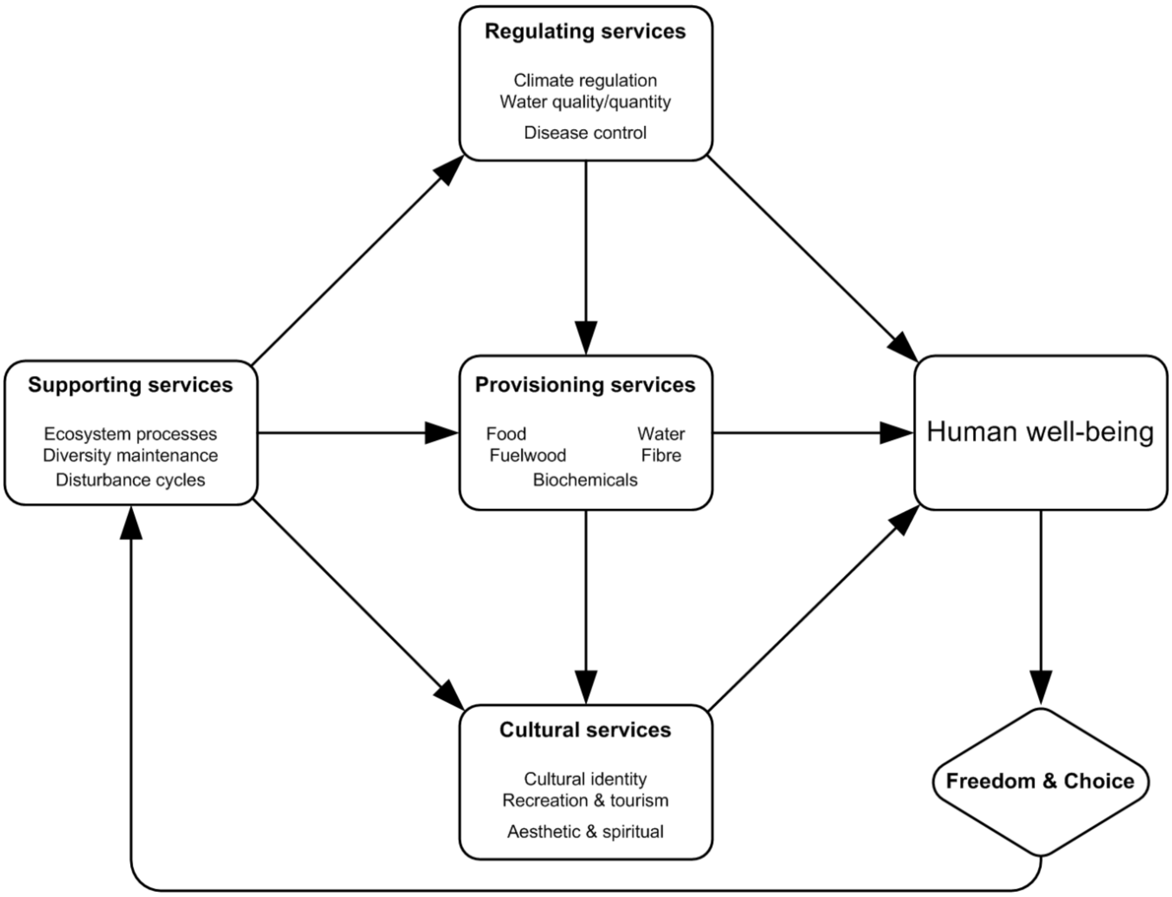

Figure 1.3. A conceptual framework for ecosystem services as proposed by Chapin et al. (2009).

Few would argue that biodiversity does not inherently have value, yet many agree that it is difficult to quantify its option, bequest and existence values (Pearce 2007). Whether or not biodiversity is an ecosystem service in itself is debated, though it has clear cultural values in many cases and is therefore plausibly viewed as a cultural service (MEA 2005a). Mace et al. (2012) suggest that there are generally two perspectives: the ‘ecosystem service perspective’ (biodiversity underpins ecosystem services) and the ‘conservation perspective’ (biodiversity is an ecosystem service) and argue that both are valid due to the complexity of both biodiversity and ecosystem services. But more importantly, they bring these issues into the contexts of valuation:

> *Equating biodiversity with ecosystem services implies that managing one will automatically enhance the other. Alternatively, regarding biodiversity itself as an ecosystem service reflects an intrinsic value for biodiversity, whereby organisms have value that is by definition unquantifiable and therefore non-transactable. In practice, most people intuitively assign very different values to different groups of organisms, so that when biodiversity itself is seen as a service, it is particular groups, often charismatic ones, whose conservation is sought. Nevertheless, biodiversity has existence value to many people who wish it to continue to be there, irrespective of any direct experiences or benefits they derive from it.* (20)

Given that ecosystem services is in part an economic concept (Bateman et al. 2011), the status of biodiversity as an ecosystem service can be evidenced by people's willingness to pay for more of it (Hockley et al. 2007). Furthermore, some studies have shown that more diverse ecosystems function more efficiently and provide more goods and services. For instance, Potvin et al. (2011) found evidence that species-rich forests stored on average nearly twice as much carbon as agroforests containing fewer species in the tropics. In a more locally relevant example, Vilà et al. (2007) found that species-rich Mediterranean deciduous forests were more productive (i.e. significant increase in wood production) than coniferous and sclerophyllous (hard-leaf, scrubby) forests. Overall, evidence appears to suggest that more specie-rich forests provide greater levels of ecosystem services, including carbon sequestration and provisioning services, e.g. wood production (Gamfeldt et al. 2013).

In Lebanon, and elsewhere, there is a clear desire to preserve and enhance biodiversity both for its own sake, and for the role biodiversity may play in supporting other ecosystem services. Throughout this thesis, I therefore consider biodiversity as an ecosystem service, and incentives for increasing biodiversity as a form of Payment for Ecosystem Service (discussed below).

1.1.5 Definition of Natural Capital

Natural resources (or natural capital stocks) are the materials and components found in nature, often characterised by the amounts of biodiversity as well as the diversity of abiotic (e.g. geological) matter found in a particular ecosystem (Common et al. 2003; Chapin et al. 2009). Ecosystems have been referred to as 'living natural capital' where flows of natural resources are derived (Turner and Daily 2008). Thus, ecosystems goods and services can be conceptualised as the stocks and flows of natural capital.

Non-renewable natural resources including minerals, e.g. gold, petroleum, etc., are fixed in quantity and potentially exhaustible. However, even renewable natural resources such as fish and forests, though capable of regenerating after being used, are potentially exhaustible if not managed sustainably (Turner et al. 1994). Some have called for cost-effective approaches to conserving natural capital through prioritising natural capital 'hotspots' (Crossman and Bryan 2009; Raymond et al. 2009; Kareiva et al. 2011). Examples include maintaining upland watersheds, wetlands and riparian ecosystems for ensuring water flow and quality, which also create habitats for biodiversity. Conserving natural capital for its benefits to society is not a new concept, but has been emphasised in public policy more recently largely because of the ecosystem services approach.

1.2 Causes of Forest Loss: Externalities and Institutions

1.2.1 Externalities and Public Goods

Economists view externalities as either a cost or benefit not captured in the market by the parties making a transaction or exchange, thus affecting a third party's welfare (Laffont 2008). Externalities exist when "the market price or cost of production excludes its social impact, cost, or benefit" (Hanley et al. 1997). The free market has failed the environment partially because there is a lack of incentives for internalizing externalities from environmental goods and services (Laffont 1988; Hanley and Barbier 2009). Hence environmental goods and services are undersupplied due to being outcompeted by private goods (e.g. food and timber) that are bought and sold in markets.

The theoretical basis of externalities is attributed to A.C. Pigou's contribution to classical welfare economics (Baumol 1972). Whereas Pigouvian taxes (or subsidies) can reduce market failures to a degree, Pigou himself noted that government inefficiencies often lead to political failures (Pigou 1929). In contrast, Coase (1937; 1960) argued that externalities are less prevalent in markets where property rights are well-defined and consumers and producers can easily come to mutually beneficial agreements. From this perspective, Coase reasoned that externalities are the result of transaction costs being too high due to weak or absent institutions for delineating property rights and securing ownership.

In the real world, however, some externalities are inevitable due to high transaction costs of obtaining and processing information efficiently, inability to solve collective action problems, and because property rights to some goods and services remain difficult to define (Pascual et al. 2010). Transaction costs can be viewed as the inevitable "friction" present when exchanging goods and services between at least two people in real world settings (Williamson 1985). Arrow defined them as simply the "costs of running the economic system" (1969: 48). These include the temporal and spatial factors, e.g. search, distance, and technological barriers, where at least one transacting party has to bear the residual costs (North 1990). Transaction costs occur because transacting parties have "incomplete information and limited capacity by which to process information", which leads to imposing informal constraints (a type of institution) in order to structure exchange within imperfect markets (North 1993:1).

Public goods[5] (goods that are non-excludable and non-rivalrous – i.e. can be consumed simultaneously by more than one person) give rise to positive externalities (Table 1.1).

Table 1.1. Simplified classification of goods; adopted from Pearce & Turner (1990).

Category	Rivalrous	Non-rivalrous
Excludable	Private	Club
Non-excludable	Open-access	Public

Real public goods often lie along a spectrum from 'pure' to 'impure' public goods (Ostrom et al. 1994). For example, some public goods may be partially rivalrous e.g. public beaches and parks at high season (Table 1.2).

Table 1.2. Spectrum of goods; adopted from Turner et al. (1994), p. 78.

Type	**Private Goods**		**Public Goods**	
Sub-type	Pure private goods	Quasi-private goods (impure)	Quasi-public goods (impure)	Pure public goods
Characteristic	Exclusive (excludable) & rival (divisible)	Non-exclusive & rival	Non-exclusive & partially rival	Non-exclusive & non-rival
Examples	Goods bought and sold in markets, e.g. commodities	Regular payment is required for good, e.g. co-op for groundwater	Congestible goods, e.g. Public beaches or parks in high season	Biodiversity, ozone layer, climate-change protection

1.2.2 Why Agriculture Increases at the Expense of Forests

The majority of ecosystems on Earth have been modified for the production of private goods bought and sold in markets such as crops, livestock, timber and so forth. This often happens at the expense of ecosystems that supply non-private goods, or positive externalities, which are not traded in markets (Foley et al. 2005). In natural resource management, social (or

5 There are also "public bads" that have external costs, such as pollution, which impacts social welfare negatively (Kolstad 2000).

allocative) inefficiencies occur when institutions fail to adequately incentivise the production of these non-private goods. Ecosystem services other than those for producing private goods (generally ‘provisioning services’) are often externalities because there are no market prices to signal the scarcity of the goods produced from those services, resulting in inefficient resource allocation (Daily and Matson 2008).

1.2.3 Externalities of Ecosystem Services and Biodiversity

The production of private goods may give rise to externalities in a variety of ways. The most common and recognizable form are negative externalities, e.g. pollution from a factory or fertiliser runoff from a farm, that escape the ‘private property boundaries’ and affect others (Kolstad 2000). On the other hand, positive externalities can be produced on private property as well. An example of this would be private land with an abundance of trees and wildlife that produce some public goods, such as landscape beauty or carbon storage. The owner of a given property with these characteristics, however, may rationally decide to do something more ‘productive’ with his or her land because there is no financial incentive[6] for maintaining it in its current state. Hence, excessive deforestation can be largely attributed to market failure since the benefits from forest ecosystems not captured in the market cannot compete with other ecosystems services, e.g. agriculture (Godden 2006; Zilberman et al. 2008). Land cover change driven by agricultural activities often results in losing other ecosystem services, e.g. nutrient and water cycling, pollination, climate regulation, etc. However, diversified agro-ecosystems can also provide a wide range of ecosystem services along with marketable commodities (e.g. Kremen et al. 2012).

1.2.4 Environmental Valuation in the Context of Policy and Governance

Environmental policies in natural resource management have frequently been analysed through an economic lens (Bowles 2008; Barbier 2011; Muradian and Gómez-Baggethun 2013). Examinations of how environmental policies are influenced by (or even influence) social norms and local perceptions have also been growing recently (Chen et al. 2009; St John et al. 2010; Kinzig et al. 2013; Entenmann and Schmitt 2013). However, quantifying (or estimating) social values placed on nature and ecosystem services (and the benefits therefrom) remains one of the biggest challenges for ensuring that efficient and equitable

[6] One could argue that there might be other motives for keeping the land in its current state, such as altruistic motives or perhaps for hunting or aesthetic reasons (Field and Field 2009).

resource governance is achieved (Turner et al. 2003; Bateman et al. 2011). There are also limitations to aggregating benefits and costs across individuals at temporal scales (Hockley 2008). However, analysis of the social costs and benefits (or social CBAs) applied in the context of social learning can help to identify collective values and social perceptions placed towards ecosystem services and biodiversity (Wilson and Howarth 2002; Spash 2008; Kumar 2010). Since values and perceptions are complex and may differ between individuals within the same community (Kenter et al. 2015), the need arises for organising public deliberations (or forums) to engage community members in a social learning environment of knowledge exchange, or a change in understanding, to be put into practice (Reed et al. 2010). Community engagement also enables for adaptive co-management and capacity-building efforts to be made possible, which includes shared responsibilities in designing projects and organising workshops, awareness campaigns, fundraising, and so forth (Berkes 2009). Engaging numerous stakeholders may result in inefficient decision-making (Irvin and Stansbury 2004), yet environmental management decisions often deal with benefits (or ecosystem services) that are public goods (difficult to charge for and prevent those from enjoying). Understanding the roles, responsibilities and viewpoints of multiple stakeholders are necessary for identifying synergies and complementarities in the objectives (e.g. kinds of environmental benefits or improvements desired in the future and why) as well as reducing potential conflicts from differences in opinion (Reed et al. 2009).

Since biodiversity and ecosystem services are complex and ambiguous concepts in and of themselves, it is not uncommon for land managers (or even the general public) to question whether biodiversity is even worth conserving (Pearce 2007). In addition to social learning and public deliberations, social benefits (or positive externalities) from conserving or enhancing biodiversity are directly or indirectly related to the effectiveness of institutions, e.g. policies and markets, in disseminating information thoroughly and convincingly (Vatn 2009). But this mainly pertains to the existence values society places on biodiversity as indirect consumers of this public good. Stern (1999) suggests that pro-environmental behaviours are influenced partially by information and partially by incentives, each having their specific functions on behaviour, and both important facets of institutions.

1.3 Institutional Responses

1.3.1 Definition and Overview of Institutions

A simplified definition of institutions is offered by Young et al. (2008: xxii) as "[a] cluster of rights, rules, and decision-making procedures that give rise to a social practice, assign roles to participants in the practice, and guides interactions among occupants of these roles". Institutions are essentially "complex social forms that reproduce themselves such as governments, the family, human languages, universities, hospitals, business corporations, and legal systems" (Miller 2011). North (1990: 3) defines institutions as "humanly devised constraints that shape human interaction", reduce uncertainties, and "structure incentives in human exchange, whether political, social or economic". Thus, institutions play a vital role in determining the outcomes of human-environmental relationships (Gibson et al. 2000; Tucker and Ostrom 2005; Young et al. 2008).

Institutions are often distinguished as being either "public" (the state) or "private" (the market), yet there are also institutions for more complex systems of governing common-property, such as common-pool resource (CPR) regimes (Ostrom et al. 1994). Additionally, a competitive market, i.e. private institution, is also essentially a public good where individuals or groups (e.g. firms) have the freedom to buy and sell goods and services (Ostrom 1990). Institutions, therefore, can be seen as lying along a spectrum from local (e.g. local-level public administrations) to national and international (e.g. the UN). The theoretical basis of institutions combines social and economic concepts pertaining to decision-making (e.g. public choice and game theory) that are fundamental to understanding how human behaviours are shaped over time through evolving rules, norms, and constraints (North 1990; Ostrom 2005).

Informal constraints are cultural (or context) social norms that may not be explicitly stated or written, e.g. whether to bow or shake hands, physical proximity during conversations, eye contact, etc. Informal constraints are important features of institutions that arise from repeated interactions defined as "extensions, elaborations and modifications of formal rules" derived from "socially sanctioned norms of behavior, and … internally enforced standards of conduct" (North 1990: 40). Informal constraints play a central role within the transaction cost framework in that they enable more effective enforcement and sanctioning measures. Such arrangements for enforcement and sanctioning, such as those for common ownership of property (or common-property regimes), may gradually become more efficient due to repeated interactions, self-organizing, learning and negotiating (Agrawal 2001; Lebel et al. 2006). Local participation in this process builds trust and social capital, which enables more efficient ways of identifying the most *effective* modes of governance, e.g. sanctions or compensations, in order to ensure higher levels of social welfare in the long run (Blomquist 2009; Baliamoune-Lutz 2011). Thus, informal constraints are essential components and the building blocks for developing local institutions.

The importance of local institutions in governance and development studies has been demonstrated in great depth by Uphoff (1986). His analysis points to how local institutional development is essential for effective governance in five main areas: 1) natural resource management, 2) rural infrastructure, 3) human resource development, 4) agricultural development, and 5) non-agricultural enterprises. Uphoff illustrates the various institutional categories and types under three sectors: public, voluntary, and private (Table 1.3):

Table 1.3. Continuum of local institutions by sector; adopted from Uphoff (1986), p. 5.

Sector types	***Public***		***Voluntary***			***Private***
Categories	Local Admin. (LA)	Local Gov't (LG)	Member Organization (MO)	Co-operative (Co-op)	Service Organization (SO)	Private Business (PB)
Institution types	Bureaucratic Institutions	Political Institutions	Local Organizations[7] (based on the principle of membership and control; these can become institutions)			Profit-oriented Institutions

In Uphoff's framework, organizations and institutions share common attributes, but are also distinguished from each other depending on the context. Some institutions are systems of institutions; for instance, judicial courts are both institutions and organisations whereas a law (or a language), is simply an institution (Miller 2011). While not all organisations are institutions, they have the capacity to become "institutionalized" through utilising their membership base and social capital for attaining political mobilisation. For example, organisations can become institutions if they have "… acquired special status and legitimacy for having satisfied people's needs and for having met their normative expectations over

[7] These can also include local, national and international organisations, e.g. clubs, societies, NGOs, community-based organisations

time" (Uphoff 1986). Hence, non-governmental organisations (NGOs)[8] may start out as voluntary and non-profit establishments that later gain political power through social capital and broad based support (e.g. funding, petitions, etc.), thus acting as an institutional intermediary within the public-private interface (Uphoff 1993).

Institutions are by no means static paradigms frozen in time and space. In fact, institutions that do not change and evolve to meet societal demands essentially fall out of use (North 1990). In more extreme cases, they generally fail to survive as a result from not being passed on from one generation to the next. An unfortunate yet very real example of this would be that of languages going 'extinct'. Contrary to this are examples of extremely robust institutions such as the market. All institutions, one can argue, are in some way or another economic, especially since social and political institutions are largely driven by economic decisions on issues related to private and public life (Denzau and North 1994; Evans 2004). It can also be argued that macroeconomic institutions operating at the global level are far from perfect (Arrow et al. 1995; Levin et al. 1998), but they too have the capacity to change and evolve, albeit at incremental levels and stages (Faber et al. 1997; Bowles 1998; Dietz et al. 2003).

Local institutions must change and evolve in order to maintain efficient and optimal states in order to compete and adapt in a highly complex, growing and increasingly globalized world (Bennett and Balvanera 2007; Berkes 2007). Hence, institutions at various scales help address the importance of biodiversity through combining biodiversity conservation, business development and local community empowerment (Yorque et al. 2002; Barbier 2011). In retrospect, determining which incentives motivate local actors to participate in conservation or restoration project redirects us to how institutions influence and are influenced by the social learning process.

One of the key challenges for enabling effective decentralised local governance regimes is learning and adapting strategies within the local context (Brosius et al. 1998; Andersson and Gibson 2007). From a research perspective, identifying local needs, constraints and opportunities are perhaps best understood through a participatory approach (e.g. Chambers 2008). Participatory learning is essential for obtaining information for the development of

[8] Uphoff (1986) considers non-governmental organisations (NGOs) as private voluntary organizations rather than 'third sector' (see Uphoff 1995); although there are numerous categories of NGOs that cannot be ignored (see Vakil 1997).

institutional arrangements for managing natural resources (Bouwen and Taillieu 2004; Pahl-Wostl and Hare 2004; Keen et al. 2005; Berkes 2009). This theoretical framework is intended to analyse how local actors develop adaptive co-management strategies to identify risks and incentives, build capacity, and deliberate on causes for (or against) participation (Cooke and Kothari 2001; Plummer and Armitage 2007; Armitage et al. 2008; Reed et al. 2010).

1.3.2 Protected Areas: Pros and Cons

Establishing protected areas (PAs), such as national parks and nature reserves, has been the most common approach employed for preventing deforestation and conserving biodiversity. Globally, protected areas cover roughly 13% of the Earth's terrestrial surface and are on the rise (Coletta 2010; FAO 2011). They continue to be viewed as the most effective means of protecting biodiversity and scarce natural resources (Bruner et al. 2001; Rodrigues et al. 2004; Andam et al. 2008). However, PAs have been criticised as neo-liberal policies (West et al. 2006; Roe and Elliott 2010), relying on 'command-and-control' measures that are costly and often undermine the rights and livelihoods of forest-dependent communities (Holling and Meffe 1996; Agrawal and Gupta 2005; Ferraro et al. 2012). While there has been a gradual expansion of PAs, debates continue to surround their effectiveness (Hayes 2006), impacts on livelihoods of the poor (Hutton and Adams 2007; Andam et al. 2010; Pullin et al. 2013), as well as displacement of pressures onto neighbouring forests (e.g. Andam et al. 2008).

From the start, conservation agencies and governments came under attack for displacing indigenous and traditional forest societies through establishing PAs, while displaced deforestation at their margins became more severe (Brockington et al. 2006; Andam et al. 2008). Moreover, PAs provide little insurance for biodiversity conservation as isolated islands (or fragmented habitats), reducing the natural range of species (particularly large mammals) as well as the flow of genetic diversity (Wilson et al. 2014)[9]. In turn, protected areas do little for biodiversity-rich forests around their periphery that are liable to becoming concessions for other land-use practices, e.g. timber, soy, cattle, palm oil (Margules and Pressey 2000; Wilson et al. 2007; Gibbs et al. 2010).

[9] Some have argued for low-impact, multipurpose land-use strategies for 'greening the agricultural matrix' (including plantations) in helping to reduce the edge effects from intensive land-use practices in biodiversity-rich areas (Lindenmayer and Franklin 2002; Perfecto and Vandermeer 2010).

1.3.3 Decentralisation in the Context of Natural Resource Management

Efforts to place local communities at the forefront of more participatory natural resource management grew largely out of global trends in decentralisation of public policy (Agrawal and Ribot 1999; Agrawal and Ostrom 2001; Andersson et al. 2006; Coleman and Fleischman 2011). Democratic decentralisation is the transferring of decision-making power from central authority (or national governments) to local-level administrators and governments (Ribot 2003). Its stated objective is to increase efficiency and equity via “public decisions being brought closer and made more open and accountable to local populations” (Larson and Ribot 2004:3). Devolution is one form of administrative (or political) decentralisation and consists of transferring specific decision-making power, such as administering and monitoring local rules and rights (Blaser et al. 2005).

Decentralisation and devolution[10] of natural resource management responsibilities were initially sought as a strategy that would lead to economic development for more marginalised groups, such as indigenous peoples (Bardhan 2002; Grindle 2004). Central governments from numerous less developed countries have begun the process of decentralising some aspects of natural resource management (NRM from here onwards), e.g. reforestation and forest management, to local-level governments and organised groups (Agrawal et al. 2008). Under these policies it was assumed that popular participation and local empowerment would increase, which in turn would result in more equitable benefit sharing through providing fair access (Ribot 2005). However, international agencies seeking to integrate community members into their agenda often undermined existing local institutions and favoured elites (Cooke and Kothari 2001; Mansuri and Rao 2004; Iversen et al. 2006)[11]. Not surprisingly, decentralisation outcomes have been largely disappointing, with little evidence that it has resulted in both social and environmental improvements (Larson 2005; Blaikie 2006; Palmer and Engel 2007; Larson and Soto 2008; Ribot et al. 2010; Loayza et al. 2011; Bowler et al. 2012).

While conventional top-down policies have been criticised (Holling and Meffe 1996), decentralised policies have not always resulted in efficient and equitable outcomes for certain

[10] Meinzen-Dick and Knox (1999) provide an extensive framework on devolution in the context of institutions and community-based natural resource management.

[11] Cooke and Kothari (2001) also argue that these agencies often promote “participation” as a strategy to attract funding.

groups (Litvack et al. 1998). Successful outcomes depend on factors ranging from socially-embedded institutions at the group level (e.g. local norms and values) to the accountability, capacity, incentives, and commitments of local political actors (Agrawal and Ribot 1999; Larson 2002; Berkes 2010). More importantly, these factors are contingent upon the multifunctional role of institutions in securing property rights while reducing transaction costs (Ménard et al. 2005). Some of the key factors limiting the effectiveness of decentralisation include insecure property rights for marginalised groups and elite capture (Leach et al. 1999; Kellert et al. 2000; Mansuri and Rao 2004). For example, the process of allocating rights and responsibilities to local governments often results in the consolidation of power amongst the elite within the community and unfair outcomes for local users of natural resources (Mansuri and Rao 2004; Colfer and Capistrano 2005; Iversen et al. 2006).

Critical analyses of institutional dynamics and processes have helped to address the importance of understanding how polycentric institutions perform and evolve (Ostrom 2005). For instance, it is apparent now that central governments must also play a role in fostering good relations and assisting local governments through capacity building and extension services (Agrawal and Ostrom 2001; Ribot et al. 2006). These are also important factors for ensuring that new types of institutions (e.g. market-based) perform and adapt within existing government policies at different scales, and how they would be perceived in the context of local institutions.

1.3.4 Incentive-Based Mechanisms

Environmental externalities caused by land-use change can theoretically be solved by internalising them through market*S*-based policy instruments such as payments for ecosystem (or environmental) services (PES). Incentive-based strategies such as PES provide rewards or compensations, such as paying the opportunity costs of conserving forest that would likely have been converted to other land-uses, through direct payments (Wunder et al. 2008; Swallow et al. 2009; Gómez-Baggethun et al. 2010). PES is often viewed as an umbrella term for most incentive- or market-based strategies for internalising environmental externalities, which also include Reduced Emissions from Deforestation and Degradation (REDD/REDD+), conservation contracts or auctions (e.g. Jack et al. 2009; Porras et al. 2011), as well as many agri-environmental schemes (e.g. Bryan 2013). PES is currently being adopted in many parts of the world for conserving scarce natural resources, biodiversity, and other benefits from ecosystems (Landell-Mills and Porras 2002; Ferraro and Kiss 2002; Salzman 2005; Wunder et al. 2008).

1.4 Payments for Ecosystem Services: Definition and Overview with Cases

1.4.1 Conceptual and Theoretical Foundations of PES

PES are economic strategies aimed at capturing external benefits from the environment through 'quasi-markets' and transforming them into real financial incentives for local actors stewarding those services (Wunder 2005; Engel et al. 2008; Sommerville et al. 2009). It has been described as the inverse of the 'polluter pays' principle to control negative externalities to the 'supplier gets paid' for providing positive externalities (Engel et al. 2008). The theoretical foundations for a PES scheme are defined by Wunder (2005:3) as: 1) a voluntary transaction where 2) a well-defined environmental service (ES), or a land use likely to secure that service, is 3) being 'bought' by at least one ES buyer 4) from at least one ES provider 5) if, and only if, the ES provider secures ES provisions (i.e. meets the conditions agreed upon).

Costa Rica's *Pagos por Servicios Ambientes* (PSA) scheme has received a great deal of attention as a PES, most notably with an increase in areas designated for biodiversity conservation (Thacher et al. 1996; Rojas and Aylward 2003; Zbinden and Lee 2005; Pfaff et al. 2006; Pagiola 2008). Its success has been partially attributed to the numerous support mechanisms in place, e.g. local NGOs, coupled with political stability and quality of infrastructure in the country (Wunder et al. 2008). In addition, it has a relatively long history for PES in a developing country context and has been extensively studied (Rojas and Aylward 2003; Miranda et al. 2003; Zbinden and Lee 2005; Pagiola 2008; Morse et al. 2009). Another important factor to consider is that most forested land in Costa Rica is privately owned[12] (Arriagada et al. 2009).

Other nations have also begun to show some progress through newly established PES schemes, although they differ substantially in objectives and institutional design (Brouwer et al. 2011). The Chinese government has launched perhaps the most ambitious 'PES' through its Sloping Lands Conversion Program (SLCP) by retiring and re/afforesting millions of hectares over the past decade (Bennett 2008; Bullock and King 2011; Yin and Zhao 2012). A review of the PES schemes from around the world has shown that user-financed programs

[12] Over 50% according to the FAO (2010).

had more effective outcomes in both design and additionality than those that were government-financed (Wunder et al. 2008). However, governments are more likely to accept schemes with high transaction costs than private entities, whether buyers or users of ES (*pers. comm.* S. Wunder, Apr. 2013).

1.4.2 Common Property Problems with PES

PES schemes are favoured in situations where property rights are well-defined, e.g. private/individual landowners or strong local regimes/institutions (Pattanayak et al. 2010; Rode et al. 2013). While PES has also been used to improve community-based conservation projects, fair distribution of benefits can be a contentious issue (Sommerville et al. 2010). In some cases, PES schemes geared towards wildlife protection may require collective participation efforts on common-property, as is the case with conserving large mammals in sub-Saharan Africa (e.g. Nelson et al. 2010). In addition, PES or other policies (e.g. subsidies) may crowd out already existing institutional arrangements or introduce perverse incentives if it replaces cooperation with competition (Kerr et al. 2012). In case where PES is targeted for restoration projects (e.g. re/afforestation), there might be the risk of undermining collective action processes that helped to secure access and ownership rights in the first place (Agrawal and Ostrom 2001). There is also the additional risk that destabilising socially-embedded institutions, making property rights less secure, would result in increased transaction costs (Ménard et al. 2005; Swallow and Meinzen-Dick 2009).

1.4.3 Principal-Agent Problems with PES

Principal-Agent dilemmas are common economic problems relating to conflicts of interest, moral hazard, and asymmetrical (incomplete or imperfect) information (Holmstrom and Milgrom 1991; Bolton and Dewatripont 2005). They occur in both the marketplace and political arena, generally between a ‘principal’ who hires (or delegates a task for) an ‘agent’. From a political perspective, bureaucrats can be seen as the agent while voters are their principals. In the free market, the objectives of land managers and contracted agents, for example, might be conflicting since both parties intend to maximize their own utility (Shogren et al. 2010). Moreover, cases where private information, e.g. costs of land, labour and capital, is withheld lead to either moral hazards (or hidden action) or adverse selection (or hidden information). Optimal institutional designs (or contracts) are intended to minimise principal-agent dilemmas through revealing the incentives of each party (Grossman and Hart 1983; Rogerson 1985; Eisenhardt 1989; Gibbons 1998; Laffont 2003). Contract (or agency) theory, therefore, helps frame issues related to principals and agents within the context of incentive-based mechanisms (e.g. PES) used to internalise benefits from the environment.

In the context of PES, the ‘service buyer’ can be considered as the contracting ‘principal’ and the ‘service seller’ the contracted ‘agent’ (Grossman and Hart 1983). In such contractual arrangements, a conditional agreement is reached between both parties with the expectation of increasing or enhancing a clearly defined environmental (or ecosystem) service (ES). This includes alternative land-use practices, where payments may be based on estimating the opportunity costs of foregoing to land conversion, e.g. avoided deforestation (Wunder 2007). While some PES schemes (e.g. REDD/REDD+) are strictly aimed at reducing net carbon emissions from land-use changes (e.g. deforestation) by conserving existing forests, wetlands, and other natural ecosystems, there are concerns that such narrowly focussed PES could lead to the planting of monocultures of faster-growing exotics (Murray 2000; Sayer et al. 2004; Pagiola et al. 2004a; Bäckstrand and Lövbrand 2006; Montagnini and Finney 2011). This issue arises partly because of difficulties in specifying and quantifying non-commodity ecosystem (or environmental) goods or services (Ferraro 2008). North (1992) illustrates the complexities involved in estimating the costs of difficult goods and services for principals:

> *The costs of transacting arise because information is costly and asymmetrically held by the parties to exchange. The costs of measuring the multiple valuable dimensions of the goods or services exchanged or of the performance of agents, and the costs of enforcing agreements determine transaction costs.*

Thus, more narrowly focussed PES (e.g. carbon-only) would likely have lower transaction costs than broader-based PES (e.g. bundled or layered ES) or those focussed on ES that are harder to define and estimate, like biodiversity.

1.4.4 Carbon Markets, Climate Change & the Biodiversity Paradox

International market-based policies have emerged to boost forest protection and restoration efforts under the United Nations’ Reduced Emissions from Deforestation and Degradation (REDD/REDD+) and the Clean Development Mechanism (CDM). Meanwhile, governments have begun adopting large-scale tree planting (re/afforestation) driven by these and other objectives, motives and incentives (Edwards et al. 2010). Current net gains of global forest cover are partially due to large-scale afforestation efforts, particularly in India, the US and China (Houghton 2003). In fact, China was the biggest contributor of ‘new forests’ in the last two decades through government-sponsored PES schemes (Bennett 2008). However, these achievements have also had negative social and ecological impacts (e.g. Cao et al. 2011) in spite of increases in carbon storage from afforestation (Fang et al. 2001). Despite the general trends of marginal expansion of forest cover, conversion of species-rich areas (e.g. primary forests[13] and wetlands) has continued to increase in many parts of the world contributing to both carbon emission and biodiversity loss (Hansen et al. 2010; FAO 2011). As a result, the expanding of the new "carbon markets" could contribute to biodiversity loss (or exacerbate it) if there are no institutional mechanisms for integrating biodiversity as a co-benefit (Busch et al. 2011). In turn, these efforts could result in moral hazard, displacement, and "leakage" issues for forests and biodiversity outside protected areas or under these schemes (Wunder and Albán 2008; Edwards et al. 2010; Busch et al. 2011; Harrison and Paoli 2012).

1.4.5 Challenges and Constraints with PES as a Policy Instrument

PES has been conventionally applied as a mechanism for preventing deforestation, but is also being increasingly applied to incentivise restoration efforts for enhancing different kinds of ES, also referred to as asset-building PES (chapter 3). Many studies have emphasised adopting ecologically-sound restoration practices through selecting the right native tree and shrub species and prioritising degraded areas (Mansourian et al. 2005; Chazdon 2008; Rey-Benayas et al. 2009; Hall et al. 2011a). Some have also advocated targeting ecologically important areas for restoration, such as riparian systems (e.g. Rodrigues et al. 2011). Yet, there are numerous challenges when attempting to enhance biodiversity simultaneously with other ecosystem services, particularly under private property regimes. For instance, restoration efforts that emphasise attaining broad-based ES in multifunctional landscapes can theoretically enhance biodiversity, yet are likely to face higher transaction costs, e.g. compliance monitoring. Hence, PES schemes that are designed for compensating land managers for 'inputs' that are 'action-based', such as number of trees planted, may or may not produce the same effects as PES that are 'performance- (or results-) based and focussed on 'outputs' (Ferraro 2011; Gibbons et al. 2011; Montagnini and Finney 2011). Institutional designs are therefore of considerable importance to ensure the ES buyer(s) obtain the expected additionality being paid for since conditions and objectives are agreed upon through contracts[14]. (Paoli et al. 2010; Bullock et al. 2011; Busch 2013).

[13] Classified as forests with no previous signs of human interference by FAO (2010)
[14] Issues of PES contract design for biodiversity are examined in more detail in chapter 3.

It is necessary to view PES as one of many kinds of environmental policy options, particularly for correcting market failures through addressing the 'free rider' problem, or society's failure to pay for the external benefits from the environment (Salzman 2005). As opposed to other environmental policy mechanisms such as regulations, e.g. restriction on cutting trees or protected areas forbidding entry, which also require strong public institutions able to cover the transaction costs, PES relies on incentives and voluntary participation, similar to new institutions being introduced in private markets (e.g. carbon trading or government tax breaks). As a voluntary policy option, use-restricting PES are considered to be more efficient and equitable than 'command-and-control' policies for regulating deforestation. However, asset-building PES often requires incentivising people to plant trees they normally would not plant and quite often rely on social and institutional factors ensuring effective outcomes, such as secured property rights (chapter 2). These are important aspects to consider when designing PES schemes in contexts where they have not been fully introduced or experimented with, such as in Lebanon.

1.5 Lebanon: Overview of a Relevant Case-Study

1.5.1 Public Administration and Decentralisation

Lebanon gained its independence in 1943 following the French Mandate period (1918-1943) during which it was annexed with Syria. It has an unconventional political system based on confessional ties[15] ruled as a parliamentary republic with a legislative branch forming the National Assembly of a 128-seat unicameral cabinet (Chamber of Deputies). Deputies (including ministers) are voted in through public elections (5 year terms) who then elect with two-thirds majority the president (always a Maronite Christian)[16]. The president leads the executive branch government and is head of the army, and therefore quite often a former general. Once voted in, he appoints a prime minister (always a Sunni Muslim), who then assembles the Council of Ministers (roughly 20). The Speaker of the House of Parliament (always Shi'a Muslim) is elected by the parliament and has a significant amount of negotiating power. He is in charge of setting the legislative agenda with laws and policy

[15] Consociationalism is a form of government and power-sharing in deeply divided or fractured societies (ethnic, religious, linguistic, etc.) where there is a lack of majority rule but rather a coalition of communal autonomy that is intended to serve all (see Harb 2006). Note that Lebanon's political structure is an example of *confessional* consociationalism, meaning that members are associated through religious confessional lines (Salamey 2009).

[16] This arrangement changed at the 2008 Doha Agreement in which there are 1/3 seats equally distributed to Christians, Sunni and Shiite.

presented by the central government and judiciary committee. The deputy parliamentary official represents the speaker' district, which is characterized by sectarian and political party ties (CEIP 2008; ROL 2008).

Lebanon's political administration is divided into 6 governorates (*mohafazet*), each led by a governor (*muhafez*). Each governorate contains a number of districts[17] (*aqdiya*) led by a district commissioner (*qa'immiqam*). There are 26 districts (including Beirut) each containing a variable number of municipalities, the lowest level of local administrative government. Municipalities are defined as having municipal councils consisting of a set number of council members whose numbers (9, 12, 15, 18, and 21) are determined by population of the village. Of the 1,296 towns and villages Lebanon, 963 have municipal councils as of the 2010 municipal elections (MOIM 2011). Towns and villages without municipal councils are sometimes represented by neighbouring municipalities. The rest are represented by a *mukhtar* (or *mukhatir*, plural [Arabic]) that are administratively connected to the district commissioner rather than to the Ministry of Interiors and Municipalities (MOIM). There are few recent references that describe the differing roles and responsibilities between mayors and mukhtars in Lebanon. However, Salem (1965) describes this quite succinctly (presuming their roles have not changed dramatically over the last few decades):

> *The ra'is[18] presides over the council of the municipality, and in consultation with his council, supervises the opening of roads, repairing schools, installing electricity and administering the internal affairs of the municipality. The mukhtar, on the other hand, is the official link between the village and the central government. He verifies births, deaths, and signatures, and performs a variety of para-governmental services requested by the qa'immaqam, such as helping the gendarmes (rural police) in locating a criminal.* (380-381)

Virtually every town and village contains at least one mukhtar who is also elected by their constituents during municipal elections that take place every three years[19]. During these elections Lebanese citizens vote in their constituency (i.e. town or village where they were born) and not their permanent place of residence. This means that while a town or village may have a small number of permanent residents or households, the number of constituents

[17] With the exception of the governorate of Beirut.

[18] *Ra'is baladiyeh* translates to 'president of municipality', i.e. mayor.

[19] There are approximately 2,753 mukhtars in Lebanon as of 2010.

may be much higher. Similarly the number of council members in municipalities reflects that of the number of constituents, not the number of residents.

Lebanon has been described as a nation under ‘regularised instability’ due to its political culture and weak legitimacy that result in constant political gridlock and crises (Al-Khouri 2006; Nasnas et al. 2007). According to the Carnegie Endowment of Peace, Lebanon could benefit from a shift towards a bicameral parliament through the establishment of a Senate to represent the 28 districts (*majilis cadat*). Each district would be represented by a democratically elected senator (*rayeez cadat*) who would not be bound by sectarian or confessional lines, but rather ensure that a proper consensus is developed towards improving services and local infrastructure of each of the municipalities within their district (CEIP 2008). This effort towards decentralisation might enable more empowerment and capacity from the bottom up while the Senate would balance that process as a means of ‘recentralizing’ authority and confidence back to the central government (Atallah 2002). This would perhaps be the most optimal means of sharing power while sustaining a certain level of authority, e.g. reducing ethnic conflicts (Ciepley 2013) and awareness of broader national interests, e.g. social and environmental (Bissat 2002).

1.5.2 Ecological Significance of the Mediterranean Basin and Lebanon

Mosaic landscapes of the Mediterranean basin have been shaped by humans over millennia (Blondel 2006; Zohary et al. 2012). Domestication of plants and animals began as early as 10,000 years ago in the eastern basin, followed by population growth and decline, wars and invasions, which have all had profound social and ecological implications for biodiversity therein (Barbero et al. 1990; Naveh 1998; Braudel and Reynolds 2002; Thompson 2005; Reyers et al. 2009; Blondel et al. 2010). This co-evolutionary process, along with climate change and diverse topography, has contributed to the high levels of plant species richness and endemism around the basin, recognised as a biodiversity ‘hotspot’ (Médail and Quézel 1999; Mittermeier et al. 2011). Of the 25 biodiversity ‘hotspots’ identified by Myers et al. (2000), the Mediterranean basin is the second richest in plant diversity after the tropical Andes in spite of losses of forests and other woodlands over the ages (Médail and Quézel 1999; Myers et al. 2000)[20]. While dry forests around the basin offer relatively lower carbon

[20] Historical patterns of gradual disturbances, both natural and human caused, may have contributed to this increase in biodiversity (Blondel et al. 2010).

sequestration services than the humid tropics, its biodiversity is a major yet undervalued ecological asset (Merlo and Croitoru 2005).

1.5.3 Lebanon as a Centre for Plant Diversity

Lebanon is a relatively small (10,452 km²), predominantly mountainous country located in the eastern Mediterranean. Despite its small size it still harbours over 2,600 vascular plant species, of which around 12% are endemic to the eastern Mediterranean region (Zohary 1973). Of these, over 300 are endemic to Lebanon alone (Davis et al. 1994), with some occurring exclusively in isolated areas within the country (Tohmé and Tohmé 2007). Some of these steno-endemics occur in high altitude landscapes above the tree line (*jurd* in Arabic) while the majority of rare and endemic species documented are found in forest and woodland ecosystems (Yazbek et al. 2010; Sattout and Caligari 2011).

Inspired by the success of Important Bird Areas initiated by Birdlife International, leading botanists from around Europe discussed the urgent need to prioritise areas of exceptional plant diversity under threat. Important Plant Areas (IPAs) was the outcome initiated by Plantlife International in the mid-1990s. The initiative was developed as a means for identifying and protecting a “network of the best sites for plant conservation throughout Europe and the rest of the world...” (Anderson 2002:6). Objectives include the documentation of wild plants and their habitats with special attention placed on promoting education, awareness and capacity building on the sustainable use and conservation of plant diversity. The programme’s Guidelines have gained broad support from multinational stakeholders, including the UN’s Convention on Biological Diversity (CBD) and the International Union for the Conservation of Nature (IUCN), with contributions to both policy and practice (Anderson 2002).

With threats to plant diversity in the eastern and southern Mediterranean basin increasing, a project was initiated for rapid assessment of IPAs in North African and Middle Eastern countries (Radford et al. 2011). A team of scientists from the American University of Beirut’s Nature Conservation Center (AUB-NCC) and experts from other institutions participated in defining IPAs in Lebanon (Yazbek et al. 2010). The team identified endemic plants in Lebanon and neighbouring countries using the most recent reference on the flora of Lebanon (Tohmé and Tohmé 2007) along with several published reports and regional references on the flora of the eastern Mediterranean Basin (e.g. Post 1932; Mouterde 1966; Zohary 1973). The authors defined a total of twenty IPAs in Lebanon using the discussed methods presented in

Figure 1.4 below. Nine IPAs are located on the western slopes of the Mount Lebanon range, with an average elevation of approximately 1200 metres (ranging from sea level to 3,044[21] meters). The majority of Lebanon's protected areas (e.g. nature reserves, Biosphere reserves, Ramsar sites) occur within these IPAs. Designated IPAs are shown to represent the major ecosystems and unique habitats of Lebanon.

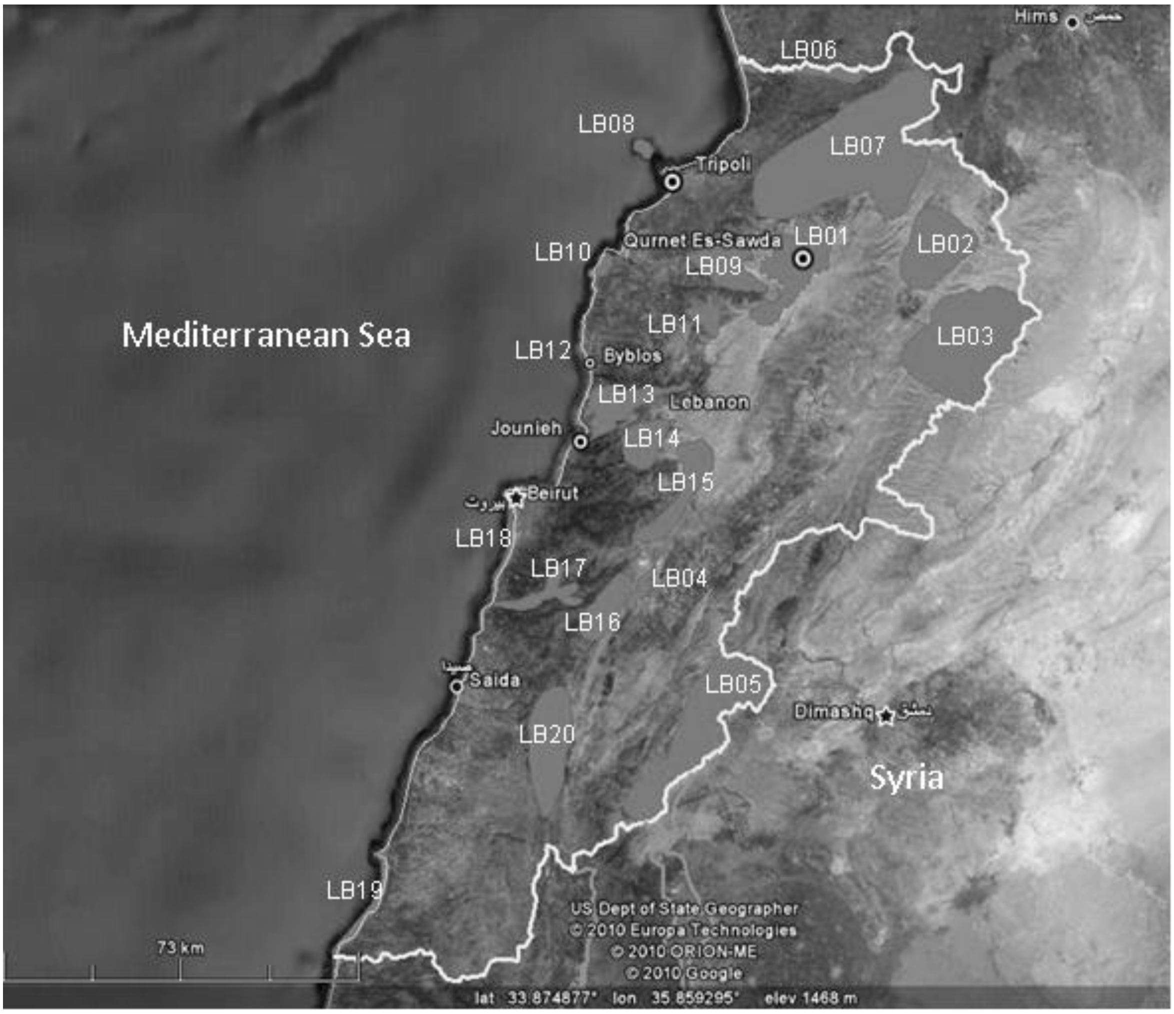

Figure 1.4. Google Earth map showing the 20 IPAs of Lebanon in green developed by Yazbek et al. (2010).

Endemic and/or threatened species are found in virtually all IPAs, most containing more than 10 nationally endemic species. Agricultural intensification, particularly through overgrazing, was considered the main threat for over two-thirds of the 144 IPAs across the 10 participating countries in the Middle East and North Africa (Radford et al. 2011). However, development (through urbanisation) was considered to be biggest threat to most IPAs in Lebanon. In addition to urban development are threats from quarrying activities taking place in most of

[21] Qornet es-Saouda (highest peak in Lebanon).

the mountainous IPAs as well as Hermel (LB02) and Aarsel (LB03) IPAs, and tourism development along the coast (Yazbek et al. 2010).

Deforestation, quarrying, and urbanisation are the major land-use changes that have contributed to the degradation of natural forests and woodlands. This was especially acute during the civil war period when forest protection and regulations on land-use were virtually absent (Abi-Saleh et al. 1996; Masri 1999; Nasr et al. 2009; Darwish et al. 2010a). Forests containing large trees are sparse and highly fragmented, mainly occurring on the western ridge of Mount Lebanon (Talhouk et al. 2003). Some contiguous forests (coniferous and broadleaved) are now protected by law under nature reserves since the establishment of the Ministry of Environment shortly after the civil war (Abu-Izzeddin 2000). However, the majority of the forests and other woodland types outside these protected areas lack management arrangements for effective conservation (Sattout et al. 2005). Forest ecosystems and biodiversity in Lebanon continue to be threatened by land conversion and habitat fragmentation (Talhouk et al. 2005). To a certain extent, land abandonment has led to natural regeneration in some parts of the country. But the lack of proper management, partially a result of the current forestry laws (discussed in chapter 2), as well as inadequate response to more frequent and destructive forest fires, are major threats to Lebanese forests today (Jomaa et al. 2009; Mitri and Gitas 2011).

Aside from greater efforts needed for improving the nation's forest management policies, some national stakeholders in Lebanon, particularly NGOs, have expressed interest in long-term reforestation efforts taking place in some IPAs (discussed in more detail below), such as the corridor separating Bcharre-Ehden (LB09) and Tannourine (LB11) IPAs (see Figure 1.4). Their aim is to connect the Tannourine and Haddath el-Jobbe cedar forests with the Cedar of God forest patch in Bcharre (LRI, 2012. *pers. comm.).* In addition to these two IPAs, reforestation campaigns have recently taken place in various other IPAs as well, for example the Keserouan (LB14), Chouf (LB16), Jabal ech-Cheikh (LB05), and Rihane (LB20) regions. Since re/afforestation can also have adverse impacts on biodiversity through excessive planting of monoculture or limited species (Alrababah et al. 2007), IPAs serve as important research sites for this study.

1.5.4 Historic Deforestation in the 19th – 20th Centuries

Much like the rest of the Mediterranean, deforestation in Lebanon has had a long history (Thirgood 1981). The Phoenicians were perhaps one of the first cultures to trade timber (mainly cedar) for gold and other precious metals with early Egyptians (c. 3000 BCE) (Hitti 1967; Chaney and Basbous 1978). As one of the provinces (*villayet*) of the Ottoman Empire (1299-1923), settlements in Mount Lebanon began increasing, predominantly with mixed agriculture (e.g. wheat, grapes and mulberry[22]) and livestock (mainly goats and sheep). The last major impact on forests in Lebanon took place during the end of the Ottoman rule when wood resources were used to fuel the First World War (1914-1918) followed by the construction of railway networks (Hitti 2002). Effects of grazing, wood collection, and gradual land-use change from urbanisation and agriculture in the highlands have contributed to forest degradation in the early half of the 20th century (Beals 1965; Mikesell 1969).

1.5.5 Forest Characteristics and Tenure

Lebanon currently has around 13% forest cover (1,394 km^2)[23] classified as subtropical mountain (48%), subtropical dry (38.1%) and subtropical steppe (13.9%). Of these, 97.4% are classed as 'production' and 2.6% as nature reserves. Another 10% of land-cover in Lebanon is classified as 'other wooded land' (or 1,084 km^2)[24], having canopy cover of less than 10%, and also largely classed as production (3% within nature reserves). The majority of Lebanon's forests and other wooded lands occur along the western and eastern flanks of Mount Lebanon, beginning from Akkar in the far north to Marjayoun in the far south (Figure 1.5). Patches of forests and other woodlands also occur to a much lesser extent along the Anti-Lebanon mountain chain (e.g. Mount Hermon in the southeast).

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[22] For silk production, predominantly in the 18-19th centuries (see Salibi 1988).

[23] Based on FAO classification of land having trees of at least 5 meters with a minimum canopy cover of 10%.

[24] Of which 44.3% is subtropical mountain, 31.7% is subtropical dry and 24% is subtropical steppe (Estephan and Beydoun 2005).

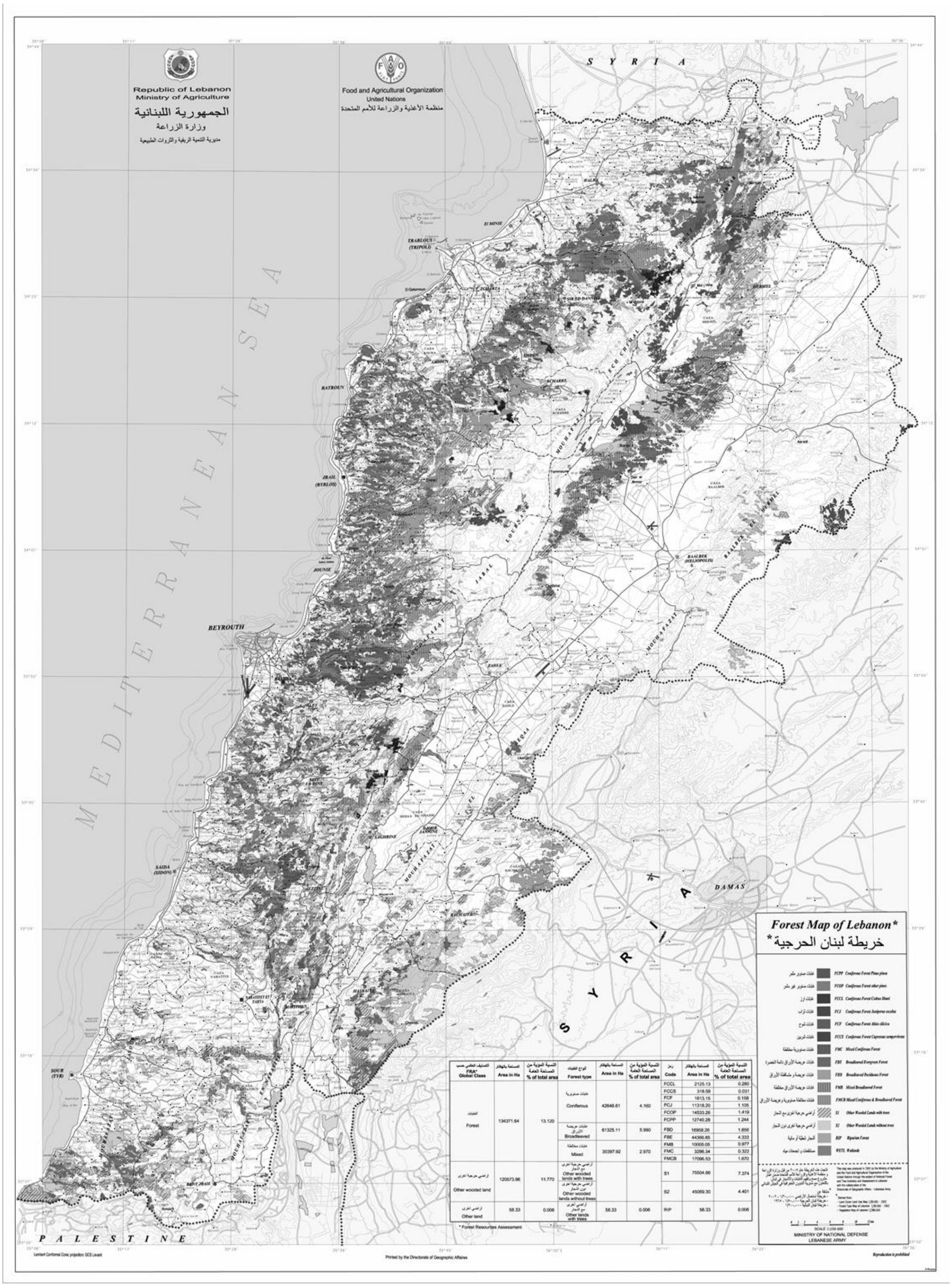

Figure 1.5. Forest map of Lebanon developed by the Ministry of Agriculture and FAO.

Approximately 70% of forests and other wooded lands are under private tenure (Estephan and Beydoun 2005). Similarly, land tenure in Lebanon is predominantly under private ownership (Figure 1.6).

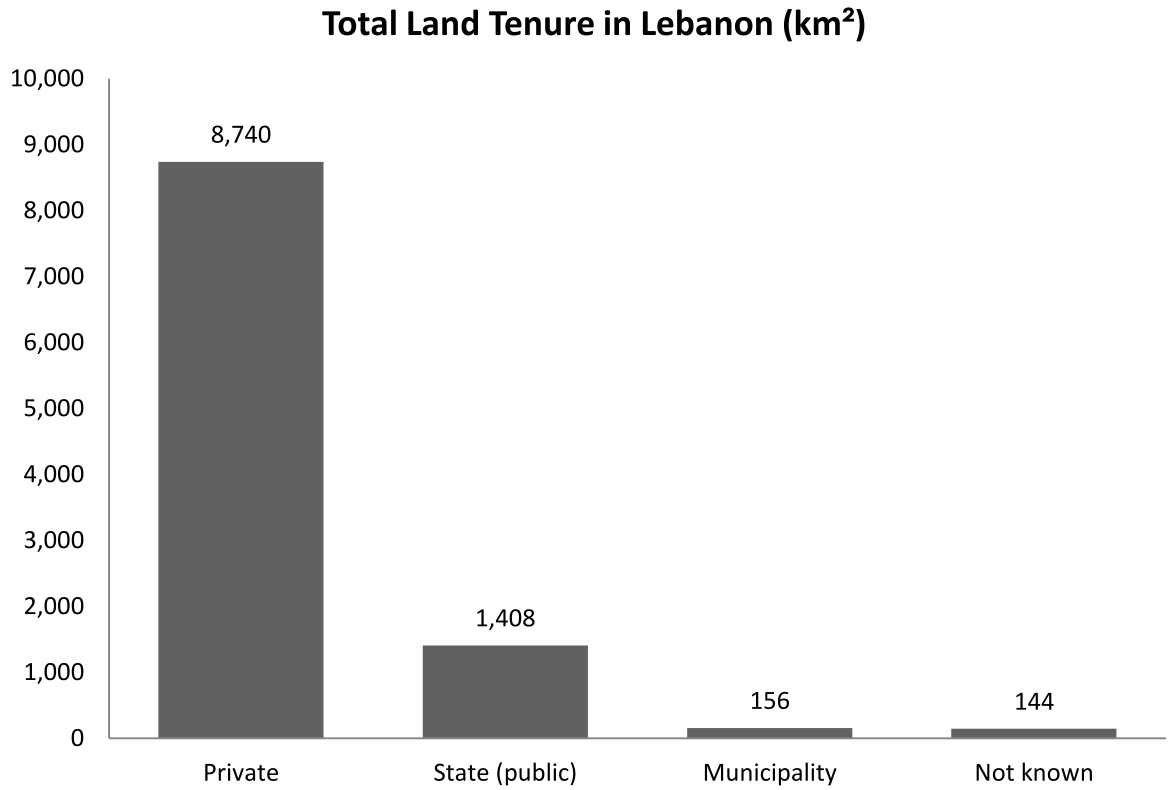

Figure 1.6. Total land tenure (forest and other land cover) in Lebanon (10,452 km^2) based on data from Estephan & Beydoun (2005).

Forest tenure in Lebanon is loosely categorized under private and public (state) ownership based on FAO land cover categories (FAO 2010). The National Forest and Tree Resources Assessment and Monitoring report for Lebanon (FAO, TCP/LEB/2903) classify private forests as those "owned by individuals, private co-operatives, corporations and other business entities, private religious institutions (*waqf*)[25]". Private forest comprise roughly 73% of total forests (not including 'other wooded lands') in Lebanon (Table 1.4). Public ownership of forests falls under the category of 'State', which include "administrative units of the public administration; or by institutions or corporations owned by the public administration"[26]. Other categories of forest ownership fall under either 'Municipality' (Arabic – '*mesheaa*')[27],

[25] Religious institutions own approximately 35% (or roughly 300 km^2) of private forests in Lebanon.

[26] The FRA 2010 Categories and Definitions for private forests also include families, communities, educational institutions, pension and investment funds, NGOs, nature conservation organizations and other private institutions.

[27] Owned by the municipality, union of municipalities, or the population (community) of the concerned villages or towns.

'Community'[28], and 'Not known', classified as subcategories of 'Private ownership (FRA 2010:9-12).

Table 1.4. Distribution of forest tenure types and area (in hectares) in Lebanon based on FAO Forest Resource Assessment categories (FRA 2010)

National Category	FRA Category	Area (ha)	
		(subtotal)	
State	Public ownership		37,388
Private	Private ownership		99,636
	• Individuals/families	47,745	
	• Private businesses/institutions	34,673	
	• Local communities	14,216	
	• Indigenous/tribal	1,637	
	• Other types	1,365	
Total			137,024*

*Indicates land with forest cover of known tenure only and includes communal tenure

1.5.6 Recent Land-Use and Land-Cover Change

The earliest aerial forest mapping of Lebanon was conducted by the FAO in collaboration with the Ministry of Agriculture and the Directorate of Geographic Affairs of the Lebanese army (1963-65). Results from the report indicated a forest cover of roughly 7% (El-Husseini and Baltaxe 1965; Baltaxe 1966). These earlier maps, however, did not provide sufficient data on density of forest stands. More recent studies using satellite images indicate that while the general trend has been marginal increases in forest cover, they have become highly fragmented and patchy (Jomaa 2008). Forest loss during the civil war period was acute in many parts of the country, but the war also contributed to land abandonment (Khuri et al. 2000). For example, some highland areas of Mount Lebanon have shown gradual recovery of forests following agricultural abandonment with relatively little impact from urban development (Jomaa et al. 2009). On the other hand, significant losses of juniper (*Juniperus excelsa*) forests were detected in the foothills of eastern Bekaa Valley (Anti-Lebanon

[28] Forest owned by a tribe, or a family without having a clear share of its members (Arabic '*waqf thurri*').

Mountains) and along the eastern flank of Mount Lebanon over the last 40 years (Jomaa et al. 2008).

Grazing has been a contentious issue with respect to forestry in Lebanon. Much like in other parts of the Mediterranean, the forestry sector tends to be at odds with herders (Dumrongrojwatthana et al. 2011). The lack of policies for controlling grazing limited regeneration in different Mediterranean countries at different phases of their history (Thirgood 1981). On the other hand, grazing has also played an important role in shaping Mediterranean landscapes and biodiversity while reducing the risk of forest fires (Perevolotsky and Seligman 1998; Joffre et al. 1999; Cingolani et al. 2005). Such complex social-ecological systems may have also contributed to high plant diversity around the basin over long temporal scales (Blondel et al. 2010; Zohary et al. 2012). While integrated strategies were used to manage agro-silvopastoral systems in many rural Mediterranean societies for hundreds of years (e.g. *dehesa*), many began to fade under increasing land pressure, economic development and wars (Blondel 2006), as well as poorly planned policies (e.g. Lorent et al. 2009). Interestingly, rangelands in Lebanon have been gradually lost to cultivated land while livestock has increased by nearly 50% in the last few decades, resulting in land degradation due to overgrazing on marginal, erosion-prone areas (Darwish and Faour 2008). Pastoral to cultivated land-use changes are becoming increasingly problematic to rangeland ecosystems resulting in fragmentation and loss of biodiversity, especially wild cereals and forage plants. Rangeland in the Beqaa Valley, the breadbasket of food production in Lebanon, have decreased by 60% while irrigated land increased twofold in the last 30 years (Darwish and Faour 2008). Issues pertaining to grazing pressures due to competing land-uses and agricultural policies, including afforestation activities, have also been problematic in other Mediterranean countries (Bengtsson et al. 2000; Alrababah et al. 2007; Lorent et al. 2009).

In spite of having higher than the global average of forest cover (FAO 2011), forests and biodiversity in Lebanon still face numerous threats and challenges. Rural emigration has, on one hand, led to natural regeneration of woodlands in previously cultivated lands. However, the lack of incentives for sustainable forest management has made existing forests more vulnerable to pest outbreaks, storms, and more frequent and aggressive forest fires (FRA 2010). Additionally, legal constraints may be limiting the development of sustainable measures for collecting fuelwood and charcoal production, as well as non-wood forest products. The lack of common-property regimes and other institutional mechanisms (e.g.

property/access rights) lowers socioeconomic conditions of many forest-dependent communities, inhibiting their capacity to manage common-pool resources effectively, and instead contribute to rather than deter overharvesting (Gibson et al. 2000).

1.5.7 Forestry and Environmental Policy

Lebanon's 'Forest Code' was drafted in 1949 and served as a legal benchmark for forest policies related to forest protection, tenure, management, restoration and investment (Regato and Asmar 2011). In spite of the Forest Code being amended over the years through numerous decrees and decisions, certain aspects remain counterproductive in promoting sound forest management practices. For example, local authorities and landowners are required to obtain permission from the Ministry of Agriculture (or other ministries) to cut down or even remove dead limbs from mainly coniferous trees. This not only constrains measures to prevent forest fires, e.g. thinning, but also discourages tree planting in general. Outdated infrastructure[29] and understaffing, compounded by the lack of cooperation between ministries, has resulted in a fragmented public sector unable to efficiently respond to applicants requesting forestry-related permits. In addition, pervasive rent-seeking behaviour, e.g. extracting bribes, has also weakened Lebanon's public institutions and undermined any efforts in building public trust (Svensson 2005; MOIM 2011). Consequently, rejected applicants seeking such permits could (and often do) obtain them from another ministry[30] (*pers. comm.* AFDC, July 2012), especially if they have special privileges or connections.

Public opinion in Lebanon tends to favour reforestation. A reason for this could be attributed to 'historical fidelity' (Cole et al. 2010); a general belief that the country at one point in time was predominantly covered in forests, which are now lost. While reforestation accounted for 23% of environmental activities reported from 1994-2002 (Djoundourian 2009)[31], such efforts in post-war Lebanon appeared to be sporadic in subsequent years, suggesting that these efforts are strongly linked to the economic and political stability of the country. Sattout et al. (2007) provided evidence of strong public support for protecting cedar forests in Lebanon based on a recent stated preference study indicating willingness-to-pay for non-use values of these forests. However, this support was predominantly for Lebanese cedars

[29] Most documents are still paper based.

[30] Ministries of environment (MOE), energy & water (MOEW), and interiors & municipalities (MOIM).

[31] These were indexed as number of activities, seminars, workshops, publications, etc. recorded monthly.

(*Cedrus libani* Rich.) given the symbolic and cultural significance this species has to Lebanese citizens. The authors of that study further stated that research is needed to move beyond focusing on single species to one that broadly encompasses forest ecosystems. While there are a substantial number of native trees and shrubs that can be used in reforestation in Lebanon, only a limited number are used[32]. There are no clear indications as to why, but one assumption may be the lack of familiarity with most native species by the general public. Another possibility might be their availability in private nurseries. In response, some NGOs and research centres with interests in conserving forest biodiversity have recently published books and technical manuals on the propagation and planting of various indigenous tree species (chapter 4). Similarly, a small number of private nurseries have begun producing a variety of native species that were previously unavailable, largely incentivised by those NGOs and research centres (*pers. comm.,* LRI, June 2012).

1.5.8 Reforestation Stakeholders in Lebanon

Public and private sector stakeholders in Lebanon sharing similar concerns over historic deforestation have given considerable priority towards funding re/afforestation efforts over the last few decades. The Lebanese government intends to increase forest cover from 13 to 20% (an increase of roughly 73,000 ha) over the next few decades through active replanting, mainly targeting ‘other wooded lands’ (Regato and Asmar 2011). This ambitious goal raises some important questions pertaining to policy and management decisions. Yet no rigorous evaluation has been conducted to calculate the costs of establishing planted forests or how to account for natural regeneration of forests taking place on abandoned private farmlands in many parts of the country. There are also numerous technical and social challenges for ensuring acceptable rates of tree establishment, from planting and maintenance to measures for ensuring protection of trees (which also includes establishing secured tenure). Aside from these, there are also critical issues pertaining to biodiversity and ecosystem services that includes examining the potential effects large-scale re/afforestation (or plantations) may have in ecologically sensitive areas such as IPAs. Below I present the main stakeholders involved in Lebanon’s past, present and future reforestation efforts (please see Appendix 1.1 for the matrix of reforestation stakeholders).

[32] Some endemic tree and shrub species to Lebanon include three-lobbed crabapple (*Malus trilobata*), Lebanon oak (*Quercus libani*), and Lebanese willow (*Salix libani*).

Ministry of Agriculture's 'Green Plan'

The first major national reforestation campaign in Lebanon was conceived in 1959, led by the Ministry of Agriculture in partnership with the Lebanese Army and FAO consultants. The 'Green Plan' (MOA/GP) was launched in the early 60s as part of a national effort to improve the Lebanese highlands through land rehabilitation, irrigation and large-scale reforestation[33]. In addition to 14,200 ha of land rehabilitated (or re-terraced) from previous land-uses (e.g. old wheat fields and rangelands), there was the objective to reforest some 142,000 ha of mountainous landscapes over a 20 year period (Regato and Asmar 2011). Large-scale tree nurseries were established with the help of foreign funding and technical aid, mainly from the British and French governments, to facilitate the production of millions of saplings (predominantly conifers). With the help of the Lebanese army and volunteers from civil society, reforestation activities took place in terraced mountainsides from Bcharre in the north to the Shouf mountains further south (Mikesell 1969; Chaney and Basbous 1978). Yet these efforts ceased shortly after the start of the civil war in 1975 with only a fraction (around 2,000 ha) of the proposed area planted (Regato and Asmar 2011).

National Reforestation Plan (NRP)[34]

Both the ministries of environment (MOE) and agriculture (MOA) share forestry related responsibilities. The former was allocated funds towards large-scale tree planting campaigns under the National Reforestation Plan (1998 – 2013). However, reforestation activities were traditionally the responsibility of the MOA (e.g. the Green Plan described above), who until recently, have focused solely on enforcing protective and regulatory measures (e.g. forestry guards, issuing harvesting permits) in public ('State') forests and rangelands. They are also responsible for managing forest tree nurseries (most of which are in need of renovation) and distributing seedling to municipalities. On the other hand, the MOE, along with a growing number of non-governmental organisations (NGOs), are undertaking reforestation in municipal lands (*mesheaa*) with municipalities and, in some case, with local associations.

[33] Established as a Decree No. 13335 on 07 October, 1963 (MOA 2014).

[34] Details of this section were acquired from interviews with stakeholders from the MOE and MOA at various phases between October 2011 and July 2012. However, permission was not granted (and consent forms were never signed) from those higher up in the MOE for conducting formal semi-structured interviews with project staff.

The Directorate General of Environment of the Ministry of Environment (MOE) was given the mandate and funds (UN-GEF and Lebanese Government) for executing all reforestation activities in Lebanon from 2002-2012. They commissioned a multi-phased project coined National Reforestation Plan (NRP) with an overall target to plant 200,000 ha (roughly 20% of Lebanon's surface area) over the next 3-4 decades, incorporating villages from each of the 26 districts (*cadat*). In the first two phases, all aspects of reforestation were subcontracted through biddings in which 3rd party agents were then required to plant in public (state or municipal) lands and manage seedlings for at least 2 years.

Following mixed results and with less than 700 ha being subcontracted by the end of 2004, the MOE recognised the need for incorporating municipalities as agents. They adopted an incentives-based approach in the last phase (2008-2013) of its NRP. A 'payment for reforestation' scheme was developed that offered conditional payments for the planting and care of seedlings for a duration of two years to heads of municipalities in around 60 villages. A budget of US$2,225,000 was allocated for the last phase, half of which was covered by UN-GEF and the other half was in-kind contributions by the Lebanese government. Since permission was not granted to obtain quantitative data on which municipalities the MOE selected, it was difficult to determine planting and survival outcomes or obtain feedback from mayors on the programme. However, a brief overview of Phase III of the NRP was presented by my informants[35] as followed:

1. formal call for participation was sent via fax to all municipalities (> 900) from the MOE headquarter with over 200 responses
2. municipalities were short-listed based on previous reforestation efforts[36] and were required to provide cadastral maps of their municipal areas and attend a workshop
3. municipalities selected for the program were required to provide a purchasing order or invoice of saplings purchased from 'designated tree nurseries' in order to receive first payment (conditionality 1)
4. subsequent monitoring sessions were conducted; the first directly following the planting to assess planting outcomes and the second the following year to estimate survival, respectively; and payments were made based on outcomes (conditionality 2)

[35] Project manager for the NRP at the MOE (interviewed in October, 2011).

[36] Municipalities that participated in previous reforestation efforts with the MOE were not eligible.

The payment scheme was based on a 60-20-20 format, where 60% would be paid up front once the municipality had submitted a plan (e.g. cadastral map of planting area, number of seedlings, and purchase order/invoice for seedlings). The second payment (20%) would be paid based on planting results and the last payment (20%) based on survival results after monitoring in the second year after planting. Requiring that municipalities provide a copy of the purchase order was a criteria for receiving payments as a measure to ensure that only forest (and not fruit) trees were planted. In addition, municipalities were required to purchase seedlings from local commercial nurseries rather than acquiring them by other means, e.g. gifts.

While it is not clear whether or not the Ministry of Environment will continue with its reforestation programme, the Ministry of Agriculture has set forth its own forestry agenda for the coming years. However, political instability in the central government continues to hamper progress in forestry and other environmental sectors in Lebanon.

National Forest Programme (NFP)

The MOA is currently campaigning to produce 40 million forest saplings to meet its target for planting 70,000 ha. Similarly, it intends to increase forest cover from 13 to 20 per cent over the next 20 years. Entitled the "National Afforestation Program", the Ministry's forestry policy aims "to encourage investments towards stimulating economic functions of forests, to enhance the value of biologically diverse forests, both aesthetically and environmentally" (translated from Arabic, see footnote #37). They identify eight 'benefits' (or ecosystem services) that are recognised as important goods and services provisioned from forest and other woodlands (OWLs)[37]:

1. Biodiversity Conservation
2. Ecotourism and recreation
3. Soil and water conservation
4. Fuelwood and charcoal
5. Pine nuts production
6. Medicinal, aromatic, and edible plants
7. Honey production
8. Mitigate impacts of climate change

[37] Found on the News and Events web page of the Ministry of Agriculture (MOA 2015).

In terms of reforestation, there was no mention of whether the order of these benefits listed is hierarchical and even less clarity on the kinds of trees and their proportions that would need to be produced and planted for provisioning these ecosystem goods and services. The title of the program, on the other hand, suggests that the objectives are leaning more towards afforestation, but it is unclear whether they foresee having enough public or municipal land to plant trees on.

At present, the MOA (despite at the time of this study having no financial means of performing extensive reforestation) have been conducting small-scale pilot projects to test new planting techniques. However, under the developing NFP, the MOA is exploring various financial mechanisms, such as PES and CDM, to finance its forestry efforts (*pers. comm.* C. Mohanna, 2011). Additionally, the Ministry is working towards developing a National Forest Center and various local extension offices in order to provide training on mapping, reforestation and forest management.

In the meantime, the majority of reforestation is being undertaken by a small number of NGOs in Lebanon. These NGOs have contributed tremendously to reforestation efforts over the last few decades. There are three major reforestation NGOs working at the national level: 1) Association for Forests, Development & Conservation (AFDC), 2) Jouzour Loubnan (JL), and 3) Lebanese Reforestation Initiative (LRI). Organisations working at the regional (or district) level include Al-Shouf Cedar Society (Shouf Mountains) and Association for the Protection of Jabal Moussa (APJM). Other NGOs and community-based organisations (CBOs) working at the village level include Cedar Friends (Bcharre municipality), TERRE Liban (Baabda Forest area), and Reforest Lebanon (Qalayaa municipality, South Lebanon).

Figure 1.7. Community tree planting event organised by the Nature Conservation Centre of the American University of Beirut (AUB-NCC) in the village of Ain Zebde, West Beqaa.

In addition, specialised tree planting initiatives, such as the Nature Conservation Center of the American University of Beirut (AUB-NCC), have emerged to promote biodiversity conservation and community involvement in reforestation efforts (Figure 1.7 and Figure 1.8). Many of the NGOs mentioned have also recently begun to engage in more biodiversity-oriented reforestation efforts, which includes the diversification of species and types (e.g. shrubs) produced from seeds sourced from the wild[38]. National-level NGOs and research centres have also begun partnerships with other local organisations and private nurseries to provide expertise and new technology to improve the quality of tree production and knowledge of those species. At present, there are about nine forest tree nurseries producing a variety of native species that were previously not available.

[38] Both AUB-NCC and AFDC have published materials to inform the general public about Lebanese native species, their uses and production, in order to promote the diversification of indigenous tree species (Navarrete-Poyatos et al. 2011; Talhouk et al. 2014). The latter has recently partnered with the IUCN, which has helped to encourage a move away from plantation-type reforestation to produce and plant other species besides stone pine and cedar.

Figure 1.8. Restoration of a biodiversity corridor in the Chouf Cedar Reserve led by the Nature Conservation Centre of the American University of Beirut (AUB-NCC) with volunteers from the Lebanese Scouts Association.

1.5.9 Forest Cover vs. Tree Diversity in Reforestation

An important objective for informing policy is to identify trade-offs and synergies between agricultural development, forestry and biodiversity conservation. Agricultural development projects are partially subsidised by the MOA's (current) Green Plan, where landowners are offered financial and technical support for infrastructure (e.g. terraces, irrigation, and trees). Additionally, there are internationally funded projects in various 'poverty pockets' in the country ranging from canalisation and constructing of farm roads along with farm-scale infrastructural improvement, e.g. terracing, irrigation networks, and integrated pest management (*pers. comm.* ADELNORD, 2012). However, there are fewer incentives to landowners for planting forest trees other than those that produce commodities, e.g. nut-bearing trees.

There are important alternatives to consider in restoring forest ecosystems to generate more goods and services. For instance, the use silvicultural species that are easy to propagate (be they native or exotic) can help establish well-functioning ecosystems while also creating habitats for other species. Silvicultural species may also be more cost-effective (and potentially take less time to establish) than reforesting with diverse, poorly known natives that are well-suited, require fewer inputs, and have better survival rates. While the evidence I have come across varies considerably, there are valid arguments pointing to cost-effective restoration using silvicultural treatments that also help create habitats for biodiversity, particularly in heavy degraded ecosystems (e.g. Lugo 1997; Hartley 2002; Brockerhoff et al. 2008)[39]. However, in the case of Lebanon, silvicultural practices are virtually non-existent and further hampered by current policies (Law 85/1996), which prohibits the cutting or removing of native conifers (chapter 2)[40]. If these laws were to be amended or relaxed in the future, it may encourage more silvicultural activities in the country, particularly in the Beqaa Valley. Yet given that stone pine (*Pinus pinea* L.) is the main plantation species in Lebanon, and that its management often requires clearing any understory vegetation (including native shrubs) for ease of collecting cones (*pers. comm.* K. Slim, 2012), it would seem unlikely that land managers would plant rarer native species under the canopies of these forests without incentives (e.g. payments).

Finally, some stakeholders expressed concerns and even objected to the recent policy trends pushing for large-scale reforestation in the country, especially with regards to the limited kinds of species being used (*pers. comm.* AUB-NCC, LRI, AFDC, 2012). Moreover, while goats are considered a major threat by reforestation stakeholders, others view them as providing beneficial services (e.g. fire prevention) if grazing were managed properly. Prioritising landscapes in need of restoration is also being overlooked in the policy sphere. For example, little attention has been paid towards restoring quarries using methods other than reforesting with trees, such as seeding with native shrubs and other perennials (Khater and Arnaud 2007; Darwish et al. 2010b). Hence there are numerous challenges faced and

[39] Although in most Mediterranean climate-types, poor soils and extreme climatic conditions (low precipitation and very hot, long summers) often requires using drought-tolerant silvicultural species, while caution should be taken on the use exotic species that may have long-term ecological implications on ecosystems (Gritti et al. 2006).

[40] Moreover, Lebanon imports virtually all of its timber products from abroad mainly for furniture production in Tripoli (*pers. comm.* MOA, 2011). Wood harvesting is usually done for the production of charcoal and household firewood in more rural areas, particularly in forest-dense areas such as Akkar and Dinniyeh (IPA# LB-07 in chapter 2).

objectives to fulfil with respecting reforestation in Lebanon, and one critical aspect of that involves trade-offs between increasing forest area (or cover) and enhancing biodiversity.

1.6 Overview of the Thesis and Research Questions

The undersupply of environmental goods and services necessitates devising institutional mechanisms for internalising externalities, and Payments for Ecosystem Services (PES) is a potential strategy for correcting these market failures. As discussed, public and private sector reforestation stakeholders in Lebanon are investing heavily in reforestation efforts to meet ambitious forest cover targets over the next few decades. Most of the concerns are cost-related, given recent experiences with suboptimal tree survival, and interests in exploring cost-effective incentives-based strategies like PES have increased. Other concerns are environmental, particularly with respect to the limited number and proportions of forest species used in re/afforestation. I therefore set out to investigate how to design asset-building PES that would incentivise planting and managing an appropriate mix of native tree species as an institutional measure for enhancing biodiversity in reforestation efforts.

My study areas were located in highland villages within Important Plant Areas (IPAs) along the Mt Lebanon chain. In chapter 2, I examined the potential for incentives-based reforestation targeting municipalities within nine of Lebanon's 20 IPAs. I employed semi-structured interviews to engage local authorities, key informants, and residents in dialogue about the prospects for and constraints on reforesting municipal lands. In chapter 3, I conducted a mixed-methods survey with landowners from 17 villages within those IPAs to gauge their willingness to accept reforestation incentives of varying degrees of conditionality. In chapter 4, using online surveys, I asked 34 stakeholders from Lebanon's public and private sector institutions to rate 22 native forest trees in order to derive a list of native trees considered to be of high conservation value in reforestation. In chapter 5, I employed this list of mixed-native species as one of three reforestation options in a choice experiment conducted with landowners in the Bcharre-Ehden IPA in North Lebanon. The choice experiment was aimed at estimating the trade-offs between diversity (number of species used) and extent (or area of forest increase) in reforestation, producing a production possibility frontier. Finally, in my discussion (chapter 6) I review key findings relevant to PES policies in a global context and conclude with some recommendations for Lebanon's reforestation stakeholders.

2 Prospects for Designing Biodiversity-Enhancing Reforestation Incentives with Highland Municipalities in Lebanon

Many of the costs and benefits of environmental management are felt locally, therefore local governments can be important actors and often have substantial landholdings. As administrative decentralisation efforts continue to progress in Lebanon, national stakeholders have begun exploring ways to incentivise municipalities to reforest municipal lands in an effort to increase its current forest cover by 7%. Reforestation in Lebanon faces threats from grazing while concerns have been raised about ecological impacts of reforesting with a limited number of species. In this chapter I examine the prospects for involving municipalities in native species reforestation efforts by asking *how promising are municipalities as ecosystem services suppliers through biodiversity-enhancing reforestation?* A conceptual model was developed to identify opportunities and constraints based on institutional and biophysical attributes of villages (with municipal governments) in my sample. Semi-structured interviews were conducted with local authorities, experts, and residents from a stratified sample of 48 highland villages located within Important Plant Areas along the Mount Lebanon range. The results indicated that few municipalities in the sample had sufficient or suitable municipal land for reforestation. For those that do, most are rangelands that are difficult to guard from grazing, and transactions costs are expected to be high given their remoteness. Unclear tenure, principal-agent dilemmas, patronage politics and the potential for crowding out pro-environmental behaviour are the main socio-institutional constraints in designing reforestation incentives for municipalities. Policy constraints also hamper effective forest management in municipal lands leading to dense woodland thickets and increasing the risk of forest fires. Biodiversity-enhancing reforestation incentives should be targeted towards municipalities that have enough suitable land with clearly defined cadastral boundaries and mechanisms for monitoring to ensure tree retention. Since these are rare, alternative strategies, including contracting directly with private landowners, should be explored.

Keywords: biodiversity; land tenure; local government; native species; natural resource management; incentives; Payments for Ecosystem Services; semi-structured interviews; SWOT analysis

2.1 Introduction

Many developing countries have been decentralising responsibilities, including over natural resources, to local-level governments over the last few decades (Larson 2005; Agrawal et al. 2008). National-scale re/afforestation initiatives often gain a lot of public support and funding, yet objectives are often political and short-sighted (Ribot et al. 2006). Since the costs and benefits of environmental management are felt locally, local governments are therefore important stakeholders in re/afforestation. Establishing new forests in Mediterranean climates require long-term management where underestimating maintenance costs and effort result in poor outcomes and mortality of saplings (Scarascia-Mugnozza et al. 2000; Vallejo 2005). Decentralising forest management responsibilities and decision making to local authorities therefore requires providing technical expertise to administrations that may not have prior experience in reforestation. Furthermore, ensuring long-term tree retention requires well-developed local institutions involving participation from members of the community that go beyond those of political terms of local administrations (chapter 1).

Governments, international agencies and NGOs have begun adopting incentive-based mechanisms such as payments for ecosystem services (PES) aimed at directly paying people to plant, manage and conserve forests (Larson 2011; Barr and Sayer 2012). PES initiatives geared towards reforestation efforts often frontload planting costs while using productive trees to help cover long-term maintenance costs (Hegde and Bull 2011). Some studies have shown that plantations of mixed native species can produce viable economic and environmental benefits (Bremer and Farley 2010; Piotto et al. 2010). However, PES can potentially incentivise monoculture plantations with narrower objectives, ultimately threatening biodiversity and other ecosystem services (Bäckstrand and Lövbrand 2006; Boyd 2010; Cao 2011). One of the overarching challenges with PES includes increasing high-conservation-value species used in reforestation, especially since many of these species offer few private benefits. There are also many challenges and constraints in designing biodiversity-enhancing PES with local-level governments. Recognising these social, institutional and ecological (or biophysical) constraints can help for more effective targeting of biodiversity-enhancing reforestation incentives.

2.1.1 Socio-Ecological Dimensions of Payments for Ecosystem Services

Numerous social and ecological factors determine the effectiveness of Payments for Ecosystem Services (PES). Insecure (or unclear) tenure and ownership often have undesirable implications for PES outcomes (Swallow and Meinzen-Dick 2009; Bennett et al. 2011). For example, parallel regulatory (institutional) measures that restrict access (e.g. protected areas) may conflict with decentralised institutional arrangements secured under PES contracts (Ferraro 2011). On the other hand, the lack of parallel (or coercive) institutional measures for ensuring that property rights are protected, particularly in remote and difficult-to-police areas, obstruct the efficacy of PES (Börner et al. 2010)[41]. PES can also result in perverse incentives such as legitimising illegal land-use practices, and 'crowding out' embedded social institutions such as norms, values, and local rules (Van Hecken and Bastiaensen 2010a). These factors have implications for the cost-effectiveness of schemes by raising transaction costs (e.g. costs of monitoring and enforcing compliance) and increasing leakage (Vatn 2010; Muradian and Gómez-Baggethun 2013). PES contracts may have lower transaction costs if geared towards private landowners who are sole decision-makers (Engel et al. 2008). Yet socio-institutional problems can exist even when contracting parties are minimised to a single 'buyer' of ecosystem services (ES) and a single 'supplier' of those ES (Van Hecken and Bastiaensen 2010b). Some of these problems are rooted in agency theory that I discuss below.

2.1.2 Principal-Agent Framework

Agency (or contract) theory examines the relationships and interactions between transacting parties (groups or individuals) based on a set of formal institutional agreements, e.g. terms and conditions, developed by the parties (Laffont and Martimort 2002). The principal-agent framework therefore can be simplified as any given individual (or 'principal') seeking a good or service from another individual (or 'agent') willing to provide those goods and services in a voluntary market (Laffont 2003). Incentives are what drive transactions between principals and agents (Holmstrom and Milgrom 1991). PES and related incentives-based mechanisms are sometimes analysed from a principal-agent framework (e.g. Hanley et al. 2012), in that at least one principal (or 'ES buyer') is willing to pay (or compensate) a potential agent (or 'ES supplier') for a good or service rendered. In the case of PES, this entails conditional payments for an incremental supply[42] of a well-defined environmental (or ecosystem) service (Wunder 2005).

[41] While institutional measures may obstruct the efficacy of PES in some contexts, it is evident that markets need strong and supportive public institutions particularly for public goods-related PES (Wunder et al. 2014).

[42] The theoretical definition of additionality is where it is assumed that no incremental increase in supplies of a given ES from a given baseline would have occurred in the absence of the incentive (Pattanayak et al. 2010)

Transactions under imperfect markets also involve hidden costs due to incomplete or asymmetrical information, potentially resulting in moral hazard (or risk-taking behaviour) and conflicts of interest (Bolton and Dewatripont 2005). PES contracts inevitably incur variable transaction costs resulting from principal-agent dilemmas (e.g. costs of monitoring). One of the main challenges for ensuring efficiency in PES schemes is to keep these costs to a minimum. Studies on PES and related mechanisms (e.g. conservation contracts) have addressed principal-agent dilemmas when buyers lack sufficient information about ES suppliers' actions (Shogren 2005; Ferraro 2008; Zabel and Roe 2009; Ando and Chen 2011). Asymmetric information surrounding tenure and property rights are common principal-agent problems, as are biophysical characteristics of property under a contract that may be strategically withheld, such as natural regeneration or existence of rare species (Shogren 2005). In the latter case, information on existing land-use and land-cover is needed in order to measure additionality of biodiversity or other ecosystem services over time.

2.1.3 Perverse Incentives and Crowding-Out

PES can result in unintended consequences that reduce rather than increase environmental benefits, thus acting as perverse incentives. For example, if a criterion under a PES scheme is for land managers to plant a certain number of trees, there is the potential to incentivise the clearing of existing forests if the agent's land already has trees or natural regeneration occurring (Pagiola et al. 2004a; Lamb et al. 2005; Montagnini and Finney 2011). In addition, PES schemes lacking mechanisms for conserving biodiversity may incentivise the planting of inappropriate species or mono-cropped plantations in ecologically sensitive areas (Niesten et al. 2002; Barr and Sayer 2012; Pandey et al. 2014). Perverse incentives are almost impossible to eliminate, but are exacerbated by poorly designed policies or contracts that lack institutional measures for targeting, monitoring and enforcement (Vatn 2010; Pattanayak et al. 2010). Similarly, incentives also have the potential to 'crowd-out' existing pro-environmental behaviours. Several studies have shown how PES and related incentive-based mechanisms have the potential for crowding out pre-existing altruistic motives, such as environmental stewardship, which have repercussions for long-term participation and sustainability (Frey and Jegen 2001; Bénabou and Tirole 2005; Fisher 2012; Kerr et al. 2012; Rode et al. 2013). The difficulties in specifying desirable outcomes, such as reducing the risks of perverse incentives and crowding out, are principal-agent problems themselves.

2.1.4 Elite Capture

Elite capture has been a contentious issue referred to in many case-studies involving decentralised NRM[43] (Iversen et al. 2006; Saito-Jensen et al. 2010). An example relates to efforts to decentralise REDD+ schemes that have been met with resistance from political elites in central governments seeking to capture the majority of the (financial) benefits from such schemes (Sandbrook et al. 2010). Issues with equity and fairness as a result of elite capture have also been raised in recent literature on PES, especially where payments are allocated to groups (Sommerville et al. 2010; Clements et al. 2010; Muradian et al. 2010; Dickman et al. 2011). It is also possible for local elites to abuse their social (and political) capital by siphoning off benefits from social or environmental projects, thus creating opposition towards such initiatives by other members of the community (Woolcock 1998). While donor agencies require mechanisms for ensuring funds reach the right beneficiaries (Platteau 2004; Dasgupta and Beard 2007), reducing elite capture under REDD+ and community-based PES will likely depend on how well decentralised institutions deal with land tenure and use rights (Larson 2011).

2.1.5 Political Patronage

Political patronage refers to a type of social obligation involving client-patron relations. Much like elite capture, patronage politics are subject to local norms and customs, frequently involving rent-seeking behaviour, and largely driven by political forces and alliances (Ribot et al. 2010). Exchanging of favours and gifts, as well as allocation of local public goods, are common strategies employed by political incumbents (or parties they represent) to ‘buy’ votes (Moser 2008). Patronage is not exclusively related to political factions, but also includes social networks of patronage. Mosse (2001) described how donor-driven programmes implemented by NGOs in India developed strong patronage relationships with villagers in order to ensure their participation and timely delivery of the programme’s objectives. Social and political capital play an inherent role in patronage politics, which often shows path dependency and can influence policy outcomes (Putnam et al. 1994; Woolcock 1998).

[43] I consider decentralised natural resource management (NRM) as the managing of existing forests as well as the planting and managing of new forests by local-level organisations (including municipalities) on non-private lands.

Patronage politics could also undermine decentralised decision-making by local (e.g. municipal) authorities, particularly where NRM is concerned. Self-interested political actors may seek to establish strategic ties to patronage networks that are not in accordance with others in their administration or constituency (Klopp 2012). Case-studies examining NRM have shown that patronage politics interferes with democratic decision-making processes, hindering local institutional development and further weakening existing institutions (Mwenda and Tangri 2005; Larson 2005; Nelson and Agrawal 2008). Decisions surrounding access to natural resources are largely influenced by those in control of local government, but tend to favour local over outside interests in some developing countries (Kaimowitz et al. 2001). External agencies have begun to recognise the prospects of working with local rather than national governments, which may then have implications (positive or negative) for patronage networks as well as elite capture by national stakeholders.

2.1.6 Biophysical Constraints

Availability and suitability of land is the main limiting factor for participation in re/afforestation (or other kinds of restoration) incentives (Zbinden and Lee 2005; Bastiaensen and Van Hecken 2009; Cole 2010). Trade-offs need to be considered when planting trees, and poorly thought-out re/afforestation programmes could potentially have adverse impacts on other ecosystem services and local biodiversity (Sayer et al. 2004; Alrababah et al. 2007; Cao 2011; Whitfield et al. 2011). Targeting incentives for restoring degraded lands seems logical, particularly where there is evidence of high soil erosion and desertification. Yet these strategies are replete with their own set of risks and challenges (Bullock et al. 2011). While opportunity costs may be considerably lower in remote or degraded areas, other costs could be unexpectedly higher due to soil conditions, topography (e.g. slope and aspect) and accessibility. Unlike agricultural areas that have been worked through terracing and enrichment, re/afforestation may be too costly in semi-arid landscapes shaped by historical deforestation, extensive grazing and degradation due to exposure (Rey-Benayas et al. 2008). Having sufficient information on both land-use and land-cover characteristics is critical for estimating the potential costs and benefits of biodiversity-enhancing PES schemes on common property. Yet as discussed, obtaining the right information is both costly and challenging, particularly from local authorities who may not possess sufficient knowledge or experience in NRM.

2.1.7 Lebanese Municipalities

There are 963 Lebanese villages with municipal governments as of the 2009 municipal elections (MOIM 2010a). Municipalities are led by an elected mayor and appointed vice-mayor, secretary and treasurer, and consist of council members in the local administrations. The number of council members assigned is based on the population of voters in the village (MOIM 2011)[44]. Most villages with municipalities have both private and public land tenure, the latter split between municipal and republic land. Conversely, villages without municipal government (i.e. no cabinet/council members) have no registered municipal lands (*mesheaa* in Arabic). These villages are usually headed by another type of elected official called a 'mukhtar' with much less political or decision-making powers (Salem 1965)[45]. Some villages without municipalities have communal (or tribal) lands within property belonging to the republic (*amiri* in Arabic). Lebanon's Municipal Act (Decree law #118/1977) does not specify the roles and responsibilities of municipal administrations in managing municipal lands (MOIM 2010b), but rather a general requirement to protect the environment (Article 74, p. 29). With public attitudes towards forests conservation and expansion becoming more favourable (Sattout et al. 2007; Djoundourian 2009), national reforestation stakeholders[46] (or 'principals') have begun exploring PES as a viable policy instrument and municipalities have become the prime focus as potential reforestation 'agents'.

2.2 Research Questions

This chapter examines the advantages and disadvantages of incentivising biodiversity-enhancing reforestation activities with Lebanese municipalities within ecologically important areas (IPAs). Lebanese villages can be characterised as having certain institutional (social, economic and political) and biophysical attributes that either limit or permit desirable re/afforestation outcomes. Institutional factors include existing policies, socio-political dynamics (e.g. elite capture and patronage politics), and variable transaction costs contingent upon the principals and agents involved, competing land-uses, and property or access rights. Biophysical attributes pertain to land availability, remoteness, existing land-cover, climate, elevation, topography, and soil conditions. Some attributes are common to (and would

[44] Voters are not required to be permanent residents of their village, but vote according to the village they were born in (please see chapter 1).

[45] Please see chapter 1, section 1.5.1 for details.

[46] Public sector (MOA and MOE) and NGOs that are aligned with their interests (chapter 1).

therefore affect) all Lebanese villages, such as national policies, climate change and international markets. Others may only pertain to specific villages, such as local politics and decision-making behaviour, land-cover/land-use and degree of development. Institutional attributes could invite varying degrees of principal-agent problems, perverse incentives and crowding-out, thus affecting PES programmes. Within this context, I address the main research question and following sub-questions for this study:

1. *If incentivising reforestation efforts at the village level, how promising are municipalities as suppliers of biodiversity-enhancing reforestation?*
2. *Which municipalities are most suitable for incentivising through PES and why?*
3. *Is current policy and its implementation favourable towards reforesting non-private lands, and if not, how can this be improved and what are possible alternatives?*

In section 2, I present the methods employed for obtaining descriptive and qualitative data and conducting qualitative analysis on issues pertaining to tree planting at the village level. Section 3 follows with results and discussion where I present the three outcomes relating to themes and attributes introduced. I conclude with some general recommendations and future prospects.

2.3 Methods

2.3.1 Selection of Research Sites

Natural and semi-natural habitats within Lebanese IPAs face numerous threats, largely from urban development (Yazbek et al. 2010). Of the twenty, I excluded five smaller IPAs along the developed coast which have little reforestation potential, one (LB01) with average elevation above the tree line (> 2,500 m), and IPAs (and parts of IPAs) in regions with high security risks. These included five IPAs within the Beqaa Valley, a riparian IPA bordering the northern border with Syria (LB06), parts of the Qammouaa-Dinniyeh-Hermel IPA (LB07) in North Lebanon (Akkar and Hermel districts) bordering Syria, and some villages within the Rihane IPA (LB20) below the Litani River in Nabatiye. The nine remaining IPAs included in the study stretch from the Akkar Mountains in North Lebanon to Nabatiye along the western ridge of Mount Lebanon (Figure 2.1). Their average elevation is approximately 1200 m.a.s.l. and villages within these IPAs are mainly located on the western slopes of the Mount Lebanon range. Most of the country's forests and protected areas lie within these nine IPAs, which also contain the majority of native tree and shrub species found in Lebanon (Tohmé and Tohmé 2007). Biodiversity-enhancing reforestation has the potential to reduce fragmentation through creating future habitats and corridors for wildlife (Honnay et al. 1999; Perfecto and Vandermeer 2010; Wilson et al. 2014) and this was the main justification for choosing these sites (chapter 1).

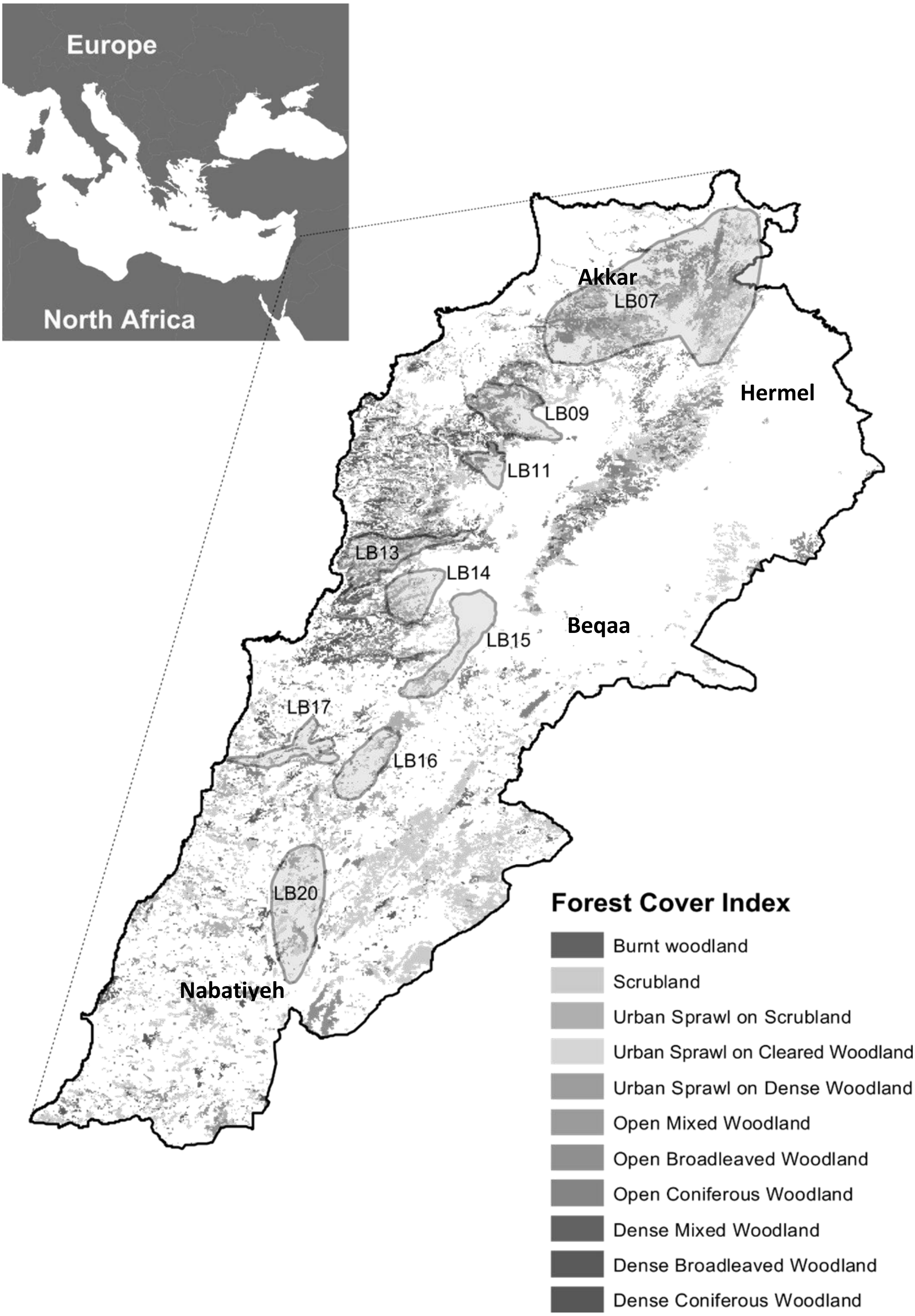

Figure 2.1. Land-cover map of Lebanon showing 9 of the 20 Important Plant Areas (Yazbek et al. 2010) within the grey borders.

I identified villages within the selected IPAs using Google Earth images embedded with IPA layers that were copied and transposed over administrative maps showing all villages with and without municipalities (MOIM-IFES 2010). After identifying all villages within and around the periphery of the nine IPAs, I then stratified them based on their associated IPA, administrative district, land area ('Size'), number of council members (used as a proxy for population size), average elevation, percentage of area within IPA, and rurality[47] (Table 2.1). Data on the number of council members, populations (based on the number of council members), and other information about the village (e.g. cultural and environmental features) were gathered from online sources (e.g. L'association du Local Liban 2009) and public documents.

Table 2.1. Stratification criteria for sampling of villages within Important Plant Areas (IPAs)

Strata	Details
IPA#	9 identified for inclusion
Villages	248 in total
Districts	14 in total
Size*	From 'very small' (1) to 'very large' (5)
Rurality	'very rural' (1); 'rural' (2); 'urbanising' (3); 'very urban' (4)
Ave. Elevation	central location of village
No. of Council Members†	None, 9, 12, 15, 18, or 21
% of village within IPA	< 25%, 25-75%, or > 75%

*Strata refers to relative land area that were subjective estimates based on 2-D maps and coded 1-5
† Used as a proxy for population

A total of 248 villages were identified within the nine IPAs (Table 2.2). Seventy-two villages within this sample did not have council members, and therefore no municipal governments. While I focused mainly on the villages with municipalities, I chose not to omit the rest given their frequency in the sample (nearly 30%). This was also motivated by the need to understand how decisions are made in villages without mayors or council members. However, only three were represented in the sample because of the difficulty in finding telephone numbers of most *mukhtars*.[48]

[47] Rurality is an attribute/variable that is independent from size (i.e. surface area); for example, a 'very rural' village is sparsely populated, remote, and had few buildings whereas a 'very urban' village is one that was densely populated, had many buildings, a commercial centre, hospital, etc.

[48] Villages from the Wadi Jannah IPA (LB13) were omitted due to sensitivities between the Jabal Moussa Biosphere Reserve stakeholders and local authorities of the villages. I therefore considered the potential ethical implications of conducting interviews that may reveal sensitive issues surrounding proposed reforestation in that region. A pilot interview was, however, conducted with the mayor of Zaytre.

2.3.2 Participant Recruitment

The main target group for this study were local authorities, which included mayors, vice-mayors, council members, and *mukhtars*[49]. In addition, I conducted interviews with national stakeholders in biodiversity conservation and forestry fields (e.g. public sector, NGOs, research institutions). These began with largely informal (unstructured) interviews that were conducted between October 2011 and June 2012 to help me understand the broader context of national reforestation objectives. I also conducted more in-depth, structured interviews with directors/project managers from the MOA and the main reforestation NGOs in that same period. Information from these interviews is cited in the results as personal communications.

Recruitment of the main target group involved contacting local authorities from the sampled villages by telephone and took place between May and June 2012. A standardised recruitment script was read by one of two field assistants with a brief description of the study and free prior informed consent was obtained orally. Meetings for interviews were then scheduled with participants at a location of their convenience. All respondents were reassured over the telephone that their participation was completely voluntary and confidentiality would be respected through anonymity[50].

The second target group interviewed were residents. The aim was to assess their involvement in (or perceptions of) tree planting activities in their village. Local participants were mainly farmers and non-farming landowners as well as key informants (described in Section 3.1). Key informants were referred to me by national stakeholders, municipal officials or other village contacts (through snowballing)[51]. A total of fifteen local residents were approached opportunistically (convenience sampling) while in the field and asked with prior informed consent to participate in a short interview. The research received ethical approval from both AUB's (Institutional Review Board) and Bangor University's ethics boards.

[49] Most villages with municipalities also have *mukhtars*.

[50] Please see Appendix 2.1 for a copy of recruitment phone script and consent form.

[51] I consider certain biases that this type of sampling could lead to for some research questions, e.g. would respondents chosen by municipal officials criticise the municipality? However, I believe interviews with national stakeholder helped to balance these biases.

2.3.3 Piloting and Initial Findings

Unstructured interviews were first piloted with the mayor and a *mukhtar* of a village in the Chouf region (LB16) in early spring 2012. Subsequent piloting of semi-structured interview questions was conducted with local authorities representing four randomly selected villages from different IPAs in April and early May of that year. This was followed by extensive fieldwork (formal and informal interviews, and field visits) carried out with field assistants in a village within the Qammouaa IPA (LB07). Residents and farmers from the Qammouaa region in the nearby highlands were also approached opportunistically and informally interviewed. Important insights from the pilot study not only helped determine appropriate follow-up or probing questions but also led to understandings of future research objectives.

2.3.4 Main Survey

Semi-structured interviews were designed to obtain quantitative and qualitative data on tree planting at the village level. Interviews aimed to gather data on tree species used, where trees/saplings/seedlings were obtained (and how), quantity planted, estimated planting area, and approximate survival rates[52]. Respondents were asked to provide us with the surface area of municipal lands (if known) and, where appropriate, average planting and management costs. Supplementary questions related to land-use/land-cover in the villages were also asked, such as grazing grounds, existing forest cover and estimated areas of abandoned agricultural land.

An important qualitative inquiry was asking all respondents to state any advantages and disadvantages they perceived in local reforestation. Local authorities were also specifically asked how decisions were made in their administrations with respect to species and site selection and what criteria (or incentives) would lead them to engage in tree planting with third party organisations. Subsequent questions were more hypothetical and aimed at gauging whether they would plant native species on municipal lands voluntarily if saplings were provided free of charge[53]. If they answered no, they were then asked whether they would participate in a hypothetical reforestation programme if they were paid to plant and manage trees. If they answered yes, they were asked where they would plant trees and why in those

[52] I determined whether or not tree planting had taken place recently based on responses from screening questions that I discuss in the following section 2.7.

[53] Many reforestation and conservation organisations have been providing municipalities with saplings.

specified locations. Lastly, they were asked what would happen to the land after it was planted, mainly who would be the responsible caretaker and who would be allowed (or prohibited) from using/entering these areas.

2.3.5 Data Acquisition

Over 80% of the interviews with local authorities were conducted in their villages while the rest took place at either their residences or offices in and around the capital Beirut. All interviews were conducted in Arabic by one of two trained field assistants in my presence. Interviews lasted between 25 minutes and one hour, although some also involved field-based observations guided by our respondents (e.g. to reforestation sites, areas affected by fires, etc.). We averaged around seven interviews per week from mid-June to August 2012 resulting in a total of 67 interviews (Table 2.2 in section 2.4.1 below).

2.3.6 Additional Data Sources

Preliminary quantitative data were obtained from telephone interviews during the recruitment stage. This included the estimated surface area of the village (within its municipal boundaries), and surface area of municipal land (or the area belonging to and managed by the municipality, if any). Respondents were also asked to give approximate figures (in ha) of abandoned agricultural land in their village (if known). Data were transferred onto a spreadsheet and served as a reference for cross-checking responses as well as debriefing and probing questions during interviews. Additional quantitative data gathered from interviews (e.g. surface area of reforestation, number of trees planted) were added later (Table 2.3). Some of this information was also available online or from grey literature (e.g. government portals, ministry or NGO websites, etc.).

2.3.7 Data Analysis

Audio-recorded interviews were transcribed from Arabic to English text by field assistants. Transcripts were reviewed to identify responses that needed clarification. A few randomly selected transcripts were reviewed by a colleague at the American University of Beirut's Nature Conservation Centre (AUB-NCC) to check for clarity. Transcripts were then uploaded onto Atlas.ti® (qualitative data analysis software), grouped according to respondent types, and later coded for grounded analysis (identifying themes and relationships). Coded themes included "Aims & objectives of tree planting", "Decisions made by mayor with municipal council", "Responsibilities of municipality". Code families (or 'nodes') were later created that grouped similar codes. For instance, under the family code "Environmental benefits of trees" are the codes 'landscape beauty', 'cleans the air', 'prevents erosion', and so forth. Codes were also created to identify species of trees planted, which were grouped as 'forest trees' (e.g. stone pine, cedar, oaks, etc.) or 'fruit trees' (e.g. apple, cherry, pear, etc.). The former group was also split between 'productive' (e.g. stone pines) and 'non-productive' (e.g. cedar) types. Qualitative responses to the advantages and disadvantages of tree planting were analysed heuristically to identify benefits and costs. The analysis also helped in identifying relationships and common themes through conceptual mapping and triangulation with other data sources, particularly policy papers.

2.4 Results and Discussion

2.4.1 Recruitment Outcomes

Ninety-six of the 248 villages identified within the nine IPAs were selected randomly (using dice rolls) from the stratified sample (Table 2.2). My field assistants were unable to reach a representative from the municipality in 32 of the 96 villages contacted by telephone (after at least three attempts). Of those contacted, ten were unable to participate due to the lack of their availability at the time[54]. Fifty-four of the 64 local authorities contacted by telephone all tentatively agreed to participate in the study with some referring us to meet with other representatives (e.g. vice mayor, council member, key informants, etc.). Of the 54 local authorities that agreed to participate, nine cancelled or were unreachable at the time of the interview. Thus a total of 45 local authorities (representing 45 villages) were interviewed: 36 were mayors, five were council members, three were *mukhtars* and one was vice-mayor. An additional 22 interviews were conducted with 15 local residents (eleven farmers and four non-farmers) and seven key informants, totalling 67 participants representing the 48 villages in this study. Key informants comprised heads of agricultural cooperatives, local experts, and professionals residing in (or originating from) their associated villages[55]. Amongst them was a forest guard responsible for monitoring and responding to forest-related issues (e.g. fires, issuing permits, etc.).

[54] Some were clearly uninterested but did not specifically say so while others suggested we meet with other village representatives instead.

[55] Three of those key informants were referred to us by local authorities and the rest by national stakeholder (e.g. NGOs and public sector).

Table 2.2. Sampling frame showing selection and recruitment process of stratified villages within associated Important Plant Areas (IPAs)

Important Plant Areas (IPAs) selected for study	No. of villages identified	No. of representatives of villages contacted (SRS)‡	No. of Interviews set with representatives	No. of villages in the sample**	No. of respondents interviewed
LB07 - Qammouaa	76	30	7	7	16
LB09 - Bcharre-Ehden	28	12	8	5	5
LB11 - Tannourine	6	3	1	1	2
LB13 - Wadi Jannah	32	1†	1	1	1
LB14 - Keserouan	18	6	5	5	4
LB15 - Sannine-Kneisseh	6	6	4	2	3
LB16 - Chouf	10	6	5	4	6
LB17 - Nahr ed-Damour	30	15	12	12	16
LB20 - Rihane	42	17	11	11	14
Total	248	96	54	48	67

* Some villages in these districts were omitted from the sample for safety reasons (based on FCO advisories)
**Where local authorities (e.g. mayors), key informants and/or residents were interviewed
‡ Stratified random sampling
† Originally 13 in the stratified sample but later omitted from the sample (please see Footnote # 50 above)

2.4.2 Village Tree Planting Details

The majority of planting campaigns at the municipal level were conducted in small areas of less than 3 hectares (13 villages). Four villages in our sample participated in the Ministry of Environment's National Reforestation Plan (NRP) and twelve other villages had partnered with third sector organisations (mainly NGOs) in tree planting efforts. Ten local authorities reported no reforestation activities in their villages. Mayors from six villages within the sample mentioned recent or ongoing reforestation of relatively large-scale (> 10 ha within municipal or republic lands, see Table 2.3) largely using Lebanese cedars (*Cedrus libani* Rich.). For example, 100,000 cedar trees were planted in the reserve of Ehden (LB09) within the last decade. More recently, the Lebanese Reforestation Initiative (LRI) funded the planting of some 70,000 cedars in the Tannourine reserve (LB11). In Kfardebiane (LB14), an estimated 30,000 trees, mostly cedars and some Grecian juniper (*Juniperus excelsa* M. Bieb.), were planted in 70 ha of fenced municipal land in partnership with Jouzour Loubnan (JL)[56]. Aside from having available municipal land, these villages also have (or are near) protected forests within nature reserves.

[56] A relatively new NGO with a focus on reforestation.

Table 2.3. Villages in the sample that have conducted reforestation in areas over 10 ha

IPA	Village	Est. area (ha)	Species	Partner	Date(s)	Details
LB07	Qobayat	70	Cedars	MOA-LA[1]	2008-2009	Air seeding on republic land
LB09	Ehden	> 10	Cedars	MOE-NRP[2]; JL[3]	Since 2003	Yearly planting in the reserve
LB11	Tannourine	> 10	Cedars	LRI[4]	2012	Plans to plant 60-70,000 seedlings in the reserve
LB14	Kfardebiane	70	Cedars & Junipers	JL	2010	Mentioned plans to plant 100 ha in 2012
LB16	Bmehray	40	Stone pine	None	2005	Planted in former sand quarries
LB20	Rihane	> 10	Mainly stone pine	Various	Since 2005	Some oak, poplar and walnut trees

[1] Ministry of Agriculture and the Lebanese Army
[2] Ministry of Environment’s National Reforestation Plan
[3] Jouzour Loubnan (an NGO)
[4] Lebanese Reforestation Initiative (an NGO)

While Lebanese cedars have traditionally been used in large-scale reforestation in the past (chapter 1), the most common forest tree species mentioned by the majority of interviewees, whether in terms of reforestation on municipal land, roadsides, or on private lands, was stone pine (*Pinus pinea* L.). Stone pines are highly valued for their kernels (processed pine nuts wholesale at approximately US$40/kg[57]) and planted extensively on municipal lands in the villages of Bmehray (LB16) and Rihane (LB20)[58].

Fifteen local residents (including eleven farmers) from 11 villages were interviewed on aspects related to reforestation (both public and private lands). Eleven mentioned tree planting in their villages that had taken place in the last 5 years conducted by their municipalities. The main types mentioned were stone pine, cedar and carob trees (*Ceratonia siliqua* L.). They mentioned economic benefits from productive trees, e.g. stone pine, chestnut (*Castanea sativa* Mill.), carob, and environmental benefits (mainly landscape beauty) as the main advantages of increasing forest cover. None mentioned any

[57] Recent spikes in demand compounded by labour scarcities has driven the costs of pine nuts up since 2010 (Weatherbee 2014).

[58] Although Bkessine (in LB20) contains the largest contiguous plantation of stone pine in Lebanon, no major reforestation efforts were mentioned there in recent years.

disadvantages with reforestation or forest trees, though at least five farmers expressed their discouragement with laws preventing them from removing wild trees growing on their property.

Over half the mayors interviewed also mentioned both economic and environmental benefits of trees as the main advantages of tree planting and increasing forest cover. In terms of environmental benefits, over 80% of local authorities interviewed mentioned increasing landscape beauty as an important motive for planting trees. Over a third specifically mentioned that trees play an important function as natural ‘filters’ by cleaning dust during the long, dry and windy summers. The economic benefits of trees mentioned predominantly referred to stone pine, which generates substantial revenues for municipalities managing plantations:

> *Concerning the [stone] pines, they are a source of incomes for the municipality that are used for the municipal work in the village; construction of roads, lighting … Stone pine generates 20,000,000 Lebanese Lira[59] [USD 13,330] per year for the municipality. Our annual budget totals 30,000,000 LL [USD 15,000], so it generates a large sum of our total [expenditures]. (P83)[60]*

As mentioned in chapter 1, public and private sector stakeholders expressed concerns over ecological impacts that monoculture plantations (e.g. stone pine) could have on forest ecosystems and biodiversity in the future. While efforts have slowly emerged recently to promote native species diversity in reforestation, the opportunity costs of diversifying are high since stone pine has significant private benefits in addition to other environmental services, such as carbon sequestration and landscape beauty.

2.4.3 Land Tenure and Transaction Costs

Aside from the challenges in promoting species diversification, interviews with national stakeholders (chapter 1) described various institutional factors that affect reforestation outcomes in Lebanon. Perhaps the most important relates to unclear tenure due to the lack of cadastral maps. Municipalities (and especially villages without municipal councils) from less-developed regions[61] are the most problematic in this subject matter. These issues have created

[59] 1,500 Lebanese Lira (LL) equivalent to 1 US dollar.

[60] These coded numbers are allocated for each respondent interviewed to maintain confidentiality and anonymity.

[61] These include more remote villages in Akkar and Dinniyeh districts (LB07).

conflicts between landowners and local authorities, especially where municipal lands are concerned. An official from the Ministry of Agriculture's (MOA) forestry sector stated that their department has been facing land disputes with residents due to outdated entitlements that used impermanent landmarks to delineate property, such as forest borders. He mentioned that it was not uncommon for landowners to cut into (or burn back) the boundaries of the forest in order to claim more property (*pers. comm.*, C. Mohanna, 2011). This was also evident from an interview with one of the respondents:

> *We have mesheaa [municipal land], but we don't have cadastral maps; so all the locals are building in the mesheaa... and all the mesheaa is managed by the private "owners". In general, each one has a part of the mesheaa. 70% of the locals are enlarging the areas around their houses as if this is their land! If [our municipality] wants to get [projects going] in these lands we'll enter into disputes with the locals. We are waiting for the cadastral maps because we don't want to get into conflicts with the villagers. (P52)*

These issues are further complicated by multiple categories of public lands, including variations of municipal property and lands belonging to the republic. One mayor, who also practiced law, explained that "all the *mesheaa* lands are private – every piece of land that has a cadastral number is private. The owners can be the community, family, or the Lebanese republic …" (P55). When asked about the total area (ha) of municipal lands in his village, another mayor explained:

> *There are many types of mesheaa. There is municipal land [in Arabic: '<u>mesheaa baladiyeh'</u>] that, like anyone who owns a plot of land, the municipality has a title deed for. It's very easy to register it under certain laws. There is the mesheaa of public residents ['<u>mesheaa 3oumoum al-ahāli</u>']; this is considered as ownership to the villagers… and it is managed by the municipality. Most of the forests are mesheaa but the municipality invests in them and the [revenues] generated[62] go to the municipality. (P86)*

Evidently, registering of public lands was also met with some resistance by local residents, and actually posed a risk to community tenure, as reported by a mayor here:

> *We don't have mesheaa because there are no cadastral maps. We don't know how much land belongs to the municipality or to the republic. The problem is that when [they[63]] come to survey this land and see that it's not being used and has some trees or shrubs, they'd consider it [republic land]. This is a problem for the residents because they would no longer be able to access or use the land. So the residents are*

[62] This was specifically referring to harvesting cones from stone pine plantations.

[63] Referring to surveyors, generally appointed by the Ministry of Interiors and Municipalities (MOIM) through the Council of Development and Reconstruction.

> *against the surveyors coming and would rather register the land as private so they can have access and use the land. (P53)*

Any attempts at incentivising municipalities or other agents to enhance biodiversity or other public ecosystem services requires taking into account the transaction costs resulting from insecure property rights, something addressed in many other studies (Boyd et al. 2007; Corbera et al. 2011; Lockie 2013). Perhaps the most important limiting factor pertaining to institutional attributes shared by the majority of the villages in this sample concerns transaction costs associated with tenure and opportunity costs of displacing land-uses. Roughly speaking, there may be an inverse relationship between opportunity costs (which may be highest on private lands) and transaction costs (which may be highest on public lands), though with considerable variation (Figure 2.2). Transaction costs are expected to be high in municipal rangelands if institutional mechanisms (e.g. herder fees or social fencing[64]) are not in place to prevent open-access grazing[65]. Communal rangelands that are on the property of the republic (*amiri*) may incur high transaction costs since they lack formal management regimes such as municipalities, yet would also depend on the effectiveness of the existing local regime[66]. However, transaction costs may also be considerably lower if users are relatively small and homogenous groups with local governance regimes in place, such as arrangements between tribal elders and herders that have rules-in-use (e.g. informal constraints).

[64] Social fencing is a term used to describe an institutional mechanism for delineating property boundaries without constructing actual fences (Saxena et al. 2003).

[65] I consider these as transaction costs as they are the costs of marking and protecting property rights.

[66] In the case of Dinniyeh (in LB07), this usually consists of a council of tribal elders.

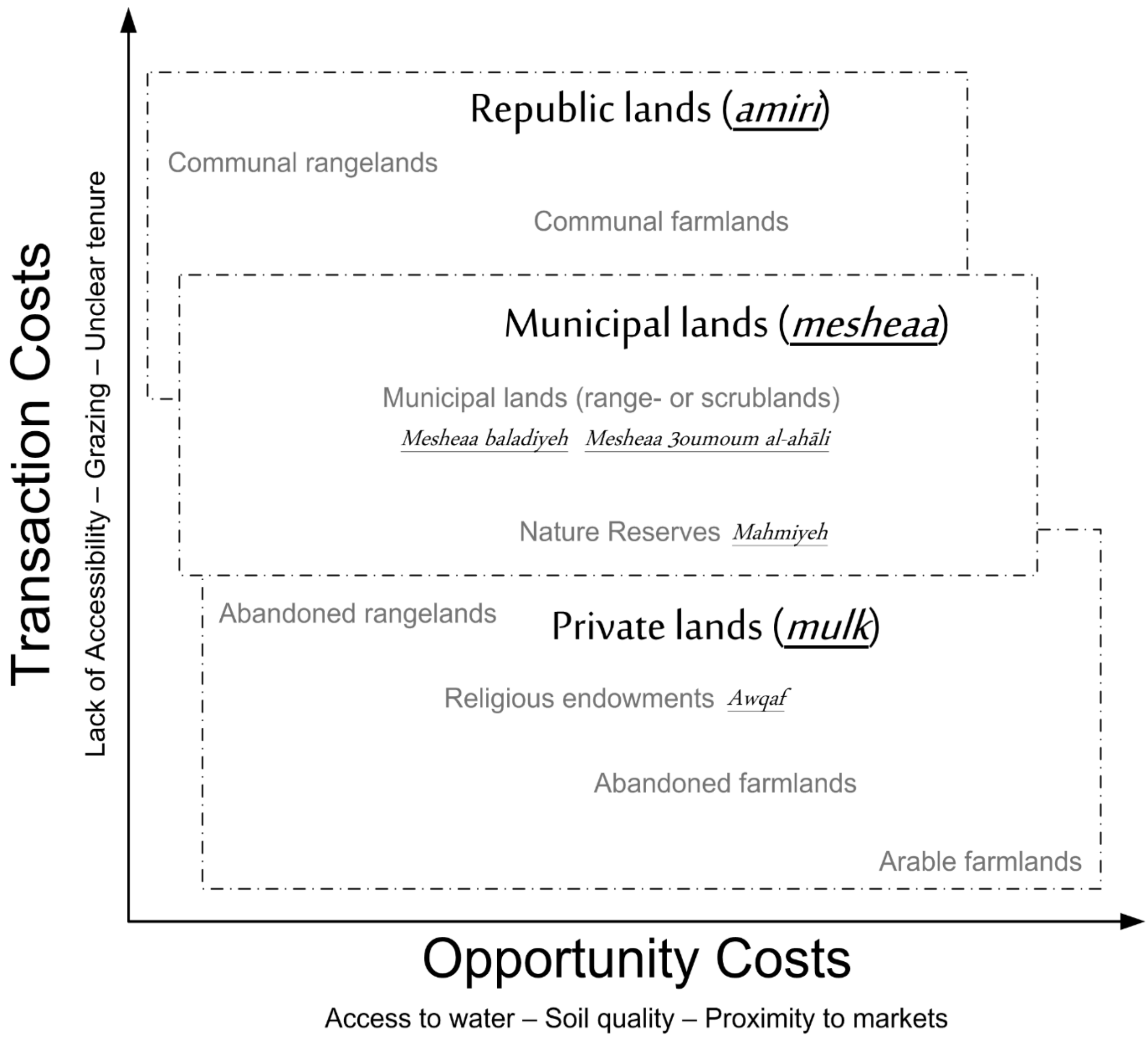

Figure 2.2. The main land tenure types in Lebanon arranged according to transaction and opportunity costs. Latinised Arabic names are underlined. Under this conceptual model, transaction costs in reforestation are likely to be higher in republic lands (open-access rangelands), with variable opportunity and transaction costs in municipal lands based on tenure, land-use and accessibility[67].

In my sample, four out of the twelve municipalities (see section 2.4.8) with land available for reforestation expressed concerns that they would likely face problems with tree retention. The main reasons mentioned were insecure tenure from lacking cadastral maps or that reforestation would result in displacing local herders' grazing grounds. Land tenure issues also stem from ambiguous land classification systems, which have been reported in carbon-based reforestation project in Africa as well (Unruh 2008). These issues ultimately require revisions to the land registry at different administrative levels. Evidently, limitations to

[67] Republic lands (*amiri*) are largely rangelands (*jurd*), but also contain some farmlands granted to tribal communities by the state (usually through the MOA). Municipal lands (can be rangeland or forest) that are the responsibility of municipalities are *mesheaa* (the two types above), but some also contain nature reserves or other protected areas (administrative responsibility of the MOE, but sometimes shared with municipalities). The two main classes of private land are religious institutions (*awqaf*) or private owners (*mulk khass*).

excludability from other land-uses when establishing new forests also exist, particularly with respect to herders and recreational users[68]. The long-term benefits of diverse native forests on municipal lands may require substantial short-term costs of establishment (up to 5 years or so). For future PES buyers in Lebanon (e.g. national stakeholders), transaction costs in monitoring municipalities for compliance and success could be significantly higher under circumstances where weak tenure and competing land-uses threaten tree establishment as discussed in other case-studies (Pagiola et al. 2002; Swallow and Meinzen-Dick 2009). Where the potential risks, e.g. trees damaged or destroyed from grazing livestock, are partially but not completely under the control of ES suppliers, PES initiatives become more vulnerable to moral hazard since it is difficult to observe suppliers actions.

Such issues surrounding tenure have further hampered effective forest management across Lebanon, particularly fire prevention measures at the municipal level. In this study some of the biggest threats to forests that mayors and other respondents pointed to were regulatory constraints prohibiting tree cutting and wood removal (Article 85, MOE/96). For example, a mayor from a village within LB07 expressed concerns with access in order to manage forests for preventing fires:

> *We are not benefitting from the forests on these lands, only benefitting from them from a visual standpoint. [Our municipality] doesn't have the ability to fight forest fires effectively because of water shortages and access [e.g. fire roads]. I wanted to bring workers to prune trees and open paths, but the government won't allow it since these lands belong to the republic. (P54)*

A similar lack of vertical cooperation between state agencies and local authorities is one of the principal-agent problems presented by Andersson's (2004) study of Bolivia's decentralised forestry sector. In Lebanon, these constraints are counterproductive to effective forest management. In contrast, adopting locally regulated coppicing and biomass removal (or thinning) has been shown to reduce the risk and magnitude of forest fires (Barbero et al. 1990; Allen et al. 2002). Villages in North Lebanon, particularly where Calabrian pine (*Pinus brutia* Ten.) forests dominate[69], have experienced extensive forest fires over the past few decades. Fires have been a natural part of Mediterranean landscapes (Cowling et al. 1996;

[68] Some respondents mentioned seedling mortality caused by snowmobiles and off-road vehicles.

[69] *Pinus brutia* is considered by many experts to be an extremely aggressive and proliferous species that largely occupies abandoned agro-pastoral lands in North Lebanon (Sattout et al. 2005).

Bond and Keeley 2005), yet it appears that many of those in Lebanon are caused intentionally:

> *There are lots of fires in the region because there are lots of forests. Each year we have forest fires between June and October. Since 10 years we've had an increase of forest fires… And the forest fires are 95% human-caused, where 50% are due to the negligence and 50% are intentional. (P95)*

Arson is not uncommon in other parts of the Mediterranean and often viewed as an act of protest in response to government policies, poor socioeconomic conditions, or both (e.g. Skouras and Christodoulakis 2013). Similar concerns were shared by other mayors further south. One mayor expressed his discouragement with current forest policies and poor infrastructure:

> *Imagine that in the biggest forested area in the village we don't have a centre for forest management. Each year we have two to three fires and we try to control them all by ourselves. Two years ago, a pine forests with an area of 1 km^2 located between [us] and two other villages, burned down because the civil defence couldn't reach the area [in time]. (P73)*

Lebanese institutions have been critically weakened since the civil war (c. 1975-1990) due to lack of oversight and accountability (Makdisi 2004). Given that many public sector offices are lagging in infrastructural improvements, compounded by political conflicts within parliament and between ministries, permits and licenses for managing forest even on private property are rarely expedited efficiently. For example, one mayor [P119] explained how a major forest fire that required the evacuation of residents from his and four surrounding villages could have been prevented if the MOA had granted a permit to trim the trees around the power lines that sparked the fire. Forest fires consumed over 4,000 ha of forest and "other wooded lands with trees" in 2007 alone; the vast majority (> 90%) that took place on private property (Fanous 2007)[70]. This constituted over half the area reforested during nearly two decades of the Green Plan (Regato and Asmar 2011).

2.4.4 Elite Capture

Participation, as discussed in the introduction, is perhaps the most complex factor in reforestation campaigns and related activities. The focus has been predominantly on mobilising the 'local community' to plant a substantial numbers of trees in public or

[70] This report states that "land owners tend to burn their lands in order to change their lands' classification to get permits to use their lands in different ways that were prohibited according to the previous classification" as one of the possible explanations to fires concentrated on private lands (p. 15).

communal areas (e.g. *mesheaa*). Yet post-planting costs are often underestimated by implementing agencies and borne by municipalities, especially maintenance (e.g. irrigation) and protection from grazing. Consequently, the main disadvantage of tree planting expressed by most local authorities pertained to post-planting follow-up and care. It seems evident that most of the funding is allocated (or frontloaded) towards planting events and very little towards covering management costs, specifically watering and additional care for the first few years after planting.

As mentioned in chapter 1, reforestation was one of the predominant environmental activities in Lebanon in the last decade alone (Djoundourian 2009). Major international governmental funding agencies mentioned by interviewees involved in extensive reforestation included the European Union (EU), United States Agency for International Development (USAID), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), and Agence Française de Développment (AFD). Yet the real objectives of donors investing in social and environmental project such as tree planting campaigns are often unstated (Bäckstrand and Lövbrand 2006; Springate-Baginski and Blaikie 2007; Braverman 2009). Similarly, a few of my informants also expressed disdain with externally funded reforestation programmes, claiming that they only serve the interest of donors and political elite:

> *All these [reforestation] projects that come to our village and others around here representing their particular nations or national governments, the people responsible for implementing these projects don't give the best benefits to the local community, and instead are doing these projects for their own interests. (P100)*

Another major criticism was the short-sighted motives of most reforestation campaigns:

> *We have lots of [reservations about] the planting campaigns in Lebanon. Each year lots of money is being spent on reforestation and planting; and what are the results? Each year there are planting campaigns and most of them end in a short period because there is no follow up. (P90)*

> *We tried to collaborate with other NGO's but it didn't work because their main purpose was to advertise their planting campaign in the media, instead of providing care after the planting. (P68)*

Some mayors expressed concerns over how this has hampered and even politicised NRM. Many community-based initiatives around the world tend to be dominated by elites who not only capture the majority of the benefits but also influence decisions, particularly in social contexts where members are heterogeneous and unequal (Mansuri and Rao 2004). For instance, Platteau et al. (2014) investigated how local elites under these circumstances strategically propose projects to major agencies by distorting information, especially in cases where donors may possess imperfect knowledge (or asymmetric information) of project details. In essence, there are consequences and unforeseen risks involved when municipalities decide to partner with external organisations given the volatile socio-political conditions in Lebanon. In fact, some of these issues surrounding politicised obligations are directly related to patronage politics.

2.4.5 Political Patronage

There are numerous players in Lebanon's reforestation scene currently, which include organisations that have both religious and political affiliations. Gaining support from local residents is one of the strategies political actors employ through complex patronage networks involving political parties, local associations (generally registered as cultural NGOs), public institutions, and to some extent, foreign agencies[71]. An interesting issue raised by more than one mayor pertained to how political parties use trees provided to them from the MOA as political leveraging (or campaigning) by passing them on to farmers and other local authorities (or candidates). Three respondents raised issues relating to political patronage between the ministries, political parties, and certain associations/NGOs:

> *Most of the NGOs follow certain parties [and] are providing trees received [from the MOA]. They sometimes provide fruit trees and sometimes wild trees. We are trying to push the MOA to give more [seedlings to municipalities] than it is giving currently... (P85)*

> *The MOA gives political parties seedlings to distribute to the farmers, most of which were distributed to their followers only. (P74)*

> *I would only like to add that we don't believe it is right for the MOA to provide us with seedlings through political parties. We would all benefit if they would work directly with the municipalities and not [through] the political parties. (P79)*

Past studies in patronage politics have shown that it not only hinders democratic processes of institutional development but also tends to legitimise corruption (e.g. rent-seeking), further empowering elites while increasing economic inequities for more disadvantaged communities (Mosse 2001; Mwenda and Tangri 2005; Nelson and Agrawal 2008).

[71] Braverman (2009) makes a compelling argument on how Zionists agencies based in the US raise funds for reforestation efforts in Israel, involving mainly exotic trees, with the objective of transforming the landscape to accommodate ideological objectives of occupation.

2.4.6 Principal-Agent Problems

Potential investments in biodiversity-enhancing reforestation projects would require contractual agreements between stakeholders and municipal authorities. Some reforestation NGOs have begun to employ contracts with their municipal partners, but details on how responsibilities would prevail if another administration came into office were not discussed. Contracting with municipalities would require some form of institutional mechanisms for ensuring the subsequent administrations continue to meet obligations agreed upon by previous ones. Collective action from local groups, such as environmental committees or community-based organisations, are potential strategies for ensuring new administrations maintain the duties of previous ones (Nygren 2005). However, even these efforts are often undermined through patronage politics and elite capture. Internal conflicts were mentioned by eight local authorities, ranging from power struggles between decision-makers in municipalities, with elite landowners over quarries, and historic conflicts over land and resources between powerful families (or tribes). In Lebanon, legal institutions are undermined through a customary system of bribery known as *'wasta'*. Similar to rent-seeking behaviour of client-patron relations, information can be easily distorted by powerful elites. While *wasta* is often discussed as an impediment to democratic governance, it is perhaps so culturally ingrained that it has become accepted as a norm:

> *Today if [someone] wants to make a project he should know someone with power. And the papers that are needed are sometimes impossible and incapacitating; you will need 1,000 "wastas" to get [an applications processed]. In the law there are obstacles; most of the laws are delicate and complex. [An] employee can hinder the operation so he can benefit or… make it easy [for himself]. (P85)*

Considering the extent of historic deforestation in North Lebanon over various eras (Mikesell 1969; Thirgood 1981), there has also been a fair amount of natural regeneration in return. Yet information regarding land cover dynamics as well as ownership (e.g. communal land) could be incomplete or asymmetrical (Shogren et al. 2010), and therefore prone to perverse incentives.

2.4.7 Perverse Incentives & Crowding Out

Some of the largest villages in the sample had extensive tracts of natural and managed forests as well as a fair amount of forest recovery (particularly in Mtein, Qobayat, Akkar Atika, Ain Zhalta, Hrajel, and Kfarselwen). One key informant, for instance, expressed his opposition to reforestation despite it taking place in his village and preferred more effective forest management strategies to be implemented instead:

> *As you saw, the area is very green and all the mountains are [already covered with trees]. So our problem is not the lack of [forests] but in the protection of the existing trees. Therefore, we [as a committee] haven't implemented many planting projects. The region needs protection; and when we protect, nature will [regenerate] on its own. (P95)*

Such instances could pose dilemmas for PES buyers targeting reforestation funds not only in areas that have sufficient natural regeneration but that are also biologically diverse. If the criteria involve land cover characteristics to fit a certain description, such as 'treeless' or 'degraded', this could potentially incentivise municipalities to clear existing (shrubby) trees and other native vegetation in order to qualify entry into the programme (Wunder 2007; Porras et al. 2011). PES schemes targeting municipalities could therefore potentially incentivise the clearing of native vegetation, or transforming native forests or woodlands into mono-cropped plantations.

Intrinsic pro-environmental behaviours may motivate certain local authorities to effectively manage forests on common (or municipal) property without financial incentives. Consequently, for those who have the capacity and goodwill to do so without financial incentives, PES schemes could potentially crowd out these motivations and undermine long-term management (Rode et al. 2013). Much like other formal policies have already done in Lebanon (Makhzoumi et al. 2012)[72], PES could act as a perverse incentive by crowding out local customary rules in use (Pattanayak et al. 2010). Sattout et al. (2005) pointed out that laws and regulations on forest resource use have crowded out traditional management regimes and created animosity between local communities and state agencies. Evidently, cases where social institutions or altruistic motives are crowded out once policies (e.g. rewards or punishments) are introduced may trigger principal-agent problems, such as information distortion and non-compliance discussed earlier (Frey and Jegen 2001).

2.4.8 Biophysical Suitability – Land Cover & Accessibility

Quantitative data gathered from both telephone and face-to-face interviews are presented in Table 2.4 below. This was an important criterion to determine re/afforestation potential for

[72] Mainly subsidies and regulations

each village. Surface area of villages was obtained through interviews and online sources[73]. Estimated area of municipal land (in hectares) was determined for 37 of the 48 villages during interviews. Thirteen of the villages in the sample did not have significant municipal land (other than roadside verges, etc.). Some large villages without municipal lands were either without municipal councils, e.g. Jurd Mrebbine, or lacked cadastral maps, e.g. Kfar-Bebnine. Of the 25 villages with municipal lands, around half claimed to have municipal areas of 10 ha or more available for tree planting. The remaining indicated having extensive municipal lands that are already forested (or are naturally regenerating after fires, e.g. Rechmaya) or have relatively small plots of less than 5 hectares. Hence around a dozen villages (all with municipalities) were identified as having suitable land for reforestation[74].

Table 2.4. Geographic and land-use data of villages gathered from telephone calls during recruitment and face-to-face interviews

	N		Mean	Std. Dev.	Min.	Max.	Sum
	Valid*	Missing					
No. of villages in sample	48	0	--	--	--	--	--
Est. surface area of village† (ha)	48	0	1,230	1,632	110	8,583	59,041
Elevation (average)	48	0	926	318	425	1,800	--
Est. area of municipal land, *mesheaa baladiyeh* (ha)	37	11	482	1,480	0	7,200[1]	17,825
Est. area of abandoned farmlands (ha)	36	12	416	583	5	2,000	14,975

*Figures based only on valid villages within the sample
† Areas based on boundaries of municipalities; areas of villages without municipalities were not determined.
[1]Kfardebiane

Hence, from a biophysical perspective alone, few montane villages in Lebanon with available municipal lands are suitable for reforestation. In addition, accessibility of municipal lands by road and other biophysical limitations, such as gradient and slope, was a limiting factor for many larger villages. Most land-use/land-cover types that could be reforested are at higher elevations (mainly rangelands, often referred to as *jurd* in Arabic), which are characteristic of scrub type systems (or *maquis*) that are often remote and typically grazed.

[73] Preliminary findings indicated that the total surface area of the villages with municipalities in my sample accounts for approximately 6% of Lebanon's total surface area (10,452 km^2). While there were a few very large municipalities in my sample (e.g. Kfardebiane, Tannourine, and Ehden), these estimates do not include areas of villages without municipalities as there was no spatial data available.

[74] Local authorities from four of those mentioned potential threats from grazing (Section 2.4.3 above).

2.4.9 Outcome 1: Are Municipalities Promising Agents as Biodiversity-Enhancing Ecosystem Service Suppliers?

In the conceptual framework introduced in this chapter, I laid out important institutional and biophysical attributes derived from the literature on decentralised NRM in the context of incentivised reforestation. Using a mixed methods approach that allowed for rich discussion I determined how promising municipalities are as biodiversity-enhancing PES agents. Results suggest that investing in biodiversity-enhancing reforestation efforts with Lebanese municipalities would involve numerous challenges. This is illustrated using a strengths, weaknesses, opportunities and threats (SWOT) diagram in Figure 2.3 below.

Figure 2.3. 'Strengths, Weaknesses, Opportunities and Threats' chart for employing biodiversity-enhancing reforestation incentives with Lebanese municipalities.

Endogenous (strengths and weakness) as well as exogenous (threats and opportunities) factors should be considered when targeting municipalities as biodiversity-enhancing reforestation agents (Figure 2.3). In short, there are a limited number of municipalities that can serve as biodiversity-enhancing reforestation agents based on analyses of those in my sample.

2.4.10 Outcome 2: Which Municipalities are most Suitable for Incentivising through PES and Why?

As shown, biophysical suitability is a limiting factor in supporting large scale reforestation, therefore likely affecting a number of smaller villages along the Mount Lebanon chain. From an institutional perspective, municipalities with clearly defined cadastral boundaries indicating the formal extent (ha) of their municipal lands, along with institutional mechanisms (inclusion/exclusion) in place for accessing or using these areas, are likely to produce better reforestation outcomes than those without these measures. Thus, villages with municipal lands that have cadastral numbers and are free (or guarded) from grazing could be considered as candidates for PES reforestation. If re/afforestation efforts were to take place in rangelands with active grazing, some funds would need to be allocated towards fencing off areas (or hiring guards). The success of extensive reforestation efforts in Kfardebiane and Bcharre, for instance, was partly attributed to having fences around planting sites (*pers. comm.* P16 and key informant, 2012). Key informants involved in reforestation efforts in Bcharre (LB09) and within the Chouf Biosphere Reserve (LB16) also mentioned arrangements made with local herders whose grazing paths were taken over by reforestation. In both cases, hill lakes were constructed away from the planting sites where herders were granted access on condition that they would keep livestock away from the newly planted trees (an example of social fencing).

Forestry experts from the MOA discussed reforestation in the Barouk reserve (within the Chouf Biosphere Reserve) as an example where the Green Plan was successful (chapter 1). Bcharre and Jezzine also had extensive reforestation under the Green Plan but failed to meet targets. There is, however, a common agreement amongst experts that the managed stone pine forests of Bkessine could serve as a good model for effective forest management (*pers. comm.* M. Khouzami, 2011). They also mentioned that NRM was better controlled under the French Mandate period up to the 1950s through state-imposed taxes on wood resources and livestock. Herding on public lands was also managed through rents. More importantly, herders were integrated into re/afforestation projects to supplement their incomes. Notwithstanding, the three key issues raised by stakeholders from the MOA were; 1) political divisions between ministries resulting in unclear aims, objectives, and responsibilities, 2) concerns over imported trees, and 3) issues pertaining to property and tenure.

Interestingly, one of the criteria for selecting villages mentioned by a project manager of the Lebanese Reforestation Initiative (LRI) was the existence of community-based organisations working directly with municipalities (*pers. comm.* R. Patton, 2012). Similarly, participation criteria for the biodiversity award scheme initiated by the Nature Conservation Centre of the American University of Beirut (AUB-NCC) required the creation of local municipal committees (*pers. comm.* L. Tawk, 2012). Ensuring successful reforestation efforts on municipal lands often requires strong local support and collective action. Decentralised institutions in the form of local committees can help reduce transaction costs through assigning members tasks and duties that aim to protect collective assets. But nested institutions take many years of collective experience and trust-building to become robust (Ostrom 2005). Any reforestation stakeholder acting as a 'principal' must therefore consider developing sound and fair conditions in order to ensure the objective of establishing and retaining trees met by the contracted 'agent'. In the absence of contracts or formal agreements, the ability of principals to gauge whether or not objectives are met becomes limited and the success of projects less likely. Local participation would probably be unlikely in villages with a large number of absentee residents, which also raises interesting questions as to who the real beneficiaries of potential biodiversity-enhancing reforestation initiatives would be.

While there are advantages in targeting municipalities with well-established environmental committees or community-based organisations[75], this may be difficult or even counterproductive if there are competing patronage networks already in place. While many local authorities mentioned collective decision-making regarding reforestation prospects, the final decision is often undertaken by mayors:

> *When it comes to the decision making, if the municipality acquired land and wants to plant it the decision could be taken by the president of the municipality [i.e. mayor] or by the [municipal] council board. According to the law, both decisions are valid. According to the law, the [mayor] manages the properties of the municipality alone without consulting the council board. (P65)*

Exogenous institutional factors could potentially hamper the efficacy of contracting with municipalities. This appeared to mostly affect a number of middle to small-size municipalities in my sample. Reforestation outcomes may therefore depend on how much political power and charisma a mayor has in appealing to both national stakeholders and local constituents (Avellaneda 2009). But the objectives of local actors are often determined by other priorities (or incentives) and immediate needs, as well as fiscal constraints, which directly affect environmental management responsibilities (Andersson 2003). Such is the case in Lebanon where many municipalities failed to receive funds from the central government due to bureaucratic (or political) constraints (Manassian and Majdalany 2011). Even more

[75] Some of those mentioned included religious associations, scouts, and youth groups

challenging are objectives for encouraging the planting of diverse native trees with little or no direct market benefits, unlike stone pine. Thus it is likely that most municipalities would require higher payments to cover the opportunity costs for planting other species than purely stone pine. With this in mind, I asked municipal authorities whether they would accept and plant diverse non-productive native trees voluntarily if seedlings were provided at no charge. Seventeen responded that they would, of which only six mentioned having significant available municipal lands for reforestation (> 1 ha) and not simply planting roadsides verges and small areas.

Reforesting in areas with existing native vegetation contributes to loss of habitat for these species despite other environmental gains (including habitats for other species such as birds). Trade-offs must be carefully considered and weighed according to their importance, yet these kinds of decisions are never easy to make (Reed et al. 2013). Stakeholders inherently have heterogeneous preferences and are therefore likely to disagree. While knowledge and information is often contested, decentralised decision- and rule-making surrounding common-pool resources are also important (Agrawal 2007). Public opinions matter to political actors, which therefore necessitates having venues for public deliberations at the village level. The importance of multistakeholder involvement in decision-making is clear, yet there are also disadvantages in that important decisions might be made less efficiently. With these factors in mind, PES programmes might be broadened to include sole decision-making landowners with secure titles to property, yet keeping some of these important institutional and biophysical factors also in mind. For instance, despite having secure titles, contracting with landowners may also present problems including unclear tenure (e.g. familial disputes), principal-agent problems, perverse incentives (e.g. clearing of native vegetation to plant new trees) and the potential to crowd out intrinsic motives.

2.4.11 Outcome 3: How can Policy be Improved and what Alternative Considerations are there for Targeting PES?

A viable alternative to reforesting on municipal or state lands would be private lands, whether owned by individuals (or households), businesses or religious institutions. Some reforestation stakeholders have mentioned an interest in conducting reforestation on religious estates (‘*awqaf*’ [plural] in Arabic), which are lands belonging to churches and mosques *(pers. comm.* LRI, June 2012). Religious estates are the largest landowners of private property in Lebanon (chapter 1). The majority of these lands are already forested and generally well-protected, such as the UNESCO site of Wadi Qadisha in Bcharre and Ehden (LB09). However, similar issues regarding competing land-uses may be faced within these religious endowments, especially since many rent lands out to herders and local farmers (*pers. comm.* C. Tawk, July 2012). Interestingly, reforestation stakeholders have been reluctant to consider reforesting on private lands belong to individuals (or households). The main reason mentioned was that landowners may decide to remove trees, which is why binding agreements such as contracts are important for ensuring compliance in much the same way it applies to municipalities. Another reason given by stakeholders and professionals is the notion that environmental services should come from public lands, but as we have seen, this can be complex. Conversely, opportunity costs may be low on abandoned private farmlands, which are extensive in the majority of villages in my sample (Figure 2.4). In addition, transaction costs in the long-run might be lower on private property because fewer people make decisions, while private property may also be better guarded from grazing. Assessing whether landowners would consider subscribing to PES is therefore needed.

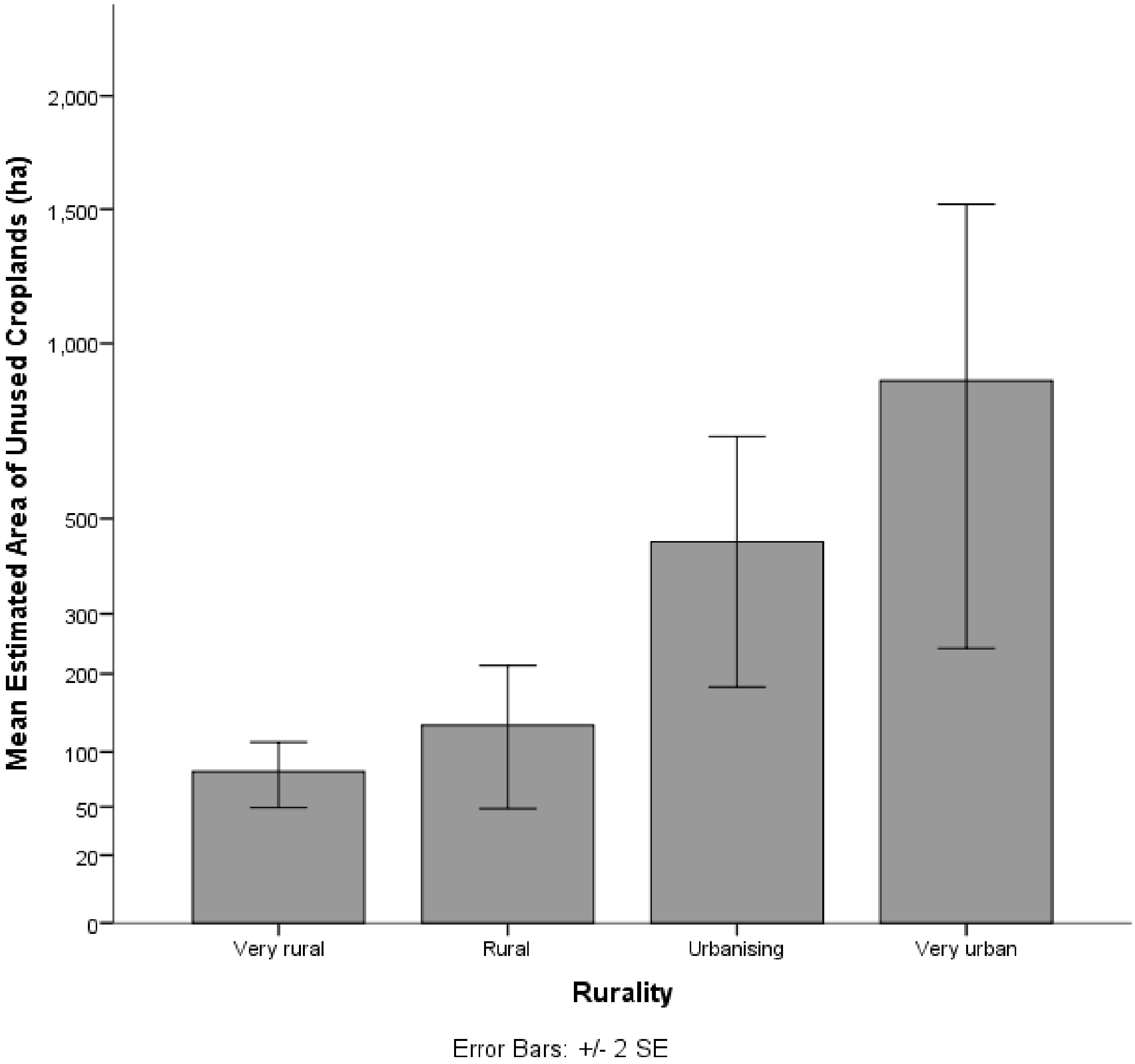

Figure 2.4. Estimated mean areas of abandoned or unused agricultural lands in 36 villages by rurality category. More urbanised villages had substantial land abandonment (rescaled at power exp. 0.05). Data was estimated by respondents (mainly mayors).

Farmers and other local residents interviewed were asked to share their thoughts regarding reforestation on private lands. The majority stated that if there was support or incentives to cover planting and management costs, they would consider this feasible on marginal land:

> *The area that doesn't have any fruit trees on it or wild trees such the range lands should be planted with wild trees. If I have an empty land I would plant it with wild trees, they will preserve the climate and give a nice view. Plus wild trees need less care than fruit trees. If you are planting fruit trees in difficult lands it will be very costly and [most] farmers can't handle those* cost. *(F20)*

One farmer who expressed interests in the idea of reforestation incentives for landowners was not very keen on planting trees of little direct use value, and even considered some productive trees to be indifferent from native forest trees:

> *With respect to reforestation [on private land], why would we plant forest tress if we can plant fruit trees? Between the oak and the chestnut, what's the difference? It's the same type [of tree]. Chestnut is a wild tree. And I know of farmers grafting chestnut [branches] onto maloul [Quercus infectoria] trees… If you compare oaks and chestnuts, they're the same [to me]. (F15)*

Finally, there are important policy shortcomings that constrain effective forest management and may also contribute to a reluctance of landowners to participate in reforestation incentives (or future PES schemes targeting private lands). The last research question addresses whether current forest policies and their enactment are fit for the purpose of reforesting non-private lands. As it currently stands, I view certain policies as being counterproductive for reforestation on both public and private lands. Below I present some policy recommendations that could help improve current policies and possible alternative to consider for better management of existing forests and future reforestation efforts.

Policy recommendations and future prospects

Aside from reforestation, protecting and managing existing forests is also an important policy measure that has received far less attention and funding than it deserves. Dense thickets in many forests in North Lebanon are clearly fire hazards and should be better managed. Yet these efforts are currently impeded by policy measures prohibiting the cutting of native conifers, resulting in fires that could have otherwise been prevented. The challenge with increasing forest cover through planting should run parallel to protecting existing forests and encouraging natural regeneration. Anecdotally, goats can help in the first instance through controlled grazing in understories of forests. Conversely, they tend to inhibit natural regeneration of trees when grazed in open fields. A more holistic, multifunctional approach is needed for identifying trade-offs and synergies in order to integrate various land-use needs for effective NRM in Lebanon, such as silvopastoral practices. This study highlights three important policy needs:

1. Revision of the Forestry Code to relax (with conditions) forest management constraints and introduce locally regulated tree cutting and biomass removal
2. Reassess the potential for integrating private landowners into incentivised reforestation projects (e.g. asset-building PES)
3. Devise policies that integrate rather than segregate competing land-uses, specifically between agriculture, forestry, pastoralism, and conservation

While it is illegal to harvest wood from coniferous species on public lands in Lebanon, there are poverty pockets in parts of Dinniyeh and Akkar districts (LB07) where these practices continue. However, key informants mentioned that it is mainly broadleaved species, particularly native oaks (e.g. *Quercus coccifera* and *Q. infectoria*) that are harvested through coppicing. This activity is largely for the purpose of charcoal production especially since there is high market demand for this type of charcoal (*pers. comm.* August 2012). Since wood harvesting remains and contentious issue in Lebanon, I chose not to investigate this topic as it given its sensitivities and the potential ethical implications it may have caused. Some residents from the villages in my sample mentioned gathering wood from their own property (e.g. dead fruit trees) for fuel, though many mentioned burning diesel-burning furnaces as their main source of heat. Fuelwood is scarce in the more rural areas lacking forests, such as along the eastern facing ridge of Mt. Lebanon (e.g. Hermel district). One landowner I interviewed at an early stage in Tripoli was complaining about illegal cutting of forests on his property in Akkar from people he claims are from Hermel. While I was informed from some respondents that illegal wood harvesting is a common problem both on private and public lands in the Akkar and Dinniyeh IPA (LB07), it was beyond the scope of my thesis to investigate this. But this also reinforces the need for more research in other parts of Lebanon that are facing greater threats of desertification and degradation such as Hermel. In this context, research efforts can help in devising policies for encouraging native as well as non-native silvicultural planting and management of wood resources that can have direct benefits to local communities.

2.5 Conclusion

Decentralisation has the potential for bringing local governance decisions closer to the real beneficiaries. But socio-institutional processes, such as popular participation, collective action and democratic deliberations, are never guaranteed to result from this policy measure. Local involvement and organisation towards effective natural resource management is apparent in circumstances where local people are dependent on a particular natural resource. In the case of Lebanon, municipalities face many obstacles and constraints in managing natural resources on common (or municipal) lands. Local authorities therefore have an important role as managers of common-pool resources in the absence of collective action by other members of the community. But they also face numerous institutional constraints (endogenous and exogenous), especially with regards to securing tenure, accessing forest resources, competing land-uses, and socio-political patronage networks deeply ingrained in an ancient and dynamic culture.

Results derived from interviews show that municipalities with sufficient and suitable municipal land, having clearly defined cadastral boundaries of (and mechanisms for protecting) these lands, would likely produce more cost-effective reforestation outcomes. However, the analysis conducted suggests that few municipalities located along the Mt. Lebanon range fit these criteria. In addition to policy changes that will support future reforestation and forest management efforts, alternative strategies for targeting reforestation agents are therefore needed. National stakeholders interested in adopting incentives-based mechanisms such as PES would find it advantageous to target municipalities with the capacity and desire for managing biodiversity-enhancing reforestation efforts (or delegating those responsibilities). Municipalities with established environmental committees may be better candidates for ensuring long-term tree retention, but efforts should be made to integrate these groups into decision-making and design of schemes. Existing incentives to plant trees were evident from respondents acknowledging the long-term benefits in having more natural forest cover (both aesthetic and functional) in villages. Given that these benefits were clearly recognised as a means of attracting visitors while keeping local residents aiding the local economy, PES may crowd-out pre-existing intentions, potentially inviting problems such as elite capture or fuelling more patronage politics.

This study presents some of the many challenges and obstacles with community-based natural resource management in Lebanon articulated through interviews with various local authorities and members of Lebanon’s civil society. It also presented future prospects and limitations of working with municipalities and highlights policy considerations for Lebanon’s institutions. Given the historical realities of a nation that has faced major social and political challenges, there are considerable institutional hurdles at the national scale that still need to be overcome for future PES schemes to effectively take shape. Broadening these objectives to include private landowners may help reduce some of these obstacles as constraints to reforestation. Recognising the implications of these constraints will help in designing more cost-effective PES schemes with landowners in mind. But this will also require understanding landowner perceptions of asset-building PES, particularly those designed to include mixed native forests with few private benefits to landowners.

3 Asset-Building Payments for Ecosystem Services: Assessing Landowner Perceptions of Risks and Reward from Reforestation Incentives in Lebanon

Incentivising landowners to supply ecosystem services remains challenging, especially when this requires long-term investments such as reforestation. I investigated how landowners perceive and would respond to different types of incentives for planting diverse native trees on private lands in Lebanon. Mixed-methods surveys were conducted with 34 landowners from mountainous villages to determine past, present and future land-use strategies. My aim was to understand landowners' attitudes towards three differently structured hypothetical Payments for Ecosystem Services (PES) contract options; their likely participation; and the potential additionality (or estimated area enrolled minus displacement) they would provide. The three schemes (results-based loan, action-based grant, and results-based payments) differed in their expected risks and benefits to landowners. The majority of reforestation was proposed for uncultivated plots, suggesting limited agricultural displacement. Although the results-based loan did deter uptake relative to the low-risk action-based grant, results-based payments did not significantly increase uptake, suggesting asymmetric attitudes to risk. Qualitative probing revealed economic, social (e.g. trust) and institutional factors (e.g. legal implications with planting non-productive forest trees on private land) that limited willingness to participate in the results-based PES. This study presented a novel approach in gauging landowner attitudes and risk behaviour necessary for designing asset-building PES schemes. It demonstrates the importance of combining qualitative and quantitative methods to better understand landowner perceptions towards incentives and their associated risks.

Keywords: Agro-ecosystems; biodiversity; displacement; incentives; landowners; Lebanon; mixed-methods; payments for ecosystem services (PES); reforestation; risk-behaviour

3.1 Introduction

To date, payments for ecosystem services (PES) have largely focused on use-restricting strategies, e.g. avoided deforestation (Wunder 2007). Yet PES are being increasingly employed to finance reforestation (or afforestation) efforts, referred to as asset-building schemes (Wunder 2008). However, recent studies have criticised carbon-focused PES and Reduced Emissions from Deforestation and Degradation (REDD+) for incentivising monoculture plantations, negatively impacting biodiversity and local livelihoods (Edwards et al. 2010; Lindenmayer et al. 2012). It is also well recognised that competitive PES schemes could displace agriculture or other productive activities, leading to land conversion and intensification elsewhere – a process known as 'leakage' (Murray 2008). As a result, PES would generate few additional benefits (or overall additionality) at landscape or regional scales (Grieg-Gran et al. 2005). While additionality is a defining feature of cost-effective PES, it is as important to determine the capacity and willingness of landowners to provide it in the future, and what constraints they may face.

Designing biodiversity-enhancing reforestation schemes (e.g. proportional mixes of native species) that are both cost-effective and attract participants remains challenging. This may depend on landowners' perceptions of off-farm ecosystem services (ES) and biodiversity, since farmers are used to producing and selling marketable goods (i.e. commodities) and not intangible services. Additional challenges exist in contexts where there is interest in asset-building PES but knowledge of landowner perceptions is lacking, such as with Lebanon. I administered a mixed-methods survey to explore the willingness of Lebanese landowners from highland villages to accept incentives for planting diverse native tree species of limited direct use-value on private lands. Survey participants were presented with three alternative, non-randomised PES contracts schemes in the following order: Scheme 1, a results-based loan (involving repayments conditional on seedling survival, or negative conditionality); Scheme 2, an action-based grant (conditional on planting only); and Scheme 3, results-based payments (conditional on seedling survival, or positive conditionality). The main objective was to investigate how landowners perceived and evaluated the schemes, which served to motivate discussion with the participants. My aim was to understand landowners' attitudes towards these three differently structured hypothetical PES contracts options; what factors influence decisions to participate; and the potential additionality (i.e. area enrolled and associated land-use/land cover types) they would provide.

3.1.1 Factors Affecting PES Uptake

Recent case studies have shown that participation in PES schemes largely depends on the landowners' opportunity costs determined by, *inter alia*, land productivity and distance to markets (Layton and Siikamäki 2009; Chen et al. 2010). Yet the literature has identified several other factors that affect participation, including contract design; social and institutional issues; as well as biophysical characteristics. I discuss these factors below.

Conditionality is a defining feature of PES (Wunder et al. 2014). Payments must be conditional on verified actions (e.g. planting trees) or results (e.g. carbon sequestration), requiring monitoring of sellers to ensure compliance (Honey-Rosés et al. 2009). For PES buyers, contract designs often involve trade-offs between supplier uptake, transaction costs, and expected outcomes (Engel et al. 2008; Jindal et al. 2013). For example, contracts that are highly bureaucratic or involve excessive conditionality are perceived as being too risky or onerous, reducing landowner uptake (Hudson and Lusk 2004). In contrast, lack of conditionality or monitoring could result in non-compliance (e.g. hidden action) by sellers (Vedel et al. 2010). Cost-benefit trade-offs are therefore important in setting conditions for service deliver. The choice of payment by actions or results, together with the optimal level of conditionality and monitoring, will depend on the context, the strength of the connection between actions and results, the ease of monitoring each, and the level of risk aversion of sellers and buyers (Gibbons et al. 2011; Banerjee et al. 2013). Results-based payments may also capture existing benefits, thus reducing costs and perverse incentives to clear native vegetation in order to plant new trees (Pagiola et al. 2004b). Technical assistance has also been shown to help less experienced landowners make better decisions about what to plant and where, ensuring existing native trees are not removed, thus increasing benefits at lower costs to buyers (Bennett et al. 2011). Allowing PES participants to choose tree species for planting has been shown to increase seedling survival rates (Kelly and Huo 2013), but could also result in fewer high-conservation-value species being established (Pandey et al. 2014). Setting conditions for ensuring mixed native species are used in reforestation and retained *ex post* is therefore vital for safeguarding biodiversity in asset-building PES schemes (Bullock et al. 2011; Montagnini and Finney 2011).

In asset-building programmes like reforestation, with high short-term costs and delayed benefits, a fundamental issue of concern to PES buyers is ensuring long term delivery of ecosystem services (Pattanayak et al. 2010). Asset-building PES may therefore require a mixture of results- and action-based payments over time to cover high initial costs whilst ensuring tree retention (Wunder et al. 2014). In some cases, asset-building PES contracts have used payments that are frontloaded and gradually decreased once private benefits from planted trees were available to participants, but this is best suited to productive species (Pagiola 2008; Hegde et al. 2014). Changing the timing of payments, offering longer-term contracts or the option to renew short-term contracts, are possible strategies for ensuring tree retention (Ando and Chen 2011).

Studies have also shown that asset-building PES schemes that vary payments based on landowners' opportunity costs have been shown to be more cost-effective than flat-rate payment schemes (e.g. Chen et al. 2010). Yet determining a landowner's true opportunity cost is challenging because private information[76] is often costly to obtain (Wünscher et al. 2011; Jack 2013). Recent studies have investigated ways to reduce landowners' informational rents through offering them a menu of contract options (i.e. screening contracts) as a strategy for revealing landowner attributes (Ferraro 2008; Mason and Plantinga 2013). This method also serves to reveal landholding characteristics by asking where and why specific planting sites are selected by study participants. Asset-building investments are often subject to high start-up costs that vary depending on biophysical characteristics, such as level of difficulty, topography (e.g. exposure), soil quality, access to roads and water, and microclimates (Zbinden and Lee 2005; Ma et al. 2010; Kelly and Huo 2013). For example, landowners may rationally decide to reforest only marginal lands with poor soils or conditions unfavourable for farming (Crabtree et al. 2001), yet these areas may also be subject to high planting and maintenance costs (e.g. protection from grazing).

Aside from contract design, social and institutional factors such as trust in (or experience with) incentive-based schemes (or outside actors in general), local norms and values, and income dependence from farm-based activities also influence landowners' decisions to join PES schemes (Miranda et al. 2003; Chen et al. 2009; Van Hecken and Bastiaensen 2010a; Fisher 2012). Factors such as age and level of education are important as well (Zbinden and Lee 2005). Participants in asset-building PES tend to have relatively large landholdings, with enough land unsuitable for agriculture, and have incomes that were largely off-farm (Cole 2010; Ma et al. 2010). Households' dependency on forest resources (e.g. firewood, timber,

[76] Ferraro (2008) reasons from contract theory literature that sellers (or agents) use their private information as a source of market power for leveraging gains in PES transactions.

charcoal production) was also found to affect uptake of PES schemes (Hegde et al. 2014). The context under which the farming system is structured, along with secure tenure and technical or financial know-how, have also been found to be determinants of landowner uptake (Pagiola et al. 2005; Kosoy et al. 2008). Building trust in the institutions responsible for ensuring payments often takes time, and poorer, more risk-averse landowners may be less willing to participate than wealthier ones (Garbach et al. 2012; Fisher 2012). These issues are particularly critical in cases where governments are buyers or intermediaries, yet have lost the confidence of farmers through previous policies. Beyond this, PES is even more challenging to implement under circumstances where legal and property institutions are weak, which is common in many developing countries (Swallow and Meinzen-Dick 2009; Van Hecken and Bastiaensen 2010b; Matzdorf et al. 2013). Even in more developed countries such as Germany, land tenure implications and contractual uncertainties were principle reasons behind farmers' reluctance to join PES schemes (Schleyer and Plieninger 2011).

Factors affecting uptake in reforestation incentives therefore require understanding of farmer identity and how they perceive risks or uncertainties towards livelihood changes (Knoke and Wurm 2006; Duesberg et al. 2013; Wynne-Jones 2013b; Blennow et al. 2014). Some of these perceptions are reflective of social norms, for example, in how risk-averse farmers make decisions based on actions made by other members of their community (Chen et al. 2009; Ma et al. 2010). PES programmes rely on informing suppliers about payments for services that are difficult to grasp by many people outside the scientific or policy sphere. It is therefore important to investigate how landowners would perceive (or even conceptualise) the risks of entering into 'uncharted territories' of new institutions and markets (Wunder 2007; Knoke et al. 2011). This necessitates more thorough investigations into risk behaviour of property owners under hypothetical markets. Such studies can help in designing appropriate incentives for delivering the environmental benefits being paid for.

3.2 Materials and Methods

3.2.1 Study Area

Lebanon is a small (10,452 km^2), predominantly mountainous country located in the eastern Mediterranean basin and recognised as a centre for plant diversity (Davis et al. 1994). My study area comprised the western slopes of Mount Lebanon where 10 of Lebanon's 20 newly designated Important Plant Areas (IPAs) are located (Radford et al. 2011). This area is characteristic of eu-mediterranean (> 1,000 meters) to oro-mediterranean (> 2,000 meters) bioclimatic zones. The vegetation types are typical of Mediterranean forest, woodland and scrub communities containing coniferous, deciduous and mixed forest/woodland (Abi-Saleh and Safi 1988). Habitats are increasingly threatened by land-use including intensive agriculture, overgrazing, urbanisation and quarrying, as well as fires (Talhouk et al. 2001; Sattout and Abboud 2007; Darwish et al. 2010a).

3.2.2 Sampling

I focused on villages within 8[77] Important Plant Areas (IPAs) from Akkar to Chouf districts given their priority status for conservation and reforestation potential (Figure 3.1). A stratified random sample[78] of 17 villages within these IPAs were selected from a near-complete sampling frame of 248 villages (Table 3.1).

Table 3.1. Sampled respondents and villages and their respective districts and Important Plant Areas

IPA No.‡	Name	District	Elevation (Ave.)	No. of landowners
LB07	Qammouaa*	Dinniyeh	1695	5
LB09	Bcharre-Ehden	Bcharre / Ehden	1425	3
LB11	Tannourine	Batroun	1500	3
LB13	Wadi Jannah	Keserouan	950	1
LB14	Keserouan	Keserouan	1300	7
LB15	Sannine-Kneisseh	Metn	1325	6
LB16	Chouf	Chouf	1100	5
LB17	Nahr ed-Damour	Chouf	1050	4

*Excludes Akkar and Hermel districts
‡ 'LB' denotes Lebanon

[77] I excluded the whole of LB20, and villages in LB07 in the Akkar district due to security concerns in those regions. LB01 was also omitted given its high elevation (> 2,500 m, i.e. beyond the tree line).

[78] Stratified according to IPA, estimated geographic size, population, rurality and elevation.

Figure 3.1. Map of Lebanon showing the eight Important Plant Areas (IPAs) in the study area in green (Yazbek et al. 2010). Landowners from 17 villages located within these IPAs were sampled for this study. Source for base mapping: Google Earth.

Due to social and political sensitivities associated with conducting research in rural Lebanon, especially at the time when the field work was conducted, it was necessary to obtain contact details of landowners from mayors and other key informants from these villages who acted as my gatekeepers and facilitated my research[79]. I obtained contact details for 52 landowners who were sole proprietors of their holdings, who were then contacted by telephone. After at least two attempts I spoke to 46 landowners, informed them of the study objectives, and

[79] Gatekeepers distributed recruitment flyers I produced to landowners (an English version is available in Appendix 3.1.). Academic experts and national officials also recommended that I take this approach especially given my foreign status as a visiting researcher.

asked for their oral consent[80]. Twelve landowners declined to participate for various reasons ranging from lack of land, land tenure issues (decisions shared between family members), age and inconvenience. The final survey was conducted with 34 participants with their written consent; all were newly recruited and had not participated in the pilot (see section 3.2.4).

3.2.3 Conceptualising PES in Lebanon

I presented three hypothetical schemes to respondents in order to gauge their acceptability and to stimulate discussion of the key research themes identified above.

Scheme 1 – Results-based loan

The first scheme presented would provide the landowner with free seedlings[81] and technical assistance at no charge. In addition, they would receive money up-front to cover the direct costs of planting and maintenance, in the form of an interest-free loan, repayable over a period of five years. It was explained that repayments would be cancelled each year if survival was above 80% of the initial planting, but if below this threshold, participants would be required to pay the proportion of the seedlings lost from the total, e.g. 65% survival = 35% repayment. Seedling survival would be estimated by a monitoring team using randomly selected plots (e.g. Griscom et al. 2005), assessed on a yearly basis during the five-year period. Respondents were assured that repayments would be cancelled if the project collapsed for any reason, thus reducing external risks to participants.

Scheme 2 – Action-based grant

Scheme 2 contained the same baseline support as Scheme 1 (i.e. free seedlings and technical assistance) along with the same payments to cover planting and maintenance costs. However, in this case these were in the form of a grant, conditional only on planting taking place, but unconditional on survival. Comparison of uptake across Schemes 1 and 2, in addition to discussion with participants, allowed me to assess their perceptions of risk and negative conditionality, without focussing on specific payments levels.

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[80] Thirty-seven orally consented to participate of whom three declined to participate due to inconvenience (surveys were conducted at the height of the apple harvesting period).

[81] A printed list of native tree and shrub species was provided for the respondents that included productive, e.g. stone pine (*Pinus pinea* L.), and non-productive trees (see Appendix 3.2.). The list was derived from a native tree species database developed through research conducted by the American University of Beirut's Nature Conservation Center (AUB-NCC). The database also includes GPS data and images of species used for monitoring biodiversity and locating specimens for harvesting seeds that are later used in seedling production.

Scheme 3 – Results-based payments

The last scheme offered the same free seedlings and technical assistance as Schemes 1 and 2, together with payments to cover direct planting costs[82]. In addition, participants would receive annual performance payments at US$3.00 per seedling conditional on and proportional to survival outcomes (e.g. 65% overall survival = 65% payment). Planting and survival would be assessed through annual monitoring (same methods as first scheme) over five years. Analogously, if survival were less than 25%, participants would receive no results-based payments.

3.2.4 Data Acquisition and Survey Instruments

A questionnaire-based survey was conducted in Arabic by my field assistant in my presence. An extensive pilot was conducted with twenty landowners over a two week period in August, 2012 to ensure it was locally appropriate. Surveys were conducted in the participants' villages, either at their farm, home, workplace, or the municipality office. Each participant was given an introduction to the study, and explanation of how and why they were contacted. The introduction was kept general in order to reduce biased responses. Participants were presented with a written consent form prior to commencing[83]. Each survey took approximately 40-50 minutes to complete and each respondent received a small gift for their participation following the interviews[84].

Section 1 of the survey[85] focussed on current and intended land-use, including the kinds of crops planted, quantities of each and their densities (% coverage), and area in hectares ('ha' here onwards), how long ago, and land-use/land-cover characteristics. This section also contained questions related to planting objectives, any difficulties faced, and whether they had received any third-party support (e.g. MOA, cooperatives, NGOs, etc.).

Section 2 of the survey introduced the first of three hypothetical PES schemes. A preamble informed the respondents that this section would involve presenting hypothetical planting

[82] Because this scheme introduced specified results-based payments in later years, these planting payments were also specified at US$7.00 for every seedling planted. This rate was a generous estimate of the planting costs mentioned, but unspecified in Schemes 1 and 2.

[83] The study received ethics approval from both Bangor University and AUB review boards

[84] As compensation, each participant received a book (Plants and People, AUB-NCC publication) at the end of the interview. Cost of each book was US$12.99. All books were donated to me by AUB-NCC.

[85] A copy of the survey is included in Appendix 3.3.

schemes. Follow-up questions were asked after each scheme was presented, which included where they would plant the seedlings and on how much land (in 1,000 m^2). They were also asked whether schemes would change their intended planting plans for that plot, e.g. if they had previous plans to plant crop trees. In addition, they were asked open-ended questions regarding perceived benefits or advantages of the proposed schemes. Respondents who did not wish to participate in any of the schemes were prompted to discuss why they would opt out.

Section 3 of the survey contained questions aimed at determining what sort of constraints or possible land-use changes the participants envisaged in the future. Open-ended questions were coded with responses seen only by the interviewer, thus encouraging the respondents to give more qualitative answers. This was followed by a short section on socioeconomic questions (section 4).

3.2.5 Data Analysis

Quantitative data was analysed using SPSS version 20 (Pallant 2010) to determine 1) whether there was a significant difference in uptake and area enrolled for reforestation under each consecutive scheme, 2) whether there was a significant difference in land-use types that would be reforested to determine agricultural displacement[86], and 3) whether landowner type, age or landholding size influenced participation and land enrolment into corresponding schemes. Qualitative data was transcribed and translated into English by my field assistant. Audio recordings and transcriptions were analysed using Atlas.ti® (qualitative data analysis software) to identify important themes.

3.3 Results

3.3.1 Basic Attributes of Sample

All participants in the sample (n=34) were males between the ages of 30 and 81 with a median age of 57. Median household size of respondents was five members. Over three quarters of the respondents indicated they were permanent residents of their villages while

[86] Land-use types were categorised as those "in use", e.g. containing orchards / crops, and those "in disuse", e.g. abandoned farms or rangelands not being grazed (*maquis* / *garrigue* landscapes).

the remainder (n=8) spent only summers there[87]. Ninety-one per cent indicated that their landholdings were located within villages where they resided. Fifteen of the respondents (55%) stated “baccalaureate” (end of high school, or 18 years old) as their highest level of education, eleven were university graduates and four graduated from technical schools (Figure 3.2a).

Eleven of the respondents were full-time commercial farmers, nine were part-time farmers and fourteen were hobby or retired farmers (Figure 3.2). Landholding size per respondent ranged from 30 ha to 0.15 ha. The median area of landholdings was 3 ha with around 70% owning 6 ha or less. Only three respondents owned property that was contiguous. Nine landowners owned property over 10 ha, consisting of mainly hobby / retired farmers. Landholding size differed weakly between level of education (Kruskal-Wallis H-test = 7.810, p = 0.099). Part-time and hobby farmers did not have smaller landholdings than full-time farmers (Kruskal-Wallis H-test = 0.258, p = 0.879; Figure 3.2b).

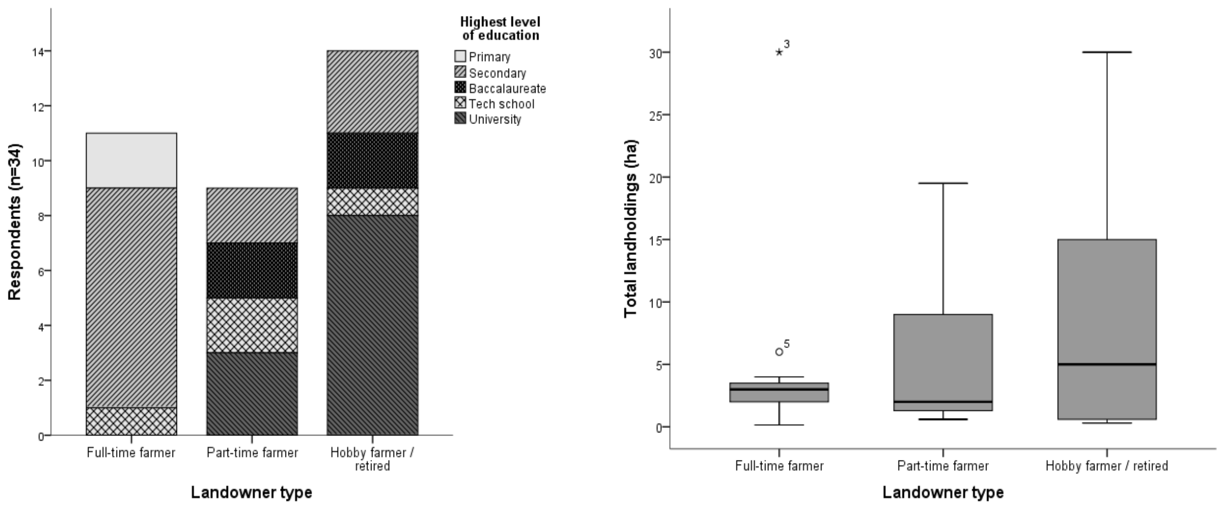

Figure 3.2. a) Landowner type subdivided by education (left panel). b) Total landholdings by landowner type (right panel). Landowner type was divided between full-time farmer (most income derived from farming), part-time farmer (e.g. employee) and hobby / retired farmer.

[87] This is likely to be an artefact of sampling since contacts provided by the municipalities were largely permanent residents. While it is possible that I have underrepresented absentee landowners, I believe that my sample is broadly representative of the relevant population, i.e. landowners with some active level of interest in managing the land. Contracting with other landowners is likely to be difficult. Similarly, the high median age of respondents reflects the age composition of villages where many younger landowners are absentee residents or have left their native villages to find employment in cities.

3.3.2 Past and Intended Future Planting (in the Absence of PES)

Apples (*Malus domestica* Borkh) were the main commercial crop trees planted, followed by stone fruits (e.g. *Prunus* spp.). The largest number of crop trees recently planted on a single plot by a landowner was 14,000, accounting for roughly 43% of the aggregated total of apple trees planted in the sample. Four respondents indicated that they had planted productive forest trees, e.g. stone pine, walnut (*Juglans regia* L.), and chestnut (*Castanea sativa* Mill.); none had mentioned planting other native forest trees (e.g. Lebanese cedar). Nearly 75% of the respondents stated they had planted over 100 commercial saplings within the last 10 years. The sample was highly skewed with respect to total landholding size and area recently cultivated, as well as number of crop trees planted per respondent. There was also considerable variability in land-use/cover types and motives for planting (Figure 3.3).

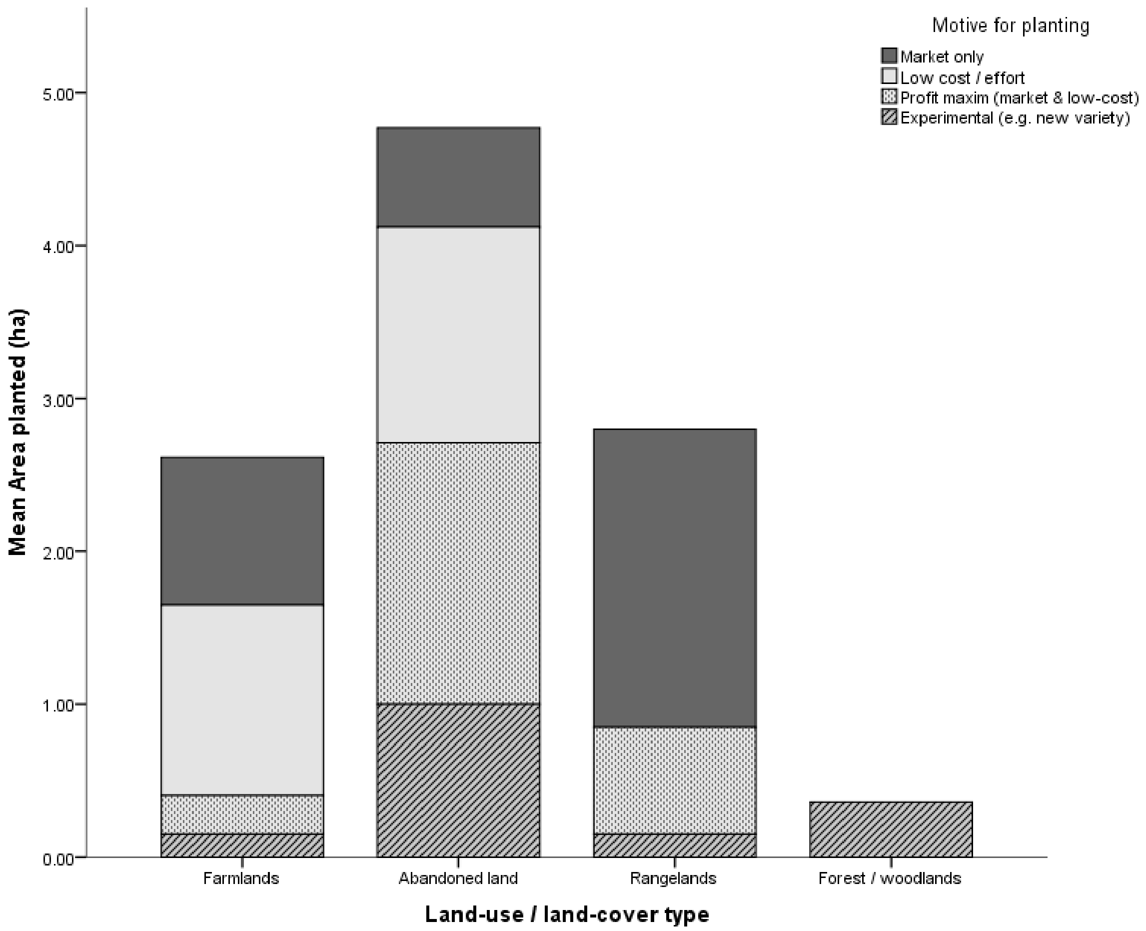

Figure 3.3. Mean area planted with commercial crops under different land-use/land-cover types subdivided by farmers' motives for planting the crops mentioned. 'Low cost / effort' refers to easy management of the trees, 'Market only' refers to high market value of the crop, and 'Profit maxim' denotes respondents who mentioned both low cost and high market value. *Note:* An outlier was excluded in order to better present the results in this figure.

Just over half of the respondents (n=18) intended to plant more trees in the near future. Fifteen ha was the approximate total area expected to be planted with over 75% taking place on abandoned farmlands. Apples, stone fruit, and seed / nut-bearing trees (mainly stone pine and walnut) were the main commercial trees to be planted, with mean anticipated areas of 7.1, 5.5 and 2.1 ha, respectively. None of the respondents in my sample mentioned intentions of planting native forest trees in the future other than stone pine.

3.3.3 Participation and Land Enrolment in the PES Schemes

Twenty-two landowners (roughly 65%) were willing to participate in the results-based loan (Scheme 1), with 21.9 ha of land offered for reforestation. Although the action-based grant (Scheme 2) increased participation to 27 with 35.5 ha land enrolled, the results-based payments (Scheme 3) did not change the number participating (both around 80%), and only slightly increased the land area to 37.5 ha[88]. There was an average of 0.8 ha increase in potential area reforested from consecutive schemes for 6 of the 21 respondents who answered yes to all three schemes[89]. Fifteen of those 21 enrolled the same area for Schemes 2 and 3, of which 8 enrolled the same area for all three schemes. A Friedman test indicated there was statistically significant difference in land enrolment between schemes (Friedman's ANOVA χ^2 (2) = 25.10, p < 0.001). *Post hoc* Wilcoxon tests found a significant increase in land enrolment from Scheme 1 to Scheme 2 (T = 169, r = −0.62, p < 0.001) and Scheme 1 to Scheme 3 (T = 198, r = −0.60, p < 0.001), but not from Scheme 2 to Scheme 3 (T = 77.5, r = −0.27, p = 0.116).

3.3.4 Agricultural Displacement under PES Schemes

Seventeen per cent of reforestation would be on cultivated lands (or land in use) under the results-based loan (Scheme 1), 11.5% under the action-based grant (Scheme 2), and 12.4% under the results-based payments (Scheme 3). However, over 65% of respondents that indicated reforestation taking place on cultivated lands under any of the schemes mentioned they would plant only at the margins of existing cultivation, e.g. borders of orchards. Eight respondents stated their intended plans would change under schemes (i.e. native forest trees

[88] One landowner who was willing to participate in Scheme 1 chose not to participate in Scheme 2, but then did participate in Scheme 3. One other who had not participated in either Scheme joined Scheme 3, while two who had participated in Scheme 2 were put off by Scheme 3.

[89] This was averaged at 0.95 from Scheme 1 to 2 and 0.65 from Scheme 2 to 3.

would be planted in place of intended crop trees) of which four mentioned plantings would take place on land in use[90].

3.3.5 Predicting Landowner Uptake and Potential Additionality

I tested whether total landholding size (in ha), age, and landowner type (divided between 'full-time farmer' and 'other'[91]) influenced responses to each of the three schemes (binary Yes/No) using logistic regression (Pallant 2010). Higher landholding size and age increased and decreased (respectively) participation in Scheme 1, but these effects disappeared for Schemes 2 and 3 as a greater number of older landowners and landowners with smaller holdings were attracted to the schemes (Table 3.2)[92].

Table 3.2. Logistic regression for predicting likelihood of enrolling in PES schemes

		B	S.E.	Wald	d.f.	Sig.	Odds Ratio	95% C.I. for Odds Ratio Lower	Upper
Scheme 1	(Constant)	3.969	2.235	3.152		.076	52.911		
	Landowner type	1.182	1.079	1.200	1	.273	3.260	.393	27.015
	Age	-.090	.043	4.342	1	*.037	.914	.839	.995
	Landholding size	.368	.183	4.044	1	*.044	1.4450	1.009	2.068
Scheme 2	(Constant)	.689	1.994	.119		.730	1.991		
	Landowner type	-1.808	1.271	2.024	1	.155	.164	.014	1.979
	Age	-.009	.036	.065	1	.799	.991	.923	1.063
	Landholding size	.863	.557	2.399	1	.121	2.370	.795	7.064
Scheme 3	(Constant)	2.574	2.092	1.514		.219	13.112		
	Landowner type	-.072	.997	.005	1	.943	.931	.132	6.568
	Age	-.039	.036	1.159	1	.282	.962	.896	1.032
	Landholding size	.319	.236	1.821	1	.177	1.375	.886	2.185

*$p < 0.05$

Respondents who declared they would participate in at least one of the three schemes (n=29) were asked if they would foresee any possible land-use changes that may affect the trees in the future. Respondents gave open-ended answers but were also prompted by the interviewer on possible responses coded in the survey, e.g. land prices increasing, agricultural product

[90] 0.6 ha under Scheme 1; 1.7 ha under Scheme 2; 2.3 ha under Scheme 3.

[91] For the purpose of analysis I consolidated part-time farmers and hobby farmers (n=23).

[92] Preliminary analyses were conducted to ensure assumption of normality, linearity, multicollinearity and homoscedasticity were not violated. Collinearity diagnostics showed that there was no violation of multicollinearity assumptions with the variables tested (VIF = 1.015). Normal probability plots of the regression standardised residuals showed there were no outliers (critical value = 13.82; Mahal maximum distance = 8.84).

prices changing, and intrinsic environmental values. Twelve mentioned no foreseeable changes in the future, ten indicated they may build on those plots, four mentioned passing land onto children, and three indicated possible land-use changes relating to agriculture. Ten respondents mentioned on-farm benefits of forest trees as possible factors for maintaining trees beyond the life of the scheme. These included the functional role of trees for increasing environmental benefits, such as erosion prevention, regulating local climates, filtering the air, and as windbreaks. Four respondents also mentioned increasing landscape beauty as a benefit, related to possible future investments in ecotourism activities, e.g. bed-and-breakfast. Finally, over half of the participating respondents indicated that they would be interested in longer term payments, but that this would largely depend on the success of the programme in the long run.

3.3.6 Landowner Perceptions of PES Schemes

The hypothetical schemes were used to initiate a discussion of landowners' perceptions of PES schemes in general, and specific characteristics of the three schemes. Respondents' general views of PES varied, but a large portion mentioned financial and technical support for farmers as being key advantages of schemes. One respondent claimed he would buy more land to enrol if these specific types of support from a PES project were genuine and trustworthy. Respondents who would participate in one or more of the schemes discussed advantages of PES for its role in generating greater environmental benefits, both on- and off-farm. One respondent, for example, suggested PES schemes should include mainly productive native trees:

> *"The proposed scenarios may encourage farmers to replant their land that was burned during the [civil] war, [but] only if [these] trees are productive such as olive, [stone] pine, walnut, fig… consequently, the benefit will be for the farmer and the environment." (Resp. # 16)*

Perceptions towards individual schemes also varied. Unsurprisingly, respondents showed a greater keenness towards the action-based grant over the results-based loan due to relaxed conditions of the latter (i.e. lower risk). Interestingly, however, while three respondents who indicated that they would participate in the action-based grant opted out of the results-based payments, two others who opted out previously joined, albeit with very little land enrolled. One respondent, who owned 6 ha of largely abandoned farmlands enrolled 1 ha under results-based loan (Scheme 1) and 4 ha under the action-based grant (Scheme 2), but nothing under results-based payments (Scheme 3). His explanation was as follows:

> *"The 3rd [scheme] is like a gambling game and the farmer can't take [such] risks. I can't trust such [a] scheme especially [since] the success of this plan is mainly related to natural [environmental factors] which I can't [control]. So who will compensate the lost investment if for example 30 of 100 seedlings survived after [some] unpredictable natural [disaster]?" (Resp. #18)*

This suggests that some landowners may not believe future payments would in fact occur under results-based payments for 'unproductive' species (since Scheme 3 carried no higher risk than Scheme 1 in addition to providing higher payoffs), but trusted they could make repayments (Scheme 1). However, there were respondents who also saw advantages in the results-based payments (Scheme 3), even by those who decided not to participate for other reasons:

> *The third scheme can be more applicable especially since the farmer will be paid on each planted tree. [This] type of scheme had been implemented in the past by the government for silk production, so each farmer who plants a mulberry tree was given an amount of money. The more he planted the more money [he received], even if he [wasn't] a silk (or silkworm) producer." (Resp. #20)*

This may suggest that landowners would prefer more autonomy over how many trees to plant based on characteristics of their holdings and their own capacity. However, many non-participants, including Respondent #20, simply did not see any benefit of planting native trees regardless of the contract type or money offered. Most of the respondents who opted out of all schemes shared a dislike of non-productive native trees and/or diversified land-uses. For instance, one respondent mentioned he would not even consider diversifying his production, preferring to plant one profitable crop, stating that "nothing beats apples in this region". If given the option to plant native trees, the most likely candidate would be stone pine for its revenues from pine nuts. However, even the high returns from processed pine kernels are no match for apples. One respondent summarised the following:

> *"Landowners won't grow forest trees on their agricultural lands for the following reasons: Fruit trees are more profitable [in the short-run] because they require less time to produce as opposed to [productive] forest trees; fruit trees can be secured as a source of revenue while the majority of forest [species] don't generate revenues; the government has put a lot of restriction on forest trees, [so] once planted they cannot be removed." (Resp. #34)*

In general, respondents' comments on PES schemes would suggest that opportunity costs were considered to be high. Yet institutional factors may also influence uptake of PES as mentioned by Respondent # 34 above. At least three of my respondents referred to the legal implications of planting forest trees. Since permits are required for cutting or removal native forest species[93] even on private lands (Law 85/1996), it is not surprising that landowners (especially farmers) would be reluctant to plant non-productive species on productive farmlands. While Lebanon's current forestry policies may have contributed to relative gains in forest cover on abandoned farmlands, it may have also hindered effective forest management and reluctance of landowners to plant more forest trees:

> *"In the past, forests were well managed and protected by the local people because they were a source of [fodder], wood, and medicinal and aromatic plants... Today, more restrictions have been implemented by the MOA to protect forest areas, but this has actually discouraged people from preserving their forested lands because [these new laws have made forests] 'useless'. Now violations, neglect and forest fires have increased... [because only] when people find a benefit from something, they will work to protect [it]." (Resp. #1)*

Other factors contributing to lack of uptake and land-enrolment mentioned were land availability and the land-use types in question (e.g. lack of land unsuitable for agriculture). Attitudes towards native species, as well as changing trends in land market prices, were also important factors respondents raised that affect participation.

This brings us to another important research question: *What types of landowners would be more likely to provide greater additionality? What variables would likely contribute to this?* Various factors could make future PES projects in Lebanon challenging to implement. Land availability was a constraint mentioned by both participants and non-participants alike. It is also clear that fewer younger landowners are actively managing their holdings than before, hence age will likely be a factor affecting uptake as well. Respondents in my sample were quite aged (median 57), which is reflective of a declining agricultural sector driving many households into cities in search of work. For instance, one respondent chose not to subscribe to any of the schemes both due to his age and the fact that his children no longer live in the village. He gave interesting insights that point to potential constraints in implementing a PES programme with landowners in Lebanon:

> *"Nowadays, the younger generation is not interested in agriculture and the older generation is no longer able to maintain the land... so [younger landowners] are selling their lands instead of [maintaining] and cultivating them…" (Resp. #17)*

This statement suggests that opportunity costs may be too high for reforesting private lands due to either development, lack of human resources to manage land, or both. While

[93] This pertains mainly to native conifers (e.g. *Pinus* spp., *Juniperus* spp., *Cedrus libani* Rich., *Abies cilicica* Carr., *Cupressus sempervirens* L.).

landowner type (full-time farmer vs part-time and hobby / retired farmer) did not exert any significant influence on PES uptake, there is a trade-off between targeting farmers who would have a greater capacity to plant and care for trees, yet may also have higher opportunity costs than non-farmers.

Quantitative results indicated that PES schemes would likely take place on abandoned farms or rangelands of low opportunity cost. But this may entail high operational costs since these lands are also likely to be remote, lacking access to roads and water. This brings us to my final research question: *would agricultural land be displaced under PES schemes, and does this level of displacement differ between schemes?* While it is likely that most landowners would choose to plant forest trees on land unsuitable for agriculture, there is a possibility that a PES programme could inadvertently bring marginal lands (e.g. abandoned farms or remote rangelands) into production. Take for example the following statement:

> *"[constructing] agricultural roads is a must [in order for farmers] to access all the abandoned land. So when a farmer has land suitable for [production], he will plant it with fruit tress because the benefits from these trees will be more than forest trees, even if [the latter] is supported by any [reforestation] plan or schemes." (Resp. #21)*

Increasing land prices may also influence policymakers to build roads to access abandoned farmlands in remote areas, thus posing a threat to tree retention under future PES schemes.

3.4 Discussion

One of the most important outcomes of this study for policy was a better understanding of landowners' perceptions of PES and how they differed. Asset-building PES such as reforestation requires long-term maintenance to ensure future additionality of off-farm ES. While frontloading payments to cover direct costs of planting and maintenance is common in PES using productive trees with private benefits (Hegde and Bull 2011), it is much more challenging under biodiversity-focused PES as in this study. Landowners may be especially reluctant to plant trees that offer little private benefit in the long-run (as is the case with most native tree species). Although results-based schemes may be more effective in ensuring long-term tree retention of native trees than action-based schemes, they depend heavily on landowners perceiving the credibility of such long-term payments.

Recent studies on incentives for re/afforestation have shown that landowners are heterogeneous in their preferences and their decisions to participate in such schemes may not be solely based on present or perceived opportunity costs, but also on non-financial factors related to risks and uncertainties (Knoke and Wurm 2006; Ma et al. 2010; Duesberg et al. 2013; Blennow et al. 2014). Reasons why landowners in my study (particularly full-time farmers) would opt out of schemes relate directly to other studies conducted, particularly how livelihoods could be affected from having native species on farms, such as loss of tenure and negative perceptions of biodiversity, e.g. native trees attract insects (Zubair and Garforth 2006). Others have indicated that uptake of re/afforestation initiatives depends more on landowner attributes and perceptions than landholding characteristics (e.g. Mahapatra and Mitchell 2001). In my sample, there was also considerable heterogeneity amongst farmers and their preferences, yet social and institutional aspects appeared to play an important role in uptake for most. These included issues with credibility and trust in new institutions as well as legal implications of planting native trees on private lands, resulting in high opportunity costs and unforeseeable risks in the future.

Schemes were designed specifically to investigate how landowners perceive risks related to conditionality. While it plays an important role in asset-building schemes, conditionality may also limit participation if landowners perceive schemes as too risky (Chen et al. 2009). The first two schemes (results-based loan and action-based grant) differed substantially in their level of risk to landowners, and a reduction in risk predictably increased enrolment. However, surprisingly the addition of results-based payments (Scheme 3) did not significantly increase uptake. Reasons for this may pertain to landowner perceptions of risk and uncertainty in general (Blennow et al. 2014), as well as risks specifically attributed to results-oriented schemes (Burton and Schwarz 2013). There is also the possibility that Scheme 3 was not considered to be credible over the long timescale required to ensure tree retention by landowners in a country which has experienced considerable turmoil (Makdisi 2004). Since results-based payments might ensure greater retention over time, targeting PES involves trade-offs for both buyers and potential suppliers with respect to risks. For example, buyers would have to weigh trade-offs between efficiency (e.g. low payments and transaction costs, displacement- and risk-reduction) and effectiveness (e.g. supplier uptake, extent of land enrolled, tree retention) when designing contracts while sellers weigh the risks and reward of those contracts (Table 3.3).

Table 3.3. Trade-offs between efficiency and effectiveness of schemes

Variables	**Scheme 1**	**Scheme 2**	**Scheme 3**
Farmer uptake	Medium	High	High
Area enrolled	Low	Medium	Medium
Displacement	Medium	Low	Low
Risks (to farmers)	High	Low	Low/Med.
*Transaction costs**	High	Low	High
*Payment costs**	Low	Med	High

* These are reasonable estimates of the costs to buyers involved in mounting the schemes

Hudson and Lusk (2004) found that autonomy of farmers plays an important role in the context of risks and transaction costs in contracting decisions. In our experiment, landowner autonomy under results-based schemes (1 and 3) can be perceived to be limited with respect to higher transaction costs for the buyer (since these schemes both required monitoring). Scheme 3 potentially gives landowners more autonomy than Scheme 1 in deciding how many trees to plant in relation to the extent of land to be enrolled. Our results indicated that landowners are unlikely to enrol more land under results-based payment (Scheme 3) than action-based grant (Scheme 2) despite higher payoffs in the long run. This may be attributed to loss of autonomy, especially since monitoring could be viewed as an annoyance, implying a loss of utility. It is also possible that Scheme 1 could invite principal-agent problems (e.g. hidden action). For example, participants in results-based loan could potentially use planting funds to rehabilitate abandoned lands and deliberately allow native trees to die in order to plant productive trees in their place. While it is important to increase uptake in PES schemes by reducing risks, allowing landowners autonomy in contracting decisions should be used with caution in contracts that are liable to invite principal-agent dilemmas, thus increasing transaction costs for buyers.

Aside from a prohibitively small sample size that limits using more robust parametric analysis, other issues and limitations of this study include whether respondents were able to fully grasp these types of schemes in order to make better assessment of their risks and reward. An example of this includes a quote by respondent # 20 who, even though he chose to participate in Scheme 2, viewed Scheme 3 to be too risky. This type of response poses an anomaly. On one hand, it might suggest that some landowners may not believe future payments would in fact occur under results-based payments for 'unproductive' species (since Scheme 3 carried no higher risk than Scheme 1), but trusted they could make repayments (Scheme 1). On the other, it highlights difficulties in assessing risks associated with schemes presented since landowners' perceptions towards risks and uncertainty often vary and may have been biased by the order of the schemes presented. This may have also explain why opportunity costs were fairly ubiquitous.

Many studies have found that participation in asset-building PES is contingent upon farm-based incomes (i.e. opportunity costs), farming systems (e.g. available marginal lands), landholding size, and age (Zbinden and Lee 2005; Pagiola et al. 2008; Bastiaensen and Van Hecken 2009; Cole 2010; Liu et al. 2010). My results suggest that consideration of opportunity costs was ubiquitous amongst respondents, especially if they could foresee possibilities of bringing land in disuse back into cultivation, or even the prospects of the value of their land increasing in the future. Respondents in my sample owned modest size holdings in comparison to other countries, and may have been conservative with how much land they would be willing to enrol. This is especially true if they believed payments may not have been sufficient enough to cover future revenues foregone. This is to be expected in the context of an agricultural sector that is changing rapidly with emigration of rural households, combined with urbanisation and increasing land prices in some areas. Perceived opportunity costs are difficult to assess in many respects since future land-use is highly speculative and contingent upon various factors. Landowners' opportunity costs could also vary from one parcel to the next, and perhaps even within the same parcel (Wunder 2007). For instance, while present opportunity costs of arable land that is currently in use would be higher than marginal abandoned cropland or remote rangelands[94], this could inevitably change in the future if new infrastructure was developed (Crabtree et al. 2001). Hence, landowners would have to consider important trade-offs when selecting plots with the lowest opportunity costs, such as direct costs of planting and irrigating seedlings on difficult terrain. This is particularly critical for less experienced tree planters who may underestimate the level of difficulty or work involved, especially for those who are quite aged.

The overall success of an asset-building PES programme in Lebanon requires not only long-term tree retention, but would also have to factor in the programme's potential for displacing agriculture. According to the latest agriculture census, there is an estimated 9,800 ha of abandoned farmlands in the six districts where my study was conducted, more than half of which are considered to be suitable for agriculture (Salibi 2007). Many are abandoned due to

[94] While it is not uncommon for landowners to rent these lands out to herders, there were none in my sample that indicated this for any of their plots.

lack of access to water and roads, in which case road-building and agricultural development projects could potentially increase opportunity costs. Further, they could potentially threaten future tree retention if an asset-building PES programme were implemented, and these infrastructural improvements could be stimulated by the programme itself.

3.5 Conclusion

This paper examined the potential for PES to incentivize landowners to plant diverse native trees on private property. The objective of this mixed-methods study was to examine how Lebanese landowners perceive PES schemes and how different forms of conditionality might affect participation. Combined qualitative and quantitative methods enabled me to gauge landowners' perceptions towards schemes, helping to identify factors that would influence uptake, land enrolment and establishment of native trees on private property in the long run. Lebanese landowners from montane villages are heterogeneous in their occupations, landholdings, and preferences. Despite this, many (over 60% in my sample) appeared willing to participate in asset-building PES aimed at enhancing biodiversity. Qualitative probing revealed some of the constraints and challenges perceived by landowners, which helped strengthen my quantitative results. I found that the addition of results-based payments (Scheme 3) did not increase participation or land enrolment, possibly due to a lack of trust in long-term programmes, especially in a society facing constant turmoil. I also identified the importance of uncertain future opportunity costs in a rapidly changing rural context. This study demonstrates the importance of combining qualitative and quantitative data collection in studies of PES and shows that the potential for tailoring PES schemes to supply off-farm ecosystem services will depend on understanding landowners' perceptions.

4 Prioritising Native Tree Species for Reforestation Efforts in Lebanon

Choosing species for reforestation often requires making trade-offs between different objectives. Reforestation stakeholders may have different preferences for species based on their perceived biodiversity conservation value and the ecosystem services that they are expected to provide. I surveyed stakeholder preferences for species to be included in reforestation within an ecologically important region in North Lebanon. Of the 30 native tree species being produced in Lebanese nurseries, 22 were identified as ecologically suitable by experts. Stakeholders (n=34) in Lebanon's public, private and academic sectors were then asked to rate these 22 species according to conservation priority and ecological suitability. Different methods of ranking species were then compared in order to select the top 10 species. Non-parametric analysis was conducted to determine whether there were significant differences between stakeholders from biodiversity- and forestry-focused sectors. While forestry-focused respondents rated broadleaved species higher and conifers lower than biodiversity-focused ones, results indicated that no significant differences in species ratings existed between the two stakeholder groups. The variability in preferences between stakeholders, including the considerable within-group variability that I found, highlights some of the challenges with soliciting preferences from multiple stakeholders when selecting species to be used in reforestation efforts.

Keywords: native species; reforestation; Lebanon; stakeholders; non-parametric tests; preferences; ranking; species rating

4.1 Introduction

Despite continued deforestation and forest degradation, agricultural abandonment has led to the recovery of some forests (Sitzia et al. 2010), particularly in Mediterranean Europe (Poyatos et al. 2003; Bonet 2004). However, active restoration (e.g. re/afforestation) is often necessary on lands lacking natural regeneration, particularly landscapes where soil and gully erosion is prevailing (Scarascia-Mugnozza et al. 2000; Rey-Benayas et al. 2008; De Baets et al. 2009). Decisions on the species used in restoration are quite often geared towards meeting short term objectives, such as mitigating on-site degradation. But species selection decisions also have important implications for biodiversity and other ecosystem services in the future (Aronson et al. 1993; Lamb et al. 2005; Carnus et al. 2006; Bullock et al. 2011).

4.1.1 Species Selection in Restoration

The literature on species selection for restoration has largely focused on biophysical and ecological assessments in order to determine suitability and desirable outcomes. These include selecting species based on biomass yields, survivability, and other biophysical attributes of trees (Pedraza and Williams-Linera 2003; Delagrange et al. 2008) while Matías et al. (2009) determined the seed dispersal rate by analysing species-selection patterns by post-dispersal seed predators. Methods for selecting candidate (or focal) species of fauna for structuring site-based conservation have also been developed (Coppolillo et al. 2004). Others have taken a more landscape-level approach to enhancing biodiversity, such as through enrichment planting (Martínez-Garza and Howe 2003) or the development of framework tree species aimed at biodiversity recovery in tropical forest restoration (Elliott et al. 2003). Technical aspects with respect to seedling production, site-selection, planting techniques, post-planting maintenance, and the appropriate selection of species all contribute to the overall success in reforestation (Castro et al. 2004; Healy et al. 2008; Garen et al. 2011). Yet species selection becomes contentious when there are multiple decision-making stakeholders (e.g. experts, policymakers, and practitioners) with varying aims and objectives in restoration.

The importance of stakeholder participation in facilitating more adaptive co-management of complex social-ecological systems has been well documented (Fraser et al. 2006; Stringer et al. 2006; Reed 2008; Kofinas 2009; Berkes 2010; Plummer et al. 2013). Stakeholders involved in restoration or other conservation measures often face difficult trade-offs between social, economic and ecological objectives. Restoration objectives that support multifunctional landscapes often require the assessment of a suite of potential scenarios in order to minimise future ecosystem services trade-offs (Reed et al. 2013). Understanding the aims and objectives of various stakeholders is therefore crucial for identifying trade-offs in order to better deliver environmental benefits to a wider range of beneficiaries. For example, Reubens et al. (2011) have emphasised the importance of incorporating stakeholder attitudes towards and preferences for different restoration strategies. Similarly, McDonald et al. (2003) have shown the importance of turning to local stakeholders for evaluating and selecting indigenous tree species, which benefits practitioners as well as meeting the needs of local communities. Yet stakeholder preferences for species may vary by subjective tastes and the extent of knowledge individuals have about the species and their ecology. Eliciting preferences that are often subjective and with a considerable degree of heterogeneity is a challenging yet necessary means of engaging multi-stakeholder participation in policy and practice (Ananda and Herath 2003; Caparrós et al. 2011; Newton et al. 2012; Reed et al. 2013).

Re/afforestation can potentially provide multiple ecosystem services both on- and off-site; including erosion prevention, soil amelioration, and creating shade/windbreaks, as well carbon sequestration, landscape beauty and biodiversity enhancement (Caparrós et al. 2010; Hall et al. 2011a). Selecting hardier and more adaptable (e.g. to harsh climates) species that are readily available (or easy to produce) may be a more cost-effective means of meeting some of these objectives, but may compromise others: certain species may also be unsuitable or even detrimental to local biodiversity, especially if they are exotic and potentially invasive (Le Maitre et al. 2011; Jellinek et al. 2013; Levin et al. 2013). Many have argued that re/afforestation with narrow objectives, such as planting fast-growing exotics for timber or climate regulation, have resulted in the deterioration of biodiversity and other ecosystem services, and even detrimental to local livelihoods (Bäckstrand and Lövbrand 2006; Bremer and Farley 2010; Barr and Sayer 2012; Lindenmayer et al. 2012). Perhaps there are competing aims between those with professional interests (or foci) in forestry and those with interests in conserving biodiversity. Despite both fields having some overlapping aims and objectives in reforestation (e.g. increasing and/or maintaining forest cover), the motive was to assess whether conflicts between forestry and biodiversity conservation exist as some studies have found (Niemelä et al. 2005; Angelsen et al. 2012). Evidently, decisions based on what the expected or desired benefits from reforestation will be for society ultimately influence the types and quantities of tree species to be established in a given area (de Koeijer et al. 1999; Wossink and Swinton 2007; Nelson et al. 2009; Barraquand and Martinet 2011).

4.1.2 Research Objectives

The main objective of this study was to identify native tree and shrubby tree species that are considered to be of the highest conservation value for use in reforestation according to stakeholders in forestry and biodiversity conservation sectors in Lebanon. The resulting priority species list served as one of three reforestation options within a choice experiment survey that I conducted with landowners in villages from Bcharre and Zghorta-Ehden districts of North Lebanon (chapter 5). This research site is one of twenty newly designated Important Plant Areas (Yazbek et al. 2010) in Lebanon[95]. Aside from its ecological importance[96], landscape-scale re/afforestation in this region has been planned over the next few decades by national stakeholders (*pers. comm.* LRI, July 2012).

In addition to identifying priority species for the next chapter, I also aimed to explore the consistency of preferences across individual stakeholders and to determine whether ratings differed systematically between respondents with a professional focus on biodiversity versus forestry.

4.2 Methods

4.2.1 Developing the Candidate List of Species

The first stage involved compiling a preliminary list of all native tree and shrub species in Lebanon. I used an existing database developed by researchers at the American University of Beirut's Nature Conservation Center (AUB-NCC). The database used earlier literature on flora in Lebanon and the Levant region (Post 1932; Mouterde 1966) and later updated it with the most recent reference on Lebanese flora (Tohmé and Tohmé 2007), noting that nomenclature often differed[97]. New species tentatively included were those that were found in recent journal articles, e.g. *Tilia silvestris intermedia* (Tohmé and Tohmé 2009). Nomenclature for species gathered in the preliminary list was later cross checked and updated using international (online) indices (International Plant Names Index 2005). A basic analysis using search engines and online databases (Royal Botanic Garden Edinburgh 1998; The Med-

[95] Please refer to chapter 2 for details on Important Plant Areas

[96] There are four protected areas; two Natural Reserves and two UNESCO World Heritage Sites.

[97] AUB-NCC conducted field research that included collection of voucher specimens and photographing key morphological features (e.g. flowers, seeds, leaves, etc.) in addition to obtaining locations through GPS. Collected specimens and images were later cross-referenced with existing literature and Internet searches for more in-depth identification.

Checklist 2007; Encyclopedia of Life 2011; Euro+Med Plantbase 2011; Lebanon FLORA 2013; The Plant List 2013; Catalogue of Life 2014) was used to cross-check taxonomic names and other relevant information with the list of native trees prepared by AUB-NCC. This was followed by web-based research into whether any information on the conservation status of the species existed (e.g. IUCN 2014).

4.2.2 Ecological Suitability and Availability

The preliminary species list was later shortlisted based on 1) their suitability for the research sites and 2) their availability in commercial tree nurseries in Lebanon. For the former, this list was revised with the help of experts at AUB-NCC in order to identify which species were thought to be suitable for planting in the research area, the mountainous region of North Lebanon, within an altitude range of 1,000 – 1,500 m.a.s.l. For the latter, organisations involved in the Lebanon's forestry sector were contacted to determine which nurseries were producing native forest trees. These nurseries were then contacted to provide me with a list of native species that they are currently producing.

4.2.3 Eliciting Stakeholder Preferences

An online survey was conducted with stakeholders in both English and Arabic. The survey was delivered via personalised email invitations with a brief description of the study and a link to the online survey[98]. Respondents were first asked to rate each of the 22 species listed as either: 'High', 'Medium', or 'Low' conservation priorities for inclusion in reforestation in the research site (which was described in the email). They also had the option to select 'Ecologically Unsuitable' if they believed the species should not be planted in the site described, or 'Don't know this species' if they had insufficient knowledge of the species[99]. A hyperlink was provided next to each species directing the respondents to the 'Euro+Med PlantBase' website (2011) providing extra details of the species (e.g. nomenclature reference, distribution, etc.).

An optional second question asked participants to list up to five additional species that were both suitable for this research site and which they would consider as high conservation priority for reforestation. The third and fourth part of the online survey asked respondents to

[98] A copy of the email and survey are provided in Appendix 4.1-4.2

[99] The pilot survey included an option 'Not sure' that was later removed since the relationship between knowing the species yet unsure about its habitat is the same in the context of this study.

describe their profession (‘Academia’, ‘Gov’t / Public sector’, ‘Private sector’, and ‘Other’) and sectorial focus (Biodiversity conservation, Forestry, Agriculture, and Other[100]).

Stakeholders selected to participate in this online survey were identified with the help of colleagues from AUB-NCC who provided us with contacts from their professional networks. Contact details and additional candidates were also obtained through searching the public domain and through snowballing (word-of-mouth). Invitees included researchers, policymakers, forestry specialists, and natural resource managers from both public and private sector institutions and organisations. This included individuals in sub-sectors of forestry and biodiversity conservation, such as forest ecology and agro-ecology. The online survey was created and administered using LimeSurvey®. Statistical analyses were conducted using SPSS® (version 20).

4.2.4 Ranking Species for Reforestation

There are numerous ways to prioritise species based on diverse stakeholder preferences. All are inherently subjective, and depend on the respective weight put on ordinal ratings of importance (high, medium and low), unsuitable classifications and how missing ratings (where respondents did not know a species) are treated. For example, numerous missing values (indicating that a species was poorly known) could indicate that it is of marginal importance in that habitat, or that it is rare, in which case we could argue it having high-conservation-value. Similarly, respondents’ preferences might be weighted according to their knowledge (e.g. ratings by respondents who admitted ignorance of several species might be down-weighted) but there is a risk of confounding caution with a lack of expertise.

I used the following procedure in order to derive a list of 10 priority species for chapter 5:

1. Species with seven or more missing values (‘Don’t know this species’) were omitted given that the rate of respondents fell below 80% for those species;
2. Species with median ratings of ‘High’ were then selected that had the fewest ‘Ecologically Unsuitable’ ratings;
3. Where species were tied on median ratings *and* numbers of ‘Ecologically Unsuitable’ ratings, I then selected species with median ratings of ‘Medium’ with fewest ratings of ‘Low’.

[100] Respondents were asked to provide details if they chose ‘other’ as their profession or focus

4.3 Results

4.3.1 Stage 1: Preliminary Species List

The preliminary list consisted of 74 tree and shrubby tree species native to Lebanon. Sixty-four of those species were obtained from the AUB-NCC database and an additional 10 from other sources[101]. Some of these additional species included were considered to be 'naturalised', e.g. sweet chestnut (*Castanea sativa* Mill.) and Old World walnut (*Juglans regia* L.). The 74 species were later analysed for their conservation status through IUCN's Red List database (Table 4.1).

Table 4.1. Lebanese native trees/shrubs searched in IUCN RedList website search engines

Category	**No. of species**
Vulnerable (populations decreasing)	1
Near threatened (lower risk)	3
Least concern (lower risk)	14
Not assessed (as of yet) but listed in Catalogue of Life	39
Not listed in IUCN Red List or Catalogue of Life	17
Total	**74**

The conservation status provided by the IUCN Red List was available for only a portion of the species native to Lebanon and neighbouring countries (broad endemics). Over half of the species have yet to be assessed, and approximately a quarter were not listed (as of 09/2013). Most of the rare and endemic plant species in Lebanon that are listed in current references (e.g. Tohmé and Tohmé 2007) have not yet been listed and/or updated for their conservation status in Internet-accessible databases, e.g. IUCN, Catalogue of Life.

4.3.2 Stage 2: Ecological Suitability and Availability

As of spring 2013, just over 30 species of native trees were being produced in local nurseries and were available in the market[102]. With the help of experts from AUB-NCC, 22 of these species were considered suitable based on their natural range in mountainous areas (1000-1500 m.a.s.l.) on the east-facing mountain range surrounding the Qadisha Valley (a UNESCO

[101] While there are many other woody species of shrubs identified by experts (Tohmé and Tohmé 2007), I included only those with growth potentials over 1 metre.

[102] Some nursery owners/producers mentioned new species they had just begun propagating that would be available by the following year; however, these were not included in the original list of species for this study.

World Heritage Site) watershed in North Lebanon. Species with altitudinal ranges well below 1,000 meters above sea level were discarded from the list, e.g. carob (*Ceratonia siliqua* L.). The majority of the species selected are found naturally at various elevations along the east-facing habitats of mountainous landscapes in North Lebanon, along with a few once-abundant species that are now relics, such as Taurus maple (*Acer hyrcanum* subsp. *tauricolum*)[103].

4.3.3 Stakeholder Preferences

In total, 80 individual invitations (with LimeSurvey tokens) were sent to respondents from various academic and professional backgrounds. Thirty-four respondents fully completed the survey from early May to mid-June, 2013 (44% response rate). Eleven recipients did not take the survey and there were 35 incomplete responses[104]. Four invitees emailed me personally explaining they did not have sufficient expertise in this field to make any meaningful contributions. The sample included respondents largely from academic institutions (50%) and NGOs (30%), with professional foci split between forestry and biodiversity conservation[105] (Figure 4.1).

[103] This was mentioned to me by key informants in a previous study (*pers. comm.* July 2012).

[104] Having received only completed responses, I did not have access to incomplete surveys (IRB regulations for ensuring confidentiality) and was therefore unable to assess how incomplete responses were. However, I suspect that these respondents opened the link but never went any further.

[105] Two respondents that stated ‘Agriculture’ as their focus were involved in agro-biodiversity research and therefore placed under Biodiversity.

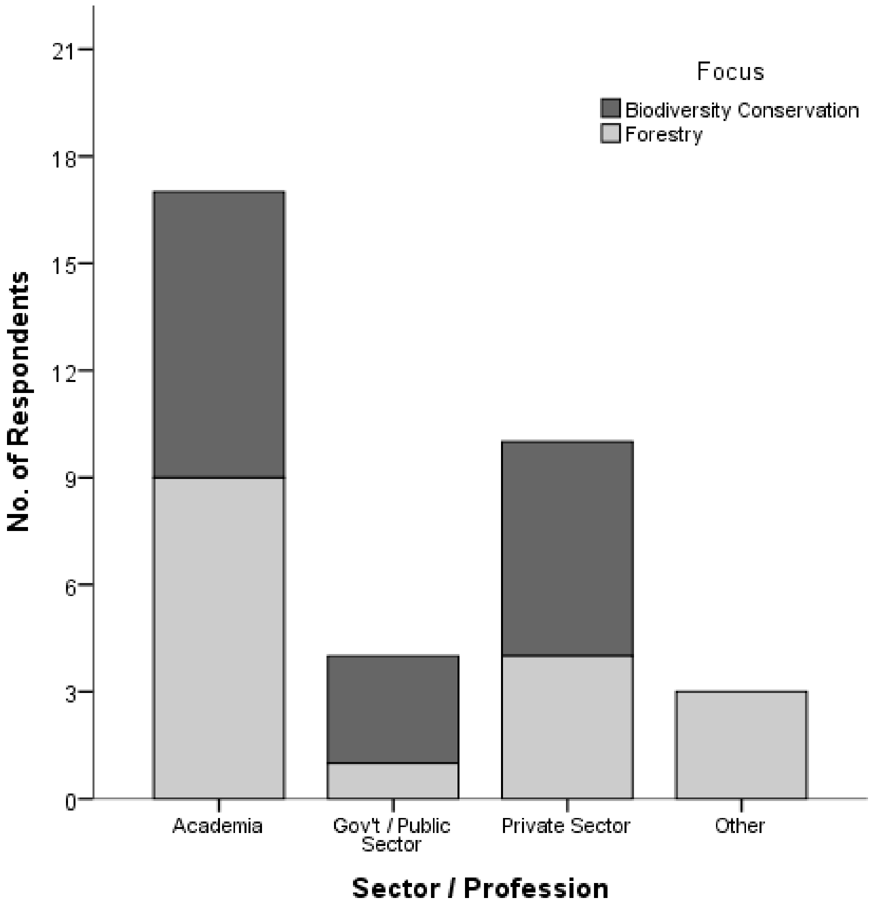

Figure 4.1. Respondents classified according to Sector / Profession and Focus. Participants who selected ‘Other’ under *Sector / Profession* indicated forestry expert, international agencies, and researcher as open responses.

The 34 completed responses were transferred into SPSS v. 20 for statistical analyses. Categorical responses were coded as follows:

- 0 = ‘Ecologically Unsuitable’
- 1 = ‘Low’
- 2 = ‘Medium’
- 3 = ‘High’
- N/A = ‘Don’t know this species’ (treated as missing values)

An initial analysis of the ratings showed that there were four species with median ratings of ‘High’, three between ‘High’ and ‘Medium’, thirteen with ‘Medium’, one between ‘Medium’ and ‘Low’, and one with ‘Low’ (Table 4.2). Cedar of Lebanon (*Cedrus libani* Rich.) received the largest number of ‘High’ ratings by respondents (n=26, 77% of respondents). Grecian juniper (*Juniperus excelsa* M.-Bieb.) received the most ratings for ecologically unsuitable (n=5). Only six of the 22 species were rated (i.e. were known) by all respondents. Eight of the 22 species were unfamiliar to six or more respondents.

Table 4.2. Summary of responses (n=34) to the online survey divided by foci

Species (22)	**Biodiversity (n=17)**			**Forestry (n=17)**			**Combined**		
(alphabetical order)	Don't know	EU*	Median	Don't know	EU*	Median	Don't know	EU*	Median
Abies cilicica	0	1	3.0	1	2	2.5	1	3	3.0
Acer hyrcanum	0	2	2.0	2	0	3.0	2	2	2.0
Acer monspessulanum	3	1	2.0	3	1	2.0	6	2	2.0
Alnus orientalis	4	2	2.0	2	2	2.0	6	4	2.0
Cedrus libani	0	1	3.0	0	0	3.0	0	1	3.0
Celtis australis	1	2	2.0	2	2	1.0	3	4	1.0
Crataegus monogyna	0	0	2.0	0	0	2.0	0	0	2.0
C. sempervirens†	1	0	2.0	0	0	2.0	1	0	2.0
Fraxinus angustifolia	5	1	2.0	3	2	2.0	8	3	2.0
Fraxinus ornus	5	1	2.0	2	0	2.0	7	1	2.0
Juniperus excelsa	1	3	3.0	0	2	2.0	1	5	3.0
Ostrya carpinifolia	4	1	2.0	4	0	3.0	8	1	2.0
Pinus brutia	0	2	2.0	0	0	2.0	0	2	2.0
Pinus pinea	0	1	1.0	0	2	2.0	0	3	1.5
Prunus cocomilia	4	0	2.0	2	0	2.0	6	0	2.0
Prunus dulcis	1	1	2.0	2	0	2.0	3	1	2.0
Pyrus syriaca	1	0	2.0	0	0	2.0	1	0	2.0
Quercus brantii	4	0	2.0	0	4	2.0	4	4	2.0
Quercus cerris	0	0	3.0	0	0	2.0	0	0	2.5
Quercus infectoria	0	0	3.0	0	0	2.0	0	0	2.5
Sorbus flabelifolia	2	0	3.0	5	0	2.5	7	0	3.0
Sorbus torminalis	2	0	2.0	4	0	3.0	6	0	2.5

*Ecologically unsuitable
†*Cupressus*

4.3.4 Variability in Species Ratings

There was significant variation in ratings across respondents (n=23) for those species (n=14) that were unknown to fewer than five respondents (Friedman's ANOVA, χ^2 (13) = 64.02, p < 0.001). An analysis was conducted to determine whether this variability between respondents was explained by their foci (see Table 4.2 above). Friedman's tests on each subset of respondents indicated no significant variation between respondents within the biodiversity foci (Friedman's ANOVA, χ^2 (6) = 36.64, p = 0.18) but variation of respondents within the forestry foci was significant (Friedman's ANOVA, χ^2 (10) = 50.15, p < 0.001). Post-hoc Mann-Whitney U tests showed no significant difference (p < 0.05) in ratings between forestry- and biodiversity-focused respondents for the 22 species, even before correction for multiple comparisons (Table 4.3).

Table 4.3. Non-parametric test results for the 22 species (listed in alphabetical order)

Species	Mann-Whitney U	Z	Asymp. Sig.[a]
Abies cilicica	105.00	-1.28	0.20
Acer hyrcanum	96.00	-1.30	0.20
Acer monspessulanum	95.00	-0.16	0.88
Alnus orientalis	81.50	-0.80	0.43
Cedrus libani	143.50	-0.05	0.96
Celtis australis	91.50	-1.21	0.23
Crataegus monogyna	139.00	-0.21	0.83
Cupressus sempervirens	113.50	-0.86	0.39
Fraxinus angustifolia	76.00	-0.44	0.66
Fraxinus ornus	73.50	-0.89	0.37
Juniperus excelsa	100.00	-1.51	0.13
Ostrya carpinifolia	62.00	-1.23	0.22
Pinus brutia	136.50	-0.29	0.77
Pinus pinea	126.00	-0.67	0.50
Prunus cocomilia	79.50	-1.01	0.32
Prunus dulcis	101.50	-0.80	0.43
Pyrus syriaca	128.50	-0.30	0.76
Quercus brantii	65.50	-1.98	0.05
Quercus cerris	118.00	-1.01	0.31
Quercus infectoria	115.50	-1.11	0.27
Sorbus flabelifolia	82.50	-0.40	0.69
Sorbus torminalis	92.50	-0.25	0.80

[a] 2-tailed; corrected for ties

Median ratings were equal for respondents in both groups (Figure 4.2) for 12 of the 22 species. There were eight species that differed in median ratings by 1 (scaled at 0-3) between the two foci. Two of those species received ‘Low’ median ratings: *Celtis australis* by forestry-focused and *Pinus pinea* by biodiversity-focused respondents (Figure 4.2).

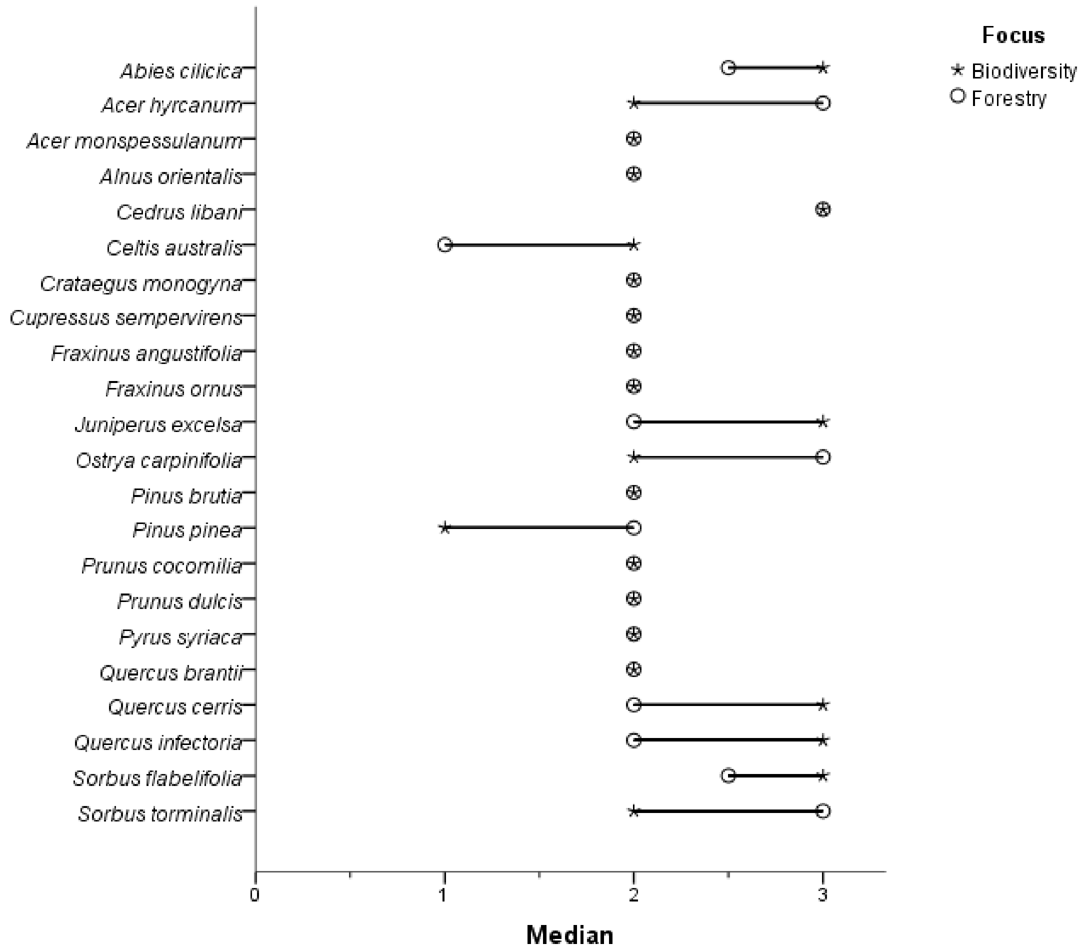

Figure 4.2. Medians of respondents' rating of species split between two foci – 'Biodiversity Conservation' and 'Forestry'. The other two categories ('Agriculture' and 'Other') were omitted from this graph.

Ratings between biodiversity- and forestry-focused individuals were similar for 'High', 'Ecologically Unsuitable' and 'Don't know this species' (based on averages of counts). However, forestry-focused respondents gave more 'Low' ratings while biodiversity-focused more 'Medium' ratings (Figure 4.3).

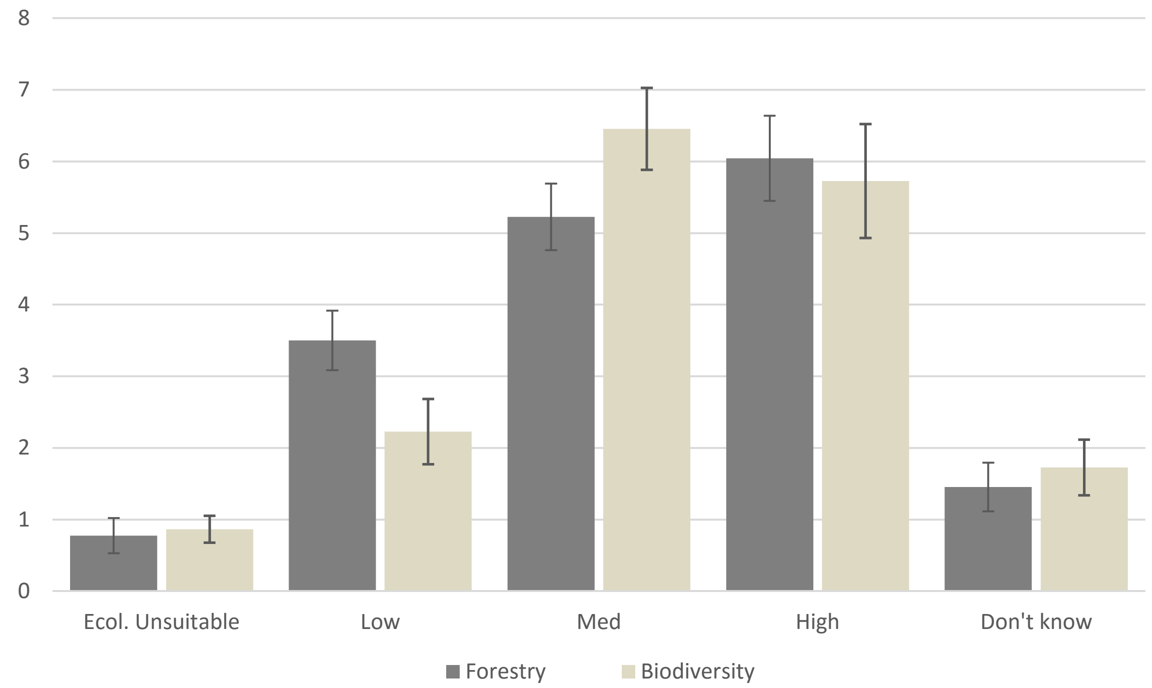

Figure 4.3. Average number of respondents' rating of species divided by foci. Error bars are one standard deviation.

4.3.5 Additional Species Provided by Respondents

Respondents were also given the option to include up to five other species (Question 2 in the survey) that they would consider to be a high conservation priority for inclusion in reforestation efforts. Eighteen of the 34 respondents listed additional species[106]. A total of 26 species from 16 genera were suggested, 22 of which were broadleaved. Ten of those species were mentioned by more than one respondent. Kermes oak (*Quercus coccifera* L.) had the highest frequency, mentioned by six respondents. Of the respondents who listed additional species, ten were forestry-focused, providing 34 additional species and eight were biodiversity-focused providing 18. Ten respondents were from the academic sector, five from the private sector (mainly NGOs), and three from the public sector (Table 4.4).

[106] One respondent listed *Quercus brantii*, which was one of the 22 species rated.

Table 4.4. Additional native species mentioned by 18 respondents showing frequency mentioned and availability in the market

Species	Family	Frequency: Biodiversity (n=8)	Frequency: Forestry (n=10)	Frequency: Total	Available*
Quercus coccifera [a]	Fagaceae	3	3	6	√
Crataegus azarolus	Rosaceae	2	3	5	
Malus trilobata	Rosaceae	1	4	5	√
Styrax officinalis	Styracaceae	1	4	5	√
Juniperus oxycedrus	Cupressaceae	2	2	4	
Juniperus drupacea	Cupressaceae	1	2	3	
Myrtus communis	Myrtaceae		2	2	√
Pistacia palaestina	Anacardiaceae	1	1	2	√
Prunus argentea [b]	Rosaceae	1	1	2	
Quercus cedrorum	Fagaceae	1	1	2	
Acer hermoneum	Aceraceae		1	1	√
Arbutus andrachne	Ericaceae		1	1	√
Ceratonia siliqua	Fabaceae		1	1	√
Cornus sanguinea ssp. *australis*	Cornaceae		1	1	
Cydonia spp. (Quince)	Rosaceae		1	1	
Juniperus foetidissima	Cupressaceae		1	1	
Laurus nobilis	Lauraceae		1	1	√
Pistacia atlantica	Anacardiaceae	1		1	
Pistacia lentiscus	Anacardiaceae	1		1	√
Platanus orientalis	Platanaceae		1	1	√
Prunus arabica [c]	Rosaceae	1		1	
Prunus mahaleb	Rosaceae		1	1	
Pinus halepensis	Pinaceae		1	1	√
Quercus cerris var. *cerris*	Fagaceae	1		1	√
Quercus brantii	Fagaceae	1		1	√
Quercus pinnatifida	Fagaceae		1	1	
Total 26	13	18	34	52	14

[a] Basionym: *Quercus coccifera* subsp. *calliprinos* (Webb.) Holm
[b] Synonymous with *Amygdalus orientalis* Mill.
[c] Synonymous with *Amygdalus spartioides* Spach.
*From private nurseries at the time of the survey

4.3.6 Ranking Species for Biodiversity-Enhancing Reforestation

The top 10 species ranked as detailed in the methods is shown below in Table 4.5. Grecian juniper (*Juniperus excelsa*) was excluded given the high frequency of 'Ecologically Unsuitable' (EU) ratings. There were a total of 13 median ratings of 'Medium' where those with the fewest EU and 'Low' ratings were selected.

Table 4.5. Final list of 10 species selected based on respondents' ratings

		Biodiversity				Forestry				Med.
Rank	Species	Med.	DKTS[1]	E.U.	Low	Med.	DKTS[1]	E.U.	Low	(Aver.)
1	*Cedrus libani*	3.0	0	1	1	3.0	0	0	2	3.00
2	*Acer hyrcanum*	3.0	2	2	1	3.0	2	0	2	3.00
3	*Sorbus torminalis*	3.0	2	0	2	3.0	4	0	2	3.00
4	*Abies cilicica*	3.0	0	1	0	2.5	1	2	1	2.75
5	*Quercus infectoria*	3.0	0	0	0	2.0	0	0	3	2.50
6	*Quercus cerris*	3.0	0	0	1	2.0	0	0	4	2.50
7	*Crataegus monogyna*	2.0	0	0	1	2.0	0	0	2	2.00
8	*Pyrus syriaca*	2.0	1	0	1	2.0	0	0	2	2.00
9	*Acer monspessulanum*	2.0	3	1	0	2.0	3	1	2	2.00
10	*Prunus cocomilia*	2.0	4	0	1	2.0	2	0	3	2.00

[1] 'Don't know this species'

4.4 Discussion

The objective of this study was to understand how stakeholders would prioritise native tree species for reforestation on the basis of conservation priority, how variable those preferences were, and whether stakeholders with similar professional foci had similar preferences. The preferences elicited were used to select ten species for use in a choice-experiment study with private landowners (chapter 5). I found that there was a great deal of variability in preferences between individual respondents. Moreover, this variability was not explained by accounting for professional focus (biodiversity- and forestry-focused): there was no clear difference of ratings between these two groups. This could be because these categories failed to adequately represent respondents' perspectives (e.g. perhaps they were too arbitrary). However, most respondents (91%) readily self-identified with one or other of these categories. An alternative explanation is therefore that even within these groupings, preferences are diverse, something which has implications for planning biodiversity-focussed reforestation. Conflicts or disagreements to policies exist between stakeholders in forestry and biodiversity conservation (Niemelä et al. 2005; Angelsen et al. 2012), especially with regards to international-scale policies such as REDD+ (e.g. Pistorius et al. 2012). Yet results from this study suggest that even where there seem to be no differences in opinions or preferences between groups of stakeholders, disagreements may exist amongst stakeholders within those groups. These results also suggest that stakeholders exhibit heterogeneous preferences for species they consider to be of high conservation priority in reforestation, despite their professional foci being geared more towards either forestry or biodiversity conservation. But more importantly, heterogeneity in ratings makes it extremely difficult to detect differences relative to a sample size, which was to be expected given that there are few professionals in Lebanon within these fields.

Another caveat about these results concerns the behaviour of participants in surveys like this, which require considerable engagement on the part of respondents (e.g. Manski 2004; Behrend et al. 2011). Although the response rate in this survey was fairly high for an online survey (86%, aided presumably by the personalised invitations) a large proportion (44%) of the original sample started the survey but did not complete it. It is therefore possible that those respondents who completed the survey did not maintain concentration throughout. The variability in completed surveys also raised questions about respondents' level of engagement, and perhaps even their understanding of my research objective. For instance, there were a few additional species respondents suggested that had been omitted from the list of candidate species due to their natural altitudinal limits (e.g. *Arbutus andrachne* and *Ceratonia siliqua*). Missing values (i.e. 'Don't know this species') from both foci also suggest that many respondents were either unfamiliar with the species and/or their natural habitats, or perhaps the nomenclature used. For example, a subspecies of Montpellier maple (*Acer monspessulanum* subsp. *microphyllum* (Boiss.) Bornm) is classified as a synonym of Mount Hermon maple (*Acer hermoneum*)[107] according to some sources (The Plant List 2013). This underlines the need for standardising and updating the ever-changing taxonomic nomenclature. This is one instance where there is an opportunity and need for stakeholders in the forestry and conservation sectors to work collectively towards improving plant identification in Lebanon and help make knowledge dissemination more effective. Disseminating biodiversity knowledge to the general public, particularly with regards to native trees, has already begun with recent technical and educational publications (Navarrete-Poyatos et al. 2011; Talhouk et al. 2014).

The results also confirm that our understanding of how these two fields differ cannot be based solely on affinity to species, thus requiring further research into how individuals rate species in general, particularly when ratings are subjective (Albert et al. 2009; Steg et al. 2012). For example, why would respondents consider certain species to be of a higher conservation priority than others, or unsuitable for including in reforestation altogether? Were respondents rating species based on the rarity of those species in the wild, or on the basis of

[107] *Acer hermoneum* (Bornm.) Schwer.

their importance in underpinning ecosystem functioning or in supplying particular ecosystem services? For example, there were candidate species from the original list that experts consulted did not consider should be included in the survey given their abundance in the wild, such as Kermes oak (*Quercus coccifera*). This resilient evergreen species is grazed heavily year round in the wild and has remarkable post-fire recovery (Perevolotsky and Seligman 1998; Pausas et al. 2008). While not included in the ratings, it was listed by six respondents (three from each foci) as additional species, suggesting that respondents were not predominantly considering rare species.

A shortcoming of this study was not asking respondents about the reasoning behind their ratings[108]. The main reason for not doing so was to minimise the burden on respondents. To assume these questions would require organising focus-groups with stakeholders to encourage discussion and social learning as done in other parts of the Mediterranean region (Patel et al. 2007). Of course, other factors need to be considered when determining the appropriateness of species, beyond their conservation value, particularly local soil and climate characteristics. Just as important are the preferences of local people who will be directly involved in (and therefore affected by) reforestation. This is also true for lay members of the public who may hold existence values for species and habitats, even if they lack expert ecological knowledge. Yet what is evident from this study is that a greater understanding of stakeholder typologies is needed in order to facilitate collaborative engagement between stakeholders from different research and policy fields (or foci), including social scientists and local stakeholders involved in community-based projects. These efforts would help various stakeholders become more familiar with each other’s perspectives and thus help generate a better understanding of both shared and diverse perspectives. For example, Reed et al. (2009) developed key typologies for analysing the complexities of stakeholder participation and inter-(and intra-)group relationships in various aspects of natural resources management and decision-making. One possible strategy would be to analyse these relationships through the process of social learning by inviting stakeholders to participate in open-discussions and deliberations in order to understand where perceptions and preferences diverge or come together (Bouwen and Taillieu 2004; Stringer et al. 2006).

[108] This was considered in the design stage, but rejected.

Multi-stakeholder engagement efforts are vital yet challenging objectives needed for maintaining resilient forest and woodland ecosystems, biodiversity conservation, and human well-being. Yet for reforestation to succeed, heed must be paid to the preferences of landowners and managers who will be the main caretakers. We need to understand what costs they will bear and what preferences they hold for species. This will be addressed in chapter 5, which focuses again on the supply-side of PES for reforestation.

4.5 Conclusion

Diversifying reforestation is a costly and difficult task that requires special attention in order to maintain resilient forest ecosystems for the future. This study highlights the importance of eliciting preferences for native species to be considered in Lebanon's reforestation efforts through involving a broad sample of stakeholders from various sectors and foci. In particular, it demonstrates that considerable diversity may exist within, as well as between, groups of stakeholders. In addition, the results of this study were essential for informing my own fieldwork by helping me to identify species for one of three reforestation options presented to landowners who participate in a choice experiment survey.

Websites[109]

International Plant Names Index – http://www.ipni.org/ipni/plantnamesearchpage.do

Euro+Med Plantbase – http://ww2.bgbm.org/EuroPlusMed/query.asp

Flora Europaea – http://rbg-web2.rbge.org.uk/FE/fe.html

IUCN Red List – http://www.iucnredlist.org/

Lebanon Flora (USJ) – http://www.lebanon-flora.org/default.php

Encyclopaedia of Life (Flora of Lebanon) – http://eol.org/collections/5984

Catalogue of Life – http://www.catalogueoflife.org/

The Plant List – http://www.theplantlist.org/

Med-Checklist – http://ww2.bgbm.org/mcl/home.asp

Botanical Gardens Conservation International – http://www.bgci.org/plant_search.php

[109] Websites listed here are largely databases that were accessed regularly for cross-referencing.

5 Can Ecosystem Services be Bundled? Quantifying Trade-offs in Payments for Reforestation in Lebanon

Payments for ecosystem services (PES) are becoming widely employed globally as a strategy to increase the provision of non-market ecosystem services. However, re/afforestation efforts aimed at cost-effectively meeting narrow objectives (e.g. increasing forest cover) tend to use limited numbers of highly productive species. Integrating biodiversity co-benefits into forest restoration may therefore pose difficult trade-offs between forest cover or biomass and diversity. In order to derive a production possibility frontier (PPF) for species diversity and quantity of trees planted for a given budget, I conducted choice experiments with Lebanese landowners (n=106) to determine their willingness to accept payments for reforestation with three different species mixes. The reforestation options offered were A) monoculture native stone pine (*Pinus pinea* L.) with direct use values (pine nuts); B) 50/50 stone pine & Lebanese cedar (*Cedrus libani* Rich.) mix with direct use and conservation values; and C) mixed native woodland species considered to be of high-conservation-value by stakeholders in Lebanon, but with limited use value. Overall willingness-to-accept (WTA) reforestation incentives was 75.5%. The majority of plantings would occur on abandoned lands, suggesting low agricultural displacement. Multinomial logit (MNL) results indicate that on average landowners require substantially higher payments (and are willing to commit less land) for the mixed-species option (option C) than for productive stone pine (option A) implying a strong trade-off between potential area (hectares) reforested and biodiversity. Landowner preferences were then modelled using latent class analysis (LCM) that showed there was considerable heterogeneity in landowner preferences: at least 10% of landowners sampled had strong positive preferences for mixed native species and another group of 8% for stone pine and cedar, both groups with low utility scores for the payment attribute. A larger segment of respondents (28.5%) showed high utility scores for the payment attribute with preferences split between stone pine (Option A) and stone pine & cedar mix (Option B). Disaggregated utilities were estimated using hierarchical Bayes (HB) regression to simulate the proportion of landowners who would subscribe to the three reforestation options, for given payment levels. Simulation models showed that 10.7% of landowners would prefer mixed species even if the lowest payment level was offered for all reforestation options (equating to a total present value cost to the buyer of US\$23,000 ha^{-1} at a discount rate of 5% over 15 years). This rises to 26.1% uptake if payments for mixed species were increased to the highest level (total present value cost of US\$107,137 ha^{-1}). From these I derived a PPF for hectares reforested and Shannon-Wiener species diversity, for given budget constraints. The PPF allows the identification of Pareto optimal reforestation schemes: due to the heterogeneity of landowners' WTA, a suite of reforestation contract options are recommended in order to maximise area reforested and species diversity for any given budget.

Keywords: Agro-ecosystems; choice experiments; hierarchical Bayes regression; landowners; Latent Class; market simulator; native species; production possibility frontier (PPF)

5.1 Introduction

Payments for ecosystem services (PES) are increasingly employed globally to increase the supply of environmental benefits from private lands (Wunder et al. 2008; Ferraro 2011; Schomers and Matzdorf 2013). Their implementation as a policy measure for incentivising re/afforestation in agricultural landscapes has been well documented (Pagiola et al. 2004a; Bennett 2008; Engel et al. 2008; Paquette et al. 2009). In use-restricting PES and Reduced Emission from Deforestation and Degradation plus (REDD+), biodiversity can be conserved as a co-benefit bundled together with carbon in cases where effective deforestation or forest degradation avoidance targets species-rich forests (Wendland et al. 2010; Visseren-Hamakers et al. 2012; Busch 2013). However, when PES is applied to asset-building strategies such as re/afforestation (Wunder 2008), trade-offs between ecosystem services like carbon and biodiversity[110] become more relevant in decision-making (Venter et al. 2009; Harvey et al. 2010; Angelsen et al. 2012; Phelps et al. 2012).

Plantation forests, which are predominantly composed of limited though highly productive species, have increased in their extent globally while natural forests continue to decline (FAO 2010; Brockerhoff et al. 2013). Recent studies argue that asset-building PES are often geared towards a narrow suite of ecosystem services (ES), such as carbon sequestration from monoculture plantations, with lack of consideration for biodiversity and future livelihoods (Jindal et al. 2008; Putz and Redford 2009; Barr and Sayer 2012). One possible explanation for this is that carbon is more easily quantifiable than other ES (e.g. cultural) and is therefore more amenable to inclusion in PES contracts (Engel et al. 2008; Corbera et al. 2009). In contrast with species-diverse reforestation, monoculture plantations of fast-growing trees (e.g. eucalypts) will often be more cost-effective at delivering carbon than diversified species that deliver biodiversity and carbon simultaneously (George et al. 2012). Hence there is a risk that PES focussed solely on meeting single objectives (e.g. increasing forest cover) could have damaging consequences for biodiversity and other ES (Niesten et al. 2002; Alpízar et al. 2007; Bremer and Farley 2010; Boyd 2010; Lindenmayer et al. 2012).

Policymakers and firms often face difficult trade-offs when deciding how much to spend on a specific production or outcome. The production possibility frontier (PPF), based on the concept of Pareto efficiency, models these trade-offs expressing the opportunity cost of one

[110] I present the arguments for considering biodiversity as an ecosystem service in chapter 1.

good in terms of the other (Dasgupta and Heal 1979; Robertson and Swinton 2005). If all tree species cost the same amount to plant, sequester the same amount of carbon per hectare, and landowners were indifferent to the species offered, then there would be no trade-off between carbon and biodiversity in incentivised reforestation schemes. Trade-offs arise if farmers' willingness-to-accept (WTA) payments for reforestation are not equal for different species or if species differ in their rates of carbon sequestration. Thus, diverse, slow growing species with little use value may lock up less carbon for a given budget than productive monocultures. But as discussed in chapter 1, biodiverse forests are thought to be more resilient (having better functioning ecosystems) and have been shown to produce a variety of goods and services (including carbon sequestration) more efficiently than mono-cropped plantations (Gamfeldt et al. 2013; Hulvey et al. 2013). In contrast, plantations may be a more cost-effective means for restoring heavily degraded ecosystems and biodiversity through facilitating faster recovery of habitats for other species (Brockerhoff et al. 2008). Trade-offs may also exist in cases where increasing forest cover through tree planting is the main objective (rather than carbon payments based on biomass) resulting in a range of ecosystem services (of which carbon stocks are one). Under such instances, it is possible to test whether trade-offs may be extensive between the area planted (measured in hectares of increased forest cover) and diversity / mixture of native species used. An important question to consider therefore in the context of PES is: *how much of a trade-off really exists between biodiversity and forest cover (or extent) in reforestation?* Answering this question requires assessing how landowners' WTA payments for reforestation varies depending on the species mix used.

In this chapter, I model trade-offs between biodiversity (quantity and abundance of native tree species) and area enrolled (or potential forest cover that would be gained) on results from choice experiments conducted with Lebanese landowners from highland villages surrounding the Wadi Qadisha watershed located within one of Lebanon's 20 Important Plant Areas (IPAs). The main objective of this study was to estimate the marginal cost of planting high-conservation-value tree species of little direct use value on private lands compared to a more productive monoculture species, stone pine (*Pinus pinea* L.). Choice experiments were designed to gauge Lebanese landowners' WTA one of three hypothetical reforestation schemes offered based on their payment levels (details below). The three hypothetical reforestation schemes were: A) stone pine plantation, B) 50/50 stone pine and Lebanese cedar

(*Cedrus libani* Rich.), and C) even mixture of ten native species[111]. Three payment levels accompanied each of the reforestation options as US$2,000, 6,000 and 10,000 ha^{-1} yearr^{-1}. Land-use/land-cover (LULC) classes and the area (ha) of landholdings was also collected and used to assess past, present and future plantings, as well as for identifying the extent (ha) of reforestation and the LULC classes that would potentially be displaced. I then estimated the production possibility frontier (PPF) for ecosystem services that would be generated from having forests established via re/afforestation efforts (e.g. regulating services) measured as trees per hectare planted for a given budget and biodiversity (based on the Shannon-Wiener index for tree species diversity). My three research questions are as follows:

1. *What is the cost of paying landowners to plant diverse native tree and shrub species of high-conservation-value on private lands relative to a single productive species?*
2. *What is the form of the production possibility frontier for biodiversity (i.e. species richness and evenness) and forest cover / extent (measured in hectares)?*
3. *What types of land-use and land-cover would be affected by incentivised reforestation?*

This chapter is divided into five sections. In the remainder of the introduction (section 5.1), I review the literature on estimating WTA payments using choice experiments. I then set out the conceptual framework for assessing trade-offs using the PPF for the three proposed reforestation schemes. In section 5.2, I present the materials and methods used in designing the choice experiment and provide an overview of the analytical tools used for estimating costs, followed by results (section 5.3) and discussion (section 5.4). I conclude with some general recommendations and future prospects in section 5.5.

5.1.1 Literature Review

As payments for ecosystem services (PES) are becoming more prevalent, technical and institutional challenges have emerged as a consequence (Pirard 2012; Robert and Stenger 2013; Banerjee et al. 2013; Lockie 2013). Much of this stems from the complexity of defining ecosystem services in the context of policy and decision-making and the quantification of certain ecosystem services (ES) (Boyd and Banzhaf 2007; Fisher and Turner 2008; Bateman et al. 2011). For instance, numerous factors may affect the quality and flow of fresh water from watersheds, beyond that of removal of natural vegetation (King et al. 2005;

[111] These species were selected based on ratings given by national stakeholders (see chapter 4, section 4.3.6) and are listed in the methods, below. Lebanese cedar was one of the ten species.

Brauman et al. 2007; Quintero et al. 2009). Similarly, quantifying biodiversity in terms of the presence of species diversity, abundance and ratios (or evenness), its services (e.g. supporting, cultural, and final goods), and its value to society can be unduly onerous (Magurran 2004; Christie et al. 2006; Wallace 2007; Daily et al. 2009). In contrast, it is generally easier to estimate above-ground carbon sequestration (or the extent of forest surface area planted) than the quantity of most other ES. Quantification becomes substantially more complicated when dealing with multiple services, confounded by difficulties with predicting ecosystem service flows in the future (Bennett et al. 2009; Nelson et al. 2009).

Stated preference techniques are widely employed for determining the costs and benefits of goods and services not currently traded in markets (Louviere et al. 2000). These techniques have been widely used to elicit people's willingness-to-pay (WTP) or willingness-to-accept (WTA) payments in compensation for hypothetical changes (positive or negative) in the environment (Hanley et al. 2007). While revealed preference techniques may be more robust (relying as they do on actual behaviour), their applicability is limited in environmental valuation due to the lack of proxy markets for most environmental goods (Bateman et al. 2002). In cases where PES have not yet been implemented, stated preference techniques can help to estimate potential suppliers' WTA, aiding in the design of PES contracts (Bennett and Blamey 2001). Landowners' preferences for reforestation options (or schemes) offered can then be modelled to determine whether there are strong trade-offs (or opportunity costs) between different ES to be provided (de Groot et al. 2010). Choice experiments are one possible means for estimating marginal costs of re/afforestation through eliciting the willingness of landowners to accept payments (or compensation) for reforestation based on trade-offs they make on hypothetical contracts (or schemes) with different attributes (Vedel et al. 2010; Broch et al. 2013). While many WTA studies employing choice experiments have emerged recently (Espinosa-Goded et al. 2010; Christensen et al. 2011; Beharry-Borg et al. 2013; Kaczan et al. 2013), the present study is unique in explicitly examining trade-offs between species diversity and extent of forest cover (hypothetical gains) through investigating landowner preferences for reforestation options with different species mixes at different payment levels.

5.1.2 Case-Studies: Choice Experiments for Estimating Costs of Incentives

Choice experiments (CE) are increasingly being used to estimate costs in agri-environmental schemes (AES) through gauging landowners' WTA payments (or compensation) in return for supplying additional environmental services on agricultural lands (Espinosa-Goded et al. 2010; Broch et al. 2013; Beharry-Borg et al. 2013). Many of these studies have shown that heterogeneity in respondents' willingness to subscribe to AES depends largely on farm and farmer characteristics (Espinosa-Goded et al. 2010; Christensen et al. 2011; Garrod et al. 2012; Broch and Vedel 2012; Beharry-Borg et al. 2013). Broch et al. (2013), for example, show that farmers' preferences for afforestation schemes were linked to the kinds of on-farm services that would result, which varied due to the heterogeneous spatial characteristics of their holdings. Heterogeneity of preferences is also a major obstacle in the design and targeting of incentives mechanisms, where CE have proven to be useful. In an effort to explain the heterogeneity in UK farmer's willingness to join a PES programme, for example, Beharry-Borg et al. (2013) used latent class models to segment farmers based on their preferences for attribute levels of hypothetical contracts[112]. In an analysis of EU-wide acceptance of joining AES, Ruto and Garrod (2009) found that farmers in general required higher financial incentives under longer-term contracts (using multinomial logit), while latent class models found a large segment of 'low resistance adopters' willing to join for lower payment levels than 'high resistance adopters'. Studies have also found that heterogeneous preferences to choice attributes range from a mixture of financial and non-financial factors, such as non-timber amenities from forests (Majumdar et al. 2008). Correspondingly, studies on afforestation adoption in Wales and Ireland found that policies aimed at increasing forest cover require a better understanding of how farmers perceive such schemes within the context of local farming culture (Duesberg et al. 2013; Wynne-Jones 2013b). Indeed, not all incentives have to be monetary, and many farmers would prefer to see more support through extensions services, knowledge (and technological) exchange, and better information regarding markets and costs in production (Van Hecken and Bastiaensen 2010a; Kinzig et al. 2011).

5.1.3 Production Possibility Frontier of Ecosystem Services

Governments and firms face trade-offs when deciding how to allocate scarce resources to the supply of competing goods. Allocating more land or money to the production of one ES may reduce the supply of others. The production possibility frontier (PPF) is a way of representing these trade-offs. PPFs have been used extensively for estimating trade-offs between multiple-function strategies such as timber production and biodiversity conservation (Rohweder et al.

[112] These and other models used for estimating utilities (e.g. preferences) are detailed in Methods.

2000; Calkin et al. 2002; Nalle et al. 2004; Polasky et al. 2008; Löf et al. 2010; Hauer et al. 2010). For instance, Barraquand & Martinet (2011) modelled the trade-offs between intensive agriculture and biodiversity conservation through examining the probability and persistence of species under various farming systems. In another example, Barton et al. (2009) evaluated these same trade-offs to aid in more cost-effective PES targeting in Costa Rica. While some theoretical studies have addressed ecosystem (or environmental) services trade-offs in the context of PES (e.g. Nelson et al. 2008; Robert and Stenger 2013; Busch 2013), there are few if any empirical studies using PPF to calculating trade-offs between competing ES asset-building PES, to my knowledge.

5.1.4 Conceptual Framework

In this study, I estimate the PPF for the extent of reforestation (as an indicator of a broad range of ecosystem services, as well as a policy goal in its own right) and biodiversity (Shannon-Wiener diversity of tree species)[113]. Below I provide a conceptual illustration of the PPF (Figure 5.1) where each bundle of goods along the frontier is Pareto efficient (Baumol and Oates 1988; Lockwood 2008). In Figure 5.1a, the opportunity cost in area planted (y-axis) is relatively small when only a few species are added, but increases substantially when many more are added (x-axis). In other words, the quantity of one good (forest cover / extent) cannot be increased without decreasing the quantity of the other (number of tree species). Moving along the PPF from a point closer to the x- or y-axis to a point further away entails relatively low opportunity cost in terms of the good foregone.

[113] The Shannon-Wiener *H* is a widely used index that takes into account the number of species and the relative numbers of each (Magurran 2004). Spellerberg and Fedor (2003) suggest that species richness be used to refer to the number of species in a given sample, and that ‘species diversity’ is retained given that it is “an expression or index of some relation between number of species and number of individuals” (p. 178). As a widely used and understood index, I used Shannon-Wiener as a measure that captures both species diversity and evenness for illustrative, noting that the same approach could be repeated with other measures of diversity.

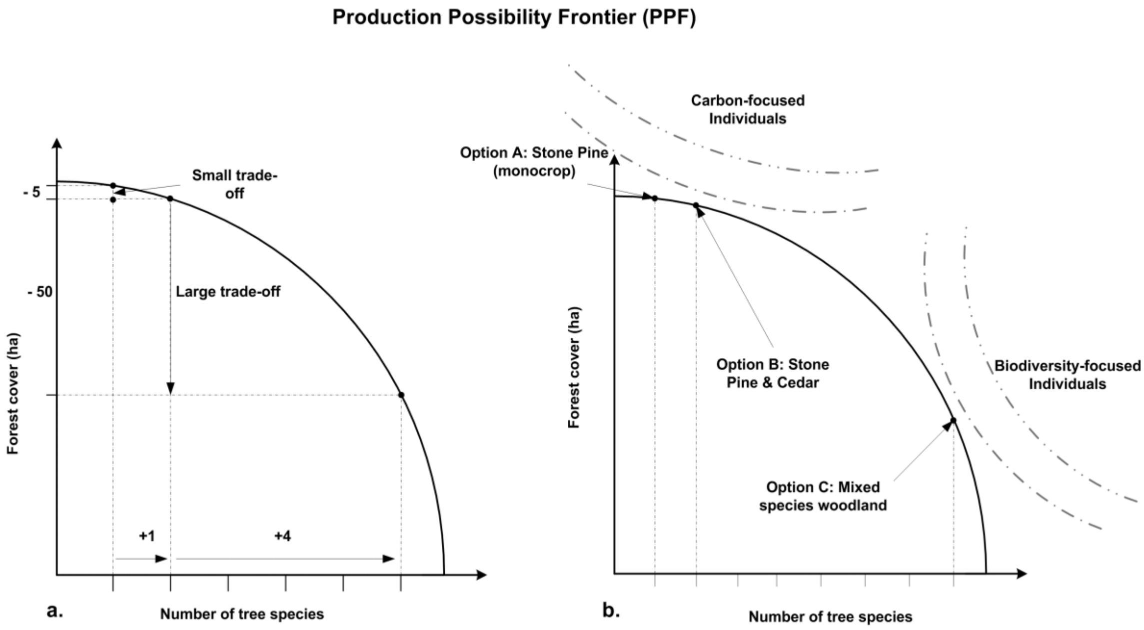

Figure 5.1. (a) Example PPF diagram showing gradually increasing opportunity costs in hectares of trees planted as more species are added; (b) Example PPF showing strong heterogeneous societal preferences represented by indifference curves (inverted dashed curves), with some stakeholders preferring biomass (near y-axis) and some tree diversity. This diagram is based on Pareto's optimality theory that are also referred to as Pareto efficiency curves (Lockwood 2008).

In the context of my study, trade-offs may exist for at least three reasons:

1. Monocultures of certain species may grow faster and thus provide a range of ES more efficiently or sooner (e.g. locking up more carbon ha^{-1} $year^{-1}$) than diverse natives;
2. Landowners might prefer to plant monocultures of productive, low conservation value species, therefore these would cost the PES "buyer" less per hectare;
3. Productive species may tend to be planted on different land, or by different types of landowners, than mixed native species.

Ecosystem Services of Lebanese Forests

Lebanon's forests, comprising approximately 13% (134,876 ha) of the country's land area (10,452 km^2), store around 1.795 million tonnes of above- and below-ground carbon C (Estephan 2010). This equates to approximately 71.88 tC ha^{-1}. While biomass estimates are only available for the main forest types (e.g. stone pine plantations, mixed conifers, broadleaved), per hectare carbon uptake for most native forest species in Lebanon are not available in the published or grey literature (Dalsgaard 2005). Rough estimates can be averaged broadly for forest type given that there is data on pure stone pine, pure cedar, and mixed (broadleaved-conifer) forests (at least 20% conifers), which are presented in Table 5.1.

Table 5.1. Estimated biomass (in million tonnes) and carbon (tonnes per hectare) under reforestation options (Dalsgaard 2005)

Reforestation Option	Forest type†	Total Biomass	tC/ha^{-1}
Stone pine plantation (Option A)	Conifer	0.185	1.33
Stone pine & cedar (Option B)	Mixed conifer	0.143	1.02
Mixed woodlands (Option C)	Mixed forest*	0.220	1.58

*Conifer and broadleaved (both evergreen and deciduous)
†Closest associated forest type for which data was available

Given the scarcity of reliable data on carbon and biomass for individual species, and also on rates of growth, these averages do not provide sufficient information for analysing carbon uptake for the three potential forest types. Biomass and carbon estimates must take into account biogeoclimatic (e.g. climate, rainfall, temperature, soil type) and topographical (e.g. slope, aspect) factors (Jandl et al. 2007; Cañellas et al. 2008). They must also consider both sink and source effects from management regimes (e.g. thinning) and forest fires (Río et al. 2008). Moreover, these factors can vary considerably amongst villages within the same region (or even parcels within the same village) despite sharing similar attributes. All of these contribute to difficulties in estimating biomass or carbon uptake for the 11 tree species used in my study, particularly for the mixed species option (details in section 5.2.3 of this chapter).

Relative to tropical or temperate forests, Mediterranean forests are less productive due to climatic constraints (e.g. low precipitation and high temperatures), which can be further exacerbated by climate change and increasing forest fires (Lindner et al. 2010). Although carbon benefits of reforestation in Lebanon are uncertain, they are likely to be low[114]. Thus re/afforestation in the Mediterranean is unlikely to be cost-effective enough for private carbon markets compared to avoided deforestation or afforestation elsewhere (Caparrós et al. 2011). Nevertheless, it is important to acknowledge that Lebanese forests provide numerous ecosystem services[115] such as watershed maintenance, soil conservation, cultural and landscape values. Many government-financed re/afforestation initiatives use area as a proxy for other ecosystem services (e.g. Bennett 2008; Clement et al. 2009; Wynne-Jones 2013a).

[114] I discuss these issues within Lebanon in relation to other Mediterranean countries in chapter 6, section 6.4.2.

[115] There are also a wide range of economic benefits that Mediterranean forests provide from non-timber forest products (NTFPs), such as honey, wild mushrooms and medicinal / aromatic plants (Croitoru 2007).

In essence, the overall objective of re/afforestation by Lebanese reforestation stakeholders[116] is to reach 20% forest cover (or a 7% increase from its current cover) over the next few decades (chapter 1) and this is considered a greater priority than carbon sequestration. This target suggests that the Lebanese government expects several ecosystem services to correlate with forest extent, perhaps including wood and non-wood forest products, as well as habitats for biodiversity, soil and water conservation, and landscape beauty.[117].

The focus of this chapter is to explore point 2 above (landowner preferences)[118]. Assuming that most landowners would be willing to enrol more land (as a whole) for planting productive forest trees for less money than mixed species offering little private benefits, this would cost PES buyers less money towards reforestation. If buyers are more focused on cost-effectively meeting forest cover targets as their main objective[119], we could expect a social optimum on the PPF towards the y-axis (Figure 5.1b). But if buyers were more biodiversity-focused, then efficient outcomes would occur on the PPF near the x-axis with more species planted on fewer hectares.

5.2 Methods

5.2.1 Study Area

The study area for this chapter comprised villages surrounding the Qadisha Valley watershed and villages lying north of the Tannourine Cedar Reserve. This is an important region from both ecological and cultural perspectives, which includes UNESCO World Heritage Sites (Qadisha Valley and Bcharre Cedar Forest) and Nature Reserves (Tannourine and Ehden forests)[120]. The region is also within three adjacent IPAs (Radford et al. 2011). This area is characteristic of eu-mediterranean (> 1,000 m.a.s.l.) to oro-mediterranean (> 2,000 m.a.s.l.)

[116] The Ministry of Agriculture (MOA) and the Ministry of Environment (MOE) as well as NGOs whose work is closely aligned the government’s reforestation policy, e.g. National Reforestation Plan of the MOE and National Forest Programme of the MOA.

[117] As well as acting as a proxy for carbon sequestration, area reforested is also frequently a policy objective in its own right (including in Lebanon) and may be related to the provision of other ecosystem services.

[118] Also to collect some information pertinent to point 3 regarding displacement of agricultural production.

[119] While there were no specific ecosystem services officially mentioned by reforestation stakeholders in achieving a 20% forest cover target, some of them gave me a range of benefits including soil protection, fuelwood and non-timber forest products, cultural and landscape values, and biodiversity (*pers. comm.* 2011-12, LRI, AFDC, MOA).

[120] Previous research with landowners in villages within IPAs of Mount Lebanon was also conducted in this study area (chapter 3).

bioclimatic zones. Average annual precipitation in this region ranges from 850-950 mm, mainly from October to May with the heaviest occurring between December and March (Jomaa 2008). The vegetation types are typical of Mediterranean forest, woodland and scrub communities containing coniferous, deciduous and mixed forest/woodlands (Abi-Saleh and Safi 1988). Forests, woodland and scrub communities in this region are under severe pressure from urbanisation, agricultural expansion, mining (stone and sand quarries) and overgrazing, as well as fires (Darwish et al. 2010a; Sattout and Caligari 2011). Long-term reforestation has been proposed by national stakeholders aimed at connecting the corridor between the Bcharre and Tannourine forests (MOA and LRI, *pers. comm.* 2012).

5.2.2 Sampling

A total of 32 villages were identified within three adjacent districts (Batroun, Bcharre, and Zghorta-Ehden) and IPAs (LB01, LB09, and LB11). Key informants[121] from 29 out of the 32 villages that were contacted helped provide contacts of landowners, which totalled 229 names (Table 5.2). A small number of landowners were also approached opportunistically in the village of Hadchit). Surveys were conducted with 130 landowners[122], of whom twenty were part of the pilot study for calibrating the choice experiment design. Of the 110 surveyed using the final experimental design, four were omitted from the sample post hoc as their landholding status was atypical[123]. The original intention was to survey 150 respondents (see choice experiment design, below) using the final survey, but fieldwork had to be curtailed due to a deterioration in the security situation in Lebanon. The criteria used for eliciting participants for our study were landowners that are the main decision-makers for their holdings, preferably with at least 1 hectare of land. The criterion for landholding size was determined from the results of chapter 3 while our motive for seeking single decision-makers was to ensure that the respondents had the authority to determine the use of the land in question.

[121] These included: mayors, representatives from local agricultural cooperatives and NGOs, and representatives from the Ministry of Agriculture's Bcharre and Zghorta extension offices. As in Chapter 3, this method of recruiting respondents was necessary given the security situation in the area.

[122] Of the 99 landowners for whom contact details were obtained but that we did not succeed in interviewing, more than 60% were unreachable (e.g. telephone lines no longer in service). The rest that were contacted did not participate due to scheduling conflicts (e.g. weekend residents only), lack of time or interest, as well as inheritance issues.

[123] These respondents were decision-making representatives of large religious estates (e.g. head priests).

Table 5.2. Participant recruitment process

Villages in sample	No. of landowners (contact list)	No. of survey participants	District	Population
Ehden	46	18	Zghorta-Ehden	>24,000
Bcharre	34	23	Bcharre	12,001-24,000
Haddath	28	13	Bcharre	2,001-4,000
Hasroun	21	15	Bcharre	4,001-12,000
Bane	15	12	Bcharre	<2,001
Bekaa Kafra	15	8	Bcharre	2,001-4,000
Hadchit	9	6	Bcharre	4,001-12,000
Mazraat Beni Saab	9	6	Bcharre	<2,000
Blaouza	8	2	Bcharre	<2,000
Qnat	8	6	Bcharre	2,001-4,000
Dimane	7	6	Bcharre	<2,000
Kfarsghab	7	5	Zghorta-Ehden	N/A
Al-Bouhayrat	5	2	Zghorta-Ehden	N/A
Ayto	4	1	Zghorta-Ehden	<2,000
Aintourine	3	2	Zghorta-Ehden	<2,000
Billa	3	2	Bcharre	N/A
Serael	3	1	Zghorta-Ehden	<2,000
Barhalioun	2	1	Bcharre	N/A
Qnaywer	2	1	Bcharre	N/A
19	229	130	2	

5.2.3 Reforestation Options in the Choice Experiment

Option A – Stone pine plantation

Stone pine (*Pinus pinea* L.) is the most common native[124] forest species managed on private lands in Lebanon. There are approximately 8,000 ha of total aggregated stone pine forests of over 10% crown cover on public (municipal) and private lands (Estephan 2010). While only a fraction of total coniferous forests (< 18%), it has the highest growth stock and second highest total biomass (above and below ground) of the most common managed forest species in Lebanon (Talhouk et al. 2001). Stone pines are largely managed as monoculture plantations for the production of pine nuts and generally well protected by owners against exogenous threats. Often heavily pruned for the purpose of increased yield, they are less susceptible to crown fires than other forest species such as *Pinus brutia* (Talhouk et al. 2001), and are therefore likely to store greater quantities of biomass. Much like other forest trees,

[124] Some have argued that it is a naturalised species, naturally occurring in other Mediterranean countries (Martínez and Montero 2004).

stone pines require fewer inputs (e.g. agrichemicals) and much less water and general maintenance than most fruit trees. Preference for stone pine under a hypothetical PES was expected to be high, particularly amongst active farmers in Lebanon.

On the other hand, there is a considerable time gap of around 10-15 years from planting stone pine seedlings (< 2 years old) to cone production stage[125]. The species also prefers sandy soils (Lower Cretaceous substrata), and cone production and quality may be much lower if planted in other soil types (Masri et al. 2006). Lastly, collection of cones on mature trees can be extremely risky and requires skilled climbers for whacking cones off branches while others collect (*pers. comm.*, K. Sleem, 2012). A subsequent drying process is then required in order for cones to open, which then go through two additional processing stages before entering the market as a final product. The advantages and disadvantages of adopting stone pine may not be as straightforward as described. They need to be contextualised in current commodity-driven production systems. For example, the net benefits of apple production might be more competitive in the short term due to faster returns; however, costs may be higher in the long-term due to high inputs, unstable market conditions, and climate change affecting pollination, pests, and water availability. The fact that stone pines are not new or unfamiliar to most landholding farmers in Lebanon, and that demand for pine nuts continues to increase, suggests that decisions to invest in them are contingent upon a number of factors.

Option B – Stone pine and Lebanese cedar (50/50)

Cedar of Lebanon (*Cedrus libani* Rich.) is both a culturally and ecologically important species. It is the most widely planted forest species in Lebanon at elevations between 1,000 – 2,000 m.a.s.l. There are currently 15 fragmented forests presently covering around 5% (approx. 2,300 ha) of its estimated natural range in Lebanon (Khuri et al. 2000). Cedars also received the highest aggregated rating by national stakeholders (chapter 4) as a conservation priority in reforestation from a list of 22 native species.

Both stone pine and cedar have been extensively planted in national re/afforestation campaigns since the MOA's Green Plan was launched in the early 1960s (Regato and Asmar 2011). Substantial numbers of these two species were produced in public nurseries for the campaign that ended with the start of the civil war in 1975 (Chaney and Basbous 1978). Both

[125] Some studies have suggested that prime production capacity of cones for *P. pinea* begins when trees are at least 25 years old (Mutke et al. 2005; Masri et al. 2006).

species continue to be employed in reforestation efforts today by public sector (MOA/MOE) and third sector (non-governmental) organisations.

I expected the utility of Option B (50% stone pine / 50% Lebanese cedar) to be lower than Option A due to the lower production value of cedar. This reforestation option was offered in order to gauge whether landowners would make trade-offs with at least one other non-productive species of high conservation and cultural significance (but little use[126]) value.

Option C – Mixed native woodland species

Until recently, there were limited species produced in Lebanon for re/afforestation purposes. However, Lebanese academic institutions (American University of Beirut, University of Saint Joseph, Balamand University) and NGOs (AFDC, LRI, Jouzour Loubnan) have begun initiating efforts to diversify native tree and shrub species through seed collection and seedling production. There are currently over 30 species of trees and shrubs available from mostly private Lebanese nurseries. The top ten species ranked for conservation by stakeholders (chapter 4), including cedar but not stone pine, were selected as the third reforestation option (Option C) in the choice experiment. All can be found naturally occurring with varied abundancies in forests and abandoned lands in the region. This option was selected because it was more diverse than the other two, although even re/afforestation under this option could potentially displace some native species, particularly understory endemics (both plant and animal).

5.2.4 Data Acquisition and Survey Instrument

A questionnaire survey was conducted in Arabic by my field assistant while I observed, asked questions when appropriate, and prepared choice cards. Surveys were conducted in the participants’ villages, either at their farm, home, workplace, or the municipality office. Each participant was given an introduction to the study, and an explanation of how and why they were contacted. The introduction was kept general in order to reduce biased responses. Informants were presented with a written consent form prior to commencing[127]. Each survey took approximately 40-50 minutes to complete on average. Respondents received two native tree saplings as a thank-you gift for their participation following the interview.

[126] It is currently illegal to cut cedars, even on private property, without permits issued by the MOA.

[127] The study received ethics approval from both Bangor University and AUB review boards.

The survey was divided into four sections[128]. Section 1 focused on past, present and intended future land-use strategies, followed by the choice experiments (section 2), open-ended debriefing questions on future plans following hypothetical reforestation schemes (section 3), and ending with a few socioeconomic questions (section 4). Follow up questions were also used during the choice experiments, to gather spatial and land-use/land-cover (LULC) data, while also aimed at understanding perceptions and constraints to participation.

In section 1 of the survey, spatial and temporal LULC data was obtained by asking respondents the number of plots they own, types of land-use for each of these plots (e.g. abandoned, commercial farming, recreation, etc.), type of land-cover on these plots (e.g. orchards, forest/woodland, vegetable/cereal/forage crops, native forest/shrubs, etc.), and the number of years since last major planting. Plots were sketched on an A4 sketchbook with appropriate LULC codes, areas (in m^2 and later converted to ha) and approximate elevations. Respondents were also asked to list the types of vegetation occurring on abandoned lands (if known) to determine the extent and kinds of natural regeneration taking place. Future intentions for tree planting were elicited, followed by reasons for not wanting to plant for those who had no intentions to do so. Additional questions were also asked to determine whether respondents were sole decision-makers, renting land from or to anyone, main source of irrigation, and whether they received external assistance (e.g. MOA, municipality, farmer cooperatives, etc.).

During the choice experiment section of the survey (section 2), participants were given a simulation of a hypothetical reforestation programme. My field assistant set the stage by asking participants to imagine we were an independent reforestation agency interested in paying landowners to plant forest trees on their property. Participants were then shown three A4 posters with landscape photographs to help illustrate each reforestation options (Appendix 5.2). Accompanying the mixed native woodland options (C) was a fourth poster with photographs of the individual species (Appendix 5.3a)[129]. A fifth poster showing a diagram of the hypothetical reforestation programme was then presented (Appendix 5.3b).

[128] Please see Appendix 5.3 for a copy of the survey.

[129] Participants were informed that these species were selected based on results from an online survey conducted with professionals and stakeholders in the forestry and conservation sectors (chapter 4).

In this programme, regardless of which reforestation option was chosen, each subscriber would receive free saplings (1-2 year old) and a standard payment US$3 per sapling for planting a minimum of 1,000 m^2 (commonly referred to as 1 Turkish *dunum*). We averaged a maximum of 800 saplings ha^{-1} at roughly 4*4 metre spacing, or 80 saplings/*dunum*. Participants were informed that these were to be considered as fixed costs that apply to any one of the reforestation scheme, which would be followed by annual payments that varied in three of the choice cards that were about to be presented to them. The programme would consist of performance payments following four monitoring sessions to estimate survival (payments-by-result based on percentage survival) over the course of 15 years. Technical assistance (e.g. planting and post-planting care) and a 24-hour hotline service would also be provided at no cost. Once the preamble for the hypothetical reforestation programme was described, participants were asked if they had any questions before proceeding with the choice experiment.

Participants were then presented with the three choice cards showing the three reforestation options with randomised payment levels (different for each reforestation option) plus a card indicating a 'None' option (i.e. 'I don't want any of these choices')[130]. They were presented with five choice tasks in total and spatial/LULC data was gathered after each choice task[131]. Responses from the choice experiments were logged into a response matrix that included four columns per task (including the 'none' option), a column indicating plot number, and another column indicating planting area (see Appendix 5.4).

5.2.5 Choice Experiments: Theoretical Underpinnings

Choice experiments (CE) were initially developed in marketing and consumer research as a technique for studying consumer behaviour and predicting consumer preferences for novel products (Louviere and Hensher 1983). Louviere defines CE as "samples of choice sets or choice scenarios drawn from the universe of all possible choice sets" (2001:13). The logic of CE is grounded in random utility theory (RUT) of decision-making behaviour in economics and psychology (Manski 1977; Louviere et al. 2000; McFadden 2001). Under RUT, utility is described as a latent construct that may or may not exist in the psyche of consumers, which

[130] Choice cards were all written in Arabic and included the same photographs presented in the A4 posters.

[131] I referred to the sketches prepared during section 1 of the survey. For instance, when respondents selected one of the three concepts other than the 'None', they were asked 1) which plot and 2) how much area (in 1,000 m^2) they would be willing to enrol.

cannot be directly observed by a researcher. Yet through eliciting the subject's preferences for a set of alternatives (in a given choice set), the researcher is able to explain and measure a sizeable proportion of the unobserved utility, or part-worth, even while the rest remains stochastic from the viewpoint of the researcher (Louviere 2001:15). The random utility function is expressed as follows:

$$U_{an} = V_{an} + \varepsilon_{an} \tag{5.1}$$

Where U is the latent (unobserved) utility for choice alternative *a* held by consumer *n,* V_{an} is the observable (or explainable) portion of the latent utility that consumer *n* has for option *a*, and ε_{an} is the random (unexplainable) component of the latent utility associated with option *a* and consumer *n.* The stochastic nature of predicting preferences leads to formulating a probability of choice expression:

$$P(a|C_n) = P[(V_{an} + \varepsilon_{an}) > (V_{jn} + \varepsilon_{jn})], \tag{5.2}$$

Where all *j* options exist in choice set C_n, the equation states that "the probability of consumer *n* choosing *a* from choice set C_n is equal to the probability that the systematic and random components of option *a* for consumer *n* are greater than the systematic and random components of option *j* for consumer *n* in choice set C_n." (Louviere 2001:16).

Depending on assumptions about the distribution of the random component (εs), linear regression models such as multinomial probit (MNP) and multinomial logit (MNL) are commonly used for calculating the probabilities. Unlike MNP, MNL models are based on assumptions that εs are independently and identically distributed Gumbel random variables (Louviere 2001:16). The MNL model can be used to estimate the rate at which consumers (or respondents) are willing to make trade-offs between attributes such as a non-marketed attribute (e.g. forest cover or biodiversity) and a monetary attribute. An implicit price or 'part worth' is therefore determined through dividing the first coefficient by the second and multiplying through by –1 (Bennett and Adamowicz 2001:63). While MNL models give fairly good aggregated representations of preferences based on choice responses, examining unobserved preferences requires different techniques.

Given the heterogeneity of individual preferences, aggregated part-worth utilities fail to capture underlying differences and similarities from a sample of respondents. Latent class models (LCM) and hierarchical Bayes (HB) regression reduce the problems associated with ‘independence from irrelevant alternatives’ (IIA).

5.2.6 Latent Class Models

An approach to pooling often scarce and unobservable information (*β’*) across respondents widely being used in modelling choice-based conjoint data in many recent environmental valuation studies is latent class (Campbell et al. 2011; Broch and Vedel 2012; Garrod et al. 2012; Beharry-Borg et al. 2013; Kaczan et al. 2013). Latent class models (LCM) group respondents according to homogenous classes that best fit their preferences based on an unobservable (or latent) membership likelihood function that classified individuals into one of a number of segments based on latent variables, e.g. attitudes, perceptions, tastes (Boxall and Adamowicz 2002). As specified by Allenby and Ginter (1995), LCM employ a set of finite mass points (with χ^2 rather than normal distribution) to capture heterogeneity. However, while LCM assumes that these are groups of homogenous consumers and identifies them based on membership likelihood, they do no specifically associate covariates with part-worth estimates, but rather estimate them with “the size of the point mass” (Allenby and Ginter 1995:401). Analysing this complexity of heterogeneous preferences requires estimating individual (or disaggregated) part-worth utilities.

5.2.7 Hierarchical Bayes Regression

Grounded in the laws of conditional probability, the Bayes theorem “provides a means of moving from probability statements about the outcome of events assuming we know how the world works, to statements about how we think the world might work based on what we observed in the data” (Allenby et al. 2005:9). HB estimates individual coefficients for each respondent based on a hierarchical upper model (or the alpha matrix) of the sample of respondents (Allenby et al. 2005).

The Bayes theorem is expressed as:

$$Posterior \propto Likelihood \times Prior \qquad (5.3)$$

where "∝" indicates the proportionality of likelihood times prior odds.

Hierarchical Bayes (HB) is mathematically identical to mixed logit, with the added advantage of modelling disaggregated (rather than segmented) part-worth utilities (Train 2009). HB provides a unified treatment of the three components mentioned (equation 1.3). It also enables analysis of covariates with respect to individual part-worths (Orme 2013).

The Bayesian procedure can be used to estimate the parameters of a mixed logit model with an error component (Train 2009). Following Train (2009: Ch.12), assume that the utility (*U*) person *n* obtains from alternative *j* in time period *t* is denoted as:

$$U_{njt} = \beta'_n x_{njt} + \varepsilon_{njt} \tag{5.4}$$

Where ε_{njt} is the independently and identically distributed (iid) extreme value and giving β_n a normal distribution, $\beta_n \sim N\ (b,\ W)$, where *b* (normal with unbounded large variance) and *W* (inverted Wishart with *K* degrees of freedom) are priors (equation 1.3). Assuming the error term ε_{njt} is independently and identically distributed, the logit model is often employed to produce relatively efficient estimates of part-worth utilities from choice experiments (Allenby et al. 2005):

$$P_{ni} = \frac{\exp(\beta\prime x_i)}{\sum_j \exp(\beta'^{x}i)} \tag{5.5}$$

This procedure is often referred to as *hierarchical* Bayes given the hierarchy of parameters (posterior and prior): β_n are the individual-level (or lower model) parameters (e.g. tastes, preferences) for person *n*; and where the β_n's are distributed in the population with mean *b* and variance *W*, where *b* and *W* are the population-level (or upper model) parameters (Train 2009). Rossi and Allenby (2003:304) argue that since consumers inherently possess heterogeneous preferences, researchers in market-based studies need to statistically analyse three important components:

1. Within-unit (*n*, or individual consumers') behaviour (the conditional likelihood);
2. Across-unit (*N*) behaviour (the distribution of heterogeneity);
3. Action: the solution to a decision problem involving a loss function (or trade-off)[132]

Utilities (part-worth or linear coefficients) generated from HB models for each attribute level can then be used to simulate different scenarios (or combinations of these attribute levels)

[132] The authors contextualise these three components under Bayesian decision theory, which involves two critical components, 1) loss function and 2) the posterior distribution, the former associated with "a state of a nature and an action, $l\ (a,\ \theta)$, where *a* is the action and θ is the state of nature (parameter). They show that optimal decision-makers will choose an action so as to minimise loss (a quadratic function), in which case "the optimal 'action' is an estimator taken to be the posterior mean of the parameters" (p. 317).

using Sawtooth's SMRT (market simulator) to project shares of preferences for new products or concepts (Orme 2002).

5.2.8 Choice-Based Conjoint Design

I used the traditional full-profile Choice-based Conjoint CBC design under Sawtooth's SSI Web program (Sawtooth Software 2013), with two attributes (reforestation and payment options) each having three levels (see Appendix 5.5.). Conditional relationships and prohibition options were initially explored, e.g. prohibiting higher payment level for stone pine, but were abandoned in the final design. Fixed-choice tasks were also initially included in two of five tasks, but were later changed to full random choice-tasks. These changes helped improve the design considerably in terms of estimated errors and maintaining orthogonal design parameters.

The software calculated the parameters of the CBC design based on the number of questionnaires generated. I estimated recruiting around 5-10 landholding farmers from approximately 20 villages (150-200 participants) within two adjacent districts in North Lebanon (Bcharre and Zghorta-Ehden), located between 1,000-1,500 m.a.s.l. I therefore chose a maximum sample frame of 150 respondents based on my capacity and possible constraints faced (i.e. time, financial resources and security risks). CBC designs generally require relatively large sample sizes; however, this also depends on the complexity of a design. For example, the more attributes and levels included in a CBC design, the higher the sample size required (Sawtooth Software 2013).

One hundred-fifty questionnaire versions using the 'Shortcut' method with five random choice tasks were generated using the SSI Web software. This method was considered to have minimal overlap, i.e. identical consecutive choice tasks (Sawtooth Software 2013). There were three concepts per choice task excluding the 'none' option. There were 750 total choice tasks generated for 150 versions (at five per version).

Once the design was finalized, and following the piloting stage, 150 HTML versions (i.e. browser-based interviews with five tasks per version and three concepts per task plus a 'None' option per task) were created using the 'Paper-and-Pencil' option. Each HTML version contains five choice tasks for each respondent. These are normally displayed on a laptop or PC as a web-based interface, but in my case involved transferring onto a spreadsheet for displaying choice cards for my respondents.

The Sawtooth SSI-Web software is largely geared towards the marketing sector as a web-based interface for conducting CBC experiments online. In this context, the program saves and processes each respondent's completed results online, whereas the 'Paper-and-Pencil' method requires manually inputting results into an 'Accumulated Data File' (.csv) and later uploading the datasets (spreadsheets) back into the software in order to process the data into another file types (.dat, .cho). These files can later be analysed using other CBC modules provided by Sawtooth (e.g. hierarchical Bayes, CBC/Latent Class, Logit). The Market Simulator software, for instance, is aimed at projecting market sales through simulating hypothetical products (or scenarios in my case) in order to estimate the shares of preferences (number of respondents who would "buy" a novel product) based on results from CE surveys (Orme 2002). This was very similar to my intended use, hence my choice of Sawtooth software.

5.2.9 Focus Groups and Piloting

Informal focus groups were first conducted with reforestation experts from the American University of Beirut to discuss contract design options for a hypothetical reforestation programme. I then sought opinions from local landowners in Bcharre village regarding farmers in the region and how they would perceive my experiment. A similar focus group was conducted with a small group of farmers in Bcharre with the same objective. A forestry expert from a local NGO in Bcharre also provided me with some very helpful information pertaining to planting costs that aided in designing the hypothetical PES programme and approach[133]. A few changes were made to the land-use/land-cover survey following the piloting phase; however, the CE section of the survey underwent a series of adjustments. Initial designs were tested prior to formal piloting. Modification of later designs included adjustments made to the payment levels (increased payments) as well as to the random generation methods (i.e. from 'Complete enumeration' to 'Shortcut') in order to reduce overlapping concepts within each version.

[133] I initially piloted the CE with a minimum payment level set to US$500 ha^{-1} $year^{-1}$, but local farmers and forestry experts helped to clarify that this was an extremely low figure and aided me in determining what would be an acceptable (or minimum) annual payment level for one hectare by landowners in the area. Experts also recommended that the duration of the programme be 15-20 years to ensure that trees become established. Similarly, incentivised re/afforestation projects in African countries (e.g. Tanzania) used contracts for 20 years or more (Jindal et al. 2008).

5.3 Results

5.3.1 Landowner Attributes

Respondents were sampled from 17 villages within the Bcharre and Zghorta-Ehden[134] districts (74.5% from the former) with landholdings ranging from 800-2300 m.a.s.l. (μ = 1491.2, σ = 243.6). All but two respondents were male with a median age of 53 at the time the surveys were conducted[135]. Most (83%) were married and the median size of households was four members. The majority (72%) were permanent residents, 27% spent weekends/holidays and summers in the villages, while two were non-residents (Figure.5.2). Around a quarter of the respondents indicated that they were full-time farmers, 43% earned off-farm incomes (either as employees or self-employed), 23% were 'hobby farmers' (working or retired), and just under 10% were non-farmers.

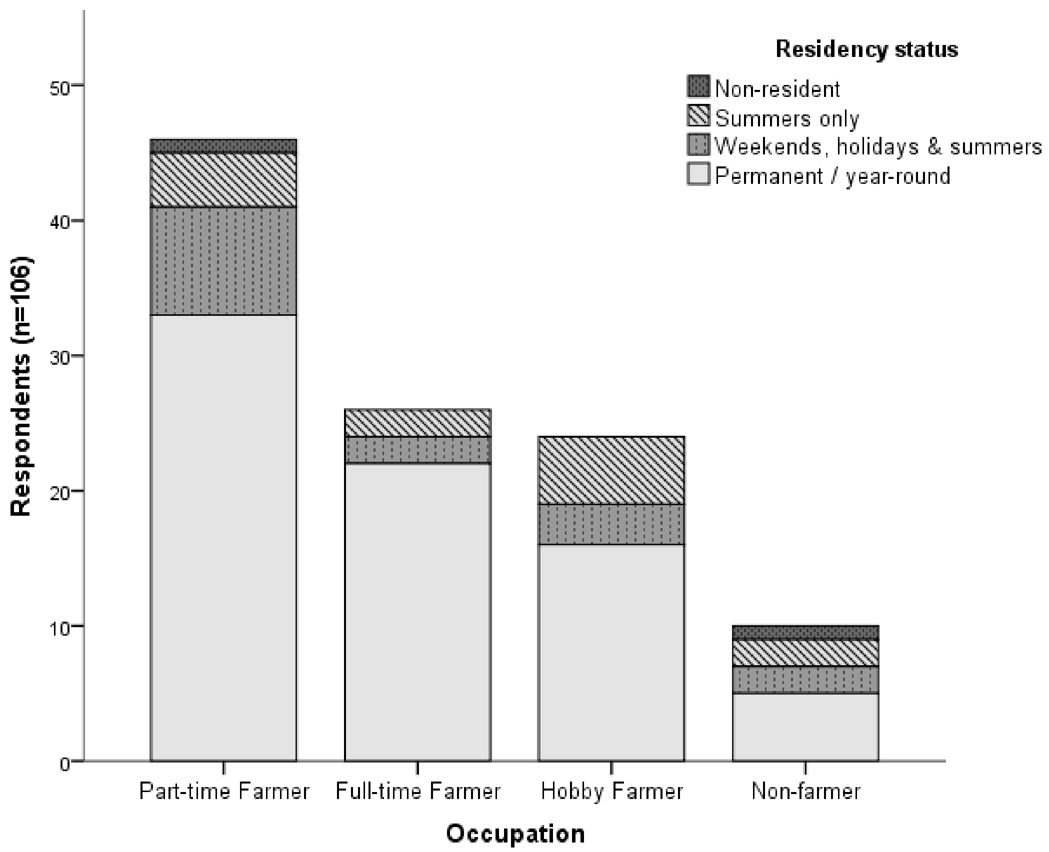

Figure.5.2. Land-based occupation divided by residency status of respondents (n=106).

[134] Ehden is part of the Zghorta district, the latter located closer to the coast just south of Tripoli.

[135] Median age of respondents from previous fieldwork (chapter 3) was 57.

5.3.2 Farm / Landholding Attributes (past & present)

All respondents interviewed owned at least one parcel of land (median of 3; max 7 parcels) averaging approximately 3.4 ha per respondent (σ = 4.59); however, 16% owned less than 1 ha. Approximately 36% of the aggregated total of 360.6 ha of land was abandoned (i.e. land in disuse), 58% was cultivated (>99% orchards), the remainder being mixed land-uses[136] (Table 5.3).

Table 5.3. Land-use and land-cover data

Land-use & Land-cover		Subtotal Area (Ha)
Land in use (e.g. commercial farmlands)		208.34
Of which (land-cover):	*208.34*	
Orchard crops	206.24	
Other crops	2.10	
Land in disuse (e.g. abandoned farms or rangelands)		129.14
Of which (land-cover):	*129.14*	
Range, scrub & shrub	89.77	
Forest/woodland	39.17	
Other/unknown	0.20	
Mixed land-use/land-cover (e.g. some farming)		23.07
Total		360.55

Of the land in disuse, 25% was described as open range, scrub or shrub type systems and 11% as forest/woodland systems. Around 83% of the respondents mentioned natural regeneration taking place on land in disuse (Table 5.4).

Table 5.4. Native species mentioned by respondents as occurring on land in disuse

Species	Common name	No. of responses
Prunus cocomilia	Bear plum	27
Quercus spp.	Oaks	23
Pyrus syriaca	Syrian pear	17
Crataegus monogyna	Hawthorn	15
Quercus coccifera	Kermes oak	13
Juniperus excelsa	Grecian juniper	9
Pinus brutia	Turkish pine	9
Quercus infectoria	Aleppo oak	6
Spartium junceum	Spanish broom	6
Pistacia spp.	Wild pistachio	4

[136] Landholdings were consolidated for ease of analyses categorised under these three major land-use types.

Average length of time since major plantings (or other major land use changes) was 32.4 years. Three respondents mentioned no major changes taking place on plots that were range/scrublands for 100 or more years. Six mentioned no major changes taking place on cultivated lands for 60 or more years.

5.3.3 Future Planting Objectives

Around 53% of the respondents with plans for future planting of crops provided spatial and LULC details[137] (Figure 5.3); in total 32 ha of planting was planned for land in disuse, 12.9 ha on land under cultivation, and 22.9 ha on mixed land-use, totaling 67.8 ha (μ = 0.99, σ = 1.11). Of these respondents, over half intended to plant commercial trees (fruit and/or nut)[138] and around 30% were not sure what crops to plant[139]. High costs and lack of suitable land were the main reasons for not planting more trees in the future mentioned by at least 12 of the 30 respondents. High risks (or concerns about success/failure), lack of support (e.g. family, government, community), and lack of interest (or need) were also mentioned as major constraints to future planting of commercial trees or other crops.

[137] Sixty-six respondents indicated future planting plans of which six were unsure and four mentioned replacing dead trees annually.

[138] Five respondents intended to plant stone pine.

[139] It may have also been likely that they did not want to share this information.

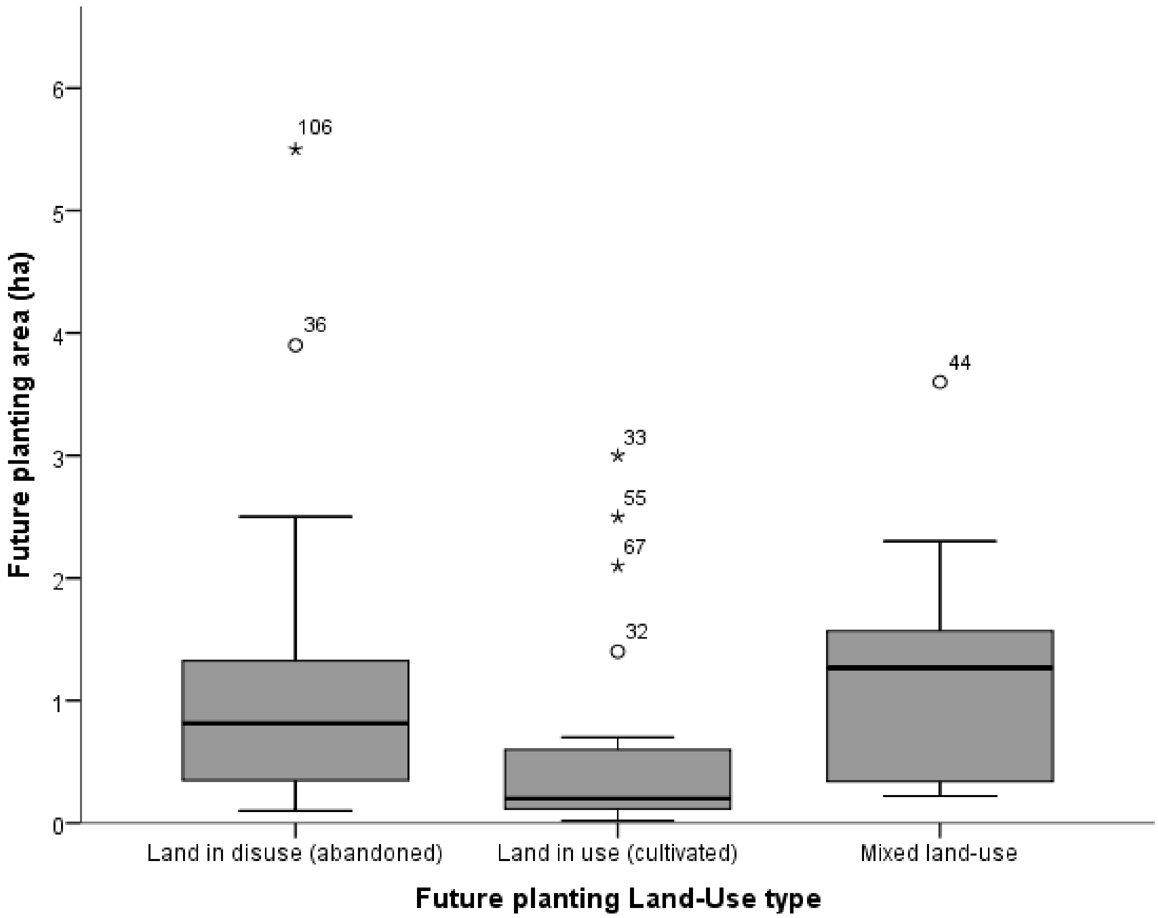

Figure 5.3. Land-use types and area for landowners (n=59) with plans to plant more crops in the future. *Note:* an outlier with 10 ha of intended planting on mixed land-use was removed for the purpose of displaying this graph.

5.3.4 Land Tenure

Seventy per cent of respondents were sole decision-makers of their holdings. Around 30% shared ownership with other family members (mainly siblings), and six respondents shared land-based decisions with non-familial property owners. Eleven respondents mentioned renting/leasing their property to others and seven rented or leased from other people.

5.3.5 Other Farm-Related Attributes

Water resources for agriculture were largely from springs managed by local cooperatives or municipalities (83%), followed by private wells or reservoirs (26%)[140]. Thirteen per cent mentioned other third party resources, mainly hill lakes constructed by the MOA or other

[140] Total percentages > 100% since most farmers indicated more than one source of water.

agriculture development agencies. Four respondents mentioned planting only rain fed crops (including trees such as cherry) due to a lack of water supplies. Two others indicated having to truck water in to fill reservoirs during the summer months. Fifty-eight per cent of respondents involved in farming claimed to receive no support from any third party organisation (e.g. MOA, NGOs). Twenty-five per cent mentioned receiving support from the MOA's Green Plan and around 20% from their municipality, local associations, NGO's or agricultural coops.

5.3.6 Results from Choice Experiments

Eighty of the 106 respondents chose at least one of the reforestation concepts offered out of the five choice tasks presented. The remaining twenty-six respondents selected the 'None' (status quo) option in all of the tasks presented[141]. The main reasons given (in order of the frequency reported) were: lack of suitable land, high opportunity costs, concerns about losing tenure, and risk-aversion (or not wanting to take on these kinds of responsibilities). Only four respondents mentioned a lack of interest in planting forest trees and two others mentioned distrust in these kinds of schemes altogether.

Aggregated results

Multinomial logit (MNL) models estimate average preferences for the aggregated sample (Figure 5.4). The stone pine option (Option A) generated the highest utilities for the reforestation attribute as a whole with preferences nearly equaling the status quo ('None') at the lowest payment level (US\$2,000 ha^{-1} year^{-1}) offered. The mixed species option (Option C), on the other hand, only becomes competitive with the status quo around \$10,000 ha^{-1} year^{-1}, with the stone pine and cedar mix (Option B) being intermediate. However, MNL models often fail to take into account heterogeneity of the sample and are thus prone to the independence from irrelevant alternative (IIA) problem discussed earlier (Louviere and Woodworth 1983).

[141] Where respondents chose the status quo in the first three choice tasks, I terminated the choice experiment as there was a risk of antagonising the respondent.

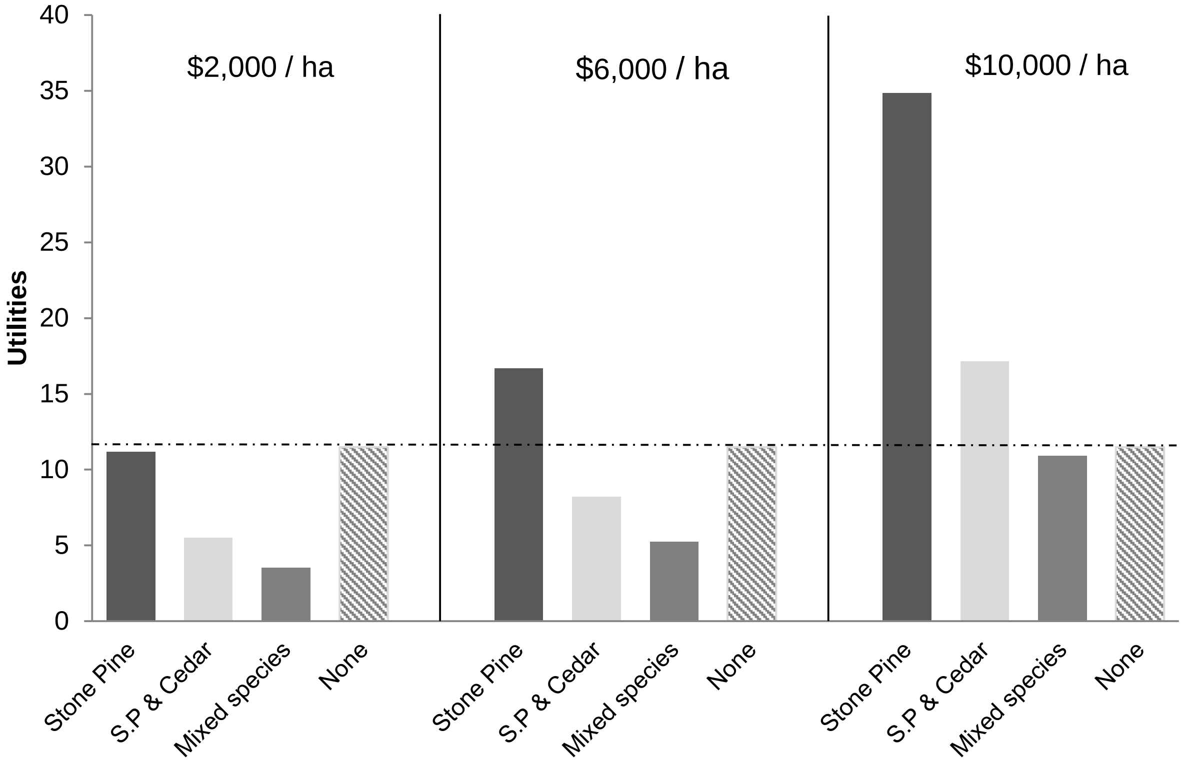

Figure 5.4. Estimated utilities of attribute concepts using multinomial logit (MNL). Utilities were rescaled from zero-centred differentials using the antilog * 10.

Group membership (latent class models)

Latent class models (LCM) segment respondents into groups (or classes) according to the strength of preferences for attribute levels. Latent class runs were conducted for two to five groups (four replications each). The solution for five groups was selected as the best supported model[142]. The first three groups in Table 5 and Figure 5 include respondents who had positive preferences for one of the reforestation options. Thus, although the MNL results show that *on average* this sample of landowners preferred Option A (stone pine) over Option B (stone pine and cedar), and Option B over Option C (mixed species), the LCM show that each of these options was the most preferred reforestation option for at least some respondents (Figure 5.5). In addition, the LCM identified a group of respondent who favoured no reforestation (none) even at the highest payment levels offered, and a group that

[142] Lowest Consistent Akaike Info Criteria (CAIC) selected with high relative Chi-square (Boxall and Adamowicz 2002).

were split between Option A and Option B. The model also showed that for respondents who preferred the mixed species or stone pine and cedar options (Option C and B, respectively), the reforestation attribute had substantially higher importance than the payment attribute, whereas for the group split between Options A and B, the payment attribute had a relatively larger importance (Table 5.5).

Table 5.5. Latent class runs with five groups segmented based on percentage of attribute importance

Part Worth Utilities	Stone Pine (A)	S.P. / Cedar (B)	Mixed spp. (C)	Split w/ A&B	None
Segment Size (% of sample)	29%	7.8%	10.2%	28.5%	24.5%
No. of Respondents	31	8	11	30	26
Attribute Importance (%)					
Reforestation option	54.7	88.5	93.5	38.4	47.6
Payments level	45.3	11.5	6.5	61.6	52.4

59.9% Certainty; 705.4 CAIC; χ^2 = 794.8 (Relative χ^2 = 33.12)

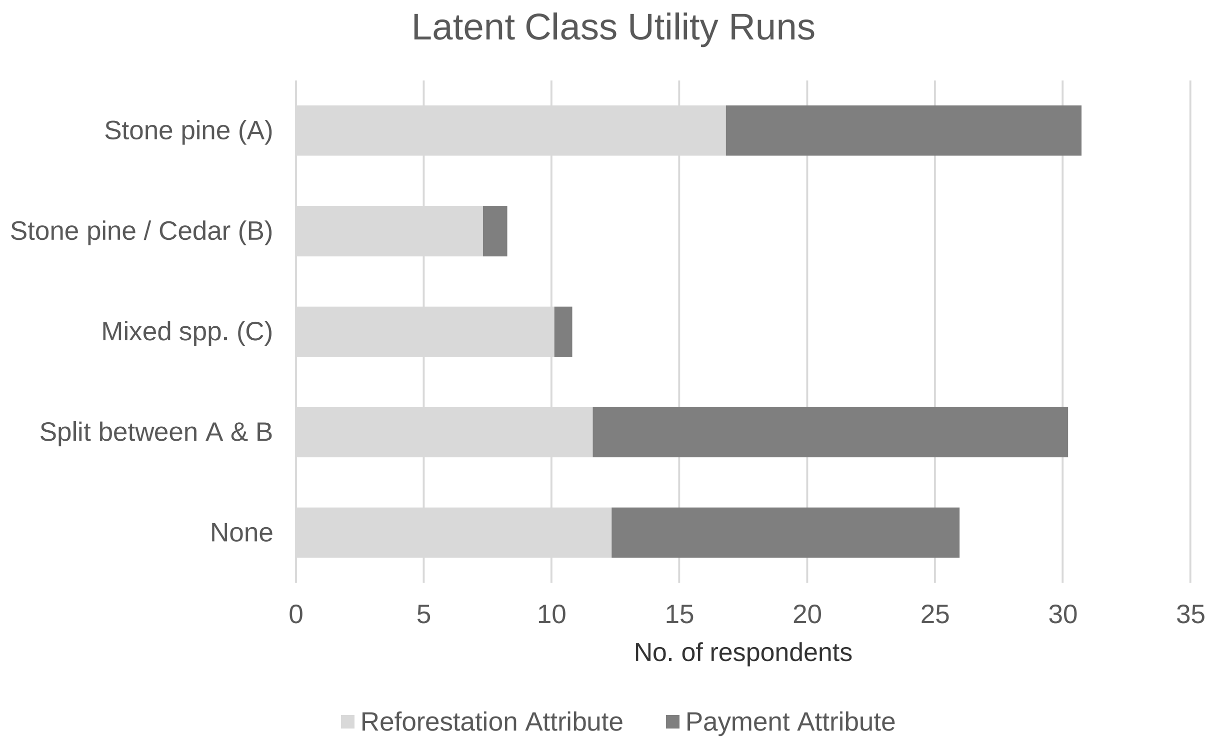

Figure 5.5. Latent class model for five groups showing all respondents (n=106) segmented based on average attribute importances (utility estimates).

5.3.7 Estimating the PPF

The choice-based conjoint hierarchical Bayes module (CBC/HB) was used to estimate respondents' disaggregated part-worth utilities of the reforestation attribute (dummy-coded) and a linear coefficient for payment level (2, 6, and 10). Utilities were imported into Sawtooth's SMRT simulator to develop a set of 27 scenarios containing different combinations of attribute levels to determine the share of preferences (the proportion of the sample of landowners who would choose each reforestation option, given the payment levels) for each scenario. An example of the first three scenarios is shown in Table 5.6.

Table 5.6. Sub-sample of simulated scenarios showing the share of preferences (%) for each concept

	Payment Level (hectare^{-1} year^{-1})						
Scenario	Stone pine (A)		S.P / Cedar (B)		Mixed spp. (C)		None
1	2,000	45%	2,000	18%	2,000	11%	26%
2	6,000	55%	2,000	10%	2,000	9%	25%
3	10,000	58%	2,000	8%	2,000	9%	25%

This allowed me to determine 1) the number of landowners in my sample that would choose the option, and hence the number of hectares that would be planted under each reforestation option[143], 2) total cost per hectare for each option (including fixed costs of planting trees plus variable costs of the payments), 3) number of hectares that could be planted for each reforestation option under two possible budgets (US$500,000 and US$1,000,000)[144], and finally 4) the trade-off between the diversity of species and hectares that would be planted with a given budget (two examples are given for illustrative purposes in Figure 5.6). Species diversity was determined using the Shannon-Wiener index below:

$$H = -\sum_{i=1}^{s}(\mathrm{p}i)(\mathrm{Lnp}i) \qquad (5.6)$$

Where *H* is the index of species diversity, *s* is the number of species, and p*i* is the proportion of the total hectares planted with the *i*th species (Magurran and McGill 2011).

143 The number of respondents was multiplied by the mean planting area (1.10 ha^{-1} σ = 1.55) that would be enrolled by the 80 respondents who chose a reforestation option (26 consistently opted out after a minimum of three choice tasks were presented).

144 Because it proved impossible to extract raw coefficients for individual landowners from Sawtooth, I assumed that all landowners who would choose a particular option would be paid (and would need to be paid) the same.

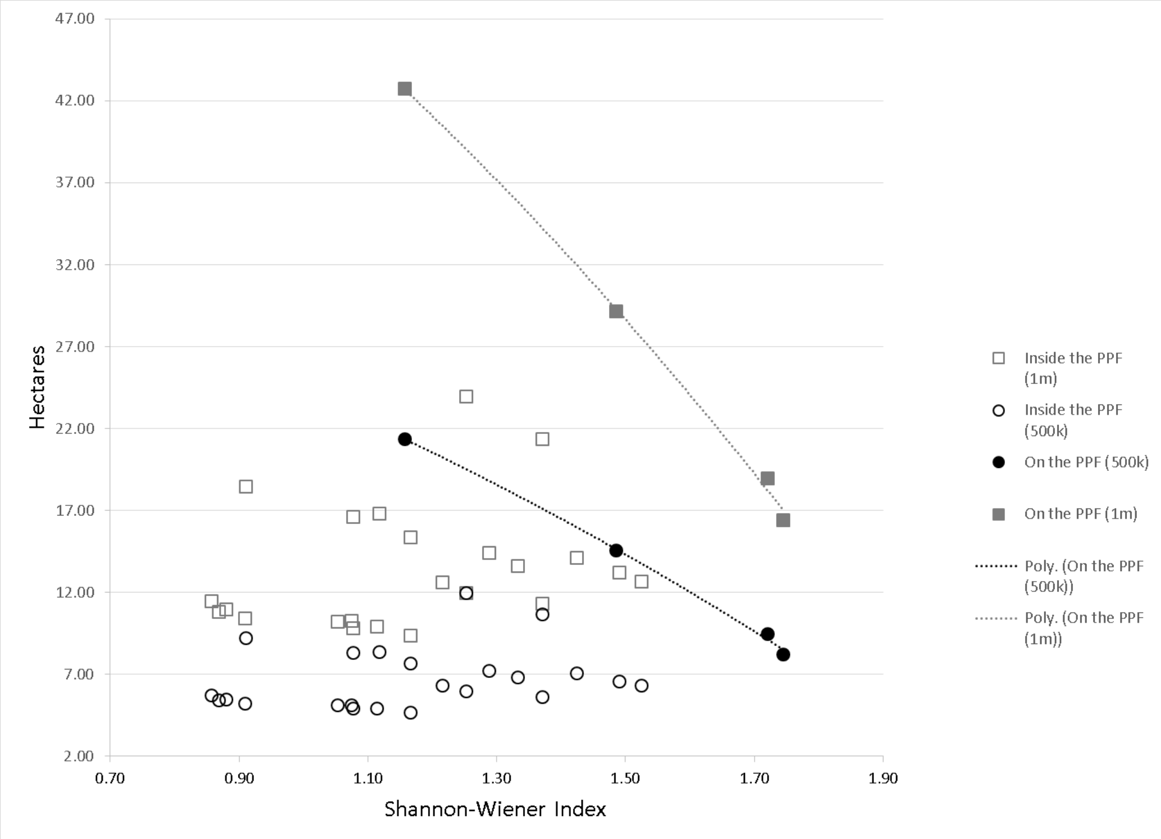

Figure 5.6. The production possibility frontier (PPF) illustrating the trade-off between diversity of species and hectares that would be planted (ha) under two budget options (500k = US$500,000 and 1m = US$1,000,000). Scenarios on the PPF are Pareto optimal (no increase in diversity is possible without a decrease in area).

Results from the simulation indicate that a large portion of the scenarios are Pareto inefficient (Figure 5.6). Four scenarios from each of the two budget examples lie on the production possibility frontier (PPF). Three of those scenarios had the lowest possible payment levels for reforestation options A and B, and the highest payment levels for the mixed species options (Option C). Interestingly, one scenario on the PPF included an intermediate payment level for the stone pine and cedar (Option B), and this scenario appears to kink the estimated PPF outwards, suggesting that other combinations of payments that were not included in the original choice experiment might mean the true PPF lies even further from the origin.

5.3.8 Analysis of Displacement under Reforestation Options

The spatial and LULC data gathered allowed me to assess the level of agricultural displacement. For respondents who chose at least one reforestation option (n=80) the land proposed for reforestation was classified as either 1) land in disuse, 2) land in use, and 3) mixed land use (Figure 5.7), similar to section 5.3.2 above.

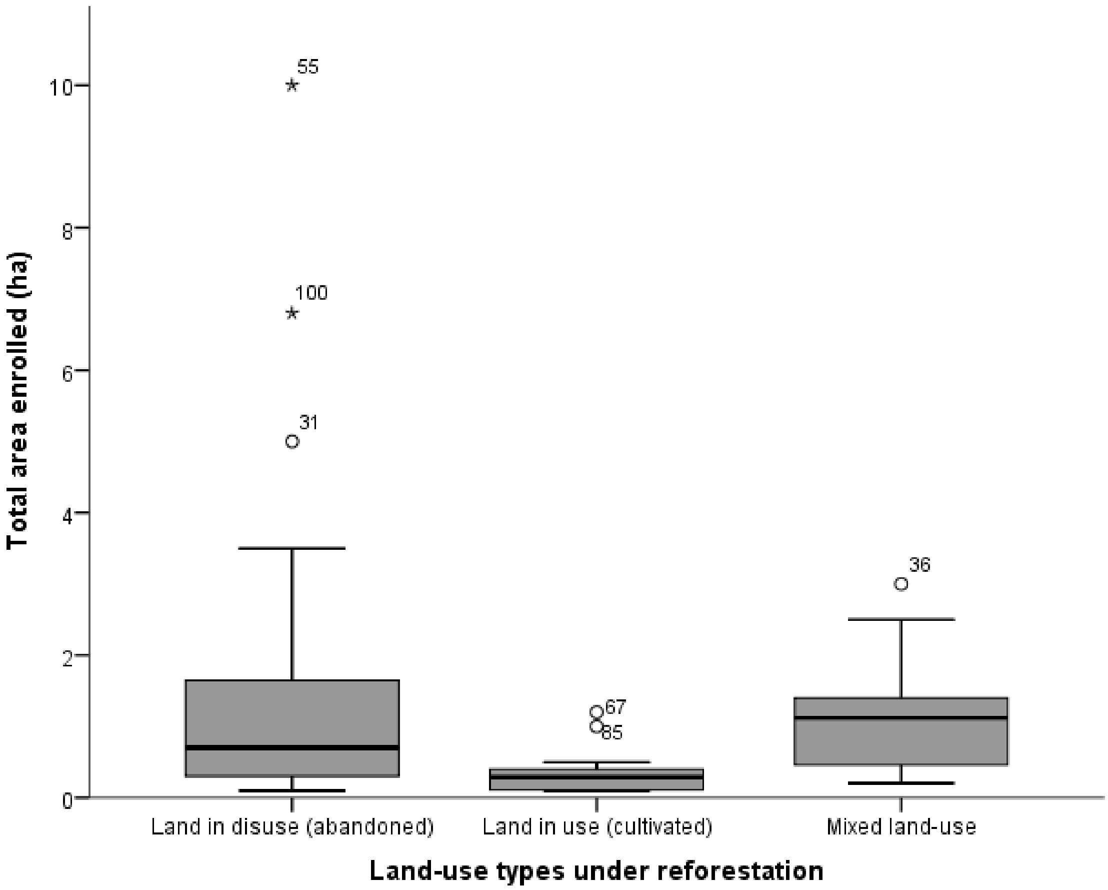

Figure 5.7. Land-use types and their associated areas that would potentially undergo reforestation based on responses from choice experiments by respondents (n=80).

Most reforestation would take place on land in disuse, however a higher proportion of stone pine would be planted on land in use and land with mixed land-use (Figure 5.3).

5.3.9 Foreseeable Land-uses Changes and Factors Ensuring Tree Retention

Respondents who would participate in a future PES programme were asked whether they could foresee any land-use changes after planting. Twenty-six of the 80 stated they would not foresee any changes, 25 mentioned building or construction on the plots that would be reforested, five mentioned selling land and another five mentioned passing land onto their children.

The main factors that would help to ensure tree retention were amenity or aesthetic values of forest trees (e.g. which increases land value) mentioned by 24 respondents. On-farm benefits were mentioned 21 times and intrinsic values seven times. Many respondents compared planting trees to having and raising children as reasons for retaining trees. On the other hand, the potential for prices of agricultural products (e.g. apple) increasing were mentioned by roughly 15% of respondents as factors that may result in removing planted trees *ex post*.

5.4 Discussion

The main objective of this study was to determine whether a significant trade-off exists between potential area reforested (or that extent of forest cover that would be achieved) and tree species diversity, for a given budget. The simulations showed that there is indeed a strong trade-off, for example between attaining extensive forest cover (approx. 43 ha) using fewer species (the Shannon-Wiener H index = 1.15) than with higher diversity re/afforestation (approx. 17 ha; H = 1.75), for an arbitrary budget of US$1m. It is also important to note that there are other possible Pareto efficient outcomes along the production possibility frontier (Figure 5.6). Interestingly, the multinomial logit model captured these trade-offs by showing that most landowners would likely reforest with stone pine (Option A) at the lowest payment level offered (US2,000 ha^{-1} yr^{-1}) while it would require much higher sums to induce the planting of diverse native species (Option C; Figure 5.4). However, these aggregated models give us an incomplete picture and provide us little insight on what preference heterogeneity may exist, as discussed earlier. Results from the latent class models (LCM) were therefore important in demonstrating that there is a small proportion of landowners (roughly 10%) that would prefer reforesting with mixed species (Option C), and another group (roughly 8%) who would prefer the stone pine and Lebanese cedar mix (Option B; Figure 5.5). This model also found a fairly large proportion of landowners (nearly 30%) that were more or less indifferent between Options A and B, and would be swayed by payments levels, but would not consider Option C regardless of payment level (within those tested). Interestingly, simulations predicted that at baseline payment levels (US$2,000 ha^{-1} yr^{-1}) for Options A and B, landowner preferences for mixed species (Option C) at the highest payment level (total present value cost of US$107,137 ha^{-1} discounted after 15 years) increased from 10.7% to 26.1%.

Results from the analyses are consistent with similar studies using production possibility frontiers to model trade-offs between competing (ecosystem) goods and services (e.g. Robert and Stenger 2013). Such models are also very useful for policy, particularly in aiding decision-making when resources are scarce and demands are often competing. Recent studies have drawn attention to the importance of understanding trade-offs between different ecosystem services, particularly how provisioning services such as food production have undermined most non-market environmental goods and services (Pretty 2008; Foley et al. 2011; Bowman and Zilberman 2013; Reed et al. 2013). Yet studies have found multifunctional landscapes that combine various land-use practices[145] provide more public benefits from the environment than highly modified and productive (of provisioning services) landscapes (O'Farrell et al. 2010; Kremen and Miles 2012; van Noordwijk et al. 2012). However, policymakers and practitioners will likely face difficult trade-offs when deciding on the kinds and quantities of ecosystem services being paid for, as well as what ES are likely to be displaced. For example, paying for regulating services such as carbon sequestration, either through forest protection or re/afforestation, could potentially displace provisioning services, or commodities like agriculture and timber, elsewhere. Minimising these trade-offs may therefore require incentivising the management of ecosystems for multiple services as proposed by Reed et al (2013).

The results also raise another important issue with respect to farmer (or landowner) attitudes and behaviours. For example, Espinosa-Goded et al. (2010) found that farmers are often reluctant to join incentives-based schemes for fear of losing tenure, or at least the ability to continue cultivating their lands. Perhaps many Lebanese landowners who are farmers consider planting diverse forests a threat to their livelihoods, particularly since there are legal implications restricting them from accessing land and resources (including planted trees) in the future. Other issues mentioned were perceptions that native species invite pests, and therefore even planting them at the periphery of their orchards (given that this may be the only land available) was considered a threat (shade was another issue). These issues not only echo opt-out responses from landowners interviewed in chapter 3, but were also mentioned in other case-studies (Zubair and Garforth 2006). In addition to this, and as discussed in the chapter, there are constraints to both buyers and sellers of ES generated from reforestation given the long time-frame required for planted forest to become established before generating those services. This can be financial burden for buyers required to pay a much higher premium for high-conservation-value species (e.g. those presented as Option C) than for productive species such as stone pine, which would require much lower payments and more willing adopters. However, as the results from the choice experiment suggest, there are also

[145] This includes reductions of inputs (e.g. agrichemicals) or adopting alternative techniques or land-uses that reduce negative outputs, e.g. no-till farming.

willing adopters of high-conservation-value reforestation payments that would be cost-effective for buyers.

Preference heterogeneity is one of the major challenges faced by researchers using environmental valuation techniques such as choice experiments. Heterogeneity of preferences could be across or even within regions, based on farm and farmer characteristics, and influenced by the institutional setting and environmental or other exogenous factors (Espinosa-Goded et al. 2010). Yet there are also preferences (or land-based decisions) that many landowners share, particularly with regards to LULC types. For instance, we could expect that landowners would rationally choose to enter PES/AES schemes for land with the lowest opportunity costs. Hence they would likely choose to plant forest trees on less fertile, marginal lands that would otherwise prove too difficult or costly to convert to orchards. As Hanley et al. (2012) pointed out, ES buyers will likely invest first in changes that involve the lowest cost and still be compatible with improving biodiversity. Identifying those who are willing to accept payments to plant diverse native trees offering fewer private benefits is amongst the many challenges of cost-effective targeting with PES.

Results from this study indicate that a substantial portion of Lebanese landowners from the Bcharre-Ehden IPA would be willing to accept payments for reforestation (> 75%). Yet it is also important to assess whether biodiversity-enhancing reforestation would be cost-effective with private landowners. One way to compare this is to look at the costs involved with current reforestation efforts in Lebanon, which are mainly taking place on municipal lands with municipalities as managing beneficiaries. The Ministry of Environment's (MOE) National Reforestation Plan was initiated in 2001, yet only direct planting and administrative costs were estimated (MOE 2001). More recently, the office of the MOE made a public announcement of its plans to partner with 27 municipalities in planting at least 135 ha, amounting to roughly US$1m (L'association du Local Liban 2010). This equates to approximately US$7,400 ha^{-1} as a one-time cost. Although the present value of the schemes considered in this study would be higher than this (on average approximately US$23,000 ha^{-1} at a discount rate of 5%), it is also necessary to consider the maintenance costs (e.g. irrigation and protection from grazing) on the one hand, and transaction costs (e.g. monitoring to ensure compliance) on the other. These components and their related costs are often required for ensuring optimal survival outcomes and long-term tree retention. Since there are no provisions for ongoing payments based on performance as part of the MOE's reforestation scheme (at least to my knowledge), ensuring long-term tree retention is limited despite short-term (e.g. 2-3 years) maintenance costs being covered. In contrast, landowners who joined the hypothetical reforestation programmes would receive conditional payments over a period of 15 years contingent upon tree survival and retention.

Constraints to effective uptake into PES include opportunity costs (e.g. agricultural and land prices increasing), inheritance issues surrounding tenure, laws prohibiting cutting of conifers, and lack of suitable land. Constraints to ensuring the efficacy of a PES programme (particularly for buyers) includes the high cost of reforesting with landowners, especially since tree retention requires long-term payments. Yet as discussed previously (chapter 3), reforestation is generally a costly endeavour given that a great deal of funds has to be frontloaded to cover planting costs while benefits (both private and non-private) may take many years to come into effect. In other words, the additionality of various forest ES from asset-building PES schemes take place slowly and incrementally over long temporal scales. This raises important questions for policy, particularly whether more funding should be directed towards managing existing forests. Furthermore, results from this study are preliminary in the context of future research prospects in this field. If asset-building PES were to become a reality in Lebanon, adopted as a policy instrument by the Lebanese government and the handful of NGOs aligned with their policies, more studies would be needed. A more pragmatic approach to estimating costs when private information is costly to obtain would be through reverse auctions, which has been adopted in applied research in various asset-building PES studies (Groth 2011; Ajayi et al. 2012; Jindal et al. 2013). Using reverse auctions by inviting landowners to place silent bids on the payments offered could help reveal their true opportunity costs and aid in identifying willing adopters of various kinds of PES schemes being offered. Moreover, just as it would be desirable to explore stakeholder preferences on the trade-off between extent and diversity, it would be good to explore stakeholder preferences for the balance between richness and evenness.

5.5 Conclusion

There is a growing need to develop institutions through new markets and policies for efficient delivery of multiple ecosystem services that will lead to more sustainable means of land-based production (Robertson and Swinton 2005; Bryan 2013). Yet we often face an undersupply of non-commodity ecosystem services such as biodiversity when we fail to pay for them, and carry on treating them as public goods or externalities. This study has investigated the potential for asset-building PES with Lebanese landowners from highland villages, in a region with ecological and cultural significance. I examined how landowners trade-off hypothetical reforestation options with payment levels, and modelled those utilities to illustrate potential production possibility trade-offs. Most Lebanese landowners would prefer stone pine plantations as a reforestation option, suggesting a strong trade-off for reforesting with mixed species under budgetary constraints. However, latent class models and hierarchical Bayes estimates helped identify subgroups of respondents that can enable for more cost-effective targeting of PES to achieve at least some level of reforesting primarily with mixed native species. The results from this study reinforce the need for recognising heterogeneity of preferences amongst landowners. Doing so will enable for more diverse PES designs that will attract a variety of landowners capable of supplying different kinds of ecosystem services. Navigating policies towards achieving multiple objectives will ultimately push the frontiers of many production possibilities in the future for Lebanon.

6 Discussion

Conversion of forests or other natural landscapes to agriculture occurs because many of the ecosystem services provided by these landscapes are undervalued in the market. Payments for ecosystem services (PES) are increasingly employed as a strategy to correct this market failure by internalising environmental externalities (van Noordwijk et al. 2012). However, there are numerous complexities associated with such markets because of transaction costs, or the inevitable 'friction' between transacting parties (Jack et al. 2008; Gibbons et al. 2011), and principal-agent problems such as imperfect (or asymmetric) information and hidden action (Ferraro 2008; Jindal et al. 2013). These issues are especially problematic in the context of less tangible ecosystem services (like biodiversity), because they are hard to measure and are often public goods (non-rivalrous and non-excludable), and therefore non-payers cannot be excluded despite enjoying them for free.

My thesis has explored ways of delivering biodiversity co-benefits alongside reforestation in Lebanon. In chapter 2, I found that if biodiversity-enhancing reforestation incentives are restricted only to public or municipal lands, they should be targeted towards municipalities with clearly defined cadastral boundaries and institutional mechanisms for ensuring tree retention. Given that these types of municipalities are scarce in highland villages of Lebanon, and many lack available lands for reforestation (or already have enough forest), alternative strategies should be considered, including contracting directly with private landowners. In chapter 3, I explored the attitudes of private landowners to PES for reforestation, and found that there are constraints on incentivising biodiversity-enhancing reforestation on private lands as well, despite a general acceptance by landowners of this type of scheme. Encouraging uptake of reforestation schemes requires understanding how heterogeneous landowners perceive the risks of participation, particularly future opportunity costs and land tenure issues affected by current forest policies. In chapter 4, I considered the demand side, and found considerable heterogeneity among reforestation stakeholders who are likely to be PES buyers in the future. Results from the choice experiments conducted in chapter 5 show that Lebanese landowners would likely participate in reforestation incentives, yet also found a great deal of heterogeneity in their preferences for different reforestation options relative to payments offered. Although a small proportion of landowners had positive preferences for diverse species, the remainder would require significant premiums to diversify planting. This implies a significant opportunity cost (in terms of extent reforested or carbon sequestered) of supplying biodiversity co-benefits alongside reforestation, at least on some lands. Recognising the heterogeneity in landowners' preferences, the characteristics of their holdings, and their capacity to manage lands effectively, will play a critical part in designing effective asset-building PES schemes for Lebanon.

Below I discuss some of the key themes that emerge from this research that I believe could help inform asset building PES policy in Lebanon and elsewhere. The overarching issues I discuss relate to general constraints on reforestation, heterogeneity amongst stakeholders and potential suppliers, and the trade-offs between single and multiple objectives when incentivising reforestation.

6.1 Constraints on Reforestation

6.1.1 Land Tenure

Lebanon's reforestation stakeholders are primarily interested in reforesting municipal lands, though they are more engaged with integrating municipalities and local members of those villages than they had been in the past. However, insecure tenure is likely to be a key constraint in reforesting municipal lands. Incursions by competing land-uses, particularly goats (as well as recreationists, e.g. snowmobiles), were reported by many local authorities (chapter 2). Many municipalities lacked clear cadastral maps delineating municipal lands, thus making it difficult to reduce encroachment and ensure reforestation does not conflict with other land-uses. Whether planting forest trees on public or private lands, lack of secured property rights could result in reduced planting survival and tree retention, because land managers lack the incentives or ability to protect trees. This may discourage potential ES buyers from seeking investments under such circumstances as shown in other case-studies around the world (Swallow et al. 2010; Corbera et al. 2011; van Noordwijk et al. 2012). In other contexts, lack of sufficient enforcement of property rights could result in weak land tenure, despite landowners having proper titles. Börner et al. (2010), for instance, found how insecure tenure has negatively impacted REDD projects in the Brazilian Amazon due to pervasive illegal encroachment and land grabbing, and concluded that PES would require parallel coercive measures under such contexts. Therefore, even when contracting with individuals with formal land titles, securing those titles requires strong formal institutions at various administrative levels often reinforced through informal norms, rules and customs (Jack et al. 2008; Corbera and Brown 2008).

Given Lebanon's socio-political complexity (including ethnic, religious, and class-based divisions), it is important to recognise that enforcement of land tenure is not exclusively the role of public institutions, but involves social and political capital (Korf 2009). Such issues may also influence landowners to be more risk-averse, especially if planting forest trees on private lands is viewed as losing tenure. Landowners, particularly farmers, may be reluctant to join reforestation schemes fearing they will lose some part of the bundle of rights they have over their property. Similarly, there was a sense of discontent shared by many Lebanese farmers pertaining to laws prohibiting the cutting or removal of forest trees without formal permits. While these measures may have aided in gradual forest recovery, they may also be contributing to forest loss from arson (as a means of regaining tenure). Since asset-building PES has never been done with Lebanese landowners, it is not surprising that they would view it more cautiously than if they had (or heard of) previous experiences. Similar instances relating to policies preventing rights to access natural resources, particularly tree tenure, have been shown to deter rather than encourage effective reforestation and forest management objectives (Bäckstrand and Lövbrand 2006). Moreover, while results from chapters 3 and 5 suggest that Lebanese landowners (whether active farmers or not) are accepting of incentivised reforestation schemes, many expressed concerns about inheritance issues tied to tenure. If property rights are secured and factors affecting long-term tree retention were purely within the landowner's control, incentives would in theory only have to cover the direct costs in planting and each landowner's opportunity costs.

6.1.2 Variable Opportunity Costs

Findings from my research suggest that landowners' opportunities costs varied considerably. For the most part, reforestation would take place on land that is considered to be of poor quality for orchard crops, thus it is unlikely that agriculture would be displaced. Preference for planting marginal land of poor quality over that of productive lands appears to be common place in other asset-building PES and reforestation-related studies (e.g. Kelly and Huo 2013). But this would also require that payments are kept relatively low enough to not incentivise agricultural displacement and land-use change at larger scales. Furthermore, land in disuse could range from degraded scrub (or *garrigue*-type systems) to recently abandoned farms. The former might have more disadvantages for potential ES suppliers given the poor conditions for ensuring high enough survival rates. In addition, more remote lands with lower opportunity costs may face greater threats from other factors like grazing. An important question for future PES buyers in Lebanon is whether they are willing to invest in many agents with smaller parcels, or would they prefer targeting landowners with relatively large holdings willing to enrol substantial areas. The latter might reduce transaction costs and improve contiguity of habitat, but may also increase opportunity costs, as well as increasing agricultural displacement. It is also likely that landowners with relatively larger holdings are limited in numbers, and their capacity for effective land management could also be much lower than more active farmers. Farmers focus on short-term opportunity costs and expected revenues from their holdings, while reforestation schemes require much longer contract terms to ensure additionality. Given that Lebanon's agricultural export sector is largely restricted to Arab-speaking nations in the MENA region, some of their more profitable markets have been lost to political crises (e.g. Syria, Libya and Egypt). My fieldwork took place during a period of economic hardship for many apple growers in Lebanon given these volatile circumstances in the region. In retrospect, responses to reforestation incentives could therefore change with fewer landowners showing interest if the market for agricultural products gains ground in the future.

6.1.3 Impacts of Reforestation on Biodiversity

The lack of institutional mechanisms for enhancing native tree diversity can also have negative repercussions for biodiversity and the resilience of ecosystems to deal with a changing climate. While attention to biodiversity and ecosystem services has focused largely on the tropics, sustainable land-use practices (including with re/afforestation) are also needed around the biodiversity 'hotspot' region of the Mediterranean basin (Blondel et al. 2010; Mittermeier et al. 2011; Caparrós et al. 2011). Moreover, protected areas alone provide little insurance for biodiversity conservation as isolated island (or fragmented) habitats vulnerable to edge effects (Dewi et al. 2013). They also restrict the natural range of species (particularly large mammals), thus impacting the flow of genetic diversity. In turn, protected areas do little for biodiversity-rich forests around their periphery that are liable to becoming agricultural or timber concessions (Margules and Pressey 2000; Wilson et al. 2007; Gibbs et al. 2010).

As incentive-based mechanisms like PES are being implemented globally, questions remain about the long-term viability of schemes, particularly asset-building. Other important questions pertain to the objectives of future PES buyers, some which have been already mentioned. For instance, would buyers be happy with investing in a multifunctional landscape matrix with fragmented reforestation on marginal lands, or would they prefer contiguous forests (perhaps at a higher cost)? There are also important trade-offs to address, particularly for policymakers deciding what services are in demand, how much they are going to cost (transaction and opportunity costs), and what guarantees are in place to ensure that they are getting what is being paid for (conditionality). All these factors remind us that it is important to recognise heterogeneity of stakeholders, from policymakers to buyers and suppliers.

6.2 Heterogeneity of Stakeholders

Stakeholders in my study ranged from local authorities, members of the public and private sector reforestation agencies, researchers, policymakers, and landowners. Designing effective PES schemes requires identifying the constraints on reforestation with these stakeholders in mind. A key strategy for accomplishing this is to recognise that stakeholders are all very different in their preferences, objectives, risk behaviour, and attitudes towards the environment or other public goods (Kenter et al. 2015).

Recognising and making sense of preference heterogeneity is also one of the key objectives in many stated preferences studies on PES and related incentive-based mechanisms (Colombo et al. 2009; Reed et al. 2014). Choice experiments are widely employed as a technique for identifying unobserved preference heterogeneity by analysing how people make choices (or trade-offs) when presented with alternatives. While it is not uncommon to expect that most ES suppliers are likely to be profit maximisers, recognising that some are not is crucial for targeting the right payments to the right suppliers (Ruto and Garrod 2009; Espinosa-Goded et al. 2010). For example, my choice experiment design enabled me to identify a small portion of landowners willing to participate in biodiverse reforestation schemes with few private benefits at lower payment levels than the productive stone pine option (chapter 5). While it is also likely that these individuals are less farm-dependent and have more unused land of low agricultural potential, there were landowners who were not farmers with relatively large holdings that either preferred stone pine or not joining such schemes altogether. Similarly, there were also a few modest farmers whose livelihoods were largely farm-based who were keen on reforesting with mixed species, despite being offered higher payment levels for stone pine.

I also found heterogeneity amongst municipal stakeholders' in how responsive or accepting they were of reforestation initiatives, particularly with respect to how decisions are made and with whom they would prefer to partner. Evidence of preference heterogeneity was found amongst another important group of stakeholders; ones who are likely to develop and implement PES programmes in the future (chapter 4). Considerable preference heterogeneity between stakeholders with different professional foci, including within-group variability, highlights the importance of soliciting preferences from multiple stakeholders when selecting species to be used in reforestation efforts. Future research will need to explore what trade-offs PES buyers wish to make between biodiversity and other ecosystem services – i.e. to estimate the indifference curves illustrated in chapter 5, and to gauge marginal willingness-to-pay estimates. Eliciting reforestation preferences would also have to go beyond decision-making stakeholders and include a wider spectrum of the Lebanese public. A preferable means of estimating the environmental benefits and the trade-offs they entail would be to employ choice experiments (Kallas et al. 2007; Brey et al. 2007). Given the likelihood that there would be considerable preference heterogeneity amongst various potential 'buyers', it would be necessary to employ a more complex design (e.g. more attributes and levels) that offers many different reforestation options at different prices. In turn, this would also require corresponding with a greater number of respondents.

6.3 Reforestation Trade-Offs in Lebanon

Present and past reforestation decisions have been largely made with single objectives in mind. Lebanese cedar (*Cedrus libani*) and stone pine (*Pinus pinea*) were the main forest species used in past reforestation efforts on public and municipal lands (including protected areas) and continue to be today. Increasing forest cover from the current 13% to 20% is still the main objective of the MOA and MOE, and with virtually all taking place on public / municipal lands. But preferences are beginning to change amongst some key reforestation stakeholders (both public and private sector) who are being guided by research and experiences taking place both in Lebanon and abroad. Given that the costs (both fixed and variable) of reforestation are high, single objectives could potentially lead to a significant waste of resources: although chapter 5 demonstrated that there are trade-offs between reforestation objectives, it also found synergies. Increasing the diversity of reforestation from the current low level is likely to require modest trade-offs (Figure 6.1) and might help ensure more resilient forest ecosystems. Recognising these trade-offs will require targeting a wide variety of potential suppliers who are more likely to provide these services over longer time frames. Recognising landowner heterogeneity, and designing PES accordingly permits buyers to target a wider variety of ES producers for a given budget, thus allowing the (future) production possibility frontier of planned reforestation to be pushed outwards (Figure 6.1).

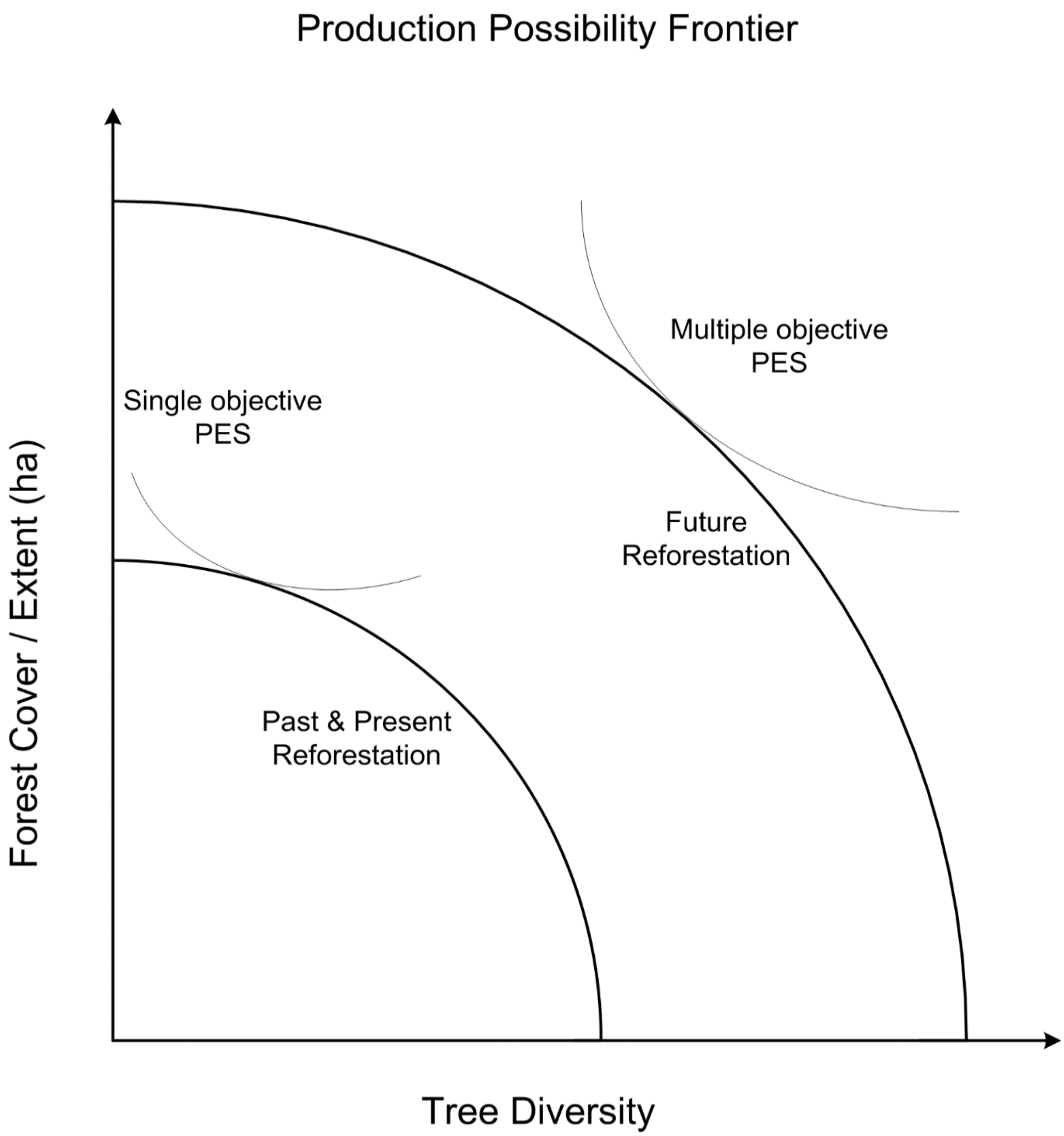

Figure 6.1. Inner production possibility frontier (PPF) highlights past and present reforestation in Lebanon geared toward single objectives / ecosystem services (forest extent) illustrated by the indifference curve; future PPF (outer curve) with multiple objective indifference curves would result in trade-offs between tree diversity and forest cover in reforestation incentives.

6.4 Reflections – Success, Limitations, and Recommendations

Landowners I interviewed appeared genuinely honest in their responses, which is indicative that face-to-face interviews, or surveys with supplementary qualitative methods, help validate environmental valuation studies as addressed elsewhere (Arriagada et al. 2009; Entenmann and Schmitt 2013). For example, when asking landowners (particularly farmers) who would not even consider the highest payment level offered for mixed species why they would still opt to plant stone pine at the lowest payment, many simply said “money is not an issue”[146] (chapter 5). This suggests there are other factors affecting certain landowners’ decisions, perhaps the intrinsic nature of farming behaviour, often overlooked in policies aimed at environmental improvements (Duesberg et al. 2013; Wynne-Jones 2013a). Hence there are potential instances where PES can become a perverse incentive or crowd out other institutions and pro-environmental behaviours as discussed in chapter 2.

6.4.1 Critical Reflections on the Limitations of the Study

There were some key methodological limitations in my research that need clarification. One was the use of a trained field assistant for conducting semi-structured interviews as opposed to a translator (chapter 2), and the other was the impact of the order of which reforestation schemes were presented to respondents (chapter 3).

In the semi-structured interviews conducted for the study in chapter 2, I hired two field assistants to conduct the interviews. My field assistants were selected based on the strengths of English and Arabic (both written and spoken), their experience in social studies interviews, and their capacity to translate Arabic to English text efficiently. We conducted extensive pilots, beginning in-house (with colleagues at AUB-NCC) and in the field. One of the limitations of this research was the decision to conduct interviews through a trained field assistant as opposed to me conducting interviews through a translator. This decision was chosen based on the assumption that it was a more efficient means of conducting interviews, particularly since initial telephone calls using standardised scripts were made by my field assistants. My ability to follow the Arabic interviews enabled me to ask my field assistants to make clarifications (or translations) in English, which allowed me to ask certain follow-up questions where appropriate (that was then translated by my assistants). The use of a translator as an interview medium may have enabled me to ask more in-depth probing questions, which would have resulted in more detailed explanation of underlying constraints or weaknesses informants face with respect to reforestation. However, there were opportunities where I asked follow-up questions in a number of interviews, and the majority of our informants provided us with sufficient responses for this study using this approach.

[146] In contrast, when asked how much more he would expect to be paid to change from the stone pine option to the mixed native species one, one respondent (who was not even a full-time farmer) replied that he would require a minimum of US$100,000 per hectare annually.

While the majority of those interviewed were generous in sharing information, there were a few who were reluctant to give details for reasons unknown. It may have been possible to probe further, which I had done in a few cases early on. I realised this was neither appropriate nor ethical after I was prompted by my field assistant that we should stop interviewing. This reminds us that there are ethical considerations that are often overlooked when trying to meet research objectives with limited funds and time that place researchers and their respondents in difficult and uncomfortable situations. This is particularly true when dealing with sensitive questions that could unravel complex issues that are political or socially-embedded. In addition, the AUB's institutional review board (IRB) required that all questionnaires be reviewed and all researchers and their assistants to complete an exam after undertaking an online course before fieldwork can even begin (and this included piloting of questionnaires/surveys).

In chapter 3, the order the schemes were presented to respondents in the consecutive order for the purpose of gauging their acceptability by starting with the most plausible (or least 'giveaway') option, and building towards the least familiar (and most plausible) option. They were not, therefore, intended to test the effect of randomisation. I believe this was the best way to explain the options (or schemes) and further elaborated using follow-up questions to gauge their perceptions to these hypothetical scenarios. The objective in using this ordered rather than randomised method of presenting schemes was to investigate whether respondents' acceptability differed substantially from a higher risk scheme (results-based loan) to a risk-neutral scheme (action-based grant), and whether there was a substantial difference in uptake / land enrolment when presented with a scheme characteristic of additional benefits with equal risk (i.e. results-based payments) to a results-based loan. The results suggest that the majority (n=21) of respondents would be interested in any of the schemes as potential adopters and gave reasons as why. Eight of those chose to enrol the same amount for all three schemes, seemingly disregarding risks and benefits of each (or perhaps this was the maximum potential area they would be willing to plant). There were five respondents who would not participate in any of the schemes and gave reasons for not accepting (e.g. lack of land, don't like native species, don't trust these schemes, simply not interested, etc.). Finally, there were some that viewed advantages increasing incrementally from the ordered schemes, and there were a few that did not fit in (asymmetric attitudes to risks and benefits). It is quite possible that some respondents may not have fully grasped the concepts of the schemes or may have varying attitudes to risks or uncertainties they are unfamiliar with. Further research could explore a randomised approach using similar schemes and asking respondents to rate them accordingly. However, this research focussed on more qualitative responses to support our understanding of landowner attitudes to risks and reward.

6.4.2 Recommendations for Research and Policy Improvements

There is a strong need for more adaptive forest management practices and policy reforms in Lebanon (chapter 2), particularly with respect to laws that counter effective management while discouraging reforestation, on both private and non-private lands. Managing existing forests are crucial for reducing fires while maintaining biomass accumulation, and possibly more cost-effective than re/afforestation, especially in regions with high natural regeneration capacity. For instance, De las Heras et al. (2013) found that silvicultural treatment (e.g. thinning to encourage productivity) of native Aleppo pine forests in Spain helps increase carbon uptake. In addition, re/afforestation (or natural regeneration) on abandoned farms has also been shown to increase biomass more efficiently relative to native forest and woodland systems (García Morote et al. 2012). Empirical data on the carbon sequestration potential of Lebanese forests and tree species is another potential area for future research. In Turkey, for example, Evrendilek et al. (2006) found Mediterranean coniferous forests to be significant carbon sinks. In another example, Gratani et al. (2013) quantified the carbon sequestration of high-density Mediterranean shrubland ecosystems (*maquis*) in Italy on average at 22 Mg C ha^{-1} year^{-1} and approximated the market value of carbon at around US$500 ha^{-1} year^{-1}. This suggest that Mediterranean-type ecosystems also have potential for entering carbon markets, and therefore allometric data on Lebanese forest, woodland and shrub communities would be useful. Moreover, increasing our understanding of the costs and benefits of regulating services (e.g. carbon and watershed services) are critical in regions that are highly vulnerable to climate change and desertification (Grünzweig et al. 2007; Correia et al. 2010).

There are, however, social and ecological constraints that would affect the probability of carbon being traded through the private sector in Lebanon. Aside from the biogeoclimatic characteristics affecting the productivity of forest carbon in the country, an overarching constraint in carbon-based PES contracts with Lebanese landowners include the increasing cost of real estate, driven both by touristic development and fluctuating agricultural interests. This is especially true in more developed parts of the Mt Lebanon region. While there are exceptions to this, particularly farmers from economically marginalised parts of Mt Lebanon range (e.g. Akkar and Dinniyeh), these areas contain some of the largest expanses of forests in the country and therefore could not support extensive reforestation efforts (chapter 2). Generally speaking, carbon-focussed re/afforestation contracts with private landowners would not be as cost-effective for buyers as those targeting landowners (with much larger landholdings) from much lower income tropical countries.

In contrast, further research is needed to determine WTPs for a variety of ecosystem services, including soil and water conservation (and other mitigating strategies from restoration in general, especially in the context of increasing desertification), watershed maintenance, fuelwood and NTFPs, functional (e.g. windbreak and air-filtering services from trees) and aesthetic values of landscapes, as well as biodiversity (including cultural and supporting services). People's perceptions of forests also have important implications for the design of reforestation initiatives. Results from chapter 5 can be used to design a multi-attribute choice experiment to elicit preferences for different kinds of reforestation schemes in Lebanon. This would include gauging people's perceptions to different kinds of ecosystem services generated from increasing forest cover. For example, in eliciting visitors' stated preference for scenic values on reforestation, Caparrós et al. (2010) found that visitors preferred scenic values from cork-oak reforestation areas over that of eucalypts. The latter showed a much higher rate of carbon uptake based on the increase of forest surface area to that of the former. This case-study showed there were strong trade-offs in landscape preferences as one type of ecosystem services (e.g. cultural) over that of the more globally significant carbon sequestration (e.g. regulating). In our example, using carbon as a proxy ES may have been possible if eucalypts or other fast-growing trees were included in reforestation.

While genetically-modified eucalypts have been shown to sequester significant amounts of carbon even in drier climates, their extent as monocultures can have severe impacts on biodiversity and other ES (Boyd 2010; Shekhawat et al. 2014). Moreover, there are potential pitfalls with using forest cover (or extent) as a proxy for measuring a range of ES. Using reforested area as a proxy under PES contracts can potentially lead to perverse incentives. For example, if the area planted with trees were only used, this could incentivise the monocropping of productive (or valuable) species as opposed to a mixture of native species that are beneficial for biodiversity. Alpízar et al. (2007) elaborated on these concerns with respect to Costa Rica's national PES programme (Pagos por Servicios Ambientales):

> *... The Costa Rican national initiative—probably the world's most famous PES program—uses a simple proxy: whether a parcel is forested or not. The proxy does*

> *not take into account variation in the levels of ecosystem services that forested plots provide due to the number and type of trees present, proximity to surface and to ground water, or slope. Such blunt proxies can be inefficient. Land managers in Costa Rica receive the same payments for a hectare planted with commercial teak as for one planted with native species. However, by definition, teak plantations harbor less biodiversity. In addition, it can actually contribute to soil erosion rather than preventing it because teak's large leaves tend to concentrate rain droplets into more disruptive streams. The Costa Rican program would get more "bang for the buck" if it used a proxy that distinguished between types of forests. (22)*

While the extent of forested area may enhance biodiversity as well as a number of other ES, the relevant question here is whether participants should be paid the same amount regardless of which species and their associated mixes are used in reforestation.

An important revelation for me, synthesised through my own empirical research and theoretical comprehension of PES, was that there are limitations and potential setbacks relating to single objectives. Ultimately, I see PES as a policy option, one that can only work properly if developed to become a genuinely flexible market-based instrument, and not treated as a panacea. The idea of designing PES as a policy option means that it would serve as an alternative type (or possibility) of production, where demand would incentivise supply, as we would see under any free market institution. As challenging as this will be, PES should be designed with multiple objectives in mind to attract heterogeneous suppliers willing to render those services effectively, and heterogeneous buyers willing to pay for (or invest in) those services. Since opportunity costs are expectedly higher on some types of land (e.g. orchards), keeping payments low will help to avoid agricultural displacement. There may be some potential suppliers that are willing to plant and care for rarer native tree species, perhaps ones that are difficult to produce in nurseries, assuming that some potential buyers are willing to make higher premiums. Others may be willing to plant only productive trees at much lower costs. Within these extremes, I predict we would find a much larger and diverse group of potential suppliers willing to accept a flexible scheme tailored to meet their expectations, thus minimising overall trade-offs. Accounted for together, I could foresee the possibilities of many different kinds of people being paid for producing multiple environmental goods and services. Recognising this heterogeneity and acknowledging the need for encouraging multiple objectives in reforestation or other asset-building incentive schemes will help raise our understandings of how to better govern complex and dynamic social-ecological systems.

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Appendices

Appendix 1.1. Matrix of Lebanon's Key Reforestation Stakeholders

Organisation/Institution	**Activities**	**Year Est.**	**Local Partners***	**Int'l Partners***
Public Sector				
Ministry of Environment (MOE)	National Reforestation Plan	1993	AFDC	UN-GEF
Ministry of Agriculture (MOA)	National Forest Programme	1948	LU[1], AFDC, JL	FAO, Sylva Med
Private Sector				
Association for Forests, Development & Conservation (AFDC)	Nationwide forestation	1993	MOE, MOA, LRI, APJM, SCR	IUCN, USFS
Lebanese Reforestation Initiative (LRI)	Nationwide forestation	2010	AFDC, JL, APJM, CFC, NCC, RL, NCC	USFS/IP[2]
Jouzour Loubnan (JL)	Nationwide forestation	2007	MOA, MOE, LRI	n/k
Shouf Cedar Reserve & Society (SCR)	District-level reforestation	1996	MOE, AFDC, APJM, EFL	IUCN, WWF, UN-GEF
Association for the Protection of Jabal Moussa (APJM)	District-level reforestation	2007	MOE, LRI	IUCN, UN-GEF
Cedar Friends Committee (CFC)	Village-level reforestation	1985	LRI	n/k
TERRE Liban (TL)	Village-level reforestation	1995	--	UN-GEF
Reforest Lebanon (RL)	Village-level reforestation	2010	LRI	n/k
Rotary Club of Baabda - Trees4Lebanon (T4L)	Regional tree planting	2008	--	n/k
Nature Conservation Center of AUB (NCC)	Specialised tree planting	2002	LRI	USFS[2]

* Forestry-related sector

[1] Lebanese University

[2] US Forest Service /Int'l Programs

Appendix 2.1a

Institutional Review Board: Protocol# FAFS.ST.05

Recruitment Phone Script for Heads of Municipalities:

Good day Mr. [Name],

I am calling you on behalf of Mr Arbi Sarkissian, a PhD research student with Bangor University (UK) and the American University of Beirut. I am his fieldwork assistant, (Mohamad or Paul) and I am assisting Mr Sarkissian on a study about land use and natural resource management throughout Lebanon. We obtained your number from a public directory (e.g. OMSAR website, Ministry of Interiors and Municipalities website, or other*).

[*contact number provided by person 'x' at the municipality HQ]

We are contacting you today because your municipality was randomly selected for this study. We would like to ask if you would be interested in participating in this study and to share some of your experience and insights with us.

This study is intended to help us gain a better understanding of challenges and opportunities involved in managing natural resources.

[Provide mayor with more info if asked, e.g. objective of this study]

We'd like to assure you that your participation in this study is completely voluntary. Please note that your decision to decline in participating will not affect you or your municipality in any way. Also, there are no foreseeable risks to you or to your municipality for your participation, and all information you provide will remain strictly confidential and used only for the purpose of scientific research.

If you wish to participate with us, may I proceed to set a date and time for the interview as per your convenience? We would be more than happy to meet you at your village or another suitable location. I will call you one day prior to the interview date to confirm.

I thank you for the time you have dedicated to this call.

Appendix 2.1b

Consent for Participation in a Research Study

Institutions and natural resource management: Exploring payments for ecosystem services (PES) to support decentralized community-integrated native tree planting in Lebanon

Investigators: Mr. Arbi Sarkissian – Thesis Student (TS)

Dr. Salma Talhouk – Principal Investigator (PI)

Co-investigators: Drs. Neal Hockley & Amin Kamete (thesis advisors – Bangor University, UK)

Fieldwork assistant: Mr. Edward Antoun and Ms. Marieange Saady

Contact Details of Principal Investigator:

Address American University of Beirut

Bliss Street

Beirut, Lebanon

Telephone: 01-350 000 Ext 4508 (AUB)

Study sites: Municipalities – public and private (or communal) land where seedlings are being planted and managed

We would like your consent to participate in this doctoral (PhD) research project. Please take the time to read the information below before deciding whether you wish to participate in this study or not. We thank you for your interest and look forward to your participation.

Description of the study and its objectives

This study aims to address the various social, environmental and economic challenges and opportunities in managing natural resources in Lebanon with a special focus on tree planting. We have identified over 200 villages with municipal councils that are within ecologically important areas in three regions of Lebanon (North, Mt Lebanon, and South). Of these villages, we have randomly selected 50-60 to serve as a representative sample for Lebanon. We aim to conduct up to 60 interviews with heads of municipalities in the course of this study.

We have prepared a set of basic questions about your municipality and community, along with some technical questions regarding trees, property, and management methods. With your permission, my fieldwork assistant will be conducting a one-hour audio-recorded interview with you. Once the interview is finished, the recordings will be immediately transcribed and translated by him in order for the Investigators to analyze the data. The recordings will be coded to conceal identities and maintain confidentiality. Once the audio files have been transcribed and translated, they will be permanently deleted. Only the Thesis Student, fieldwork assistant, Principal Investigator and co-investigators will have access to the data. We will be happy to provide you with the results once the study has been completed.

What is the benefit of participating in this study?

There are a number of direct and indirect benefits we expect that will emerge from this study. Information on the cost-effectiveness of tree planting and natural resource management will be provided to the participants of the study and made available to researchers and practitioners. We also hope that the findings will enable us to develop new strategies for managing natural resources and improve the environment for future generations.

What risks or discomfort might be experienced through participation in this study?

Your participation in this study will not involve any risks beyond those you face on a daily basis.

What are my rights?

You are entitled to taking enough time to decide whether or not you wish to participate in this study. Your participation is completely voluntary, you may discontinue participation at any time, and your refusal to participate will not reflect negatively on you in any way. If you choose to discontinue participating in the study at any point, any information obtained up to that point will be deleted in your presence. You have the right to skip answering any question during the interview just by saying “skip.” A copy of this consent document will be provided to you for your records. Please feel free to ask me any questions you may have regarding this study.

Please indicate whether or not you are willing to participate in future research activities and give permission for us to contact you: [Yes] / [No]

Statement by investigator:

I have explained to the participant the study in detail including the proceedings and any disadvantages. I have answered all questions clearly to the best of my abilities.

______________________________ _________________________

Name of researcher/representative Signature of researcher or representative

______________________________ _________________________

Date

Consent of participant

I have read this letter of consent and understood its content. All my questions have been answered. Accordingly, I hereby agree to participate in this study, and I understand that the Principal Investigator and co-investigators mentioned above will stand ready to answer my questions, and that I may contact the Principal Investigator at 01-350000 ext: 4508. If my questions have not been answered, I can contact the University's Institutional Review Board to discuss my rights on 01-350000 ext: 5445. I understand fully that I am free to withdraw from this study at any time and this will not affect me in any manner.

I, the undersigned, agree to participate in the study:

______________________________ _________________________

Name of participant Signature of participant/ representative

______________________________ ____________________

Date

Appendix 3.1

Call to Participate in Research Study

American University of Beirut – Lebanon

Bangor University, Wales – United Kingdom

We would like to invite you to participate in survey for a doctoral thesis project. The main objective of this thesis project is to determine what incentives would encourage land managers to plant a diverse array of native trees and shrubs on their property. Our aim is to assess the risks and benefits of planting and conserving native species on both public and private lands.

Research Objective

Exploring incentives for natural resource management and alternative land-use strategies in Lebanon

Who is eligible?

Landowners with at least 1,000 m^2 of unbuilt property who are sole decision-makers of their holdings

What your participation will entail?

A maximum 1-hour anonymous survey that will entail

- Open- & closed-ended questions on basic land management, such as types of crops being grown
- Discussing the potential of different reforestation schemes on private lands as one land-use option

Contact Information of Researchers:

- Mr Arbi Sarkissian (doctoral student): 03/ 024 967
    - Email: arbi.sarkissian27@gmail.com
- Mr Edward Antoun (fieldwork assistant): 71/ 203 803
    - Email: edantoun@gmail.com

Appendix 3.2. List of native trees and shrubs obtained from the AUB-NCC database

Native Trees of Lebanon - AUB-NCC Species Database

Scientific Name	Family	English Common Name	Arabic Common Name	Elevation (range)	Height (aver)	Habitat
Abies cilicica (Antoine & Kotschy) Carrière	Pinaceae	Cilician fir	تنوب تركي	1500-1800	30-40m	Dry
Acer hermoneum (Bornm.) Schwer.	Aceraceae	Mt. Hermon maple	قيقب حرمون	1000-1500	< 3m	Dry
Acer hyrcanum Fischer & C.A. Meyer ssp. *tauricola* (Boiss. & Balansa)	Aceraceae	Taurus maple	قيقب طروسي	1500-1800	5-10m	Dry
Acer monspessulanum L. ssp. *microphyllum* (Boiss.) Bornm	Aceraceae	Montpellier maple	قيقب كوردي	1000-1500	10-15m	Dry
Acer obtusifolium Sibth. & Sm.	Aceraceae	Syrian Maple	قيقب سوري	0-1000	5-10m	Dry
Alnus orientalis Decne.	Betulaceae	Oriental alder	نغت	0-1200	5-10m	Wet
Arbutus andrachne L.	Ericaceae	Strawberry tree	القطلب	500-1200	5-10m	Dry
Cedrus libani Rich.	Pinaceae	Lebanese Cedar	أرز لبنان	1200-2000	30-40m	Dry
Celtis australis L.	Ulmaceae	Mediterranean hackberry	ميس	0-1000	20-25m	Dry
Ceratonia siliqua L.	Leguminosae	Carob	الخرنوب	0-800	5-10m	Both
Cercis siliquastrum L.	Leguminosae	Redbud/Judas tree	زمزريق سرسس	0-1200	5-10m	Both
Crataegus azarolus L. (yellow)	Rosaceae	Mediterranean azarole	الزعرور الأصفر	500-1500	5-10m	Dry
Crataegus monogyna Jacq. (red)	Rosaceae	Whitethorn	زعرور أحمر	500-1500	5-15m	Dry
Cupressus sempervirens L. ‡	Cupressaceae	Mediterranean Cyprus	السرو العمودي	0-1500	25-35m	Dry
Ficus carica L.	Moraceae	Common fig	تين	0-1500	< 5m	Dry
Fraxinus angustifolia (Vahl.) ssp. *syriaca* (Boiss.) Yalt.	Oleaceae	Syrian ash	الدردار القوقازي	0-1500	20-30m	Wet
Fraxinus excelsior L.	Oleaceae	European ash	الدردار الباسق	500-1200	25-35m	Dry
Fraxinus ornus L.	Oleaceae	Manna ash	الدردار المزهر	1000-1200	15-25m	Both
Juniperus drupacea (Labill.)	Cupressaceae	Drupe-bearing arceuthos	العرر السوري	1200-1800	10-20m	Dry
Juniperus excelsa M. Bieb.	Cupressaceae	Greek juniper	لزّاب	1000-2200	10-20m	Dry
Juniperus foetidissima Willd.	Cupressaceae	Fetid juniper	العرعر كريه الرائحة	1200-2200	15-25m	Dry
Juniperus oxycedrus L.	Cupressaceae	Prickly juniper	عرعر	500-1800	10-15m	Dry
Laurus nobilis L.	Lauraceae	Bay Laurel	غار	0-1200	10-15m	Wet
Malus trilobata (Poir.) C.K. Schneid.	Rosaceae	Three-lobed apple	تفاح بري	1200-1500	10-15m	Dry
Myrtus communis L.	Myrtaceae	Myrtle	حب الآس أو الريحان	0-1000	< 1m	Both
Ostrya carpinifolia Scop.	Corylaceae	Hop-hornbeam	مرّان	1200-1800	15-25	Dry
Phillyrea latifolia L. var. *media* (L.) C. K. Schneid.	Oleaceae	Phillyrea	زرود	0-800	5-10m	Dry
Pinus brutia Ten.	Pinaceae	Calabrian pine	صنوبر تركي	500-1800	20-35m	Dry
Pinus halepensis Mill.	Pinaceae	Allepo pine	صنوبر حلبي	0-500	10-15m	Dry
Pinus pinea L.	Pinaceae	Stonepine	صنوبر مثمر	0-1200	15-25m	Dry
Pistacia atlantica Boiss. ‡	Anacardiaceae	Betoum	بطم اطلسي	1200-1800	5-10m	Dry
Pistacia lentiscus L.	Anacardiaceae	Mastic	بطم	0-500	< 3m	Dry
Pistacia terebinthus L.	Anacardiaceae	Terebinth	بطم فلسطيني	0-1200	5-10m	Dry
Pistacia terebinthus L. ssp. *palaestina* (Boiss.) Engler	Anacardiaceae	Palestine pistachio	بطم العلكي	0-1200	5-10m	Dry
Platanus orientalis L.	Platanaceae	Oriental plane	دلب	0-1500	20-30m	Both
Populus bolleana Lauche	Salicaceae	White poplar	حور أبيض	1000-1500	20-30m	Both
Prunus arabica (Olivier) Meikle ‡	Rosaceae	Plum-like Spanish broom	لوز شبي الوزال	500-1200	< 3m	Dry
Prunus argentea (Lam.) Rehder ‡	Rosaceae	Oriental almond	لوز شرقي	1200-1500	< 3m	Dry
Prunus cocomilia Ten. ‡	Rosaceae	Bear Plum	برقوق	1000-1500	5-10m	Dry
Prunus dulcis (Mill.) D.A. Webb.	Rosaceae	Common almond	لوز مر	500-1500	5-10m	Dry
Prunus korshinskyi (Hand.-Mazz.) Bornm.	Rosaceae	Korschinsky's almond	لوز كرشنسكي	1000-1200	< 3m	Dry
Prunus mahaleb L.	Rosaceae	Mahaleb cherry	محلب	1500-1800	< 3m	Dry
Prunus microcarpa C.A. Meyer ‡	Rosaceae	Small-fruited cherry	كرز صغير الثمار	500-1500	< 3m	Dry
Prunus prostrata Labill.	Rosaceae	Wild cherry	خوخ مستلقي	1500-1800	< 1m	Dry
Prunus tortuosa (Boiss & Hausskn.) Aitch. & Hemsl. ‡	Rosaceae	Tortuous cherry	كرز متعرج	500-1500	< 3m	Dry
Pyrus syriaca Boiss.	Rosaceae	Syrian Pear	إجاص سوري	1000-1500	5-10m	Dry
Quercus brantii subsp *look* (Kotschy) Mouterde ‡	Fagaceae	Mt. Tabor oak	بلوط إيراني	1200-1800	5-10m	Dry
Quercus cedrorum Kotschy ‡	Fagaceae	Cedar oak	بلوط الأرز	1500-2000	10-15m	Dry
Quercus cerris L. ‡	Fagaceae	Turkey oak	العذر أو البلوط الشعري	500-1800	25-35m	Dry
Quercus coccifera L.‡	Fagaceae	Kermes oak	سنديان	0-1200	5-25m	Dry
Quercus infectoria Olivier	Fagaceae	Cyprus or Aleppo oak	مللول أو بلوط العفصى	0-1500	5-10m	Dry
Quercus ithaburensis Decaisne	Fagaceae	Tabor oak	بلوط طابور	1000-1500	10-15m	Dry
Quercus libani G.Olivier	Fagaceae	Mount Lebanon oak	بلوط لبناني	1000-1500	10-20m	Dry
Quercus pinnatifida C.C.Gmelin ‡	Fagaceae	Downy/Pubescent oak	بلوط ريشي	1200-1800	< 5m	Dry
Rhus coriaria L.	Anacardiaceae	Tanner's sumach	سماق	0-1500	< 3m	Dry
Salix libani Bornm.	Salicaceae	Lebanese willow	صفصاف لبناني	0-1000	< 3m	Wet
Sorbus flabellifolia (Spach) Schneider	Rosaceae	Fan-leaved service tree	غبيرة مروحية الورق	1200-1800	< 5m	Dry
Sorbus torminalis (L.) Crantz.	Rosaceae	Wild service tree	غبيرة	1200-1800	5-10m	Dry
Styrax officinalis L.	Styracaceae	Storax	لبان أو حوز	0-1500	< 5m	Dry

‡ Contains basionym(s)
Note: coastal and lowland species (< 500 m) are not included in this list

Other species mentioned in references (e.g. basionyms)
Cupressus sempervirens var horizontalis
Pistacia mutica Fisch. & Mey.
Prunus spartioides (Spach.) Shneid.
Amygdalus orientalis Mill.
Prunus ursina Ky.
Prunus microcarpa C.A.Meyer subsp. Tortuosa
Prunus microcarpa C.A. Meyer
Quercus ithaburensis Decaisne
Quercus petraea subsp pinnatiloba (K.Koch) Menitsky
Quercus pseudocerris Boiss.
Quercus coccifera subsp calliprinos (Webb.) Menitsky or Holmboe
Quercus pubescens subsp crispata (Steven) Greuter & Burdet

Appendix 3.3

PES Survey – General understandings of respondents' current or previous experience with tree planting

<u>Section 1</u>

Preamble 1

We are conducting a study on tree planting efforts in Lebanon. In this phase of our study, we are conducting land-use surveys to know more about tree planting taking place on private lands.

1) Have you done any tree planting (of any kind) on your property? [Y]/[N] – (If no, jump to Q7) – if yes, then:
   a) When did you last plant trees (EA to write year & season): ___________/____________
   b) Where have you planted these trees (EA to tick below and note the exact plot referred if there are many):____
      i) ☐ In cultivated farmlands, e.g. terraced orchards (fruit, olive, stone pine)
         (1) ☐ Intermixed with crops
         (2) ☐ Along borders/margins
         (3) ☐ As woodlots (small batches)
      ii) ☐ In previously abandoned farmlands
      iii) ☐ In range/scrublands, e.g. *jurd* or rocky slopes/outcrops
      iv) ☐ In forests or woodlands, e.g. recently burned
      v) ☐ Along roadsides
      vi) ☐ Near residence
      vii) Other:____
   c) What kinds of trees did you plant, their approximate numbers, and approximate coverage (such as % of area) – see plot map in appendix:

Table of tree species – trees planted				
Q1c	Species		Numbers	Coverage (%)
Fruit	1	Apple		
	2	Citrus		
	3	Stone fruits		
	4	Avocado		
	5	Pomegranate		
	6	Other:		
Nut	7	Stone pine		
	8	Walnut		
	9	Almond		
	10	Chestnut		
	11	Other:		
Oil/fruit	12	Olive		
Forest	13	Cedar		
	14	Cypress		
	15	Poplar		
	16	Oak		
	17	Fir		
	18	Melia		
	19	Eucalyptus		
	20	Other:		

2) Did you face any problems with the planting or management of the trees? [Y]/[N] – if yes, please explain (EA to tick any that apply):
   a) ☐ Difficulty in planting, e.g. rocky soils
   b) ☐ Difficulty in getting seedlings
   c) ☐ Difficulty in watering
   d) ☐ Poor survival due to pests, drought, poor seedlings, etc.
   e) Other:____

3) Would you say that your efforts were successful? [Y]/[N] – Please explain (EA to tick any that apply and add details)
   a) ☐ High survival (%): ____________________________________
   b) ☐ High yield (e.g. fruit/nuts):________________________________
   c) ☐ High growth rate: _____________________________________
   d) Other:____

4) Why did you plant these trees?
   a) ☐ Market the products, i.e. income
   b) ☐ Self-consumption, including wood products
   c) ☐ Erosion control
   d) ☐ Windbreak

e) ☐ Landscape beauty
f) ☐ Healthy environment, e.g. clean air
g) ☐ Likes to plant trees
h) Other:____

5) Did you get support or services from somewhere to help you plant these trees, either organizations or individuals? [Y]/[N] – if so, please provide details:
   a) ☐ Agricultural coop:____
   b) ☐ MOA:____
   c) ☐ NGOs:____
   d) ☐ Agricultural expert:_______________________________________
   e) ☐ Municipality
   f) ☐ Family members
   g) ☐ Community
   h) Other:____

6) Do you have plans to do any more of this or any other kind of tree planting? [Y]/[N]/[Not sure] – (if no, jump to Q7) – if yes, then:
   a) Where would you plant more trees?
      i) ☐ In cultivated farmlands, e.g. terraced orchards (fruit, olive, stone pine)
         (1) ☐ Intermixed with crops
         (2) ☐ Along borders/margins
         (3) ☐ As woodlots (small batches)
      ii) ☐ In previously abandoned farmlands
      iii) ☐ In range/scrublands, e.g. *jurd* or rocky slopes/outcrops
      iv) ☐ In forests or woodlands, e.g. recently burned
      v) ☐ Along roadsides
      vi) ☐ Near residence
      vii) Other:____
   b) What kinds of trees would you like to plant, how many of each and how much coverage [refer to map of original planting to determine which plot(s)]:

Table of tree species – trees to be planted				
Q6b	Species		Numbers	Coverage (%)
Fruit	1	Apple		
	2	Citrus		
	3	Stone fruits		
	4	Avocado		
	5	Pomegranate		
	6	Other:		
Nut	7	Stone pine		
	8	Walnut		
	9	Almond		
	10	Chestnut		
	11	Other:		
Oil/fruit	12	Olive		
Forest	13	Cedar		
	14	Cypress		
	15	Poplar		
	16	Oak		
	17	Fir		
	18	Melia		
	19	Eucalyptus		
	20	Other:		

d) How are you planning on doing this: ____
   i) ☐ Myself / on my own cost (time/labour)
   ii) ☐ Hiring someone
   iii) ☐ Help from 3rd party (e.g. NGO, MOA, etc.)
      (1) Details:____
   iv) Other:____

7) If you don’t plan on planting trees either now or in the future, what is the reason for this:
   a) ☐ Lack of know-how
   b) ☐ Lack of interest
   c) ☐ Cost/effort – inputs, labour, etc. (i.e. direct costs)
   d) ☐ Age (too old to take care of land; no interest from children/family members)
   e) ☐ Availability of suitable land
   f) ☐ Prefer to use the land for other uses (i.e. opportunity costs)
   g) ☐ Availability of seedlings
   h) ☐ Concerns about success/risk of failure
   i) Other:____

Section 2

Preamble 2

We would like to present a set of hypothetical scenarios in which external organisations interested in conserving biodiversity would help landowners willing to plant native trees on their land. Here is a list of species we've identified along with some photos of the trees and shrubs.

Scenario 1:

Let's imagine that you are given seedlings and technical advice free of charge. In addition, you were offered money to cover the costs of planting and managing seedlings in the form of an **interest-free loan**. The loan repayments would be annual over a period of 5 years. However, the repayments would be cancelled if the survival rate is over 80% each year from the initial planting. Hence, survival rates below 80% would reduce the cancellation proportionally and you would pay only for those seedlings which don't survive. Or in other words, if you had 65% survival, your repayment would be 35%.

If the project collapses for some reason, debts would be cancelled. Your role would be to plant and manage the seedlings given to you to ensure survival.

8) Would you be interested in such a scheme? [Y]/[N] – (if no, jump to Q9) – If yes, then:
   a) Where would you plant the seedlings: ____
      i) ☐ In cultivated farmlands, e.g. terraced orchards (fruit, olive, stone pine)
         (1) ☐ Intermixed with crops
         (2) ☐ Along borders/margins
         (3) ☐ As woodlots (small batches)
      ii) ☐ In previously abandoned farmlands
      iii) ☐ In range/scrublands, e.g. *jurd* or rocky slopes/outcrops
      iv) ☐ In forests or woodlands, e.g. recently burned
      v) ☐ Along roadsides
      vi) ☐ Near residence
      vii) Other:____
   b) How much land would you plant? (approx. area):____________units:_____________
   c) What % of this area would you plant (or # of seedlings per 100 m²): ______________
   d) Would this scheme change the existing planting plans you have (if applicable – refer to Sect. 1) [Y]/[N]/[maybe]
      i) Explain:____
   e) What would you see as the main benefits of this scheme?

i) Explain: ______________________________

9) If you wouldn't be interested in such as scheme, please explain why (open-ended and coded):
   a) ☐ Don't trust these kinds of schemes
   b) ☐ Don't like taking on debt
   c) ☐ Age (don't like taking on debt which might be passed onto next generation)
   d) ☐ Other land uses still more attractive (thus indicating would need payments)
   e) ☐ Worried about losing tenure / not being allowed to clear land
   f) ☐ Get better assistance (i.e. free seedlings etc.) from other NGOs or gov't (probe to specify organisation and scheme, what species):
      i) Details:______________________________
   g) ☐ Don't like these species – would prefer others
   h) Other:______________________________

Scenario 2:

Now, let's imagine that you are given seedlings and technical advice free of charge. In addition, you are given money to pay for labour in planting and managing the trees in the form of a **grant or gift**. In other words, you would receive the same assistance as the previous scenario, but it would be free with no repayments from you.

10) Would you be interested in such a scheme? [Y]/[N] – (if no, jump to Q11) – If yes, then:
   a) Where would you plant the seedlings: ______________________________
      i) ☐ In cultivated farmlands, e.g. terraced orchards (fruit, olive, stone pine)
         (1) ☐ Intermixed with crops
         (2) ☐ Along borders/margins
         (3) ☐ As woodlots (small batches)
      ii) ☐ In previously abandoned farmlands
      iii) ☐ In range/scrublands, e.g. *jurd* or rocky slopes/outcrops
      iv) ☐ In forests or woodlands, e.g. recently burned
      v) ☐ Along roadsides
      vi) ☐ Near residence
      vii) Other:______________________________
   b) How much land would you plant? (approx. area):____________units:____________
   c) What % of this area would you plant (or # of seedlings per 100 m²): ____________
   d) Would this scheme change the existing planting plans you have (if applicable – refer to Sect. 1) [Y]/[N]/[maybe]
      i) Explain:______________________________
   e) What would you see as the main benefits of this scheme?

i) Explain: ____

11) If you wouldn't be interested in such as scheme, please explain why (open-ended and coded):
   a) ☐ Don't trust these kinds of schemes
   b) ☐ Don't believe that receiving money for free (w/o conditions) would motivate me
   c) ☐ Age (don't have the physical capacity to take on such responsibilities)
   d) ☐ Other land uses still more attractive (thus indicating would need payments)
   e) ☐ Worried about losing tenure / not being allowed to clear land
   f) ☐ Get better assistance (i.e. free seedlings etc.) from other NGOs or gov't (probe to specify organisation and scheme, what species):
      i) Details: ____
   g) ☐ Don't like these species – would prefer others
   h) Other:____

<u>Scenario 3:</u>

In this scenario, you would be given seedlings and technical assistance for free, money to pay for the full direct costs of planting (but not income foregone), *and* annual payments based on survival rates. You would receive 10,000 LL (or about $7) per seedling planted in the first year, so the more you plant, the more payments you receive. Additional payments (around 5,000 LL per seedling) would be made each year over a period of 5 years that are based on % survival (for example, 65% survival = 65% of the payment), but if it's less than 25%, there is no payment. Annual payment rates are also based on difficulty of terrain being and the number of different native species being planted.

12) Would you be interested in such a scheme? [Y]/[N] – (if no, jump to Q13) – If yes, then:
   a) Where would you plant the seedlings: ______________________________
      i) ☐ In cultivated farmlands, e.g. terraced orchards (fruit, olive, stone pine)
         (1) ☐ Intermixed with crops
         (2) ☐ Along borders/margins
         (3) ☐ As woodlots (small batches)
      ii) ☐ In previously abandoned farmlands
      iii) ☐ In range/scrublands, e.g. *jurd* or rocky slopes/outcrops
      iv) ☐ In forests or woodlands, e.g. recently burned
      v) ☐ Along roadsides
      vi) ☐ Near residence
      vii) Other:____

b) How much land would you plant? (approx. area):____________units:_____________
c) What % of this area would you plant (or # of seedlings per 100 m²): ______________
d) Would this scheme change the existing planting plans you have (if applicable – refer to Sect. 1) [Y]/[N]/[maybe]
   i) Explain:____
e) What would you see as the main benefits of this scheme?
   i) Explain: ____

13) If you wouldn't be interested in such as scheme, please explain why (open-ended and coded):
a) ☐ Don't trust these kinds of schemes / not interested
b) ☐ Don't like taking on debt / these kinds of responsibilities
c) ☐ Age (don't like taking on debt which might be passed onto next generation)
d) ☐ Other land uses still more attractive (thus indicating would need payments)
e) ☐ Worried about losing tenure / not being allowed to clear land
f) ☐ Get better assistance (i.e. free seedlings, etc.) from other NGOs or gov't (probe to specify organisation and scheme, what species):
   i) Details:____
g) ☐ Don't like these species – would prefer others
h) Other:____

Section 3

Preamble 3

We understand that circumstances change and that you might want to do other things with the plot of land that you planted (assuming they expressed interest in a least one scenario?). Regarding this:

14) What are some of the possible land-use changes you would foresee in the future on these specific plots of land that you might consider planting native trees on:
a) ☐ Building
b) ☐ Changing crops
c) ☐ Stopping cultivation
d) ☐ Raising livestock
e) ☐ Passing land onto children / family members
f) ☐ Tourism
g) ☐ Selling the land
h) Other:____

15) In the long run (following the project), what factors would determine whether you would maintain the trees on the land once they were planted (open ended question, coded by interviewer)?
   a) ☐ Land prices for development, e.g. value of land increasing
   b) ☐ Agricultural product prices – i.e. competing land uses
   c) ☐ Biodiversity – intrinsic value motivations
   d) ☐ Environmental benefits – e.g. erosion control, windbreaks, etc.
   e) ☐ Amenity/aesthetic benefits – increase landscape beauty
   f) ☐ Passing on land to descendants
   g) ☐ Other decision makers (family members, etc.)
   h) ☐ Whether the NGO (other any other 3rd party) maintained its interest
   i) ☐ Opinion of neighbours, community, etc.
   j) Other:____

If yes to one or more of the options above:

16) What other incentives would encourage you to plant more of your land with forest trees?
   a) ☐ Financial support, e.g. longer term payments
   b) ☐ Technical support, e.g. consulting
   c) ☐ Market support, e.g. access to market
   d) ☐ Help with infrastructure, e.g. roads, irrigation, etc.
   e) Other:____

17) Would you be interested in longer term agreements, to receive payments say every 5 years conditional on survival [Y]/[N]
   a) Explain:____

18) In your opinion, how do you think planting of forest trees on private land should be encouraged by organisations interested in native biodiversity?
   a) Explain:____

<u>Section 4</u> (socioeconomic details)

19) Participant ID # (internal): ________________
20) Year of birth: ________________________
21) Sex: [M] / [F]
22) Married: [Y] / [N] – Other (optional, only if mentioned):__________________
23) Number of household members: _________________
24) Amount of time spent in village (near plot of land being surveyed/studied):
   a) Permanent/year round [ ]
   b) Weekends and holidays only [ ]
   c) Summer only [ ]
   d) Rarely – non-resident [ ]
25) Residency details (near plot of land being surveyed/studied):

a) Family house, i.e. reside with parents, siblings, in-laws, etc. [ ]
b) Own residence [ ]
c) Rental [ ]

26) How much non-residential land do you own? (approx. m²):________________________
   a) Is this property contiguous? [Y]/[N]

27) Occupation:
   a) Full-time farmer [ ]
   b) Part-time farmer, e.g. hobby [ ]
   c) Subsistence [ ]
   d) Employee (private sector) [ ]
   e) Employee (public sector) [ ]
   f) Self-employed/entrepreneur; freelancer [ ]
      i) Details: ____

28) Education (highest level):
   a) Primary/école primaire [ ]
   b) Secondary/lycée [ ]
   c) Baccalaureate [ ]
   d) Technical school [ ]
   e) University [ ]

Appendix 4.1

Dear Ms/Mr/Dr …,

I hope this email finds you in good health.

I am conducting my PhD thesis on **reforestation with native species in Lebanon** and would like to ask if you could take a few minutes to complete a very short survey of 4 questions.

The aim is to get your opinion on **which native tree species you consider to be the highest conservation priority for planting in villages within the eastern part of Bcharre and Batroun districts**. This area is between 1000-1500m in altitude and averages between 1000-1200 mm/yr. precipitation.

I have compiled a preliminary list of 22 suitable native species. I would be grateful for your own opinion on their ecological suitability and conservation importance. **This survey aims to understand which species conservationists would most like to see included in reforestation efforts.**

The survey is completely voluntary and anonymous – **no personal information will be collected**. Data will be used for my thesis and I will be happy to share the results with you once the study is completed.

Please click on this link for the survey (it should take **less than 10 minutes of your time**):

LimeSurvey

Please don’t hesitate to contact me if you have any questions or would like more details about my research project.

Thank you,

حضرة السيد ....السيدة................

تحية وبعد

على أمل أن تصلكم هذه الرسالة وأنتم بصحة جيدة

إنني بصدد إعداد أطروحة الدكتوراه عن إعادة التحريج في لبنان بواسطة الأشجار الموطنية. لذا أود أخذ القليل من وقتكم لملئ هذه الإستمارة عبر البريد الإلكتروني بهدف معرفة أي نوع من الأشجار الحرجية برأيكم يعتبر ذا أولوية للمحافظة عليه وزرعه في البلدات شرق قضائي بشري والبترون. تقع هذه المنطقة على إرتفاع 1000 الى 1500 متر من سطح البحر، ويقدر فيها المعدل الإجمالي لهطول الأمطار سنوياً ما بين ال 1000 و 1200 م.م.

لقد جمعت لائحة أولية من 22 نوع من الأشجار الحرجية.

أود معرفة رأيكم عن مدى الملاءمة البيئية لهذه الأصناف وأهمية المحافظة عليها.

تهدف هذه الدراسة إلى معرفة رأي الناشطين في مجال البيئة حول الأصناف التي يجب إدراجها على هذه الائحة.

إن هذه الإستمارة طوعية بالكامل وسرية- حيث أن لا حاجة لإدراج أسماء المشاركين أو أي معلومات شخصية فيها.

سوف تستخدم المعلومات في إعداد رسالة الدكتوراه، وسوف نكون سعداء لتبادل النتائج معكم بمجرد الإنتهاء من الدراسة.

لن تأخذ تعبئة الإستمارة أكثر من 10 دقائق من وقتكم

لملئ الإستمارة، الرجاء الدخول الى الموقع

LimeSurvey

لمزيد من المعلومات عن موضوع الدراسة او للأستفسار أكثر الرجاء مراجعتي

شكراً

Appendix 4.2

1. Please rate each of the following species as high, medium, or low conservation priorities for inclusion in reforestation of this site (between Bcharre and Tannourine). If you would not consider the species as being suitable for this area, despite its overall importance, please tick 'Ecologically Unsuitable' (E.U.). If you know the species but are unsure of its suitability in these sites, please tick 'not sure'.

	High	Med	Low	E.U.	Not Sure
Abies cilicica (Antoine & Kotschy) Carrière - Cilician fir - شوح					
Acer hyrcanum ssp. *tauricola* (Boiss. & Balansa) Yalt. - Taurus maple - قيقب طروسي					
Acer monspessulanum ssp *microphyllum* (Boiss.) Bornm. - Montpellier maple - قيقب كوردي					
Alnus orientalis Decaisne - Oriental alder - نغت					
Cedrus libani Rich. - Cedar of Lebanon - أرز لبنان					
Celtis australis L. - Mediterranean hackberry - ميس					
Crataegus monogyna Jacq. – Single-seeded hawthorn - زعرور أحمر					
Cupressus sempervirens L. [*C. sempervirens* var. *horizontalis*] - Mediterranean cypress - السرو العمودي					
Fraxinus angustifolia ssp. *syriaca* (Boiss.) Yalt. - Syrian ash - الدردار القوقازي					
Fraxinus ornus L. - Manna ash - الدردار المزهر					
Juniperus excelsa M. Bieb. - Greek juniper - لزّاب					
Ostrya carpinifolia Scop. - Hop-hornbeam - مرّان					
Pinus brutia Ten. - Calabrian pine - صنوبر تركي					
Pinus pinea L. - Stone pine - صنوبر مثمر					
Prunus cocomilia Ten. - Bear plum - برقروق					
Prunus dulcis (Mill.) D.A. Webb. - Common almond - لوز					
Pyrus syriaca Boiss. - Syrian pear - إجاص سوري					
Quercus brantii ssp. look (Kotschy) Mouterde [syn: *Q. ithaburensis* Decne.] - Mt. Tabor oak - بلوط إيراني					
Quercus cerris L. [syn: *Q. pseudocerris* Boiss.] - Turkey oak - العزرأو البلوط الشعري					

	High	Med	Low	E.U.	Not Sure
Quercus infectoria Olivier - Cyprus or Aleppo oak - العفص أو الملول	○	○	○	○	○
Sorbus flabellifolia (Spach.) Schneider - Fan-leaved service tree - غبيرة مروحية الورق	○	○	○	○	○
Sorbus torminalis (L.) Crantz. - Wild service tree - غبيرة	○	○	○	○	○

2. Please indicate if there are any other species you would consider to be suitable for these sites AND a high conservation priority for reforestation

1.
2.
3.
4.
5.

3. Please indicate which category best describes your occupation (whether active or retired)

○ Academia - scientist, researcher, lecturer (University and/or research center)

○ Environmental policy - biodiversity conservation, forest management and planning

○ Private sector - NGO, consultancy, business

○ Other (please specify)

4. How would you best describe your professional focus?

● Biodiversity conservation

○ Forestry

○ Agriculture

Other (please specify)

Appendix 5.1

PES II Survey – mixed-methods choice experiment

Section 1 – LULC characteristics

Preamble 1

In this part of our survey, we would like to ask you a few questions about current land-uses and tree planting.

1) Do you own at least 1 hectare of land? ☐ Yes ☐ No

2) How many plots do you own and how would you characterize the land cover and land-use of each plot? [Interviewers will use sketchbook with participants to ID plots]

Q2. Current land cover				
Plot #	Land-cover code	Land-use code	Years past*	Area (approx.) in *dunums*
1				
2				
3				
4				
5				
6				
7				
8				

*Planted or abandoned since

Land-cover code	Land-use code
1. Fruit trees & nut trees	1. Abandoned
2. Vegetables or forage crops (no trees)	2. Commercial farming
3. Natural forest / shrubland (*garrigue*)	3. Personal consumption farming
4. Rangeland (little vegetation, rocky)	4. Recreational (hunting, fishing...)
5. Other	5. Other (quarry, ecotourism...)

3) About the abandoned plots you mentioned [gesture to plots on map] could you tell us about any wild trees or shrubs that are growing on them? [Prompt to include abandoned lands identified as rangeland or other, as well as land cover codes 2&3]

a) ☐ Yes – please specify kinds: ____
b) ☐ No
c) ☐ Not sure

4) Do you plan on planting any (more) trees on your property?
a) ☐ No, don't intend to plant any trees (jump to Q. 5)
b) ☐ Yes, what kinds [Coded by interviewer], estimated area and which plot?

Q4. Forest/fruit trees to be planted		
Plot #	Enter species code	Est. Planting area

1. Fruit & nut trees (incl. walnut, chestnut, olives & grapes)

2. Stone Pine

3. Non-productive trees (aesthetic, recreational, landscape, etc.)

4.Other: ____

5) If you don't plan on planting trees in the future, could you elaborate on the reasons why not? [Open-ended question, coded by interviewer, keep prompting until no further response is given]
a) ☐ Lack of know-how
b) ☐ Lack of interest
c) ☐ Cost/effort – inputs, labour, etc. (planting and maintenance costs)
d) ☐ Age (too old to take care of land; no interest from children/family members)
e) ☐ Availability of suitable land
f) ☐ Plans to sell land
g) ☐ Prefer other land uses (i.e. opportunity costs)
h) ☐ Availability of seedlings
i) ☐ Concerns about success/risk of failure
j) ☐ Other:____

6) Do you rent or lease any of these plots **from** other people?

a) ☐ No
b) ☐ Yes (plot #’s) ________________________

7) Are you renting or leasing out any of your plots **to** other people (e.g. farmers, herders, quarrying, etc.)?
a) ☐ No
☐ Yes

Plot # _____ to (type) _____________________

Plot # _____ to (type) _____________________

8) Are you the sole decision-maker with respect to these plots of land? [Y] / [N] – if not, with whom do you share this responsibility?
a) ☐ Spouse
b) ☐ Parents
c) ☐ Children
d) ☐ Siblings
e) ☐ Other family members (e.g. uncle, cousins, etc.)
f) ☐ Owner of the land, if rented
g) ☐ User of the land, if rented out
h) ☐ Other: ____

9) What is your main water source for cultivation (if applicable)?
a) ☐ Private spring plot #’s: ______________________
b) ☐ Drilled well / reservoir plot #’s: ______________________
c) ☐ Municipal plot #’s: ______________________
d) ☐ Other:____

10) Have you received any technical or financial support or services (including seeds/seedlings, fertilizers, etc.) either from organizations or individuals?
a) ☐ None
b) ☐ Agricultural coop:____
c) ☐ MOA – Green Plan , or: ____
d) ☐ NGO or association:____
e) ☐ Agricultural expert/consultant
f) ☐ Municipality (e.g. building roads)
g) ☐ Family members
h) ☐ Community members
i) ☐ Other:____

Section 2 – hypothetical reforestation programme

Preamble 2

PES reforestation schemes (options) – Attribute 1

We would like to present you with a hypothetical reforestation programme. Imagine that an organisation, e.g. a non-governmental organisation, interested in reforestation is offering payments to landowners for planting native trees.

There are three reforestation options in this hypothetical program to choose from. We would like to know which one you would be interested in (if any). You also have the option (Choice D) to refuse any of the reforestation options presented. Below are the options for planting a minimum of 1 *dunum* (dn) of your property: [Interviewers present three A4 reforestation options here]

We would now like to find out what kinds of payment arrangements landowners would be willing to accept to plant native trees on their property. In this programme you would receive seedlings and technical assistance free of charge, a standard payment for planting a minimum of 1 dn of land, followed by three instalment payments over a ten year period. [Interviewers present A4 diagram below to participants illustrating the hypothetical reforestation programme]

The programme would consist of 5 trips in total. As mentioned, seedlings will be provided on the first trip along with technical assistance (both free of charge) that includes an assessment of the property where the planting would take place, techniques on planting, irrigation and care. This would be followed by 4 monitoring trips to assess the planting outcomes in which payments will be made based on percentage of seedling survival, hence you will receive payments based on that percentage, e.g. 100% survival = full payment, 75% survival = 75% of full payment, 10% survival = 10% of payments, etc. Every monitoring session will be assessed from the original baseline when seedlings were first planted. The payments mentioned below are in today's money, and would increase in line with inflation (i.e. the cost of living).

There will be consultants who can be reached by phone if you run into problems or need technical assistance over the course of programme. Note that the seedlings are produced in state-of-the-art nurseries for the purpose of reforestation efforts and require minimal irrigation if planted properly and in the right time of year (Oct-Dec). Also, native species such as the ones provided are naturally adapted to the climate and do not require as much care as most fruit trees do.

There are a total of 5 sets that are random combinations of reforestation options and payment levels. Bear in mind that each choice set is like a new 'programme', so you can choose a different option for each choice set – and for different plots – if you wish. The 4 instalments relate to the payment levels (i.e. performance payments) that are made over the course of 15 years and are conditional upon the survival outcomes mentioned earlier (refer to diagram). <u>Our aim is to determine which of the combinations (reforestation scheme and payment level) are most attractive to you through this choice experiment</u>. [Begin choice experiment]

11) If you chose D0 (refuse option) for any of the choice sets, please explain why? [Open-ended question, coded by interviewer, keep prompting until no further response is given; to be used after each choice set if applicable]
   a) ☐ Simply not interested
   b) ☐ Don't trust these kinds of schemes / unfamiliar
   c) ☐ Don't like taking on these kinds of responsibilities / too risky
   d) ☐ Don't have enough land
   e) ☐ Age (don't like taking on debt which might be passed onto next generation)
   f) ☐ Other land uses still more attractive (thus indicating would need more payments)
   g) ☐ Worried about losing tenure / not being allowed to clear land
   h) ☐ Don't like these species – would prefer others,
   e.g.:__________________________________
   i) ☐ Get better assistance (e.g. tech support, etc.)
   from:__________________________________
   j) ☐ Other:____

12) Are there any kinds of forest trees you would consider planting, whether from the list (i.e. Option C) shown or not?
   a) ☐ None
   b) ☐ Type 1:____
   c) ☐ Type 2:____
   d) ☐ Type 3:____

Section 3 – future plans and challenges

Preamble 3

We understand that circumstances change and that you might want to do other things with the plot of land that you planted with trees under the scheme:

13) What are some of the possible land-use changes you would foresee in the future on this specific parcel of land? [Open-ended question, coded by interviewer, keep prompting until no further response is given]
   a) ☐ Building, e.g. house, villa, chalet, etc.
   b) ☐ Growing crops
   c) ☐ Raising livestock
   d) ☐ Passing land onto children / family members that would want to do something else
   e) ☐ Tourism
   f) ☐ Selling the land
   g) ☐ Other:__________________________________

14) After the last monitoring visit in 15 years' time, what factors would determine whether you would maintain the trees on the land once they were planted? [Open ended question, coded by interviewer, keep prompting until no further response is given]
   a) ☐ Land prices for development, e.g. value of land increasing
   b) ☐ Agricultural product prices, i.e. competing land uses / high opportunity costs
   c) ☐ Intrinsic value motivations, e.g. nature-oriented benefits
   d) ☐ Functional environmental benefits, e.g. erosion control, windbreaks, etc.
   e) ☐ Amenity/aesthetic benefits, e.g. increase landscape beauty
   f) ☐ Passing land onto children
   g) ☐ Other decision makers (family members, etc.)
   h) ☐ Continued payments
   i) ☐ Opinion of neighbours, community, etc.
   j) Other:__________________________________

Section 4 – Socioeconomic info of respondents

15) Participant ID #: ____________________
16) Year of birth: ______________________
17) Sex: [M] / [F]
18) Married: [Y] / [N] – Other (optional, only if mentioned):_________________
19) Number of household members: ________________
20) Amount of time spent in village (near parcel of land being surveyed):
    a) ☐ Permanent/year round
    b) ☐ Weekends and holidays (incl. summer and winter) only
    c) ☐ Summers only
    d) ☐ Rarely – non-resident
21) Occupation:
    a) ☐ Full-time farmer (main source of income)
    b) ☐ Part-time farmer, e.g. hobby / self-consumption
    c) ☐ Employee (private sector)
    d) ☐ Employee (public sector)
    e) ☐ Self-employed/entrepreneur
        i) Details: ____

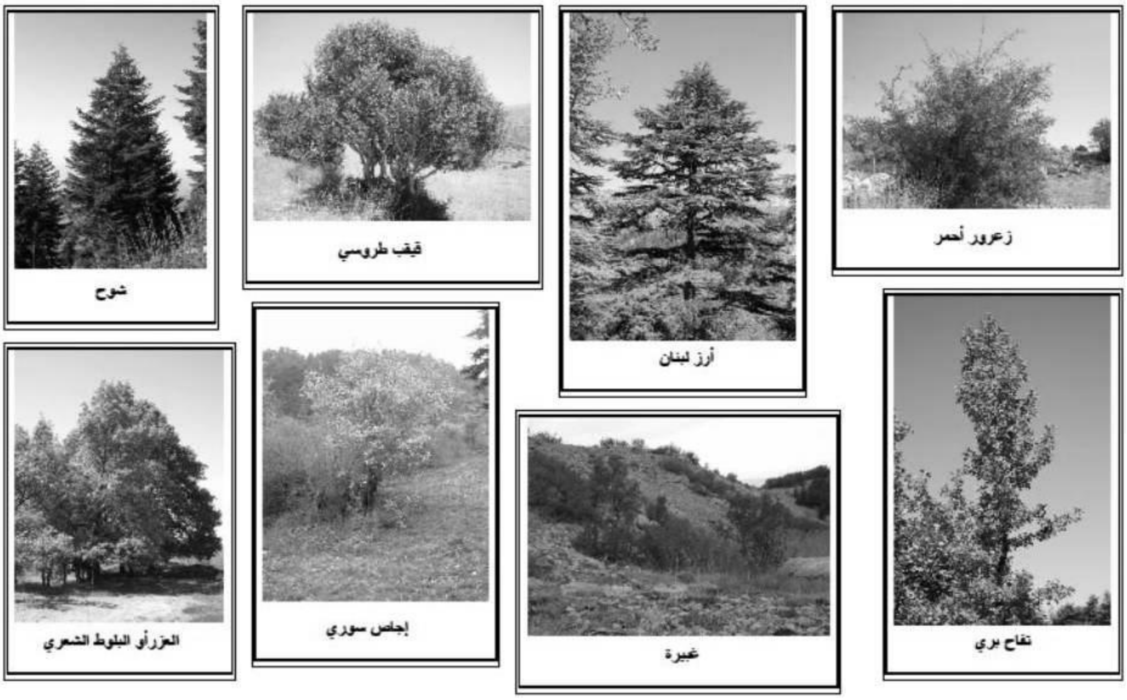
Appendix 5.2

مزرعة صنوبر ثمري – Option A: Stone pine plantation

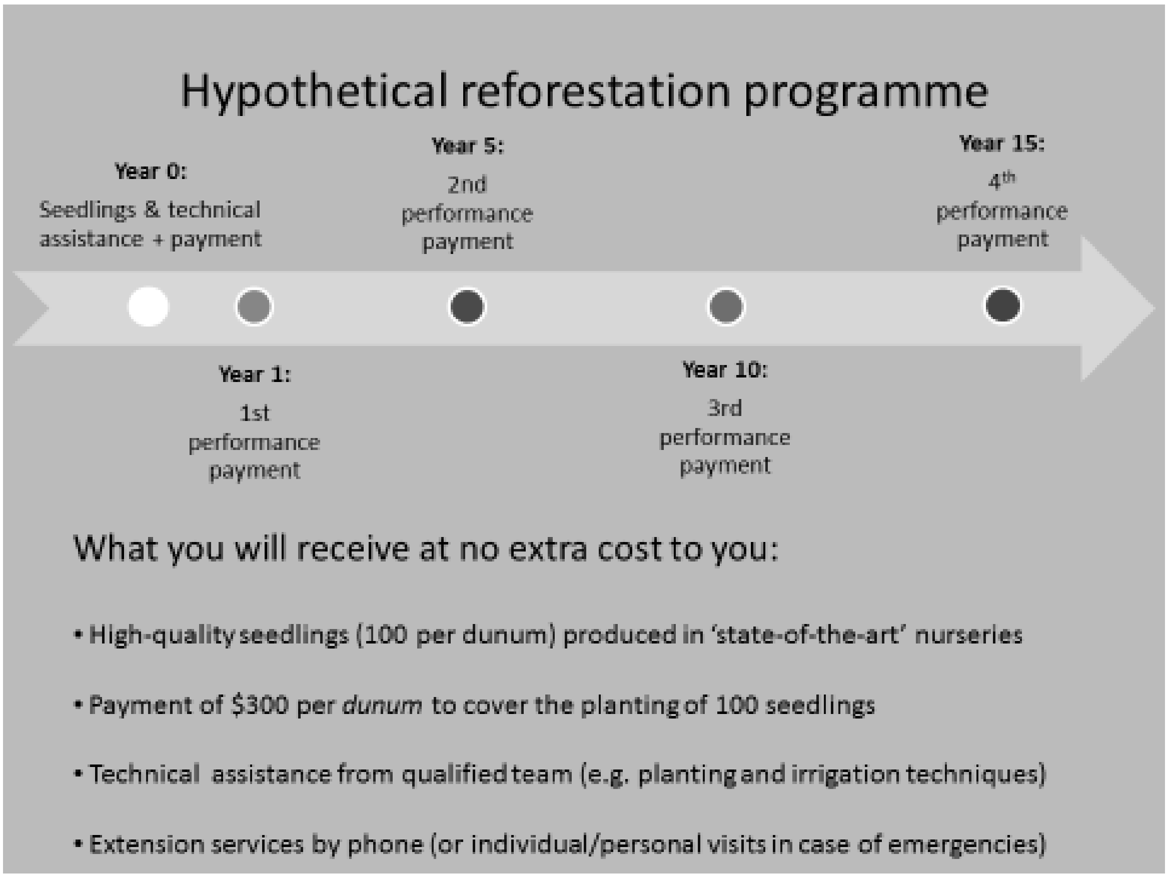
نص - نص صنوبر ثمري وأرز – Option B: Stone pine & cedar

خلطة أصناف أشجار حرجية محلية – Option C: Mixed native species

Appendix 5.3



5.5a: A4 poster of mixed native species (Option C) shown to respondents



5.5b: A4 poster of reforestation programme shown to respondents (*dunum* = 1,000)

Appendix 5.4

Ver #	LO#	Task 1				Plot#	Area	Task 2				Plot#	Area	Task 3				Plot#	Area	Task 4				Plot#	Area	Task 5				Plot#	Area (	T1	T2	T3	T4	T5
1	25	**A3**	C1	B2	D0	1,2	8	C2	B3	**A1**	D0	1,2	8	B3	C1	**A2**	D0	1,2	8	C1	**A3**	B2	D0	1,2	8	**A3**	B1	C2	D0	1,2	8	1	3	3	2	1
2	26	A2	C1	B3	**D0**	0	0	A3	B2	C1	**D0**	0	0	B3	A2	C1	**D0**	0	0	C2	A3	B1	**D0**	0	0	C3	A2	B1	**D0**	0	0	4	4	4	4	4
5	15	C2	B1	A3	**D0**	0	0	C2	B3	A1	**D0**	0	0	C3	B1	A2	**D0**	0	0	B2	A1	C3	**D0**	0	0	C3	A1	B2	**D0**	0	0	4	4	4	4	4
6	24	B1	**A3**	C2	D0	2	7	B3	**A2**	C1	D0	2	7	B1	**A3**	C2	D0	2	7	**A1**	C3	B2	D0	2	7	B2	C3	**A1**	D0	2	7	2	2	2	1	3
7	37	**B3**	C1	A2	D0	4	10	**B3**	C2	A1	D0	3,4	13	A1	B2	**C3**	D0	4	10	A1	C2	**B3**	D0	3,4	13	B1	A2	**C3**	D0	4	10	1	1	3	3	3
8	10	A1	C3	**B2**	D0	3	5	**A3**	C2	B1	D0	3	5	A1	C3	**B2**	D0	3	5	**B3**	C1	A2	D0	3	5	A2	C1	**B3**	D0	3	5	3	1	3	1	3
9	17	**A3**	B1	C2	D0	6	1.2	**B3**	C2	A1	D0	6	1.2	C2	A1	**B3**	D0	6	1.2	B1	**A2**	C3	D0	6	1.2	**A3**	B1	C2	D0	6	1.2	1	1	3	2	1
10	23	C3	B1	**A2**	D0	2	5	C2	A1	**B3**	D0	2	5	**A2**	B1	C3	D0	2	5	C2	B1	**A3**	D0	2	5	**A2**	C3	B1	D0	2	5	3	3	1	3	1
11	22	B2	C1	A3	**D0**	0	0	C1	A3	B2	**D0**	0	0	C3	A1	B2	**D0**	0	0	B3	A1	C2	**D0**	0	0	B1	A2	C3	**D0**	0	0	4	4	4	4	4
13	43	C2	A1	**B3**	D0	1	3	**B3**	A2	C1	D0	1	3	C2	**B3**	A1	D0	1	3	**B3**	A1	C2	D0	1	3	C1	**B3**	A2	D0	1	3	3	1	2	1	2
14	21	B3	C1	A2	**D0**	0	0	A2	B1	C3	**D0**	0	0	A1	B2	C3	**D0**	0	0	B3	A1	C2	**D0**	0	0	B3	A2	C1	**D0**	0	0	4	4	4	4	4
15	27	C2	A1	**B3**	D0	2	1.5	C3	A1	**B2**	D0	1,2	3	B2	**A3**	C1	D0	1,2	3	C3	B1	**A2**	D0	1,2	3	**A3**	C1	B2	D0	1,2	3	3	3	2	3	1
17	32	B1	C2	**A3**	D0	2,3	15	B1	A2	**C3**	D0	3	10	C1	**B3**	A2	D0	2,3	15	C2	B1	**A3**	D0	2,3	15	B1	A2	**C3**	D0	1,3	16	3	3	2	3	3
18	13	A1	**B2**	C3	D0	6	6	B2	C1	**A3**	D0	1,5,6	13.5	C1	**A2**	B3	D0	1,5,6	13.5	B1	C3	**A2**	D0	1,5,6	13.5	**A2**	B1	C3	D0	1,5,6	13.5	2	3	2	3	1
19	31	**A3**	C1	B2	D0	4,5	6	**A2**	B1	C3	D0	4,5	6	**A2**	C1	B3	D0	4,5	6	C2	B1	**A3**	D0	4,5	6	B2	**A3**	C1	D0	4,5	6	1	1	1	3	2
20	28	B3	C1	**A2**	D0	2	2.4	C1	**A3**	B2	D0	2	2.4	C3	**A1**	B2	D0	2	2.4	**A3**	C1	B2	D0	2	2.4	C3	B1	**A2**	D0	2	2.4	3	2	2	1	3
21	9	**A2**	C3	B1	D0	3,5	2	C2	B1	**A3**	D0	3,5	2	A2	**B3**	C1	D0	3,5	2	**A3**	B1	C2	D0	3,5	2	A1	**B3**	C2	D0	3,5	2	1	3	2	1	2
36	36	A1	C3	**B2**	D0	2,4	2.4	C2	**B1**	A3	D0	2,4	2.4	A3	**B2**	C1	D0	2,4	2.4	A1	C3	**B2**	D0	2,4	2.4	**B2**	C1	A3	D0	2,4	2.4	3	2	2	3	1
38	38	A3	C1	B2	**D0**	0	0	C3	A2	B1	**D0**	0	0	B1	A2	C3	**D0**	0	0	A1	C3	B2	**D0**	0	0	C1	B2	A3	**D0**	0	0	4	4	4	4	4
39	39	C1	B2	**A3**	D0	1	1	B3	**A1**	C2	D0	1	1	B1	**A3**	C2	D0	1	1	C3	B1	**A2**	D0	1	1	B1	C2	**A3**	D0	1	1	3	2	2	3	3
40	40	**A2**	C1	B3	D0	5	5	**A3**	B1	C2	D0	5	5	**A3**	B2	C1	D0	5	5	C1	B3	**A2**	D0	5	5	A1	**C3**	B2	D0	1	3	1	1	1	3	2
41	41	B1	C3	**A2**	D0	5	5	**B3**	A1	C2	D0	2,5	8	A1	C3	**B2**	D0	2,5	8	**B3**	A2	C1	D0	2,5	8	C2	**B1**	A3	D0	2,5	8	3	1	3	1	2
42	42	C1	B2	A3	**D0**	0	0	A1	B2	C3	**D0**	0	0	A2	C3	B1	**D0**	0	0	C2	B1	A3	**D0**	0	0	C1	B3	A2	**D0**	0	0	4	4	4	4	4
44	44	B1	C2	**A3**	D0	2	5	C3	B2	**A1**	D0	2	5	**A3**	B2	C1	D0	2	5	**A3**	B2	C1	D0	2	5	**A3**	C1	B2	D0	2	5	3	3	1	1	1
45	45	C1	A2	**B3**	D0	1	1	A2	**B1**	C3	D0	1	1	**B2**	C1	A3	D0	1	1	**B3**	C2	A1	D0	1	1	**B3**	C1	A2	D0	1	1	3	2	1	1	1
46	46	C1	B3	A2	**D0**	0	0	C1	B3	A2	**D0**	0	0	A1	B3	C2	**D0**	0	0	C1	A3	B2	**D0**	0	0	C1	B2	A3	**D0**	0	0	4	4	4	4	4
47	47	C1	**A3**	B2	D0	2	6	B2	A1	**C3**	D0	2	6	C3	B1	**A2**	D0	6	4	B3	C1	**A2**	D0	6	4	**A3**	B1	C2	D0	6	4	2	3	3	3	1
49	49	A1	B2	**C3**	D0	5	5.3	B2	C1	**A3**	D0	6	21	C1	B2	**A3**	D0	6	21	B1	**C3**	A2	D0	1,5	15.3	A1	**B3**	C2	D0	All*	43	3	3	3	2	2
50	50	**A3**	B2	C1	D0	1	2	C3	B1	**A2**	D0	1	2	B2	C1	**A3**	D0	1	2	B1	C2	**A3**	D0	1	2	**A1**	B2	C3	D0	1	2	1	3	3	3	1
51	51	**C2**	B3	A1	D0	5	2	B3	**C2**	A1	D0	5	2	A3	B1	**C2**	D0	5	2	B2	A1	**C3**	D0	5	2	**C1**	A2	B3	D0	5	2	1	2	3	3	1
52	52	A1	**B3**	C2	D0	2	1	**C1**	B3	A2	D0	3	6	A2	B3	**C1**	D0	3	6	**C3**	B2	A1	D0	3	6	A1	**C2**	B3	D0	3	6	2	1	3	1	2
53	53	A1	**B2**	C3	D0	1	3	C1	B2	**A3**	D0	1	3	**A3**	C1	B2	D0	1	3	B1	**A2**	C3	D0	1	3	**A1**	B2	C3	D0	1	3	2	3	1	2	1
54	54	C2	B1	**A3**	D0	3	5	**A2**	C1	B3	D0	3	5	**A1**	B3	C2	D0	3	5	**A1**	B2	C3	D0	3	5	B3	**A2**	C1	D0	3	5	3	1	1	1	2
55	55	B1	A2	C3	**D0**	0	0	A2	C1	B3	**D0**	0	0	B2	A1	C3	**D0**	0	0	B3	C2	A1	**D0**	0	0	A1	C3	B2	**D0**	0	0	4	4	4	4	4

Appendix 5.7: Sample of logging matrix used for responses to choice experiments identify LU/LC and area (in 1,000 m^2)

Appendix 5.5

CBC Design Efficiency Test
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Task generation method is 'Shortcut' using a seed of 1.
Based on 150 version(s).
Includes 750 total choice tasks (5 per version).
Each choice task includes 3 concepts and 2 attributes.

A Priori Estimates of Standard Errors for Attribute Levels

Att	Lev	Freq.	Actual	Ideal	Effic.	
1	1	750	(this level has been deleted)			Stone pine (A)
1	2	750	0.0517	0.0516	0.9995	S.p. / cedar (B)
1	3	750	0.0517	0.0516	0.9989	Mixed species (C)
2	1	750	(this level has been deleted)			\$2,000 ha^{-1} $year^{-1}$
2	2	750	0.0517	0.0516	0.9992	\$6,000 ha^{-1} $year^{-1}$
2	3	750	0.0517	0.0516	0.9988	\$10,000 ha^{-1} $year^{-1}$

Note: The efficiencies reported above for this design assume an equal number of respondents complete each version.

Two-Way Frequencies

Att/Lev	1/1	1/2	1/3	2/1	2/2	2/3
1/1	750	0	0	237	261	252
1/2	0	750	0	247	241	262
1/3	0	0	750	266	248	236
2/1	237	247	266	750	0	0
2/2	261	241	248	0	750	0
2/3	252	262	236	0	0	750

Logit Report with Simulated Data

Main Effects: 1 2
Build includes 150 respondents.

Total number of choices in each response category:

Category	Number	Percent
1	188	25.07%
2	174	23.20%
3	221	29.47%
4	167	22.27%

There are 750 expanded tasks in total, or an average of 5.0 tasks per respondent.

Iter 1 Log-likelihood = -1036.58762 Chi Sq = 6.26630 RLH = 0.25105
Iter 2 Log-likelihood = -1036.47256 Chi Sq = 6.49641 RLH = 0.25109
Iter 3 Log-likelihood = -1036.46792 Chi Sq = 6.50570 RLH = 0.25109
Iter 4 Log-likelihood = -1036.46773 Chi Sq = 6.50607 RLH = 0.25109
Iter 5 Log-likelihood = -1036.46773 Chi Sq = 6.50609 RLH = 0.25109
*Converged

	Effect	Std. Err	t Ratio	Attribute Level
1	0.07244	0.05764	1.25686	1 1 Stone pine (A)
2	-0.06346	0.05965	-1.06385	1 2 S.p. / cedar (B)
3	-0.00898	0.05886	-0.15261	1 3 Mixed species (C)
4	-0.06300	0.05966	-1.05593	2 1 \$2,000 ha^{-1} $year^{-1}$
5	0.06273	0.05776	1.08592	2 2 \$6,000 ha^{-1} $year^{-1}$
6	0.00027	0.05870	0.00465	2 3 \$10,000 ha^{-1} $year^{-1}$
7	-0.14858	0.08782	-1.69191	NONE

The strength of design for this model is 335.30501
(The ratio of strengths of design for two designs reflects the D-Efficiency of one design relative to the other.)