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Strategies for Landscape-Scale Restoration in the Tropics

January 26-28, 2012
Yale University, New Haven, CT

Proceedings, 2012 Conference of the International Society of Tropical Foresters, Yale Student Chapter

Conference Proceedings

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the International Society of Tropical Foresters,
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List of Acronyms

AGRA	Growing African Agriculture
BARCA	Brinkman & Associates Reforestation Central America
CAPPRU	The Alternative Cooperative of Small Urban and Rural Producers of Xingu, Brazil
CIPAV	Center for Research on Sustainable Agricultural Production Systems
COP	Conference of the Parties
GPFLR	Global Partnership for Forest Landscape Restoration
ELTI	Environmental Leadership and Training Initiative
GHG	Greenhouse gas
ICRAF	International Center for Research in Agroforestry
IMAFLORA	Forest and Agriculture Management and Certification Institute
ISA	Socio-Environmental Institute
ISTF	International Society of Tropical Foresters
LERF	Forest Ecology and Restoration Laboratory
NGO	Non-Government Organization
NTFPs	Non-Timber Forest Products
PES	Payments for Ecosystem Services
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SFM	Sustainable Forest Management
SPS	Silvopastoral Systems
STRI	Smithsonian Tropical Research Institute
UCS	Union of Concerned Scientists
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
WWF	Worldwide Fund for Nature (International); World Wildlife Fund (US)

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Executive Summary

On January 26-28, 2012, the Yale Student Chapter of the International Society of Tropical Foresters (ISTF) held their 18th annual conference at the Yale School of Forestry & Environmental Studies in New Haven, Connecticut. The conference, titled *Strategies for Landscape-Scale Restoration in the Tropics,* brought together over 200 practitioners and researchers from academia, government, and environmental organizations to discuss ways to implement large-scale initiatives to restore forests and sustain human livelihoods.

At the conference, there was widespread recognition of both the biophysical and socio-political difficulties and opportunities for forest restoration in the tropics. Speakers from around the world shared examples of innovative projects seeking to take on the challenges of restoration, as well as scale-up efforts to transform landscapes. Opening remarks were made by David Lamb, professor at the University of Queensland, who presented a suite of options to consider for restoration. He stressed the importance of not taking certain restoration strategies "off the table" without first asking important questions about the science and policy that influence a given area.

Two complementary keynote addresses were provided at the conference. Firstly, Jan McAlpine, director of the United Nations Forum on Forests, highlighted the importance of public-private partnerships and cross-sectoral cooperation needed to advance the social and political will for restoration. In the second keynote, Robin Chazdon, professor at the University of Connecticut, provided a framework to understand the ecological patterns of forest regeneration as a way to evaluate the management options available for restoration.

In the first panel, 'Forest regeneration in human-modified landscapes', Zoraida Calle, from the Center for Research on Sustainable Agricultural Production Systems (CIPAV), gave examples of how the implementation of intensive silvopastoral systems has afforded both ecological and economic benefits enjoyed by cattle ranchers in Colombia. Aerin Jacob, doctoral candidate at McGill University,

presented findings of her research in Uganda, showing that different land-use histories in the same region can lead to different outcomes of regeneration and restoration. Laura Snook, from Bioversity International, then proposed a strategy for regenerating mahogany and other valuable hardwoods in Mexico, by using restoration techniques that emulate the region's natural disturbance regime.

In the second panel, 'Private sector engagement in forest restoration', Chris Meyer from Planting Empowerment, and Ricardo Luján from Brinkman & Associates presented examples of successful for-profit reforestation projects in Central America. Both highlighted the importance of incorporating into their business models ways to improve local human livelihoods and specifically benefit the communities at each project site.

In the third panel, 'Economic viability of landscape-scale initiatives', Matheus Couto from the Forest and Agriculture Management and Certification Institute (IMAFLORA) presented on a program for smallholders to grow certified cacao in the Brazilian Amazon. Cacao production, along with the capacity-building efforts of his organization, have positively impacted the local communities' living conditions while simultaneously restoring tree cover to a previously deforested region. Next, Jens-Peter Barnekow Lillesø, from Forest & Landscape Denmark, described his team's work to provide technical tools and seed networks to encourage the distribution of quality genetic material for agroforestry and restoration projects.

The fourth panel, 'Scaling up —applying lessons learned', addressed the issues of governance, financing, and stakeholder-involvement, needed to advance restoration beyond a collection of small project-based initiatives towards coordinated landscape-scale efforts. Pedro Brancalion from the University of São Paulo introduced the history and methods employed by the Atlantic Forest Restoration Pact in Brazil. Eduardo Malta Campos Filho from the Socio-Environmental Institute (ISA) explained an innovative proj-

ect to encourage collaboration and cooperation between indigenous and farmer groups for the goal of restoration for water quality. Next, Pipa Elias from the Union of Concerned Scientists discussed the potential role of restoration in international agreements to finance reductions in global carbon emissions. Finally, Cora van Oosten from the Wageningen University and Research Center concluded the panel with a call for restoration efforts to work not only with different scales of governance but also among different types of social relationships.

The conference concluded with an engaging group discussion involving all of the conference speakers and moderated by Tim Rollinson, director general of the U.K. Forestry Commission and chairman of the Global Partnership on Forest Landscape Restoration (GPFLR). Two themes that arose from the panel discussion were the need for improved lines of communication between scientists and practitioners, and the importance of considering agriculture and livelihoods as a part of forest restoration discussion.

From the three days of keynotes, panel discussions, and other activities, the following ideas emerged as important ingredients for restoration success:

- Each restoration action requires careful tailoring of strategies to meet the ecological conditions, social context, and management goals of the specific sites.
- Locally run seed collection and nursery management can become an additional means for local peoples to benefit from restoration; however, to be effective, those networks must consider the quality of the material to be planted.
- Restoration can have real financial benefits and in many cases may only require technical assistance and start-up money rather than continued payments.
- Encouraging participation by landowners and the broader community and building a sense of ownership over restoration projects is important for their long-term success.

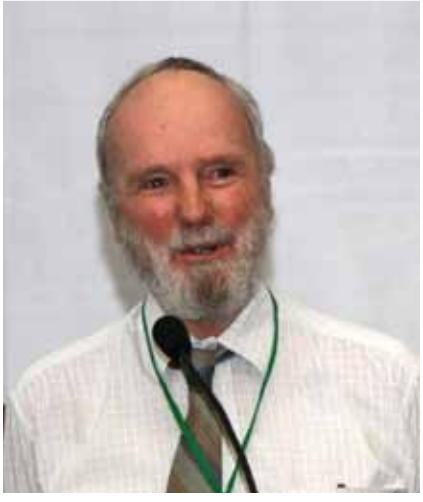
Overall, the conference highlighted that landscape-scale restoration is possible, but requires much creativity to: (i) balance the standardization of methods across a landscape with the need for site-based decision-making; and (ii) bring together oftentimes disparate groups such as farmers/ranchers, indigenous peoples, conservation practitioners, and scientists to achieve the common goal of restoration.

INTRODUCTION

Large-scale Tropical Forest Restoration: Some Necessary Policies and Important Research Questions

David Lamb

University of Queensland, Brisbane



As an introduction to the conference, David Lamb was invited by Yale ISTF members to give a live videoconference framing the topic of tropical forest restoration by presenting the fundamental questions that are important for directing research and policy into the future.

Professor Lamb began his presentation explaining that the large and increasing areas of degraded lands in the tropics often result from the clearing of natural forests. That process of clearing and degradation not only generates a host of environmental problems, but also can have negative impacts on the local poor who depend on functioning forest ecosystems for their livelihoods. Lamb asserted that reforestation and restoration have the potential to help address both problems, poverty and environmental degradation. However, for this to happen successfully, the opportunities must be attractive to land owners and must involve diverse stakeholders, ranging from smallholders and communities to industrial organizations. Along similar lines, Lamb stressed that "reforestation is not going to work everywhere and should be considered as part of a mosaic of land uses." Instead, large-scale restoration programs must contain a suite of options that serve as intermediates between purely ecological restoration and industrial scale plantation monocultures.

Historically, governments in Asia such as those in South Korea, Vietnam, and China, have planned large-scale restoration efforts on over a million hectares of deforested land. In these national initiatives, governments played the major coordinating role and were able to approach the restoration programs with secure government land tenure, a long term commitment of resources and financial support, and a variety of forest management goals, including timber production and provisioning of ecosystem services. While individual or community land managers played a much larger role than corporate or private industry in the implementation of such efforts, Lamb explained that oftentimes governments failed to recognize their role.

Successful restoration also requires thoughtful and carefully crafted policies. Lamb illustrated this point with an example from

Tanzania. In an attempt to provide better public services, the Tanzanian government implemented a policy called "village-ization" encouraging people to settle in villages rather than be dispersed across a landscape. The policy, however, had an unintended consequence: it lead to the breakdown of traditional land use practices, including the maintenance of forest reserves as a source of fodder and NTFPs. Ultimately, by altering the traditional structure of forest stewardship, this policy led to widespread land degradation. Upon realization of the negative land use impacts of its policy, the government backtracked its decision, thus avoiding further forest degradation, and subsequently began reversing the damage.

Lamb then moved on to discuss some fundamental questions that need to be addressed when designing restoration policies:

Where and how much land should be restored? The extent of land needed for a restoration project depends on how much forest remains on the landscape, on the opportunity costs for the landholder who wants to restore forests on his/her property, and on the management goals of the restoration project. The land required to establish an economically sustainable timber operation is different from that needed to protect a watersheds or to re-establish habitat for wildlife. The management objectives also affect the location. For example, Lamb suggested that for timber management, restoring closer to roads makes more sense because it makes harvesting more feasible; for watershed protection, restoring steep slopes and riparian areas makes the most sense; and for wildlife conservation, the key is to restore lands that link natural forest remnants, thereby increasing habitat connectivity. However, determining restoration targets for wildlife management, Lamb cautioned, is especially difficult because it depends on whether one is seeking to improve the habitat(s) for a particular species or biodiversity in general.

What type of forest restoration? The type of forest restoration depends mainly on the landowners' preferences and on the ecological conditions of the site. Land managers can choose from a wide

spectrum of options including, but not limited to: (a) allowing for natural regrowth, (b) assisting natural regeneration with or without enrichment planting, (c) creating multi-species plantations, and (d) establishing monoculture plantations on short rotations. Throughout these processes it is important to acknowledge the differences in the site's ecological restoration potential, which depends on factors such as the level of degradation and the capacity of a species to regenerate naturally. In addition to this, the preferences of the land managers for different goods and services need to be considered when selecting a restoration strategy.

Who decides and who implements? Lamb explained that history is littered with examples of failed top-down reforestation schemes, which result from the government ignoring the views of the land managers and imposing industrial-style monocultures or projects with strict conservation goals, which often are of little interest to them. Land managers, on the other hand, often make land use decisions that are in their best interest but may impose costs, especially environmental costs, on other stakeholders. In order to find a balance, restoration planning ideally should include a decision-making process that considers both top-down and bottom-up level planning components, such that the costs and benefits of reforestation are equitably shared.

Given the fact that these major questions need to be addressed for each circumstance, every restoration situation will require different strategies. Thus, Lamb stressed that each program needs to include participatory, collaborative, and facilitated coordination, long-term adaptive management, and compensation, when necessary. He also argued the need to revisit policies regularly, and contemplate mechanisms to address the issues that will inevitably arise over time.

Finally, Lamb posed questions to guide future research on restoration strategies:

- How can the benefits landowners receive from reforestation be maximized, thus making it a more attractive land use option?
- What are the best forms of assistance to landholders to facilitate large-scale reforestation?
- What plantation designs might improve livelihoods as well as generate conservation benefits?
- How well are different types of restored forest able to supply ecosystem services?
- Will carbon markets incentivize industrial scale monocultures over other strategies?
- How can we best identify complementary species able to grow in multi-species plantations?
- How do we design landscape mosaics to conserve regional biodiversity?
- What are the design principles for reforesting degraded land in the face of climate change?

Lamb ended his presentation with a call to develop a long-term restoration vision that both benefits human livelihoods and improves ecosystem integrity. As he pointed out, “achieving this vision will require using the full suite of strategies and systems available with a special focus on smallholders, natural regrowth and mixed species plantations.”

Keynote Address 1

Reshaping the Landscape for Forests and People

Jan McAlpine

United Nations Forum on Forests -UNFF

To begin the conference, Jan McAlpine, director of the United Nations Forum on Forests offered a keynote address. This speech, reproduced below in its entirety, set the stage for many of the themes to be discussed by the other speakers and panel discussions. In particular, McAlpine highlighted the importance of forests in the lives of rural communities, cooperation across sectors, and the great potential of landscape-scale forest restoration.

Fellow Foresters, Ladies and Gentlemen,

It is a great pleasure to be here this evening, at the 18th Annual Conference by the Yale Chapter of the International Society of Tropical Foresters. I would like to thank the Yale School of Forestry & Environmental Studies for hosting this important dialogue on Landscape-Scale Restoration.

The UNFF is a world body comprised all 193 UN countries with a facilitative and catalyzing role in engaging and strengthening cross-sectoral linkages with various partners within the UN system, and outside. Since its creation in 2000, the UNFF has promoted a 360-degree perspective of all things forests, recognizing the need to widen the debate on forests well beyond the deforestation and afforestation, to a broader sense of its economic, environmental and social values.

I often like to point out that forests are a cornerstone of the entire landscape, including wetlands, agriculture, mountains, drylands, rivers, biodiversity and people. They are an essential source of livelihoods, food, water, and medicine for some 1.6 billion people, a quarter of the world's population.

We are all aware that forests are critical for human well-being and poverty reduction across landscapes and economic sectors. Many rural communities rely on forest benefits and functions as a means of their livelihoods, including, for example, food, fuel, water, medicine as well as the cultural and spiritual values so fundamental to people in different countries. All of these elements taken together reinforce

the message that forests are vital to the survival and well being of people everywhere, all 7 billion of us.

If we turn our attention to the country level we can truly understand the needs of forest-dependent communities. Take the example of energy; in many developing countries, it is estimated that more than 80% of total energy consumption comes from fuelwood. National trade in many countries is also a significant source of employment, contributing to poverty alleviation in rural areas. In Cameroon, nearly half the cost for logging in rural areas by the forest industry goes to rural communities as their income.

Addressing the needs of forest-dependent communities requires a cross-sectoral approach. Simply put, the cross-sectoral approach is about breaking down the institutional silos and working horizontally across institutions in various sectors, including agriculture, community and rural development and natural resources management, to name a few.

A great example of the cross-sectoral approach is landscape restoration, which brings together forest-dependent communities, private sector and local governments to identify and put in place land-use systems that will help restore the various forest functions across a whole landscape. In practice, the landscape approach is intended to shift the emphasis away from simply maximizing only the economic or environmental benefits to optimizing the social, economic and environmental benefits of forests within the broader landscape, including agriculture, mountains, drylands, rivers, wetlands, biodiversity and people.

Landscape restoration can only be achieved when private institutions, along with local communities and governments work together towards Sustainable Forest Management, which is informally called "SFM." The challenge ahead is to explore institutional arrangements that are better suited to each country's dynamic conditions as there is no one-size-fits-all solution. Each country's government must determine its own priorities. What is essential for this exploration is

a practical approach for the reform of public institutions that can reinforce cross-sectoral cooperation, including through public-private partnerships, utilizing market incentives.

In order to achieve SFM we have to move past our narrow silvicultural-only approach to forest management. We are well past the point where we only value the timber production value of forests. We need to integrate, in particular, managing agriculture with managing forests. It is a fundamental priority. It is the new horizon, without which we will simply not be able to achieve not only sustainable forests for future generations, but also sustainable development.

In many countries, the private sector is at the forefront of providing forest products to the end customers – their actions directly influence consumer behavior. Positive support from consumers of forest products from sustainably managed forests can help restore the forest landscape. By the same token, public institutions are in a position to put in place incentive mechanisms for the private sector to support

changes required to meet the needs of forest-dependent communities. This will entail utilizing market incentives through measures such as voluntary codes of conduct for industry, certification and labeling of sustainably sourced products, and payment for ecosystem services.

When the United Nations General Assembly declared 2011 the International Year of Forests, it created an opportunity to highlight the great value of forests, and the social, economic and environmental values and benefits they provide. "Forests for People" was the theme of Year and continues to be the focus of the United Nations Forum on Forests Secretariat's outreach activities.

The message behind the Year is that humanity's connection to forest ecosystems is innate. Active participation in their sustainable management is thus vital to safeguarding our shared future.

You'll be hearing from the Global Partnership on Forest Landscape Restoration, in which our UNFF team is an active partner. As you will note from their site, it is estimated that 1.6 billion hectares of forests world-wide are eligible for landscape restoration. This is land that currently contributes little to biodiversity, to people or the economy. But it has the potential to explode our small visions into amazing results—on a landscape scale worldwide.

At the global launch of Forests 2011, Rwanda announced its plan for achieving border-to-border landscape restoration over the next 25 years. This was the first time that such a project encompassed an entire country. In Rwanda the "landscape" included not only forests, but trees as part of agriculture, subsistence agriculture, protection of water resources, and other ecosystem planning. This landscape approach was seen to be critical for the natural environment, but also critical for the economy and the people who inhabit the land.

Land restoration requires patience and vision —it is a long and decidedly complex process. But, it is a proven solution that reaps benefits even in places where forests were no longer there. In China's Loess Plateau, in a project funded by the World Bank, innovative

action regenerated a barren landscape that had been degraded from centuries of unsustainable agriculture. Communities worked to replace overgrazing with terrace-building and tree planting practices. In just a decade, the dry, dusty plateau had become a mixed green landscape of forests and fields, an incredible feat of recovery for an area approximately the size of Belgium, 640,000 square kilometers. Moreover, this restoration contributed towards lifting 2.5 million people out of poverty.

The International Year of Forests which we have celebrated since February 2011 brought people back into the forest equation. As part of our activities to promote "forests for people" stories throughout Forests 2011, the UNFF Secretariat launched the Forest Heroes Programme and Awards to celebrate individuals who are dedicating their lives to sustaining forests. I would like to share the stories of two of our short-listed nominees Shigeatsu Hatakeyama, and Rhiannon Timtishen and Madison Vorva.

Oyster fisherman Shigeatsu Hatakeyama planted the first broadleaf trees that cleaned the river habitat of oysters in Kesennuma Bay (Japan), after discovering the link between forests and clean water. His work with non-profit "Kaki no Mori wo Shitau Kai" (Rebuilding from land to Sea), which spans two decades, has inspired annual afforestation activities and greater environmental awareness in the community. However, when the Tsunami occurred, most of the forest and the oyster beds were destroyed. While both can come back —they are renewable resources— we once again see that actions cannot take place in isolation.

Rhiannon and Madison, two young girl scouts, mounted a campaign against major opposition to require that the source of palm oil for girl-scout cookies is only from sustainable sources. Their work prompted Girl Scouts USA to commit to requiring that Palm Oil be used only from sustainably sources for their cookies. This had the net effect of boosting efforts to reduce deforestation for palm oil monoculture plantations.

Everyday heroes like Shigeatsu, Rhiannon and Madison remind us that we live in an interconnected landscape, which must be addressed through a cross-sectoral and cross-institutional approach.

We must facilitate conditions for sustainable forest management by boosting collaboration in the areas of finance and trade in sustainably produced forest products, by transfer of ecologically sound technologies, capacity building and governance, by promoting secure land tenure, as well as coherent and participatory decision making and benefit sharing. But also by working extremely closely with other "sectors," cooperating with them to help address their objectives, identifying conflicts from their sector which affect forests, and partnering to find an effective resolution to the each area's objectives. We are not talking about new institutions. We are talking about building on the institutions and governance systems that exist, strengthening our partnership and truly working together.

There is no denying that forest loss has many roots; from illegal logging, to people's critical need for food security, resulting in requirements for agriculture, to roads and mining activities within natural standing forests. Misplaced economic values and pressure from an increasing population are costing us our natural environment and further relegates the most vulnerable people and forests to the fringes of society.

If I may, I'd like to end this speech tonight with a final thought. Forests are a mirror of evolving human needs, one that is dynamic and ever-changing. In our fields, we often use statistics to convey the magnitude of forests' significance to humanity. It is an important way to convey the importance of forests, or agriculture, for example, and what needs to be done. But sharing the true value of forests will be best understood in the context of the impact forests have on the lives of real people, in the ways non-technical people can grasp. We must work together to cross this new horizon.

I am certain that discussion and mutual exchange of good practices will benefit everyone at this conference.

Keynote Address 2

Making Tropical Forest Succession Successful

Robin Chazdon

University of Connecticut

In her keynote address, Professor Robin Chazdon presented a conceptual overview of forest succession and how land managers can facilitate forest restoration. Using numerous examples from the literature, Chazdon introduced the pioneering work that has served as the foundation for understanding the ecology of tropical forest succession.

The first example came from Uhl and Jordan[1], who in the 1970's studied regrowth following traditional slash and burn in the Venezuelan Amazon. After just five years, the growth of early-successional species had already peaked and started to decline, while late-successional species were beginning to grow on the site. It was clear that very early on in succession, the forest was already undergoing self-assembly. In a chronosequence study[2] of 23 sites of different ages, Saldarriaga *et al.*[3] revealed that 80 years after abandonment, roughly 70-80% of the biomass and species number had recovered. However, the authors estimated it would take approximately 190 years for biomass to reach the levels found in mature uncut forests in this region.

Chazdon provided other examples of studies that demonstrate how both land-use history and the method used to clear the land (burning, bulldozing, etc.) impact the initial colonization and the nature of species assemblages during regrowth. In Ghana, Swaine and Hall[4] found that three years after land abandonment, prolific regrowth was found everywhere except where the soil had been

1 Uhl, C. and C.F. Jordan. 1984. Successional and nutrient dynamics following forest cutting and burning in Amazonia. *Ecology* 65:1476-1490.

2 A chronosequence study evaluates similar forests of different ages. This is a method of studying forest succession in a shorter amount of time than it would take to evaluate the succession occurring on a site over the course of decades to centuries.

3 Saldarriaga, J. G., West, D.C., Tharp, M.L. and C. Uhl. 1988. Long-term chronosequence of forest succession in the upper Rio Negro of Colombia and Venezuela. *Journal of Ecology* 76:938-958.

4 Swaine, M.D. and J.B. Hall. 1983. Early succession on cleared forest land in Ghana. *Journal of Ecology* 71:601-627.

5 Moran, E F., Brondizio, E., Tucker, J.M., da Silva-Fosberg, M.C., McCracken, S. and I. Falesi. 2000. Effects of soil fertility and land-use on forest succession in Amazônia. *Forest Ecology and Management* 139:93-108.

bulldozed. From their study in the Amazon, Moran *et al.*[5] concluded that interregional differences in regeneration could often be attributed to soil fertility, but within each region, those differences were due to other factors. They found that the number of times individual sites were burned had a huge impact on the successional pathway moving forward. Similar findings were obtained by Mesquita *et al.*[6] whose research found that regrowth in less frequently burned sites was dominated by *Cecropia* trees and had a diverse understory of non-pioneer species, while more frequently burned sites regrew with *Vismia* trees and less diverse understories.

Chazdon explained that shifting cultivation is often touted as an example of unsustainable land-use, which is not necessarily the case. For example, a study by Lawrence *et al.*[7] demonstrated a very clear effect of fallow length on forest regeneration, with longer fallow periods leading to greater replenishment of species and ecosystem services. In Madagascar, Styger *et al.*[8] found that with each successive reduction in the fallow period, forest regrowth became more and more depauperate. Ultimately, the forest failed to recover, and the people were unable to grow food in it anymore.

However, Chazdon cautioned that the length of the fallow period is not the only factor. According to Lawrence *et al.*[7], local people have accumulated a wealth of ecological knowledge that allows them to better manage the land, ultimately accounting for site differences that fallow period length alone cannot explain. There are several examples of indigenous ecological knowledge applied to regeneration. The Kayapo people of Brazil use the same word for forest and field, because for them the land is a single entity with many

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6 Mesquita, R.C.G., Ickes, K., Ganade, G. and G. B. Williamson. 2001. Alternative successional pathways in the Amazon Basin. *Journal of Ecology* 89:528-537.

7 Lawrence, D., Radel, C., Tully, K., Schmook, B. and L. Schneider. 2010. Untangling a decline in tropical forest resilience: Constraints on the sustainability of shifting cultivation across the globe. *Biotropica* 42:21-30.

8 Styger, E., Rakotondramasy, H., Pfeffer, M., Fernandes, E. and D. Bates. 2007. Influence of slash-and-burn farming practices on fallow succession and land degradation in the rainforest region of Madagascar. *Agriculture, Ecosystems, and Environment* 119:257-269.

dimensions. The Dayak people in Borneo view the forest itself as a regenerative cycle. Rubber cultivation in Kalimantan is done to mimic natural succession and follows a long fallow cycle of 40-70 years. In Yucatan, balsa trees *(Ochroma pyramidale)* are used to facilitate succession and control invasive weeds such as bracken fern. Chazdon highlighted that "these and other peoples were reforesting long before the concept existed [in the West]… we can learn from this."

To help the audience understand the multiple components of forest regeneration and restoration, Chazdon provided a checklist of ecological elements and conditions that need to be in place for succession to follow its course:

- **Topsoil** is a basic ingredient for regeneration and needs to be present on site.
- **A forest fragment**, preferably large, well preserved, and nearby to the target site is needed as a source of seeds.
- **Resprouts** provide a head start on forest regrowth.
- **Seeds of early and late successional woody species** should be present in the seed bank and seed rain.
- **Opportunities for continuous colonization by common and rare native species** in the seed rain must be present on a permanent basis, not just at the beginning of the process.
- **Weed suppression** needs to happen rapidly after site abandonment to avoid their becoming dominant.
- **A diversity of animals** (insects, vertebrates) acting as pollinators and dispersal agents is needed to re-establish the forest trophic system.
- **Fire protection** is needed to prevent fire from setting back regeneration to the point where fire resistant grasses dominate and arrest forest succession.
- **Hunting and excessive harvesting of litter and forest products** should be prevented.

In addition to this checklist, Chazdon highlighted the concept of "ecological memory", which encompasses all the biotic components of the landscape that act as ingredients for forest regeneration. This memory includes the network of species, the interactions between them and with the environment, and the combination of structures that makes reorganization after disturbance possible.

Chazdon illustrated her point with two examples of large-scale regrowth where the items on the checklist were in place for successful natural regeneration. In the Guanacaste province of Costa Rica, the forest grew back from an all time low of 23% forest cover in 1979 to a 47% cover in 2005. In the island of Krakatau near Sumatra, a volcanic eruption in 1883 eliminated all vegetation cover and

completely sterilized the site. Over time, wind dispersed seeds as well as bat and bird dispersed seeds colonized the site, and the forest came back. Chazdon explained that "When we look at forests, we really see them as systems that are in progress… like construction sites and basically if the tools for making the building are there in the landscape, it will regrow."

In some cases, however, forest regeneration does not occur naturally or as fast as expected. Therefore, in addition to the checklist, Chazdon provided a number of management options that can catalyze forest regeneration when some of the conditions are lacking. These tools for assisted natural regeneration include actively suppressing weeds, protecting sites from fire, and protecting sites from hunting or overharvesting of forest products, which could limit the sources of seed for regeneration. If needed, planting seeds (direct seeding) or nursery-grown seedlings of forest species that are not present in the soil seed bank or seed rain can also assist the regeneration process. She suggested that planting patches of native tree species, rather than spacing them evenly across the landscape, can be beneficial because those patches serve as foci for seed dispersing birds and mammals. In some cases, exotic species known to restore soil fertility and shade out weeds and grasses can also be planted to help jumpstart forest establishment.

Chazdon cited examples of management interventions that have been successfully used to help forest return, even when natural succession had failed. In Uganda, fire suppression was used to enable forest regeneration, and in China, the establishment of exotic eucalyptus trees helped to catalyze native regrowth. In Brazil, regeneration in an aluminum-mining site was facilitated by bringing in topsoil, leaf litter, and the seed bank from surrounding forests. By providing all of the necessary ingredients, a dense and diverse forest cover had developed just four years later.

In addition to the ecological requirements for reforestation, Chazdon spoke of the importance of considering the variety of ob-

jectives, both different and shared, among stakeholders involved in reforestation. For example, it would seem that farmers' interest in restoration would be limited to timber harvest and restoring soil fertility, while conservationists may have their mind set on biodiversity and carbon sequestration. Nevertheless, different groups of stakeholders can have common goals; farmers can benefit from biodiversity and potential payments for carbon storage, and conservationists may be interested in improving soil fertility and providing sustainable livelihoods. These shared goals create opportunities to collaborate and empower people to improve the methods for assisted natural regeneration.

Chazdon suggested that a variety of skills will be needed to advance restoration and regeneration on a large scale. She explained, "a bunch of ecologists aren't enough to figure this out… we need geographers and political scientists and economists… to work with us and to come up with ways of how can we understand the drivers of reforestation, what we need to make it work and what we need to know in order to proceed and really combine our efforts and do something meaningful that's not just piecemeal." In response to this need, Chazdon and her team are seeking funding for the NeoSelvas Project, which hopes to provide a venue where specialists from different disciplines can come together to discuss what information they have, what they need, and what can be done to move forward.

The goal of NeoSelvas is to gather the right people around the table, provide the right information to policymakers, and advance the process in a meaningful way. Along those lines, Chazdon ended with an idea borrowed from Hillary Clinton: "it takes a village to raise a forest." She explained that restoration success is not just about the local site characteristics or the soil, but instead it requires that people work together with the forest. Only through an effective mutual relationship between stakeholders and the forests can we achieve what Chazdon calls a "socio-ecological success story."

Panel 1: Forest Regeneration in Human-Modified Landscapes

A Strategy for Scaling-Up Intensive Silvopastoral Systems in Colombia

Zoraida Calle

Center for Research on Sustainable Agricultural Production Systems -CIPAV

Zoraida Calle spoke about her organization's experience in developing and implementing silvopastoral systems (SPS) in Colombia. In Latin America, pastures for cattle production are currently among the most extensive land uses and are often associated with large-scale forest destruction and land degradation. Conventional ranching systems based on extensive grass monoculture are extremely different from the diverse structure and function of natural tropical ecosystems. However, cattle ranching is not expected to decline anytime in the near future because it is not only an important economic activity, but also an integral part of the local culture rooted in the region's Spanish and Portuguese heritage. Thus, there is a real need to develop strategies that improve cattle ranching systems in order to reduce their environmental impacts, so that cattle can shift from their traditional role as "enemies of the forest" to a new role that Calle memorably called "mobile solar-powered catalytic converters".

CIPAV has identified the potential for sustainable cattle ranching systems to play a key role in transforming working landscapes, by helping to restore degraded lands and promoting forest connectivity. An important first step in this transformation, though, is recognizing how inefficient current extensive cattle production systems are. In Latin America, the average per hectare stocking rate is only 0.59 cattle. With such low productivity, Calle explained, the fact that cattle ranching creates very few opportunities for rural employment comes as little surprise.

CIPAV's strategy to transform cattle production is comprised of four key components:

- increase plant biomass and biodiversity;
- curb soil loss and promote its recovery;
- protect water sources and use them rationally; and
- increase animal productivity on a per hectare basis (rather than per animal).

Addressing these components will help improve the productivity and profitability of the production systems in the most suitable lands. It will also allow for the release of the more fragile lands, which can be dedicated to conservation, thus enhancing the generation of environmental goods and services. As a result, the transformed productive systems both provide environmental benefits and human well-being.

SPS use a combination of productive pasture grasses, fodder plants and trees that enhance animal nutrition and can diversify income generation through timber and fruit production. Tree and shrub species are carefully selected to create a more complex biological system with high levels of primary productivity, nitrogen fixation, and soil stabilization. The backbone of 'intensive' silvopastoral sys-

tems is the use of fast growing fodder shrubs to increase productivity of the ranching system. Mexican sunflower *(Tithonia diversifolia)*, planted at high densities has been used to supplement the nutritional value of pastures. Calle highlighted that, among the fodders species studied so far, *Leucaena leucocephala* has proven to be particularly effective; not only as a source of quality feed for cattle, but also for its ability to facilitate the growth of other plants in the system by retaining soil moisture, accessing the nutrients in the deeper soil layers, and fixing nitrogen. As a result, the amounts of animal fodder produced in these integrated systems can be comparable or superior to that produced in conventional grass monoculture pastures, but without the use of chemical fertilizers.

Through a series of examples from different climates and scales of implementation, Calle illustrated how SPS are shifting the paradigm of tropical cattle production. She presented the farm 'El Hatico', located in the state of Valle de Cauca, Colombia, which has exemplified the productive potential of sustainable cattle ranching. In the 1970's, the landowners initiated the transformation of their conventional pastures into SPS, gradually increasing tree cover from under 10 trees to 30-60 trees and palms per hectare, and planting fodder shrubs at high densities. The change not only created a more wildlife-friendly farm, but also resulted in an impressive increase in production from 7,436 to 18,436 liters of milk per hectare, achieved while reducing the area under production.

More recently, CIPAV has facilitated the establishment of SPS in the dry Caribbean savannahs of the state of Cesar, where annual precipitation is 1000-1200mm. Degraded after decades of extensive cotton monoculture, these lands were later converted to conventional cattle pastures, where productivity remained low due to the loss of topsoil and the absence of edible biomass during the dry season. In only seven months, the establishment of SPS in these lands resulted in substantial increases in stocking rates, from 1.2 to 5.1 large animals per hectare, and daily milk production, from 1.7 to 4.1 liters

per cow. In addition, temperatures measured inside the silvopastoral plots were 12°C cooler than those in nearby conventional pastures, a significant difference that helps to reduce heat stress for the cattle, and demonstrates the climate change adaptation of SPS.[1]

Moving beyond the farm level, Calle described how SPS can also be integrated with restoration and conservation efforts in cattle ranching landscapes, providing more complex habitats that serve as connectivity corridors and incorporating endemic and threatened tree species. For example, in the wet foothills of the state of Meta, CIPAV has implemented SPS incorporating the highly vulnerable tree species *Mimosa trianae* into the pastures. In the dry forest region of the state of Tolima, soils degraded by years of rice monoculture and overgrazing have been restored to productivity using a combination of cut-and-carry fodder banks[2], live fences, and SPS that incorporate valuable timber trees like teak *(Tectona grandis)*. Compared to conventional pastures, these systems can support stocking rates of up to seven times more dairy cows and five times more beef cattle per hectare. At 1036 kg of beef per hectare, production in this farm is 14 times higher than the local average of 74 kg per hectare, and 51 times higher than the Latin American average of only 20 kg per hectare. As described by the landowner himself, his farm went 'from desert to paradise.'

According to Calle, while pilot farms like those mentioned exemplify the potential of SPS, scaling up their use to restore entire landscapes is a bigger challenge, as it requires a shift in the way at thinking at all levels, from researchers to farmers, and from extensionists to policy makers. With this in mind, CIPAV has developed a five-pronged approach to large scale change which involves:

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1 Rueda, O., Cuartas C., Naranjo J., Córdoba C., Murgueitio E. and Anzola H. 2011. Comportamiento de variables climáticas durante estaciones secas y de lluvia, bajo influencia del ENSO 2009-2010 (El Niño) y 2010-2011 (La Niña) dentro y fuera de sistemas silvopastoriles intensivos en el Caribe seco de Colombia. *Revista Colombiana de Ciencias Pecuarias* 24(3): 512.

2 Cut and carry fodder banks are areas densely planted with fodder grasses or shrubs, where animals are not allowed to graze; instead the farmer harvests the plant biomass and delivers it to the animals elsewhere.

1. Participatory research to adapt SPS to different local conditions;
2. Pilot farms to enable farmer to farmer learning;
3. Capacity building at all levels;
4. Pilot projects to test the effectiveness of different incentives; and
5. Large projects based on the lessons learned.

For example, from 2001 to 2007 the pilot project known as Regional Integrated Silvopastoral Approaches to Ecosystem Management (RISAEM) tested the role of payments for ecosystem services (PES) to promote SPS implementation. Results showed that farmers responded favorably to PES and did implement the changes promoted; however, after implementation, many farmers realized the systems were profitable on their own, and perceived a variety of benefits beyond the payments. Thus, Calle suggested that direct payments may not be necessary to incentivize the use of SPS, but credit to cover the startup costs and technical assistance may instead be more effective tools.

In 2010, CIPAV launched a major project called Mainstreaming Biodiversity into Sustainable Cattle Ranching with the support of the Global Environmental Facility and the World Bank. Focusing on areas of high biodiversity, this project aims to transform 45,500 hectares of treeless pastures into productive systems that are both biodiversity-friendly systems and more profitable for the farmers. With this goal in mind, the project is using tree cover, live fences, and intensive SPS with *Leucaena* to intensify production in the best lands, while releasing riparian corridors and more fragile areas for forest conservation and restoration, incorporating threatened species, and creating corridors to connect the landscape. Drawing on the lessons from the RISAEM pilot, this new project addresses two of the major barriers to adoption of SPS. To address the issue of financial capital, the project provides low interest flexible loans for the implementation of SPS, and uses PES to reward farmers who convert pastures to forests other biodiversity-friendly land uses. To bridge the

knowledge gap, which Calle emphasized as crucial, CIPAV carefully organizes and supports the work of agricultural extension agents to provide training and technical assistance for implementing the program. Ultimately, this project aims to prove at a national scale the point that CIPAV has been making all along: that sustainable cattle ranching can be effective for improving rural livelihoods, conserving biodiversity, and restoring landscapes.

Long-term Patterns in Restoring Forest Diversity and Structure after Burning, Farming and Logging in Kibale National Park, Uganda

Aerin Jacob

McGill University

Aerin Jacob from McGill University discussed her PhD research on the influence of land use history on pathways to forest restoration in eastern Africa. She explained the cycle of deforestation in Africa, where tropical forests and their biodiversity are being quickly lost to logging and agricultural conversion. However, unsustainable agricultural practices often result in rapid degradation of the lands, making farming less profitable, and leading to land abandonment and secondary forest regrowth. According to Jacob, understanding the relationship between tree diversity, forest structure, and food sources for wildlife within these regenerating forests, can inform decision-making to better the manage and restore these lands for wildlife.

Jacob's research focuses on Kibale National Park in western Uganda. Established as a forest reserve in 1932 and declared a national park in 1993, this 795 km^2 area has a diverse land use history. In the 1960s, the northern part of the park was harvested for timber, heavily logged in some areas and lightly in others, while grasslands were converted to pine plantations and harvested in 1993. In the 1970s, an area of approximately 146 km^2 along the southern corridor was illegally settled and converted for subsistence agriculture. The settlers, estimated to range between 9,000 to 170,000 people, were evicted in the early 1990s, and some of the cultivated areas were planted with five species of native trees. Jacob's team thus has the unique opportunity to study forest regeneration in adjacent areas with very diverse site histories, including:

- unlogged forest
- secondary forest recovering after selective (light) logging
- secondary forest recovering after heavy logging
- secondary forest recovering on harvested pine plantations
- early forest regeneration on grasslands protected from fire
- early forest regeneration on former agricultural lands
- former agricultural lands that have been planted with native trees.

To compare the recovery of forest diversity and structure across regenerating forest, Jacob's team set up transects to identify tree species and measure tree sizes in each of the land use types. They estimated diversity using multiple indices and measured forest structure parameters including tree density, cumulative basal area, and aboveground woody biomass. According to their findings, unlogged, lightly logged, and heavily logged sites had significantly higher species richness than the other four land uses, forest regenerating on grasslands, former pine plantations, and former agricultural land with and without native species plantings. They found no significant difference between lightly logged and unlogged areas in terms of their tree density or basal area, both of which were significantly higher in these two land uses than in the rest of them. However, the analysis of individual species[1] abundance values showed that heavily logged forest was more similar to unlogged than to lightly logged forest.

Jacob emphasized the importance of considering animal diet preferences as well as forest structure when restoring forests specifically to conserve wildlife. While a regenerating forest might contain many of the tree species that make up a primate's diet, the trees need to be of sufficient size for these arboreal animals to be able to access the food. Combining their own data on species composition and forest structure with extensive data on primate diets in Kibale National Park, Jacob's team developed models to compare the quantity of primate food (e.g. leaves and fruit) provided by each of these regenerating forest habitats. Using hierarchical clustering analyses, they evaluated the similarity between land-use types using data collected for different variables. The first cluster analysis considered only tree species that provide food for red colobus monkeys (*Procolobus [Piliocolobus] rufomitratus tephrosceles*), and showed that logged and

1 Chao, A., Chazdon, R. L., Colwell, R. K. and Shen, T. 2005. A new statistical approach for assessing similarity of species composition with incidence and abundance data. *Ecology Letters* 8: 148–159.

unlogged forest were clustered together with higher ability to provide food than the other land uses. A second analysis that included tree abundance and size showed three distinct groups: unlogged forest, logged forest of both types, and other land uses. Jacob plans to combine this information with data from the long-term monitoring of Kibale's primate population to investigate mechanisms that regulate primate density in the different parts of the forest that have different land use histories.

The results of Jacob's research on forest regrowth and its potential for animal use can be applied to adapt management practices to specific site conditions. They highlight the importance of using multivariate methods, and focusing on plant species that directly relate to animal habitat quality when assessing restoration success. Jacob's study revealed that forty years after logging, heavily logged forest is similar in species composition but very dissimilar in forest structure to unlogged forest, a fact that highlights the need for more active interventions if the goal is to promote forest restoration in this habitat. Previous research in Kibale has shown that in many parts of the heavily logged forest trees have failed to establish because the interaction between the fast growing shrub *Acanthus pubescens* and elephant populations[2] is arresting succession.

Jacob cited examples of other studies that illustrate why restoration management and planning must consider site-specific factors and land use history, and how different methods to measure diversity can produce different results. For example, a study in Madagascar found that regeneration was similar in logged sites of different ages, all of which had lower species diversity, fewer large trees, and higher invasion by non-native plants than remnant forest.[3] Another study from Borneo found similar levels of diversity as this study,

2 Paul, J.R., A.M. Randle, C.A. Chapman, and L.J. Chapman. 2004. Arrested succession in logging gaps: Is tree seedling growth and survival limiting? *African Journal of Ecology* 42:245-251.

3 Brown, K.A. and Gurevitch, J. 2004. Longterm impacts of logging on forest diversity in Madagascar. *Proceedings of the National Academies of Science USA* 101: 6405-6409.

but differences in species composition and lower species turnover.[4] Meanwhile, a study in Puerto Rico found that even after a pasture had been abandoned for 60 years, the regenerating forest had fewer large trees and endemics, and lower basal area than the remaining forests.[5,6]

Lastly, Jacob made a point about the effectiveness of tree planting versus natural regeneration in facilitating restoration in degraded areas based on her study. Thus far, her research shows no significant difference in diversity or basal area of trees in planted vs. unplanted areas, and that protecting grasslands from fire leads to forest regeneration. Given the high financial costs of planting programs, Jacob questioned whether strategies like protecting areas from fire would be a more effective use of the resources, at least from a strict restoration perspective. However, she did acknowledge that some studies predict faster biomass accumulation in planted areas, and thus there are ecological benefits that come from facilitating tree succession and animal movement. Additionally, native tree-planting programs have socioeconomic benefits like job creation in local communities surrounding the park. Thus, Jacob stressed the need for future studies and experiments. Overall, however, her work challenges traditional ideas about restoration and encourages further evaluation about the need to replant, and the impact of restoration actions on important animal species.

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4 Berry, N.J., Phillips, O.L., Ong, R.C. and Hamer, K.C. 2008. Impacts of selective logging on tree diversity across a rainforest landscape: the importance of spatial scale. *Landscape Ecology* 23: 915-929.

5 Aide, T. M., J. K. Zimmerman, J. Pascarella, J. Marcano-Vega, and L. Rivera. 2000. Forest regeneration in a chronosequence of tropical abandoned pastures: implications for restoration ecology. *Restoration Ecology* 8:328-338.

6 Lugo, A.E. and Helmer, E. 2004. Emerging forests on abandoned land: Puerto Rico's new forests. *Forest Ecology and Management* 190:145-161.

Subsistence Agriculture can Foster Forest Restoration in the Tropics: Commercially Viable Multispecies Stands Result from Slash and Burn in Quintana Roo, Mexico

Laura Snook

Bioversity International

Laura Snook began by introducing the region in Mexico where she has conducted research[1] on the restoration of mahogany *(Swietenia macrophylla)*, since her days in Duke University and continuing through her time working CIFOR and now Bioversity International. The Mexican state of Quintana Roo, well known for its beaches, is also noteworthy for being about 80% covered by forests. The largest tract of tropical forest in Mesoamerica, called the "Mayan forest", extends into Guatemala and Belize, and is home to jaguars, tapirs, monkeys, toucans, and well over 100 tree species.

Much of the land in Quintana Roo is allocated by the Mexican government to *ejidos*, community groups granted collective land tenure rights. Many of the nearly 150 different ejido communities manage their extensive forest holdings, and have established nearly 800,000 hectares of permanent forest reserves. They practice subsistence agriculture, but have also diversified their economies based on multiple resources, including NTFPs like chicle latex *(Manilkara zapota)*, palm thatch, and honey. They also share the profits of timber extraction, mainly Mahogany and other valuable hardwoods, and work to develop markets for other tree species.

Snook explained that because the communities protect the forests that support their livelihoods, the deforestation rate in the ejidos' forest reserves is lower than in nearby protected areas. Guided by professional foresters, the ejidatarios manage their reserves on a polycyclic system with a 25-year cutting cycle, harvesting one cutting area each year and conducting annual inventories for about 20 species to determine harvest volumes. In each annual cutting they fell all mahogany trees over 55 centimeters in diameter, and harvest additional species only when there is a market.

This practice of extracting large trees, known as selective logging, is very different from the natural disturbance regime in these

1 This research was carried out in collaboration with Patricia Negreros-Castillo and Raimondo Capitanio, among others.

forests. The Yucatan peninsula is frequently affected by severe hurricanes, which topple many trees at a time, damaging the forest canopy and producing significant amounts of forest debris. Fueled by this woody debris, post-hurricane fires are common in these forests. Fire resistance and its ability to grow under direct sunlight historically enabled mahogany to regenerate in these areas. However, the change in the disturbance regime from hurricanes with fire to logging gaps has affected the species' ability to regenerate. In response to the problem, the ejidos have conducted a variety of regeneration treatments that include collecting seeds, establishing seed reserves, setting up nurseries and doing enrichment planting in the felling gaps, skid trails and timber landings.

Mahogany is a sun-loving species, and therefore light appeared to be the main factor limiting regeneration in the small and shaded gaps. To better understand this limitation, Snook and her team measured and monitored tree gaps following the removal of 183 trees. They found that the gaps created by the standard harvesting method covered only about 2.5% of the total forest area, and that in only four years the gaps size was reduced by 90%. They also found that mahogany seedlings planted in these gaps had low survival and growth rates. To evaluate the effect of gap size on seedling growth, the team created a replicated set of artificial gaps ranging from 500 to 5000 m^2 and planted mahogany seedlings. Their results showed that seedlings responded to gap size and the associated light levels, with twice as much growth in the 5,000 m^2 gaps compared to the 500 m^2 gaps.

According to Snook, however, "it isn't only light that matters." So in 1996, her research team decided to compare methods for land clearing, and thus created replicated clearings using three different methods: 1) machine clearing; 2) slashing and felling; and 3) slashing and felling followed by burning. The third technique, "slash and burn", is the most commonly used method in this region to clear land for agriculture. They then planted mahogany seedlings and seeds in the gaps.

Ten years after the gaps were created, growth and survival of mahogany was best on the "slash and burn" openings. Over 90 tree species were found regenerating naturally in the clearings, with no statistically significant differences among the treatments in terms of species richness, basal area, or stem density. There was, however, a difference in the origin of the regeneration, with significant sprouting from stumps and roots occurring in plots that had been felled without burning. The team also found that stem grew faster from seeds than from sprouts, contrary to what they expected. Overall, they found growth to be best in the burned treatment, a fact that Snook attributed to the release of nutrients after fire, which explains "why local people use the technique for agricultural clearing."

Because timber production is a strong incentive for the ejidos to conserve their forests, Snook's team also evaluated the timber values in the regenerated stands. They found that the proportion of commercially valuable species differed among treatments. In the machine-cleared and slash-and-burned treatments, about 60% of the basal area of trees had current commercial timber value. In contrast, less than 50% of the basal area in the felled alone treatment was of species with commercial value, and many of those trees were resprouts with poor stem quality, and therefore little commercial value. The three methods also differed in their feasibility of use: machine clearing requires costly bulldozers, fuel, and trained operators, while slash and burn is less costly technique that is well known by local communities, and provides additional benefits like preserving the topsoil and liberating nutrients from the cut trees.

Overall, Snook's research showed that in the context of the Quintana Roo forests, the use of slash and burn for clearing may favor the rapid regeneration of forests rich in commercially valuable species. Therefore, she suggests that in addition to selective harvesting, regeneration treatments should include the use of slash and burn to create clear cut gaps of about 5000 m^2. This technique can help sustain forest diversity by facilitating the reproduction of those species that are being harvested but cannot effectively regenerate in smaller gaps.

In Quintana Roo, where forests are large and human density is small, Snook believes it would be viable to use the clearings for agriculture during a year or two before allowing the forests to re-grow for decades, when possible even a hundred years. This method, often referred to as 'swidden agriculture', would not only recreate the disturbance regime needed to regenerate commercially viable species, but could also benefit the livelihoods of the ejidos. While Snook pointed out that current forest conservation policies banning burning and agriculture in forest reserves could impede the use of this technique, she thinks these issues could be addressed. When these ejidos established their permanent forest estate, they agreed to ban agriculture in order to prevent the risk of further expansion into the forest. Now, after managing their forests for over 25 years, these communities have a good understanding of the value of standing forests over permanent agricultural sites. Given the secure land tenure, the defined forest estate, and communities' fire management skills, Snook recommends making an exception to allow the use of agricultural clearings as a temporary regeneration treatment.

Snook also mentioned that the current focus on climate change might be having some unanticipated consequences. When Mexico hosted the COP 16 in Cancun in 2010, they sought to demonstrate their leadership by passing new legislation limiting the use of fire in forest management and clearing for agricultural land. Though developed with the best of intentions, many of these policies are having unintended negative effects on forest regeneration and human livelihoods.

As demonstrated by her research, continued selective harvesting and restrictions on slash-and-burn treatments could have significant negative impacts. Snook concluded by explaining that "if the light loving species in this forest don't regenerate, it means the forest as a source of timber becomes impoverished, and if a valuable timber harvest can't be sustained, how can the forest hold its ground against other land uses?"

Panel 2: Private Sector Engagement in Forest Restoration

Reforestation with Indigenous Peoples and Small Landowners

Chris Meyer

Planting Empowerment

Chris Meyer presented on the reforestation work of Planting Empowerment, a Panama-based for-profit private company, which focuses on reforestation projects with social and environmental benefits. The company operates in the Darién region, which until the 1980's was comprised mostly of contiguous forest managed by indigenous communities. At that point, the Panamanian government established policies aimed at attracting settlers to the region, which required them to "improve" land by cutting down forest and thus incentivized deforestation. Since then, the Darién has been a hotbed of colonization and land conflict between local indigenous communities and settler groups known as *colonos*.

Planting Empowerment works with both the *colonos* and with the local indigenous Arimae community. The indigenous peoples collectively own their lands, but they have developed an internal system for dividing and using it. Depending on their interests and variables such as proximity to markets, different community members engage in a variety of activities including cash crops, subsistence agriculture, cattle ranching, sustainable forest management, or more extractive logging. Meanwhile, the *colonos* have individual land titles and much more individually based production systems. Most of them started out logging for timber, followed with swidden and subsistence agriculture, and then moved on to cattle ranching.

All four founders of Planting Empowerment, including Meyer, were Peace Corps volunteers in the region and had lived and worked with these communities. They witnessed the arrival of industrial monoculture teak plantations to the region, which appeared to be the origin of some of the land conflicts. These industrial plantation companies came to the region buying out small to medium sized *colonos*, who then began squatting on lands that often belonged to indigenous peoples. These project promoters would then sell a hectare of teak plantation for $30,000, significantly more than the cost of growing the trees. Thus, the founders of Planting Empowerment realized there were opportunities to establish a profitable model that would be more economically inclusive of the local population.

Planting Empowerment was established in 2006 as a for-profit company with investors in the United States and elsewhere. Rather than purchase the land, they lease it by partnering with local communities. In its initial stages, the process involves consultation with a small-scale landowner with the goal of leasing part of his/her denuded land, roughly 5-10 hectares out of 20-50. Following this negotiation, the company establishes and manages a mixed native species timber plantation, paying to prepare the lands, plant, prune and maintain the trees. When the time comes to harvest the trees (Planting Empowerment's trees have not yet reached maturity), the profits will go back to the project investors with a return for the landowner as well.

Planting Empowerment operates on the principle that by offering a competitive price to lease the land, some landowners will be open to planting trees instead of leasing it for other uses. For example, a colono who would normally lease his land for cattle ranching at $10-12 hectare per month signed a contact with Planting Empowerment to lease five hectares for tree planting at $13 per month per hectare. He will be paid $65 per month, adjusted to inflation every five years, and he will also receive 4% of the net revenues generated from the plantation at harvest. An additional 2% share of the revenues will be allocated back to the community as a strategy for social inclusion designed to ensure that all members feel they have a stake in the success of the project. This should help prevent timber theft by creating a sense that the benefits of the project will reflect beyond the landowner and Planting Empowerment. As explained by Meyer, these payments are high enough that they can compete with the opportunity cost of cattle ranching, rice cultivation, and subsistence corn cultivation in the region.

With indigenous communities, the process is different. First, Planting Empowerment engages with multiple individuals through a consultative process to ensure that all community members understand what they are signing up for. Meyer explained that if Planting Empowerment were to pay the community $60 a month per hectare,

when split among 50 or 100 families who collectively own the five hectares, the impact of the payment would be insignificant. Instead, the money is pooled and paid in two installments. A first payment of $2,000 per hectare for a total of $10,000 per five-hectare is made at the time the plantation is established. Planting Empowerment works with the community to ensure that the distribution of funds is transparent. Later, when the time comes to harvest, the community will receive 10% of the net revenues. As with the *colonos*, the community does not pay for any of the set up or management costs.

Meyer stressed the importance of recognizing the central role land plays in these peoples' lives and incorporating that into the business models. In general both the indigenous and colono communities cannot afford to take on a lot of risk, as they live month-to-month and do not have many assets beyond their land. Thus, they need some kind of income source to support them through the years that it will take until the plantation matures and begins to generate cash. Therefore, Meyer described, "it's a better strategy to avoid a scenario where they might place all their eggs in one basket; it's best to lease just a portion, rather than all of their land in order to maintain some of the food production and other activities that they currently practice."

Meyer highlighted the importance of considering the landowners' different levels of interest and capacity to engage in the actual process. In some cases there may be a high level of forest management capacity, while in others the landowner may need the help of a professional manager not only for the setup phase, but also in the long term, throughout the ten to fifteen year period. Planting Empowerment hires professional foresters to work on the land and consult with the landowners. Additionally, they have created an apprentice program whereby a professional forester mentors young adults from the communities who are interested in forestry, thus developing their skills and helping to build the local capacity needed to manage the lands at a higher standard.

Finally, Planting Empowerment has assisted with the process of seeking "soft money" for projects that benefit the community. For example, the company helped the community write a project proposal to the UNDP, which funded the establishment of a native tree nursery. By using locally produced saplings in the plantations, the community receives additional economic benefit and Planting Empowerment can avoid some of the high transportation costs of bringing saplings from other nurseries.

So far, Planting Empowerment has learned four main lessons from their experience in this project:

1. When working with smallholders and indigenous peoples, a company must make every effort to reduce the risk for those stakeholders. This can be done by releasing earlier cash flows and by minimizing the landowners' out-of-pocket expenses.
2. Because land is one of the only assets these stakeholders have, it is instrumental to maintain land ownership. By doing so, the future net worth is maintained, as is the peoples' ability to partake in the economic benefits generated by their land.
3. Including the communities in the project's equity can help increase buy-in for the project by creating a direct link between personal benefits and the project's overall success.
4. While the scales of needs vary across populations and regions, a company should be able to develop a model that provides the necessary technical assistance for 10-15 years in order to maximize economic returns.

Planting Empowerment hopes that these practices will prove the viability of their business model by providing competitive returns for their investors, ecological benefits of reforestation, and positive economic and social impacts for the land partners.

Restoration Initiatives in the Lowland Tropics of Central America

Ricardo Luján

Brinkman & Associates Reforestation, Central America -BARCA

Ricardo Luján spoke about his experiences developing timber production and restoration projects in Central America. Luján works for Brinkman & Associates, a Canada-based timber company that has projects throughout North America, and also operates in Central and South America under the name BARCA. Much of Luján's work has been conducted in the company's tropical program, which focuses on agroforestry, forest management for indigenous landowners, and ecosystem restoration.

Luján began by describing a restoration project located on the central Pacific coast of Costa Rica. In that site, BARCA established a tree plantation consisting of 50-60% exotic teak (*Tectona grandis)*[1] mixed with other species such as rosewood (*Dalbergia retusa*) and trees in the Meliaceae and Fabaceae families (mahogany and legume, respectively). According to Luján, following the establishment of the plantation, the site had been transformed from grassland into a young forest, where economically and ecologically valuable hardwood species are now growing in the understory. With an estimated 6% return on investment, the project is considered a financial success. Beyond these long-term returns, however, investors also hoped to see results in terms of ecological restoration and income generation for local communities. The fact that hunters are being attracted to the area by the increasing presence of wildlife, including spotted pacas, peccaries, and small felines, seems to provide evidence of the restoration progress. Meanwhile, in some plantations the project managers allowed workers to plant beans during the stages prior to canopy closure, when light was still available. This proved beneficial to the restoration process, since bean plants control weeds and add nitrogen to the soil. It also provided additional income for the workers, who, according to Luján, had an additional incentive to weed thoroughly, which was good for the young trees.

1 The planting of teak (*Tectona grandis*), a species native to India, has expanded greatly throughout the Neotropics because of the combination of its fast growth rate and timber value.

In another restoration project in Costa Rica, BARCA worked with the non-government organization Osa Conservation to plant along the corridors that connect national parks. They have been conducting enrichment plantings to diversify the species in areas dominated by teak and other monoculture plantations. The enrichment species selected for this project included endangered trees such as *Platymiscium pinnatum*, and other natives like *Aspidosperma grandiflorum* and *Cojoba arborea.* BARCA is working to expand this project, which hopes to promote the change in land use from grasslands to forests, and in the process create corridors that link Costa Rica's National Parks. To do so, their strategy is to leverage private investment funds that will be used towards projects that promote connectivity and restoration, but will also generate returns.

In the Darién region of Panama, Luján has been working with the indigenous Kuna community from the *Comarca* Kuna of Madugandí, to develop a mosaic-planting program incorporating a mixture of 21 native species. Using assisted natural regeneration, the plan aimed to create mixed species forests that include both shade-tolerant and non-tolerant species. BARCA worked closely with the Kuna to develop a 35-year management plan with different harvest rotations to serve different objectives. This type of management allows for the selective harvest of specific trees in different years, but ensures a permanent forest cover while minimizing visual and environmental impacts. The community participated directly in the species selection, choosing trees that they value for specific uses, such as timber for bridge construction and leaves for roofing. The project provided nursery jobs to some women in the community, and allowed them to intercrop cassava, beans, and corn along with the young trees.

Luján then addressed the issue of genetic stock improvement and selection of planting material, which, from his experience, is extremely important for the success of native species restoration. As he noted, oftentimes with high-value timber species the trees that are available for seed collection are precisely the ones that were

left standing due to their poor quality or undesirable characteristics. Therefore, he highlights the need to specifically look for high quality individuals as seed sources in order to maintain desirable traits in the species' gene pool. Thus, BARCA uses its tree plantations to select and propagate the best-adapted trees with the best phenotypes for sale as seed stocks. However, microsite conditions are crucial to consider when selecting species and genetic phenotypes to plant, which, as Luján pointed out, is part of the challenge of scaling up these efforts to the landscape level.

Luján expressed his desire to expand the role of native timber trees within his company's restoration and plantation efforts. So far, they have identified several native tree species that grow faster than teak, but significant gaps remain in the knowledge about the growth potential, wood properties, and market prospects for such species. Thus, Luján hopes they can establish partnerships with universities

in order to fill some of those gaps, and advance in the identification of the best individuals and species for restoration. To date, Brinkman & Associates have achieved Forest Stewardship Council (FSC) certification for which all their plantations must follow good practices in order to gain access better markets. Luján expressed his hope that certification may help create future markets for native tree species.

Finally, Luján highlighted that there are still opportunities to increase revenues in native tree plantations. For example, there is an untapped market for the production of NTFPs, especially medicinal plants. He also sees real potential for restoration on indigenous and communal lands, as long as the communities are involved throughout the decision making process. He expressed optimism that, by using a mix of revenue-generating activities, restoration efforts will be able to compete with less desirable land uses, such as industrial-scale agriculture.

Panel 3: Economic Viability of Landscape-Scale Initiatives

Certified Cacao as a Strategy for Ecosystem Restoration in the Amazon Forest of São Félix do Xingu, Pará, Brazil

Matheus Couto

Forest and Agriculture Management and Certification Institute -IMAFLORA

Matheus Couto spoke about the work of IMAFLORA, a non-profit organization established in 1995, to promote social and environmental changes in the forest and agricultural sectors in Brazil. Certification schemes are an important focus of the organization, which worked with the Forest Stewardship Council to establish the first forest certification scheme in Brazil in the 1990s. IMAFLORA is also a member of the Sustainable Agriculture Network and manages the Rainforest Alliance certification audits in Brazil.

IMAFLORA has been developing a smallholder certification project in São Félix do Xingu, a remote municipality in southeast Pará state in the Amazon. The municipality is located in the "arc of deforestation" and is considered a deforestation hotspot. Degradation began in 1910-1912 with rubber extraction, followed by cassiterite and aluminum mining, and later by the logging of valuable hardwoods, especially mahogany and cedar. The roads built for those projects triggered the settlement by farmers in both large estates and smallholder lands. By 2010, São Félix do Xingu was the municipality with the most cattle in Brazil. Couto explained that this combination of large estates, small settlers, and indigenous lands, along with federal and state protected lands, is the origin of frequent conflicts among the diverse stakeholders.

As an alternative to cattle ranching, IMAFLORA has been working to promote cacao production in São Félix. According to Couto, planting cacao makes sense in São Félix because it is well adapted to the soil and climate. The region's cacao has a high fat content and high melting point, two highly sought-after traits in the chocolate industry. Unlike more perishable crops, cacao is viable in this remote area because the crop can wait more than a week to be transported to the market in Bahia (a two day drive) before being sold. In addition, because cacao can be grown under a greater forest cover than that used in conventional cattle ranching, this industry can have positive implications for conservation in such a threatened ecosystem of the Amazon Basin.

IMAFLORA has been working with a smallholder cacao cooperative (CAPPRU, the acronym in Portuguese), which was created and managed by the smallholders in São Félix to promote cacao production. There are currently 170 producers in the cooperative, producing 900 tons of cacao every year. The cacao seeds come from the Brazilian government, which has encouraged production by distributing disease resistant and more productive varieties to smallholders. The cacao farmers approached IMAFLORA in 2010, asking for help to produce high-quality cacao as part of a certification scheme, given the 200% premium that high quality, certified cacao can receive from European chocolate manufacturers.

Couto explained that IMAFLORA's goal for the past two years has been to prepare the producers for certification. They are work-

ing with a pilot group of 46 producers in five distant villages served by only two agricultural extension agents. The process began with a rural participatory appraisal, during which the team observed many poor cacao management practices, including cacao planting directly onto degraded pasture, poor fermentation practices, and a lack of pruning, fertilizer use, and shade trees. On the good side, however, IMAFLORA found that 76% of the producers are organic by default, mostly because agrochemical fertilizers are often too expensive.

IMAFLORA compared the two main products that the settlers produce and found that cacao farmers earn more on seven hectares of land that dairy cattle farmers earn on thirty-seven hectares of pasture. So far, cacao cultivation in São Felix do Xingu has generated as much as US$1196.72 per hectare per year, while cattle ranching yields US$ 164.44 per hectare per year. And, Couto adds, along with cacao cultivation, producers are allowing for increased forest cover in the region and reducing pressure on the conserved forests.

Couto cited the many additional challenges faced by the growers, including poor road conditions, lack of clean water and waste treatment, few educational opportunities, poor housing conditions, and a shortage of education and technical assistance for best farming practices. Despite these problems, the productivity of these farms is above the Brazilian average.

As part of the project, IMAFLORA created a committee of extension agents and a group of farmers to "train the trainers." These trained farmers then teach others because they can speak to them in a language they understand. As part of the increase in technical assistance in the region, IMAFLORA also performs internal inspections to identify areas for improvement. The trainings aim to improve the fermentation and drying process so that the farmers can produce a higher-quality cacao and sell to better markets. A major goal of the trainings is for São Félix to become a center for disseminating knowledge and practice on certified cacao growing for the Amazon region.

In addition to the project's goals of improving cacao production and commercialization, IMAFLORA also aims to encourage social and environmental responsibility. Planting the cacao with shade creates a more diverse agroforestry system. When asked what trees they would like to plant with cacao, farmers cited a number of native species that are also economically productive, including açaí (*Euterpe edulis*), rubber (*Hevea brasiliensis*), Brazil nut (*Bertolletia excelsa*), mahogany (*Swietenia macrophylla*), and cupuaçu (*Theobroma grandiflorum*). One Brazilian law requires public schools to purchase food from local smallholders, so the fruit produced by these smallholders has been sold to the public school as juice pulp. The cooperative also has an initiative to establish a Brazil nut manufacturing unit. They already buy Brazil nuts from the indigenous territories and the improved processing capabilities will allow them to increase their sale price.

Finally, Couto described IMAFLORA work with the farmers to carry out restoration of forests on parts of their land, especially to comply with the certification regulations and the relevant Brazilian legislation. According to Brazil's Forest Code[1] as of 2012, landowners in the Amazon must retain 80% native forest cover in their land, although they may use it for sustainable purposes. Couto explained that the program favors natural regeneration over tree planting because it is the cheapest option. In only five years, areas that are fenced off can substantially regenerate, and riverbank areas planted only with açaí have shown similar abilities to regenerate naturally. Overall, Couto highlighted that growing cacao instead of cattle ranching not only facilitates natural regeneration, but also is profitable way to sustain livelihoods and restore ecosystem health to the region.

1 The Forest Code was changed on May 25th 2012, but there are still some paragraphs under negotiation. For São Félix do Xingu one of the possible impacts is that the current requirement that 80% of land be covered by forest could be changed to 50% of the property required to be forest. This would make the certification standard higher than the legal standard, reducing the legal incentive for restoring forest as part of cacao production.

The Role of Old Maps and Nursery Entrepreneurs in Restoration of Forests in Eastern and Southern Africa

Jens-Peter Barnekow Lillesø

Forest & Landscape Denmark, University of Copenhagen

Jens-Peter Barnekow Lillesø from Copenhagen University described an institutional collaboration with the World Agroforestry Center to support smallholder farmers by advancing the tools for establishing successful agroforestry systems. Their focus is on understanding the natural variation of tree species and vegetation types across landscapes and finding strategies for matching trees to their optimal sites based on their genetic characteristics. Lillesø and his partners are also looking at ways to improve seed distribution mechanisms so that smallholders can acquire quality seed for restoration and agroforestry.

Lillesø introduced his topic by explaining that a major shortcoming of current reforestation and smallholder tree planting programs in Africa is the use of species, provenances, or varieties that are poorly adapted to the specific sites. While the practice of conducting growth trials to select those best adapted to a site is common in temperate regions, the high diversity of potential suitable species makes such trials expensive, time intensive, and thus not feasible in the tropics. Lillesø and his partners believe that more immediate methods can be developed to predict which species and provenances are most likely to survive in a given area. Specifically, Lillesø's team is working to create maps that can guide replanting efforts by spatially linking planting sites to those species likely to be adapted to the vegetation types in those areas. For example, *Prunus africana* can be found in seven different vegetation types, so rather than collecting seeds from any of those vegetation types, the maps can help focus seed collection to only the vegetation types that match the planting site.

Currently there are two major ecoregional datasets from Nature Serve and WWF showing vegetation types in Africa, but the maps created with them are too coarse in scale to be relevant for on-the-ground decision making. So in order to support restoration and agroforestry efforts, Lillesø's team is using old maps and records of vegetation to create maps on a much more detailed scale. The old

maps include those gathered by Frank White from the Kew Gardens and from botanists sent from Europe to Africa at the end of the colonial period. Botanical surveys from colonial times are very detailed, Lillesø explained, because botanists were looking closely at species and vegetation types to determine what potential resources could be extracted from African forests.

One of the challenges Lillesø's team faces in their mapping effort is that the original land cover type is obscured by the long history of agriculture and land-use change in Eastern and Southern Africa. Areas now considered homogeneous farmland actually used to be mosaics of forests, savannas, and woodlands with diverse environmental conditions for tree growth. Thus, the old data is particularly helpful to determine the original vegetation cover and uncover what Lillesø calls the 'potential natural vegetation' of a site. Furthermore, the maps can help identify regions with more than one potentially stable vegetation cover, such as the Serengeti-Mara region which over time has oscillated between grasslands and woodlands.

The potential vegetation maps have been digitized and analyzed by the team of experts from ICRAF and the University of Copenhagen along with botanists from seven African countries. The maps will be publicly available on Google Earth and, as a form of citizen science, input from the people working on the ground will be encouraged. Additional information about the use of the maps can be found on the project's website[1] and in scientific papers.[2]

Lillesø also discussed his team's efforts to enhance seed distribution as a means to provide smallholders with quality plant material. In recent years, important efforts have been made to improve smallholder access to agricultural crop seeds, which can be categorized

1 See the map Lillesø's team has developed at: http://vegetationmap4africa.org/

2 Lillesø, J. B. L., Graudal, L., Moestrup, S., Kjær, E.D., Kindt, R., Mbora, A., Dawson, I., Muriuki, J., Ræbild, A. and Jamnadass, R. 2011. Innovation in input supply systems in smallholder agroforestry: seed sources, supply chains and support systems, *Agroforestry Systems* 83(3):347-359.

in three groups based on their stages of distribution (adapted from Lillesø *et al.* 2011):

- **Breeding seed:** earliest generations of seed to be collected and bred
- **Foundation seed:** generations of seed used by seed producers
- **Commercial seed:** generations of seed purchased by farmers and smallholders

Because these seed stages are so distinct, different entities are usually involved in each stage, with private business often being involved only in the latter. One example of this is the Growing African Agriculture program (AGRA), a Gates/Rockefeller initiative that works to increase breeding of relevant crop varieties for smallholder farmers. AGRA supports medium size commercial seed companies that produce commercial seed based on foundation and breeding seed, and supports distribution to smallholder farmers through networks of small-scale sales outlets.

Unlike agricultural crop seeds, those intended for reforestation and smallholder tree planting have received little attention in terms of quality improvement and establishment of efficient distribution networks. In the case of tree seeds, there is not clear separation in the stages or sectors involved in the distribution process. Because producing successive generations of planting stock for long-lived trees is a lengthy process, Lillesø suggests that the breeding process should be done with the specific area intended for distribution in mind, and that all steps of seed breeding and distribution would be better served by small-scale private entrepreneurs.

Lillesø also explained some of the problems with the current model of seedling production and distribution in Africa. Many governments have recently privatized the national seed centers, making them exclusively dependent on their sales and thus removing the incentive to distribute seeds to people who cannot afford them. Meanwhile, approximately 90% of tree seeds and seedlings used by smallholders are procured and distributed by NGOs, who often es-

tablish their own community-run nurseries and give away seedlings in order to meet their large tree-planting targets. Since most of these nurseries are not really viable without the NGO support, their existence undermines the livelihoods of the small private entrepreneurs trying to make a living by producing and selling seedlings. Additionally, NGOs often fail to consider matching seed provenance to the target planting site, and therefore mostly source their seeds from farmland trees, which are easily accessible but of inferior quality than those collected from forests of similar vegetation type.

To address these problems, Lillesø recommended reorganizing the roles of those organizations involved in smallholder tree-planting. He suggested that the thousands of small private nurseries throughout Africa have the potential to become more efficient breeders and distributors of quality seedlings. By involving them in their smallholder tree-planting programs, the government and NGOs could enable and empower these nurseries to produce the needed quality seed material.

To test their ideas for reorganizing tree seed distribution networks, Lillesø and his team are working in southwestern Kenya, where land degradation has led to an increase in urban water shortages. Working with the government, NGOs, and entrepreneurs, they are providing small-scale nurseries with more accurate information on where to collect seed based on their vegetation maps, as well as building their business and marketing skills for running a nursery. If this project is successful, they will use it as example for other African countries where they work. Overall, by developing detailed vegetation maps and better strategies for entrepreneur-based distribution of quality tree seeds, Lillesø and his team hope to empower grassroots level restoration and agroforestry efforts in Africa.

Panel 4: Scaling Up: Applying Lessons Learned

The Atlantic Forest Restoration Pact: A Major Effort by Brazilian Society to Restore and Transform its Most Threatened Biome

Pedro H.S. Brancalion

University of São Paulo

Pedro Brancalion, professor at the University of São Paulo, spoke of the rationale, organization, goals, and current work of the Atlantic Forest Restoration Pact. The Atlantic forest once covered most of Brazil's coast with its complex and heterogeneous mosaic of forest types, including tropical rainforest, seasonal moist forest, dry forest, and temperate forests in the south. This ecosystem is known for its high biodiversity, with more than 20,000 plant species and hundreds of animal species, most of them endemic.

Despite the biome's biodiversity, much of the forestland has been removed or degraded as a result of coastal development and agricultural expansion. Currently only 12% forest cover remains, mainly in very small and isolated fragments, while just 2% of that forest is legally protected. With so little forest left, Brancalion emphasized that conservation and restoration outside of forest reserves is crucial, as existing protected areas alone are not enough for the long-term persistence of biodiversity.

More than 60% of the Brazilian population lives in this region and much of Brazil's wealth has been produced based on the water resources and other ecosystem services provided by the Atlantic Forest. This connection was understood as far back as 1862, when Manuel Archer planted more than 100,000 seedlings to restore Rio de Janeiro's watershed. Brancalion noted that this was long before the birth of Aldo Leopold, who is considered the father of ecological restoration, and suggested that "perhaps, Archer should be considered the grandfather of restoration."

Restoration efforts in Brazil have multiplied, mainly as a result of legislation that uses ecological restoration as a tool for mitigating environmental impacts to water resources. This expansion is due to efforts to comply with the Brazilian Forest Code[1], market

1 The Brazilian Forest Code prohibits deforestation along riverbanks and requires that riparian areas that have already been cut down be reforested or restored. The Code is now under revision, which may adjust the width of riparian areas that need to be protected.

requirements for environmental certification, and more recently PES projects. However, the main drawback to the predominance of small-scale projects is a lack of landscape level integration. Although, at the local scale, these projects have represented progress, Brancalion explained that, at the regional scale, they were no more than "environmental gardening... We were not changing the landscape, the Atlantic Forest was still degraded at the landscape level and there was also a low level of involvement of society in restoration. Restoration was carried out as a means of compliance with the law, not as part of a different view of land use, and there was no real perspective on upscaling these restoration efforts."

To address these issues of scale, the idea of creating a regional pact emerged in 2006, and by 2009 the Atlantic Forest Restoration Pact had been launched. It is a network of NGOs, research institutions, governments, private companies, and landowners that carry out restoration in the field. In three years, the Pact has involved more than 200 institutions ranging from local governments to some of the largest companies in Brazil. So far, in the three years since its launch, large-scale restoration has been carried out on more than 58,000 hectares, and there are more projects that have yet to be brought into the Pact. The Pact's long-term goal is to restore 15 million hectares by 2050.

The Pact itself does not plant trees, but rather, tries to identify the proven strategies for large-scale restoration and seeks to create the conditions for its members to implement restoration. Also, the Pact facilitates restoration efforts by linking those who are interested in restoring lands to those who own lands that need to be restored. Through a regional database, every farmer who has lands available for restoration but lacks the funding can be matched an can colaborate with companies and NGOs looking for lands to restore.

Brancalion explained the operational and scientific questions that guide the functioning of the Pact:

Where to restore? A key strategy of the Pact is to determine which areas should be a priority for restoration in the near future, either because they are easy or key to restore. One priority is non-forested land protected by Brazilian legislation, which landowners are obligated to restore. Another priority is to restore degraded pasturelands on steep slopes that are less productive than other agricultural lands. Their approach for pasture restoration, based on their collaboration with CIPAV[2], consists of first improving the efficiency of agricultural lands through the application of technologies to intensify production in the areas most suitable for farming, thus releasing the least productive or marginal areas for restoration. The Pact has also produced thematic maps for guiding and mainstreaming restoration and improved productivity in major watersheds and as part of PES and carbon projects.

How to restore? There have been great advances in the development of restoration methodologies on areas with different land use histories, including former sugarcane plantations, degraded pasturelands, and highly degraded former bauxite mining sites. So far, there has been success with methods tested by the Forest Restoration Ecology Laboratory (LERF) for high-diversity restoration planting with over 100 native tree species. The Pact has produced a substantial body of research and related scientific papers on these methods for restoration. Brancalion and colleagues have also written a book on the concepts and actions of Atlantic Forest restoration for use as a practical guide based upon previous experience and current scientific knowledge.[3] The goal of the book is to avoid past mistakes, establish guidelines, and provide a baseline for advancing science-based restoration.

How to monitor and track the advances of restoration? In response to the need for a standard evaluation protocol for use by all Pact members, Brancalion and the Pact's Science and Technology

2 See page 31 to learn more about CIPAV's work.

3 This work is freely available at the Pact's website http://www.pactomataatlantica.org.br/

working group developed a monitoring protocol based on social, economic, project management, and ecological criteria. This protocol is already in use by Pact members and is available on the Pact's website.

How to communicate and involve society in the movement? Brancalion stressed that it is not sufficient to develop methods and restore lands if stakeholders do not have access to this knowledge. To this end, members of the Pact have invested a great deal in capacity-building. Seed collectors, for instance, are trained to provide minimum guidance to others for seedling production. For those interested abroad, the Pact has a website as well as brochures in English, a Facebook page, a Twitter feed, and a bi-monthly newsletter for members.

Where will the money come from? Brancalion reminded the conference participants that, "when we talk about large-scale restoration, basically we are talking about restoring land that belongs to someone else." Of the 15 million hectares the Pact aims to restore, more than seven million are low productivity pasturelands and hillsides where farmers earn less than $100 per hectare per year. He suggested that convincing stakeholders to change land use and allow forests to come back, requires developing restoration alternatives that can compensate for these opportunity costs. Thus, the Pact is developing restoration models that combine revenue from timber and NTFPs with payments for ecosystem services that provide income until the timber trees reach a marketable size. The idea is to restore the Atlantic Forest and harvest some species in order to maintain forest cover. Overall, Brancalion explains that economic concerns were the driver of degradation, and they must likewise be the driver of restoration.

Brancalion concluded the presentation by highlighting the need for political involvement, citing a few examples where this has been successful. In the past, Brazil's National Development Bank funded deforestation through large infrastructure projects. Members of the Pact convinced the bank to invest 200 million dollars in loans for Atlantic forest restoration, and the bank has promised additional

funds to support restoration models that provide strong economic returns. The Pact has also been actively involved in discussions of the Brazilian Forest Code, which is currently being reformed. In another example, the state of Pernambuco is building the largest port in northeast Brazil, which will require substantial forest clearing. The state's governor Eduardo Campos recently signed a commitment with the Pact to restore 4,000 hectares of Atlantic forest in northeast Brazil; in turn, the pact will provide the technical assistance to achieve true ecological restoration with social and economic involvement.

Finally, Brancalion pointed out that while there are several proposals for large-scale restoration worldwide, a large gap remains between project intentions and on the ground results. According to Brancalion, the Pact provides a compelling model of how to transform these proposals into reality.

Mechanized Seeding of Forests in Xingu, Central Brazil

Eduardo Malta Campos Filho

Socio-Environmental Institute

Eduardo Malta Campos Filho presented his work for the past six years with the Socio-Environmental Institute (ISA in Portuguese) on ecological restoration in the headwaters of the Xingu River, Brazil. The Xingu's source is in the Brazilian savannah from where it runs 2,000 km north to the Amazon River through many ecosystems, including the Amazon rainforest itself.

This region boasts extensive water resources, high biodiversity, and cultural and linguistic diversity. The many local indigenous peoples who inhabit the central part of the watershed use the environment in different ways, but they have managed to preserve the forest on much of their lands. In the last few decades other groups have arrived to the region from different parts of Brazil and have settled in the surrounding areas. The diversity of their cultures is reflected in the variety of the cropping systems they use, which include slash and burn agriculture, polyculture systems, soy monoculture, and cattle ranching. There has been a great deal of illegal deforestation, especially in riparian zones, which is specifically forbidden by the Brazilian Forest Code.

To date, ISA has mapped 300,000 hectares of degraded riparian areas in the Xingu watershed and its goal is to restore forest in these areas, "no matter how long it takes." In his presentation, Campos Filho explained that the first step in restoring forest to the Xingu was to seek a regional consensus among the many stakeholders, especially indigenous groups and farmer/rancher groups. These stakeholders have a history of conflict that stems from differences in their cultures and values. However, they also have a common link –water– because, as he explained, "everybody likes to go fishing, everybody likes the transparent, crystal-clear water. Indigenous people depend on it for [subsistence] fishing, while the big landowners depend on water resources for irrigation and for their cattle."

In 2004, ISA convened a meeting that brought together the region's stakeholders in a campaign to start building consensus about

improving water quality through restoration actions. The stakeholders were given the "homework" of finding ways to achieve their goals to conserve and restore water in their communities. ISA called this a campaign of "shared social environmental responsibility" with three main components: 1) forest restoration; 2) education in schools and local media on agroforestry, forests, and the products and incomes they can provide; and 3) regional engagement with NGOs, communities, and public policy for a common cause.

To address the challenge of promoting restoration actions among peoples of very different backgrounds, ISA used participatory planning and provided a menu of options from which each landholder could choose. Campos Filho explained, "If they want to plant seedlings, they can do that. If they prefer direct seeding or facilitating natural regrowth with enrichment, these options are also available. Each landholder must choose if he or she prefers to plant trees for fruit or timber, to comply with legal requirements, or for aesthetic reasons." ISA also offered the flexibility to integrate restoration with crops and livestock in the Legal Reserve and outside of riparian areas, where it is legally permitted. Some people chose to plant a small number of pequi trees *(Caryocar brasiliense)* in pastures while others planted rubber trees mixed with cassava (manioc). ISA provided technical assistance in order to facilitate the aligning of the different restoration goals with the management interests of the stakeholder.

An essential component of the project was the requirement for each landowner to participate in the planning and planting on their own land. This kind of engagement would allow landowners to view the restored forest as theirs, rather than solely the product of ISA's actions. Campos Filho explained, "They shouldn't wait for ISA to say what they should do, but rather they will carry out what they themselves have planned." Local leaders involved in the project are later asked to present their work to their community of peers; by communicating in the same language they are best able to make the case for restoration.

Financing for the pilot projects originally came from ISA, but as time went by, farmers started investing their own funds in what they saw as profitable systems —fruit, timber, etc. These landowners were also interested in compliance with the Forest Law because this allows for certification and access to European markets with higher prices. Additional funding came from carbon projects and some Brazilian companies that chose to participate as part of their marketing strategy.

Over a period of six years, a total of 2,400 hectares belonging to 211 landholders were reforested: 400 hectares were planted with

seedlings, 1,000 hectares with direct seeding, and 1,000 hectares through regeneration. Activities have been carried out on farms of all sizes, from very large 150,000 hectare holdings to small one hectare plots, and across many municipalities in the 450 kilometer range of the Xingu headwaters. Campos Filho explained that, in general, indigenous peoples and small landowners have more manual labor available so they tend to prefer agroforestry systems, while large landowners avoid labor-intensive operations and choose mechanized systems or regrowth strategies.

Such results were only possibly by getting such different groups to come sit at the same table, and valuing the knowledge and capacity they could contribute towards a common goal. Opportunities for collaboration emerged when ISA asked the groups to work together. Indigenous people contributed their knowledge on planting trees through direct seeding, while the settlers offered their expertise and farm equipment conventionally used for large scale planting of soy and pastures. As a result, a new technique for the mechanized planting of native forests was developed. The system uses a mixture of seeds of native trees, crops, and green manure[1], known as "muvuca", all planted simultaneously using machinery.

Campos Filho expressed that the muvuca planting system has showed excellent results. Three months after planting, fast growing species form a low canopy layer underneath which slow-growing trees can develop, nurtured by the green manure. One year later, the short-lived, fast-growing species die and the new canopy is composed of shrubs. At 2.5 years, all of the green manure dies out and the first pioneer species create a canopy with the non-pioneer species underneath.

Throughout his presentation, Campos Filho stressed the many advantages of direct seeding over planting of seedlings, in terms of

1 'Green manure' is a type of living fertilizer composed of mainly leguminous herbs, climbers and shrubs (beans), such as *Cannavalia ensiformis, Crotalaria juncea, Crotalaria spectabilis, Cajanus cajan*, and others.

both efficiency and survival rates. In view of this, ISA has purposely avoided sponsoring the establishment of large nursery operations, unlike many other organizations involved in restoration. While they still encourage enrichment planting in areas under natural or assisted natural regeneration, for large-scale reforestation efforts they prefer direct seeding because it offers:

- more protection against herbivores (who naturally thin the dense vegetation);
- variety of vegetation layers that create many habitats and niches
- higher rainfall absorption;
- earlier flower and fruit production;
- better root development and drought resistance;
- more diversified biomass with better nutrient cycling and soil restoration;
- higher growth and survival rates; and
- more planting efficiency, with up to 20 hectares per day.

The large demand for native seeds required for ISA's projects led to the creation of Xingu Seed Network, composed by indigenous peoples and smallholders who collect, process and sell the native seeds. The network started in 2006 and by 2011 it had grown to 200 members who produce a total of 20 tons of seeds each year. So far, US$250,000 have been transferred directly to these people who work in the forests; thus, by compensating the people who work in the forest, the network is helping to preserve it. Finally, the network has created a positive relationship among people who have been historically in conflict: big landowners, smallholders, and indigenous people.

Challenges and Opportunities of International Policies for Tropical Forest Restoration

Pipa Elias

Union of Concerned Scientists

Pipa Elias from the Union of Concerned Scientists (UCS) provided an update on the status of the United Nations Framework Convention on Climate Change (UNFCCC) negotiations as of January 2012, and how they are relevant to restoration efforts. For restoration, the most important component of the negotiations is developing the rules for REDD+ (Reduced Emissions from Deforestation and Land Degradation). The 'plus' in REDD+ refers to benefits that go beyond the reduction in carbon emissions, such as carbon sequestration and improved land management. Other components of REDD+ include social and environmental safeguards intended to provide income generation for poor communities and benefits for biodiversity conservation. Currently, REDD+ and "REDD+ readiness" programs are being implemented outside of the UNFCCC by the World Bank, the United Nations REDD program, and other bilateral programs. However, it is likely that the rules being developed under the UNFCCC will eventually determine the direction of international REDD programs and whether or not restoration will be included.

Deforestation and land degradation are the cause of approximately 15-20% of total global GHG emissions, more than the entire global transportation sector. Given the emission reductions goals agreed during the 15th and 16th sessions of the UNFCCC Conference of the Parties (COP), REDD+ needs to be part of the global emissions reduction strategy. At the COP 16 held in 2010 in Cancun, Mexico, agreements were made that provide guidance to policymakers to develop a basic blueprint for REDD+ programs. Potential financial flows from developed to developing countries for REDD+ implementation could exceed one billion dollars per year. With such amounts of money on the table, safeguards are required to ensure that the environmental benefits are realized without violating the rights of local communities.

During COP 16 meetings, rules were developed for environmental and social safeguards. Environmental safeguards are intended to ensure that reforestation of recently converted forestlands do not

receive REDD+ credits. Social safeguards are intended to ensure participation by all stakeholders, especially indigenous peoples, as well as to guarantee the transparency of the operations. At the COP 17 in Durban, South Africa, discussions on the issue of safeguards focused on the challenge of enacting them without compromising each nation's sovereignty. According to Elias, several organizations felt that the language adopted on safeguards was not strong enough to effectively protect community rights. Also notable during COP 17 was the inclusion of agriculture in the agreement, a topic that can be expected to be increasingly important in the agenda of future UNFCCC negotiations.

Another controversial topic during COP 17 was the establishment GHG emissions reference levels —projected emissions under a business-as-usual scenario at the national and regional levels—, to be used as baseline to measure the progress of REDD+ programs moving forward. Accurate reference levels are instrumental in order for implementers to have clear goals and for funders to estimate their payments, as well as to confirm that REDD+, in fact, useful to mitigate climate change. As pointed out by Elias, the UCS considers that the language used by COP 17 was strong enough and will result in most countries using historical deforestation rates as baseline for estimates of their future deforestation.

So far, however, restoration has been virtually ignored by governments and NGOs in the climate change negotiations, including the REDD+ discussion. The reasons for this omission include the high cost of restoration, the difficulty to measure carbon benefits from different restoration actions, as well as the fear of creating perverse incentives for recent deforestation. While such challenges have generally kept restoration out of REDD+ discussions, largely deforested countries like India have recently expressed their interest in including restoration within the REDD+ programs.

Elias explained that, given the urgent need for tropical countries to achieve net zero emissions from their forests, any action that re-

duces net emissions should be considered relevant to REDD+ policy. The UCS considers that the definition of REDD+ is broad enough to include a variety of strategies to restore forest in degraded lands and/or to focus production on currently degraded lands in order to spare standing forest. The local context, the drivers of deforestation, and the opportunities available for restoration need to be considered before determining the type of action at each site. However, she did caution that the current shift from smallholder farming towards the industrial-scale production for the commodities market might cause an increasing scarcity of land for restoration, despite increasing migration to the cities. Thus, there is a need to develop incentives that help restoration compete with other potential land uses, and as she highlighted, REDD+ financing can serve as one of them.

Another challenge that must be tackled in the UNFCCC negotiations is leakage, the displacement of deforestation activities from areas covered by policy to areas outside its scope, which results in no net reduction in global emissions. Elias cited studies showing that, in the cases of Costa Rica and Vietnam, restoration and conservation efforts created some leakage of deforestation into neighboring countries, but not the full amount. Regarding the role of shifting land uses, restoration has the potential both to help increase carbon stocks and to enhance the provision of forest products on lands that are already cleared. There is, however, a caveat that needs to be considered carefully: while intensifying agricultural productivity may help reduce pressure on forests, it can also increase the value of these lands for agriculture, thus making them too expensive to maintain as forests even with REDD+ funding.

Before REDD+ can move forward at a significant level, a number of different issues will have to be worked out. Financing REDD+ remains a challenge, and current payment schemes focus only on carbon values, failing to reward other benefits like watershed and biodiversity protection. Political issues and concerns over governance are slowing down the implementation of REDD+ programs,

and Elias recommends patience because, like any new program, REDD+ will require time for its implementation. Meanwhile, few governments or NGO's are even discussing restoration as part of REDD+, which highlights the need for more information and advocacy on the potential role for restoration within REDD+. Overall, Elias asserts that restoration can and should play a larger role in the REDD+ discussions, but warns that REDD+ would play only part of a broader suite of incentives needed to promote tropical forest restoration at a relevant scale.

Restoring Landscapes, Governing Space

Cora van Oosten

Wageningen University
and Research Center

Cora van Oosten from Wageningen University and Research Center spoke about opportunities for scaling up restoration efforts to a landscape level and the role of governance in those efforts. First she asked the attendees to share with their neighbors a memory of the landscape where they grew up or to which they feel most attached. Then, she encouraged the attendees to consider the emotions generated by that landscape and their own sense of place. According to her, people often feel a connection with natural areas, but in much of the world that connection has been disrupted by human activities including urbanization, agriculture, movement, and others.

The dramatic decline in forest cover in recent decades has been linked to the expansion of agricultural and livestock industries, resulting in mosaics of land uses across the landscape. Within that mosaic, van Oosten said "there is great biophysical potential for restoration, but biophysical potential is not everything because we all know that reversing a trend is more than just biophysical conditions. The Global Partnership for Forest Landscape Restoration (GPFLR) has taken on the issue of creating the social circumstances necessary for restoration, with its slogan 'ideas transform landscapes'."

She then made the point that since land degradation and forest loss are closely tied with poverty and subsistence agriculture, restoration can be a strategy to improve both socio-economic and environmental conditions. To provide an example, she showed a video of the Loess Plateau in China where residents have built terraces and planted native vegetation on the slopes, reducing soil loss and accumulating biomass, and restoring both their forests and their livelihoods. The filmmaker John Liu stated that restoring forested landscapes on a global scale requires technology and capita transfer, as well as empowering the people. As noted by van Oosten, scaling up people empowerment may be the most difficult part.

According to van Oosten, when working on a landscape scale, it is important to consider more than the complex land use mosaics; the place-specific social networks and the complex governance

structures ruling at multiple levels need to be considered as well. However, as she pointed out, the different elements that comprise the governance, biogeographical, and relational scales do not necessarily match, which makes it difficult to move between the scales:

Governance scales:
Community→ District → Province → Country → Region → World

Biogeographical scales:
Tree → Forest → Region → Continent → Globe

Relational scales:
Family → Peers → Society → Trans-society

The challenge is that governance structures are generally disconnected from the complex social networks that make up landscapes, and therefore bear no connection to people's sense of place. In order for restoration to be effective, van Oosten called for a "spatialization" of governance, meaning that environmental decision-making needs to be reconnected to the logic of socially constructed landscapes. However, this requires a mindset shift, which involves looking beyond the formal governance structures and implementing learning across landscapes, harnessing the multiplicity of social networks present in the landscapes. Thus, she believes that networking across scales is more likely to succeed than traditional scaling up efforts.

A common challenge across restoration efforts is finding the key element that inspires and motivates people to take action. As an example, van Oosten cited the construction of a highway in the transboundary region known as MAP, which includes Madre de Dios (Peru), Acre (Brazil) and Pará (Bolivia) in southwestern Amazonia, and how it indirectly triggered restoration. The MAP has become a regionally important hub for the development of east-west transportation infrastructure, which have resulted the creation of new businesses and jobs and the subsequent migration. While the residents of this landscape recognized the positive implications of the new highway in terms of connecting them to global markets and value chains,

they also expressed deep concerns for the potential negative impacts on their community identity. Through a series of regional dialogues, the community addressed these issues and created their own map of the region, and exercise which, according to van Oosten, provided them the opportunity to redefine and literally 'make' their place. As part of their efforts to maintain their own cultural identity, the coali-

tion began a series of forest restoration efforts incorporating the use of rubber trees. They then used their access to the various scales of governance and policymaking to connect with potential export markets for the rubber. They also contacted local factories and secured funds from the Brazilian government to build a condom factory to which they could supply the rubber. Ultimately, the coalition has been able to impact national and international networks of decision-makers.

Using this example, van Oosten illustrated how, despite diverging and even conflicting interests prior to the road development, through their shared landscape identity, the community was able to find a common concern that sparked them to take action. She explained that "a major factor of the project's success was that residents shared information, technologies and market opportunities across national boundaries, thus creating landscape-wide learning networks, and cleverly linking to higher scale political decision making and value chains. In this way, inhabitants made use of ecological and geographical opportunities, and created landscape institutions, embedded in politics of scale". In this case, forest restoration occurred not through an outside conservation initiative, but instead as a result of local drivers which built the connections between different social and governance scales.

Finally, van Oosten concluded by emphasizing that in her experience, providing an opportunity for people to create a feeling of place and ownership can be an effective strategy to promote conservation and restoration. Her organization, the Global Partnership on Forest Landscape Restoration, enhances landscape learning within and across landscapes, aiming to create the political will to stimulate experience-sharing among different stakeholders and across different governance scales.

Group Discussion Panel

The Road Ahead: Scaling-Up Restoration Successes to the Landscape Level

Moderator

Tim Rollinson

U.K. Forestry Commission and Global Partnership on Forest Landscape Restoration -GPFLR

To close the conference, Tim Rollinson moderated a panel where all the speakers participated in a wide-ranging discussion on issues raised over the previous two days. Among the topics discussed were ways to:

- bridge the gaps in communication between those working in academia and restoration practitioners; and
- motivate the environmental community to integrate issues of agriculture and food security into their current focus on forests and carbon.

The panel discussion began with detailed commentary and debate on the role that effective communication and sharing of ideas can play in promoting landscape-scale restoration. Firstly, keynote Robin Chazdon asked the panel how the abundance of quality research that ultimately does not make it into peer-reviewed journals might be better shared with academics and practitioners. In a similar vein, Ricardo Luján wondered how to share valuable indigenous and traditional knowledge, given that in many cases local people have already developed solutions for reforestation. From the audience, Doug Boucher from the Union of Concerned Scientists suggested that a web portal might be developed where unpublished manuscripts, field interviews, DVDs and other information could be easily accessed. Also from the audience, Gillian Bloomfield from the Environmental Leadership and Training Initiative (ELTI) described a web-based tool that ELTI has developed to serve as a virtual library for the sharing of resources on tropical forest restoration and reforestation.[1]

Both Tim Rollinson and Cora Van Oosten warned that for some audiences, talking about restoration in a way that is too technical and complex could be a turn-off. Instead they suggested communicating in a way that evokes a personal and positive connection to restoration. The use of cultural media has been a successful strategy to

1 ELTI's Tropical Native Species Reforestation Information Clearinghouse can be accessed at http://reforestation.elti.org.

bridge this gap in some regions; Matheus Couto described of the use of a DVD that uses a colloquial language to disseminate knowledge among farmers in the Xingu. Even though literacy rates are low, he explained, "everybody has DVD player." Similarly, Zoraida Calle mentioned how technical messages about silvopastoral systems have been incorporated into songs that use the local musical styles from the various regions of Colombia. Songs have been written for each of several useful plant species, and humorous dialogues are used to explain their uses and benefits. As Rollinson described, simple messaging about the beneficial functions of trees has been effective for audiences ranging from school children to politicians.

The language of communication is in of itself a challenge in some cases. Pedro Brancalion spoke of the difficulties non-native English speakers face when trying to publish in academic journals. Aerin Jacob suggested that a formalized system of exchange among native and non-native English speaking researchers would improve this situation as well as serve as a means to build scientific networks. In legal discussions, Jan McAlpine noted that simply translating the phrase "illegal logging" into French was much more complicated than it might appear, as there is no commonly used phrase with the same meaning.

The problem of linking the knowledge gained in the field with academic knowledge continued to drive the conversation. Brancalion noted that the gap between high quality academic research and the

practice of reforestation is partly due to the fact that many practitioners do not have the time or motivation to publish; it is simply not part of their job. Meanwhile, as observed by Eduardo Campos, the standard way of delivering scientific results and management recommendations is at times incompatible with the local customs. Statistical analyses, for example, are unlikely to be a part of a farmer's decision-making, so bridging those gaps is important.

Brancalion suggested that the individuals who carry out research should source their ideas and research priorities from the field practitioners who are carrying out the work. Laura Snook cited one such study of mixed species plantations in which practitioners are providing interesting research opportunities for academics to evaluate how different species interact. The results of such research can, in turn, inform the way in which practitioners establish tree plantations. Along these lines, from the audience, Cecilia del Cid from ELTI pointed out that graduate students from institutions like Yale are available to conduct field research, and could play a larger role connecting the real on-the-ground questions and priorities with academic research.

Many speakers expressed that the demands of academia itself may be partly to blame for this gap between research and on-the-ground management. McAlpine noted that the academic pressure to publish under rigid and predefined standards drives the "siloing" effect that limits productive interaction across fields. Jacob expressed the need for change among academic committees such that they might put higher weight on service, outreach, and non-academic work when making tenure decisions. Meanwhile, Luján proposed that those who originate field-based knowledge —including traditional knowledge— should share authorship with the scientists in published papers.

Shifting focus, the panel discussion moved on to the intersections between agriculture and forests. Jens Peter Lillesø acknowledged the environmental community's bias towards forests and maintaining a

conceptual distinction between forests and agriculture. A distinction that, he explained, does not necessarily exist among the hundreds of millions of people whose livelihoods depend on forests and the practice of agroforestry. To them, forests and agriculture are different stages of the same entity. Pipa Elias expressed some of the challenges faced during the attempts to establish a multilateral carbon agreement. In her view, the inclusion of agriculture within the carbon and climate change negotiations can lead to a broader framework of thinking and can help in avoiding an overwhelming focus on forest carbon that has so far dominated climate change discussions.

McAlpine related the concurrent news out of the Davos World Economic Forum in Switzerland (January 25-29, 2012) where food security took a center stage. Campos and Brancalion agreed that food production and restoration should be addressed together, and viewing them separately or in contradiction is problematic. However, they noted that because agricultural research is largely funded by companies that sell farm machinery and chemical inputs, there is little incentive to research the potential role of trees in improving food production. Meanwhile, the food security narrative is sometimes used as an argument to minimize the importance of forests and restoration, as has been seen in the discussions of Brazil's Forest Code reform. This argument does not hold true in many cases, though. For example, Brancalion explained that by restoring part of the 75% of cleared lands currently in extensive cattle pasture to other land uses, food security could greatly improve. Similarly, the vast lands used for coffee and sugar production are also not directly improving food security.

Rollinson ended the panel on a positive note, maintaining that despite pessimism, restoration is something that can be done, especially when compared to many of the other options available to mitigate climate change. Relating an anecdote from a visit to an Indian reforestation project, he recalled the simple and profound answer the villagers gave to the question, "what benefits does the forest provide?" They replied, "the air is clean, and we get water."

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Glossary of Terms

Arrested Succession
A state of a recovering forest ecosystem that is much different from the original landcover, often maintained by continued disturbance (i.e. fire, grazing) and/or competition with herbaceous species.

Direct Seeding
A forest restoration or reforestation technique whereby seeds are planted *in situ*, rather than in nurseries.

Ecoregion
A geographic area defined by its environmental characteristics.

Ecosystem Services
The benefits to humankind provided by the resources and processes supplied by a given ecosystem, forests in this situation.

Enrichment Planting
A silvicultural practice of planting seedlings of desired species to increase their prevalence in a regenerating area or degraded forest.

Fallow Period
The period of time when an agricultural site is left untended between periods of cultivation. Where commercial fallowing may leave a field fallow for one or two growing seasons, swidden (i.e. slash and burn) agriculturalists may abandon a forest site for 10-50 or more years between periods of cultivation.

Fodder
Food for livestock, including plant material such as cut branches, leaves, stalks, or grasses.

Forest Restoration
The intentional process of initiating or accelerating the recovery of a forested ecosystem after it is been degraded, damaged, transformed, or totally destroyed by a disturbance.

Green Manure
Living cover crops that are planted along with seeds or seedlings as part of restoration efforts because of their ability to improve soil fertility through nitrogen fixation, reduce erosion, provide shade to seedlings, and increase leaf litter.

Leakage
The term used to describe a circumstance when the policies geared to prevent deforestation within one area lead to deforestation activities outside of that policy's jurisdiction.

Reducing Emissions from Deforestation and Forest Degradation (REDD and REDD+)
REDD is a mechanism to use market or other financial incentives to reduce greenhouse gas emissions from deforestation and forest degradation. REDD+ expands the scope of eligible activities to conservation, sustainable management of forests, and enhancement of forest carbon stocks.

Reforestation
The process of planting trees on degraded and deforested areas. For native species reforestation, trees indigenous to the region are specifically incorporated into the planting program.

Seed Bank
The viable seeds in the soil which have the potential to germinate after a disturbance or changing environmental conditions.

Seed Rain
The collection of seeds dispersed into a site by means of wind, water, gravity, and/or animals (small and large).

Shade Tolerance
The ability of tree species to grow and survive where sunlight is low under the canopy cover of overstory trees.

Silvopastoral Systems
Productive lands which integrate livestock grazing with the presence or cultivation of trees.

Swidden Agricultural Systems
A form of subsistence agriculture in which crop cultivation is preceded by the cutting, drying, and burning of plant material on the site and followed by a fallow period during which the land is not cultivated.

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