2018 VOL 12 ISSUE 1

current conservation

This magazine is produced with support from:

The Duleep Mathai Nature Conservation Trust

FES
FOUNDATION FOR ECOLOGICAL SECURITY

dakshin · wipro · WWF · atree · Wildlife Conservation Trust · Balipara Foundation Assam • India · BNHS India Conserving Nature Since 1883

Current Conservation carries the latest in research news from natural and social science facets of conservation, such as conservation biology, environmental history, anthropology, sociology, ecological economics and landscape ecology.

For more details, visit our website at www.currentconservation.org

ISSN 0974-0953

contents

features

spotlight

cc kids

a day in the life

storytelling

Cover by Aindri Chakrabarty

Cover by Prabha Mallya

Editor's note 12.1

While much conservation attention focuses on the protection of remnant forest fragments, big and small, the truth is that widespread loss of tropical forests in the last century requires us to think about restoring habitats where possible and enriching the conservation value of mosaic landscapes. Forest restoration efforts are urgently needed to enhance and expand conservation efforts. Such efforts are believed to fit with the goals of biodiversity conservation, livelihoods as well as mitigating climate change, and are supported by instruments such as REDD+ and CDM (Clean Development Mechanism). As appealing as planting trees may be to all concerned, from conservationists to civil society, ensuring positive long-term ecological and social impacts of restoration remains a major challenge. In this collection, Robin Chazdon (Guest Editor) outlines the advances and challenges of large-scale forest restoration, examining theory, practice and policy, and their intersections.

Rhett Harrison examines the role of agroforestry in forest and landscape restoration, which has particular significance given the staggering scale of land degradation worldwide. This is followed by a series of case histories. Pedro Brancalion describes a restoration project in Brazil which supports local livelihoods and protects biodiversity, through promoting timber and non-timber forest products. Fangyuan Hua compares native forests and plantations in China, asking what the environmental dividends of restoration are. Gregorio, Herbohn and Pasa examine lessons learned from a community-based restoration project in the Philippines. And finally, Shankar Raman, Mudappa and Osuri share their experience of restoring rainforest fragments in the Western Ghats in India. Together, these articles paint a picture of how multiple approaches to forest restoration can enrich lives, conserve biodiversity and enhance landscape functions in tropical regions.
-Kartik Shanker

CC Kids Editor's note 12.1

The bat that saved a forest, the bird that crossed the mountain and the adventures of Wooly the moth. In this issue we have three extraordinary stories about three very unusual wildlife-chatacters. Read on to find out more...
- Matthew Creasey

Advances and Challenges for Achieving Large-Scale Forest Restoration in the Tropics

Author: **Robin Chazdon** · Illustrator: **Sheena Deviah**

Loss of tropical forests accelerated greatly during the mid-20th century and continues today. More than half of the world's tropical forests have been cleared, fragmented or heavily transformed, leading to species loss and reduction in multiple ecosystem services. Between 1981 and 2003, 28% of the land in the tropics experienced some form of degradation compared with 16% for the rest of the world. Despite declines in extreme poverty worldwide, more than two-thirds of the poorest people in the world live in the tropics. The concentration of poverty and land degradation in the tropics calls for a sustained, multi-sectoral focus on large-scale restoration of tropical forests and landscapes for conserving biodiversity, mitigating climate change and providing sustainable livelihoods. Forest restoration is therefore a key approach for alleviating impoverishment of people and nature.

Here, I provide an overview of advances and challenges in large-scale forest restoration in the tropics. Most of these advances have taken place during the past ten years. The overview focuses on advances and challenges in three arenas of activity; each arena involves different actors, different types of institutions, and different modes of action (Figure 1). I also discuss the critical need for actions and institutions that link these three arenas more effectively.

In the "theory" arena are social and natural scientists; they conduct research on restoration opportunities, approaches, and biophysical and social outcomes. Researchers predominantly work within academic institutions, but also within government agencies and non-governmental organizations.

In the "policy" arena are decision-makers at different levels of government who determine restoration targets and objectives, seek and allocate funding and other sources of support for forest restoration, and make policies and regulations regarding how to incentivise and promote forest restoration in different regions. Decision-makers can also be leaders of local communities that influence land-use decisions and regulate activities.

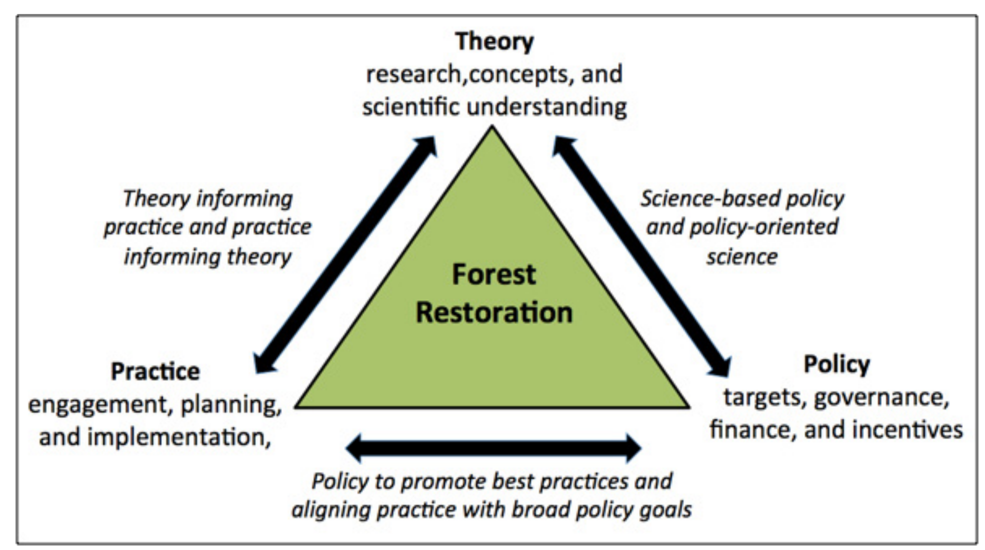


Figure 1. The three arenas of forest restoration and their intersections.

In the "practice" arena are practitioners who work on the ground to engage stakeholders, plan restoration interventions, and implement and monitor them. Practitioners can work within government agencies or non-governmental organizations and may work closely with the private sector to raise funds and develop supply chains (seeds, seedlings, or technical expertise) and value chains (products for local or commercial use) to promote and sustain forest restoration. Practitioners can also include community-based groups that implement forest restoration and monitoring.

In the middle of this triangle is the process of forest restoration, which involves civil society and the environment – locally, regionally, and globally.

Advances and challenges in theory, concepts, and scientific understanding

The scientific understanding of forest restoration in tropical regions has advanced in several dimensions. A narrow focus on restoring forest structure and diversity to the condition of a "reference forest" is shifting to more holistic perspectives that incorporate concepts of complex systems, resilience, and landscape principles. Forest restoration is now envisioned as part a "continuum" of activities that take place within landscapes, ranging from remediation and recuperation to rehabilitation and ecological restoration interventions. Forest degradation and restoration processes are linked though several common components. Recovery debt is effectively the cost of lost ecosystem functions, services, biodiversity, or other attributes due to degradation processes over time. Restoration actions strive to recover those

lost properties, but the greater the extent or duration of degradation, the higher is the recovery debt to be "repaid" through restoration processes. Further, new research is providing a more nuanced understanding of how climate, rates of tree growth and mortality, and tree succession influence tropical forest recovery and variation in temporal patterns.
Yet we still face major challenges in theory, concepts, and scientific understanding. Scientists grapple with how to define and measure degradation and how to identify restoration opportunities at different scales. Unavoidable trade-offs between different restoration objectives (carbon storage, water flows, biodiversity conservation, livelihoods, and implementation cost) are challenging to quantify. Yet, there is a need to understand how multiple objectives can be achieved with minimal cost within different landscapes or regions. It is rarely possible to maximize all of the benefits of forest restoration in particular locations, so compromise solutions need to be proposed. But we lack detailed knowledge of how different types of restoration interventions influence the supply and quality of ecosystem goods and services over time and how they actually benefit local communities. The evidence for the outcomes of forest restoration within landscapes and regions remains largely anecdotal.

Advances and challenges in policy

Several important advances in policy have propelled forest restoration to a high global priority, including incorporation into three multilateral treaties: Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change (UNFCCC), and the United Nations Convention to Combat Desertification (UNCCD). Ambitious global targets established by the Bonn Challenge and the New York Declaration on Forests call for restoration of 150 million hectares by 2020 and 350 million hectares by 2030, respectively.

Since 2011, 45 countries have committed to restore a total of 160 million hectares, and new country-level commitments are rapidly growing. These global restoration targets are based on forest landscape restoration principles and support the Aichi Targets of the CBD and the United Nations Sustainable Development Goals. Regional initiatives are promoting national-level Bonn Challenge commitments in Latin America (Initiative 20x20), Africa (AFR100), and Asia-Pacific (FAO Asia-Pacific Forestry Commission). National policies to incentivise forest restoration on private land are being implemented in Brazil, USA, Costa Rica, and Vietnam and on communal or state land in China and Philippines.

Despite this international momentum, many countries have yet to acknowledge the need to restore their deforested and degraded forests and landscapes. Even in countries that have made restoration commitments, lack of land tenure or forest-use rights impede progress with forest restoration, as farmers cannot obtain economic benefits from restoring trees or forests if they lack these rights. Large-scale monoculture forestry plantations restrict land access for local communities and can worsen environmental degradation.
A major challenge is to integrate forestry, agriculture, and conservation sectors in forest restoration activities. Finally, while restoration activities in one area, region, or country may increase forest cover and ecosystem services, these gains may be causally linked to deforestation and forest degradation in other areas. Avoiding this type of leakage is a major challenge, as it requires a holistic assessment of the impacts of forest restoration on land use and deforestation outside of target areas.

But we lack detailed knowledge of how different types of restoration interventions influence the supply and quality of ecosystem goods and services over time and how they actually benefit local communities. The evidence for the outcomes of forest restoration within landscapes and regions remains largely anecdotal.

Advances and challenges in practice

In the Atlantic Forest region of Brazil, forest restoration has become a growth industry, with investments in supply chains and nurseries that raise hundreds of species of native tree seedlings. Multi-stakeholder partnerships (researchers, different branches of government, businesses, and landowners) such as the Atlantic Forest Restoration Pact in Brazil are forging new public-private partnerships, and enhancing capacity building and broad societal and political support for forest restoration. Species and genetic diversity of seedlings and nursery practices are also increasing in many areas. A broad range of restoration interventions are being widely adopted in dryland areas in Sub-Saharan Africa that are improving land management, water availability, and generating higher incomes for farmers. Overall, forest restoration interventions are being planned and implemented with greater levels of stakeholder engagement, including participatory monitoring.

However, forest restoration practice still has major challenges. Many projects are short-lived and ineffective. It is critical to understand how to sustain the longevity and financial support of forest restoration projects. Sometimes, less costly approaches based on natural regeneration can meet restoration objectives better, and it is important to identify when this is the case. Climate change poses enormous challenges for all land management and conservation activities, including forest restoration. Planning restoration that is resilient to climate change remains a huge challenge both within as well as outside of the tropics.

The importance of integrating theory, practice, and policy for large-scale forest restoration

Despite some progress in each of these sectors, the corners of Figure 1 remain largely disconnected. Far more outreach and interaction across scientists, policy makers, and practitioners is needed to achieve effective, long-lasting, and large-scale forest restoration in tropical regions. Unfortunately, few institutions and organisations support these interactions with sufficient dedication and budgets. The research-practice or "knowing-doing" gap in forest restoration is well recognised. Many scientists fail to communicate the results of their work to practitioners in effective ways, and many practitioners fail to see the relevance of scientific results in the context of their efforts on the ground. Scientists and practitioners work on different teams and often in different research sites, and their paths rarely cross. However, there is an increasing recognition of the need for a participatory research model. Ideally, local stakeholders should be involved from the very beginning in all aspects of the intervention including study design, data collection, preliminary interpretation of results, and recommendations for future research. Much more progress could be made if practitioners and researchers worked together on the same teams.

Unfortunately, enormous chasms separate science and policy in forest restoration. Scientists and policy-makers seem to differ in every aspect – perspectives, objectives, approaches and vocabulary. Scientists generally shun the need for practicality that is essential in policy-making, and focus on fine distinctions that matter little to policy makers. A common tendency among policy-makers is to equate reforestation with forest restoration, without considering effects on native biodiversity, water resources or forest-based livelihoods. Policy-makers often overlook the potential contribution that natural regeneration of forests can make in large-scale restoration, favouring establishment of tree plantations for economic benefits. Establishing coalitions between policy-makers, scientists, and business sectors can be a starting point for bridging these gaps and creating new approaches to restoration policy that incorporates scientific viewpoints.

Finally, linking policy and practice remains another major frontier area for large-scale forest restoration in the tropics. Although high-level government support is needed for fulfilling many objectives of restoration, the most important level of activity happens within landscapes where practitioners are working with broad and inclusive engagement of local stakeholders. Forest restoration commitments and land-use policy are often generated at the highest government levels and in many cases these policies are disconnected from realities on the ground. Many opportunities for aligning national-scale targets with practice on the ground are not being explored to the full extent possible due to inadequate governance structures and lack of attention on land and use rights. Quality standards and guidelines for good practices are lacking for the broad social and environmental goals of forest and landscape restoration, and are just now being formulated for ecological restoration. In many cases, plantation forestry is disguised as restoration or restoration offsets fail to achieve even their minimal expectations and legal requirements. No system is yet in place to ensure long-lasting, equitable and multiple benefits of restoration for all stakeholders.

Although high-level government support is needed for ful lling many objectives of restoration, the most important level of activity happens within landscapes where practitioners are working with broad and inclusive engagement of local stakeholders.

Conclusion

Forest restoration is an approach, not a goal in itself. Restoration thinking crosses political, social and economic boundaries, creating a nexus for action and outcomes.

But we are not yet there in terms of bringing together the theory, practice, and policy arenas. There is an urgent need to create the time and space for these interactions, and to form local and national institutions that will work effectively toward restoring ecological functions and integrity to forest landscapes. Accountability is needed at multiple levels to ensure that forest restoration achieves broad social and environmental objectives. The role of local governance of restoration at landscape scales deserves more emphasis if forest restoration is to reach the scales needed to ameliorate the devastating effects of deforestation and degradation on people and their environment.

Further reading

Chazdon, R. L., P. H. Brancalion, D. Lamb, L. Laestadius, M. Calmon, and C. Kumar. 2017. A policy-driven knowledge agenda for global forest and landscape restoration. *Conservation Letters* 10:125-132.

Chazdon, R. L., and M. R. Guariguata. 2016. Natural regeneration as a tool for large-scale forest restoration in the tropics: prospects and challenges *Biotropica* 48:716-730.

Holl, K. D. 2017b. Restoring tropical forests from the bottom up. *Science* 355:455-456.

Locatelli, B., C. P. Catterall, P. Imbach, C. Kumar, R. Lasco, E. Marín-Spiotta, B. Mercer, J. S. Powers, N. Schwartz, and M. Uriarte. 2015. Tropical reforestation and climate change: beyond carbon. *Restoration Ecology* 23:337-343.

Moreno-Mateos, D., E. B. Barbier, P. C. Jones, H. P. Jones, J. Aronson, J. A. López-López, M. L. McCrackin, P. Meli, D. Montoya, and J. M. Rey Benayas. 2017. Anthropogenic ecosystem disturbance and the recovery debt. *Nature communications* 8:14163.

Robin Chazdon *is a retired professor at the University of Connecticut, research professor with the Tropical Forests and People Research Centre at the University of the Sunshine Coast, Australia, and adjunct professor at the University of Colorado.*

Sheena Deviah *works as an Art Director at a children's book publisher and enjoys working with her hands while surrounded by her three rowdy cats. She is constantly inspired by nature, both inside and outside.*

The Critical Role of Agroforestry in Forest and Landscape Restoration

Authors: ***Rhett Harrison*** *and* ***Andrew Miccolis*** · *Illustrator:* ***Chaaya Prabhat***

Land degradation and poverty

Land degradation is one of the most conspicuous symptoms of planetary abuse. Picture a desolate expanse of bare soil and sparse struggling vegetation, or a naked slope gouged with raw gullies, or a forest smothered under a shroud of vines. The ecological integrity of these lands has been damaged through human mistreatment to such an extent that its capacity to support agriculture and supply ecosystem services has been completely undermined. The scale of land degradation is staggering. Globally there are over 2 billion hectares – an area equivalent to Mexico, USA and Canada combined – impacting an estimated 1 billion people, predominantly in the Global South. In sub-Saharan Africa, FAO has calculated that as much as 65% of arable land and 30% of grazing land are degraded. Meanwhile, to meet the demands of growing populations and increased affluence, global food production needs to increase by 70% or more by 2030.

Poverty and land degradation are intricately intertwined, as farmers without alternatives attempt to eke out an existence in fragile environments, often having to contend with poor soils, erratic rainfall, and inequitable and limited access to resources. Land degradation reduces agricultural yields and incomes, increases the vulnerability of rural populations to climate and economic shocks, and fuels involuntary migration, social and political marginalisation, and conflict. Moreover, in an attempt to supplement meager incomes, poor farmers invade forests to clear more land or to cut trees for timber and charcoal. Thus, poverty and land degradation are also major causes of deforestation, and hence important drivers of the global climate change and biodiversity crises.

Political momentum for forest and landscape restoration (FLR) was borne out of a recognition that to maintain global temperature rise at or below 2ºC, we need to restore 300-400 million hectares (Mha) of forest by 2050. And, to achieve this, we simultaneously need to address the goals of reducing poverty and enhancing food security. Under the auspices of the Bonn Challenge, the global community has set a target of restoring 350 Mha by 2030 through FLR. While this is a very laudable political aspiration, there is a risk that in countries' rush to meet targets, authorities may advocate inappropriate and ultimately unsustainable interventions that fail to meet the needs of local populations. Agroforestry has a critical role to play in addressing this concern.

Multiple roles for agroforestry in restoration

In some parts of the tropics, marginal agricultural land is being abandoned as economically unprofitable, thereby releasing land for forest restoration without impinging on local people's productive use of the landscape. Implementation of relatively simple legal and policy instruments, including for example carbon credits, could consolidate these gains and expand the area available for restoration. However, much of the world's degraded land occurs in landscapes that are occupied by poor farmers who are dependent on the land and its natural resources for their livelihoods. In such situations, large-scale forest restoration is likely to be in conflict with development goals. Restoration instead needs to focus on restoring ecological functionality to multiuse landscapes, thereby improving the livelihoods of local people while simultaneously enhancing global goods and services, such as carbon sequestration and biodiversity conservation.

Trees on farmland provide many goods and services. Products include nutritious fruits and nuts for food, fodder for livestock, fuel for cooking, and timber for building. Trees also provide shade and shelter for crops, livestock and people, and habitat for pollinators and other beneficial organisms. Although often under appreciated, these ecosystem services can make a substantial contribution to farmers' livelihoods. For example, combining trees with grazing lands, so-called silvopastoral systems, can increase beef and dairy production by over 30% as a consequence of improved grass productivity and access to shade for livestock. Likewise, access to high quality pollination services increases coffee yields by over 20%. In farmers' fields, the judicious choice and placement of trees can improve soil health, increase water infiltration and reduce erosion. And, of course, trees sequester carbon, both in wood and in soils, and can substantially increase the value of agricultural landscapes for conservation. Although on a per area basis, the amount of carbon that can be sequestered through agroforestry is much lower than for mature forests, the size of the land area available means that agroforestry's potential for climate change mitigation is substantial. For example, it has been estimated that if all the possible agroforestry land in the EU were realised, it would offset one-third of the EU's greenhouse gas emissions. Globally, an amount of carbon equivalent to approximately 20 years' worth of deforestation is stored in agroforestry systems. Hence, most developing countries have identified agroforestry as a key strategy for meeting national commitments under the Paris Agreement.

Similarly, although agroforestry supports substantially lower biodiversity than forests, trees on farmland can provide a significant conservation benefit by creating a much more biodiversity-friendly matrix than one covered in arable or plantation monocultures, and thereby facilitate the movement of wildlife between forest patches. Improvements to soil management, food and nutritional security, and incomes also enhance the resilience of poor farmers. As farmers often fall back on destructive activities such as timber harvesting or charcoal production in times of need, improving their resilience can contribute to reduced deforestation and forest degradation.

In addition, agroforestry can provide viable forest restoration pathways in situations where restoration would otherwise be uneconomic. Natural regeneration provides the cheapest and most sustainable mode of forest restoration. However, when land is highly degraded – for example, very infertile or rapidly eroding soils – establishment of naturally seeded trees may be poor and recovery of vegetation slow. Or, if the target for restoration is far from seed sources, then the quality of vegetation arising from natural regeneration may be poor. However, the costs of land preparation and planting are often prohibitive unless there is an opportunity to recover costs. Agroforestry systems that combine natural regeneration or planting of native tree species with income generation through, for example, shade grown crops (e.g. coffee or cardamon), timber (e.g. Eucalyptus), non-timber forest products (e.g. rubber, mushrooms, fruits or firewood) or livestock grazing, can be used to transition degraded lands to natural forest. Using agroforestry in this way, as an interim step to ecological restoration of forests, may enable governments and landowners to substantially increase the scale of restoration they can consider.

Putting the "L" into FLR

The "L" in FLR speaks more to the process through which restoration should be implemented than it does to the scale of restoration. In essence, the landscape approach is one that involves inclusive, devolved decision-making to improve land-use planning and governance of common-pool resources. An essential element is the need to adopt systems thinking, so that the consequences of land management decisions at different scales are understood and acted upon.

Agroforestry by nature requires a systems perspective. At the field scale, agroforestry interventions aim to maximise multiple benefits, such as improving soil health and providing fuel wood, while minimising negative interactions between trees and crops. For example, *Faidherbia albida*, a widely promoted fertiliser tree in Africa, fixes nitrogen but its real benefit as an agroforestry tree comes from the fact that it drops its leaves in the early wet season, thereby adding nitrogen and organic matter to the soil and reducing light interception, just when the crops are growing most rapidly. At the farm scale, agroforestry contributes to economic diversification, as well as to food and nutritional security. In the developing world, many rural communities suffer seasonal hunger in the final months before harvest. Even relatively short periods of hunger can have a serious effect on a child's physical and mental development. However, the traditional practice of planting home gardens with fruit trees can be adapted, through careful species selection, so that there is a year-round production of nutritious fruit and nuts. Diversification at the farm scale is also insurance against pest outbreaks, and climate and economic uncertainty, and therefore increases resilience. Finally, agroforestry involves the integration of woods and forests into the farming system, including for example livestock grazing and the supply of non-timber forest products, such as honey, mushrooms and insects. Community level land use planning and management of these resources is essential to ensure people can continue to derive benefits. Thus, agroforestry brings with it a systems thinking that can be readily integrated into landscape approaches.

Agroforestry options for restoration: Three examples from around the world

The rubber tree is originally from the Brazilian Amazon and was introduced in plantations in Asia in the late 19th century. Almost immediately it was adopted by local farmers and incorporated into the swidden agricultural systems as a way of enriching fallows, so called jungle rubber. Rubber is in many respects an ideal smallholder crop: cultivation is low input and technically straightforward, latex tapping is labour-intensive and, as demonstrated by jungle rubber, it is easily incorporated into existing farming systems. Around the mid-20th century, rubber provided around 80% of agricultural incomes where it was grown in Indonesia. However, with the development of high yielding clones, which produce 2-3 times as much rubber, farmers began to adopt monoculture plantation management, as practiced by the large commercial firms. Often, this was perceived as improved management and promoted by government extension services. However, a sharp fall in rubber prices in the early 1980s led smallholders to experiment with intercropping. Many found that modern clones can be grown just as well when intercropped with timber or shade crops. Research has confirmed these findings and in addition shown that rubber agroforests can be used to restore impoverished soils invaded by *Imperata* grass. In North East Thailand, smallholders are rehabilitating highly degraded cassava fields with rubber agroforests. Rubber can be grown in anything from simple combinations with fruit trees (e.g. mangosteen) or shade crops (e.g. tea or cardamom) to multi-species systems incorporating high value timber species that mimic secondary forest regrowth. With the demand for rubber set to continue rising, rubber agroforestry offers options to rehabilitate ecosystem services over 5 Mha of monoculture plantations across South East Asia, as well as a strategy for restoring degraded lands elsewhere. At Hutan Harapan, an Ecosystem Restoration Concession in Sumatra, we are using rubber agroforestry as a tool for community development, to reduce land conflicts and avoid further deforestation. We can also expect greater interest of rubber companies in Africa, as land and labour become limiting in Asia, and proactively developing smallholder-managed rubber agroforestry systems would ensure that potential social and environmental benefits are realised.

The second example comes from the African dryland systems. In the early 1980s, much of the Sahel was a treeless wasteland. There were recurrent multi-year droughts, productivity had plummeted and most farmers were dependent on international aid for food. To combat desertification and restore ecosystem services, the international community invested millions in large-scale restoration efforts, planting huge numbers of seedlings of mostly exotic tree species that simply perished from neglect or were eaten by goats. Lack of farmer involvement meant they had little vested interest in the success of projects and most viewed the trees as competition for their crops. However, in the mid-1980s practitioners noticed that native trees were resprouting naturally from stumps and underground rootstocks, but were cut back each year by farmers clearing their fields. Through a couple of test projects, farmers were persuaded to allow some trees to regrow. The farmers were encouraged to select which trees they retained and to prune the stumps so that just one or a few stems grew from each stump. Almost overnight, the benefits were apparent and the results spread rapidly by word of mouth. Increased fuelwood availability provided additional income and reduced the burden on women, who previously had to walk miles in search of cooking fuel. Trees provided shade and leaves for dry season fodder, improving livestock productivity and generating manure for crops. Crops were protected from high winds, which in addition reduced soil erosion and improved soil health, with resultant increases in crop yields and incomes. Moreover, it has been estimated that the benefits in terms of asset creation, increased consumption of wild resources, health and psycho-social improvements are of even higher value than the increases in income and agricultural yields.

Over an approximately twenty year period, farmers have restored over 5 Mha of Sahel in Niger and neighbouring countries through Farmer Managed Natural Regeneration (FMNR). Largely through the work of NGOs, the technology is spreading throughout the arid to seasonally dry regions of sub-Saharan Africa. For example, it is practiced widely in both Ethiopia and Malawi today. Nonetheless, there is still scope for improving the technology and adapting it to new biomes. FMNR works because the re-sprouts from stumps and underground rootstocks are hardy and require little maintenance. However, species choice is strongly constrained by what's available in a farmer's field. Can we enrich FMNR with selected tree species to improve outcomes? For example, perhaps we could select (or plant) more multi-purpose trees, or those that compete less with crops for limited soil water, or that provide better quality fodder or nutritious fruit. Can we design species combinations based on functional traits to optimise outcomes?

The final example is from Peru. It has been repeatedly demonstrated that providing secure land tenure and resource access rights is an essential step to achieving sustainable natural resource management. In Peru, millions of hectares of national forest have been encroached, including much of the approximately 3.5 Mha of Amazonian forests managed by smallholders. This places huge numbers of poor people—the de facto land managers—at odds with the law. In an attempt to reconcile this reality with Peru's national forest laws, which preclude private ownership of forest lands and prohibit deforestation, in 2011, the government introduced an amendment to the forestry law to enable agroforestry concessions. The government now views agroforestry concessions as making a major contribution to the country's commitments under Latin America's 20x20 Restoration Initiative and the Paris Agreement. The concept is relatively straightforward – smallholders (who generally manage between 5 and 100 ha) receive a 40 year renewable concession license in return for maintaining remnant forest patches, establishing agroforestry on a minimum of 20% of the remaining area and practicing soil and water conservation measures. They can also qualify for various incentives aimed at increasing tree cover with native species. Social surveys indicate there is strong support for the concept and that it could enable restoration at scale, but researchers also warn that certain provisions will need to be made to ensure the scheme's success. Essential is a need to adopt a broad definition of agroforestry that includes long-rotation systems, such as fallow forests and small scale timber plantations.

Putting agroforestry into FLR

It has been estimated that 40% of the world's agricultural land (>1 B ha) has over 10% tree cover, although this substantially underestimates agroforestry's contribution as it omits systems defined as forests but still extensively used within food production systems. Agroforestry has also been recognised as the natural (or appropriate) way to farm in the tropics. Yet, it is one thing knowing that trees on agricultural land provide many goods and services, and another persuading farmers to plant trees. Agroforestry often does not receive the support from governments it warrants and there remains a strong tendency among farmers to eliminate trees from their farms. Indeed, for many, intensification is synonymous with the promotion of monoculture systems. How can we ensure that agroforestry contributes to FLR?

In part, agroforestry is overlooked because it is considered neither agriculture nor forestry and therefore falls outside the remit of institutional structures. A critical aspect to FLR is that it should be cross-sectoral, but nonetheless it helps if agroforestry is given a proper home, usually within the ministry or department of agriculture. A second related step is to develop a national strategy on agroforestry, such as for example in India. Critical here is consideration of land and tree tenure. Without long-term tenure, there is little incentive for farmers to grow trees. A final major constraint is the availability of planting material, which is a concern for FLR as a whole. It is essential that farmers can access high quality seeds and seedlings for the species they wish to plant at reasonable prices.

Nevertheless, even where farmers acknowledge the services trees provide, they may be unwilling to invest in planting, protecting and nurturing those trees unless there is a ready market for the products. Trees take several years to yield benefits and poor farmers often need more rapid returns on their investment, particularly if they consider it risky. There are of course many ways around these problems, such as providing structured markets or schemes for adding value, outgrowers schemes or PES schemes, but these need to planned and built into the FLR process.

Agroforestry has an important contribution to make to FLR, in particular through its role in sustainable agricultural intensification and poverty alleviation, but also through its often under-recognised potential for climate mitigation and biodiversity conservation. Realising these goals will require creating the appropriate enabling conditions so that farmers are eager, and not just willing, to invest in trees.

Further reading

Aertsens, J., L. De Nocker, and A. Gobin. 2013. Valuing the carbon sequestration potential for European agriculture. *Land Use Policy* 31: 584-594.
Calle, Z., E. Murgueitio, J. Chará, C. H. Molina, A. F. Zuluaga, and A. Calle. 2013. A strategy for scaling-up intensive silvopastoral systems in Colombia. *Journal of Sustainable Forestry* 32: 677-693.
Robiglio, V., and M. Reyes. 2016. Restoration through Formalization? Assessing the potential of Peru's agroforestry concessions scheme to contribute to restoration in agricultural frontiers in the Amazon region. *World Development Perspectives* 3: 42–46.
Reij, C., and D. Garrity. 2016. Scaling up farmer-managed natural regeneration in Africa to restore degraded landscapes. *Biotropica* 48: 834-843.
Souza, S. E., E. Vidal, G. d. F. Chagas, A. T. Elgar, and P. H. Brancalion. 2016. Ecological outcomes and livelihood benefits of community-managed agroforests and second growth forests in Southeast Brazil. *Biotropica* 48: 868-881.
Vieira, D. L. M., K. D. Holl, and F. M. Peneireiro. 2009. Agro-successional restoration as a strategy to facilitate tropical forest recovery. *Restoration Ecology* 17(4): 451–59.

***Rhett D Harrison** is a landscape ecologist with the World Agroforestry Centre, based in Lusaka, Zambia. He has diverse research interests and has worked in over 20 tropical countries.*

***Chaaya Prabhat** is an independent illustrator and graphic designer currently based in Chennai, India. Her work usually involves a combination of illustration, design and hand-lettering which she is passionate about.*

Reaping Greater Environmental Dividends from China's Reforestation Programmes

Author: ***Fangyuan Hua*** · *Illustratator:* ***Megha Vishwanath***

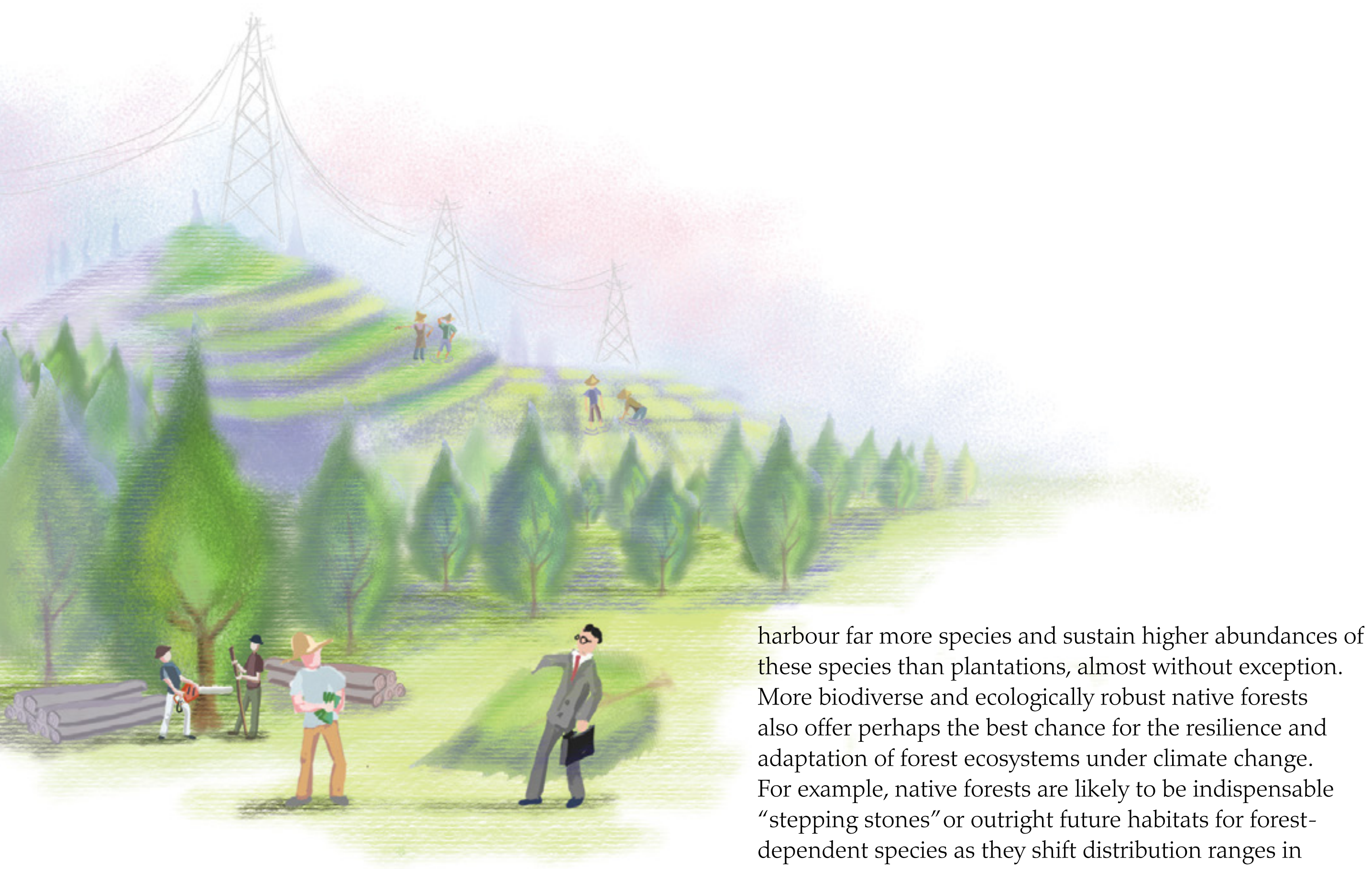
Echoing a similar story the world over, native forests in China have historically suffered severe losses linked to the expansion of agriculture and production forestry. As the ultimate source of agricultural land in much of China, native forests gradually dwindled over thousands of years, before the shock of the Great Leap Forward at the end of the 1950's when remaining native forests were extensively cleared to harvest fuel wood and expand agriculture. Industrial logging of native forests was completely unregulated in China until the mid-1970's and continued well into the late 1990's (Richardson 1990). In the meantime, large-scale deforestation for plantations and particularly rubber plantations in tropical southern China, further exacerbated the destruction of native forests.

Recognising the deleterious environmental consequences of forest loss, the Chinese government has long embraced reforestation as a mitigation strategy. Since as early as the late 1950's, reforestation has been extensively implemented using manual planting and aerial seeding. However, it was not until the massive floods across the country in 1998 – widely attributed to unchecked deforestation – that systematic nationwide reforestation programs were put in place. The Natural Forest Protection Program (NFPP) and the Grain-for-Green Program (GFGP) are not only the largest in China, but are also among the world's biggest and most extensively funded.

The NFPP, in effect in 18 of mainland China's 31 provinces since 1998, was a direct response to the 1998 floods. Aimed at protecting native forests and safeguarding against floods, it employs a combination of logging bans, natural regeneration, and the establishment of plantations for alternative timber supply. The GFGP aims to curb soil erosion by providing incentives for households to retire and reforest croplands on slopes prone to erosion, thus replacing "grain" production with "green" forest cover. It was trialled in three provinces in 1999 and rolled out to 23 more provinces in 2000. Both programmes are currently ongoing and expected to last until at least 2020. Notably, both have a clear emphasis on the key ecosystem services provided by forest ecosystems.

This recent boost of state sponsorship for reforestation coincided with profound changes in rural China. Mass emigration to urban areas reduced the availability of rural labour, while remittance from urban or other non-farm jobs accounted for an increasing proportion of rural income. The demographic and economic changes across rural China are palpable, and among them is the increasing tendency of rural households to shift land use away from crop production, or any kind of production altogether. Tree stands or forests, requiring far less labour to manage than food crops, have come to be an appealing land use option. Recent reforestation in China has thus taken place under a highly favourable socio-economic context.

The combination of strong state sponsorship and conducive socio-economic context has afforded China's recent reforestation efforts sizeable success, at least as measured by the land area reforested. State Forestry Administration (SFA) reports that 84 million hectares of land in China were reforested* between 1999-2013—an area slightly larger than Sweden and Japan combined. Independent remote-sensing studies show that China's forest cover increased from 2000 to



2013, mostly in regions under reforestation programs. *

Despite China's forest cover increase, it is important to note that these "new forests" seem to mostly comprise very few tree species on the stand level, and thus do little to restore China's beleaguered native forests. As an extensive literature review shows, individual stands of the "new forests" re-established under the GFGP mostly comprise fewer than five tree species. Worse still, with the term "forest" encompassing a wide range of tree stand types, the emphasis on simple "forest cover" as the measure of reforestation success may effectively have displaced the remaining native forests by favouring production-oriented plantations (the term "plantation" in this article refers to tree stands comprising a small number of tree species). This latter concern was corroborated by a recent study in tropical Hainan Province: in the era of reforestation, Hainan's native forest cover continued to decline despite an overall increase in total forest cover.

Why do these issues matter? The short answer is that native forests and plantations have major differences in the ecological functions they perform and ecosystem services they provide. Among these functions and services, perhaps none illustrates the differences more plainly than biodiversity: across the world's ecosystems, native forests harbour far more species and sustain higher abundances of these species than plantations, almost without exception. More biodiverse and ecologically robust native forests also offer perhaps the best chance for the resilience and adaptation of forest ecosystems under climate change. For example, native forests are likely to be indispensable "stepping stones" or outright future habitats for forest-dependent species as they shift distribution ranges in response to climate change. For reforestation to restore not native forests but plantations thus foregoes the attainable environmental benefits – derived from ecological functions and services – that native forests have over and above plantations.

Ultimately, the environmental argument behind virtually all reforestation programs should be about the environmental benefits provided by forests, not forest cover per se. The design and evaluation of reforestation programs therefore must go beyond the simple metric of forest cover to directly measure the environmental benefits delivered by the "new forests". Furthermore, it is imperative to make native forests the reference ecosystem against which the environmental benefits of these "new forests" are compared. With this vision in mind, knowledge on three issues is needed to understand the environmental implications of reforestation, and how it can be guided to deliver better environmental outcomes. First, how much forest of different types has been re-established and what land cover did it replace? Second, how do the ecological functions and services of these forest types compare with those of the land cover they replaced and with native forests? Third, what drives the choice of different forest types under reforestation? Central to these inquiries is the distinction of different types of forests involved in reforestation, in terms of plant (mostly tree) species composition.

Over the past four years, my colleagues and I asked this very set of questions with a focus on a region in Southwest China that has undergone substantial reforestation under the NFPP and GFGP. The area of roughly 16,000-km^2 lies within Sichuan, the province best known for harbouring ~75% of the extant wild population of the giant panda (*Ailuropoda melanoleuca*). It was historically forested but suffered extensive deforestation throughout its >2,000 years of human settlement. SFA statistics for the region suggest that, between 2000 and 2015, the NFPP and GFGP have curbed forest loss and contributed to substantial reforestation, but anecdotal evidence also suggests considerable loss of native forests in the region.

The approach our team used was a combination of satellite imagery analysis of land cover and fieldwork that included ecological surveys and household interviews. We analysed satellite images to understand how the region's land cover changed between 2000 and 2015, in particular distinguishing among forest types in terms of tree species composition. This analysis, however, cannot assess the land cover change specifically attributable to NFPP or GFGP. We conducted ecological surveys focusing on birds and bees to understand the consequences of such land cover change for biodiversity, the aspect of ecological functions and services that arguably best reflects the ecological distinction between native forests and plantations, yet has been severely neglected in studies thus far on reforestation in China (Hua et al. 2016). Finally, we conducted interviews of rural households to understand the reasons behind their choice of forest types under the GFGP, the single most influential reforestation scheme for this region over the study period.

In a nutshell, our findings are as follows:

• All types of forests combined, the region's forest cover increased by 32%. However, this increase was entirely accounted for by the conversion of croplands to plantations, particularly monocultures, while native forests suffered a net loss. Interviews of rural households also revealed that the GFGP in the region has overwhelmingly resulted in monoculture and mixed plantations. In other words, in the study region, reforestation has displaced native forests including those that could have regenerated on land freed up from agriculture.

• Plantation-style reforestation on croplands resulted in modest gains (via mixed plantations) and losses (via monocultures) of bird diversity and major losses of bee diversity. No plantations, however, restored biodiversity to levels approximating native forests. Thus, the region's reforestation has led to mixed results for biodiversity, and has considerable potential for biodiversity gains if it were to restore native forests rather than plantations.

• Households' choices of forest types under the GFGP were most strongly driven by two factors: their pursuit of higher profits from forestry production, and the encouragement of local governments to establish certain forest types. Households also tended to follow the forest type choices of their neighbours, reflecting the influence of social norms in the region's reforestation dynamics.

These findings provide a number of policy insights on the design and implementation of reforestation programs for better environmental gains in the region. For one thing, with its strong influence on the outcome of the region's reforestation, government policies and reforestation programs in particular should pay serious attention to safeguarding existing native forests and facilitating native forest restoration. They should discontinue providing perverse incentives for plantations to displace native forests. Additionally, non-policy factors operating on the household level, notably households' strong emphasis on profitability and their desire to conform to social norms in reforestation decision-making, should be harnessed to facilitate better reforestation outcomes. The former factor highlights the

* This figure includes afforestation, the establishment of forests on land not formally forested, since China's forest policies do not differentiate afforestation from reforestation.

necessity and potential utility of proper, socially-equitable compensation for foregone opportunity costs to obtain the support of households. The latter indicates scope for facilitating behavioural changes through avenues such as social marketing.

It is important to note two boundaries to the above policy recommendations. First, they apply to places and situations where native forests warrant restoration. Because the production of timber and non-timber products is among forests' key functions and services, production plantations are often legitimate, oftentimes necessary, components of the forest landscape for any geographical region of interest see Paquette and Messier 2010 for a review on this topic. This is particularly so when plantations' high production efficiencies enable native forests to be "spared" for conservation, and, in turn, yield better overall outcomes for both production and environmental goals. Science-informed planning should inform where to allocate land, and how much space to set aside, for native forests versus plantations. Second, the above policy recommendations may no longer apply when the geographical scope of consideration expands to regions outside of our focal region. As a poignant example, there are wide concerns and indications that the NFPP, by banning logging and considerably reducing domestic timber production in China, most likely fuelled deforestation in other countries from which China imported timber, including a number of tropical countries with arguably higher biodiversity and other environmental stakes. Knowledge of the true environmental implications of a reforestation programme or an environmental intervention at large, and how it should be steered for best environmental outcomes, therefore, would remain incomplete until these "leakage" effects are accounted for. How to assess such leakage effects is a research frontier in environmental sciences that is more urgent than ever, as countries and regions become increasingly interconnected through a vast trade network.

Worldwide, reforestation is assuming an increasingly important role in meeting the environmental and livelihood challenges of forest loss and climate change, and is rapidly garnering sizeable political will and financial investment. Experiences and lessons that China has gained with regard to the design and implementation of reforestation can provide relevant insights for other countries as they undertake reforestation efforts and grapple with similar challenges – and opportunities – associated with the recovery of their native forests.

Further reading:

Brockerhoff, E.G., H. Jactel, J.A.Parrotta , C.P.Quine and J. Sayer. 2008. Plantation forests and biodiversity: oxymoron or opportunity? *Biodiversity and Conservation* 17(5): 925-951.

Hua, F., X. Wang, X. Zheng, B. Fisher, L. Wang, Zhu, Tang, W.Y. Douglas, and D.S. Wilcove. 2016. Opportunities for biodiversity gains under the world's largest reforestation programme. *Nature Communications* 7: 12717.

Paquette, A. and C. Messier. 2010. The role of plantations in managing the world's forests in the Anthropocene. *Frontiers in Ecology and the Environment* 8(1): 27-34.

Richardson, S.D., 1990. Forests and forestry in China: changing patterns of resource development. Island Press.

Suding, K., E. Higgs, M. Palmer, J.B. Callicott, C.B. Anderson, M. Baker, J.J.Gutrich. Hondula, K.L., M.C. LaFevor, B.M. Larsonand A. Randall. 2015. Committing to ecological restoration. *Science* 348(6235): 638-640.

Zhai, D.L., J.C. Xu, Z.C. Dai,C.H. Cannon and R.E. Grumbine. 2014. Increasing tree cover while losing diverse natural forests in tropical Hainan, China. *Regional Environmental Change* 14(2): 611-621.

***Dr. Fangyuan Hua** is a conservation ecologist with a research focus on understanding and conserving forest biodiversity. She is currently a Newton International Fellow of the British Royal Society, based at the University of Cambridge.*

***Megha Vishwanath** freelances as an illustrator with a special interest in comics, children's books and conservation. Until recently, she has been consulting in technology for Bangalore based non profits in public education.*
www.moonlitnook.com

PROMOTING FOREST RESTORATION in BRAZIL THROUGH TIMBER AND NON-TIMBER FOREST PRODUCTS

Author: ***Pedro Brancalion*** · *Illustrator:* ***Manini Bansal***

Tropical forests are a huge shopping mall for indigenous and local communities, from where they obtain food, medicines, construction and building materials, fuel, and many other contributions to their quality of life, from pigments for artistic paintings to infusions for communicating with spirits. Throughout much of the tropics, forests providing such diverse uses and experiences have been converted to large-scale monoculture plantations focused on a few agricultural commodities to supply demand by global markets. In economics, the replacement of hundreds of forest products by maize, soybean, oil palm, sugarcane and other staple foods or biofuel has not been considered a problem, based on the argument that modern agriculture has found substitutes for native plants to support human wellbeing. However, it is clear now that the uses of some native species cannot be substituted by their modern counterparts.

For instance, no exotic eucalypt or pine tree species cultivated in Brazil can supply wood for producing fine bows for string instruments as good as that of the Brazilwood tree (*Paubrasilia echinata*). This tree species, endemic to Brazil's Atlantic Forest, was the first product exported by Portugal when the country was colonised in 1500, and part of the name of this tree ('brazil' is derived from the Portuguese word for 'ember' and is a reference to the red dye extracted from the wood of this species) baptized the new country. Brazilwood is now an endangered species with a few native remnant populations. Similar to Brazilwood, many other native species with commercial potential can no longer be exploited in forest remnants and rely on their cultivation to reach the shelves of stores. Cultivating native plants may be the only way to fully develop their market potential and include them in the modern economy. However, the commercial production of native tropical plants is still risky due to poor knowledge of production and processing technologies, and market uncertainties.

The production of these species could harness the emerging global forest and landscape restoration movement, which has garnered impressive international support to promote reforestation in the tropics. Part of the risks associated with land opportunity costs, tree planting costs, land tenure, forest protection, and stakeholder engagement are expected to be minimised by restoration programmes that promote the commercial cultivation of native plants. At the same time, revenues from the exploitation of native plants in productive, restored forests could contribute to offsetting reforestation costs and make forest restoration more a economically viable use of land rather than other agricultural land uses covering deforested lands. Therefore, the commercial production of timber and non-timber forest products (NTFP) in forests undergoing restoration could result in a win-win scenario and provide a path towards the large-scale restoration of deforested tropical landscapes.

The development of productive restoration models is still, however, a relatively new approach to promoting restoration. It is therefore necessary

to explore pioneer case studies as sources of inspiration and is also an opportunity to leverage the potential of this approach to promote large-scale restoration.

Here, we present a group of case studies from Brazil to illustrate restoration models that can be used to merge production and conservation in restoration.

Juçara pulp production in the Atlantic Rainforest

Regenerating forests have provided forest goods with market potential to people in many different tropical regions, like jungle rubber in southeast Asia, and firewood production in Africa. In Brazil, tropical forests yield several emblematic NTFP with high market demand in the country and internationally. Iconic examples include the yerba-mate (*Ilex paraguariensis* leaves) and pinhão (*Araucaria angustifolia* seeds) in south Brazil, the palm heart of Euterpe edulis, cashew (*Anacardium occidentale*) nuts and fruit pulp in the Atlantic Forest, the Brazil nut (*Bertholletia excelsa* seeds), cupuaçu (*Theobroma grandiflorum* fruit pulp), and açaí (*Euterpe oleraceae* fruit pulp) in the Amazon, many of them classified as"superfoods"due to their health values. Açaí, in particular, has gained international recognition as a superfood and its exploitation from native riparian forests in the Amazon basin has not been sufficient to satisfy the market appetite for this product.

In southeastern Brazil, a network of environmental NGOs, governments, and research organisations have promoted the cultivation of an açaí cousin, the juçara palm (*Euterpe edulis*), as an alternative to the market of açaí pulp in São Paulo and Rio de Janeiro states. Juçara is an endemic species of the Atlantic Forest and is now threatened by habitat loss and overexploitation of its palm heart, the main NTFP formerly exploited in the biome. Local farmers and quilombolas (communities of descendants of escaped slaves) used juçara as the main commercial species in agroforests and managed secondary forests established in abandoned banana plantations and extensive pasturelands. A cooperative was established and sells processed, frozen pulp to local markets. Many other native and exotic species are cultivated using reforestation approaches with juçara, which have helped to increase forest cover in a globally important region for conserving biodiversity. Production of NTFP is particularly important in agroforestry systems, because the cultivation of crops may create cash flow for farmers and help maintain the restored forest until commercial woody species reach productive maturity.

Timber production in forest restoration

The global market for tropical timber is huge, but still heavily dependent on logging from native forests. The reduction of tropical forest cover and enforcement of legal requirements have reduced the commercial supply of tropical timber and pushed prices up, which have fostered investments in the production of tropical timber in plantations. For highly deforested ecosystems like the Atlantic Forest, however, many unique timber species are no longer traded, and their cultivation could yield novel

wood products in the market. Several restoration models focused on native timber production have been developed across the Atlantic Forest of Brazil. Some of these models intercrop exotic eucalypts with native timber species in order to anticipate cash flow with eucalypt wood production for about 5 years after planting and offsetting restoration implementation and maintenance costs.

The main lessons learned from these projects have been that not all native timber species historically exploited from remnants are good candidates for production in regular plantation schemes because some of them grow too slowly, produce many stems when cultivated at full sunlight exposition, and suffer from pests and diseases when grown at a higher density. One of the key challenges to address when cultivating tropical timber species is the trade-off between growth and ramification or bole shape. Intercropping shade-tolerant timber species with pioneer species may be a good solution for reducing ramification and producing boles with better shape, but competition for light may compromise the growth of the targeted commercial species. At the same time, timber species grown under higher light incidence, not intercropped with shade trees, may overproduce branches and pruning may be needed. Genetic selection may be necessary, because the use of wild materials may result in too much variation in growth, bole shape, and ramification. A simple mass selection yields great results – this consists of planting trees from diverging seed sources to maximise diversity, thinning plants with undesirable characteristics, and harvesting seeds from the good trees remaining in the area.

Finally, it is necessary to develop appropriate wood processing technologies to work with native wood produced in plantations. All machinery and processing techniques employed for tropical timber were developed for working with large boles, but boles produced in plantations rarely reach such large diameters. Timber exploitation in remnants relies on logging few, but very large and old, trees per area, while in plantations a larger timber volume is produced per area,

but distributed across many smaller-sized 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

Brancalion, P.H.S., D. Lamb, E. Ceccon, D. Boucher, J. Herbohn, B. Strassburg, and D.P. Edwards, D.P. 2017. Using markets to leverage investment in forest and landscape restoration in the tropics. *Forest Policy and Economics* 85(1): 103–113.

Brancalion, P. H. S., R.A.G. Viani, B.B.N. Strassburg, and R.R. Rodrigues. 2012. Finding the money for tropical forest restoration. *Unasylva* 239(63):25–34.

Latawiec, A.E., B.B.N. Strassburg, P.H.S. Brancalion, R.R. Rodrigues, and T.A. Gardner. 2015. Creating space for large-scale restoration in tropical agricultural landscapes. *Frontiers in Ecology and Environment* 13(4):211–218.

Souza, S.E.X.F., E. Vidal, G.F. Chagas, A.T. Elgar, and P.H.S Brancalion. 2016. Ecological outcomes and livelihood benefits of community-managed agroforests and second growth forests in Southeast Brazil. *Biotropica* 48(6):868–881.

***Pedro H. S. Brancalion** is a professor of tropical forestry and restoration ecology at the "Luiz de Queiroz" College of Agriculture, University of São Paulo, Brazil.*

***Manini Bansal** is a visual communication designer whose work is mostly inspired by nature. She is trained to see through an analog lens which works its way into her illustrations.*
www.behance.net/maninibansal107

Restoring Rainforest Remnants

Experiences from the Anamalai Hills

*Authors: **TR Shankar Raman** ,**Divya Mudappa** and **Anand Osuri** · Illustrator: **Aindri Chakrabarty***

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 travancorica*, and pole-like slow-growing 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 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. The rainforests remain as fragments 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 Tiger Reserve and a clutch of reserved forests in Kerala state together form a tract of more than 3000 square kilometres of forests around the Valparai 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 remnants—anywhere 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.

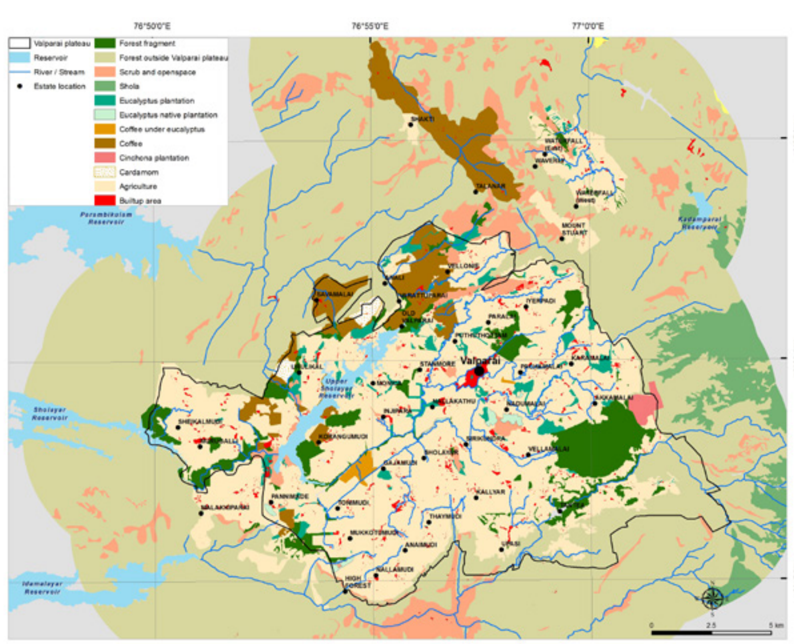
Whereas a single hectare of undisturbed rainforest would hold around 80 tree species, up to a third of which are endemic to the Western Ghats, the disturbed remnant may retain about half that diversity. On rainforest trees, looped with climbers that increase in abundance in degraded forests, troops of Nilgiri langurs forage on leaves in the canopy. In a few larger remnants, the rare and endemic lion-tailed 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 red-whiskered 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 *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.



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).

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 near-absence 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 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, during which we take care to retain all naturally established native plants. In larger fragments and remnants, we focus on the disturbed edges, reasoning that if these improve, forest interiors will automatically benefit. During the monsoon, 20 – 80 native species are planted in each site following a mixed native species planting protocol, tweaking the mix of species and planting density based on initial site conditions and the history of disturbance.

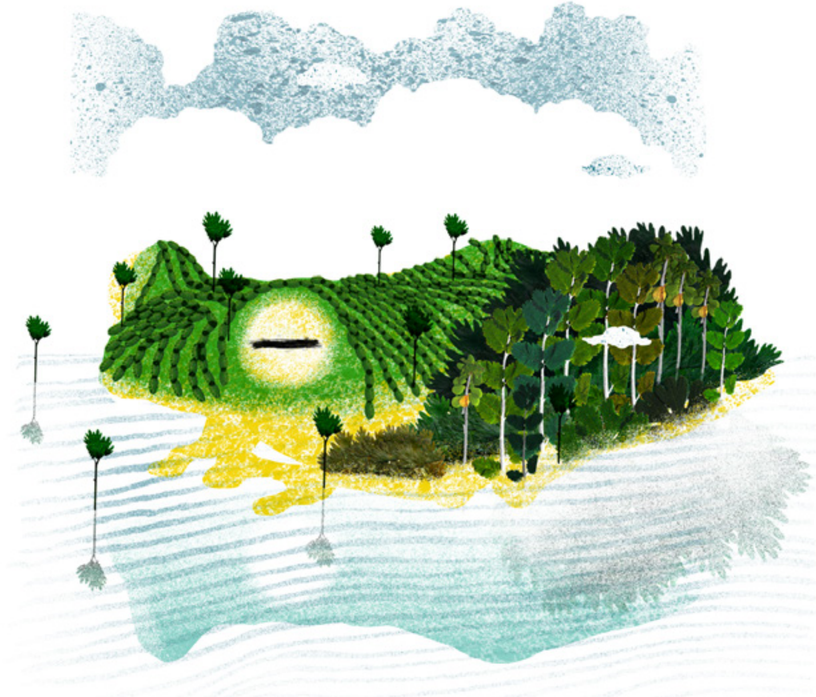
Now, in 2017, with 40,000 saplings planted out for restoration, the effort spans 50 sites and about 60 hectares in 15 rainforest remnants that together cover over 300 hectares. Over this period, plantation companies, too, planted about 25,000 saplings of around 75 native species, sourced from our nursery, 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

Still, there are questions to ask and answer. Does a plantation of rainforest trees constitute a restored rainforest? To what extent, and after how long, does a healthy rainforest's diversity, ecological processes, and intricate network of interactions re-establish in restoration sites? When will rainforest bees and beetles return to pollinate the young *Myristica* tree's flowers, or great hornbills arrive to eat the fruits, bringing in more seeds from distant rainforests? Will the trajectory of recovery bring restored sites closer to undisturbed rainforest or will competing weeds or insect herbivores overwhelm planted saplings to revert the site to a degraded state? Or will the saplings hold on only as long as they are being cared for?

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 naturally-established 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 naturally-regenerating 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 practice—also 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 in 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

Mudappa, D., T. R. S. Raman, and M. A. Kumar. 2014. Restoring nature: wildlife conservation in landscapes fragmented by plantation crops in India. In: *Nature without borders* (eds. Rangarajan, M., M. D. Madhusudan, and G. Shahabuddin). Pp. 178–214. New Delhi: Orient Blackswan.

Nature Conservation Foundation. 2018. Reviving the rainforest: ecological restoration of degraded rainforest in the Anamalai hills. http://ncf-india.org/projects/reviving-the-rainforest. Accessed March 7, 2018. [Rainforest restoration project website.]

T. R. Shankar Raman *is a wildlife biologist and writer at the Nature Conservation Foundation (NCF) with interests in tropical ecology and conservation. His research and writing focuses on tropical forests, conservation of birds and other wildlife, and human connections to the rest of nature.*

Divya Mudappa *is a wildlife biologist at the NCF with research interests in the field of tropical ecology, particularly of rainforests. Her work focuses on plant-animal interactions, animal behaviour, restoration ecology, and conservation biology.*

Anand Osuri *is an ecologist at NCF, presently a post-doctoral researcher at the Department of Ecology, Evolution and Environmental Biology, Columbia University, New York. His research interests are at the interface of tropical forest ecology and conservation, exploring the role of restoration in recovering and sustaining forest biodiversity and ecosystem functions in human-dominated tropical landscapes.*

Aindri Chakrabarty *is a communication designer specialising in animation and narrative illustration. She is a member of Kadak, an online collective of women graphic artists.*
www.kadakcollective.com

Implementing the National Greening Programme in the Philippines Lessons Learned

Authors: ***Nestor Gregorio*** *and* ***John Herbohn*** · *Illustrator:* ***Farzeen Kapadia***

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 community-based 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 community-based 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 people-based 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 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 government-funded 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

*'In this project, we know what a quality seedling is and why it is important in reforestation. The technology is simple and not expensive. We could see our trees survived even in drought and they are growing fast!' – **Anabelle Talon – PO member***

community restoration programmes. The major factors hampering the success of community-based forest restoration programmes in the country were the absence of livelihoods that provide food and income to communities, lack of social preparation, poor seedling quality, uncertainty of land and tree tenure, and corruption.

The project implemented a package of interventions to improve the success of community-based forest restoration focused on integrating timber production and ecological restoration objectives with crops to provide food and income to the community. To address inadequate social preparation, capacity building activities engaged smallholders in best practice technologies in community forest restoration. Community organising rejuvenated the group. Gender equality was promoted by engaging men and women in various aspects of the project including making decisions on tree and crop species selection, plantation establishment, livelihood identification, and development of local policies. Identifying mother trees from the natural forest helped to improve the supply of high quality germplasm. The community produced high quality seedlings using smallholder-based best practice demonstrated in training activities. Each member of the community organisation received copies of the tenurial instrument. Local policies including sharing agreements of responsibilities and benefits among community members were developed.

*'In this project, we see sustainability. We have food from crops, income from seedling sales, and trees to harvest in the future.' – **Romeo Dabalos, Peoples Organisation President***

The project initiated farmer-preferred and market-driven livelihood projects to provide short, medium and long-term benefits.

The project demonstrated early success. Community participation improved from five to thirty active members. Tree establishment and quality improved dramatically. After three years, seedling survival exceeded 80%, with Acacia mangium trees in the production zone reaching an average height of 11 metres. Fruit trees and cash crops were planted and the community started harvesting crops to supplement the food requirements of members and provide income to help meet their subsistence needs. The knowledge and skills of community members to produce high quality seedlings and apply smallholder-based best practice silviculture has significantly improved. The community received direct financial benefits from the project for three years for implementing project activities including seedling production, and plantation establishment and maintenance. The community also shifted the communal nursery seedling production into a livelihood enterprise providing income to community members from seedling sales.

The collective action of community members to implement project activities was very high when direct financial benefit was provided. For example, activities such as seedling production, site preparation, and plantation establishment and maintenance encouraged high levels of participation when wages were provided immediately after the completion of tasks. Levels of participation were lower when voluntary labour was required, such as in the management of the communal farm. Monetary benefit appears to be the greatest factor that drove community members to

*'We manage our trees voluntarily as a group because management is not intensive and we need to work together to protect them. But for the crops and fruit trees, it is better to manage them by family members because they need frequent labour. If voluntary labour is needed, some members are less active.' – **Elpidio Verba, PO member***

participate in community-based forest restoration. The lower performance of some members also led to waning interest of other members of the community to manage the communal farm.

Eventually, the community decided to divide the farm into plots for management by individual family members. This decision was supported with a community policy regarding sharing of returns between members and the community organisation, with penalties for members who would abandon their respective farms. The distribution of farm plots to individual family members was found to be effective in managing the communal farm. Apparently, community members preferred to provide voluntary labour to manage individual lots rather than work as one group in managing the communal farm. A similar scheme will be adopted in managing the established communal tree plantation.

The implementation of the pilot evidence-based community forest restoration project has provided some lessons that would help improve the success of the National Greening Programme in the Philippines and similar community-based restoration projects in other developing countries in the tropics. The project illustrated the importance of project design to match the needs, interests and circumstances of the communities, and the usefulness of the systems approach in designing the project to harmonise multiple uses of the landscape. As most of those involved in community-based forest restoration in the Philippines are poor, financial incentives and food security become primary drivers of participation. The project has showcased the crucial role of sustainable livelihoods in community forest restoration. It has also demonstrated the importance of adequate social preparation, strong leadership, security of land tenure, and supportive policy and good governance in promoting a successful community-based forest restoration project. Women play vital roles in undertaking various forest restoration activities. In the project, women members of the community were actively involved in germplasm collection, seedling production, and plantation establishment. Women were also effective extension agents, and held key responsibilities for keeping community records and administering project funds.

The factors contributing to mixed results of community-based forest restoration are complicated, and designing and implementing interventions is equally challenging. Our research demonstrated the usefulness of the systems approach in understanding causalities and developing effective interventions. The application of genuine participatory processes at all stages of the community-based restoration project is imperative, and integration of lessons learned from past reforestation programmes in the project design and implementation plan guided implementation success.

The results of our project revealed that addressing socio-economic and food security issues of smallholders is key to the success of community-based forest restoration. Hence, livelihood projects that provide food and income to the community are an essential component of community-based forest restoration. Social mobilisation and community collective action is facilitated when immediate financial incentives are offered. In the absence of financial incentives, community members prefer to work on individually allocated farm plots and woodlots rather than on commonly owned tree plantations and agricultural farms. This finding suggests that the best way to implement a community-based restoration could be through individual family members managing restoration areas, particularly when project funds are exhausted. While individual families need to form a community organisation to access government lands, and receive financial and material support to develop restoration sites, the long-term management of established trees and crops could be family-based.

The size of the community organisation is important when collective action is needed in forest restoration. Some community organisations in the Philippines manage hundreds of hectares of forest restoration projects, which is beyond the capability of community groups to manage effectively. The pilot community-based restoration in Biliran demonstrates the importance of matching the target area of restoration to the size of the community organisation.

Further reading

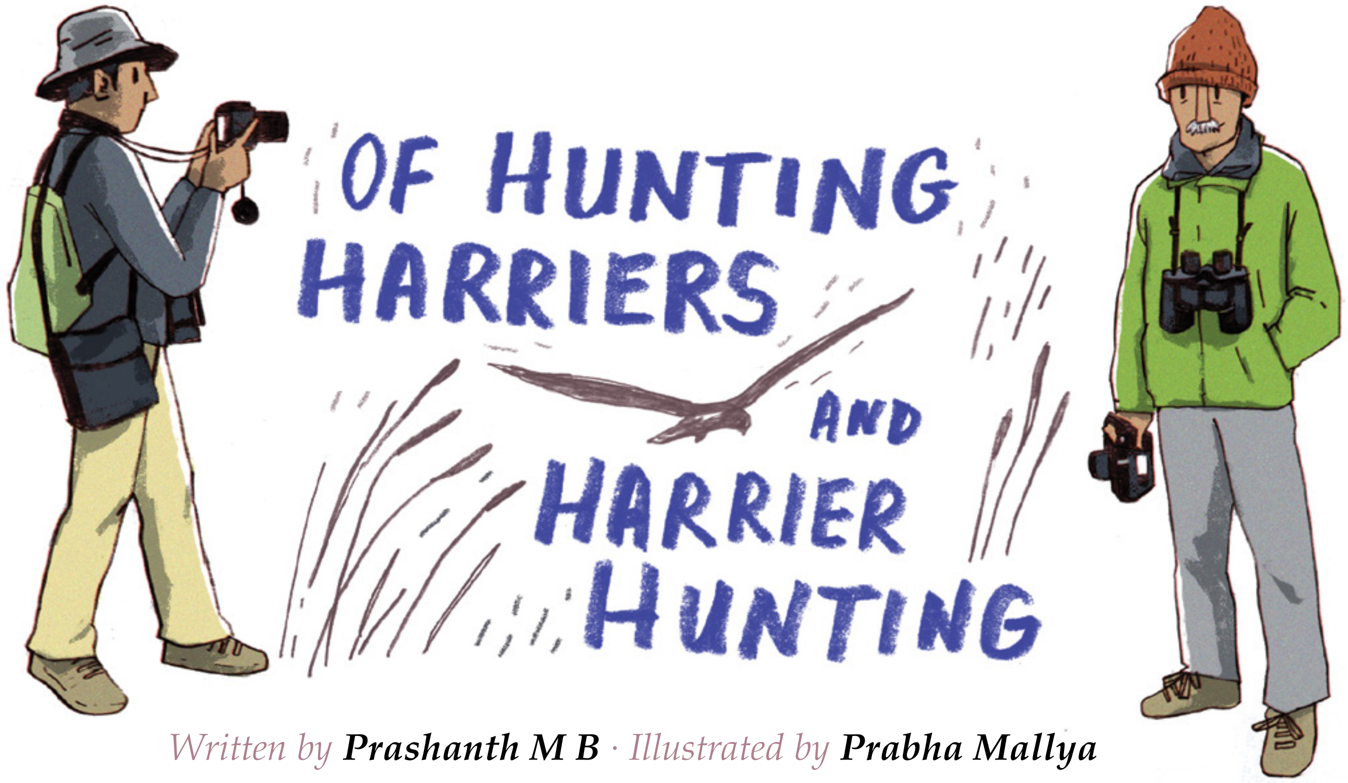
Baynes, J., J. Herbohn, C. Smith, R. Fisher, and D. Bray. 2015. Key drivers affecting the success of community forestry in developing countries. Global Environmental Change 35: 226-238.
Gregorio N., J. Herbohn, S. Harrison, A. Pasa, J. Fernandez, R. Tripoli, and B. Polinar. 2015. Evidence-based best practice community-based forest restoration in Biliran: integrating food security and livelihood improvements into watershed rehabilitation in the Philippines. In: *Enhancing food security through forest landscape restoration: lessons from Burkina Faso, Brazil, Guatemala, Vietnam, Ghana, Ethiopia and Philippines* (eds. Kumar C., C. Saint-Laurent, S. Begeladze, and M. Calmon). Pp. 174–217. doi:10.2305/IUCN.CH.2015.FR.2.e. IUCN and Gland.

Le, H.D., C. Smith, and J. Herbohn. 2014. What drives the success of reforestation projects in tropical developing countries? The case of the Philippines. *Global Environmental Change* 24: 334-348

Dr Nestor Gregorio *is a research fellow at the Tropical Forests and People Research Centre of the University of the Sunshine Coast. His research interest is in people-based forestry, and he is mainly involved in ACIAR-funded forest and landscape restoration research projects in the Philippines and Papua New Guinea.*

Farzeen Kapadia *is a freelance illustrator and graphic designer. She's happiest when she is illustrating children's books, and more recently, birds. If she's not drawing, you will find her curled up with a book and a cup of tea.*

Of Hunting Harriers and Harrier Hunting



Written by ***Prashanth M B*** · *Illustrated by* ***Prabha Mallya***

The first streaks of dawn would usher in our "hunt" – to walk through grasslands to spot the Montagu's and Pallid harriers – migratory birds of prey. By September, the summer home of the harriers, in Kazakhstan and Central Asia turns bitterly cold and getting covered with snow, leaving them with few options for finding food, such as voles, insects, and small birds. Thus, they begin an arduous migration, which will take them skimming over lofty mountains in Central Asia, over sandy and deserted dunes in Afghanistan, and into many parts of India. They arrive between September and November, to find food amidst the lush green grass and crops.

Each morning during the months that the harriers are in India, Ganesh and I walk the trails, trying to spot and count the harriers. This is like running through the attendance register at school: we want to know how many harriers have turned up, each day, and across the season. A reduction in their number can tell us if something may have changed in the grasslands, such as the availability of their food.

A gliding, elegant blue-grey harrier makes a beautiful sight and is more refreshing than our morning cups of coffee! Many harriers sport red-brown feathers, meaning they are young birds. Imagine a 4-month old bird flying over the mountains and deserts to meet you and me here in India!

a day in the life

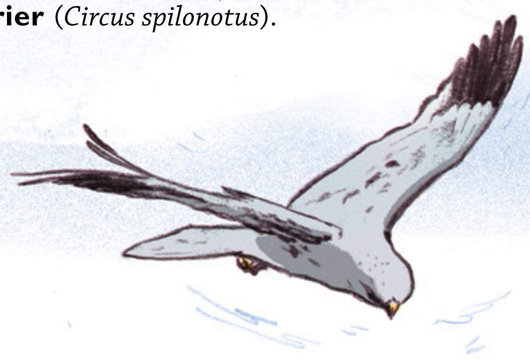
Once here, the harriers fly low over the ground, barely a few feet above the grass, unlike eagles that scan for prey from high above. We watch them eagerly, as they perform various acrobatic flights to corner their prey, finally pouncing on a large grasshopper or small bird. Having caught a meal, the harrier then flies to a small open patch on the ground to prevent its prey from escaping, and dissects it carefully, consuming only the most nutritious parts. We also take keen interest in their prey, noting down how many of each type are available in the grasslands, as this will tell us whether the harriers' food has dwindled, changed, or increased. Remember, these harriers come from thousands of kilometers away in search of food, in these fast-disappearing grasslands in India. And the grasslands and savannahs are not only important for the harriers. They are also home to various wild grasses, wolves, foxes, and unique birds, and provide pasture to goats, sheep, and cattle.

An afternoon nap for the harriers in the shade suggests that we take one too, since the grasslands are located in extremely hot and dry areas of the country: around the deserts of Rajasthan, in the grasslands of Gujarat, and on the Deccan plateau all the way into Southern Tamil Nadu. After lunch and a cup of tea we head off to the grassland once again to a small patch called a harrier roost. A roost is an interesting place – a patch of tall grass, which the harriers hustle into each evening to make their bed. They trample the soft grass into a cup and form a cozy bed just like you and I wrap ourselves in blankets. This is a safe haven for them each night, to guard themselves against large owls, foxes, and jungle cats that might prey on them. Here, they spit out small pellets. These pellets contain undigested feathers, hair, bones, and insect body parts from their food, which are a precious resource for us. We collect them to observe under the microscope later, to find out what they have eaten. Pellets can tell us more about how these harriers survive in harsh weather, and how they change their diet as the grass starts to dry out and the grasshoppers become fewer in number!

From the gliding and feeding frenzy through the morning and afternoon, it has been a long day for the harriers. It is time to rest, and just like a crowd gathering in a cafe of an evening, the harriers can be seen flocking at their favourite mound or in a bare patch close to their roost. They perch silently, sometimes inviting others flying by with a shriek, sometimes fighting for a place, and preen their ruffled feathers before sleep. They also offer other harriers a clue to the site of their 'camp,' by flying in short circles over their roost. As the sun sets, they drop into the grass ever so quietly, but remain alert enough to fly off on sensing danger. It's a day's story that recurs throughout the winter months, weaving the pattern of the seasons. As the green grass takes on golden brown hues with the onset of summer in March, the harriers start to turn back, to resume their migratory journey beyond the mountains and deserts.

FUN FACTS

There are 16 species of harriers belonging to the genus *Circus* distributed worldwide, out of which 6 species visit India each winter. These are the **Montagu's harrier** (*Circus pygargus*), **Pallid harrier** (*Circus macrourus*), **Eurasian Marsh harrier** (*Circus aeruginosus*), **Pied Harrier** (*Circus melanoleucos*), **Hen harrier** (*Circus cyaneus*) and the **Eastern Marsh harrier** (*Circus spilonotus*).



Etymology - The name "harrier" may have come from an old English term "hergian" meaning to harass by hostile attacks. The scientific name "Circus" may have come from the Greek work "kirkos" meaning to fly around in circles.

Bright and cryptic colors - The males of most harriers are a bright grey in colour, while the females and young harriers sport a subtler mix of brown, white, and red-brown plumage.

Habitat - The Montagu's, Pallid, and Hen harriers inhabit dry grasslands and savannahs in arid and semi-arid areas, while Marsh harriers inhabit wetlands and marshes.

Harriers need grass - Harriers, unlike other large birds of prey, nest and roost on the ground in tall and dense grass.

Migration - Harriers migrate over a distance of 5000 km each winter, from Central Asia into India, or from parts of Europe into Africa! They may follow one route to reach their destination and another to fly back to their breeding grounds.

A spectacle - Harrier roosts in Gujarat (in the Blackbuck National Park, in Velavadhar) can contain an astounding 1200 birds by September-October each year! They can be seen flying around in circles in unison in the late evenings.

Swoop-snatch - Harriers are adept at snatching their prey in mid-air after they flush them with their swooping flight.

Voracious appetite - From a brief survey of harriers in Velavadhar (Gujarat), the flock of harriers in Velavadhar alone was estimated to consume between 2 and 2.5 million locusts during a single winter in India.

A varied menu - Harriers consume a wide variety of prey, including grasshoppers, small birds, small lizards (*Sitana* species), and small rodents.

Living together - Harriers form communal roosts that include more than one species of harrier. Roosting is preceded by spurts of flying around in circles before diving into the grass.

A web of life - Harriers share the grasslands with other unique and endemic fauna, such as the blackbuck, the wolf, the florican, and the critically endangered Indian bustard.

Ornaments - Scientists have used small numbered metal rings, placed on the legs of individual harriers, to track their movement patterns. You can learn more about some of the birds we have ringed here:
http://harrierwatch.com/wp/index.php/report-your-sightings/

You can learn more about harriers in India here:

Harrierwatch
(http://harrierwatch.com/wp/)

How the decline in India's harrier population hurts its farmers
(https://scroll.in/article/830513/indias-depleting-grasslands-are-leading-to-a-drop-in-the-population-of-birds-that-aid-crop-growth)

Exodus at Rollapadu
(http://www.downtoearth.org.in/news/exodus-at-rollapadu-58001)

Prashanth M.B. is a Research Associate at ATREE, who has studied birds in human-dominated landscapes and grassland-savannas; apart from harriers, he has also worked on inventorying and mapping waterbirds with the help of citizen scientists. Prashanth has worked with Dr. T. Ganesh, who has led the project on tracking harriers to understand migration patterns and identifying key habitats.

Prabha Mallya is an editorial illustrator and comics creator. She is known for drawing insects in the margins, pressing flowers into endpapers, populating spines with kittens and seeing the world through dystopian lenses.

Written by ***Emmanuelle Briolat*** · *Illustrated by* ***Andrew Szopa-Comley***

Woolly took off towards the woods, and in the golden evening light he found them, fluttering around the trees and calling to each other.

"I've seen you! I've found you all!" laughed one moth in the middle.

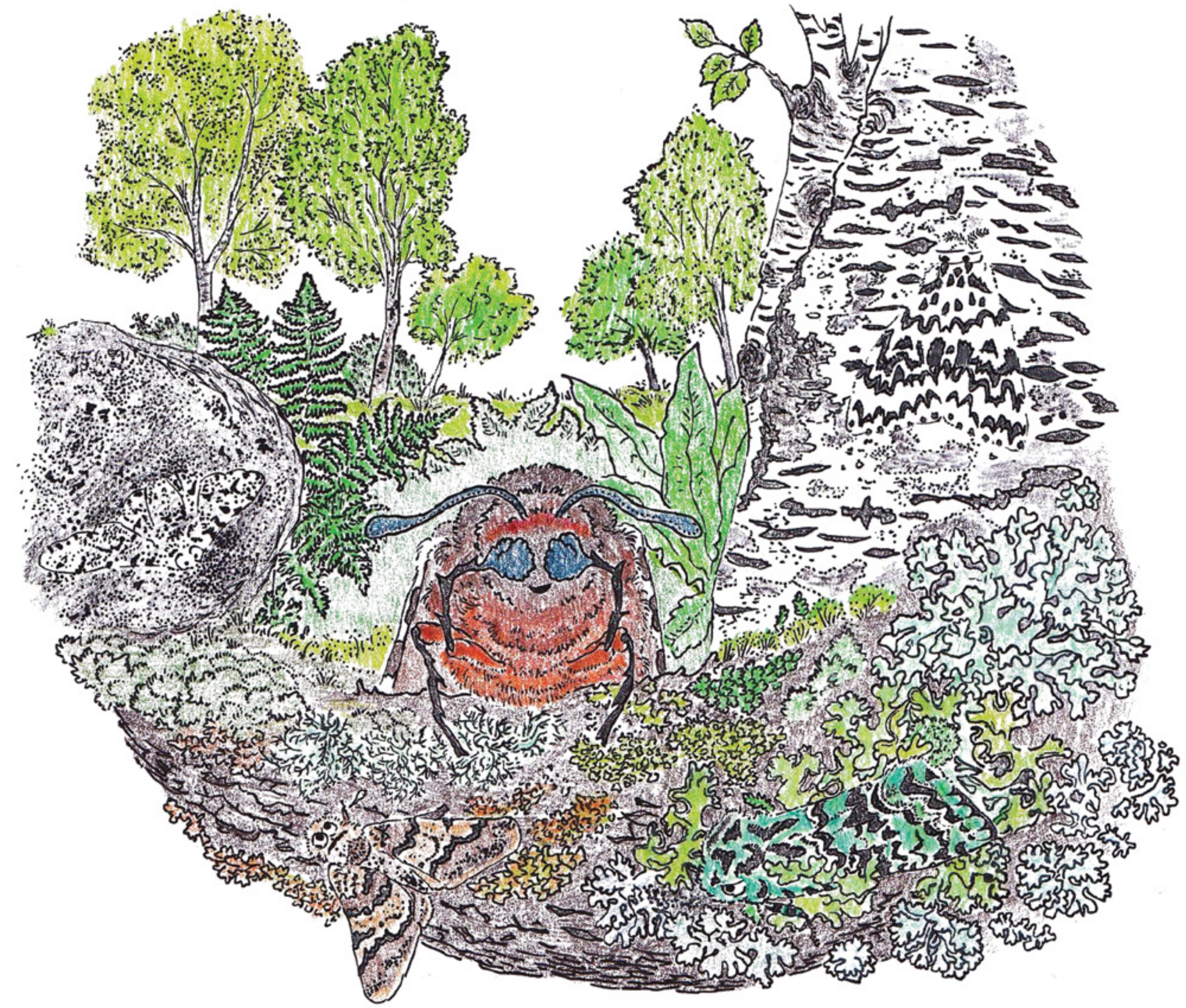
"Ooh, who are you?" she asked as she caught sight of Woolly.

"Hello! My name's Woolly. It's my first day as a moth, and I'm not really sure what I'm supposed to do. What are you up to?"

"We're just playing hide and seek here until it gets dark enough to go out. Do you want to play too?"

Of course Woolly wanted to play. Maybe his troubles were over, now that he'd found this little group of moths.

"I'll be the seeker this time," he decided, and closed his eyes to let the others hide.



They were all sorts of patterns, speckled or striped, in a multitude of shades of brown and grey and white. Once they landed on the trees and bushes, they just disappeared, and it took Woolly an awfully long time to find them again. Yet when it was his turn to hide, he was always the first to be spotted.

Copying the other moths, he hid on tree bark and in the long grass. He hid behind stones and under leaves, but still they had no trouble finding him.

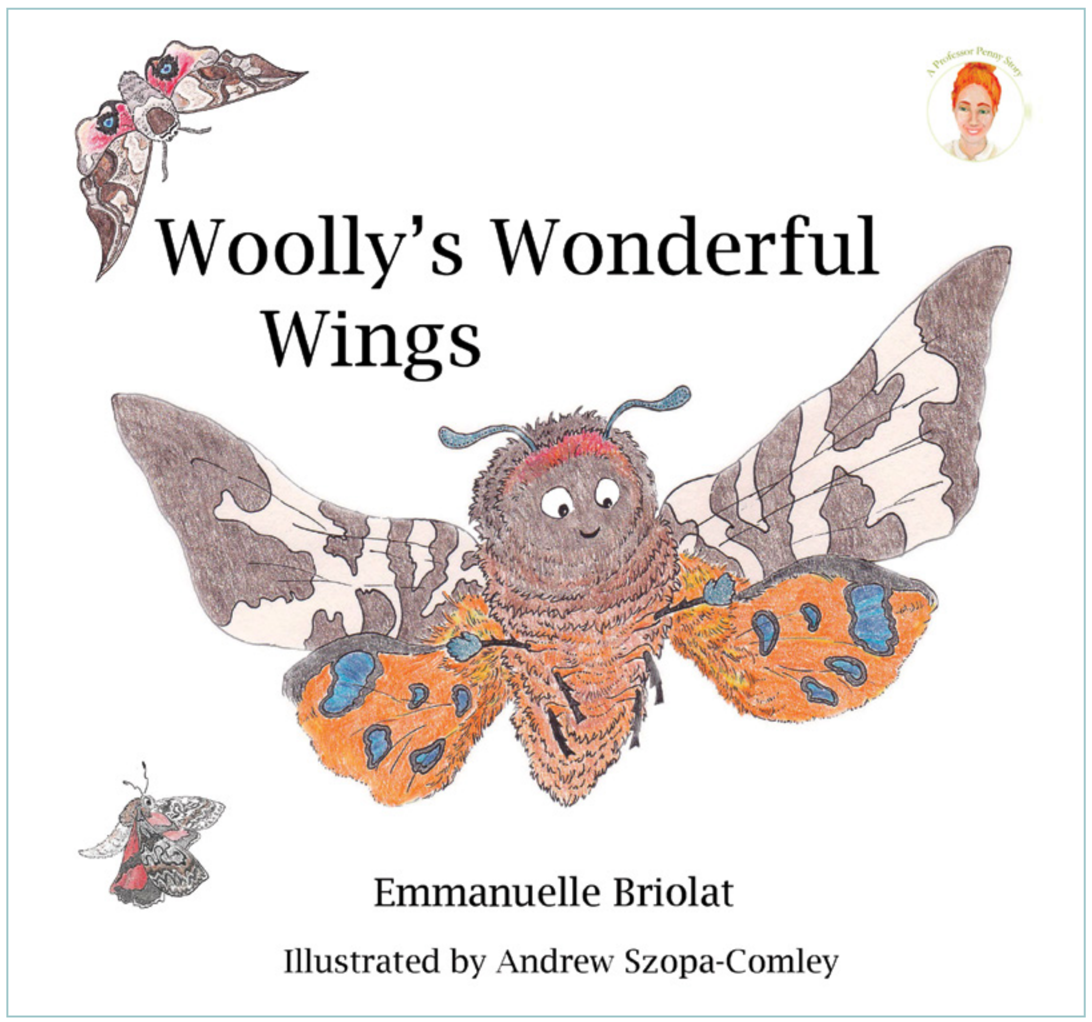
"You're all so good at this," he sighed. "I'm useless!"

"You're quite hard to see from far away," they tried to console him. "But close up, those little red patches on your face always give you away. Maybe this isn't the right game for you."

They were trying to be nice, but Woolly could tell they didn't want to play with him anymore. It really was hard to make friends out here.

He fluttered away from the other moths and settled on a fallen leaf. What should he do next? Where should he go?

These are just a few pages from a longer story, which can be found at the following link **https://issuu.com/universityofexeter/docs/woollybook_29thjune.compressed**
To buy a hard copy, email: **woollyswings@gmail.com**



***Emmanuelle Briolat** has recently completed her PhD at the University of Exeter, researching the striking warning colours of burnet moths.*

***Andrew Szopa-Comley** is a PhD researcher at the University of Bristol, working on personality and predator-prey relations in freshwater fish.*