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# Restoring Tropical Montane Forests

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## Key Points to Retain

Many characteristics of tropical montane forests make them a unique habitat for biodiversity, but they also have important economic and social values such as providing protection from landslides, and steady and clean water downstream.

Tools and approaches for restoring montane forests are not very different from those used in the lowlands; however, factors that may influence the outcome of a given restoration activity in montane areas are steep, erosion prone slopes, exposure to strong winds, and slow plant growth rates.

In the context of landscape scale restoration, there is a need to address the ecological and social linkages between tropical montane forests and their surrounding lowlands.

## 1. Background and Explanation of the Issue

### 1.1. Main Characteristics of Tropical Montane Forests

Drastic changes in elevation, precipitation, and direction of prevailing winds across small altitudinal ranges generate high levels of species' and habitat diversity in tropical montane forests. Also, because of their cool ambient temperatures, tropical montane forests serve as refugia of relict tree populations that are more typical of temperate latitudes. Moreover, tropical montane forests are home to unique vertebrate fauna—for example, mountain gorillas (*Gorilla beringei beringei*) in Africa, quetzals (*Pharomachrus mocinno*) in Central America, and spectacled bears (*Tremarctos ornatus*) in South America—and serve as elevational corridors for many bird species during times of seasonal food scarcity. Tropical montane forests are sometimes found as isolated patches within a matrix of either contrasting climate conditions (e.g., surrounded by desert vegetation such as in northwestern Venezuela) or vegetation types (e.g., surrounded by pine-oak forest in Mexico), which adds to their conservation value.

Other key characteristics of tropical montane forests are steep slopes with associated thin, infertile soils, chronic exposure to strong winds, low levels of solar radiation, and reduced rates of organic matter decomposition, all of which contribute to overall slow plant growth. From a restoration perspective, this means that recovering desired levels of forest structure and composition may take longer than in the surrounding lowlands.

### 1.2. Socioeconomic Rationale for Restoring Tropical Montane Forests

Restoration of tropical montane forests can fulfil both economic and conservation objectives. Landslides, for example, are a major source of damage to roads, dams, and human settlements in many montane areas. By restoring forest cover in deforested, landslide-prone sites, further mass erosion can be minimised through substrate stabilisation. In human-deforested areas, restoration of tropical montane forests may also be justified for the provision of environmental services as they play a critical role in the local hydrological cycle due to their role in cloud interception, especially in areas that do not receive much precipitation. Forest conservation elsewhere, however, may need to be actively linked to forest restoration in the uplands. For example, reduced forest cover in lowland areas could leave adjacent montane forests with not too many clouds to intercept.[370]

### 1.3. Restoring Montane Forests in the Face of Natural Disturbance

Although suppressing human disturbances such as fire and uncontrolled grazing is a key initial strategy of a given restoration initiative, taking into account the effects of natural disturbances on forest restoration may also be critical for success. For example, montane forests located in many tropical islands are usually prone to suffering severe hurricane damage as much as three times per century. In this case, options may include planting tree species with a known ability to resprout after stem breakage, with high stem wood density, or with specific architectural features; many palm species, for example, are known to survive hurricanes very well. Identification of naturally occurring, landslide-chronic areas may also help to prioritise or avoid investing in potentially costly restoration efforts that otherwise might be wasted.

## 2. Examples

### 2.1. Mount Kenya[371]

Mount Kenya is situated in the central highlands of Kenya. The national park is 715,000 hectares and it was gazetted in 1949. The surrounding forest reserves add another 1820 $km^2$ of protected area, making Mount Kenya the largest area of natural forest in the country.

The forest forms a major water catchment area from which two of the country's five river basins—the Tana and Ewaso Nyiro—rise, which together supply water to more than a quarter of Kenya's human population and more than half of its land area. Water users include the five main hydroelectric power sources, agricultural land, pastoralist range lands, and major urban centres.

Threats to the surrounding forests include illegal logging, charcoal production, cultivation of bhang, and encroachment. The glaciers on the mountain are also retreating because of global warming and climate change. A number of initiatives are now being undertaken together with communities to address the conservation and restoration needs of the montane forest. These are interesting examples of community initiatives of land management, restoration and protection of a unique environment in Kenya.

### 2.2. Sierra de las Minas, Guatemala

The Sierra de las Minas in Guatemala contains a biological treasure. At least 885 species of birds, mammals, amphibians, and reptiles, which amounts to 70 percent of all the species from these groups that are known to exist in Guatemala and neighbouring Belize can be found here. It is also an important tropical gene bank of conifers with 17 distinct endemic evergreen species. The area is thus considered an irreplaceable seed resource for reforestation and agroforestry throughout the tropics.

Besides its robust population of diverse flora and fauna, the Sierra de las Minas plays an important role in providing fresh, clean water to the many farms and villages in the Polochic and Motagua valleys below. More than 63 permanent rivers drain the reserve, making it the country's biggest single water resource. Local people depend on these small rivers for their agricultural crops (e.g., melon, tobacco, grapes, citric fruits, tomatoes). Bigger industries, such as soft drinks, fertiliser and paper-recycling plants, and hydroelectricity all rely on water

[370] Lawton et al, 2001.
[371] Carlsson and Lambrechts, 1999; Emerton, 1999.

generated at the Río Hondo station. A drop of 40 percent in water flow in the last 10 years has been attributed to forest loss.

Since October 1990 the reserve has been managed by a local nongovernmental organisation (NGO), Defensores de la Naturaleza. The reserve's managers are engaged in an environmental education programme designed to persuade local community leaders of the need to protect, manage, and restore the forests in Sierra de las Minas in such a way that they can continue to offer the services locally but also downstream. Payment schemes have been set up (see "Payment for Environmental Services and Restoration" for more information on such schemes) to ensure that those engaged in protecting and restoring the watershed, are paid by the beneficiaries downstream.[372]

# 3. Outline of Tools

## 3.1. Overcoming Barriers to Natural Succession

Assessing patterns of tropical montane forest succession following pasture abandonment, or after natural disturbances such as landslides, can provide important clues when designing restoration activities and when selecting what species to plant (or not) under a given level of site degradation. For example, in many tropical montane forests, those canopy tree species that dominate old-growth stands are the same colonisers of open, deforested areas.[373] Thus if a restoration goal is to re-create original species' composition, the selection of these particular species could be an appropriate choice.

Simple observations and experiments in sites that merit restoration can also help to discern what are main biotic and abiotic barriers that could be retarding natural forest recovery when designing a project. For instance (as in the lowlands), one of the main factors that retards forest recovery in tropical mountains is poor seed dispersal rates from adjacent forest.[374] Even when lack of seed supply is overcome, however, grasses and ferns that thrive in abandoned pastures tend to suppress growth and survival of tree seedlings; hence the removal of competing vegetation seems necessary during tree planting.[375] Controlled grazing can also facilitate both the establishment of planted trees and natural forest recovery through secondary succession.[376]

Another common barrier to the natural recovery of tropical montane forests is high rates of vertebrate seed predation in deforested areas. In other cases, reduced nutrient levels due to soil compaction or recurring fires can impede forest recovery even when seed survival is high. In short, strategies to restore tropical montane forests may need to be assessed on a case-by-case basis, and designed whenever possible for overcoming simultaneous barriers.[377]

## 3.2. Forest Plantations and the Role of Remnant Forest

Tree plantations in tropical montane areas can fulfil both conservation and production purposes as part of a restoration strategy. Yet, the choice of what species to plant must be made carefully, and it may be better to invest some time in selecting the appropriate species[378] rather than planting whatever is available in the local nursery. Tree species with high growth rates, prolific regeneration, or with any other desirable attributes can be easily identified after a few months of observations when published information is not readily available (Fig. 43.1).

Under conditions of severe soil degradation, for example, good candidate species are those that can quickly provide a closed forest canopy while improving soil fertility. However, in some cases, this alternative may be only part of an

[372] http://www.planeta.com/planeta/97/0897guatemala.html.
[373] Guariguata, 1990; Kappelle et al, 1996; Venegas and Camacho, 2001.
[374] Shiels and Walker, 2003.
[375] Pedraza and Williams-Linera, 2003.
[376] Posada et al, 2000.
[377] See an example in Holl et al, 2000.
[378] See an example in Knowles and Parrotta, 1995.

FIGURE 43.1. Establishment of a forest plantation for restoring tropical cloud forest in abandoned pasture in Xalapa, Veracruz, Mexico. The plantation consists of a mix of species typical of primary forest (*Quercus* and *Fagus*) and early successional species (*Heliocarpus* and *Trema*). (Photo © Guadalupe Williams-Linera.)

overall restoration strategy. For example, plantations of the fast growing, nitrogen-fixing tree *Alnus acuminata* in the Colombian Andes may not be the best long-term restoration tool as they seem to harbour fewer plant species in the understorey compared to similarly aged secondary forests following natural regeneration.[379] In severely degraded sites, however, planting nitrogen fixing trees such as *Alnus* can be an option in the short term as they help to recover soil productivity.

Planted windbreaks in montane agricultural landscapes are known to facilitate tree colonisation by increasing seed dispersal rates from nearby, remnant forest. The location and spatial arrangement of agricultural windbreaks as a restoration tool may be important in production landscapes where the enhancement of ecological connectivity and biodiversity recuperation is also a management objective. Planted windbreaks that are connected to forest may harbour more naturally dispersed seeds and contain higher diversity in their understoreys than those not connected.[380] This means that in some cases both the size and relative location of remnant forest fragments need to be considered when designing a given restoration strategy.

[379] Murcia, 1997.
[380] Harvey, 2000.

## 4. Future Needs

Currently, most tropical montane forests are highly fragmented. As a consequence, many of their component vertebrate species may be locally extinct either because of the small habitat area of the remaining fragments, or because those plant species that provide them with food resources are absent, or both.[381] In some cases, tropical montane forest restoration could focus on connecting existing fragments via forest plantations as a way to facilitate altitudinal bird migration, and therefore seed dispersal. More research is needed to support the selection of appropriate sets of plant characteristics, as well as the spatial arrangement of the planted trees in order to favour interpatch animal movement and habitat use—and not necessarily to restore forest cover per se.

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# Case Study: Conserving the Cloud Forests of Mount Rinjani, Lombok

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Rising majestically from lowland rice paddies to a height of 3726 m, Gunung Rinjani dominates the Indonesian Island of Lombok. The upper slopes of the mountain are clothed in cloud forest. The winds coming in off the sea cool as they are funnelled up the slopes of the mountain, moisture condenses onto the vegetation, and as a result the trees are permanently wet and are festooned in epiphytic orchids, lichens, and mosses. These forests are home to rare birds, black ebony leaf monkeys, barking deer, leopard cats, and palm civets.

The forests are now under intense pressure. Lombok is one of Indonesia's poorest and most densely populated islands. Pressure for land has always been intense but the problem has become much worse in recent years. First, following the Asian economic crisis in 1997 large numbers of Lombok people who had been migrant workers in Malaysia were sent home. Many of them returned to farming. Then the Bali bombing in 2001 had a huge impact on the tourist industry. As a result, the local Sassak people have fallen on hard times. A large part of their income came from work in hotels and restaurants, and from producing the beautiful handicrafts for which Lombok is renowned. Lack of cash employment is forcing them back onto the land. And with 2.9 million people crowded onto this 5625 $km^2$ island, it is hard to make a living from traditional agriculture alone.

In theory, Gunung Rinjani's cloud forests—the only ones left on Lombok—are legally protected. But the Forest Department finds it difficult to enforce the laws when they cannot offer any alternative to the poverty stricken farmers. A large swathe of forest on the lower slopes has now been reduced to a patchwork of small fields, scattered trees, scrub, and grasses. Fires originating in these degraded areas are beginning to eat into the rich forests higher up the mountain.

This has implications for the entire island. Rinjani's forests act as water collectors for all of Lombok. Water flowing from the misty upper slopes irrigates the highly productive rice cultures of the plains and supplies domestic water to the towns and tourist resorts. Now the rice farmers in the lowlands are complaining that there is not enough water for their crops in the dry season, and they experience an increased number of floods when it rains.

In response to the crisis, Lombok's provincial government has linked up with the global conservation organisation WWF, and the U.K. Department for International Development to devise a strategy that can protect the forests and their vital watershed functions and still provide land and employment for the people.

As a contribution to this effort we have been developing a simple computer model to try and unravel the complexity of the Rinjani social-ecological system. The model uses the STELLA software and enables us to investigate the main drivers of land cover change and links between these changes and the livelihoods of the people. The model has been developed with local stakeholders and it has been useful in making their assumptions and interests more explicit.

We began by investigating the possibilities for making environmental payments to upland farmers in return for better farming and forestry practices. A bottled water company in the lowlands indicated that a modest amount of money could be available for this programme. The 42,000 water users in the provincial capital Mataram have agreed to a small levy to pay for watershed protection. However, the model suggested considerable difficulties in this approach. The number of farmers is very high—several hundred thousand—and payments that were high enough to have a real impact on their behaviour would cost more than the amounts that are likely to be available. Lack of legal clarity about land rights and the high diversity of farming systems that they use would combine to make the management of such payments very complicated.

The modelling exercise suggested that few solutions would be effective if they were not accompanied by more effective application of laws. But the difficult transition to democracy that Indonesia is now experiencing and the economic crisis are combining to make law enforcement very unpopular amongst the population.

So far one of the best options that has emerged has been to abandon government attempts to protect the watershed forests and, instead, to parcel out the land to poor people, who can use it on condition that they plant trees. This is a rather revolutionary idea. It is in fact saying that conventional approaches to watershed management are not workable in the present economic and social conditions found on Lombok. The compromise of encouraging the formation of a buffer zone of agroforestry plantations around the base of the mountain seems like a better option.

The initial trials have centred on the village of Sesaot. Farmers are given 0.1 hectare of land and are allowed to grow field crops for the first 4 years, until the trees grow. In the early years the farmers made money by growing crops such as chilli peppers between the tree seedlings. Now they are planting a wide variety of fruit and even timber trees. Mangoes, papayas, durians, jackfruit, custard apples, rambutans, and salak fruit are all being produced for sale to traders in the provincial capital Mataram. Jackfruit and macadamia are especially popular as they produce valuable fruit and nuts but also timber that is in high demand for the curio carvers in Bali.

The land remains under forest department "ownership" and the farmers have to pay a small rent for the right to cultivate it. On a pilot scale this programme has been an undoubted success, and previously degraded areas are now covered in profitable agroforests. However, the market for fruit and timber is limited, and unless the general economy picks up it will be difficult to extend the scheme to all the degraded areas of protection forest around the mountain.

The agroforestry trees protect the soils and the water supplies and the people earn a good living. These artificial forests do not have the same biodiversity values as the natural forests that used to exist in the protection forests, but they are better than the degraded scrub and farmland that covered the sites when the programme began. They offer the hope of providing stable and secure land use around the lower boundary of the forests.

The success of the agroforestry approach will be very sensitive to the incomes that farmers can obtain for their fruit and timber crops. We are going to continue to use our model of the Rinjani system to track how both the environment and people's livelihoods evolve over time. The model will provide a database and monitoring tool that will be used by the local stakeholder committee to help understand how the system is performing. It should help to determine how livelihoods change over time and how this is linked to changes in landcover.

The idea of payments for environmental services is still being pursued but as a complement to other approaches. The isolated hillside villages have few social services and the people's lives are still precarious. The people in the lowlands are richer and the rice farmers are making money out of the water that flows from the mountains, so there is some potential for a small water tax. This will not be given as cash to the upland farmers but will be used to build clinics and schools and improve the roads. The hillside people will get these services only if they respect the agreement and grow only tree crops. They will lose these social contributions if they grow tobacco, cassava, or other annual crops that are bad for soil erosion and do not conserve water.

The situation in Lombok, where valuable natural forests exist alongside poverty-stricken people desperate for more land, is typical of many developing countries in the tropics.

Rinjani National Park is one of Indonesia's most spectacular natural areas but there is no way that it can be protected if thousands of poverty stricken, land-hungry people live around the base of the mountain. Giving people rights to some areas of degraded natural forest may help save the national park.