From local changes to landscape changes: how to restore degraded landscapes as well as degraded lands?

David Lamb, Rainforest Cooperative Research Centre, School of Life Sciences, University of Queensland

Introduction

Large areas of the world's forest have been degraded. Some degraded ecosystems are able to recover naturally but many do not. There may be various reasons for this. In some cases it is because too few of the original plant and animal biota remain at the site or because pests and weeds have colonised the site. In other cases some component of the biophysical environment such as soil fertility has changed or repeated disturbances prevents successional development occurring. Even at sites where natural recovery is able to take place, however, the process may be slow. This increases the chance of further disturbances re-occurring and degrading the site even more. For these reasons human intervention may be needed to either initiate the recovery process or to accelerate the rate at which it proceeds.

A variety of approaches might be used. These range from those where the objective is to restore the original ecosystem and recover the former biodiversity through to those where the aim is to simply use the site for some productive purpose such as agriculture. These different approaches have fostered a confused terminology. A distinction is made here between restoration and rehabilitation. *Restoration* is used only for those situations where the intent is to recreate an ecosystem as close as possible to that which originally existed at the site. The site then contains most of the original plant and animal species and has a structure and productivity matching that originally present. (There is some doubt whether Restoration, as define above, is ever possible, especially at sites that have been used or managed by humans for long periods of time. However, it is usually feasible to attempt to recreate species-rich systems that resemble the composition and structure of the originally communities).

Rehabilitation, on the other hand, is used where the original productivity or structure is regained and some, but not all, of the original biodiversity. This might be because commercial imperatives demand certain agricultural or timber species be included to justify the rehabilitation effort or because the site is now unsuitable for some of the original species. The term *Reclamation* is used for those situations where productivity or structure is regained but not much biodiversity. In fact, native species may not even be used at all. In such cases there are no (or few) benefits to regional biodiversity but there may be social or economical advantages or functional gains such as in improved watershed protection. The three approaches differ in the extent to which they enable the original biodiversity to be regained. The approaches are similar, however, in that they all seek to establish a productive and stable new land use.

Why undertake restoration or rehabilitation?

If a network of protected areas is established, why is it necessary to be concerned about restoration or rehabilitation? Why not use degraded lands solely for production (i.e. use only the approach referred to earlier as reclamation)? After all, such reforestation has been widely undertaken in many places and can be financially successful. There are several reasons for being more ambitious. One is because these approaches are more likely to improve the long-term sustainability of land use because they improve biodiversity and ecosystem functioning. The other reason is because they are likely to provide a wider range of ecological services. That is, these approaches are more likely to improve ecological integrity and human well-being than will most forms of reclamation.

Methods of Restoration and Rehabilitation

There are a variety of ways in which restoration might be undertaken. These are shown in Table 1. All assume animals will subsequently colonise the site from forests remaining in the landscape.

Table 1. Methods of undertaking Restoration.

Method	Comment
Passive restoration	Control exotic species; protect from further disturbances.
Enrichment of regrowth	Plant endangered species
Direct seeding	Only suitable when weeds can be controlled
Scattered tree plantings	Utilises well-known "perch tree" effect
Dense plantings of few species	Excludes weeds; provides framework for colonists.
Dense plantings of many species	Maximises diversity (but unlikely to be able to replant all)

The choice of which approach to use depends on the extent to which species remain at the site (as residual trees, in the soil seedbank, as seedlings or root systems etc.), the distance to intact forest, the nature of the lands colonists must move across to reach the site being restored, the soil fertility and the resources available for Restoration. Each approach has advantages and disadvantages. Perhaps the largest disadvantage, however, is that most approaches are either slow or expensive. This means they are often difficult to apply over large areas (although some notable successes have been achieved).

Rehabilitation offers a means of overcoming this disadvantage because it offers landowners some direct financial return. Some of the possible approaches are shown in Table 2.

Table 2: Methods of undertaking forest Rehabilitation

Method	Comment
Manage secondary (regrowth) forests	These often contain high levels of species richness
Enrich secondary forests	Add commercially attractive trees
Agroforestry	Diverse plantings though most species used are common
Monocultures of indigenous species	Use high-value native species instead of exotic species
Monoculture with buffer strips	Embed plantations in a matrix of natural or restored forest
Mosaic of species monocultures	Acquire diversity at a larger scale
Mixed species plantations	More difficult silviculture but potentially several advantages
Foster understorey development	Can be very diverse if natural forest nearby

Forest rehabilitation necessarily involves more complex forms of silviculture and work is currently underway in many countries exploring some of these silvicultural methods. These approaches also usually offer lower levels of species diversity than restoration because of the need to periodically harvest some trees or plants when the forest communities are ecologically "young". This means trade-offs are usually needed to balance the needs of production and biodiversity. The nature of these trade-offs at any particular place will depend on both ecological circumstances (what proportion of the landscape is degraded or already protected) and socio-economic circumstances (what are the patterns of land ownership? What are the food production needs of land users, what are the resources available).

Carrying out restoration and rehabilitation over large areas.

It is comparatively simple to treat small areas of degraded land but more difficult to address land degradation at a landscape level. This has been referred to as the paradox of management – one can most easily create an effect at a small scale but success only comes from changes over a large scale. There are obvious financial and resource difficulties involved but there are also some other problems. These usually involve a mix of bio-physical and socio-economic factors. Four key questions are:

(*i) How much land must be treated to obtain a benefit?*
This obviously depends on how much of the landscape is degraded (and how much is already protected in some way). In some situations it might be desirable to rehabilitate as much of the landscape as possible (e.g. when salinity is widespread or where overall biodiversity is severely threatened). In other cases it might be appropriate to treat only certain key areas (e.g. areas of severe erosion or the habitats of threatened species)

(ii) Which land in the landscape should be treated?
In some cases this is socially determined (e.g. the only land available for treatment is that not wanted for agriculture such as steep hill slopes or areas with poor soils). In some cases it is economically determined (e.g. the land chosen for treatment is that which is most – or least – severely degraded). Or it may be ecologically determined

such as buffer strips along rivers, corridors between patches of residual forest or erosion-prone areas. These are important because of the significance they have for limiting erosion or for facilitating the movement of plants or animals across the landscape.

(iii) How many species should be used?
It is difficult to re-establish all of the original plant species at a site. But we have only an imperfect knowledge of the relationship between diversity and ecological function. Are all species needed to restore ecological function? Must a certain minimum be used to cross some kind of ecological threshold? Or is the *types* of species used that is the crucial factor? These questions are currently the subject of ecological research in many parts of the world.

(iv) What are the consequences of different forms of diversity?

Diversity can be assessed at several scales. For example the numbers of species can be measured in a particular area (e.g. one hectare) or as the cumulative number present across a large landscape. Which measure of diversity has the greater ecological significance? The question can be posed in terms of two alternative forms of plantation – a mixed species plantation involving three species or three separate monoculture plantations of the same species spread over the same area. The latter format is obviously easier to manage than the former. At present we do not know the answer to this question although it is probably depends on what ecological function is being targeted (e.g. erosion protection? Habitat creation? Salinity reduction, etc.).

Adopting restoration and rehabilitation in practice

It is going to take some time before restoration or rehabilitation will be adopted widely in preference to the more traditional approach referred to here as reclamation. Adoption is more likely to occur if disincentives are reduced and benefits are increased. Disincentives include a lack of access to appropriate seeds or seedlings, a lack of knowledge about where these can be most appropriately planted and information about relevant pests and diseases and methods of control these. Other disincentives are that silvicultural methods for establishing and managing these native species in plantations are often seen as being too complex or involved to be worth the additional trouble. But even some disincentives can be overcome if the benefits from the new types of forest are large. These benefits may come from higher productivity or from greater financial returns. The greater returns may be from the higher quality products or from the value of the ecological services being provided. Ways must be found of ensuring landowners share in these additional benefits as well as in any costs. The ecological and socio-economic complexities of most situations are such that most landscapes will require a diversity of approaches to be used rather than just a single approach.