

Chapter 1

What Is Forest Landscape Restoration?

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1.1 Introduction

The extent and distribution of global forests is a matter of considerable concern. The overall rate of deforestation remains high although recent reports suggest it is finally beginning to decline (FAO 2011). But this hides regional differences. In temperate regions net forest cover is increasing because of afforestation and natural expansion of forests. By contrast, net forest cover in most tropical regions continues to decline and few of the remaining forests are being managed on a sustainable basis (Asner et al. 2010; Foley et al. 2005). This means that more and more tropical countries are changing from being exporters of forest products to being importers. Across the globe most deforestation has been carried out to create agricultural lands but a large proportion of these lands have subsequently been abandoned (Ramankuty and Foley 1999).

In upland mainland Southeast Asia, for example, Fox and Vogler (2005) note that as much as 49% of these new agricultural lands are reported to have been subsequently abandoned and become shrub, brush or other forms of secondary forest. At the same time the Millennium Ecosystem Assessment found 60% of the world's

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ecosystem services to have been degraded (MEA 2005). Much deforestation has been unplanned and has generated a series of socio-economic and ecological problems (Chomitz 2007). This is especially true within the tropics. Despite the wealth generated by logging tropical forests many poor people remain living in and around these landscapes and there have been widespread losses of biodiversity and substantial losses of soil.

But a number of changes are now underway that will also affect the extent to which existing forests are protected and the likelihood that any deforested land will be restored. These include a rising demand for food as populations continue to increase and, especially in the humid tropics, development of plantation crops such as palm oil (Gerber 2011). Both will place pressure in existing forests and on the availability of land for reforestation and afforestation. Countervailing forces are apparent in the increasing level of concern in many communities about environmental issues which makes forest restoration more attractive and a general drift of rural people to urban areas which, in some areas at least is allowing forests to regrow.

But perhaps the greatest unfolding change likely to affect the world's forests in future are the changes that will occur as a result of global warming (Bolte et al. 2009; Lindner et al. 2002; Liu et al. 2010). Although it is currently difficult to specify local impacts with any great confidence the broad global trends are reasonably clear (IPPC 2007). These mean there will be changes in the temperature, rainfall patterns and water resources and thus changes in the distribution of many plant and wildlife species (Beaumont et al. 2007; Iverson et al. 2004; Saxon et al. 2005). These will lead to changes in the distribution of agricultural crops and changes in the distribution of pests and diseases that affect them (Berry et al. 2006). Likewise, many of the existing protected areas will become unable to conserve the species for which they were originally established (Milad et al. 2011). These events will probably encourage further deforestation in some places but may act as stimuli for some form of restoration in other places including former farmlands and shrublands.

For those concerned with finding ways to restore degraded or under-used lands there are several challenges. While there are areas of extensive forest cover, especially in the boreal zone, much of the world's remaining forests exist in a landscape mosaic together with other land uses, particularly agriculture. Where property rights are well established and the rule of law prevails, restoration at a landscape scale will be constrained by the diversity of landowners. Additional limitations apply in the developing world where tenurial rights are sometimes ambiguous, governance issues abound, and corruption is often present (Kolstad and Søreide 2009).

One challenging task will be finding ways of restoring forest cover that suit the ecological constraints of particular sites as well as the socio-economic circumstances of the landowner or land user. These forms of forest restoration will have to be resilient enough to cope with the range of future uncertainties and also sufficiently economically attractive to persuade landowners to embrace them. The second task will be to find ways of implementing this restoration at an appropriately large or landscape scale. Both tasks need some explanation and this chapter firstly reviews how to carry out forest 'restoration' at a site level and then considers the most effective ways of undertaking forest restoration at a landscape scale. By doing this the chapter seeks

to provide a background and a context for the more detailed and location-specific studies that follow in subsequent chapters.

1.2 What Is Forest Restoration?

Many people see the task of overcoming degradation as one of forest restoration yet consensus is lacking on terminology (Stanturf 2005). Perceptions of degradation and naturalness are social constructs (Emborg et al., Chap. 7, this volume) without universally accepted meaning. In the present context we shall regard a degraded forest as one with a reduced capacity to supply specified goods and services. This may be because of changes to the composition, structure or productivity of the forest caused by previous usage or by a catastrophic natural event such as a storm, landslide or a tsunami. Degraded lands are those whose ecosystems have suffered a persistent loss in their productivity caused by losses in soil fertility, changes in fire regimes, modifications to microclimate or because of invasive species. Over-abundant populations of herbivores such as deer can also cause degradation.

Even here we have to recognize that this definition must be somewhat flexible to account for circumstances where fertilizers have been added, introduced species have become naturalized, or fire in adapted communities has become a problem because suppression has altered fuel loads to dangerous levels. All of these events can limit the extent to which the supply of certain goods or services can be re-established at a site. There are, of course, often degrees of degradation and some have drawn a distinction between marginal, fragile and degraded with degraded lands being most severely affected while marginal or fragile lands might have lost some of their productivity but still be useable for agricultural purposes (Hudson and Alcántara-Ayala 2006; Biot et al. 1995).

Degradation can be overcome by restoration but definitions of restoration are also contentious (Hobbs et al. 2011). The Society for Ecological Restoration (SER 2004) defines 'restoration' as the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed. The implication is that it is an intentional process which aims to accelerate the recovery of an ecosystem with respect to its structure (i.e., species composition, cover, physiognomy) functional properties (e.g., productivity, energy flow, nutrient cycling), and exchanges with surrounding landscapes and ecosystems. While not explicit in the SER definition of restoration, others have argued for the need to use reference sites to define restoration goals (Clewell and Rieger 1997), with the implication that only restoration to some historic condition is really ecological restoration.

This has proved controversial since it can present difficulties for those working in areas that have evolved after a long period of human occupancy and management and that may have involved certain grazing, burning or harvesting regimes. What should be done once these traditional management systems are abandoned? Should one try to re-establish the cultural landscape and its forests by re-establishing the former management regimes or should one seek to re-establish the supposed

'original' ecosystem assuming, of course, that condition can even be known (Aronson et al. 1995)? This means that historical settings will continue to be useful in some situations but not in others. But there are also other difficulties as well including:

- *environmental conditions at the site have altered*: the physical attributes of the site may have changed (e.g. soil fertility has been reduced by erosion or increased by agricultural fertilizers) and the sites are no longer suitable habitats for the original tree species or other biota.
- *the landscape has changed*: deforestation or farmland drainage may have altered hydrological regimes or local microclimates. Likewise, fire regimes may have been altered by fire suppression or grazing.
- *the target is unknown*: where deforestation is complete, or where humans have occupied the landscape for long periods, there may be no record, let alone examples, of the original forests or of the wildlife that occupied them. Even early records can be misleading since the site may have subsequently changed over time.
- *some species changes may be hard to reverse*: some of the original plants and animals are now extinct while the populations of others may have grown and become over-abundant; exotics may have colonised the area and become naturalized and impossible to eradicate.
- *the cost*: all forms of restoration can be expensive and many landowners may be only interested in simple forms of reforestation or afforestation involving commercially attractive species that can be harvested for a financial gain. Others may be reluctant to invest in what, to them, is a new land use about which they have only limited knowledge without substantial compensation. Still others may be concerned they may lose rights to subsidies for the present agricultural land-use and enter an unsubsidized land-use like forestry. Such a loss could affect the overall capital value of the property.

Add to these the complications arising out of the impacts of climate changes and it is clear that it may not always be possible to restore the original forest ecosystems even if one wished to.

In practice, the type of restoration adopted at a particular site is likely to depend not only on the degree of degradation that has occurred but also on the objectives of the land manager and on the resources available to them. Broadly speaking there are three possible alternatives for those interested in some form of forest restoration. The first might appeal to landowners primarily concerned with planting trees in order to generate a financial return from harvesting forest products or perhaps, where there is a carbon trading scheme by simply maximising biomass accumulation to sequester carbon. In such cases their main objective will be to increase productivity and they may be quite prepared to use a single commercially attractive native or exotic species to achieve this purpose (Fig. 1.1). This approach returns forest cover and regains some forest functions but does not strictly qualify as restoration according to the SER definition. This might be seen as the traditional approach to afforestation and is the one most favoured by industrial forestry companies primarily concerned with timber production. It might also be attractive to those wishing to accelerate the sequestration of atmospheric carbon.



Fig. 1.1 A young monoculture of *Anthocephalus chinensis* in Sabah, Malaysia

A second group of managers could be more interested in improving conservation or functional outcomes rather than maximising financial returns. Some may even wish to restore, in so far as they understand what was there before, the pre-disturbance forests. This group may attempt this through plantings at deforested sites as well as by protecting and managing natural forest regrowth (Elliott et al. 2006; Parrotta and Knowles 2001). This is illustrated in Fig. 1.2. Their emphasis will be on restoring as many as possible of the native tree species and restoring the habitats of wildlife species. In some temperate forests in particular the task may involve manipulating the density of trees in existing planted forests to allow additional species to become established (Hahn et al. 2005). This is illustrated in Fig. 1.3. Such undertakings can occur on both privately and publicly owned land. This obviously does qualify as restoration according to the SER definition although it may be many years before anything approaching pre-disturbance conditions are achieved even after an appropriate successional trajectory has been established.

A third group will be those wishing to achieve some elements of both of these objectives. This may be because they wish to generate an income as well as some conservation benefits or it might be because they recognize that the biophysical properties of the environment have changed (or will change in future as climates change) so that it is simply not feasible to attempt to restore the original ecosystem. For these reasons the forests they develop may include some native species but may also contain exotic species as well. This is because these have a higher commercial value, because they are able to tolerate the new environmental conditions better than the original native species or because they can facilitate the establishment of some of these native species (Brockerhoff et al. 2008; Carnus et al. 2006; Lamb



Fig. 1.2 Ecological restoration in Thailand. The multi-species forest is now 15 years old. It was established by planting seedlings but the site has been enriched by natural colonists from nearby undisturbed natural forest



Fig. 1.3 A Norway spruce forest in Sweden in which canopy openings have been created to allow the forest to be enriched with broadleaved species (beech, *Fagus sylvatica*)

1998; Parrotta et al. 1997; Stanturf et al. 2009). Hobbs et al. (2009) have referred to such forests as 'novel' ecosystems because of the new species assemblages present. These forests, too, might qualify as restored forests under the SER definition if they contained most of the main species that occur in a reference ecosystem and provide an appropriate community structure. On the other hand they might never develop to resemble the original ecosystems because of environmental changes that have occurred at the sites and because of the management methods being used.

These three options simplify a much richer and more diverse range of options available for landholders to restore forest cover at particular sites. However, within the present context, and for the sake of simplicity, all may be thought of as different forms of forest restoration (accepting the limitations of this terminology e.g. Hobbs et al. 2011). More than one approach may be used within a particular landscape with the actual methods used at a particular site being tailored to the landholder's objectives and the ecological conditions at that site. Note also that the methods used can change over time as ecological and economic circumstances change meaning that option 1 – simple monocultures producing easily saleable timbers – may initially be the only realistic choice for many forest managers but, over time it may become possible to introduce a wider variety of species (involving option 3 or even option 2) as environmental conditions improve and the emphasis changes from the production of goods to the production of services (e.g. Lee and Suh 2005; Madsen et al. 2005; Tak et al. 2007).

One further word on terminology is that we do recognize that while forest restoration shares many of its terms and techniques with traditional forest management, they are not always synonymous. For example we reserve the term "reforestation" for the artificial regeneration of a forest almost or completely clear-felled by harvesting, wildfire, or wind storm. Similarly we regard deforestation as the process of removing forest cover along with conversion to another land use or abandoned from management; it does not refer to periodic removal of forest cover like clear-cutting and stand regeneration in normal forest management.

1.3 The Landscape Mosaic

The opportunities for restoration and the type of restoration that is carried out depend upon the landscape in which it is being done. There is some confusion about the meaning of 'landscape' with some users of the term indicating a spatial extent while others do not. Lindenmayer and Fisher (2006) argue the definition depends on the context in which the term is being used; from a human perspective it may cover areas of hundreds or thousands of hectares but from a conservation biology perspective it depends more on the scales over which a particular species moves. Nassauer and Opdam (2008) define a landscape as a heterogeneous mosaic of ecosystems that is constantly being adapted by humans to increase its perceived value. Boedhihartono and Sayer (Chap. 16, this volume) suggest it is best thought of as the scale at which it is necessary to intervene if one is to balance trade-offs

Table 1.1 Some components of the landscape mosaic

Biophysical components	Socio-economic components
<i>Topography</i> : Hills and flatlands	<i>Population density</i> : areas where human population is concentrated (urban areas) and areas where it is sparse
<i>Soils</i> : Areas with fertile and less fertile soils supporting productive and less-productive agricultural lands	<i>Land ownership</i> : large and small farms; resident and absentee landowners, state ownership, communal ownership
<i>Vegetation</i> : annual and perennial crops, large and small patches of disturbed and undisturbed forests, regrowth forest, shrublands and grasslands; areas with invasive exotics	<i>Landholder status</i> : rich and poor landowners; traditional users
<i>Biodiversity</i> : areas with residual populations of endemic, endangered or vulnerable species (within forests, on forest margins and outside forests); areas with over-abundant populations of native or exotic species that may have become weeds or pests	<i>Infra-structure</i> : roads and railways which provide access and affect transport costs
<i>Erosion</i> : areas with severe erosion and others with none	<i>Commercial value or productivity</i> : tend to be greater in fertile lands close to transport and densely populated areas
<i>Hydrological</i> : rivers, wetlands and areas with high run-off; areas with and without severe erosion; areas with modified infiltration or drainage	
<i>Wildfire</i> : fire-prone areas with high fire frequencies and areas that are only rarely burned	

and optimize conservation and livelihood benefits. Clearly landscapes have both structural and functional components, which are influenced by the scale at which one approaches defining a landscape (Aylward 2005; Bruijnzeel 2004; Lindenmayer et al. 2008; Omernik and Bailey 1997).

Landscapes are not uniform and nor is it useful to think of them simply as containing ‘forest’ and ‘non-forest’ (Lindenmayer et al. 2008). Most landscapes are represented by spatially diverse mosaics of different types of vegetation and land use practices and it is useful to recognize some of the features that are responsible for this heterogeneity. Table 1.1 shows some of the biophysical and socio-economic attributes of landscapes. Biophysical attributes such as topography and soil fertility influence where deforestation is likely to have occurred in the past but will also influence where there may be opportunities for restoration in the future. For example, flat lands with fertile soils are likely to have been cleared at an early stage and are less likely to have been degraded and abandoned than sites with less fertile soils on steep slopes. It is the latter that are more likely to be available for restoration. These patterns will also determine where undisturbed forest persists, where regrowth is more likely to develop and where most of the original biodiversity will be retained. Some areas are also more likely to be burned by wildfires making regeneration more difficult (e.g. areas near roads and railroads or human habitations).

The socio-economic mosaic will be equally variable. Some areas will have high human population densities while others will have low densities. Farms in some places will be large because they are owned by wealthy landholders while others will be small and held by poorer landholders. Some larger farms that are close to transport may be farmed intensively while others may be farmed only episodically such as those with marginal soils or owned by absentee landholders. These various landowners are likely to have differing perceptions about whether or not to undertake restoration on their land and, if so, what sort of tree-planting to carry out. Some will be motivated by commercial considerations and driven by perceptions of the opportunity costs of reforestation. Others, perhaps those better-off farmers who have larger land holdings may be more interested in restoration on less productive parts of their landholdings to generate environmental services and protect crops.

None of these patterns are fixed. Populations of plants and animals move about landscapes depending on the types and spatial patterns of residual forests and crops. Land uses and vegetation patterns change as markets and market prices change and human populations may increase in some areas and decrease in others. Historical events such as wars, disease, fires and other natural disasters also influence settlement patterns and shape landscapes (Chazdon 2003; Foster et al. 1998). Some of these issues are explored further in subsequent chapters (See Convery and Dutson, Chap. 12; Crow, Chap. 2; Han and Oliver, Chapter 5 in Stanturf et al. 2012; Hughes et al. Chapter 15 in Stanturf et al. 2012; Nagy and Lockaby, Chap. 4; Oliver et al. Chap. 3; Wimberly et al., Chap. 6 in this volume).

As far as restoration is concerned these spatial patterns have several consequences. One is that some areas are more likely to be available for restoration than others. For example, marginal agricultural lands may be available but fertile croplands will not. A second is that natural recolonization and regeneration will be more likely in some parts of the landscape mosaic than others (e.g. regrowth is more likely at sites that have not been too heavily disturbed and are close to residual forests). And, thirdly, the areas available for restoration or able to regenerate naturally are not necessarily those parts of the landscape that are most in need of restoration to conserve biodiversity or to protect watersheds.

This last issue is critical. Most watersheds will be more effectively protected by continued forest cover on steep slopes and along riparian strips. Biodiversity conservation will be most effectively maintained by ensuring connectivity between forest remnants, by enlarging small forest patches and by creating protective buffer areas around forest patches subject to disturbances such as fires or continued clearing. Areas critical for watershed protection and for biodiversity conservation will sometimes overlap but in other cases will not.

However the location of any actual restoration will largely depend on land ownership patterns and landscape with many small farmers being unlikely to completely restore their land even when the market for forest products (or environmental services) is strong. Instead most will be inclined to use only some of their land for trees and the remainder for other purposes unless they are able to obtain most of their income from off-farm sources. And the location of any tree planting that does take place will depend upon farmers' perceptions of their opportunity costs.

While it may make ecological sense to restore steep hills or to form a link between two patches of remnant forest, individual landowners may have different perceptions of the value of such undertakings and prefer to use commercially attractive exotic species grown in a plantation monoculture.

1.4 What Is Forest Landscape Restoration and How Is It Different from Site-Level Restoration?

Forest Landscape Restoration (FLR) differs from site-level restoration because it seeks to restore ecological processes that operate at a larger landscape scale such as those maintaining the populations of species requiring large habitat areas or those responsible for hydrological flows.

But, because complete restoration of a landscape is usually unrealistic, choices must be made about where in the landscape mosaic this restoration is undertaken. FLR seeks to do this by using a strategic approach that targets key locations rather than relying on the individual decisions of separate landholders. At the same time it also seeks to improve the livelihoods of these landholders so that restoration is not carried out at their expense. According to Maginnis and Jackson (2007) FLR is defined as “a process that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest landscape”. The definition implies that FLR is a considered process and not simply a series of *ad hoc* treatments that eventually cover large areas.

Decisions about restoration will always depend on the resources available and on patterns of land tenure. But they will also depend on the aspiration and goals of individual landholders. This means some form of landscape-wide planning process will be needed to ensure key areas are restored and that incentives or compensation is provided to individual landholders to achieve this and the costs as well as the benefits are shared between landholders and the broader community.

1.5 How Is Forest Landscape Restoration Carried Out?

There are a large variety of approaches that have been used to address FLR and many of these are considered in the chapters that follow. Some involve relatively informal techniques while others require considerable planning. However the process of implementing FLR usually involves the consideration of four quite explicit questions:

- (i) How much restoration should be carried out in a particular landscape?
- (ii) Where should this be carried out?
- (iii) What type of restoration should be done at each location?
- (iv) How should the FLR process be managed?

1.5.1 How Much Restoration Is Needed?

There is no simple answer to this question. One obvious determining factor is the amount of forest that still remains in the landscape. But, more to the point, it depends on whether the previous loss of forests has given rise to particular problems. Other things being equal, a landscape with only 10 % forest cover remaining is likely to have acquired more problems and be more in need of some restoration treatment than one where 90 % of the original forest cover still remains. But, in principle, is there some kind of minimum forest cover threshold that one should aim for?

There has been considerable debate over the idea of ecological thresholds but the general conclusion is that these are hard to define (Groffman et al. 2006). There are several reasons for this. In the case of wildlife it appears that the populations of some species are adversely affected by only small proportional losses in habitat (or even simply declines in habitat quality) while others are more tolerant. For example, some woodland birds are only affected when habitat is reduced to less than 30% of the original cover (Radford et al. 2005). Species such as beetles may tolerate even greater levels of deforestation. But, even when the habitat requirements of a particular animal species are understood, it can be difficult to specify how the overall collective species richness is affected by decreases – or increases - in forest cover. The same uncertainty is likely to be true of plants with the added twist that the regional loss of plant biodiversity caused by deforestation appears to be slower than for wildlife biodiversity (probably due, in part at least, simply because species such as trees can be long-lived so that the impact of forest loss on species diversity is less obvious). Increasing the populations of residual tree species may assist the survival of what otherwise might be seen as the ‘living dead’ (Janzen 1988). But, in this case, the spatial location of any plantings may be more critical than the amount of restoration undertaken.

The relationship between the amount of forest cover and the extent of soil erosion is also difficult to define. Deforestation is known to affect erosion but it is difficult to specify a threshold cover below which accelerated erosion occurs and above which it ceases or returns to natural background levels (Lal 2001). Erosion is affected by rainfall intensity and soil type. It is also affected by slope: small areas of deforestation on steep slopes will sponsor more erosion than large areas on flatter lands. In short, increasing levels of forest cover is likely to improve many ecological outcomes but there is unlikely to be a simple threshold for forest cover that applies to all the environmental variables likely to be of concern to stakeholders contemplating restoration.

In practice a key issue, of course, is that if forest cover is to increase, even modestly, then other land uses (and habitat types) must decrease. Whether or not landholders are attracted to restoration depends on its opportunity costs. Farmers may be willing to undertake some afforestation on marginal agricultural lands where the opportunity costs are low but most will be reluctant to do so on fertile cropping lands where the opportunity costs are high. Some forms of restoration can generate financial returns but these often occur some years after planting takes place. Even when such restoration is financially rewarding many landowners will still need additional livelihood

support if they are to participate in a broad landscape restoration program. Under these conditions many will only commit a small portion of their land to tree-planting.

There are some broader financial perspectives that are also relevant to this question. The financial returns from small forest plantations scattered across a landscape will only be realised when they are collectively large enough to provide a market with a regular supply of timber. In most cases a few, small plantations will not be enough. The type of products produced is also influential. Higher-value timber can be transported to more distant markets but more modestly priced utility timbers cannot. This means there may, in fact, be a distinct economic threshold that must be exceeded. It is difficult to specify this threshold area because it will depend so much on biological and financial conditions specific to a particular location. This topic is referred to in subsequent chapters in Stanturf et al. 2012 including Booth et al., Chap. 13, Rosengren Chap. 17 and Wilson et al., Chap. 11.

1.5.2 Where Should Restoration Be Carried Out?

The functional consequence of any new forest area depends on where in the landscape it is established. As noted earlier, afforestation of a steep hillside will reduce erosion more than afforesting the same area on flat land. Likewise, a new forest that provides a link between two patches of remnant natural forest will probably help species move across the landscape and conserve biodiversity more than the same area of planted forest isolated in the midst of an otherwise homogenous agricultural landscape (Llewellyn et al. 1996). The task for those planning FLR is to strategically distribute new forest areas across the landscape in a way that maximises their ecological impact. Landscape ecologists have generated a number of recommendations for priority locations for restoration. These are shown in Table 1.2.

Economic considerations may suggest other priority locations. These might include agriculturally marginal lands (where the opportunity costs are lower), sites distant from roads (where, again, opportunity costs are lower) or, alternatively, sites near roads (where log transport costs are lower). Needless to say, certain locations will achieve some outcomes but not others and this is where trade-offs will be needed. This question is referred to in subsequent chapters in this volume including Bentrup et al., (Chap. 5), Booth et al. (Chap. 13), Gobster (Chap. 8), Harper et al. (Chap. 14) and Larsen et al. (Chap. 9).

1.5.3 What Type of Restoration Should Be Done at Each Location?

There can be large differences in the composition and structure of undisturbed natural forests, regrowth forests and plantation forests. Part of the difference is because of the relative youth of the newly created forests relative to the undisturbed forests.

Table 1.2 Priority areas for restoration in degraded landscapes to improve functional outcomes

Location of new forests	Advantage of new forests at this location
Areas able to regenerate naturally	The cost of restoration is low (although the costs of protecting these areas may be significant)
Buffer strips planted around remnant patches of natural forests	Protect these remnants from further disturbances, enlarge their effective areas and soften edge effects (highest priority being given to remnants with endangered or vulnerable species)
Corridors planted between remnant patches of natural forests	Facilitate movement of species and genetic exchange between isolated populations
Corridors or ‘stepping stones’ planted along altitudinal and longitudinal gradients	Facilitate movement of species in response to environmental stresses such as climate change
Steep slopes	Protect erosion-prone soils
Riparian strips	Protect erosion-prone soils and act as filters to limit sediments reaching waterways. Act as corridors for species movement
Areas subject to sheet erosion and with compacted soils	Protect erosion prone soils and increase infiltration capacity
Groundwater recharge areas in salinity-prone areas	Increase evapo-transpiration thereby increasing depth of water table and decreasing salinity problems
Coastal protection zones	Decrease storm impacts
Urban areas	To improve recreational opportunities

However, there can also be large differences in the composition and structure of many newly established forests even when these are of the same age. This is usually the consequence of a deliberate choice by the landholder. Plantation monocultures are obviously the simplest type of new forest (Fig. 1.1). Many are managed on short rotations, especially those established in the tropics. These represent a high proportion of most newly established forests because landowners perceive them as being more profitable and easier to manage. These plantations can restore productivity and some ecological functions but will not provide the habitats needed by many forest-dependent species. This means they will not be as useful in improving connectivity between natural forest fragments to allow species or genes to move across a landscape. On the other hand, some monoculture plantations and especially older ones with shrubby understories, can provide good watershed protection.

Mixed-species plantings are better at providing habitats for a wider variety of other species and are also able to protect watersheds. There are a variety of these including even-aged plantings and forests where an existing monoculture is enriched with additional species (Lamb 2011). But these types of plantings can have other advantages as well including improving productivity, improving nutrition or reducing damage from insect pests or disease (Dey et al. 2010; Lockhart et al. 2008; Stanturf et al. 2009; Lamb 2011). One particular advantage of mixtures that make them attractive to some landholders is that they diversify the goods and services provided and thereby reduce economic risks. This may not be an especially attractive advantage for large industrial plantation owners for whom the added management complexity is a disadvantage but could be for smallholders. This advantage

may increase as markets for environmental services develop and there is a need to develop robust and resilient new forests able to supply these services over the longer term.

The best type of new forest from a conservation viewpoint would be a species-rich forest established to restore the habitats of forest-dependent species and that was not subject to future disturbances such as those caused by tree-felling (e.g. Fig. 1.2). These forests might be established using seedlings or seeds, enriching existing monocultures by manipulating canopy covers to enhance the establishment of additional species or by protecting natural regrowth. Such forests may not produce commercially attractive goods but may be attractive where there are markets for ecosystem services.

There is often an interaction between the ‘what type’ question and the ‘where’ question. A species-rich and structurally complex new forest would be preferable when developing a corridor to provide improved landscape connectivity but a simple monoculture might be quite sufficient if there is a need to simply increase evapo-transpiration in order to lower water tables and reduce the risk of salinization (see Chap. 14 by Harper et al., this volume). Likewise, a monoculture grown for pulpwood might be commercially attractive if grown next to a road but could be worthless if grown by a smallholder in a remote mountain area without good roads and where the cost of transport was high. This question is discussed by Bentrup et al. (Chap. 5), Davis et al., (Chap. 15), Gobster (Chap. 8), Harper et al., (Chap. 14), Jim (Chapter 6 in Stanturf et al. 2012), Han and Oliver (Chapter 5 in Stanturf et al. 2012), Larsen et al., (Chap. 9 this volume), Rosengren, (Chap. 17 in Stanturf et al. 2012) and Wilson et al., (Chap. 11) later in this volume.

1.5.4 How Should This Process of Restoration Be Managed?

A single private landholder or public agency might be able to resolve each of these questions without too much trouble but it is rather more difficult to do across a broader landscape mosaic where a variety of landholders are present. Under these circumstances several different approaches have been used. One is a largely top-down approach in which a government land use planning agency sets objectives and decides where and how to restore forests across the landscape. This approach appeals to many ecologists because it allows them to apply their hard won scientific knowledge in a way they believe will generate widespread benefits.

Some sophisticated modelling techniques have been developed that facilitate this approach (e.g. see Booth et al., Chap. 13 Stanturf et al. 2012 and Wimberly et al., Chap. 6, this volume). The planners can then use incentives and compensation to try to persuade landholders in key locations to adopt their restoration plans. The advantage of this approach is that treatments can be targeted to overcome specific conservation problems such as creating more habitat in particular areas for an endangered species or to solve erosion or watershed protection problems at certain sites. The disadvantage, however, is that it can be politically difficult because

different stakeholders may have contrasting views about the need for any restoration on their land or about priorities for restoration (e.g. should the priority be given to species conservation or watershed protection?). And even where a need for restoration is accepted, landholders in priority locations might find that the compensation on offer does not match what they believe are their opportunity costs. Top-down approaches can be seemingly efficient but may be politically and economically contentious.

An alternative approach is rather more bottom-up and involves having the stakeholders themselves identify priority areas for restoration and thus where compensation might be needed. The advantage of this is that disagreements can be identified at an early stage, trade-offs can be discussed and the stakeholders as a group can decide on treatment priorities. The process is likely to be rather more complex than top-down planning but perhaps more politically acceptable and, because of this ultimately prove to be more sustainable. The disadvantage of leaving decisions entirely to local landholders can be that national priorities (e.g. including watershed protection or conservation issues) may be ignored unless external facilitators include them in the discussion. An example of a largely bottom-up approach but where external facilitators were involved is given by Boedhiatono and Sayer (Chap. 16).

There is, of course, a third possibility and that is a combination of top-down and bottom-up. There are a variety of ways this might be achieved but most involve a regional planning group identifying a series of alternative restoration scenarios and taking these to a meeting of stakeholders (or stakeholder representatives) who then discuss them and choose one (or develop a new alternative of their own based on the original proposals). Examples of this approach have been given by Bouroin and Castell (2011) as well as by Bentrup et al. (Chapter 5), Convery and Dutson (Chapter 12), Siregar et al. (Chapter 3 in Stanturf et al. 2012) and Pullar and Lamb (Chapter 1 in Stanturf et al. 2012).

1.6 Issues Deserving Further Study

Explicit (or at least implicit) answers to these four questions are needed for the implementation of all FLR projects. But finding answers to these questions often raises other more fundamental questions that must be resolved first.

1.6.1 Who Are the Stakeholders and How Can They Participate in FLR?

The most obvious stakeholders are those owning or managing land found within the landscape. But others with a legitimate interest are those who might be affected by restoration. They could include other farmers, national or regional water supply managers, consumers of forest products, those with an interest in conservation and the broader community as a whole. These various stakeholders differ in the extent of their interest, their financial resources and their political power or influence.

It is likely to be difficult to identify all of these people and devise an equitable method by which their voices can be heard and their interests represented. An even more difficult task will be to do this in a way that ensures this participation over the longer term that most FLR will normally take to implement.

1.6.2 How to Make Collaborative Decisions?

It is often difficult to get a large number of people to agree on a particular course of action, especially when it involves changing the way in which they use their land. Part of the problem is they may not all have an equal understanding of the facts of the case or of the implications of certain choices. But even when they do, some will bring quite different sets of cultural attitudes to the discussion than others. For example, some may be inclined to support 'conservation' especially if others, such as neighbours whom they respect, do so. But some people may be hostile to the notion of outsiders having any say at all in how they manage their land.

There are also difficulties in the decision-making process with the political elite tending to dominate proceedings and loud, self-confident speakers likely to overshadow quieter, less assertive speakers (and men over women). Traditional societies often have long-standing institutions or methodologies to make collaborative decisions. But communities made up of more recent arrivals are less likely to have these. It can be difficult to arrive at mutually satisfactory decisions in situations where a government agency seeks to generate a change that benefits the broader community at the (perceived) expense of a private landholder. In such cases it is usually necessary to bring in a facilitator acceptable to all parties to initiate the process. Ideally, this should be institutionalised and a new collective decision-making body established to continue to manage the process over the longer time period that is usually necessary for FLR.

1.6.3 How Can Reforestation/Restoration Be Made Economically Attractive to Landholders and Especially Those in Key Locations?

Some landholders will occupy especially important locations within the landscape such as areas that might be used to create corridors between existing forest remnants or steep lands that are currently eroding. Some of these landholders may be uninterested in planting trees or may only want to plant simple monocultures using exotic species that have limited value for conservation or watershed protection. Those with existing monocultures may not wish to enlarge the diversity of tree species present even when this is clearly necessary to improve biodiversity conservation. Some of these landholders may be persuaded to engage in restoration once the practice is more fully explained. But restoration may be seen by many landholders

as an unconventional land use activity and they may be unwilling to change unless they perceive that they will benefit (Convery and Dutson, Chap. 12). Compensation or the development of a market for ecosystem services may tip the balance in favour of some kind of restoration but then the task becomes one of coordinating activity and payments across a large number of landholders.

1.6.4 How to Accommodate Disagreements?

Disagreements can sometimes be resolved, especially if a facilitator is available. But sometimes they cannot. Where only a few individuals are involved it may be possible to offer some kind of compensation (e.g. a cash payment or alternative land elsewhere). But more fundamental disagreements between, say, the resident and non-resident stakeholders may be more difficult to resolve and could mean that certain restoration goals may take many years to achieve.

1.6.5 How to Integrate Biophysical and Socio-economic Constraints/Imperatives?

Forests are often managed to generate a variety of benefits including timber and various ecosystem services. The same is true, in theory, of restoration. But maximum financial gains to landholders may come at the expense of certain services. For example, it may be more attractive for landholders near a busy timber market to grow fast growing trees in monocultures than to grow species-rich forest for biodiversity conservation. The landholder's task of judging how to restore a forest is made more difficult because of the uncertainty over future markets for forest products or ecosystem services. In some places it seems the latter (in the form of markets for carbon sequestration) could become more important than the former. Likewise, for government agencies seeking to manage the balance between national and private benefits it is difficult to decide whether to spend a large amount of resources restoring a highly degraded resource or to use the same amount of resources improving a larger but less degraded area.

1.6.6 How to Ensure That Populations of Threatened or Endangered Species Can Persist Across Landscapes?

Restorationists generally assume that wildlife will respond to increased amounts of forest and this is probably true in many cases. But wildlife species differ in their habitat requirements. Some are generalists and are able to use pretty well any form of forest cover. But others are rather more specific in their requirements and need

particular structural features or food species to be restored before they will begin to use a site. The most difficult species to cater for are those with large home ranges and needing extensive areas of particular types of habitat. These species are often those that are most affected by deforestation and which become classed as ‘threatened’ or ‘endangered’. A key task for restorationists, therefore, is not so much one of restoring ‘biodiversity’ but to protect or restore the populations of these most vulnerable species.

Han and Oliver (Chapter 7 in Stanturf et al. 2012) provides an interesting case on forest restoration and management to protect and conserve a tiger population in north-eastern China, where the authors identify key requirements for the forest habitat that are quite different from the virgin forest habitat that traditionally has been described as key tiger habitat. This case strongly demonstrates how important it is to clearly identify the mechanisms behind a target species population decline and properly link this to informed management now and in the future. This includes proper interpretation of land-use history and its impact on the target species to reach a sound explanation of how the species became threatened; and it paves the road for efficient and reliable FLR-efforts to support such a vulnerable species.

1.6.7 Monitoring Outcomes

Restoring degraded landscapes is difficult and success is not assured (Hobbs et al. 2003). The problem of predicting successional outcomes and changes in the population of wildlife as forests are restored is complex enough but is made even more so when economic and social factors must be taken into account. Both ecological and economic circumstances can alter, unexpected events may occur and people can change their minds. The most common approach to dealing with such problems is to develop some form of monitoring and adaptive management (Walters and Holling 1990). Suggestions about how this might be approached are given in Danielson et al. (2005), Lindenmayer and Likens (2010) and Lamb (2011) but there are few examples where these have been used to monitor large landscape-scale restoration over the long time periods that are necessary to establish appropriate successional trajectories. The issue is considered further by Allan et al. (Chap.10).

1.7 Conclusion

The extent of global deforestation and of land needing some form of restoration means that ways must be found to increase the scale at which restoration is carried out. The task is not simply to scale-up using an existing set of established silvicultural techniques but to find ways of intervening within already complex landscape mosaics in order to improve ecological functioning and also improve the livelihoods of people now living within that landscape as well of those of the future.

There may be a variety of approaches actually used to restore forests within a particular landscape mosaic. Landowners at some sites may wish to maximise the production of goods such as timber while those at other sites may wish to maximise the provision of ecosystem services. Some landowners may want to achieve both.

The advantage of FLR is that it is easier to make trade-offs involving these contrasting options at a landscape scale than at an individual landholding. Future challenges such as those imposed by climate change mean that the nature of these trade-offs will vary over time. To date there are few examples of where Forest Landscape Restoration, as defined here, has been successfully achieved and where the process has been in place for any substantial length of time. This means the subsequent chapters in this book provide only a first indication of the processes involved, the variety of methods that might be employed and the problems we are still to overcome.

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