current conservation

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but distributed across many smallersized and younger trees. The VERENA project (Economic Value Increase of Reforestation with Native Species) in Brazil (http://www.projetoverena. org/index.php/en/) is an example of a collective effort to unlock the potential of productive restoration through the development of technology and market for native species.

A vision for the future

Forest and landscape restoration programmes have relied on natural regeneration and tree planting to upscale reforestation in the tropics. However, the costs of restoration are still prohibitive for most farmers, who do not wish to abandon agricultural use of their lands. Farmers in general wish to keep as much land as possible in some form of production. Developing restoration models for producing timber and NTFP – both through tree plantations in degraded lands and enrichment of natural regeneration – is a way to integrate farmers into the restoration movement. Through productive restoration, it is not only possible to transform forest restoration into an economically viable land use, but also into an effective way to promote social and gender inclusion in the rural tropics. The production of timber and NTFP is a labour intensive process and can be the basis for a wide supply chain of goods and services providing jobs and incomes to people in the countryside, from seed collection to timber and food processing in local cooperatives.

Native species may also create opportunities for the development of innovative products for a society eager for novel, healthy food, and exotic tastes. Ultra-processing a few crop species in a myriad of ways for generating novelty in the food market has proven to be bad for both people and the planet. Similarly, depleting timber stocks of native species in forest remnants and replacing the use of hundreds of natives by a few exotic species is not a sustainable solution. It is time to return to our origins and rediscover the taste, colour, shape, texture, and beauty of nature. Tropical reforestation can not only be the path to cleaner drinking water from the tap, but also healthier and tastier fruit pulps to mix it with, over a table made of marvelous wood, while listening to good classical music performed with Brazilwood bows. Life can be much richer this way.

Further Reading

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We stood in a small wood surrounded by young rainforest trees where, fifteen years ago, there was only grass. One tree, a Trichilia connaroides about 30 cm in diameter and over 10 m tall, held loose clusters of bright red fruits. This was one of the first trees to fruit among the 268 saplings of 27 tree species planted here in July 2002 at one of our earliest rainforest restoration sites. The Trichilia now stood among other trees, larger, fast-growing Macaranga peltata, *Elaeocarpus tuberculatus,* and *Semecarpus* The rainforests remain as fragments travancorica, and pole-like slowgrowing trees such as Cullenia exarillata, Mesua ferrea, and Ormosia travancorica.

Where we used to see birds of open country, such as mynas or wagtails, feeding on the grassy expanse, we now watched forest birds: a pair of Indian scimitar-babblers foraging in the Tiger Reserve and a clutch of reserved understorey, a white-cheeked barbet and a pair of Malabar grey hornbills winging between tree branches above. The restoration site was an extension of the five-hectare Stanmore rainforest fragment, around which stood a eucalyptus fuelwood plantation and large expanses of monoculture tea plantations. The plantations sprawl over the Valparai plateau here in the Anamalai hills of the Western Ghats, a mountain chain along India's west coast recognised as a biological diversity hotspot. The 220-square-kilometre

plateau, undulating between 900 m and 1400 m elevation, had been clothed in dense tropical wet evergreen forest until the late 19th century when the first plantations were established during the British colonial period. The plateau is now home to over 70,000 people who live in the estates and small towns such as Valparai.

Today, Stanmore is one of about 45 rainforest remnants on the plateau. embedded within private plantations of tea, coffee, eucalyptus, and cardamom, edged by reservoirs, roads, and human settlements, or occur as degraded remnants adjoining larger forest tracts in the surrounding protected reserves. The Anamalai Tiger Reserve in Tamil Nadu state with the Parambikulam forests in Kerala state together form a tract of more than 3000 square kilometres of forests around the Valparat plateau. No spot on the plateau is over 7 km away from these larger forest tracts. And each of the rainforest remnants, small and large, are valuable for conservation, as we were to discover.

Shredded canopies

Each of the native forest remnantsanywhere between one and 300 hectares in size—retains a tantalising trace of rainforest plants and animals

that managed to survive a century of fragmentation and disturbance. Entering a remnant from a shaded coffee or cardamom plantation entails passing through a relatively 'soft' edge, or when entering from a highway or tea estate an abrupt, 'hard' edge. Once inside the remnant, tall trees reach up into the canopy, creating many small openings that stream sunlight into the dense and tangled understorey.

Whereas a single hectare of undisturbed rainforest would hold around 80 tree species, up to a third of which are endemic to the Western Ghats, the disturbed remnant may retain about half that diversity. On rainforest trees, looped with climbers that increase in abundance in degraded forests, troops of Nilgiri langurs forage on leaves in the canopy. In a few larger remnants, the rare and endemic liontailed macaque may be seen sedately questing for juicy bites. A suite of forest birds—from babblers and flycatchers to nuthatches and hornbills-adds life and music to these remnants, but the community also includes a wide variety of birds of disturbed and open habitats, such as common tailorbirds and redwhiskered bulbuls.

Each remnant carries vegetation legacies of former land use. Some survive on rocky, shallow soils

unsuitable for plantations. Others remain as narrow windbreaks or boundary strips. Roads, trails, and past tree fellings that shredded the tree canopy brought invasions of Lantana *camara, Chromolaena odorata,* and Mikania micrantha weeds. In some patches, introduced ground cover such as *Sphagneticola trilobata* and shrubs like Montanoa bipinnatifida proliferate. Where forest understorey had been cleared and planted with coffee, cardamom, or vanilla, a few forest plants now regenerate amidst remnants of crops, particularly Robusta coffee (Coffea canephora) that has invaded into fragments. Where native trees were supplanted with shade trees such as the Australian silver oak (Grevillea robusta), and Eucalyptus, or the African musizi (Maesopsis eminii), the sites contain a mostly non-native tree canopy.

Why fragments still matter

Many research projects conducted since the 1990s confirm that these fragments matter for conservation. One survey identified the Anamalai landscape, including these rainforest remnants, as one of the most significant

areas for great hornbill conservation in the Western Ghats. In other studies, field biologists recorded in a set of remnants, virtually all the mammal species found in surrounding protected rainforests, including rare endemics like Nilgiri marten and Malabar spiny dormouse. In a landscape where three species of otters occur, otter spraints and signs are scattered along most of the rivers and streams. Several large carnivores-leopard, dhole, sloth bear, and even the occasional tiger—range over the landscape, thriving on a diet largely composed of wild prey from porcupine to sambar. Small fragments cannot meet the year-round needs of large wildlife such as elephants, hornbills, and leopards, but do serve as supplementary habitats or stepping stones in the landscape.

By night, the forests come alive with owls and frogmouths and flying squirrels, nearly twenty species of bats, and many small mammals including the endemic brown palm civet. The remnants are also home to many recently described species-such as the purple frog and the Anamalai gliding frog. Here, too, species such as the bat



Map of the Valparai plateau showing land use, human settlements, and rainforest remnants (in dark green). The plateau is surrounded by the Anamalai Tiger Reserve (to the north and west) and Reserved Forests in Kerala (west and south).

Barbastella leucomelas darjelingensis have been recorded for the first time in the Western Ghats, while others like the snail Corilla anax were rediscovered after decades.

The landscape matrix surrounding the remnants also matters. Fragments adjoining coffee or cardamom plantations with numerous native shade trees provide better support for rainforest species than those ringed by open tea monocultures. The diversity of species surviving in the fragmented landscape can be attributed to the rainforest remnants and to surrounding plantations that are biodiversity friendly, besides the proximity to surrounding forests and the nearabsence of hunting.

Overall, the research suggests that fragment size, habitat quality within fragments, and the permeability of the surrounding landscape all influence the persistence of rainforest species. It also points to ways forward to enhance the conservation value of the landscape. First, retain and protect the rainforest remnants that are in reasonably good shape and contain key species or populations. Second, work with plantation businesses and local communities to foster better and diverse land use in the surrounding landscape matrix. Finally, carry out ecological restoration of the highly degraded remnants.

Bringing back rainforests

Over the last sixteen years, we have been working to put this restoration plan into action. In 2001, we began our efforts at rainforest restoration, preparing ourselves for the long haul imagining forest recovery as an inherently long-term effort. Starting with Stanmore and the nearby nineteen-hectare Injipara rainforest fragment, we slowly expanded work in other degraded remnants in the landscape by striking partnerships with the plantation companies in whose estates the remnants are embedded.

Over several years, after long dialogues with owners and senior managers, three during which we take care to retain companies (Hindustan Unilever which later became Tea Estates India Ltd, Tata Coffee Ltd, and Parry Agro Industries Ltd) came on board. Finding that rainforest protection and restoration aligned with their efforts towards sustainable agriculture, their corporate social and environment policies, or their personal interests in wildlife, these companies and many individual managers extended support. As part of these partnerships, the three companies recognised and protected 35 rainforest remnants within their estates. Further, Tata Coffee now provides space for a rainforest nursery. In the nursery, we germinate and nurture over 160 species of trees and lianas native to mid-elevation rainforest for use in restoration and native shade plantings.

When funds started trickling in, we began restoration of other heavily degraded sites, adding one to five hectares every year. Early each year, we survey and prepare the sites for restoration. In smaller fragments, rapid assessments of forest structure and vegetation are followed by careful weed removal across the entire site, Still, there are questions to ask and answer. Does a plantation of rainforest all naturally established native plants. trees constitute a restored rainforest? In larger fragments and remnants, we To what extent, and after how long, focus on the disturbed edges, reasoning does a healthy rainforest's diversity, that if these improve, forest interiors ecological processes, and intricate will automatically benefit. During network of interactions re-establish in the monsoon, 20 – 80 native species restoration sites? When will rainforest are planted in each site following a bees and beetles return to pollinate mixed native species planting protocol, the young Myristica tree's flowers, tweaking the mix of species and planting or great hornbills arrive to eat the density based on initial site conditions fruits, bringing in more seeds from and the history of disturbance. distant rainforests? Will the trajectory of recovery bring restored sites closer to undisturbed rainforest or will Now, in 2017, with 40,000 saplings planted out for restoration, the effort competing weeds or insect herbivores spans 50 sites and about 60 hectares overwhelm planted saplings to revert in 15 rainforest remnants that together the site to a degraded state? Or will the cover over 300 hectares. Over this saplings hold on only as long as they period, plantation companies, too, are being cared for?

planted about 25,000 saplings of around 75 native species, sourced from our nursery, as shade in coffee, cardamom, vanilla, and even tea estates.

Each year, the area of restored rainforest increases in small increments, while more native shade trees spread their boughs within commercial plantations

Looking back, moving ahead



Our recent research on forest recovery and soils in restoration sites has generated some preliminary answers. After 15 years, actively restored sites are ecologically closer to undisturbed rainforests than sites left to themselves with no restoration intervention. Restored fragments manifest recovery of forest structure, as evidenced by tree density, canopy height, and carbon



storage. The number of rainforest species and the similarity of plant species mix are gradually increasing in comparison with relatively undisturbed rainforests. Soil microbes appear to be doing better in some restored sites, as shown by increases in soil nutrients and fertility. Once the growing saplings form a low canopy with other naturallyestablished native plants, weedy species thin out and decline in the shade.

Yet, restored sites lack key characteristics of undisturbed, mature rainforests. In the restored sites, natural plant colonisation and regeneration of typical rainforest plants, including shrubs and herbs, appears low. On the ground, leaf and other organic debris remains sparse, while up on the trees, epiphytes are still scarce.

While restored sites in isolated fragments are generally an improvement over adjoining naturallyregenerating sites that remain degraded, this is not always the case. At the edge of the surrounding extensive forest reserves, degraded sites appear to recover well through passive natural regeneration even when left alone. As some larger fragments and remnants were in reasonably good shape already, these edges need only protection from disturbance rather than any active restoration.

Landscape futures

Quantitative measures of recovery

may not capture other tangible and intangible benefits and spin-offs of restoration efforts. On private lands, the recognition and protection of rainforest fragments that were previously ignored by landowners help expand conservation and restoration into wider landscapes beyond protected reserves, and involve new constituencies and stakeholders. Remnants have other values, too, as watersheds and refugia for pollinators and natural predators of crop pests. While a start has been made, there is a long way to go before plantation businesses, landowners, and managers integrate ecological understanding and approaches into routine production practices.

Restoration-as a hands-on practicealso forces renewed appreciation of ecological history and the peculiarities of each restoration site. Nurturing the skills needed to work with each parcel of land and learning by doing become at least as important as grasping theoretical foundations and concepts ir restoration ecology such as secondary succession or the roles of keystone or framework species. Ecological restoration melds science and praxis in relation to land.

As oases of diversity, beauty, and wonder, rainforest remnants add to the fullness of life in heavily used and transformed landscapes. For biologists like us, they carry the additional joys

of discovery and observing recovery of remarkable rainforests. Over a century since the rainforests were fragmented, we envision a more connected future where farms and forests, wildlife and people, science and wonder, all coexist.

Further reading

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The community-based approach to forest restoration has been adopted in the Philippines for more than two decades. In context, this approach involves community members working as a group to access government lands, restore degraded forests, and utilise and manage resources in a sustainable manner. The recent National Greening Programme (NGP) aims to rehabilitate 8.6 million hectares from 2011 to 2028 mainly following a communitybased approach. However, devolving the responsibilities of rehabilitating denuded uplands and managing forest resources to communities has not been straightforward. In many cases, the primary objectives of poverty alleviation and sustainable management of forest resources are far from being realised. Community organisations disband when project funds are exhausted, livelihood projects fail, and tree plantations are abandoned.

As part of the research project funded by the Australian Centre for International Agricultural Research (ACIAR) in the Philippines, an evidence-based community forest landscape restoration project was

implemented in Biliran Province in 2014. The project aimed to identify and address key deficiencies of communitybased forest restoration programmes. Evidence for the effectiveness of these programmes is drawn from a series of ACIAR-funded forestry research projects in the Philippines over 15 years, and lessons learned from past peoplebased reforestation programmes in the country.

The project site has adverse biophysical conditions but represents sites subjected to reforestation in the Philippines. The twenty-six hectare area was used for grazing with deliberate burning to produce palatable shoots for goat, cattle and water buffalo. Also common were uncontrolled fires from slash-and-burn farms and intentional burning by land claimants due to disputes over land. The site was planted with trees under four government reforestation projects since the early 1990s, but regular fire occurrence decimated most of the trees. The community is poor, with substantial food security issues and virtually no cash earning opportunities. An existing community organisation was involved

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in implementing previous government forest restoration programmes, but with minimal participation of members. The land belongs to the government, which is usual in the case of governmentfunded forest restoration projects in the Philippines. The community holds a Community-based Forest Management Agreement, a tenurial instrument allowing the community to utilise the land for 25 years with a possible extension for another 25 years.

The project was designed following the systems approach, based on holistic thinking that integrates all elements in a system and recognises their dynamic and complex interactions. The project was designed to consider the multiple elements of a community-based forest restoration system and their intricate relationships. Project implementation followed a participatory approach, involving stakeholder groups in all stages including identification of issues and potential interventions, implementation of interventions, and monitoring of impacts. It also employed smallholder-based best practices developed from scientific investigations and lessons learned from previous