Chapter 4

Planning forest restoration

The planning of forest restoration is a lengthy and complex process involving many stakeholders, who often have contradictory opinions about where, when and how the restoration project should be implemented. The project must be supported by local people and the relevant authorities, and issues of land tenure and benefit-sharing must be sorted out. Where tree planting is needed, seeds of the required tree species must be found, nurseries constructed and trees grown to a suitable size in time for the optimum planting season. If starting from scratch, these preparations will take 1–2 years, so it is important to begin the planning process well in advance.

As the need to solve environmental problems becomes ever more urgent, funders often demand to see results on the ground within one to three years. This pressure can lead to hurried and largely unplanned restoration projects, which often result in the wrong tree species being planted in the wrong places at the wrong time of year. Project failure then discourages both stakeholders and funders from becoming involved in further restoration projects. Advanced planning is therefore essential for success.

The technical challenges that must be overcome by the project plan are decided by undertaking a site assessment and by recognising the degradation level (see Chapter 3). In this chapter, we discuss the 'who', 'what', 'where' and 'how' of project planning. Specifically, we discuss how to involve stakeholders, how to clarify the project's objectives, how to fit forest restoration into human-dominated landscapes, the timing of management activities, and finally how to combine all of these considerations into a coherent project plan.

4.1 Who are the stakeholders?

Stakeholders are individuals or groups of people who have any kind of interest in the landscape in which the proposed restoration will take place, as well as those who may be affected by the wider consequences of restoration, such as water-users downstream. They may also include those who could influence the long-term success of the restoration project, such as technical advisors, local and international conservation organisations, funders and government officials. Stakeholders should represent all those who may benefit from the full range of benefits offered by the forest (see **Section 1.3**), as well as those likely to be disadvantaged by continued degradation (see **Section 1.1**).

It is essential that all stakeholders have the opportunity and are encouraged to participate fully in negotiations at all stages of project planning, implementation and monitoring (see **Section 4.3**). Different opinions about the eventual use of the restored forest, and whose interests will be served by it, will inevitably arise. Stakeholders might also disagree about which restoration methods will be most successful. When the benefits of forest restoration are poorly understood, some stakeholders might favour traditional plantation forestry (i.e. the planting of monocultures, often of exotic species) but, by allowing all views to be heard, the case for conservation can be clearly communicated from the outset and common goals can usually be found. Successful forest restoration often depends on resolving conflicts early in the planning process by holding regular stakeholder meetings, at which records are kept for future reference. The purpose of such meetings should be to reach a consensus on a project plan that clearly defines the responsibilities of each stakeholder group, thereby preventing confusion and replication of effort.

The strengths and weaknesses of each of the stakeholders must be recognised, so that a joint strategy can be devised while each stakeholder group is allowed to maintain its own identity. Once the capabilities of each stakeholder group have been identified, their roles can be defined and the allocation of tasks agreed upon.

This is often a tricky process, which may best be led by a facilitator. This is a neutral person or organisation who is familiar with the stakeholders but is not seen as authoritarian or gaining any benefit from involvement in the project. Their role is to ensure that all opinions are discussed, that everyone agrees with the aim of the project and that responsibility for the various tasks is accepted by those most able and willing to carry them out.

Success is most likely when all of the stakeholders are content with the benefits they might receive from the project and believe that their contribution is beneficial to the project's success. When everyone is satisfied that they have had input into project planning, a sense of 'community stewardship' is generated (even though this does not necessarily mean actual legal ownership of the land or trees). This helps to establish essential working relationships amongst the stakeholders that must be maintained throughout the project.

4.2 Defining the objectives

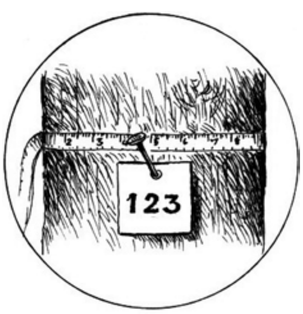
What is the aim?

Forest restoration directs and accelerates natural forest succession with the eventual aim of creating a self-sustained, climax forest ecosystem, i.e. the target forest ecosystem (see **Section 1.3**). So, a survey of an example of the target forest ecosystem is an important part of setting a project's objectives.

Locate remnants of the target forest ecosystem using topographic maps, Google Earth or by visiting viewpoints. Select one or more remnants as reference site(s). The reference site(s) should:

- have the same climax forest type as that to be restored;
- be one of the least-disturbed forest remnants in the vicinity;
- be located as close as possible to the restoration site(s);
- have similar conditions (e.g. elevation, slope, aspect etc.) as those of the proposed restoration site(s);
- be accessible for survey and/or seed collection etc.

Invite all stakeholders to join in a survey of the reference site(s). Before the survey, prepare metal labels and 5 cm galvanised zinc nails with which to tag the trees. To make labels, cut the top and bottom off drinks cans, slice open the cans and cut 6–8 square labels from the soft aluminium of each can. Lay the labels on a soft surface and use a metal stylus to indent sequential numbers into the metal (inside surface), then trace over the engraved numbers with an indelible pen.



Walk slowly along trails through the remnant forest and label mature trees growing within 5 m left or right of the trail. Tag the trees with the numbered metal labels in the order in which they are encountered, 1, 2, 3, 4, ... etc. Place the top edge of the labels exactly 1.3 m above ground level and nail them into place. Hammer in the nails only half way, because as the trees grow they will expand along the exposed half of the nails. Measure the girth of each tree 1.3 m above the ground and record the local names of the tree species. Collect leaf, flower and fruit specimens (where available) for formal identification. Continue until about five individuals of each tree species have been recorded. Take plenty of photos to illustrate the structure and composition of the target forest ecosystem and record any observations or signs of wildlife.

Use the opportunity to discuss with stakeholders:

- the history of the forest remnant and why it has survived;
- any uses of the tree species recorded;
- the value of the forest for non-timber products, watershed protection etc.;
- wildlife they have seen in the area.

After the survey, take the tree specimens to a botanist to obtain scientific names. Then use a flora or web search to determine the successional status of the species identified (pioneer or climax trees), the typical flowering and fruiting times of the species and their seed dispersal mechanisms. This information will be useful for planning species selection and seed collection later.

Select nearby remnants of the target forest ecosystem as reference sites and survey the plants and wildlife within them to help set project objectives.

The reference site can then be used for seed collection (see **Section 6.2**) and, if included in the project (see **Section 6.6**), for studies of tree phenology. Most importantly, it becomes a bench mark against which progress and the ultimate success of forest restoration can be measured.

Aiming at a moving target?

We have already stated that the target of forest restoration should be the eventual re-establishment of the climax forest ecosystem, i.e. forest with the maximum biomass, structural complexity and species diversity that can be supported by the soil conditions and prevailing climate. Since the climax forest type depends on the climate, global climate change might mean that the climax forest type for a particular site at some time in the future might differ from that best-suited to the site in the present climate (see **Section 2.3**). The problem is that we don't know how far global climate change could proceed before measures to halt it become effective, especially as (at the time of writing) international negotiations to implement such measures are stalled. With such uncertainty, it becomes impossible to know exactly what the future climate will be at any particular site and consequently which climax forest type to aim for. It is therefore possible that at least some of the tree species selected from today's remnants of climax forest might not be suitable for tomorrow's climate. Some species might be tolerant of climate change, but some may not be. So in addition to aiming for ecological richness, forest restoration should also seek to establish forest ecosystems that are capable of adapting to future climate changes.

Increasing ecological adaptability

The keys to securing the adaptability of tropical forest ecosystems to a changing global climate are i) diversity (both species and genetic diversity) and ii) mobility.

Tree species vary considerably in their responses to temperature and soil moisture. Some can tolerate large fluctuations in conditions (and are said to have a 'wide niche'), whereas others die when conditions waver even slightly from optimal ('narrow niche'). The more tree species are present at the start of restoration, the more likely it is that at least some of them will be suited to the future climate, whatever it turns out to be. So, in any restoration project, try to increase tree species diversity early in the succession as much as possible.

Genetic diversity within tree species is also important. Responses to climate change among individual trees within a species can also vary. So maintaining high genetic diversity within species can increase the probability that at least some individuals will survive to represent the species in the future forest. These genetic variants will then be able to pass on the genes that enable survival in a warmer world to their offspring. Until recently, it has been recommended that seeds should be collected from trees growing as close as possible to the restoration site (because they are genetically adapted to local conditions and they maintain genetic integrity). Now, the idea of including at least some seeds from the warmer limits of a species' distribution is being considered in order to broaden the genetic base from which genetic variants that are suited to a future unknown climate might emerge through natural selection (see **Box 6.1**, p. 159). The warmer limits of a species distribution would typically include the southern-most populations of species in the northern hemisphere, the northern-most populations of species in the southern hemisphere and the lower elevation limit of montane species.

Trees cannot 'run away' from climate change, but their seeds can (see **Section 2.2**). So, any actions that facilitate seed dispersal across landscapes will increase the probability that more tree species will survive. The mobility of seeds across landscapes can be maximised by planting framework tree species, as they are specially selected for their attractiveness to seed-dispersing wildlife. Tree species that have large seeds, particularly those that would have depended on extirpated large animals (e.g. elephants or rhinos) for their dispersal, should also be targeted for planting. Without their seed dispersers, human intervention to move their seeds (or seedlings) might be their only remaining chance of dispersal. Campaigns to prevent the hunting of seed-dispersing animals are obviously important in this regard (see **Section 5.1**). Increasing forest connectivity at the landscape level also facilitates seed dispersal because many seed-dispersing animal species are reluctant to cross over large open areas. This can be achieved by restoring forest in the form of corridors and 'stepping stones' (see **Section 4.4**).

It is fanciful to suppose that something as dynamic and variable as a tropical forest can be 'climate proofed', but some of the measures suggested above might at least help to secure the long-term future of some form of tropical forest ecosystem at today's restoration sites.

4.3 Fitting forests into landscapes

Today, no forest restoration project is carried out in isolation. Forest destruction is a feature of human-dominated landscapes, and consequently, restoration is always implemented within a matrix of other land uses. Therefore, considering the effects of restoration projects on the character of the landscape, and *vice versa*, is often one of the first considerations when putting together a restoration project plan (see Chapter 11 of Lamb, 2011). Consideration of the whole landscape in restoration planning has now been formalised within the framework of forest landscape restoration (FLR).

Forest landscape restoration

Forest landscape restoration is "a planned process, which aims to regain ecological integrity and enhance human well-being in deforested or degraded landscapes"[1] (Rietbergen-McCracken *et al*., 2007). It provides procedures whereby site-level restoration decisions conform to landscape-level objectives.

The goal of FLR is a compromise between meeting the needs of humans and wildlife, by restoring a range of forest functions at the landscape level. It aims to strengthen the resilience and ecological integrity of landscapes and hence to keep future management options open. Local communities play a crucial role in shaping the landscape, and they gain significant benefits from restored forest resources, so their participation is central to the process. Therefore, FLR is an inclusive, participatory process.

FLR combines several of the existing principles and techniques of development, conservation and natural resource management, such as landscape character assessment, participatory rural appraisal and adaptive management, within a clear and consistent evaluation and learning framework. ANR and tree planting are just two of many forestry practices that might be implemented as part of an FLR program. Others include the protection and management of secondary and degraded primary forests, agro-forestry and even conventional tree plantations.

The achievements of FLR can include:

- identification of the root causes of forest degradation and prevention of further deforestation;
- positive engagement of stakeholders in the planning of forest restoration, resolution of land-use conflicts and agreement on benefit-sharing systems;
- compromises and land-use trade-offs that are acceptable to all stakeholders;
- a repository of biological diversity of both local and global value;
- delivery of a range of utilitarian benefits to local communities including —
    - a reliable supply of clean water;
    - a sustainable supply of a diverse range of foods, medicines and other forest products;
    - income from ecotourism, carbon trading and from payments for other environmental services;
    - environmental protection (e.g. flood or drought mitigation and the control of soil erosion).

[1] A forested landscape is considered to be degraded when it is no longer able to maintain an adequate supply of forest products or ecological services for human well-being, ecosystem functioning and biodiversity conservation. Degradation can include declining biodiversity, water quality, soil fertility and supplies of forest products as well as increased carbon dioxide emissions.

The concept of FLR is the result of collaboration among the world's leading conservation organisations including The World Conservation Union (IUCN), the World Wide Fund for Nature (WWF) and the International Tropical Timber Organization (ITTO); several comprehensive text books about the concept have recently been published (e.g. Rietbergen-McCracken *et al.*, 2007; Mansourian *et al*., 2005; Lamb, 2011).

Landscape character

A landscape character assessment is often the first step in an FLR initiative. Landscape character is the combination of landscape elements (e.g. geology, land form, land cover, human influence, climate and history) that defines the unique local identity of a landscape. It results from interactions between physical and natural factors, such as geology, landform, soils and ecosystems, and social and cultural factors, such as land use and settlement. It identifies the distinctive features of the landscape and guides decisions about where forest can be restored in a positive and sustainable way that is relevant to all stakeholders.

Assessment of landscape character

Landscape character assessment is essentially a participatory mapping exercise carried out with the aim of reaching consensus on where forest can be restored while the landscape characteristics that stakeholders consider desirable are conserved or enhanced.

It begins with a review of existing information about the area, including its geology, topography, climate, distribution of forest types, plant and animal diversity, previous conservation or development projects, human population and socio-economic conditions. This information may be gleaned from maps (especially those showing forest cover), published research papers and/or unpublished reports. Such documents might be obtained from government offices (particularly the local or national forest or conservation authority, the meteorological office and the social welfare department), any NGO's that have worked in the area, and any universities that have done research. A considerable amount of information is also available on-line. Google Earth is a useful source of information on areas with limited map accessibility.

The next step is to hold a series of stakeholders' meetings to combine information from the review with local knowledge and field observations. Local people, particularly the older generations, can offer invaluable information on landscape character, particularly if they have memories of the area prior to disturbance. They may be able to identify changes in forest products and ecological processes that have occurred as a result of degradation, such as reduced dry-season stream flow, and might have other knowledge that can help to prioritise certain land uses. The stakeholders should work together to build a map that identifies potential forest restoration sites within a matrix of other desirable land uses. The processes and skills required to run effective participatory appraisals is beyond the scope of this book, but decision-support tools, such as participatory mapping, scenario analysis, role-playing games and market-based instruments have all been well reviewed by Lamb (2011), and a comprehensive body of literature has emerged from practitioners of community forestry (e.g. Asia Forest Network, 2002; www.forestlandscaperestoration.org and www.cbd.int/ecosystem/sourcebook/tools/).

The landscape character assessment should identify i) desirable landscape characters that should be conserved, ii) problems with the current landscape management and iii) the potential benefits of restoration. Field trips should include participatory assessments of i) remnants of the target forest ecosystem if present (see **Section 4.2** above) and ii) potential restoration sites (see **Section 3.2**).

The main output of landscape character assessment is a map, showing current land-uses, desired landscape features that should be conserved and degraded sites that require restoration. The map may show several sites that are potentially suitable for restoration, so the next step is prioritisation. It may be tempting to restore the less-degraded areas first, because their restoration will cost less and is perceived as having a better chance of success, but this may not be the best option. Consider each of the following issues:

- the condition of each degraded site and the time and effort required to restore each of them;
- whether forest restoration could adversely impact an existing habitat of high conservation value (e.g. wetlands or natural grassland) on the site or in the vicinity;
- whether a restored site will contribute to the conservation of biodiversity in the wider landscape, by expanding the area of natural forest, by serving as a buffer, or by reducing forest fragmentation.

Forest fragmentation

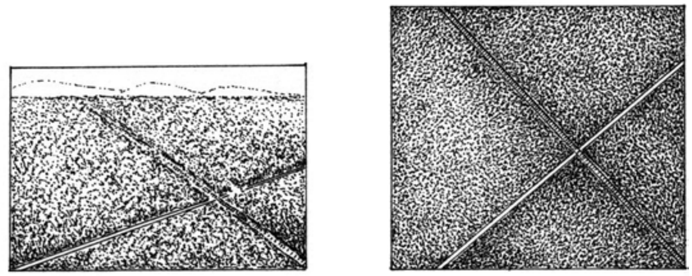
Fragmentation is the sub-division of large forest areas into ever-shrinking pieces. It occurs when large, continuous areas of forest become dissected by roads, cultivated land and so on. Small, disconnected forest patches can shrink even further because of edge effects: damaging factors that penetrate a forest fragment from the outside. These might include light that promotes weed growth, hot air that desiccates young tree seedlings, or domestic cats that prey on nesting birds. Small fragments are more vulnerable to edge effects than large ones, because the smaller the fragment, the greater is the edge to total area ratio.

A well-known example of fragmentation is the result of road construction in Brazilian Amazonia. The roads, often constructed to facilitate oil and gas exploration, allowed loggers, illegal hunters and cattle ranchers to follow. The resulting forest fragments are prone to edge effects, which can impact ecological processes over a perimeter area of at least 200 m in depth (Bennett, 2003). If such fragmentation continues, much of the Amazon could be converted to fire-prone scrub vegetation (Nepstad *et al*., 2001).

Fragmentation has important implications for wildlife conservation because many species require a certain minimum area of continuous habitat in order to maintain viable populations. Often, these species cannot disperse across inhospitable farmland, roads or other barriers of 'non-habitat'. Few forest animal species can traverse large non-forested areas (the exceptions being some birds, bats and other small mammals). Up to 20% of the bird species found within tropical forests are unable to cross gaps of more than a few hundred metres (Newmark, 1993; Stouffer & Bierregaard, 1995). This means that large animal-dispersed seeds are rarely transported between forest fragments.

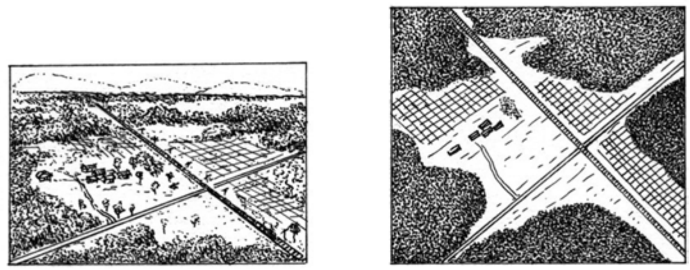
DISSECTION

Roads, railways, power lines etc. cut into a large expanse of forest..



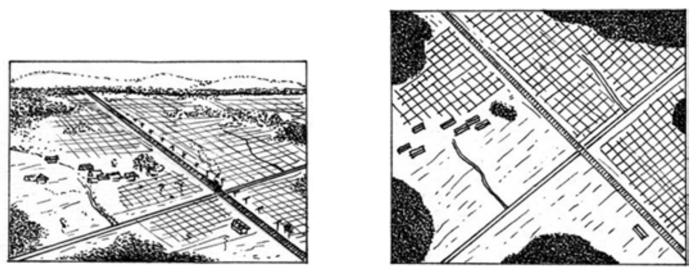
PERFORATION

Holes develop in the forest as settlers exploit the land along the lines of communication.



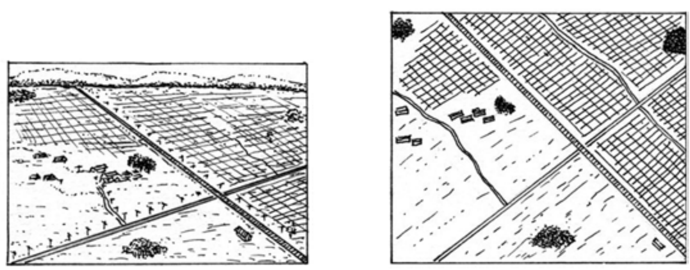
FRAGMENTATION

The gaps become larger than remaining forest.



ATTRITION

Isolated forest remnants are gradually eroded by edge effects.



Tiny forest fragments can support only very small populations of animals, which are highly vulnerable to extirpation. Once gone, species cannot return because migration between forest patches is hindered by vast areas of agricultural land or dangerous barriers such as roads. Restoring wildlife corridors to re-link forest fragments can overcome some of these problems and help to create viable wildlife populations in a fragmented landscape.

The resulting small, isolated plant and animal populations are easily wiped out by hunting, diseases, droughts and fires, which would not normally eliminate larger, more resilient, populations in larger forest areas. Genetic isolation and inbreeding further increase the risk of extirpation. In one fragment after another, small species populations disappear and cannot be re-established by migration, so that eventually the species becomes extirpated across the whole landscape (see **Section 1.1**). Re-colonisation is made impossible because inhospitable terrain (such as agricultural or urban land) between forest fragments blocks the dispersal of potential new founder individuals of extirpated species.

4.4 Choosing sites for restoration

Forest restoration can be relatively costly in the short term (although it is more cost-effective than allowing degradation to be continued), so it makes sense to implement it first where it will generate maximum ecological benefits, such as protecting watercourses, preventing soil erosion and reversing fragmentation.

How can fragmentation be reversed?

Small fragments of forest that are re-linked have a greater conservation value than those that are left isolated (Diamond, 1975). Forest restoration can be used to establish 'wildlife corridors' that reconnect forest fragments. They provide wildlife with the security needed to move from one forest patch to another. Genetic mixing recommences and, if a species population is extirpated from one forest patch, it can be re-founded by immigration of individuals along the corridor from another forest patch. Wildlife corridors can also help to re-establish natural migration routes, particularly for species that migrate up and down mountains.

The concept of wildlife corridors is not without controversy. For example, the corridors could be become 'shooting galleries', encouraging wildlife out from the safety of conservation areas and making them easy targets for hunters. Corridors might also facilitate the spread of diseases or fire. Early corridors were created with little guidance as to their location, design and management (Bennett, 2003), but there is growing evidence to suggest that the benefits of corridors outweigh the potential disadvantages. In Costa Rica, for example, riparian corridors have successfully connected fragmented bird populations (Sekercioglu, 2009), and in Australia, it was recently confirmed that genetic mixing among small mammals can be re-established by linking forest patches by even narrow corridors (Tucker & Simmons, 2009; Paetkau *et al*., 2009) (see **Box 4.1**, p. 96). Also in Australia, linear forest remnants of 30–40 m wide have been found to support the movement of most arboreal mammals, although the quality of the forest is very important (Laurance & Laurance, 1999).

How wide should a corridor be?

The wider the corridor, the more species will use it. Bennett (2003) recommended that corridors should be 400–600 m wide so that the core vegetation is buffered against edge effects and thus animals and plants of the forest interior are attracted. Nevertheless, the Australian example (see **Box 4.1**) shows that corridors as narrow as 100 m can effectively reverse genetic isolation, provided they are well-designed to minimise edge effects. Corridors of this width can be used by small to medium-sized mammals and forest floor birds, which cannot cross open land (Newmark, 1991). Large vertebrate herbivores are more likely to use corridors that are wider than 1 km, whereas large mammalian predators prefer even wider corridors (of 5–10 km in width). A reasonable strategy is to start by restoring a narrow forest corridor and then gradually widen the corridor each year by planting more trees while keeping records of the species observed travelling along it.

Box 4.1. Framework species for creating corridors.

The Atherton Tablelands in Queensland, Australia, was once covered in upland rain forest, providing habitat for a huge diversity of plant and animal species. Among these, the spectacular southern cassowary (*Casuarius casuarius johnsonii*), a large flightless bird, is a major seed disperser within these forests and now a critically endangered species. European settlers were first attracted to the area in the 1880s by the opportunities for logging and subsequently land was cleared for livestock and crop production. By the 1980s only a few fragments of the original rain forest remained in parts of the Atherton Tablelands, and these contained small genetically isolated wildlife populations each heading towards an uncertain future.

Wildlife corridors were planned to reconnect isolated forest fragments and to monitor wildlife migration through these new linkages. Donaghy's Corridor was the first such linkage, intended to link the isolated Lake Barrine National Park (491 ha) to the much larger Gadgarra State Forest block (80,000 ha). The corridor was established by planting framework trees species in a belt 100 m wide along the banks of Toohey Creek, which meandered for 1.2 km through grazing lands. With its emphasis on enhancing seed dispersal from nearby forest, the framework species method was the obvious choice for creating such a corridor.

Agreement was reached with the farm owners, by incorporating their needs into the project; for example, by providing watering points and shade trees for cattle. The Queensland Parks and Wildlife team at the Lake Eacham National Park tree nursery formed a partnership with a community group, TREAT (Trees for the Evelyn and Atherton Tablelands), that would grow and plant over 20,000 trees between 1995 and 1998. In addition to cattle management, other key design points included planting windbreaks to minimise edge effects, a rigorous maintenance program (including weeding and fertiliser application) and long-term monitoring of plant and animal colonisation.

Trees planted to establish Donaghy's corridor, February 1997.

Box 4.1. continued.

The same area in February 2010.

Recovery of the vegetation along the habitat linkage was rapid, with 119 plant species colonising transects within the corridor after 3 years. Several planted tree species fruited very quickly after planting; for example, *Ficus congesta* produced figs after 6–12 months. Several studies, using mark-recapture and genetic analysis, showed that the corridor did indeed promote the migration of wildlife and re-established genetic mixing (Tucker & Simmons, 2009; Paetkau *et al*., 2009), providing a more secure basis for longer-term population viability.

The involvement of the community group, right from the start, has resulted in widespread interest in both the framework species method and in habitat linkages. Several other linkages are now being restored throughout the region and beyond, some of them many kilometres long.

One of the most difficult aspects of creating long corridors across private land is securing the collaboration of all of the landowners along the route. But according to Nigel Tucker (see **Box 3.1**, p. 80), it may not be necessary to get everyone on board before the project starts. "We work first with the landowners who agree. The other landowners are won over later, when they see their neighbours benefiting from the corridor. It's all about building relationships and securing collaboration with a handshake — more important than formal contracts".

This well-studied demonstration site proved that corridors support the conservation of biodiversity. Now, several corridors link forest fragments across the Atherton Tablelands.

By Kwankhao Sinhaseni

Where should corridors be created?

Not all forest fragments have equal ecological value. Large fragments and those that have most recently become isolated from larger forest areas retain more biodiversity than smaller and older fragments. So, forest corridors that reconnect large and recently formed forest fragments have greater ecological value than those that reconnect smaller, older fragments. If fragments are known to retain populations of endangered species, their reconnection with large forest patches should also receive high priority (Lamb, 2011).

What about stepping stones?

There may be insufficient funds to link all forest fragments with continuous corridors, and in this situation 'stepping stones' might be more achievable. Stepping stones are islands of restored forest, created primarily to facilitate the movement of wildlife through hostile landscapes such as farmland. Stepping-stone habitats might also enhance natural regeneration in surrounding degraded areas by encouraging visits from seed-dispersers, which might deposit seeds from remnant forest areas in which they had previously fed. Once the planted and naturally regenerating trees reach maturity, they will also become sources of seed in their own right, leading to continued forest regeneration both within and outside the boundaries of the 'stepping stone'.

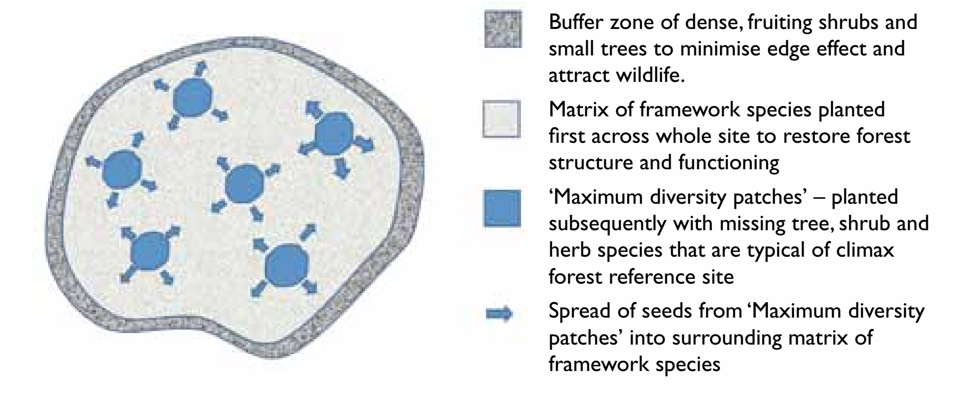
Size and shape of 'stepping stones'

Any small-scale restored site can suffer the disadvantages of small forest fragments, so the design of 'stepping stones' is important. The shape of the restoration plot should have a minimal edge to area ratio. As a rough guide, try to make the length and width of 'stepping stones' approximately equal and do not plant trees in long, narrow plots, unless your objective is to establish a wildlife corridor. A buffer zone of dense, fruiting shrubs and small trees should be planted around the edge of the restoration site to act as a wind break and to reduce edge effects still further. The rest of the 'stepping stone' can be planted with framework tree species to re-establish forest structure and attract seed dispersers.

Generally speaking, large forest plots support more biodiversity recovery than small ones. Soule and Terborgh (1999) suggest that, ideally, rapidly increasing forest cover to 50% of the landscape minimises further loss of species. Nevertheless, small restoration plots can have significant positive benefits for biodiversity conservation, especially if they are well designed in terms of tree species composition, minimisation of edge effects (buffer zones) and increasing forest connectivity. Thus, the quality and positioning of restoration plots can help to compensate for their small size (p. 448 of Lamb, 2011).

Restoring large sites

The size of the plots that are restored each year will depend on the availability of land, funding, and labour for weeding and caring for the planted trees during the first two years after restoration work commences (see **Section 4.5**). Large sites will require large quantities of seed. Seed of the relatively low number of framework species can be acquired by carefully planned advance collection and storage. But where the maximum diversity approach is to be used on heavily degraded land (see **Section 3.1**), it may be



Suggested plan for a large forest restoration site that is far away from nearest area of remnant forest. NB: Planted area is roughly circular in shape to minimise edge effects.

impossible to acquire sufficient seed to plant all the required species across the whole site. In such cases, an alternative approach is to plant the entire site with framework tree species so as to re-establish forest structure and attract seed dispersers, and then to create smaller 'maximum diversity patches' within the framework tree matrix using the 'maximum diversity' technique (see **Section 5.4**).

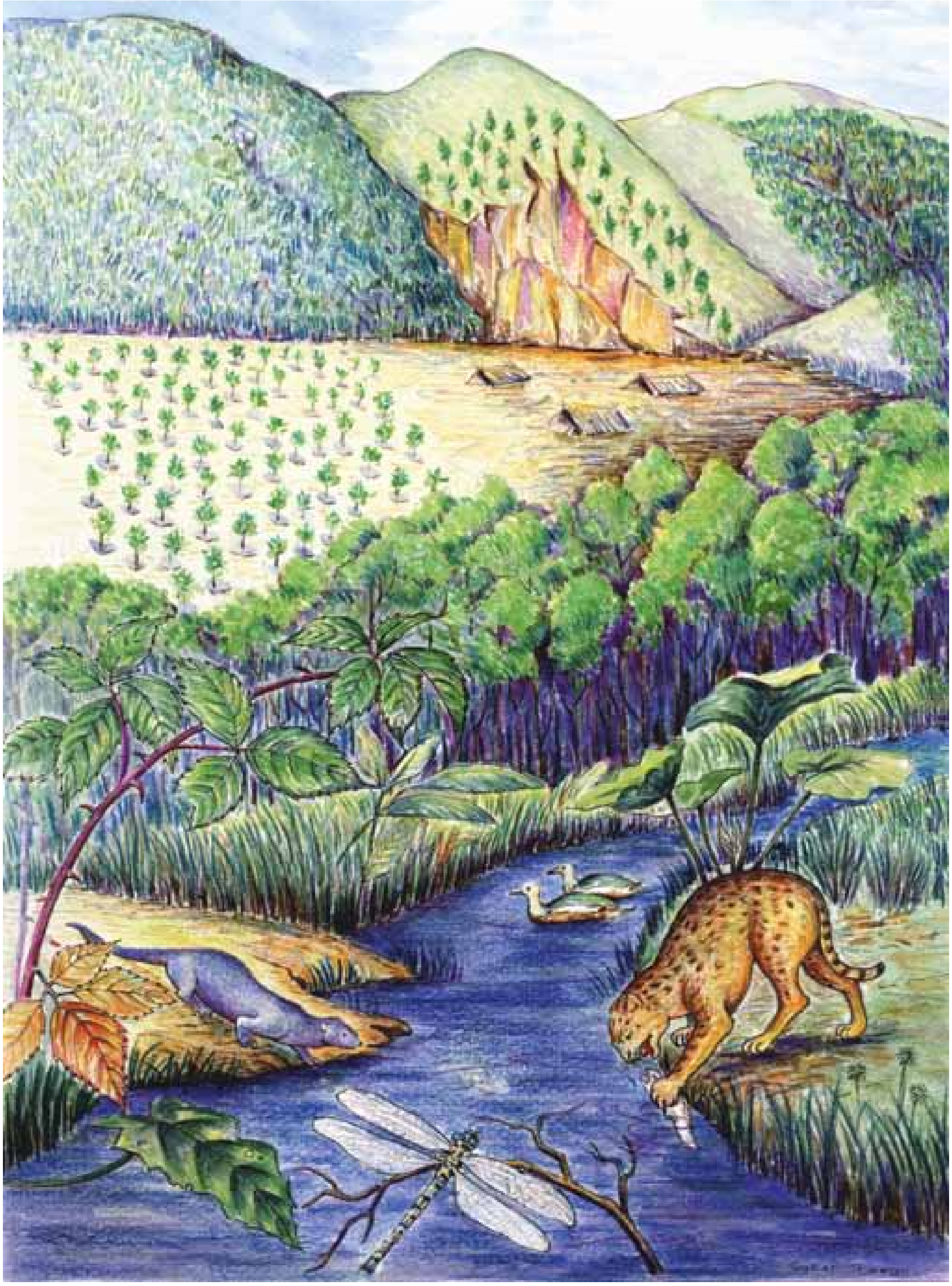
Restoration for water and soil conservation

The effects of deforestation and forest restoration on water and soil are explained in **Sections 1.2** and **1.4**. Both the regularity of water supplies and water quality can be improved by targeting upper watershed sites, particularly those around springs, for restoration. Although trees do remove water from the soil by transpiration, they more than make up for this by increasing the soil's water-holding capacity through the addition of organic matter, so that it can absorb more water during the rainy season and release it during dry periods. In this way, forest restoration can convert seasonally dry streams into permanently flowing ones, and can also help to reduce the amount of sediment in water supplies.

Planting along stream banks creates riparian habitats, which are essential for specialised species (from dragonflies to otters) that live in or beside sheltered streams. Such habitats also serve as essential refuges for many other, less specialised animal species during the dry season, when neighbouring habitats dry out or burn. Riparian tree-planting also prevents stream bank erosion and the clogging of stream channels with silt. This reduces the risk of streams bursting their banks leading to flash floods in the rainy season.

Soil erosion reduces the capacity of a water catchment to store water, which contributes to both floods in the rainy season and droughts in the dry season. Landslides may be considered to be the most extreme form of soil erosion. They can occur with such suddenness and force that they can completely destroy villages, infrastructure and agricultural land and can lead to loss of human life. Forest restoration can help reduce both soil erosion and the frequency and severity of landslides because tree roots bind the soil, preventing the movement of soil particles. Leaf litter also helps to improve soil structure and drainage. It increases the penetration of rainwater into the soil (infiltration) and reduces surface run-off.

For maximum conservation value, restore forest wildlife corridors to link forest patches and create permanent forest to reduce the risk of soil erosion or landslides and to protect water courses and their associated riparian wildlife.



To prevent soil erosion and landslides, restoration should be targeted at mountainous sites with long, steep, uninterrupted slopes. Erosion gullies and cleared sites with slopes exceeding 60% should be completely restored with dense vegetation (Turkelboom, 1999). Sites with more moderate slopes may be stabilised with less than 100% cover if the restoration plots are strategically placed to follow the slope's contours. Most countries have a national watershed classification system, with maps showing the relative risk of soil erosion in any particular area. Ask your local agricultural extension service to consult such maps to determine the extent to which forest restoration might help to reduce erosion in your locality.

Who owns the land?

When undertaking conservation activities, the last thing you want is a land dispute.

When restoring forest on public land, obtain written permission that includes a map to confirm the location of the site from the relevant authorities. Most authorities welcome help with forest restoration from community groups and NGOs, but obtaining written permission can take a long time, so start discussions at least a year before the intended planting date. Ensure that all relevant officials are fully involved in project planning. Everyone involved should understand that planting trees does not necessarily constitute a legal claim to the land, and local people will require assurance that they can access the site to implement restoration activities and/or to harvest forest products.

If planting on private land, make sure that the landowner (and his/her heirs) are fully committed to maintaining the area as forest by obtaining a memorandum of understanding or conservation agreement. Tree planting considerably increases the value of private property, so private landowners should fully cover the costs.

With the potential looming on the horizon for huge sums of money to be made by selling carbon credits under REDD+, part of the UN's Reducing Emissions from Deforestation and Forest Degradation (REDD) programme, the issue of 'who will own the carbon' has become almost as important as 'who owns the land'. Arguments over how the benefits from carbon trading will be shared amongst the various stakeholders can lead to project failure. If any of the stakeholders who contribute to the project are subsequently excluded from sharing carbon revenue, they may decide to burn the restored forest. It is therefore essential to resolve issues of ownership and/or access to land, carbon and other forest products with all stakeholders during the project-planning process.

4.5 Drafting a project plan

Once all of the stakeholders have contributed to the pre-planning activities, it is time for formal meetings to draft the project plan.

A project plan should include:

- the aim and objectives of the project;
- a clear statement of the expected benefits from the project and an agreement as to how these benefits will be shared amongst all stakeholders;
- a description of the site to be restored;
- the methods that will be used to restore forest to the site, including provisions for monitoring (and research);
- a task schedule, detailing who will be responsible for each task and calculation of the labour required to complete each task;
- a budget.

Aim and objectives

All activities depend on the project's aim and objectives. Outline the overall aim of the project (e.g. 'to secure water supplies', 'to conserve biodiversity' or 'to reduce poverty'), followed by more specific statements of the immediate project objectives (e.g. 'to restore 10 hectares of evergreen forest in location X to create a wildlife corridor between Y and Z'). The 'target forest' survey (see **Section 4.2**) will provide the detailed technical objectives, such as the forest type, structure and species composition, that the project aims to achieve.

Benefit-sharing agreement

List the full range of benefits from the project and how each benefit will be shared among the stakeholders. Once consensus is reached, all stakeholders should sign the agreement.

Table 4.1. Example of a benefit-sharing matrix.

Benefit	Protected area authority	Local villagers	Funder	NGO	University
Payments for project labour	30%	60%	0%	10%	0%
Non-timber forest products	0%	100%	0%	0%	0%
Water	50%	50%	0%	0%	0%
Ecotourism income	40%	50%	0%	10%	0%
Sale of carbon credits	30%	40%	10%	20%	0%
Research data	30%	0%	0%	10%	60%
Good publicity	20%	20%	20%	20%	20%

Where the benefits are monetary (e.g. income from carbon trading, income from ecotourism) the shares agreed in the project plan may serve as the basis for more formal legal contracts when that income is realised. A table like this serves to emphasise the range of different non-monetary benefits and their various values to the various stakeholder groups. For example 'good publicity' might result in an unquantified increase in revenue for a corporate sponsor, whereas to local villagers, it may serve to strengthen their right to remain living in a protected area or it could attract ecotourists.

When drafting the benefit-sharing agreement, it is also necessary to ensure that potential beneficiaries are aware of any legal restrictions to realising any of the benefits (e.g. laws that prohibit the collection of certain forest products), as well as any further investment that might be required before a benefit can be realised (e.g. investment in ecotourist infrastructure). Each stakeholder group can then decide for themselves how the project benefits will be shared amongst their members (e.g. how water is shared amongst downstream landowners).

Intangible benefits may be valued differently by different stakeholder groups. Good publicity might strengthen the right of ethnic minorities to live within a protected area, whereas for a corporate sponsor, it may attract new customers.

Site description

The restoration site survey report (see **Section 3.3**) provides all the details needed for the site description. It should be supplemented with annotated maps and/or satellite images and photographs. A sketch of how the landscape might appear after restoration is also useful.

Methods

The restoration site survey report also provides most of the information needed to determine the methods required to implement the restoration project. For example, it will help to determine which protective measures are required, the balance between tree planting and ANR, which ANR actions to implement, how many trees and which species should be planted and so on. Formally listing the methods that will be used in the project plan makes it easy to identify the actions required to implement them and thus to develop a task schedule. More details about the methods needed to implement the major forest restoration strategies are provided in **Chapter 5**.

Table 4.2. Example task schedule for the restoration of a seasonally dry tropical forest in a protected area by planting framework tree species in combination with ANR.

Task	When	Stakeholder with responsibility for organisation
Time before planting event		
Stakeholder consensus reached, survey target forest and potential restoration sites, start nursery establishment	18–24 months	Protected area authority
Draft project plan, final decision on restoration sites	18–24 months	Protected area authority
Start seed collection and germination	18 months	NGO and local community
Monitor sapling production, supplement with trees from other nurseries if necessary	6 months	NGO
Harden-off saplings, arrange planting teams	2 months	Local community
Label saplings to be monitored	1 month	Local community
Site preparation: identify and protect natural regenerants, clear site of weeds	1 month	Local community
Transport saplings and planting equipment to site, brief planting team leaders	1–7 days	Protected area authority
Planting event	0 days (early wet season)	Protected area authority
Time after planting event		
Check planting quality, adjust any badly planted saplings, remove rubbish from site	1–2 days	Local community
Collect baseline data on trees to be monitored	1–2 weeks	University researchers
Weeding and fertiliser application as required	During first wet season	Local community
Monitor growth and survival of planted trees	End of first wet season	University researchers
Cut fire breaks if necessary, organise fire patrols	Start of first dry season	Local community
Monitor the growth and survival of planted trees, weeding and fertiliser application as required, assess the need to replant any dead trees	End of dry season	University researchers
Maintenance planting as required	Start of second wet season	NGO
Continue weeding and fertiliser application as required	Second wet season	Local community
Monitor the growth and survival of planted trees	End of second wet season	University researchers
Continue weeding in wet season until canopy closure, monitor tree growth as necessary, monitor biodiversity recovery	Subsequent years	Local community

Task schedule

List the tasks needed to implement the methods chronologically and assign responsibility for organising each task to the stakeholder group that has the most suitable skills and resources (see **Table 4.2** for an example).

Note that a monitoring program is included in the schedule. Monitoring is an essential component of the project plan, important both to demonstrate project success (hopefully) and to identify mistakes and ways to avoid them in the future. It should involve assessments of both tree performance (both of planted trees and natural trees subjected to ANR treatments) and biodiversity recovery (see **Section 7.4**).

Underestimation of the total time required to implement forest restoration projects is a common mistake. If trees are grown locally from seed, nursery construction and seed collection must begin 18 months to 2 years before the first planned planting date.

Budget

Calculating labour requirements

The availability of labour is the crucial factor that determines the maximum area that can be restored each year. It is also likely to be the most costly item in the project budget, so calculation of labour requirements determines overall project viability.

Grand schemes, with ambitious aims to replant vast areas, often fail because they do not take into account the limited capacity of local stakeholders to carry out weeding and fire prevention. The effort required to produce very large numbers of saplings of the correct species is also commonly underestimated. It is therefore better to restore smaller areas (which can be adequately cared for by the locally available labour force) annually, over many years, than to plant trees over a large area in one high-profile event, only to see the planted trees subsequently die of neglect.

Where local villagers provide most of the labour for a forest restoration project, tasks can be organised as community activities. For example, a village committee might request that each family in the village provides one adult to work on each day that a scheduled task is to be carried out. The maximum area that can be restored each year, therefore, depends on the number of participating households. As community size increases, an 'economy of scale' comes into effect, meaning that a larger area can be planted with fewer days labour input per household.

At the outset of any forest restoration project, all stakeholders must be aware of the labour commitments. Project planners must also address the crucial issue of whether labour will be donated voluntarily or whether daily rates for casual labour must be paid. If the latter, then labour costs will dominate the budget. If local villagers appreciate the benefits of forest restoration and an equitable benefit-sharing scheme is included in the project plan, they are often willing to work on a voluntary basis to secure those benefits.

Table 4.3 outlines the labour requirements for some of the most common forest restoration tasks. Note that some tasks are required only during the first year of the project, whereas others must be repeated for up to 4 years after the first planting, depending on conditions.

Table 4.3. Checklist of the main labour requirements for the most common forest restoration tasks (for sites with stage 1–3 degradation (see Section 3.1)).

	Labour required (person days) per hectare per year	Explanation	Annual requirement (years 1 to 4) Y1	Y2	Y3	Y4
PROTECTION						
Fires breaks	Fire break length (m) divided by 30 to 40	Assumes 1 person can cut 30–40 m of fire break (8 m wide) per day (depending on vegetation density). Calculate from the length of the perimeter of the restoration site.	+	+	+	?
Fire 'look outs' and suppression team	16 × no. of days in the fire season	Teams of 8 people working in two 12-hour shifts (day and night), throughout the hot dry season can take care of sites from 1–50 ha.	+	+	+	?
ANR						
Locating and marking regenerants	12	3,100 regenerants/ha ÷ 250 (average/person/day)	+	–	–	–
Weed pressing	30	1,000 m^2 (average/person/day) × 3 times/year (for 3 years).	+	+	+	?
Ring-weeding	50	3,100 regenerants/ha ÷ c. 180 (average/person/day) x 3 times per year (for 3 years).	+	+	+	?
TREE PLANTING						
Site preparation	25	Slashing weeds followed by glyphosate application (see **Section 7.1**).	+	–	–	–
Planting	No. of trees to plant/ha divided by 80	No. of trees to plant = 3,100 – the no. of regenerants/ha (see **Section 3.3**). One person can plant about 80 trees/day (following the methods described in **Section 7.2**).	+	–	–	–
Weeding and fertiliser application	50	3,100 trees/ha (including natural regenerants + planted trees) ÷ c. 180 (average/person/day) × 3 times per year (for 2 years).	+	+	–	–
Monitoring	32	16 people can monitor 1 ha/day. Monitor twice per year (at the beginning and end of main growing season). For large sites, randomly select a few sample hectares for monitoring.	+	+	+	+

Calculating costs

The costs of restoration vary considerably with local conditions (both ecological and economic) and increase markedly with degradation stage. Therefore, we can only present guidelines for cost calculations as any estimate of actual costs would quickly become out of date. Make sure that all expenditure is carefully recorded, to enable a cost–benefit evaluation of the project in the future and to assist other local initiatives in planning their own projects.

The restoration of degradation stages 3–5 involves tree planting, so nursery costs should be included in the project budget. Construction of a simple community nursery need not be expensive: for example, the use of locally available materials, such as bamboo and wood, will keep costs down. Tree nurseries last many years, so nursery construction costs represent only a very small component of tree production costs. Reduce the costs of materials by using locally available media, such as rice husk and forest soil, instead of commercially produced potting mixes. Although many such local materials are essentially 'free', don't forget to factor in the labour and transportation costs of collecting them. The only essential nursery items for which there is no effective natural substitute are plastic bags or other containers and a means of delivering water to the plants.

A nursery manager should have overall responsibility for running the nursery and ensuring the production of enough trees of sufficient quality and of the required species. This may be a full-time or part-time salaried position, depending on the numbers of saplings to be produced. Casual labour can be voluntary or paid a daily rate as required. Nursery work is seasonal, with the heaviest workload just before planting and lighter workloads at other times of the year. Nursery staff should also be responsible for seed collection. For a typical nursery, the production rate should be 6,000–8,000 trees produced per nursery staff member per year.

Budget lines for tree production should therefore include:

- construction of a nursery (including a watering system);
- nursery staff;
- tools;
- supplies, e.g. germination trays, containers, media, fertiliser and pesticides;
- water and electricity;
- transportation (for provisioning, seed collection and delivering trees to the restoration site).

Tree planting, maintenance and monitoring costs can be divided into i) labour, ii) materials and iii) transportation. Labour is by far the largest budget item, with fire prevention being the largest labour cost. Therefore, the financial viability of forest restoration often depends on the extent to which paid labour can be replaced with volunteers. It is usually very easy to find people from local schools and businesses to help out on planting day. Fire prevention is also an activity that is usually organised by village committees as a 'community activity'. Therefore, weeding and fertiliser application are the two activities most likely to require paid labour.

To calculate labour costs, begin with the estimated labour inputs suggested in **Table 4.3**. Select those tasks that have been included in your task schedule and remove any for which voluntary labour is assured. Sum up the total person-days labour required for all tasks for year 1 and multiply the sum by the number of hectares to be restored and by the acceptable daily payment for labour. Next, consider how many tasks must be repeated in year 2 and repeat the calculation of labour costs, except add a percentage increase to the daily payment to account for inflation. By year 3, the amount of labour required for weeding and fertiliser application should fall considerably as canopy closure begins to take effect. Therefore, delay calculating labour costs for subsequent years until the progress achieved in years 1 and 2 is assessed.

Materials for planting include glyphosate (a herbicide), fertiliser, and a bamboo pole and possibly a mulch mat for each tree to be planted. Calculate the cost of applying 155 kg of fertiliser per hectare (assumes 50 g per tree × 3,100 (both planted and natural regenerants)) four times in the first year and three times in the second year. If using glyphosate to clear weeds, calculate the cost of 6 litres of concentrate per hectare.

4.6 Fundraising

Having drafted a plan and calculated a budget, the next stage is fundraising. Funding for forest restoration projects can come from many different sources, including governments, NGOs and the private sector, both local and international. A vigorous fundraising campaign should target several potential funding sources.

Corporate social responsibility (CSR) schemes have traditionally been a large source of sponsorship for tree planting events, in return for promoting a 'green image' for the sponsors. Contact local companies involved in the energy industry (e.g. oil companies), in the transportation industry (e.g. airlines, shipping agencies or car manufacturers), or in industries that benefit from a greener environment (e.g. the tourist industry or food and drink manufacturers), as well as companies that have adopted trees or wildlife as their logos.

Application procedures for private-sector grants and the administration of them are usually straightforward. However, before accepting corporate sponsorship, consider ethical issues, such as the use of your project to promote a green image for a company that might be engaged in environmentally damaging activities. To avoid such dilemmas, make sure that the project is supported by a company's social responsibility fund, not by its advertising budget, and check the contract thoroughly.

The recent surge of interest in tropical forests as carbon sinks should increase the corporate sponsorship of restoration projects. It could, however, be having the reverse effect because many companies now only sponsor tree planting projects in return for voluntary carbon credits. This requires that projects register with one of a plethora of organisations[2] that have recently set up standardisation schemes, which monitor projects to verify the additional amount of carbon stored and to ensure that they have no adverse effects. Such services currently cost from US$5,000–40,000 and registration can take up to 18 months. Having to find such hefty start-up costs is now effectively excluding smaller projects from corporate sponsorship and the lengthy and complicated registration process delays project implementation.

[2] Such as Carbon Fix Standard (CFS, www.carbonfix.info/), Verified Carbon Standard (VCS, www.v-c-s.org/), Plan Vivo (www.planvivo.org/), and The Climate Community and Biodiversity Standard (CCBS, www.climate-standards.org/).

For smaller projects, charities and foundations are often a good source of funding. They generally provide small grants with uncomplicated reporting and accounting procedures. Domestic government organisations, especially those involved in implementing a country's obligations under the Convention on Biological Diversity (CBD), should also be approached. Local government organisations might also provide small grants for environmental conservation.

If you find applying to grant-awarding organizations a bit daunting, then consider running your own fundraising campaign. For small projects, traditional fundraising events (sponsored runs, raffles and so on) may be sufficient to raise the required funds. But such events require a lot of organisation and usually some upfront payments (such as renting venues). The internet now makes it possible to reach out to more people than ever before with minimum effort. Publicising your project over social networks or through a dedicated project website can generate both interest and funding.

A common approach is the 'sponsor-a-tree' campaign. Calculate your total project costs (see **Section 4.5**) and divide that amount by the number of trees that you intend to plant (to get the cost per tree), then ask visitors to your website or Facebook page to sponsor one or more trees. Many websites currently offer such schemes from US$ 4 to US$ 100 per tree. Internet payment systems such as PayPal can be used to transfer the funds. To overcome the impersonal nature of the internet, show your appreciation of donors by providing personalized feedback. Invite sponsors to join tree-planting events and/or provide them with individual pictures of 'their' tree as it grows. One website even directs sponsors to Google Earth images of the planted sites. Learning the ins and outs of website construction and internet payment schemes will take time at the start, but will pay dividends as the project becomes better known.

On its dedicated website, "Plant a Tree Today" offers sponsorship of tree planting in one of many restoration projects from around US$ 4 per tree.

A comprehensive resource for finding funding for restoration projects agencies is the Collaborative Partnership on Forests (CPF) *Sourcebook on Funding for Sustainable Forest Management* (www.cpfweb.org/73034/en/). This excellent website includes a downloadable database of funding sources for sustainable forest management, a discussion forum and a newsletter on funding issues, as well as useful tips on preparing grant applications.