Forest Carbon Strategies in Climate Change Mitigation

Confronting Challenges Through On-the-Ground Experience

Nicole R. Virgilio and Sarene Marshall • November 2009



The Nature Conservancy

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Acronyms

AR Afforestation/Reforestation

CAR Climate Action Reserve

CAR Corrective Action Request

CCAR California Climate Action Registry

CCB Climate, Community and Biodiversity Standard

CDM Clean Development Mechanism

CIBAPA Central Indígena Bajo Paraguá

DBH Diameter at Breast Height

EU ETS European Union Greenhouse Gas Emissions Trading System

FAN Fundación Amigos de la Naturaléza

FSC Forest Stewardship Council

GHG Greenhouse Gas

GtCO2/GtC Gigatons of carbon dioxide/ gigatons of carbon

IFM Improved Forest Management

IPCC Intergovernmental Panel on Climate Change

NIR New Information Request

NGO Non-governmental Organization

REDD Reducing Emissions from Deforestation and Degradation

RGGI Regional Greenhouse Gas Inventory

SCS Scientific Certification Systems

SFI Sustainable Forestry Initiative

SGS Société Générale de Surveillance

TCF The Conservation Fund

tCO2e/tC Metric tons of carbon dioxide equivalent/metric tons of carbon

TCO Spanish acronym for titled indigenous territory

TNC The Nature Conservancy

UNEP-WCMC United Nations Environment Programme World Conservation Monitoring Centre

UNFCCC United Nations Framework Convention on Climate Change

VCS Voluntary Carbon Standard

Conversions

1 hectare (ha) = 2.47 acres (ac)

1 metric ton of carbon dioxide equivalent (tCO_2e) = 44/12 metric tons carbon (tC)

1 metric ton = 1,000 kilograms (kg) = 2,205 pounds (lb) = 1.10 short (U.S.) tons

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Executive Summary

Forests have a critical role to play in addressing climate change. Approximately 17.4 percent of annual global carbon dioxide emissions are caused by deforestation and forest degradation and it will be impossible to solve the climate change problem without addressing these emissions (IPCC, 2007b).[1] Recognizing the importance of and providing incentives for conserving, restoring and better managing forests provides an effective way to mitigate climate change while offering a cost-effective and near-term option to ease the transition to low carbon economies (Stern, 2006). Slowing deforestation, combined with changes in forest management as well as reforestation, could curb a significant portion of the emissions that contribute to climate change. In fact, halving deforestation by 2020 would prevent the release of nearly three billion tons of CO_2 per year (IPCC, 2007d). Despite this potential, nearly all climate policy frameworks fail to include the full array of forest carbon activities as a critical component of climate change mitigation, due to skepticism about whether these activities generate real benefits to the climate and questions about how those benefits can be measured, monitored and verified.

Nonetheless, advances in technology and practical implementation experience have created a growing body of research and evidence that reducing carbon emissions and enhancing carbon sequestration through forest conservation, restoration and management can be a credible part of the fight against climate change. This report explores the primary challenges in proving this credibility, including:

- Proving that the climate benefits from forest activities are ***additional***, or would not have happened anyway. (Section 1)
- Setting realistic ***baselines*** (or business-as-usual scenarios). (Section 1)
- ***Measuring, monitoring, reporting, and verifing*** the actual emissions avoided or carbon stocks preserved in forests. (Sections 2 and 5)
- Addressing ***"leakage"*** (i.e., the shifting of emissions elsewhere). (Section 3)
- Managing risks to the ***permanence*** of carbon credits. (Section 4)
- Ensuring the ***involvement of and benefits to local and indigenous peoples***. (Section 6)
- Ensuring such efforts enhance, rather than undermine, ***environmental co-benefits***. (Section 7)

[1] Eliasch Review. 2008. Climate Change: Financing Global Forests. Crown Copyright. p.1: "Analysis for this Review estimates that, in the absence of any mitigation efforts, emissions from the forest sector alone will increase atmospheric carbon stock by around 30ppm by 2100. Current atmospheric CO2e levels stand at 433ppm. Consequently, in order to stabilize atmospheric CO2e levels at a 445-490ppm target, forests will need to form a central part of any global climate change deal."

Climate change mitigation strategies across all sectors must address carbon accounting and credibility challenges, including leakage and permanence. These barriers, unfortunately, have become uniquely associated with forest carbon activities. TNC projects have provided the basis for groundbreaking methodologies in estimating, preventing and mitigating leakage, setting project baselines, and verifying carbon benefits, with the first, and still only, third-party verified REDD project in the world.[2] These projects have not only resulted in climate change mitigation, but also valuable community and biodiversity benefits, creating a triple bottom line.

The Nature Conservancy's Project Experience

During its 15-year history of undertaking all types of forest carbon pilot projects on the ground, The Nature Conservancy (TNC) has built a repository of knowledge in forest carbon science and project implementation. TNC is involved in 12 active pilot projects (with more in development) that represent the full range of "forest carbon" activities: reducing emissions from deforestation and degradation (REDD), improved forest management (IFM), and afforestation/reforestation (AR). These projects serve as examples of the important role forests play in climate change mitigation. This hands-on experience has helped dispel concerns about the effectiveness and feasibility of forest carbon projects, and contains valuable lessons for the design of other forest carbon projects and for development of climate change policy.

Each section of this report examines a specific issue or challenge inherent in proving the credibility of forest carbon projects and provides an in-depth case study of the way one of TNC's pilot projects has overcome the challenge. There are four forest carbon pilot projects profiled in this document (snapshots on pg. 4-5). Three existing projects—***the Garcia River Forest Project in Northern California, the Noel Kempff Mercado Climate Action Project in Western Bolivia and the Tensas River Basin Project in the Lower Mississippi Valley***—have provided important insights into forest carbon activities at the project scale. In the future, larger-scale undertakings, such as the district scale ***Berau Forest Carbon Program in Indonesia***, will provide even more robust examples of how nation-wide forest carbon programs may function.

These case studies help demonstrate:

The technology exists

Field studies and satellite imagery enable highly accurate measurements of the carbon sequestered in growing trees and stored in forests, as well as changes in land use (and subsequent emissions) over time. Field methods to determine vegetation cover and measure carbon density have been successfully used for more than 100 years. Global land use change data, determined from satellite photographs and used to calculate CO_2 emissions, is available from as early as 1972, and advances in the interpretation of this data are occurring every day. Such advances include methods which now allow for the estimation of degradation from logging and fire, two activities which can contribute a substantial portion to forest carbon emissions (Asner, et al., 2005 and Souza and Roberts, 2005). Measurement and monitoring techniques are steeped in rigorous scientific method and are rapidly becoming more economical to use on both small and large scales.

Credible carbon benefits can be achieved

The third-party verification of carbon offsets from two of the projects profiled in this report demonstrates that emissions reductions from forest carbon projects can be real, measurable and verifiable.[3] The project assumptions, methodologies and calculations were subject to a transparent and rigorous independent inspection, resulting in the official verification of 1,559,477 tons of carbon dioxide equivalent, with more tons expected over subsequent verification periods.[4] This is the equivalent of taking 283,541 passenger vehicles off the road from 1997-2008.[5] These and other projects have shown that:

- Methods for determining baselines are becoming highly refined, and carbon project standards, based in part on project experience, now offer guidance on how to develop them. At the project level, TNC establishes forward-looking baselines that consider historical emissions, threats, regional land use patterns and underlying socio-economic trends. Baselines are reviewed by third-party technical experts according to a recognized objective standard and are re-evaluated and adjusted over time as necessary to reflect changes in land use, behavior and/or drivers.

[2] Noel Kempff Mercado Climate Action Project, Bolivia—initiated in 1996.

[3] Standards and verification systems are very recent constructs and didn't exist when most of TNC's projects were designed. Nonetheless, TNC is working to achieve verification of earlier forest carbon projects as well.

[4] Combined total for Garcia River Forest Project and Noel Kempff Mercado Climate Action Project.

[5] Data based on 2005 EPA recommendations for calculating greenhouse gas emissions from a typical passenger vehicle: http://www.epa.gov/otaq/climate/420f05004.htm.

- Leakage, although a problem in all sectors, can be managed. At the project level, TNC addresses leakage by:
  - — Designing forest carbon strategies that minimize leakage effects, for example, by promoting improved logging practices that reduce emissions without sacrificing timber volume, creating alternative economic opportunities for local communities and promoting intensification of agriculture and ranching where previously cleared land is inefficiently used.
  - — Employing sophisticated economic analysis of any unavoidable leakage impacts and conservatively discounting the project carbon benefits accordingly.

- The risk of impermanence, another issue for all sectors, can be dealt with by aligning interests of key stakeholders, using financial, legal and institutional structures (such as endowments, easements and protected-area status) to support long-term pursuit of project goals. Also, maintaining a buffer reserve of credits, pooled across a portfolio of forest carbon projects, can provide insurance against possible carbon losses.

Win-win-win potential

Forest carbon activities offer the potential for a triple benefit—climate change mitigation, community development and biodiversity conservation—and the most robust projects make efforts to capture all three. As international climate change policy negotiations move forward, the participation of indigenous peoples, who may be the most adversely affected by the impacts of climate change, will be critical to the outcome. Projects profiled in this report have illustrated the importance of involving indigenous peoples and local communities in project planning and implementation, as well as demonstrating that forest carbon projects can be implemented to provide numerous co-benefits to local people—and the plants and animals—that depend on healthy forest ecosystems for survival.

Lessons for moving to national scale

While project-scale forest carbon initiatives, as most of the efforts profiled in this report are, can produce credible carbon benefits, there is an emerging interest, especially in the international climate policy dialogue, in scaling up these efforts to span entire countries. This is in part because of the magnitude of the positive climate impact that such nation-wide programs could have, but also because of the advantages of such large-scale efforts in engaging governments and dealing with certain technical challenges across whole countries. Establishing national carbon accounting, for example, would likely enable simpler and more cost-effective methods for dealing with baselines than at the project scale (which generally relies on complex modeling), while making intra-country leakage a non-issue.

Despite the advantages of larger-scale forest carbon programs, TNC's extensive field experience indicates that, in the near term, many countries do not have the capacity to undertake nation-wide forest carbon programs. The implementation of sub-national scale pilot projects is therefore a critical step in the "pathway to success" that most countries will need to follow. Thus, while there are benefits to moving towards national-level accounting as soon as feasible, it is likely that for some time many nations will need to address the credibility of forest carbon efforts with methods such as those profiled in this report.

Tree planter Pedro Agustin plants about 300 trees a day for the Conservancy in Extrema, Brazil. The Nature Conservancy's Atlantic Forest program has a Water Producer Program to compensate landowners who protect and reforest riparian areas on their lands. Trees planted here count towards the Conservancy's goal of planting one billion trees in Brazil's Atlantic Forest, of which just 7% currently remains. Photo Credit: © Adriano Gambarini

The Project Examples—Snapshots

The project experiences in this report are based on four Nature Conservancy and partner projects which demonstrate the full range of forest carbon activities:

The Noel Kempff Mercado Climate Action Project

The Noel Kempff Mercado Climate Action Project ("Noel Kempff"), implemented in 1996, is located in Bolivia and is addressing both D's in REDD—Reducing Emissions from Deforestation and Degradation. To alleviate the threat of deforestation from local agricultural expansion, The Nature Conservancy and Fundación Amigos de la Naturaleza (FAN), a Bolivian NGO, engaged in a comprehensive 10-year community development program. The most important aspect was assisting indigenous communities living adjacent to the Noel Kempff Mercado National Park to gain legal recognition as an indigenous organization and land tenure. Project developers also worked with the government of Bolivia to cancel timber holdings in the proposed project area and expand the pre-existing national park to encompass these former concessions, thus stopping degradation from timber harvesting. The Noel Kempff project has a lifetime of 30 years and the success thus far is demonstrated by the third party verification of 1,034,107 tCO_2e through 2005.

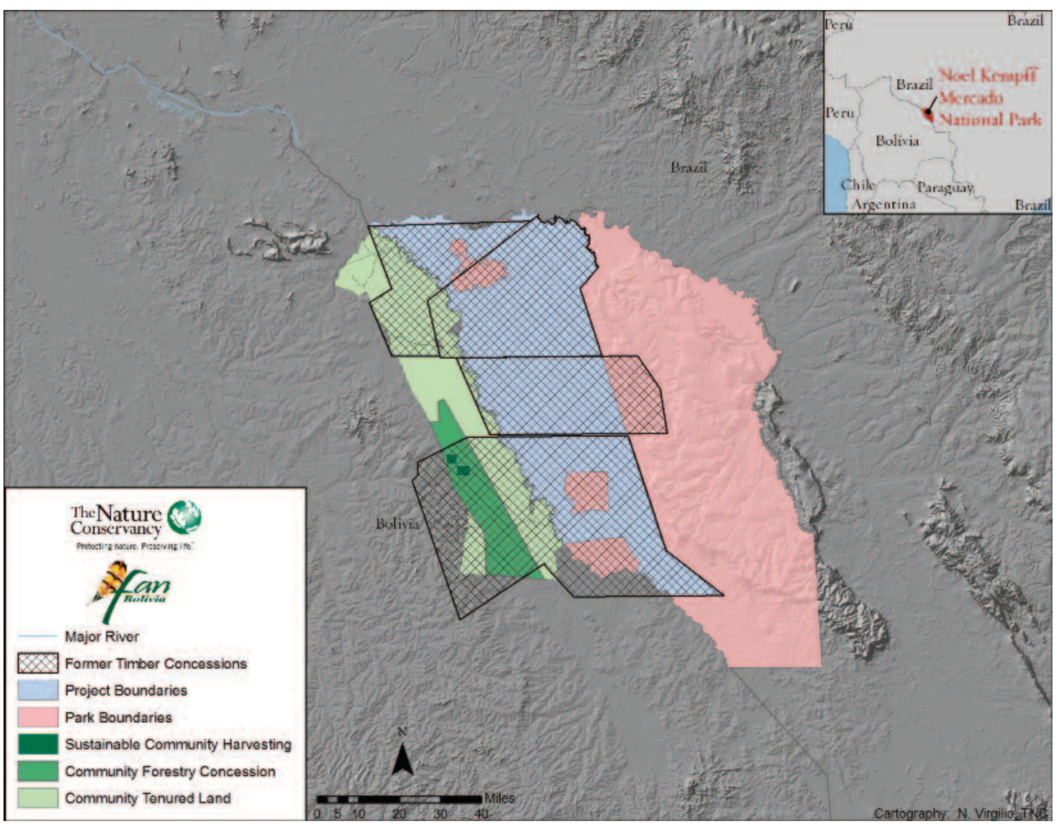


FIGURE 1 » Noel Kempff Mercado National Park, Bolivia. Cartography: N. Virgilio, TNC.

The Garcia River Forest Project

The Garcia River Forest Project ("Garcia River") was implemented in 2004 by The Conservation Fund (TCF) in partnership with The Nature Conservancy (TNC), the California State Coastal Conservancy and the Wildlife Conservation Board. The Garcia River Forest is comprised of almost 9,712 hectares of previously harvested redwood/Douglas fir forest in coastal California, one of the most carbon-rich ecosystems on the planet. The forest carbon opportunity aligned perfectly with the partners intended management—cut fewer, smaller trees than before to allow bigger trees to grow more quickly, resulting in a variety of environmental and economic benefits, including increased carbon storage on the land. The Conservation Fund has begun the process of improving the stock of high carbon native redwood and Douglas-fir trees by removing tanoak trees, as well as smaller, unhealthy Douglas-fir and redwoods which were competing for sunlight and resources. A conservation easement was purchased by TNC over the entire property which required a sustainable forest management plan emphasizing uneven-aged selection harvests. Also in accordance with the conservation easement, 35 percent of the forest was placed in a protected area to be managed for the enhancement of old growth forest.[6] Management of the property has been determined by independent auditors to be in conformance with Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) standards and has been recognized for the emphasis on watershed restoration and timber stand improvement silviculture. These changes have resulted in both carbon stock enhancement and emission reductions, and are expected to result in other ecological benefits such as improved water quality and a return to a more natural forest composition. The project has been verified in accordance with California Climate Action Registry (CCAR) Forest Project Protocol version 2.1. Its carbon benefits accrued between 2004 and 2008 have been verified by an accredited third party, for a total of 525,370 tCO_2e. Subsequent verifications are expected to occur yearly over the 100 year lifetime of the project.

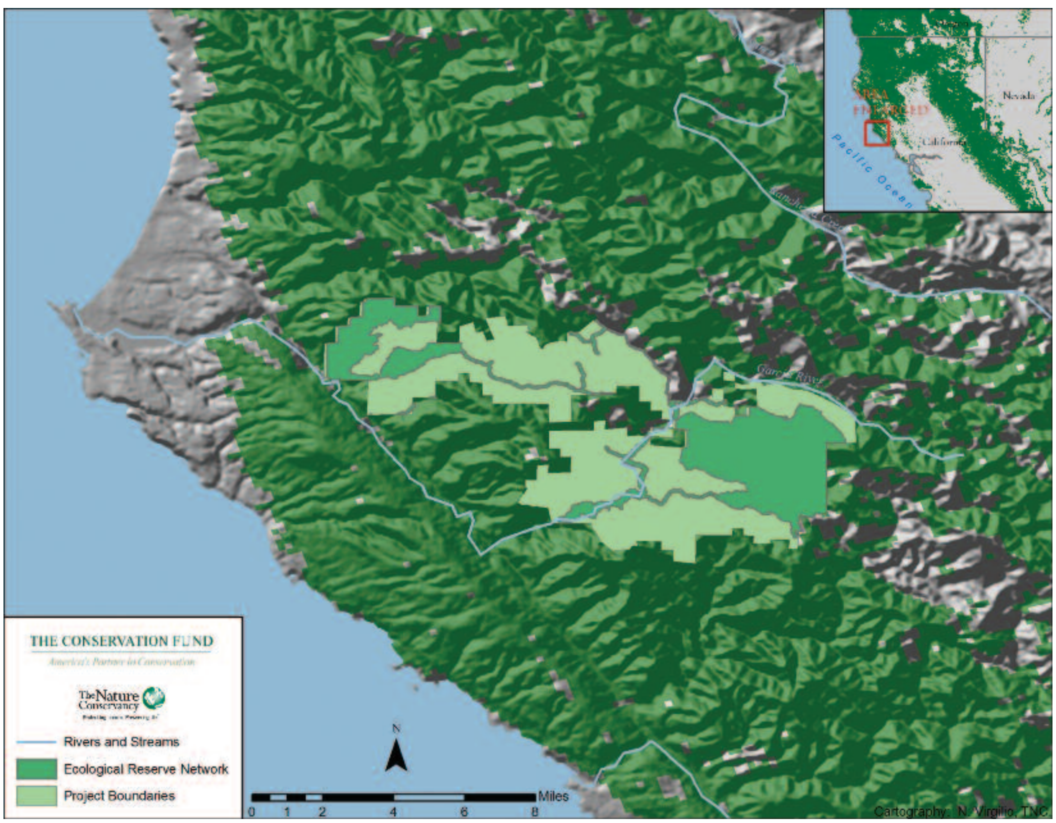


FIGURE 2 » Garcia River Forest Project, California, USA. Cartography: N. Virgilio, TNC.

[6] The Garcia River Forest Integrated Resource Management Plan can be viewed at www.conservationfund.org/sites/default/files/The Conservation Fund Garcia River Forest Integrated Resource Management Plan.pdf.

The Tensas River Basin Project

The Tensas River Basin Project ("Tensas"), implemented in 2007 by The Nature Conservancy, restored 166 hectares of bottomland hardwood forest on land previously under cultivation in Franklin Parish, Louisiana, a part of the Lower Mississippi River Valley. The Mississippi River Valley was once a vast, unbroken landscape of bottomland forest covering 9.7 million hectares across the Southeast, making it the largest expanse of forested wetlands in North America. Today, most forested wetlands of the Lower Mississippi River Valley are no longer connected to the floodplain processes that once shaped community structure, composition, and distribution, with only about 1.7 million forested hectares remaining, mostly in small, degraded patches scattered across six states. With over 80 percent of the valley converted to crop land, the remaining tracts of natural forest exist as islands in a sea of agriculture—the largest being a 32,300 hectare tract in the Tensas River Basin.

The Tensas project is a model for related projects in the Lower Mississippi Valley, creating corridors of replanted native trees to connect fragmented patches of forest. It is expected that 63,960 tCO_2e in carbon benefits from this re-established forest will be accumulated over the project's 70-year lifetime. The project is anticipated to go through verification under either the Voluntary Carbon Standard (VCS) or the Climate Action Reserve (CAR) in 2010.

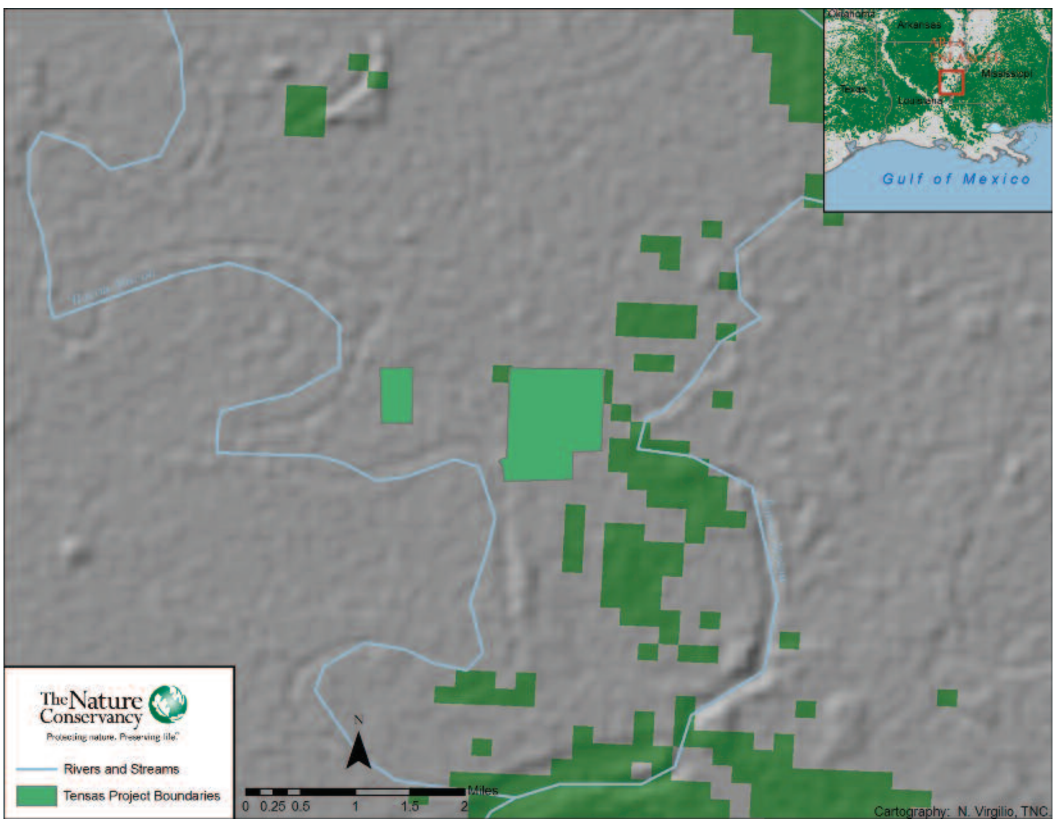


FIGURE 3 » Tensas River Basin Project, Franklin Parish, Louisiana, USA. Cartography: N. Virgilio, TNC.

The Berau Forest Carbon Program

Large-scale forest carbon programs are needed to achieve the most significant climate change mitigation impacts, and with this in mind, the Berau Forest Carbon Program ("Berau") was born. Berau, a district located in remote northeastern Borneo, heavily forested and well-endowed with wildlife, faces rapid expansion of logging and oil palm development. In partnership with the local government, the Government of Indonesia and other partners, TNC is co-developing a groundbreaking, multifaceted forest carbon project that addresses the drivers of deforestation and degradation across this entire political jurisdiction using a multi-pronged approach. First, the program is working with logging concessionaires to implement improved forest management (IFM) practices that reduce forest damage and carbon emissions while sustaining wood production and maintaining jobs. Second, the program will create a model for directing oil palm development away from healthy natural forest areas to already degraded lands. Third, the program will work with local communities to strengthen management of new and existing protected areas so they do not lose carbon through illegal logging and clearing for agriculture. These site-specific activities will be complemented with cross-cutting efforts to build the capacity and institutions to support sustainable land use planning, carbon accounting and community involvement programs that are well-integrated with existing government operations. Project partners will develop a unified, district-wide carbon accounting framework that will measure and monitor avoided emissions from all of the project components and plan to submit the methodology for approval by the Voluntary Carbon Standard (VCS).

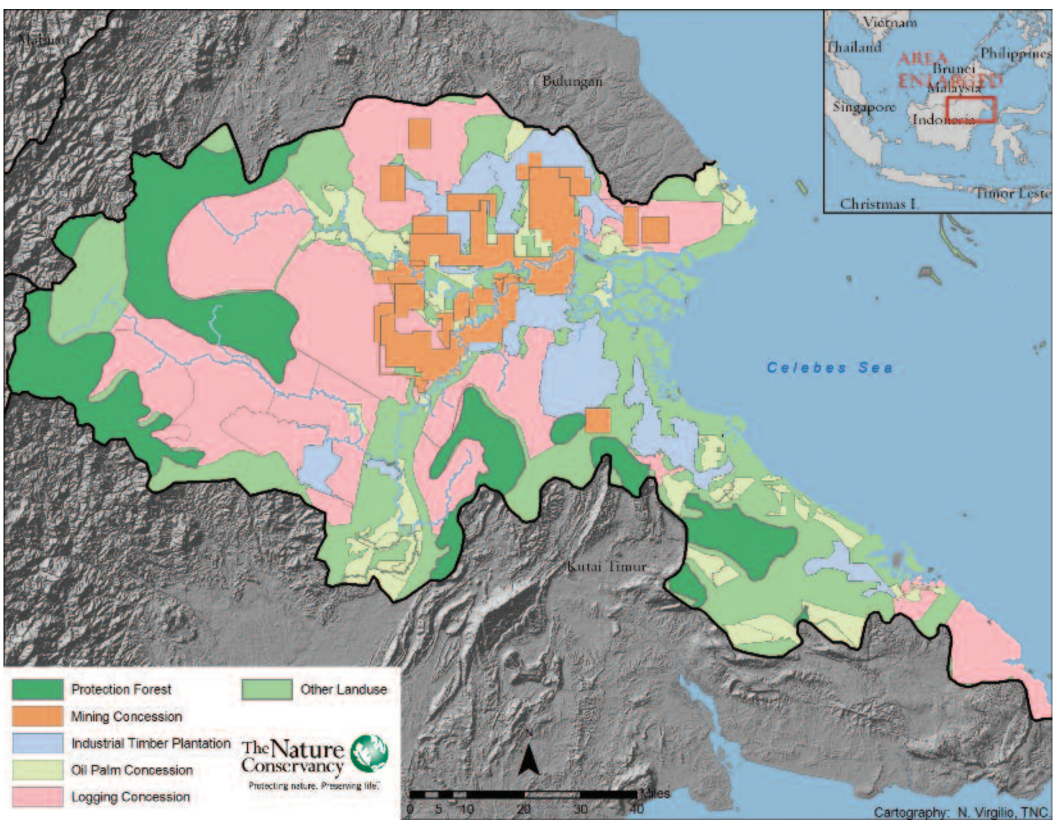


FIGURE 4 » Berau Project; in East Kalimantan on the island of Borneo, Indonesia. Cartography: N. Virgilio, TNC.

Forest Carbon 101

The science: Climate change, trees and carbon

Climate Change Science

Unequivocal scientific evidence shows that, since the industrial revolution, the burning of fossil fuels and the destruction of forests have caused the concentrations of heat-trapping greenhouse gases to increase significantly in our atmosphere, at a speed and magnitude much greater than natural fluctuations would dictate (IPCC, 2007c). If concentrations of greenhouse gases in the atmosphere continue to increase, the average temperature at the Earth's surface could grow from 1.8 to 4 °C (3 to 7°F) above 2000 levels by the end of this century (IPCC, 2007c). Impacts of climate change, many of which are already being seen, include temperature increase, sea level rise, melting of glaciers and sea ice, increased coral bleaching, changes in the location of suitable habitat for plants and animals, more intense droughts, hurricanes and other extreme weather events, increased wildfire risk, and increased damage from floods and storms. People living in marginal, poverty-stricken areas are most at risk for being severely and negatively impacted by climate change, as their livelihoods are closely tied to ecosystems which provide water for drinking, wildlife for hunting, fishing and medicinal plants (African Development Bank, 2003). Protecting forests can both mitigate climate change and protect the ecosystem services people depend on.

The Role of Forests in the Carbon Cycle

Trees absorb carbon dioxide gas from the atmosphere during photosynthesis and, in the process of growing, transform the gas to the solid carbon that makes up their bark, wood, leaves and roots. When trees are cut down and burned or left to decompose, the solid carbon chemically changes back to carbon dioxide gas and returns to the atmosphere. In the case of timber harvesting, only a fraction of the harvested trees make it into long-term wood products such as houses, chairs and tables. For example, one study estimates that for every tree harvested using conventional logging techniques in Amazonia, 35.8 additional trees were damaged (Gerwing, et al., 1996). As much as 20 percent of usable timber volume that was extracted from a typical hectare was never removed and instead left to rot in the forest. Furthermore, less than 35 percent of the timber that made it to the sawmill was actually converted into usable boards. Hence, the majority of the forest vegetation ends up as waste, and whether burned or left to decay, emits carbon dioxide gas as it breaks down (see Figure 5).

Forests and other terrestrial systems annually absorb approximately 2.6 gigatons of carbon (GtC), or 9.53 gigatons of carbon dioxide equivalent ($GtCO_2e$),[7] while deforestation and degradation of forests emit approximately 1.6GtC (5.87 $GtCO_2e$), for net absorption of 1GtC (3.67 $GtCO_2e$) (IPCC, 2007a). Forests therefore play an important role in

[7] One gigaton (Gt) is equal to one billion tons.

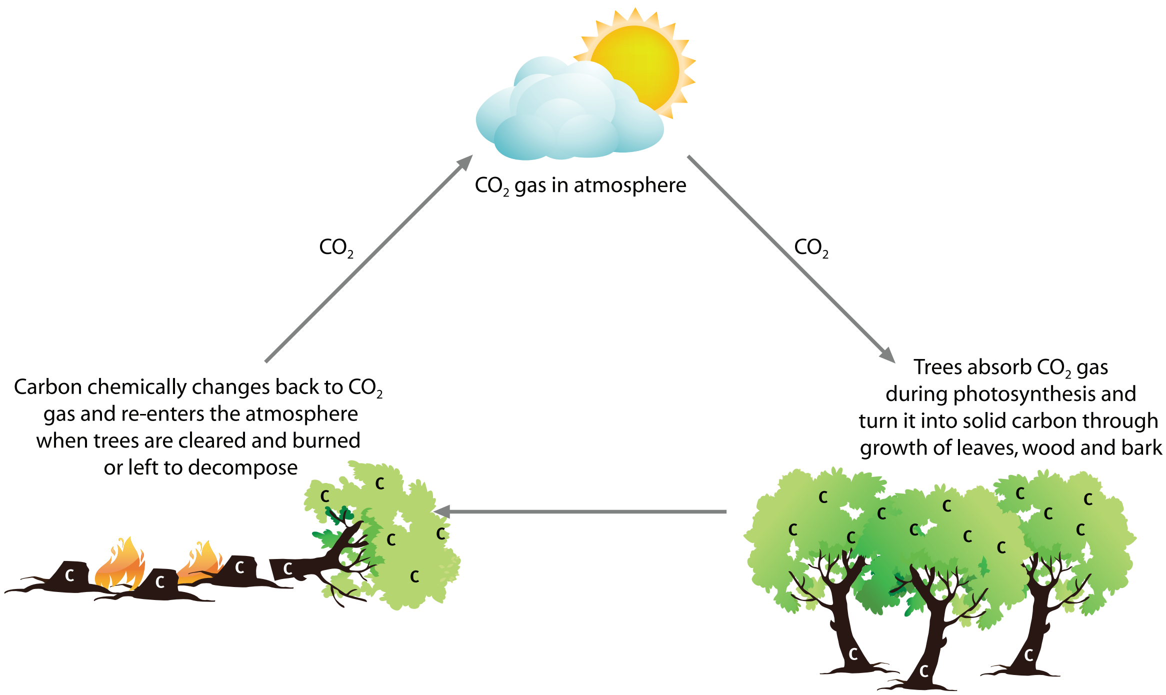


FIGURE 5 » Simplistic diagram of trees and the carbon cycle. Source: N. Virgilio, TNC.

the global carbon cycle as both a "sink" (absorbing carbon dioxide) and a "source" (emitting carbon dioxide). The 1.6GtC emitted by deforestation and degradation of forests accounts for 17.4 percent of total emissions from all sectors, more than the emissions of the entire global transportation sector (see Figure 6) (IPCC, 2007b). Thus, policy and economic incentives to curb deforestation and forest damage have the potential to enhance the natural functioning of the world's forests in sequestering, or storing, carbon and to reduce their role as a source of emissions.

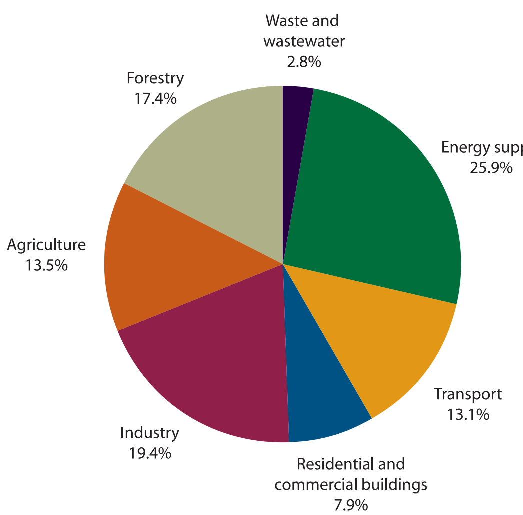


FIGURE 6 » Attribution of global greenhouse gas emissions. Source: IPCC 4th Assessment Report Summary for Policymakers (2007), p. 5.

Forest Degradation

While deforestation refers to the entire loss of patches of forest through clearing and conversion to other land uses (e.g., farming, ranching and development), forest degradation refers to the loss of biomass (living vegetation) in forests through timber harvest, fuel wood gathering, fire and other activities which do not result in complete conversion to other land uses. In its classification of "forest", the Intergovernmental Panel on Climate Change (IPCC) uses a minimum crown cover of 10 percent. Thus, by this definition, up to 90 percent of a forest can be cleared before it is considered deforested. As such, forest degradation can lead to substantial carbon emissions, and is often an important precursor to deforestation. For example, roads created by logging operations open up previously untouched land to conversion by colonists. Also, openings in the forest canopy caused by forest degradation increase the risk of forest fire, which in turn increases the risk of conversion of land to pasture for grazing and ultimately conversion for agriculture (see Figure 7) (Griscom, et al., 2009).

The IPCC estimates that of the 17.4 percent of emissions from forestry, approximately 2.2 percent are a result of tropical forest degradation (from logging alone).[8] This estimate, however, appears to substantially underestimate emissions from forest degradation, as it may undercount emissions from logging and does not consider other forms of degradation such as fuel wood harvest and fire, which, depending on location, can significantly add to emissions (Putz, et al., 2008 and Alencar, et al., 2006).

[8] This percentage is derived from studies cited in the IPCC Fourth Assessment Report (Houghton 2003 and Defries et al. 2002), which calculates emissions from tropical deforestation at about 1.6 GtC yr-1 and emissions from forest degradation to be less than .2 GtC yr-1.

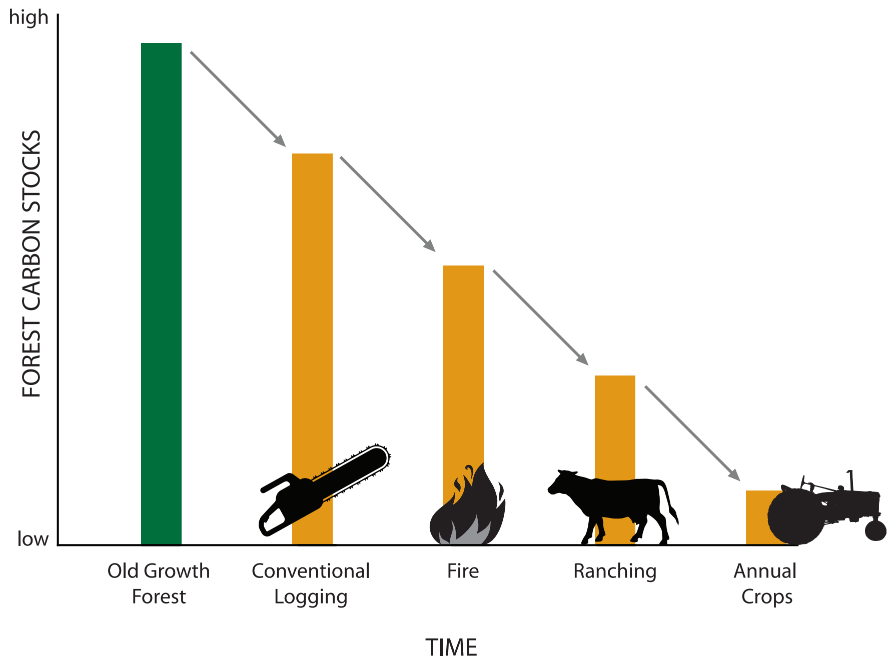


FIGURE 7 » Illustrative interaction between degradation and processes leading to conversion. Source: B. Griscom, TNC.

The policy and financial context

UNFCCC/Kyoto Protocol

The United Nations Framework Convention on Climate Change (UNFCCC) was created following the 1992 Earth Summit in Rio de Janeiro as a forum for governments to tackle the challenge posed by climate change.[9] The Kyoto Protocol, the first specific commitment to protect the shared resource of the climate system, was negotiated in 1997 and set binding targets for 37 industrialized countries and the European Community ("Annex I" countries) to reduce greenhouse gas emissions an average of five percent below 1990 emissions levels over the first five-year commitment period (2008 to 2012). All other countries, or "Non-Annex I" countries, mainly developing nations, are not currently bound to emission reduction targets. The United States did not ratify the Kyoto Protocol, thus is not bound by these targets, however, the U.S. government is actively engaging in talks about a post-2012 agreement, when the first commitment period ends.

The Clean Development Mechanism (CDM) was created as a part of the Kyoto Protocol to help Annex I countries meet their emissions targets, and to encourage the private sector and developing countries to contribute to emissions reduction efforts. The CDM allows emissions removal projects in developing countries to earn certified emissions reduction credits, which can be traded and sold, and used by industrialized countries to meet a part of their targets under the Kyoto Protocol. In the forest sector, the CDM only allows for emissions reductions through afforestation/reforestation (AR), excluding activities aimed at Reducing Emissions from Deforestation and Degradation (REDD) and Improved Forest Management (IFM). REDD and IFM activities were excluded largely because of skepticism over the credibility of carbon benefits from such projects. The CDM rules governing AR activities are extremely complex and, thus far, only eight projects have been registered, representing .35 percent of all CDM projects.[10]

In 2005, The Coalition of Rainforest Nations, led by Papua New Guinea and Costa Rica, put forth a proposal to reconsider including REDD under the UNFCCC and subsequent protocols. Since then, the push for REDD inclusion has picked up momentum. The 2007 UNFCCC meeting in Bali resulted in the creation of the "Bali Roadmap," an agreement to negotiate a new post-2012 climate change protocol by the December 2009 UNFCCC meeting in Copenhagen, which contained a commitment to include REDD. A post-2012 agreement that includes all three forest carbon mitigation strategies would represent an opportunity to address the very significant emissions and sequestration potential of the forest sector.

[9] UNFCCC website November 4, 2009: <http://unfccc.int/essential_background/convention/items/2627.php>

[10] CDM website November, 4 2009: <http://cdm.unfccc.int/Projects/projsearch.html>

a) In Annex 1 countries, an administrator will set a cap on emissions for covered entities.

b) The administrator may give some emissions allowances to covered entities for free.

c) The administrator will auction off the rest of the emissions allowances to covered entities.

d) Companies who can make reductions at a low cost will sell extra allowances to companies who can only make reductions at higher cost.

e) If countries can protect their standing forests and reduce the rate of deforestation, they can sell emission reduction credits to covered entities in Annex 1.

f) Covered entities must turn in allowances and offset credits equal to their emissions.

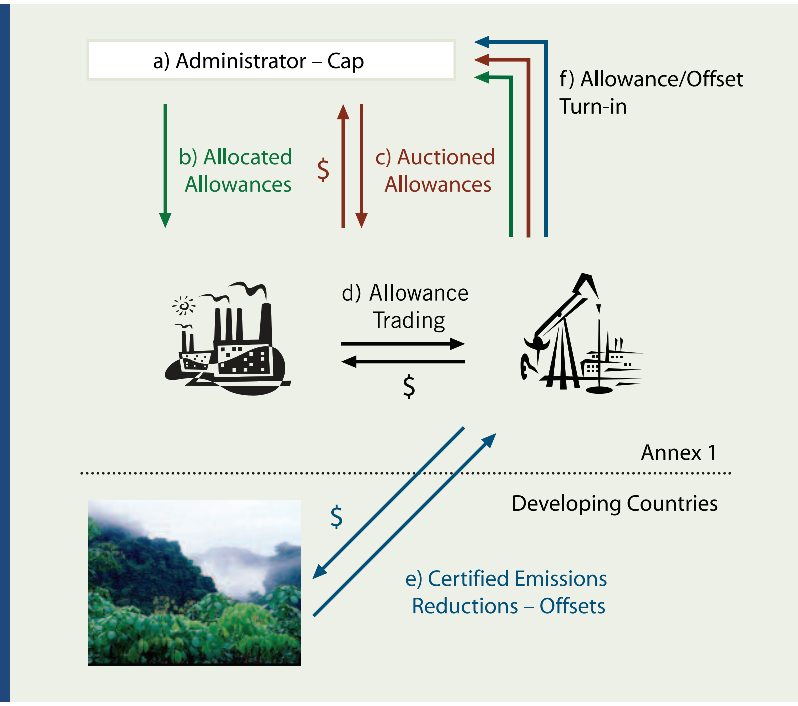


FIGURE 8 » Simplistic cap and trade diagram. Source: R. Cortez, TNC.

U.S. Climate Change Policy

Although the United States' failure to ratify the Kyoto Protocol put a chill on developing federal climate change policy, many U.S. states and regions have taken policy actions to reduce emissions. In 2006, the landmark California Global Warming Solutions Act (AB32) established a comprehensive program of regulatory and market mechanisms to achieve real, quantifiable, cost-effective reductions of greenhouse gases. Likewise, ten Northeastern and Mid-Atlantic states, which make up the Regional Greenhouse Gas Initiative (RGGI), have agreed to cap and then reduce CO_2 emissions from the power sector 10 percent by 2018. Since the political shift of the 2008 election, there has been significant momentum in the U.S. Congress to develop national climate change policy. Passage of a climate bill through both chambers of Congress would represent a landmark achievement for both domestic and international climate change mitigation efforts, as the United States contributes one quarter of global greenhouse gas emissions annually and has the potential to play an important leadership role in international negotiations.

Despite a limited role for forests in existing international climate frameworks, proposed U.S. climate policies have tended to be more favorable towards including incentives for protecting, sustainably managing and restoring forests. In part, this is because the private sector is interested in forest carbon offsets as a cost-effective vehicle for reducing greenhouse gas emissions. In fact, many U.S. corporations are adopting sustainability programs to proactively reduce their carbon footprints in anticipation of climate regulations and these efforts have spurred voluntary investments in forest carbon programs.

Cap and Trade

A "cap and trade" system is a market-based mechanism in which a regulating body establishes an upper limit—or "cap"—on the amount of carbon dioxide that may be emitted by "covered" (regulated) entities, such as power companies and manufacturers. The regulator then issues a number of "allowances" equal to the cap, and distributes these allowances to regulated entities through auction, direct allocation, or a combination of both. The regulated entities—or sources—must report on each unit of emissions they produce and submit enough allowances to cover these emissions at the end of each compliance period. Sources that do not have enough allowances to cover their projected emissions can either reduce their emissions, buy allowances on the market from sources with excess allowances, or, if permitted, generate or buy credits from emissions offset projects (see Figure 8). Offsets are emission reduction credits that are generated through activities in sectors not regulated under the cap. If the forest sector is not covered by the cap, this creates the opportunity for activities that reduce emissions from or sequester carbon in forests (so called "forest carbon projects") to play an important role in climate change mitigation.

Carbon Markets

There are various financial mechanisms which could fund forest carbon activities, both public and private, ranging from upfront grants or other payments for forest conservation to ex-post purchase of carbon credits from forest carbon projects within a "carbon market." Various carbon markets—some regulatory (e.g., CDM, European Union Emission Trading Scheme (EU ETS), New South Whales and RGGI) and others voluntary (e.g., Chicago Climate Exchange)—have developed to facilitate the trading of emissions allowances or credits for emissions reductions. Currently, only voluntary markets allow offsets from all three types of forest carbon projects (AR, REDD and IFM). Functioning voluntary markets are demonstrating that there is demand for emissions reductions generated from forest carbon activities, with a total market value of $705 million in 2008 and ten percent of the transaction volume coming from projects in the forest sector (Hamilton, et al., 2009). Many of the challenges associated with measuring, monitoring and accounting for emissions reductions from forest carbon activities can be addressed with approaches that have been applied to projects developed for voluntary markets. Official registries for these reductions assure that such credits are unique and traceable. Some compliance markets, such as the CDM and RGGI, allow for AR activities, but others, such as the EU ETS, exclude forest carbon entirely. Not all countries support the use of markets to fund emissions reductions from the forest sector and instead prefer the use of public funding.

Types of forest carbon activities

Reducing Emissions from Deforestation and Degradation (REDD), Improved Forest Management (IFM), and Afforestation/Reforestation (AR), are the three types of actions most often referred to collectively as "forest carbon activities" and each of which, if designed properly, can produce real, measurable and verifiable carbon benefits. These activities can be used alone in single projects or in combination for a larger-scale overall strategy to help mitigate climate change.

REDD

An activity which reduces forest carbon emissions by lessening or preventing forest conversion and degradation (including that which results from fire, fuel wood harvest and logging.)

IFM

An activity which increases carbon stocks and/or reduces carbon emissions from forests by changing the way in which they are managed. Management changes may include implementing harvest methods that result in less ancillary damage to remaining trees, extending harvest rotations thereby leaving more carbon stored on the land, increasing the stocking of poorly stocked forests by encouraging growth of denser/healthier trees and converting previously harvested forests to no-cut protected areas.

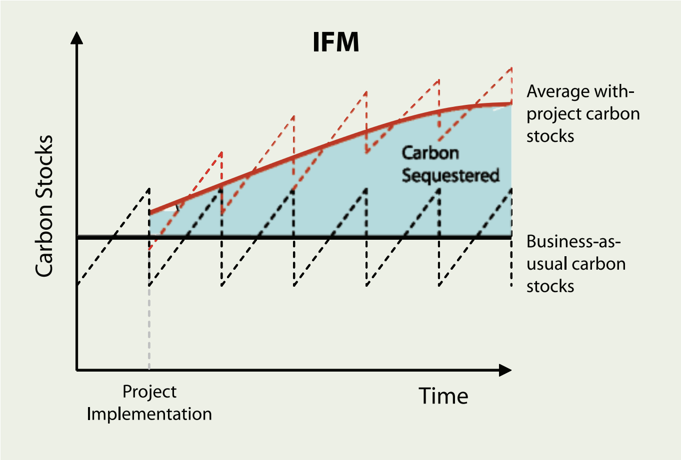
AR

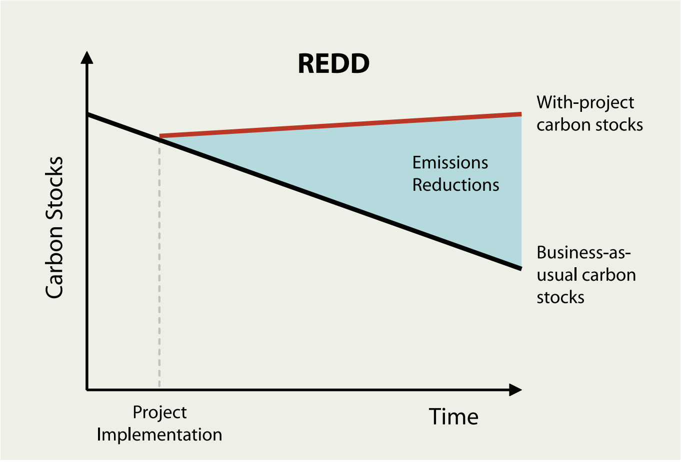
An activity which increases carbon stocks by re-establishing forest where it had previously been cleared, through planting or natural regeneration.

Technical Challenges and Field Experiences

1: Baselines and Additionality

A *baseline,* also referred to as the "business-as-usual scenario," is defined as the level of carbon emissions or carbon sequestration that would have occurred in the absence of the forest carbon project, and is required in order to calculate carbon benefits. For AR activities, the baseline is many times simply the carbon stocks of the pre-project land use. IFM activities use the average carbon stocks over the business-as-usual harvest cycle. REDD activities estimate pre-project forest carbon emissions through a combination of historical and projected activities as the baseline (see Figure 9).





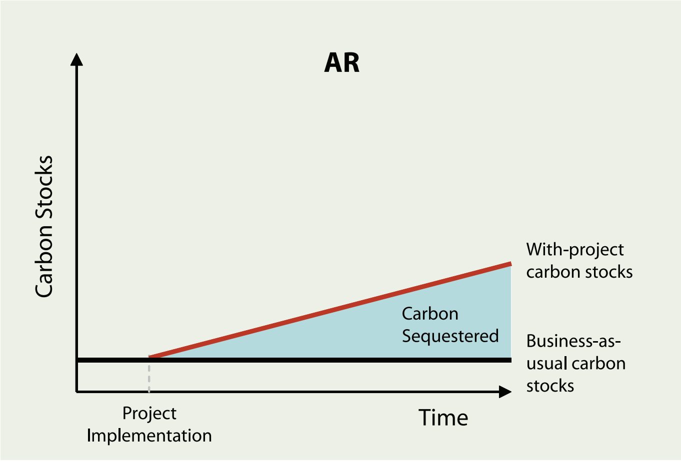


FIGURE 9 » Generic illustration of carbon benefits from REDD, IFM and AR. Source: N. Virgilio, TNC.

The simplest method for calculating a forest carbon emissions baseline for REDD activities uses an average of historic annual forest carbon emissions over a past period of years (known as a 'reference period'). More complex methods to determine forest carbon emissions baselines for REDD activities are generally used for smaller scale activities in order to account for spatial differences in local and regional drivers of deforestation. These complex methods involve projecting future emissions using models based on a combination of historic emissions, trends in emissions rates and the expected behavior of the drivers of deforestation. Such forward-looking modeling is often necessary to assess future forest loss due to frontier movement arriving from outside the project boundaries. Modeling may not be necessary to project baselines at national scales, since larger areas tend to capture more representative sampling of spatial variation (e.g., topography, forest types and land use categories) and deforestation trends and drivers (Griscom, et al., 2009). Therefore, historical rates might provide a good proxy for future scenarios.

Estimated Lifetime Carbon Benefits vs. Verified Carbon Benefits

It is important to distinguish between estimated lifetime carbon benefits, which are initially calculated at the beginning of the project and are apt to change if the baseline is adjusted in the future, and verified carbon benefits, which are confirmed by an independent third-party after each verification period as the project goes along and remain static. Eventually, when the project has reached the end of its crediting period, a final static verified lifetime carbon benefits number can be calculated.

When carbon benefits are monitored as a part of the verification process (usually every five years), the baseline is updated, based on data from the previous performance period, to accurately reflect recent trends. This results in a dynamic baseline (see Figure 10). Unlike estimated carbon benefits, verified benefits, based on these backward-looking observations, will not change regardless of any adjustments made to the baseline(s) for future periods, as they were based on the current circumstances at that time. Thus, even if the baseline is adjusted in subsequent verification periods, previously verified benefits will remain both accurate and credible.

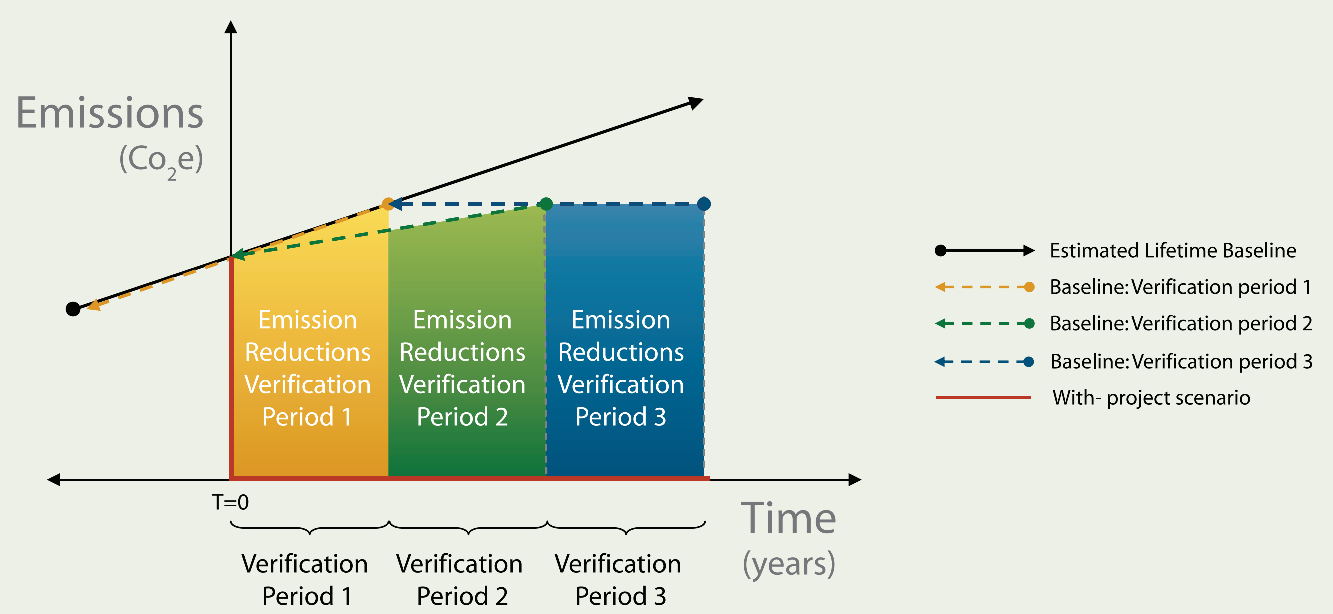


FIGURE 10 » General illustration of possible adjustments made to a project baseline vs. verified carbon benefits. Source: N. Virgilio, TNC.

Additionality refers to whether carbon dioxide captured, stored or prevented from reaching the atmosphere as a result of project activities is above and beyond what would have happened under business-as-usual (baseline) practices. All forest carbon activities must demonstrate additionality in order to prove that claimed carbon benefits are real and would not have been achieved without project interventions. Carbon benefits—the additional carbon stored or emissions prevented by forest carbon activities—are determined by comparing the with-project forest carbon stocks with business-as-usual stocks, after making appropriate deductions for leakage and/or permanence buffers (see sections entitled "Leakage" and "Permanence"). In the case of REDD, differences between the with-project and baseline forest carbon stocks are converted into carbon dioxide equivalent and spoken of as "avoided carbon dioxide emissions." In the case of AR and IFM, differences between the with-project and baseline stocks are spoken of as "carbon gains through sequestration." Since additionality involves assessing what *would have* (but did not) happen, it cannot be measured exactly. Through various systems, such as the Kyoto Protocol's Clean Development Mechanism and the Voluntary Carbon Standard, tests have been developed to determine whether project activities are additional to what would have occurred under business-as-usual practices (see Figure 11).

In summary, project baselines represent the business-as-usual carbon dioxide emission or carbon sequestration scenario and are necessary for the calculation of carbon benefits. They are one important step in demonstrating the additionality of a project or carbon benefits beyond what would have been expected without project interventions. Tests exist to help demonstrate additionality; however, in that they are essentially predictions of the future, proving additionality relies in part on good judgment and expert opinion.

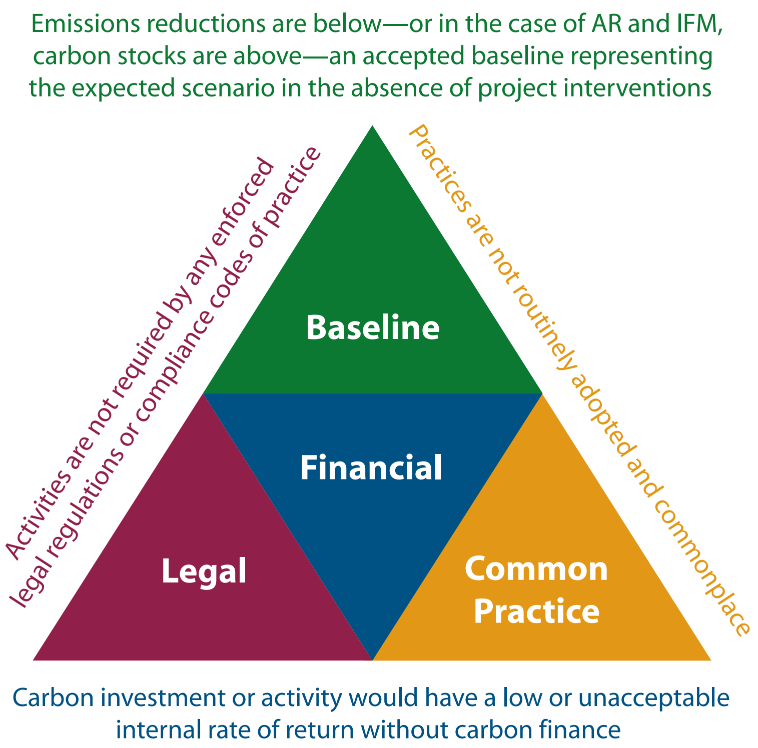


FIGURE 11 » An answer of "yes" to all four questions can help demonstrate additionality. Source: VCS, 2008/Diagram by N. Virgilio, TNC.

on the ground

Noel Kempff Mercado Climate Action Project

The Noel Kempff Mercado Climate Action Project ("Noel Kempff") was initiated in 1996, before precedents for baseline methodologies had been set. As such, baseline methodologies created for the project played an important role in informing future project development and standards such as the Voluntary Carbon Standard. As no baseline methods existed for REDD projects when Noel Kempff was initiated, the project pioneered new methods and these methods have been verified by an accredited third party using applicable standards from the Kyoto Protocol's Clean Development Mechanism (for more information on verification in general, see "Standards and Verification" section).[11] Because Noel Kempff is addressing both deforestation from subsistence agricultural expansion and degradation from commercial timber concessions, the baseline methodology relies on different approaches for the avoided deforestation and avoided forest degradation project components. This is necessary because the two components have different rates and drivers.

Avoided Deforestation Baseline

The creation of an avoided deforestation baseline in Noel Kempff required four steps: 1) determining historical deforestation rates, 2) predicting likely locations for future deforestation, 3) determining carbon content in areas predicted to be cleared, and 4) calculating emissions resulting from anticipated deforestation.

Using historical Landsat satellite imagery from 1986, 1992 and 1996, scientists tracked deforestation over time and calculated deforestation rates in the project area. The location of future clearing for agriculture was simulated with a spatial land use change model, using this historic deforestation information as input (FAN, 2006). The model identified land within the project area that was statistically the most likely to be cleared in the future, based on several drivers of deforestation, including: distance to roads, towns, rivers, forest edge and prior clearing. Model results provided a forecast of the specific forest areas most likely to be deforested over the course of the next 30 years in the absence of project activities to stop it. The forecast will be updated during each monitoring event (five-year frequency expected), reflecting data gathered since the prior monitoring event.

While satellite technology and models can provide the estimated *area* of forest loss, determining *emissions* from that forest loss involves measuring the carbon content of forest types in the area, since biomass and associated carbon density varies by forest type (e.g., a typical redwood forest in the western United States might contain 397 tC/ha, as compared to the typical aspen/birch forest in the west which might contain 161 tC/ha.[12]). To accomplish this, 625 permanent study plots were established in and around Noel Kempff to measure and monitor carbon stocks (i.e., trees, litter, soil, dead wood, roots) using techniques including measurement of tree diameter at breast height ("dbh"), measurement of length and diameter of fallen branches and dead wood, sampling the composition of surrounding litter, measuring the height and diameter of stumps, and laboratory testing of tree and soil samples.

Once these carbon stocks were estimated for each forest type, the areas predicted to be cleared by the model were assigned a forest type (e.g., tall evergreen forest) using Landsat satellite imagery double checked with on-the-ground observations (see Figure 13). These areas, with their associated carbon stocks, were presumed cleared in the baseline scenario and carbon losses were then converted into avoided carbon emissions using established formulas.

Foresters and young men from the local community of Florida work together to measure the boundaries of the forest plots where logging impacts will be measured over 30 years in a forest concession (Cerro Pelado) near Noel Kempff Mercado National Park in Bolivia. Photo Credit: © Margo Burnham.

[11] Avoided emissions from forest projects do not currently constitute an eligible activity within the CDM, but relevant parts of the AR standard were applied.

[12] Derived from tables provided on page 68 of: U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2005. Global Change Program Office, Office of the Chief Economist, U.S. Department of Agriculture. Technical Bulletin No. 1921. 161 pp. August, 2008. <http://www.usda.gov/oce/global_change/AFGGInventory1990_2005.htm>

Avoided Degradation Baseline

The avoided degradation (stop-logging) baseline was determined using an economic model of Bolivian timber markets (Sohngen and Brown, 2004). The model incorporated supply and demand data, harvest rates and damage associated with harvest activities, among many other economic and physical parameters, to predict the volume of future harvests in Bolivia, both within the project area and the country as a whole. Traditional logging practices can be quite destructive to the trees left standing. Thus, in order to quantify ancillary damage from logging activities (i.e., destruction from logging trails, breakage and death of non-harvested trees; all of which result in substantial carbon emissions), 102 survey plots were established in an active logging concession adjacent to the project area and monitored over time.

Baseline Monitoring

Both the avoided deforestation and avoided forest degradation baselines will be re-evaluated every five years, using recent historic data, to capture any changes in governance, deforestation rate, harvest rate, drivers, socioeconomic circumstance and model parameters occurring over that period which would potentially change the baselines' accuracy over time (SGS, 2005). A reference area adjacent to the Park was chosen to serve as a "control" for the baseline deforestation rate. This area will be monitored over time using Landsat satellite data and field observations and the baseline will be compared to that which was predicted for the avoided deforestation component of Noel Kempff. Differences between the two will be evaluated and adjustments to the project baseline will be made, if necessary, to maintain accuracy over time.

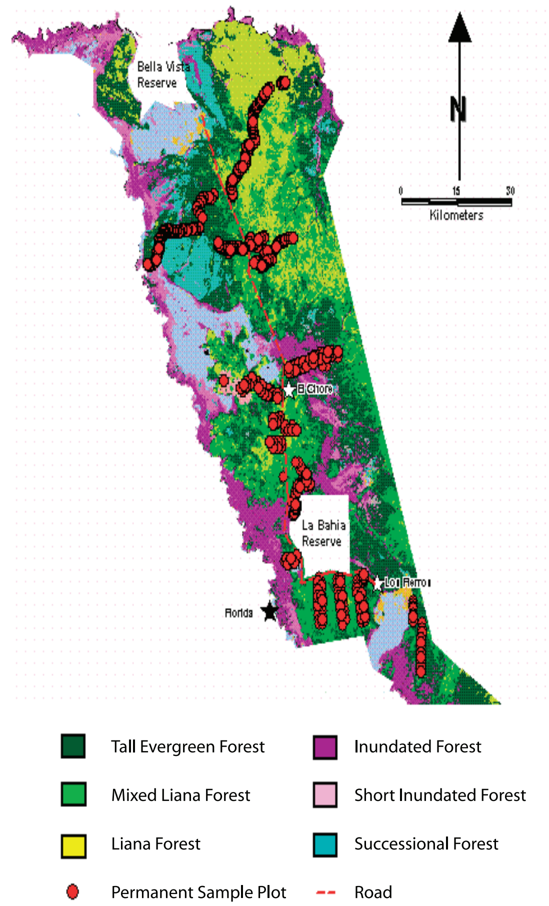


FIGURE 13 » Map of the Noel Kempff Climate Action Project showing the distribution of the six forest types and the location of the 625 permanent plots. Source: Winrock International.

LESSONS LEARNED *and* TAKEAWAYS

The technology and methodologies currently exist to create credible, verifiable project baselines. » The Noel Kempff project baselines were calculated with a high degree of scientific rigor, using methods cross-checked and verified by an independent third-party. The creation of the project's baselines required the use of satellite imagery, field measurements, laboratory work and sophisticated modeling, which helped encompass differences across various ecological landscapes and drivers/patterns of land use change.

The robust methods used in the development of the Noel Kempff project baselines have informed several subsequent projects, as well as voluntary carbon standards. The combined experience from all of these projects has led to very specific step-by-step recommendations for baseline development across varying ecological and social landscapes.

Project baseline methodologies should be based on empirical evidence and models. » The estimate of Noel Kempff carbon stocks, based on time tested field methods and 625 permanent plots in the project area, has changed very little since the project began in 1996. However, some of the other parameters required to calculate the project baselines—including associated harvest damages, timber extraction rate, area suitable for harvest and total area deforested—needed to be adjusted from initial estimates. These parameters were originally based on information from Malaysian studies, individual recollections of harvest rates and surveys of local knowledge. The methodologies since used are based on site-specific satellite data, field measurements and models, resulting in the current (verified) baseline calculations. Projects that apply similar comprehensive empirical analyses are becoming increasingly common practice.

The most accurate project baselines are cross-checked with recent historical data and adjusted over time if necessary. » Forest carbon projects generally include an estimate of lifetime carbon benefits, both for feasibility analysis and garnering investor interest. These estimates are derived from analysis of past land cover, regional land cover change and drivers, and the baseline is projected into the future, sometimes 20, 30, or even 50 years. There are inherent risks with predicting a baseline this far into the future. Given that underlying drivers of deforestation, such as socioeconomic factors and government policies may change, it is a best practice to cross-check the baseline periodically as a project progresses (the Voluntary Carbon Standard requires reassessment of the baseline at least every 10 years for REDD projects) (VCS, 2008), and to adjust the baseline if necessary to capture any changes that might affect the baseline moving forward. Indeed, the Noel Kempff project baseline, originally projected out 30 years, will be reevaluated and adjusted (if necessary) every 5 years at each subsequent verification.

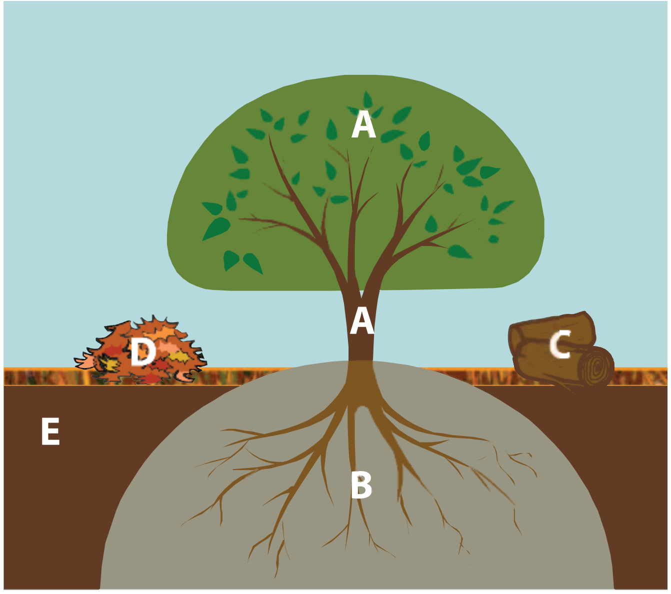
Including forest degradation in the project baseline is often critical since degradation can cause substantial forest emissions. » In the Noel Kempff project example, the avoided degradation (stop-logging) component represented the largest source of avoided carbon dioxide emissions; 64 percent of estimated carbon benefits. It is expected that this ratio will remain very similar over the course of the project lifetime. This example highlights the important role emissions from degradation can play in some areas where logging, fuel wood collection and/or fire are prevalent. Furthermore, degradation often catalyzes subsequent deforestation. Strategies that employ reduced impact logging techniques, forest certification, sustainable fire and fuel-wood management and improved forest governance can help to alleviate these drivers of degradation and eventual deforestation, thereby improving permanence of the climate benefits from the project.

Complex baseline calculations can be expensive, but efficiencies can be achieved through increased scale. » Carbon accounting associated with baseline determination in the Noel Kempff project constituted seven percent of total project expenditures, or just over $800,000. This upfront project expense can be prohibitive for smaller projects without significant external funding or those financially dependent on the selling of carbon benefits for the majority of operations. Costs associated with determining baselines will likely decrease as the scale of project activities increase and lessons from early efforts are consolidated. Statistical sampling and satellite imagery analysis both experience far less variation at the large scale. As national programs gain traction, costs will likely decrease, since historical trends, which national baselines will likely be based on, tend to capture most spatial variation and land use drivers that might not be evident at small scales, reducing the need for complex, spatially explicit models. For more on larger scale activities, see "Scale and Scope" section.

2: Measuring and Monitoring

Measuring and monitoring are the processes by which the amount of carbon stored in forests ("carbon stocks"), as well as changes in these amounts, are calculated, using both satellite technology and field measurements. Measuring and monitoring fall under the larger category of "carbon accounting," which refers to the calculation of carbon benefits over time as a result of forest carbon activities. See Figure 14 for the five carbon pools that make up the total carbon stocks of a forest.

While measuring and monitoring are perceived by some as a challenge to producing real, verifiable carbon credits due to the intensive and specialized processes involved, the methods used in carrying them out are time-tested and steeped in rigorous scientific theory. The basic steps involved in carbon accounting for REDD, IFM and AR activities are illustrated in Figure 15. The steps differ somewhat; however, the need and methods to determine initial forest carbon stocks are consistent across all three types of forest carbon activities.



A. Aboveground Live Biomass (trunk, branches, leaves)
B. Belowground Live Biomass (roots)
C. Dead Wood (stumps, broken off branches, fallen trunks)
D. Litter (dead leaves and vegetation)
E. Soil (typically up to 30 cm depth)

FIGURE 14 » Five carbon pools make up the carbon stocks of a forest. Source: N. Virgilio, TNC.

Area

It is first necessary to determine the forest types present in the project area, as well as the extent of these forest types. This is generally accomplished using satellite imagery to delineate the forest types, cross-checked with on-the-ground observations. Delineation of forest type matters because different forest types have different associated carbon content. For example, a typical redwood forest in the western United States might contain 397 tC/ha, as compared to the typical aspen/birch forest, which might contain 161 tC/ha.[13]

Density

The density of carbon stocks associated with different forest types is determined with field surveys. On-the-ground field methods for sampling forests, used in determining carbon density, have been around for over 100 years and have long been accepted as scientifically credible. Methods entail sampling carbon pools in random, statistically significant and representative sections of forest, and extrapolating that information for the entire project area. Such extrapolations are standard practice in ecological surveying and the accuracy level of the results can be specifically calculated. For example, the initial carbon stocks in the Noel Kempff Climate Action Project were determined using 625 permanent field plots, which achieved a low 2 percent margin of error (FAN, 2006).

Common sampling methods include measuring the diameter at breast height ("dbh") of live trees to determine size, and collecting soil, leaf litter and dead wood to be analysed in the lab with precise instruments for carbon content. Field measurements, when used in combination with satellite imagery to track land cover change over time, allow for the calculation of carbon stock changes.

Rate

In the case of IFM projects, annual harvest rate is usually determined by historical management plans and on-the-ground surveys. For REDD projects, the annual rate of deforestation is typically obtained using satellite imagery to track land use change over time. Landsat satellites have been collecting data on land cover since 1972, with an ability to zoom into areas as small as 60 meters from 1972-1982 and 30 meters since 1982. Historical Landsat satellite data is available, for free, from the United States Geological Survey (USGS).

Significant advances have been made in interpreting satellite data and using it to precisely measure deforestation rates by comparing change in satellite photos taken over time on a

[13] Derived from tables provided on page 68 of: U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2005. Global Change Program Office, Office of the Chief Economist, U.S. Department of Agriculture. Technical Bulletin No. 1921. 161 pp. August, 2008. <http://www.usda.gov/oce/global_change/AFGGInventory1990_2005.htm>

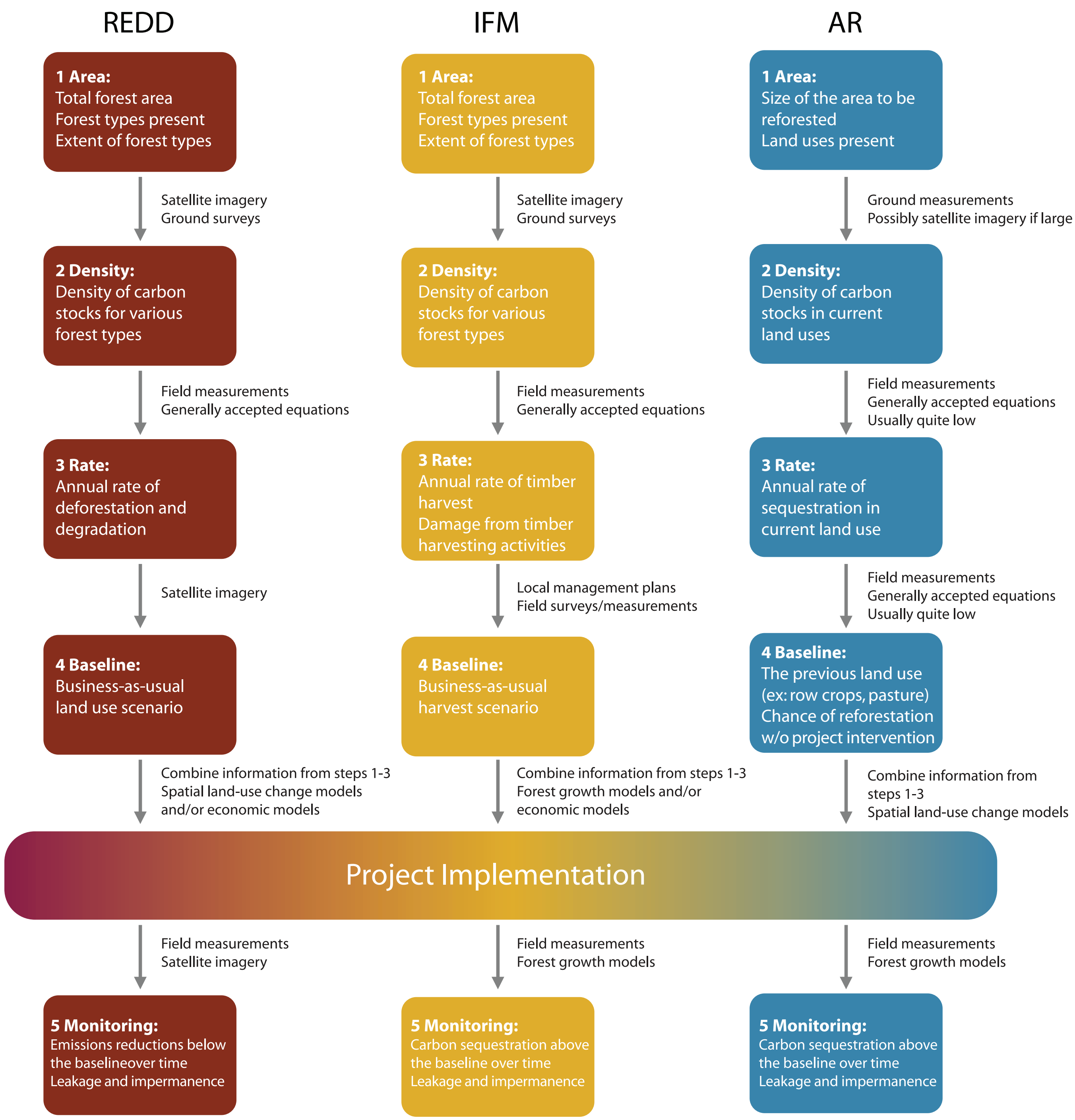


FIGURE 15 » General steps involved in carbon accounting for REDD, IFM, and AR activities on the project scale. Source: N. Virgilio, TNC.

pixel by pixel basis (see Figure 16).[14] For example, using methods such as these, Noel Kempff project scientists were able to achieve a low R^2 of .97 for the the calculated baseline deforestation rate.[15]

Other advances in the interpretation of Landsat satellite data now allow for the detection of degradation from logging and fire (Asner, et al., 2005 and Roy, et al., 2008). Lidar[16] and radar technology may be used to reduce the need for on-the-ground field measurements in carbon stock calculation and can help overcome the challenge posed by clouds, which can hide the landscape in satellite photos. With time, these latter options are expected to become more economical and easier to use on large scales.

Baseline

Using information on area, density and rate, it is then possible to calculate the project baseline; the business-as-usual emissions or sequestration scenario (baselines explained in detail in "Baselines and Additionality" section).

Along with the baseline emissions or sequestration scenario, it is necessary to calculate the with-project scenario, since the difference between the two yields the carbon benefits from project activities. Calculation of the with-project emissions/sequestration scenario might involve running spatial land use change models for REDD or forest growth models in the case of IFM and AR.

Monitoring

The project baseline is compared to the with-project scenario over time to determine carbon benefits attributable to project activities. In many cases, the project baseline will be cross-checked with data at various points in the future to ensure the predicted scenario is still on target. Monitoring also allows project developers to catch any instances of leakage and/or impermanence and apply appropriate discounts and buffers. (These concepts are covered in the "Leakage" and "Permanence" sections.)

In summary, the technology exists, and has existed for quite some time, to measure and monitor forest carbon. A combination of time-tested field measurements and interpretation of advanced satellite data results in highly accurate calculations of carbon stocks, which can be tracked over time to determine land use changes and carbon benefits above and beyond business-as-usual. Technology and the interpretation of data for use in monitoring and measurement should continue to become more advanced and cost effective in the future, leading to widespread use in both Annex I and non-Annex I countries.

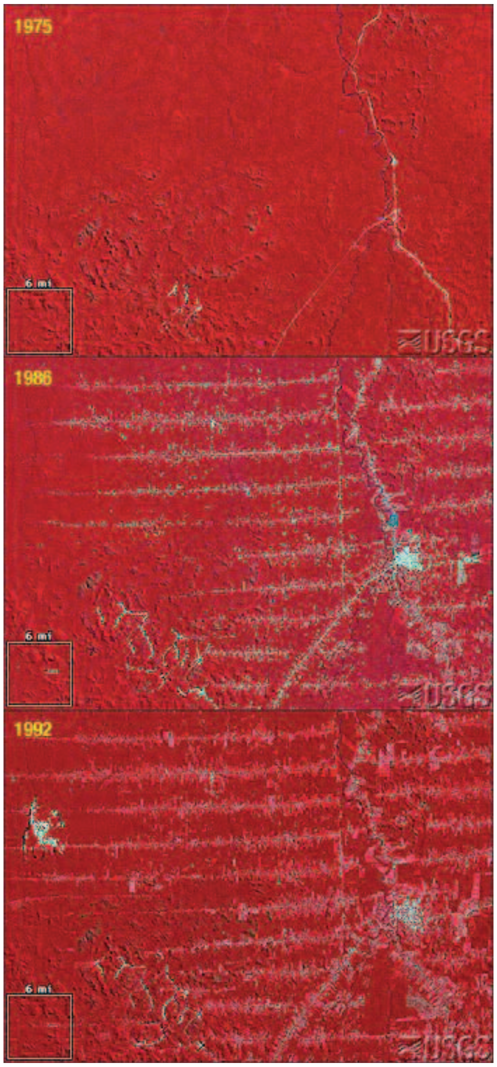


FIGURE 16 » False-color Landsat images of Rondônia, Brazil. Notice how the typical fishbone pattern of deforestation grows with time. Images like these allow scientists to determine deforestation rates. Source: USGS (Campbell, 1997).

[14] Landsat data is made up of many square "pixels" (similar to those on a TV or computer screen), which represent areas 30 meters by 30 meters in length.

[15] "R-square" is the proportion of variability in a data set that is accounted for by the statistical model. It ranges from 0 to 1, with 1 meaning 100% of the variation in the data set is predicted by the model. An R-square of .97 is considered excellent.

[16] An optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target.

on the ground

Garcia River Forest Project

To quantify and account for the increased carbon stocks on the Garcia River Forest property, the Conservation Fund used robust measuring and monitoring methodologies guided by California Climate Action Registry v2.1 (CCAR v2.1) standards (for more information on standards in general, see the "Standards and Verification" section) (CCAR, 2007). As shown in Figure 15, carbon accounting for the project required figuring out what types of forest were present and their respective sizes, carbon content associated with the different forest types, harvest rates, business-as-usual land use practices, the post-implementation management scenario, and ultimately, carbon benefits.

Area

Through aerial photos taken in 2004, twenty-one forest stand types (classified by dominant species, size and canopy closure) were identified and outlined within the Garcia River project area and confirmed with surveys on the ground.

Density

A random sampling of 1,051 permanent inventory plots have been established and measured within the project area since 2004; new plots are added annually to address recent disturbances such as harvests and fire. When combined with an additional 540 older plots, the inventory system allows The Conservation Fund to measure and monitor carbon stocks associated with the various forest types over time, with an overall carbon sampling error of less than five percent with 90 percent confidence (SGS and SCS, 2007). The CCAR v2.1 methodology required inclusion of aboveground living biomass (e.g., live trunks and branches), belowground living biomass (e.g., roots) and dead wood (e.g., stumps, dead trees, fallen trunks and fallen branches) in the initial carbon inventory. Soil and litter (e.g., dead leaves and vegetation) carbon pools were optional under the CCAR v2.1 protocol and thus were not included. These two pools are considered optional because: 1) they contribute only a small percentage to the total carbon pools, 2) they are expensive and difficult to measure and 3) it is considered conservative to ignore them.

Live aboveground biomass was estimated using direct measurements of tree diameter ("dbh") coupled with established equations for determining the total biomass of common California tree species.[17]

Because of difficulties associated with measuring the roots of trees, the Registry approach relies on estimation of the belowground live biomass component through the use of a standard equation, based on measurements of aboveground biomass (Cairns, et al., 1997).

Methods used for estimating carbon contained in dead wood pools are also explicitly described in the Protocol and required field sampling (e.g., measurements of diameter, length and weight after being kiln dried).

Field data was extrapolated to cover the entire forest, based on the previously identified forest stand types, to determine the total initial carbon stocks for the project area (1,085,652 metric tons of carbon) (TCF, 2006).

Rate

The business-as-usual harvest rate was based on the maximum allowable harvest (as per California's Forest Practice Rules, some of the strictest in the world) that would be possible on the property. As such, the harvest rate was projected to vary over the course of the project lifetime, with more than 100 percent of growth harvested during the first 28 years of the project, approximately 50 percent for the next 45 years and 100 percent for the last 25 years.

Baseline

Guidance for determining the project baseline was provided in the CCAR v2.1 standard, which is based on the maximum amount of timber harvest permitted under the California State Forest Practice Rules. Specifically, under the baseline management scenario, all forested stands outside of required no-cut riparian zones (forest lining rivers and streams) and those that harbored endangered species would eventually be harvested. Harvests would follow an even-aged management plan, where tree stands were clearcut as they became 60 years or older, followed by single tree selection harvest every 10 to 20 years as stands re-gained commercial maturity post-clearcut. This management plan would have resulted in 1,062,449 metric tons of carbon stored on the property after 100 years.

The with-project scenario will result in more carbon stored on the land than in the baseline scenario by switching to uneven-aged management with selection harvest. This means smaller trees, such as tanoak and low-quality redwood/Douglas-fir, will be harvested more frequently to make room for larger trees to grow more quickly, keeping a variety of age classes across the property. The harvest rate will be less than the growth rate for the first 80 years of the project,

[17] Originally derived by Winrock International and provided in CCAR's Forest Project Protocol: Brown Sandra, David Shoch, Tim Pearson and Matt Delaney. 2004. "Methods for Measuring and Monitoring Forest Carbon Projects in CA." Winrock International: Arlington VA, for the Regents of California/ California Institute of Energy Efficiency.

A TNC ecologist monitors in the Garcia River Forest, northern California. Photo Credit: © CJ Hudlow.

allowing surplus volume to accumulate and add to the growing stock. Thirty-five percent of the project area was placed in a no-cut protected zone (with harvest only allowed for the specific purpose of returning the forest to old-growth stage). No-cut riparian buffers along rivers are larger than they would be in the baseline scenario. After 100 years, this management plan is predicted to result in 2,223,373 metric tons of carbon stored on the property, more than twice the baseline carbon storage. While this management scenario will result in carbon benefits, it will at the same time restore the land to its historical ecological composition, improve water quality by reducing sedimentation and work towards old-growth forest conditions in the ecological reserve network.

Monitoring

The Garcia River Forest is being monitored annually, with the entire forest physically sampled over the course of each 12-year period, to identify changes in carbon stocks as a result of natural disturbances and the improved forest management practices. This information will be compared to the baseline management scenario to calculate project carbon benefits.

As required by CCAR v2.1, any significant disturbances in the project area must be reported and sampling conducted within three years. On June 20, 2008, a lightning storm caused 127 wildfires in Mendocino County, including one fire on Garcia River Forest property. Ongoing monitoring and containment action by The Conservation Fund's forestry staff and local partners ensured that the fires were detected and controlled quickly and ultimately resulted in fewer carbon losses than might have otherwise occurred. In total, 243 hectares were burned and mortality of overstory trees was estimated at 15-25 percent. In late 2008, The Conservation Fund's forestry staff re-measured the burned area as part of the annual inventory update and documented a slight increase in carbon stocks, primarily due to the increased sample size and the initial growth projections being conservative. Carbon benefits accrued between 2004 and 2008 have been verified by an accredited third party, for a total of 525,370 tCO_2e (143,283 tC).

LESSONS LEARNED *and* TAKEAWAYS

The technology currently exists to achieve high levels of certainty in forest carbon measurement. » Projects such as Garcia River utilize time tested field measurement techniques, laboratory carbon testing, aerial photographs and advanced modeling to measure and monitor carbon stocks, employed by foresters and ecologists for decades. The Conservation Fund achieved a very low carbon sampling error (less than five percent with 90 percent confidence), which was verified by a CCAR accredited independent verifier. Other technologies, potentially to be used in the future for Garcia River, include Landsat satellite imagery from as far back as 1972 (which can be downloaded for free through USGS) and more specialized imagery such as fine scale LIDAR and radar (available for a cost). It is possible to achieve high degrees of accuracy with these technologies and they will continue to improve over time.

Ground measurements are an important complement to remote sensing used in measuring and monitoring. » Remote sensing, using aerial photography or detailed satellite imagery, is helpful to determine the type of forest stands present in a project area, detect clearings and monitor over time, and in conjunction with field measurements, can be used to estimate the total biomass present. This has promising applications for large scale measuring and monitoring; however, it should be complemented by measurements on the ground, similar to those conducted in the Garcia River project—including tree volume, wood density and the dead wood carbon pool. It is possible that as detailed data is accumulated over time for many of the world's forest ecosystems and future advances in technologies are made, the need for comprehensive ground measurements will be reduced; however, it is unlikely that the need for ground measurements will be completely replaced by remote technologies.

Effective monitoring of project carbon stocks can both reduce the chance of carbon losses and ensure the integrity of estimated carbon benefits. » In the case of the Garcia River project, close on the ground monitoring and prompt containment action taken by The Conservation Fund and local contractors, helped to reduce carbon losses from fire. For larger scale forest carbon activities, where it is impossible to cover the entire area in a timely manner, it is possible for MODIS satellite imagery to play a role in detecting fire in practically real time. Satellite imagery also has the capability to detect other larger scale activities that could threaten project success, such as illegal clearing; however, it is likely that frequent on the ground monitoring will still be necessary to observe smaller-scale destructive activities. Thus, adequate staff, training and support are necessary, along with the ability to enforce protection.

3: Leakage

Leakage, in the context of project-level forest carbon activities, refers to changes in greenhouse gas emissions that occur outside of project boundaries as a result of the emissions reduction or carbon sequestration project activities. On a national scale, leakage can also occur between countries, for example, if deforestation is shifted from one country to another. Although, by definition, leakage can be positive (the "spillover effect"), resulting in the broader adoption of low-carbon activities, most debates about forest carbon activities have focused on the possibility of negative leakage. Negative leakage results from shifts in emissions and removals that negate some or all of the carbon benefits associated with forest carbon activities. For this reason, leakage must be addressed for forest carbon activities to demonstrate they produce net carbon benefits.

Leakage comes in two main forms: *Activity-Shifting Leakage*, when forest carbon activities directly cause carbon-emitting activities to be shifted to another location outside of the pro-

Forest Carbon Activity	Example: Activity-Shifting Leakage	Example: Market Leakage
AR	Small-scale corn farmers approached by project developers allow their land to be reforested. Soon after, they purchase new parcels elsewhere and clear them to make up for lost productivity.	Commercial corn farmers approached by project developers allow their land to be reforested. The decrease in the supply of the commodity they produced leads to increased prices on the domestic market. Farmers outside of project boundaries increase their production (and clearing) to meet demand.
IFM	Small-scale logging operations switch to longer harvest rotations, with reduced extraction rates, in the project area. They ramp up extraction rates in another holding to make up the difference.	Commercial logging operations switch to longer harvest rotations, with reduced extraction rates, in the project area. The decrease in timber supply (without suitable substitutes) leads to increased prices on the domestic market. Logging operations outside of project boundaries increase their extraction rates on new land to meet demand.
REDD	Farmers prevented from clearing land for oil palm plantations within project boundaries decide to instead clear outside project boundaries.	As demand for palm oil increases, it is not met with equivalent increases in supply (due to project activities), which leads to price increases on the domestic market. Farmers outside of project boundaries increase their production (and clearing) to meet demand.

TABLE 1 » Hypothetical examples of activity-shifting and market leakage for various forest carbon activities. Source: N. Virgilio.

Leakage in other Sectors

Although often thought of as an issue specific to forest carbon activities, leakage is a challenge for emissions reduction strategies in all sectors. For instance, in the global energy sector, climate change policies have the potential to change supply and demand dynamics within fossil fuel markets, resulting in market leakage (Sergey, 2001). The potential for leakage in the fossil fuel sector has been estimated at 5-20 percent and ultimately will depend on the level of participation in global mechanisms (IFCC, 2007.)
The following are examples of two such leakage scenarios:

1) Under the restrictions of the Kyoto Protocol, demand for carbon intensive energy sources such as coal might decrease within Annex I countries, leading to a price drop on global markets. Given the cheaper price of coal, non-Annex I countries, which do not have emission reduction targets under the Kyoto Protocol, might switch to carbon-intensive coal in lieu of relatively more expensive and less carbon-intensive fossil fuel options such as oil. This increase in emissions from non-Annex I countries could partially offset carbon gains achieved by Annex I countries by increasing non-Annex I country emissions higher than they would have been without the compliance mechanism.

2) The emissions restrictions placed on Annex I countries by the Kyoto Protocol could drive some energy-intensive industries (such as cement, steel, aluminum and chemical sectors) to relocate to developing (Non-Annex I) countries, where emissions are not currently strictly regulated. This has the potential to increase emissions from these countries and undermine emissions reductions in Annex I countries.

ject boundaries (or country, at the national scale); and *Market Leakage*, when a project or policy changes the supply-and-demand equilibrium, causing market actors to shift their activities. For example, if a project constrains the supply of a commodity, such as agricultural products or timber, market prices may rise and producers elsewhere may increase their activities in response. Estimates of market leakage automatically incorporate activity-shifting leakage in their calculation, since all actors, including those proximate to project activities that might shift their operations, are covered. Leakage is less likely in areas where alternative employment is available, land use activities are subsistence and land tenure is clear. In contrast, it is more likely if employment options are limited, land use activities are commercial in scale and land tenure is undefined. Leakage can occur within all three types of forest carbon activities: REDD, IFM and AR (see Table 1), but leakage is not a phenomenon unique to the forest sector (discussed in the "Leakage in Other Sectors" box).

Project-scale activities must make attempts within the project design to analyze the risk of, prevent and monitor leakage, using mechanisms such as agricultural intensification, alternative employment opportunities, tracking activities of key project participants and support for clear land titling. Additionally, leakage effects can be estimated and used to apply leakage deductions in carbon accounting. Most voluntary carbon standards now recommend a leakage deduction of 10-20 percent, dependent on a number of project risk factors. This percentage is subject to increase with higher-risk projects. One key advantage of nation-wide carbon accounting systems is the fact that they can capture leakage across whole countries without requiring the complex modeling necessary at the project scale (see "Scale and Scope" section for more detail).

In summary, although not unique to forest carbon projects, both activity-shifting and market leakage have the potential to negate some or all of carbon benefits if not considered in project planning, implementation and carbon accounting. Nevertheless, strategies exist to reduce the risk to carbon benefits posed by leakage and the means exist to measure and monitor leakage.

on the ground

Noel Kempff Mercado Climate Action Project

The Noel Kempff Mercado Climate Action Project ("Noel Kempff") provides a good example of how projects might be designed to analyze the risk of, prevent, monitor, calculate and compensate for leakage. The project considered both activity-shifting leakage and market leakage in its design and analysis. Since the project had two separate components, avoided deforestation and avoided forest degradation, with different actors and drivers, the treatment of leakage was distinct for each component.

Avoided Deforestation Leakage

For the avoided deforestation component, the potential for activity-shifting leakage was from local communities living along the border of the project area, in the form of subsistence agricultural expansion. Therefore, the communities were the focus of extensive community development activities associated with the project design, meant to both improve livelihoods and prevent leakage, including: the formation of an official indigenous organization, application for and granting of legal land tenure, educational campaigns, healthcare, workshops in sustainable agriculture, alternative employment opportunities and development of a management plan for sustainable forestry in ancestral lands. As a result of these activities, it was anticipated that there would be no activity-shifting leakage from the avoided deforestation component of the project. Similarly, as the threat of deforestation came from subsistence agricultural expansion and not commercial agricultural expansion, it was anticipated that there was no risk of market leakage.

Avoided Forest Degradation Leakage

The potential for activity-shifting leakage from the avoided forest degradation component of the project was from area timber harvesters, who were compensated to give up their harvesting rights in the project area and who might have begun new harvesting activities elsewhere. To prevent this, project developers negotiated the "Agreement to Prevent the Displacement of Noel Kempff Environmental Benefits," signed on January 16, 1997 by the former concessionaires, preventing them from initiating new logging activities for a period of five years, as well as allowing Bolivian project partner FAN to monitor their activities outside the project area. Furthermore, project developers closed sawmills operated within the concessions and purchased/retired harvesting equipment from concessionaires (as part of the overall concession buyout). Many concessionaires take out loans when purchasing equipment, thus must harvest to generate income and pay off the loans. Purchasing and retiring the equipment took away the pressure for concessionaires to shift harvest activities elsewhere by taking away the debt associated with the equipment. Furthermore, it prevented the possibility for equipment to be sold inexpensively to other harvesters when the indemnified concessionaires left the business. As a result of these equipment purchases, as well as expense and activity tracking of the indemnified concessionaires (explained below), it was anticipated that there was no risk of activity-shifting leakage from the avoided forest degradation component of the project.

A real risk of market leakage existed within the avoided degradation component of the project, as it was possible that smaller volumes of timber available on the market, due to the cancellation of project-area timber concessions, could result in higher market prices and the expansion of harvesting elsewhere. It is very difficult to prevent market effects when harvesting is stopped entirely (with IFM, on the other hand, it is possible to keep production up while still producing carbon benefits). Hence, it was necessary to calculate the market effect of reduced timber supply and deduct this from the carbon benefits of the project. Project developers employed the same national timber model developed specifically for Bolivia that was used in baseline calculations (Sohngen and Brown, 2004).

The model represented a landmark achievement in quantifying leakage on a national scale, as it analyzed the impact of project activities on the entire Bolivian timber market. The difference between the modeled total annual timber production for all of Bolivia "without-project" was compared with the modeled total annual timber production for all of Bolivia "with-project" to calculate leakage for this component of the project. Various scenarios explored the interdependence between price and demand for timber, as well as up-front cost constraints, resulting in the final leakage estimate of 11 percent of total carbon benefits from the project between 1997 and 2005 (16 percent of carbon benefits from the avoided degradation project component between 1997 and 2005). This quantity was subtracted from the initial verified carbon benefits of the project (127,515 tCO^{2}e produced for the years 1997–2005). Leakage will also be estimated and deducted from carbon benefits evaluated in future verification periods as they occur.

Leakage Monitoring

Project managers are monitoring a 15 km buffer strip adjacent to the project area for increases in community-driven deforestation in order to capture possible activity-shifting leakage from the avoided deforestation component of the project (see Figure 17). It is believed that community members, with no access to personal or public transportation, would not be likely to travel more than 15 km by foot to deforest for subsistence agriculture elsewhere. Thus far, no activity-shifting leakage has been detected through monitoring of the buffer area.

Project managers have tracked the activities and expenditures of concessionaires compensated through the project and have not seen evidence of activity-shifting leakage from the avoided degradation component. Parameters for the economic timber model, used in calculating market leakage for the avoided degradation project component, are being monitored annually to every five years, depending on the particular parameter.

International Leakage

International leakage was not included in the leakage analysis for Noel Kempff and as such, the demand function used in the economic model was assumed to be perfectly elastic. However, because it was determined that timber prices in Bolivia are not highly sensitive to supply changes (the country is considered a "price-taker" not a "price-setter" on the international markets), international leakage could be assumed to be quite small.[18]

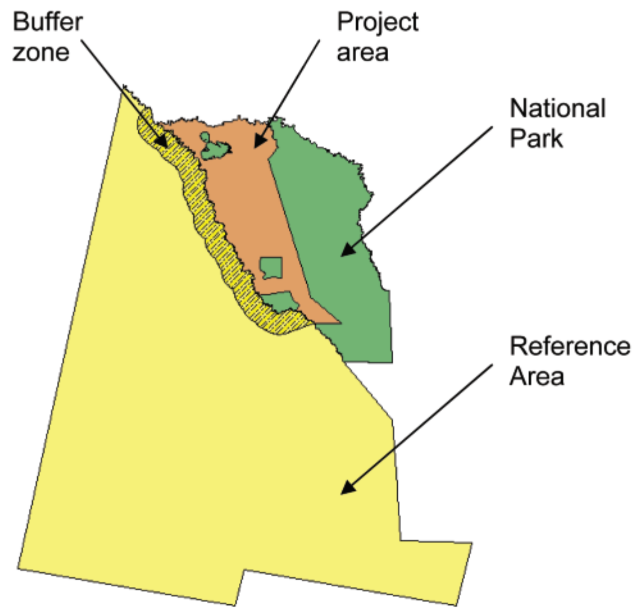


FIGURE 17 » Leakage monitoring in Noel Kempff Climate Action Project. Source: Noel Kempff PDD.

[18] Personal communication, Brent Sohngen. August 26, 2009.

LESSONS LEARNED *and* TAKEAWAYS

Projects can be designed to reduce the risk of leakage. » Careful choice of project location and design can minimize the chance that leakage occurs. In the Noel Kempff example, community development (most importantly the facilitation of land tenure by local communities), the tracking of compensation funds and purchasing/retiring of timber harvest equipment were all part of the project design to minimize activity-shifting leakage. However, since timber concessions were closed completely and converted to protected areas, it presented a risk of market leakage from lost timber production. This risk was calculated and accounted for in determining carbon benefits from the project. Project efforts which replace carbon-intensive activities with less carbon-intensive activities without sacrificing productivity reduce the chance that leakage will occur. For example, in order to minimize timber market effects, projects can utilize improved forest management techniques, which can maintain timber production near pre-project levels while still generating carbon benefits. Similarly, in areas where agricultural expansion is a driver of deforestation, agricultural production may be maintained though intensification on existing land and spatial planning/zoning that directs development to already degraded/deforested lands. Subsequent projects, such as Garcia River and Berau, are using this lesson and implementing improved forest management and other strategies to reduce the risk of and to capture leakage.

Credible estimation of project leakage is feasible. » In some cases, it might be impossible to completely avoid leakage from project activities. However, it is possible to predict leakage from project activities using econometric models. Various parameters, both economic and science-based, all of which can be tracked through time, are used to estimate the impact project activities will have on markets. For example, in the case of Noel Kempff, it was determined that the closure of four timber concessions would likely result in market leakage within Bolivia. In order to quantify and account for these effects, an economic model was developed, which predicted leakage within the Bolivian timber market to be 11% of total carbon benefits between 1997 and 2005. Parameters used in the model will be monitored over time and market leakage will be deducted from calculated carbon benefits during each future verification event.

The use of leakage discounts in project carbon accounting helps to account for the risk of leakage. » Leakage discounts, calculated according to several risk factors associated with project activities, are becoming standard practice to help assure that carbon credits will be supplied in the event that leakage occurs. Well respected voluntary standards such as VCS and CAR now require such discounts, which contribute to overall conservative estimates of carbon benefits (see "Standards and Verification" section for more information). These standards provide guidance on the size of an appropriate discount, based on various project aspects and risk factors. Default discounts, generally ranging from 10-20 percent (but sometimes larger for higher risk projects), are provided, or projects have the option of conducting their own leakage analysis, similar to the one that was performed in Noel Kempff. The 11 percent market leakage calculated for the Noel Kempff project (for carbon benefits between 1997 and 2005) serves as a leakage discount.

4: Permanence

Permanence refers to how robust a project is to potential changes that could reverse the carbon benefits of the project at a future date. Although all sectors have the potential for impermanence, forest carbon projects face particular scrutiny due to a perceived risk that poor management, fire, pests, etc. can lead to the destruction of forests and the subsequent release of emissions. The concept of permanence is the cause of much confusion mainly because of a lack of consensus of "how long is permanent" and inconsistencies with the way it is talked about across scope and scale.

All forest carbon activities, no matter the scale, are undertaken in order to produce carbon benefits, with the desired end result of lower carbon dioxide levels in the atmosphere. There is an inherent risk of partial or total reversal of carbon benefits within all sectors, forest carbon included, attributable to both natural and anthropogenic causes (e.g., fire, pests and governmental turnover). The magnitude of this risk, be it negligible or substantial, is particular to the place in which the activity is being carried out and to the drivers of deforestation, political situation, ecological conditions, socio-economic circumstances, economy, etc., and it is possible to quantifiably estimate this risk. In recognition of the risk for impermanence, it is common practice for those undertaking forest carbon activities to implement strategies to prevent reversal of carbon benefits and design safeguards to account for the unlikely event of a reversal, which will ensure the credibility of generated carbon benefits.

First and foremost, it is important that all stakeholder interests (e.g., government, communities and business) are aligned with the long-term project objectives. Several legal, financial and institutional tools are available to both prevent and deal with the possibility of impermanence. Specific approaches, such as the purchase of conservation easements, creation of protected areas, community development, and the establishment of endowments for project management and monitoring, can help ensure permanence. Ultimately, strategies must be tailored to the particular project site and situation.

Additionally, voluntary carbon standards have adopted the use of "permanence buffers," or a reserve of carbon credits, pooled over many projects (usually 10-20 percent of total benefits, determined by a risk analysis) which are set aside and not commercialized, to assure real credits can still be delivered in the off chance of a partial reversal. In some instances, these buffers can be partially recaptured as a project demonstrates permanence over time. Other compliance standards (e.g., CDM) issue temporary rather than permanent credits for forestry activities, which must be re-verified after each performance period, as a mechanism for dealing with possible impermanence.

In summary, the permanence of carbon benefits produced through forest carbon projects can be protected via legal, financial and institutional strategies. Projects can be designed to safeguard permanence and buffers can be used to ensure real credits will be delivered in the chance of a reversal.

Permanence in other Sectors

Although permanence is a consideration for all sectors involved in greenhouse gas reduction strategies, the forest sector is typically viewed as more vulnerable and held to higher expectations and stricter requirements. The following examples demonstrate how impermanence can be experienced in other sectors:

In the transportation sector, consider the implications of switching from a gas-guzzling SUV to a fuel efficient hybrid car. Even if the driver goes back to an SUV after 10 years of driving the hybrid, the result is that less is gas used over that time period than would have occurred in the baseline scenario (baseline = driving an SUV) resulting in an overall carbon benefit. The permanence of this benefit is generally not questioned; however, if the transportation sector were held to the same standards as the forestry sector, the gas saved from driving the hybrid would be required to be put aside, never to be used in the future, whether intentionally or accidentally. Forest carbon stocks—analogous to gasoline in this example—are, however, expected to be put aside and protected in perpetuity.

The same comparison could be made in the energy sector. Consider the implications of a homeowner changing from incandescent light bulbs to efficient compact fluorescents. Even if the homeowner reverts back to incandescent bulbs after the lifespan of the compact fluorescents, the energy savings over time equates to less coal burned at the plant which produced the household electricity. Again, there is no expectation that this coal be set aside and not burned in the future. Such a reduction would be considered permanent by current standards.

on the ground

Mature bottomland hardwood forest in Tensas National Wildlife Refuge. Photo Credit: © Byron Jorjorian.

Tensas River Basin Project

The Tensas River Basin Project is responsible for the reforestation of 166 hectares of bottomland hardwood forest in Franklin Parish, Louisiana. The Nature Conservancy is employing some of the legal and financial mechanisms just discussed to safeguard carbon benefits generated by the project, in the form of a permanent conservation easement, endowment and credit buffer.

The project lands were purchased with the intention of first reforesting, then selling the land to a buyer interested in maintaining the land for a conservation purpose (e.g., aesthetic value, fishing and hunting). When the property was sold, a conservation easement—a legal agreement binding a landowner to limit the type or amount of development on their property—was placed on the land. The easement stipulates that the land be kept in a natural forested state in perpetuity, to provide protection for the carbon contained in the forest and habitat for the animal and plant species that require intact blocks of natural forest habitat for their continued existence. It is expressly agreed that certain forestry practices, that are necessary to achieve and maintain the desired composition and structure of the forest, are allowed. Specifically, once the forest reaches the target carbon storage capacity, sustainable forestry activities are allowed in coherence with a sustainable forest management plan—to be developed by the land owner and subject to the approval of TNC—consistent with the objectives of retaining carbon and conserving biodiversity.

TNC will monitor the property every year to ensure the agreement is being upheld. Entrance onto the property for this reason was specifically stipulated in the conservation easement. Monitoring of the conservation easement will be funded by a permanent endowment created for the project.

Once the project is verified to the Voluntary Carbon Standard (VCS) or Climate Action Reserve (CAR) standard, expected in 2010, it will be subject to a risk evaluation in accordance with the guidelines of the applicable standard, to determine the credit buffer required to be withheld. The buffer will then be spread over the entire VCS or CAR project portfolio, pooled with other projects for diversified insurance of carbon benefits.

LESSONS LEARNED *and* TAKEAWAYS

Legal, institutional, management and governance structures can be employed to reduce the chance of impermanence. » Laws and standards are critical tools to ensure permanence, but also must be coupled with enforcement capacity, monitoring tools and processes in civil society and within various levels of government. The Tensas River Basin project relies on an established legal framework (U.S. conservation easement law) and has established an endowment to fund the monitoring and enforcement of compliance with the easement. In places where such structures or capacity do not exist prior to implementation, considerable funding and effort may be needed to work with local, regional or state-level institutions to develop them.

The use of credit buffer reserves can help manage the risk of impermanence. » Permanence buffers, calculated in accordance with several risk factors for project activities, are becoming standard practice in forest carbon projects to help ensure that issued carbon credits are not reversed. Well recognized voluntary carbon standards such as the VCS and CAR both require the use of a pooled buffer system. Registries, which bank these buffer credits together, spread the risk over the hundreds of projects they service and in effect reduce the risk posed by failure of any one project. In the event of a reversal, credits are replaced by an equal amount drawn from the credit buffer, resulting in no net loss. National scale/larger scale portfolios are naturally self-insuring, as they also spread the risk over many areas and projects, reducing the risk of catastrophic loss. However, even in a national-level system, some buffer will likely be needed.

5: Standards and Verification

Voluntary and compliance systems are inherently different; compliance systems provide regulations to guide project activities, while voluntary systems are not subject to these regulations. As such, standardized methods are required to establish the "rules of the game," ensuring quality and consistency across voluntary forest carbon projects. Over time, several comprehensive standards have been developed to meet the needs of voluntary forest carbon markets, designed to address key concerns about permanence, leakage, additionality, social and environmental benefits and risk. Various standards developed for the voluntary market include all three forest carbon activities—AR, IFM and REDD—and are serving as models for future inclusion within regulatory structures. Many of these standards not only provide a means to verify carbon benefits, but also to ensure social and environmental benefits (see Table 2 for a sampling of some of the more well known standards relevant to forest carbon projects).

Standards are comprised of general project guidance as well as specific methodologies for carbon accounting, particular to the project type. Most standards require an accredited third-party evaluation of the project to assure the project complies with the chosen standard and to verify the credibility of claimed project benefits. This process ensures transparency and usually results in the issuance of verified carbon credits and/or certification for projects that meet the requirements of the standard.

Methodologies included within standards provide specific guidance for carbon accounting which cover formulas, default values and step-by-step instructions. For example, methodologies might specifically provide the techniques, equations and assumptions to be used to determine aboveground biomass or how to calculate a baseline. Over time, methodologies have been adapted for voluntary standards, borrowing from or referring to CDM regulations and IPCC Good Practice Guidelines, or developed from project experiences where there was no prior guidance.

The Voluntary Carbon Standard (VCS) is emerging as a dominant standard for the quantification of carbon benefits from forest carbon projects within the voluntary market. One innovative aspect of the VCS is that projects are evaluated in terms of the risk of impermanence, and projects are required to deposit a percentage of their credits into a pool of credits that the VCS uses to provide a buffer in the event that a protected forest is lost during the project accounting period. Under the VCS, the risk analysis and buffer determination are subject to two separate independent third party assessments ("double approval process") to assure that risks are adequately addressed.

Other standards, such as the Climate, Community and Biodiversity standard (CCB) and Forest Stewardship Council (FSC), have been designed to ensure adequate consideration of environmental and social co-benefits in project development. Although these standards do not specifically address carbon, they can be used in conjunction with carbon standards to ensure equity, transparency and the broadest suite of project benefits.

In summary, regulatory and voluntary standards exist to guide forest carbon project development and to ensure that real, measureable and verifiable carbon benefits are produced. Comprehensive and currently operating voluntary standards will likely provide important input into regulatory standards for REDD and IFM as they develop.

Double-checking ground measurements of dbh is a standard part of the verification process. Photo Credit: © Eric Aldrich/TNC

STANDARD NAME	VOLUNTARY OR COMPLIANCE	PROJECT TYPES	CARBON VERIFICATION	ENVIRONMENTAL AND/OR SOCIAL BENEFITS	GEOGRAPHICAL REACH
Clean Development Mechanism (CDM)	Compliance	AR	Yes	No (safeguards only)	Non-Annex I countries
Regional Greenhouse Gas Initiative (RGGI)	Compliance	AR	Yes	Environmental—Yes Social—No	10 Northeast and Mid- Atlantic US states
AB32	Voluntary	AR, REDD and IFM	Yes	Environmental—Yes Social—No	California
Climate Action Reserve (CAR—Formerly California Climate Action Registry)	Voluntary	AR, REDD and IFM	Yes	Environmental—Yes Social—No	US
Chicago Climate Exchange (CCX)	Voluntary to join, compliance once committed	AR and IFM	Yes	Varies (IFM might include both benefits depending on certification system—no requirement for AR)	US or non-Annex I countries
Voluntary Carbon Standard (VCS)	Voluntary	AR, REDD and IFM	Yes	No (recommendations but no requirements)	Global
1605B	Voluntary	AR and IFM	Yes	No	Mainly U.S. (however projects outside the U.S. are technically allowed)
EPA Climate Leaders	Voluntary	AR	Yes	No	Mainly U.S. (however projects outside the U.S. are technically allowed)
Climate, Community and Biodiversity Standard (CCB)	Voluntary	All land-based projects	No	Yes	Global
Forest Stewardship Council (FSC)	Voluntary	IFM	No	Yes	Global

TABLE 2 » Sampling of standards which include forestry activities—blue indicate carbon standards and green indicate non- carbon standards.

on the ground

The Garcia River Forest Project

The Garcia River Forest Project was one of the first, and is the largest, forest project to receive verification under California's Climate Action Registry (CCAR v2.1), now updated and called Climate Action Reserve (CAR). CCAR v2.1 is a rigorous and comprehensive protocol that provides a standardized method to accurately account for carbon benefits produced from California forest projects.[19] The standard includes guidance on completing forest carbon inventories, establishing a project baseline, calculating carbon benefits and verification of carbon benefits.

The Conservation Fund developed its forest carbon offset project in accordance with CCAR v2.1 rules, falling under the conservation-based forest management project category (also called "improved forest management"). In accordance with these rules, once a carbon inventory was completed, the project baseline was set as the maximum allowable harvest under California state law and a model was used to project forest growth 100 years into the future to determine carbon benefits (see case study in "Measuring and Monitoring" section for more detail). It is required that the entire forest be resampled over the course of every 12 years to monitor carbon accumulation. Under the program, projects must submit annual reports detailing any unplanned forest destruction or activity-shifting leakage that took place over the course of that year and these reports are subject to external review for validity. To ensure permanence, the standard also requires that an easement be placed on the land, dedicating it for forest land use in perpetuity.

The conservation easement purchased by TNC required The Conservation Fund to go beyond what CCAR required to assure ecological benefits, by gaining certification under the Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) standards and employing strict conservation restrictions, including the use of reduced impact logging techniques as well as expanded reduced-harvest riparian zones. Project funders also imposed a condition that 35 percent of the property be placed in a permanent Ecological Reserve Network, to be managed in accordance with the latest understanding of conservation biology.

The Garcia River Forest Project underwent initial verification in August and November 2007 by accredited third parties Société Générale de Surveillance (SGS) and Scientific Certification Systems (SCS). Initial desk review of project

Main stem of the Garcia River in Garcia River Forest, California.
Photo Credit: © Bridget Besaw.

documents resulted in several New Information Requests (NIRs), specifically queries into habitat protection measures for listed species, description of methods to determine biomass densities in dead wood carbon pools, rules for stratification of forest stands and site index for growth models. The requested information was provided and these NIRs were resolved.

The subsequent site visit assessment resulted in several Corrective Action Requests (CARs), mainly related to compliance of baseline estimates and harvest schedules with Forest Practice Rules and sampling error. These CARs were addressed and resolved and the project was verified in December 2007. Subsequent field verifications took place in February of 2008 and 2009, conducted by SCS. Additional carbon benefits generated from the project will continue to be verified annually in order for The Conservation Fund to fulfill offset delivery obligations under its various offset sales contracts. Its verified carbon benefits accrued thus far, between 2004 and 2008, total 525,370 tCO_2e. The project provides an excellent example of how comprehensive standards, designed with carbon retention and biodiversity in mind, can result in high quality, credible carbon benefits.

[19] The new CAR standard accepts projects from all over the U.S., unlike the previous CCAR v2.1 which was specific to California only.

LESSONS LEARNED *and* TAKEAWAYS

Standards ensure forest carbon activities are consistent in their rigor and elicit confidence in the produced carbon benefits. » Detailed standards currently exist to guide projects in the production of real, measurable and verifiable forest carbon benefits, as well as to promote environmental and social co-benefits. The Garcia River project is an example of a successful project which, guided by a comprehensive voluntary carbon standard for improved forest management (CCAR v2.1), has been able to demonstrate such results. Carbon standards provide step-by-step guidance on carbon accounting and methodologies, appropriate risk calculations and deductions, and leakage buffer determination. When used in combination with environmental and social standards such as FSC and CCB, it can help projects to ensure that these aspects are adequately considered in project design. It is becoming common practice for those forest carbon projects engaged in activities not currently recognized by regulatory systems to comply with and strive to achieve verification through one or more of the recognized voluntary standards.

Third-party verification is key to providing transparency and confidence in carbon benefits produced through project activities. » Verification is a complex process by which an independent third-party organization, which has been certified to evaluate projects according to a specific standard, thoroughly reviews the design, methodologies, calculations and strategies employed in a project. The verifier then provides feedback to the project developers, requiring changes where needed prior to the granting of verification. In most cases, documentation associated with verification is publicly available to ensure transparency. This process inspires confidence in the resulting verified carbon benefits, ensuring that they were produced in accordance with the chosen standard and are indeed real and credible. The successful verification of 525,370 tCO_2e over 2004-2008 from the Garcia River project demonstrated the authenticity of carbon benefits produced.

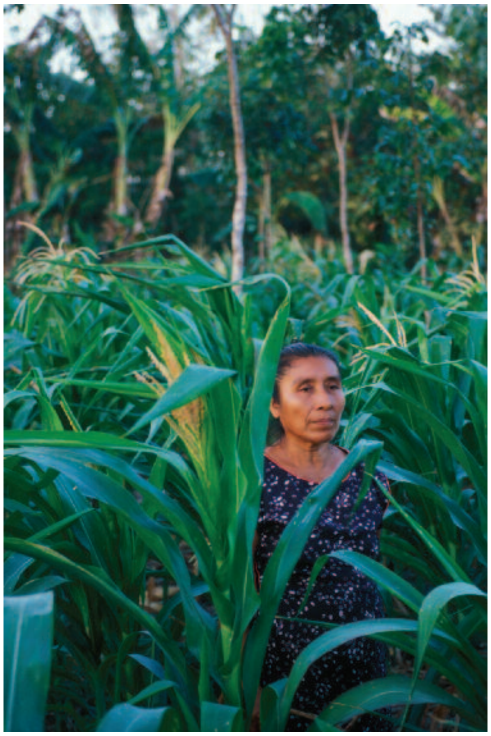
6. Involving and Benefitting Local Communities and Indigenous Peoples

More than one billion of the world's poorest people depend directly on forest resources for their survival and livelihoods. Large tracts of the world's remaining forests are on indigenous lands, and indigenous peoples are often the best stewards of the lands and waters from which they have historically met their daily needs for food, water and fuel. In fact, a 2009 study found indigenous areas provide greater protection from deforestation than other types of strictly protected areas (Nelson and Chomitz, 2009). Yet, as development pressures encroach upon once-isolated regions, changes can occur that create new economic hardships for people who are pursuing traditional lifestyles. Science tells us that these same groups, who have done little to cause the climate crisis, are among the first to face direct adverse consequences of climate change, due both to their close relationship with the environment and its resources, and their limited financial and institutional capacity to adapt to this threat (UNDG, 2008).

Interventions that assign value to forests have the potential to contribute significantly to the well-being of local communities and indigenous peoples. Such programs can provide the resources needed to support community development and sustainable alternative employment. Likewise, conserving or restoring forests can help buffer communities against the worst effects of climate change as healthy forests can better resist and recover from the impacts brought about by climate change, ranging from severe storms that cause mudslides to decreased rainfall that affects crop yields and food supply. Yet, forest carbon efforts designed without consideration of the views and needs of local communities may have negative social and financial impacts on these people, including loss of employment or access to forest resources on which they depend.

As policy-makers nationally and internationally negotiate how to design and implement forest carbon incentives, indigenous peoples must be fully and effectively engaged in the discussions to ensure that those who rely on forests for daily survival directly benefit from conservation efforts. In the context of the international climate change dialogue, concerns about the rights and participation of local and indigenous communities in the design and implementation of forest carbon programs have become very high profile. Officially sanctioned organizations, such as the UN Permanent Forum on Indigenous Issues, as well as non-governmental organizations and advocacy groups, have spoken out on the key role of indigenous peoples and their stake in the fate of forests. A well-designed forest carbon framework will depend upon, among other things, equitable participation and distribution of benefits for indigenous peoples and local communities.

Although forest carbon projects have the potential to benefit local communities by helping to avoid the worst impacts of climate change and providing opportunities for economic and community development, care must be taken to respect the rights of those who stand to be affected most by such efforts. Standards exist which can be used in conjunction with carbon standards to help guide project developers in assuring that these rights are acknowledged and maintained. The CCB standard, listed in Table 2, is specifically designed to ensure social and environmental co-benefits. This standard provides a checklist and guidance for project developers to ensure net positive community impacts, stakeholder participation and monitoring of project impacts, demonstrated through verification by an accredited third party.



A member of a women's agriculture cooperative near the town of Xpujil and the ruins of Calakmul in the Maya forest region of Mexico's Yucatan peninsula stands in a corn field that is part of a TNC and Pronatura Peninsula Yucatan (PPY) program to develop a more integrated agroforestry system. Photo Credit: © Mark Godfrey/TNC

on the ground

Noel Kempff Mercado Climate Action Project

Developers of the Noel Kempff Mercado Climate Action Project ("Noel Kempff") recognized that the project could affect communities bordering the project area. Goals of the project included minimizing negative impacts on community well-being, addressing the drivers of local deforestation and ensuring alignment of stakeholder interests (which also addressed permanence of project benefits and helped to reduce leakage). Community development activities, including organizational empowerment, capacity building, improvement of basic services and development of income generating activities, were undertaken as a part of Noel Kempff and designed to result in overall well-being at levels equal to or above where they were pre-project. Since 2001, several project impact studies have been conducted by outside parties concluding that communities have experienced net economic and other gains (Robertson and Wunder, 2005).

Community Profile

Seven indigenous communities, with a total population of 1,025, were living adjacent to the Noel Kempff Mercado Climate Action Project as of 1996. Traditionally, these communities supported themselves through subsistence agriculture, with women and children in charge of gathering firewood, fruits and medicinal plants, and men seeking income through seasonal work in sawmills, field clearing, hunting and fishing. Prior to project implementation, the communities generally did not have public services. Rivers provided water, health centers were in poor condition, public transportation did not exist and schools lacked supplies, space and teachers.

Community Development Program

To enhance livelihoods in the communities adjacent to the park, strengthen their organization and ensure in leakage and impermanence prevention, three sequential programs were initiated with project funds. The Program for the Sustainable Development of Local Communities ran from 1997-2001 and improved access to basic services such as health, education and communication. The Community Development Program, undertaken from 2002-2006, emphasized community development by securing land title, assisting self-organization and supporting income-generating activities such as community forestry and micro-enterprise. Finally, a Community Development Action Plan was carried out from 2006-2008 with the goal of raising the standard of living for the communities affected by the project to levels at or above those at which they resided prior to project implementation. It is expected that the Government of Bolivia will carry on future community development activities with a portion of the income it receives from marketing its share of verified carbon benefits from the project. Thus far, however, the government has not commercialized its share, nor has it designated exactly how much of the commercialized benefits will go back into the communities. Project developers and community leaders are working with the Bolivian Government to try to resolve these issues.

Chiquitano children living in one of the local communities just outside the border of Noel Kempff Mercado National Park in Bolivia. Photo Credit: © Hermes Justiniano.

Community Organization

In practice, community involvement can be difficult to achieve if there is a lack of formal community/organizational structure, as was initially the case with the communities surrounding the Noel Kempff Mercado National Park (Asquith, et al., 2002). As such, a major component of the project focused on assisting communities in creating an official indigenous organization, both to increase their capacity to participate in project activities and to provide them legal standing with the government. Project developers helped communities to access the appropriate government officials and prepare paperwork to group themselves into the official Central Indígena Bajo Paraguá (CIBAPA), a registered organization representing the indigenous communities around the park. As communities became increasingly organized, they were able to take a more and more active role in the project planning. They fully participate in the management committee of the Park, where all operational aspects of the project are discussed. As a group with legal standing, CIBAPA was also eligible to file for land tenure with the National Agrarian Reform Institute.

Land Tenure

Prior to project initiation, none of the communities bordering the park had property rights to the land on which they had historically resided and which they had traditionally used for hunting, logging, rubber exploitation and fishing. A presidential Supreme Decree, negotiated with the help of project developers, which officially expanded the Noel Kempff Mercado National Park, recognized and guaranteed the subsistence use and exploitation of renewable natural resources within the expansion zone by communities, subject to the park management plan. In order to further protect community members' access to timber, plants and animals, FAN facilitated CIBAPA's claim to 360,565 hectares of indigenous territory adjacent to the project area in 1998, and this claim was accepted by the National Agrarian Reform Institute. In June 2006, the official titling of indigenous territory (TCO) was granted to CIBAPA.

Sustainable Land Management

To further enhance livelihoods and to mitigate leakage, the project financed the creation of a land use plan for the newly titled indigenous territory. Through collaborative efforts of project partners and communities, the Bajo Paragua Native Communal Land Natural Resources Management Plan was developed and four communities received training in sustainable community forestry. Project developers supported the establishment of a sustainable community forest concession, guided by the sustainable management plan, within the TCO. Community members have approval by the Superintendant of Forestry to exploit heart of palm on 11,000 hectares of the TCO, as well as practice sustainable forestry in 90,000 hectares of the TCO. Today, CIBAPA is running its own sawmill and is the first indigenous organization with a timber selling point in the capital of the Department of Santa Cruz. Although the sawmill is not currently turning a profit, money generated from these activities is going directly back into the communities, and help, to offset employment losses from the closure of one of the concessions.

Alternative Employment

While a socioeconomic impact assessment concluded that, on average, the communities were benefitting from the project, the community of Florida still maintained a negative financial impact due to loss of 20 jobs from closure of the Moira sawmill (Asquith, et al., 2002). Project developers attempted to compensate for these losses by creating opportunities for alternative employment. Aside from sustainable timber operations in the TCO, approximately 80 community members have worked surveying forest resources both inside and outside of the project area (Asquith, et al., 2002). Of the 26 full-time park guards, 10 are from the local communities. Furthermore, six community members were trained as tourist guides.

At the time that the project was initiated, sustainable logging, extraction of non-timber forest products, ecotourism and bio-prospecting were all widely perceived to be promising avenues for alternative income generation for forest-dependent communities. The project employed all of these efforts to help raise the standard of living of surrounding communities, to varying degrees of success.

A visitor center was constructed with the aim of generating income through tourism activities, which would work in combination with the project endowment to fund post-project activities. Cabins were built and repaired in several communities, boats and equipment purchased, and a pontoon bridge constructed for vehicle transportation. Two communities participated in tourism activities by offering guidance, lodging and other services. Unfortunately, it became apparent that the remote location of Noel Kempff would make travel to the site by tourists both difficult and expensive. Thus, the realized benefits via ecotourism have been fewer than originally anticipated.

Park guards for Noel Kempff Mercado National Park in Bolivia. Photo Credit: © Hermes Justiniano.

A program aimed at expanding the scientific capacities of local organization FAN, while identifying marketable wild plants and products, was started. The GermoFAN laboratory was established with the goal of producing in vitro native plants, such as orchids, that would generate income through their sale, to be funneled back into project activities and help fund post-project activities. GermoFAN has commercially produced ornamental, medicinal and edible species. In addition, the largest scientific collection of live-plant ornamental Bolivian species was established through the project. Today, it includes 2,500 species, 52 of which were identified as new to science and 18 of which were sponsored for further research.

Further enterprises in biotrade have been carried out, but did not prove viable, as returns on the initial investments were too small and a strong market didn't exist. This included the creation of "Canopy Botanicals," a company whose aim was to develop products, supplied by the communities, in

Shade grown coffee plant and beans. Photo Credit: © Mark Godfrey/TNC.

three market sectors: organic foods (i.e., coffee beans, cocoa, and Brazil nuts), botanicals (i.e., medicinal plants) and ornamentals (i.e., orchids). The company promoted sustainable development as well as the equitable distribution of economic benefits to supplier communities. Unfortunately, the venture ultimately failed due to low returns on its investments, and the investors incurred costs to dissolve the company.

Education and Healthcare

To complement the creation of alternative employment opportunities, education also played an integral part of the community development plan. Agricultural promoters were educated for the sustainable forestry operations and five university scholarships in strategic areas (business administration, tourism, agricultural and forest engineering) were financed, along with seven awards for polytechnic level study. Schools in the communities of Florida, Piso Firme and Bella Vista were refurbished and, through an agreement with the project, the Municipality of San Ignacio paid the salaries of two teachers. Significant quantities of educational supplies were purchased, while scholarships were given to 120 primary and secondary school students to continue their studies in courses which were not available in the communities.

Access to proper healthcare was similarly important for the well-being of community members. Prior to project implementation, operators of the Moira concession provided the community of Florida with the services of a medical doctor for half a day each week, as well as discounts on medicine (Asquith, et al., 2002). In order to compensate for the loss of these services, project developers refurbished and expanded a pre-existing health clinic in the community of Florida, which was in very poor condition, to include living quarters for a resident nurse. Another outpost, in Piso Firme, was expanded and converted into a micro-hospital, with a delivery room, laboratory and dental services. Project funds were used to purchase medicine, which is administered by community members, and a doctor was hired to live in Piso Firme and make periodic visits to all of the communities. (Calderon, 2005).

Looking Forward

The community development activities appear to be working to both benefit local indigenous peoples and aid in permanence and leakage control, as shown by the positive results of the socioeconomic impact assessment and lack of further deforestation in the project and buffer areas. Project developers will continue to work with the communities, particularly Florida, to ensure that they benefit from project activities over time and it is believed that the government will take a more active role in future community development activities using a portion of funds generated from commercialization of its share of the verified carbon benefits. Although the project was designed with community benefits in mind, the Climate Community and Biodiversity (CCB) Standard was created well after the initiation of Noel Kempff, and so the project design was not validated under CCB. However, future TNC projects are considering the standard in project design, as it is viewed as a great means to transparently assure community benefits.

LESSONS LEARNED *and* TAKEAWAYS

Carbon projects can generate tangible benefits for local communities. » Well-designed forest carbon projects can result in significant co-benefits for local peoples in the form of alternative income opportunities, land tenure, capacity building and creating mechanisms for civil participation within government decision-making. Likewise, by protecting the forests on which traditional communities often rely for their livelihoods and customs, forest carbon projects can sustain local cultures and traditions. The Noel Kempff project serves as an example of a forest carbon project that is likely to result in an overall benefit for local communities. Through the project, local people have gained legal recognition as an indigenous organization, and have applied for and received tenure over a tract of ancestral land. They have also begun sustainable harvesting of timber and heart of palm, received training in various aspects of sustainable agriculture and forestry, and received health, education and other social services. It will be important, nonetheless, to ensure that the mechanisms exist within the government to transfer revenue to the local communities from carbon offsets that are sold, both to ensure long-term benefits to local people and to prevent leakage and risks of impermanence.

Consultation with and participation of local communities and indigenous peoples is necessary to ensure overall community benefits. » Local communities and indigenous peoples, whose lives are closely tied to the land, are likely to be the most impacted by project activities. Thus, it is essential that they are consulted and have adequate participation during all stages of project development. Impacts on local people should be monitored and rectified if found to be negative. Every effort should be made to ensure that project benefits are equitably distributed to local communities and indigenous peoples. This not only promotes fairness and equity, but reduces the risks of leakage and impermanence.

Community organization is a critical first step for community involvement. In some areas, as was the case with Noel Kempff, communities may not have an organizational structure, with designated representatives and a formal means of relaying information. The absence of such structures can pose a challenge to ensuring that community members are consulted during the initial stages of project development. Assisting communities to self-organize and gain legal standing not only assures their participation in project planning and implementation, but empowers them to participate in their local and national governments.

Alternative income activities can be a means to ensuring financial benefits for local communities, but they must be well designed to ensure success. » The Noel Kempff experience underscores the need for sophisticated advanced business planning to determine the viability of economic development strategies and avoid losses on investments. Although sustainable logging, extraction of non-timber forest products, ecotourism and bio-prospecting were widely thought to be promising avenues for alternative income generation for forest dwelling communities, not all of these ventures have panned out. For economic activities to succeed, it is important that forest carbon projects employ business planning expertise that can assess the feasibility of business ventures, adequately analyze supply chain issues, realistically project cost structures and help develop robust marketing plans to help achieve the desired results.

Project design standards help ensure that proper community consultation and participation occurs and that communities benefit from project activities. » Standards such as CCB contain specific guidelines which can be incorporated into project design and help project developers appropriately address the myriad of social factors associated with forest carbon activities. Verification to such standards provides assurances that projects comply with these rules and credits generated from these projects adequately consider social impacts. The Noel Kempff project was designed and implemented prior to the existence of social standards such as CCB; nonetheless, great effort was made to assure social co-benefits in the project design. It is becoming increasingly common for forest carbon projects to comply with a social and environmental standard such as CCB.

7. Assuring Environmental Co-Benefits

Just as forest carbon projects can be designed with benefits to the community in mind, so can environmental co-benefits (including biodiversity conservation and enhancement, ecosystem services and watershed protection) be enhanced by forest carbon activities, creating the potential for a triple bottom-line. While the absence of regulations requiring that environmental co-benefits be considered may produce perverse incentives to maximize carbon benefits to the detriment of other values (e.g., activities which introduce exotic species or low-biodiversity monoculture plantations), careful selection of project location and design can result in projects with higher environmental integrity, including enhanced resilience to potential disturbances (such as pests or disease).

Environmental NGOs typically use strategic analyses to determine the best places to concentrate their energies and resources. Under The Nature Conservancy's Conservation by Design framework, for example, project locations are chosen with respect to a variety of factors, including the prevalence, health and importance of certain ecosystems and habitats suitable for groups of plant and animal species, as well as social and political factors. Many ecosystems with high concentrations of biodiversity are also high in carbon, particularly in tropical regions (UNEP-WCMC, 2008). For example, in 2008 the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) published an atlas which highlights areas where high carbon content and high biodiversity overlap, indicating the potential for forest carbon activities (particularly REDD) to simultaneously combat climate change and biodiversity loss (see Figure 18). The use of such maps in prioritizing locations for forest carbon activities can help enhance biodiversity outcomes of such projects.

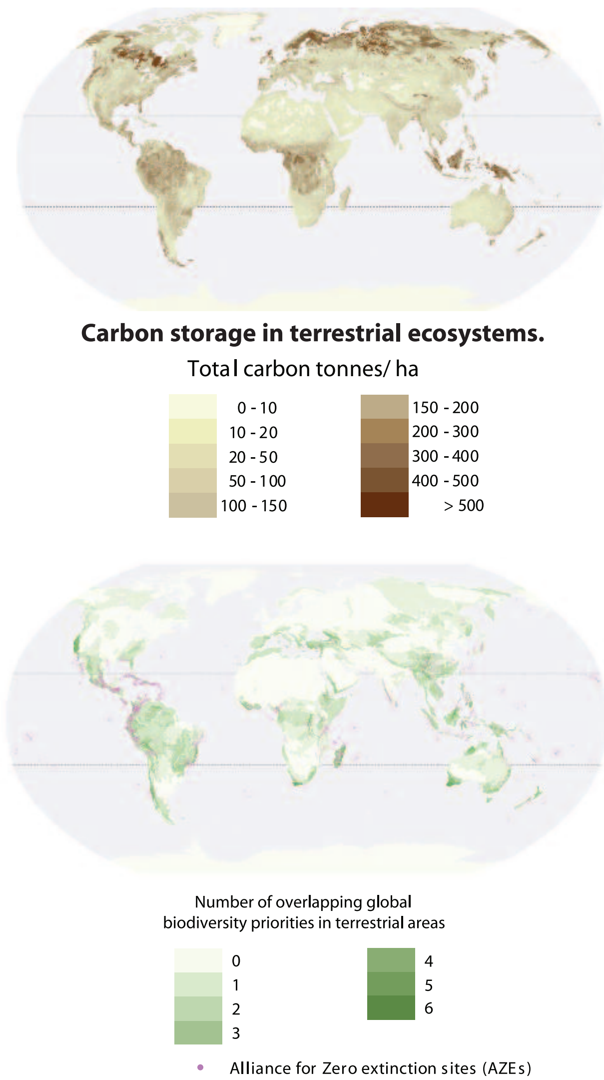


FIGURE 18 » Map of carbon storage in terrestrial ecosystems and overlap with high biodiversity priority areas. Source: UNEP- WCMC.

Project design also provides an opportunity to ensure environmental co-benefits. Designing forest carbon efforts involves identification of strategies to prevent emissions or enhance carbon stocks. Many strategies to achieve those goals—such establishment of protected areas, sustainable management plans for natural resources, or payments for environmental services, can simultaneously enhance outcomes for biodiversity or other ecosystem services, such as water.

Several standards have been created which guide project developers in the consideration of co-benefits during the design stage. The Climate, Community, and Biodiversity Standard (CCB) and Forest Stewardship Council Standard (FSC), mentioned in the "Standards" section, are two such frameworks. Particularly with regard to biodiversity, CCB requires net positive biodiversity impacts within the project zone and over the course of the project lifetime, evaluation and mitigation of negative biodiversity impacts outside of the project area and monitoring of biodiversity changes over time. FSC, pertinent to forest management projects, contains mandates to conserve biological diversity and its associated values, water resources, soils and unique and fragile ecosystems and landscapes. FSC also requires that management activities in high conservation value forests maintain or enhance the attributes that define such forests. Verification to strict standards such as these not only ensures the consideration of environmental co-benefits in carbon projects, but can elicit a price premium for the carbon benefits they generate (Neef, et al., 2009).

In summary, by carefully considering project location and utilizing design safeguards as outlined in standards such as CCB and FSC, it is possible to develop projects that help to both mitigate climate change while at the same time conserving and enhancing the natural environment.

on the ground

Tensas River Basin Project

The Tensas River Basin Project location and design was chosen to achieve both carbon and biodiversity benefits. This reforestation project is located within the Tensas River Basin of the Mississippi Alluvial Valley, an area systematically fragmented over time due to conversion to agriculture. The Tensas River Basin contains one of the largest remaining bottomland hardwood forest fragments (approximately 32,375 hectares) in the Lower Mississippi River Valley. As such, considerable opportunity existed to reconnect patches of forest by planting native tree species, creating corridors for species movement and increasing the size of suitable habitat for wide-ranging wildlife. The native hardwoods are fast growing and carbon dense, allowing carbon benefits to accrue relatively quickly compared to other areas of the United States.

The Tensas River Basin Project is part of the Lower Mississippi Valley Climate Action Program, a series of forest carbon efforts in which newly planted trees will capture carbon as they grow while simultaneously supporting biodiversity goals. The Conservancy and its partners have developed a conservation plan for the Mississippi River Alluvial Plain that prioritizes sites for ecological restoration and maximizes opportunities to achieve connectivity among existing forest patches to benefit wildlife. Similar reforestation projects are underway at other Louisiana sites, with 150,000 trees planted since 2005 in the Bayou Pierre Floodplain Project, and another site in development on the Bayou Bartholomew watershed. The goal is to replant native bottomland hardwood tree species, such as sweet gum, bald cypress and tupelo, in strategically identified marginal agricultural areas, thus linking blocks of existing forest.

In the face of temperature and precipitation shifts brought about by climate change, the region's species will need to adjust their ranges, making forest corridors critical for their movement and survival. The region is the historic range for critically endangered wildlife species, such as the Ivory Billed Woodpecker and Red Wolf, which require large, contiguous blocks of forest to persist. Other species, such as forest nesting songbirds and the Louisiana Black Bear, have experienced steep population declines, but are considered highly restorable if large forested landscapes are recreated.[20]

Beyond providing habitat for terrestrial species, The Tensas Project is improving water quality by reducing the amount of sediment contributed by agriculture in the surrounding areas, and therefore enhancing habitat for aquatic species. Mussels are adversely affected by poor water quality, especially increased sedimentation, which can result from agricultural practices. Aquatic species richness within the Tensas River Basin is considered among the highest in Louisiana and includes three globally rare freshwater mussels: The Fat Pocketbook, Pyramid Pigtoe and Ebony Shell.

Tree saplings planted in reclaimed farmers' fields in efforts to reforest the area. Rainey Lake, Tensas National Wildlife Refuge, Louisiana. Photo Credit: © Byron Jorjorian.

Several financial, institutional and legal strategies were used in the Tensas Project design to ensure biodiversity co-benefits were attained along with carbon benefits from reforestation. The project lands were originally purchased with the intention of first reforesting, then selling to a buyer interested in maintaining the property for conservation purposes (e.g., aesthetic value, hunting and fishing). When the property was sold, a conservation easement—a legal agreement requiring the landowner to limit the type or amount of development on their property—was placed on the land. In the easement, it is stipulated that the land be kept in a natural forested state in perpetuity, to provide for the protection of the carbon contained in the forest and to provide continual habitat for the animal and plant species that require intact blocks of natural forest habitat for their existence. Activities that would threaten this capacity, such as agriculture, mining, road construction and use of pesticides are strictly forbidden in the easement.

[20] TNC. Northwest Airlines Forest Carbon Project Update. January 2, 2008. Internal document.

LESSONS LEARNED *and* TAKEAWAYS

Forest carbon projects that are designed to maximize both carbon and environmental benefits help ensure the integrity of project benefits. » Forest carbon projects can be designed to assure environmental co-benefits in both the choice of location and activities undertaken. Projects, such as Tensas, specifically located in corridors which connect fragmented landscapes, help re-establish or protect movement of species. Similarly, projects can be undertaken in areas identified as endangered or critical habitat for species of concern, which often overlap with areas of high-carbon potential, as visible in advanced carbon maps. By enhancing environmental co-benefits, a project can be more robust and resilient to potential threats, including climate change itself.

Standards exist that can help ensure environmental co-benefits in forest carbon projects. » Interventions such as non-native and/or monoculture tree plantations, which focus solely on carbon benefits, lose the opportunity to maintain or enhance other environmental factors that can strengthen the integrity and permanence of such projects. Carbon project standards vary in the emphasis placed on environmental and community co-benefits. Project developers that wish to go one step further to ensure environmental co-benefits may use standards specifically designed to ensure them, such as CCB or FSC. Project-level standards can provide a good basis for developing best practices at the national level. As such, some standards, such as CCB, are working to scale up their scope to accommodate national level activities.

Black Bear. Photo Credit: © Paul Berquist.

8. Scale and Scope

Two critical policy issues being discussed in the design of incentives for forest carbon are the appropriate scale and scope of the mechanism. Forest carbon activities can be undertaken on various scales, from project level to state or provincial level to national scale. The manner with which technical issues such as baselines, measuring and monitoring, leakage and permanence are dealt with can vary according to scale. As scale increases, many REDD activities are more cost-effective at achieving carbon benefits sufficient to reduce the worst impacts of climate change, and some transaction costs associated with forest carbon projects become less expensive. The scope of activities that should be included within forest carbon mechanisms under discussion also varies widely. At one end is a view that would only recognize efforts to avoid complete forest conversions (e.g., oil palm development). Other proposals incorporate incentives to reduce forest degradation (which, when caused by logging, may include use of sustainable forest management techniques). Still others address the full spectrum of activities that cause or prevent emissions of terrestrial carbon (e.g., avoided deforestation and degradation, as well as reforestation, improved forest management, conservation of non-threatened forests and other ecosystems such as peat swamps, improved agricultural and grazing practices—See figure 19).

Scale

For a variety of reasons, there is an emerging consensus in the international community that it is important to develop nation-wide forest carbon approaches, especially REDD. The advantages of moving to national efforts are seen as three-fold: 1) magnitude of impact, 2) the ability to employ policy tools, and 3) efficiencies in addressing technical issues including leakage and permanence.

To avert the worst impacts from climate change, scientists tell us that we will need to address every major cause of emissions (IPCC, 2007b). With deforestation and land use change emitting 5.8 billion tons of carbon dioxide annually—approximately 17.4 percent of total global greenhouse gas emissions—this is a major source that cannot go unaddressed. While individual projects can credibly reduce emissions, their impact on the atmosphere is still quite small. Much larger scale efforts—in the range of millions of hectares—will be needed to achieve reductions commensurate with the billions of tons of emissions caused by this sector each year.

The causes of land use change, including deforestation, are many and variable, and some are driven significantly by government policy and action. Such factors are difficult for project developers to affect or control at the individual project level. By engaging governments in forest carbon programs

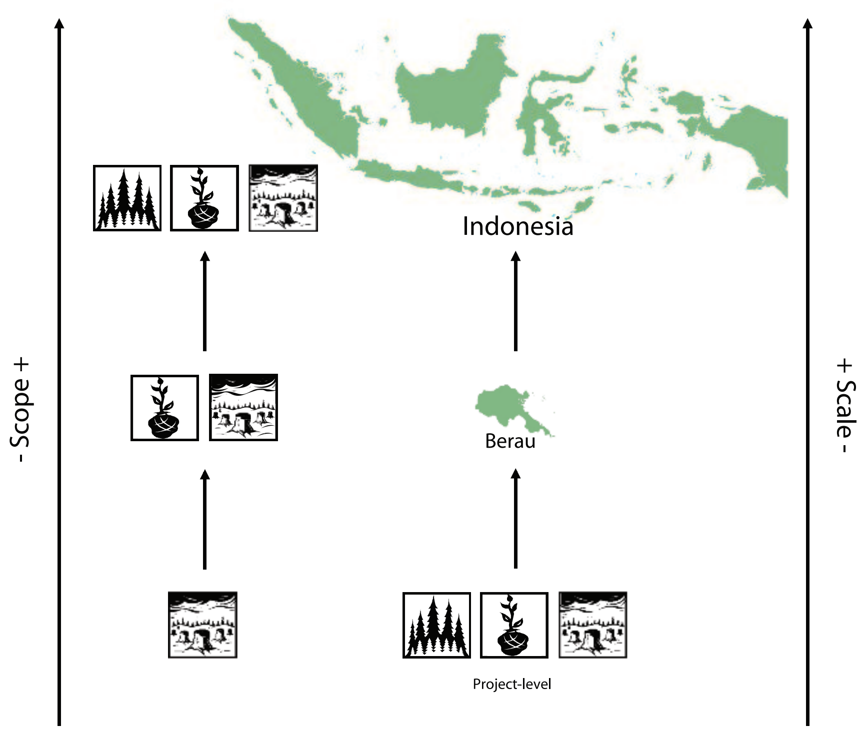


FIGURE 19 » Simple schematic depicting the range of options for both scale and scope of a forest carbon mechanism. Source: N. Virgilio.

that span entire political jurisdictions, and eventually whole countries, it is possible to address underlying policy, enforcement and institutional issues within the purview of government entities.

While individual projects can credibly deal with technical challenges such as baselines, leakage and permanence, developing the methodologies to do so over small areas can be technically complex and costly, as revealed by the project examples in this document. Nation-wide programs, especially for measuring and monitoring forest carbon, can achieve significant efficiencies through economies of scale while enabling leakage and permanence to be more easily captured and processed.

Carbon monitoring based on remote sensing data and field measurements becomes less costly per unit area as scale increases. There are efficiencies to be gained in analysis of satellite imagery, which relies on the same techniques and skills whether studying an image spanning one hectare or one million hectares. Likewise, there are significant economies of scale in the number of sampling plots needed to produce statistically robust carbon measurements across large areas. With regard to baselines, it also has the potential to become simpler and less costly per unit area to determine "business as usual" at the national scale. While project-scale activities (especially for REDD) generally must employ forward-looking spatial projections of land use change in order to capture frontier movements arriving from outside the project boundaries, historical baselines derived from recent deforestation rates tend to capture many of the spatial characteristics and frontier phenomena present within a country, and have been shown to be credible predictors of future trends (Griscom, et al., 2009).

When it comes to leakage and permanence, there are also advantages to larger-scale efforts. While individual forest carbon projects can employ measures to prevent, estimate and deduct for leakage, doing so credibly often involves complex measures such as economic modeling of commodity markets well outside the control of project developers. National-level carbon accounting and forest monitoring would enable more efficient means to capture leakage than is possible through individual projects. National forest carbon programs can function like diversified project portfolios, comprised of a variety of different efforts on the ground and at the policy level. Such programs, which span a range of activities and geographies within a country, help mitigate risks of losses that might occur from localized disturbances such as fire or pests, as well as management changes that may be confined to certain policies or places. By monitoring results across the entire portfolio, losses due to impermanence in any particular project would be reflected in nation-wide emissions numbers.

Nevertheless, implementing nation-wide programs are not without challenges. Many countries do not currently have the human capacity, financial resources, or institutions in place to plan and manage national-level forest carbon programs today. While countries work to build these programs, sub-national activities (especially those undertaken across entire political jurisdictions that can serve as microcosms of the challenges at a national scale) provide important learning opportunities as countries test options for building national capacity and institutions. As such, several proposed policy frameworks recognize the role of sub-national activities at least as part of a transition phase. Others support an important on-going role for sub-national activities, even after countries establish national carbon accounting frameworks. Some see the opportunity for private investment in concrete sub-national activities as critical to attracting the level of funding needed to substantially affect land use change.

Scope

As illustrated in the preceding sections, there are different technical challenges to measuring and accounting for carbon benefits from different types of forest carbon activities and, today, the methodologies applied to different types of projects (REDD vs. IFM vs. AR, for example) are often distinct. Nevertheless, on the ground, incorporating a range of forest carbon strategies within a single project both makes sense in terms of an integrated approach to landscape conservation and can substantially improve the overall project outcomes.

In many cases, forest degradation often catalyzes subsequent deforestation (Griscom, et al., 2009). Therefore, strategies that alleviate these drivers of degradation (including reduced impact logging, forest certification, sustainable fuel wood management and improved forest governance) can help to prevent eventual deforestation. To address the underlying causes of deforestation, some REDD projects will also include a reforestation component. Newly planted trees can provide an alternative wood source to local communities for fuel, building products and income, in effect reducing the pressure to clear primary forest for these purposes. Similarly, in areas with active commercial timber operations, improved forest management might be employed to decrease forest degradation where logging continues, while other areas might be set aside for protection as high conservation value forests. Still others may be replanted to ensure long-term sustainability of the forest. In forest carbon efforts that span large regions with a range of land use categories and practices, more complex and multi-faceted approaches will be needed to address economic, environmental and social goals.

There are a multitude of possible frameworks for addressing the scale and scope of forest carbon mechanisms being circulated by governments, NGOs and private organizations. Policy discussions within the UNFCCC and national policy development forums will flesh out the exact shape of forest carbon mechanism(s) to come. Meanwhile, demonstration projects functioning at a district or state level, can give a glimpse into what larger-scale and broader-scope efforts might look like.

on the ground

The Berau Forest Carbon Program

Large-scale forest carbon projects are needed to achieve the most significant climate change mitigation impacts. As such, TNC is co-developing the Berau Forest Carbon Program in the district of Berau, on the island of Borneo, Indonesia, which is addressing the drivers of deforestation and degradation on a regional scale using a novel approach. The project, which spans an entire political jurisdiction—a district the size of the country of Belize—takes an integrated approach to address forest-based emissions by employing a comprehensive set of strategies to address land use and deforestation. It offers a microcosm of the challenges "scaling up" forest carbon efforts, isolating site-based efforts to larger landscapes characterized by different land-use types and governed by different policies. As such, this pilot project will provide important insight into how larger-scale mechanisms can be structured and carried out on the ground in the future.

As Berau seeks economic development for its people, its forests face multiple threats from legal and illegal logging, clearing for oil palm, timber plantations and coal mining. These drivers are destroying the forests of Indonesia faster than anywhere else on earth, producing 80 percent of Indonesia's carbon emissions and placing it third among the world's top emitters of greenhouse gasses, after China and the United States (see figure 20). In 2007, the Government of Indonesia launched a national REDD strategy development process. The district of Berau, spanning 2.2 million hectares, 75 percent of which is still covered by forest, is working to become the first municipality within Indonesia to implement an integrated set of strategies to measurably conserve forests and reduce the amount of carbon it emits into the atmosphere.

Developed in collaboration with local communities, government entities at various levels, the private sector and international NGOs, including TNC, the Berau Forest Carbon Program will involve on-the-ground conservation, financial incentives, scientific monitoring, community involvement

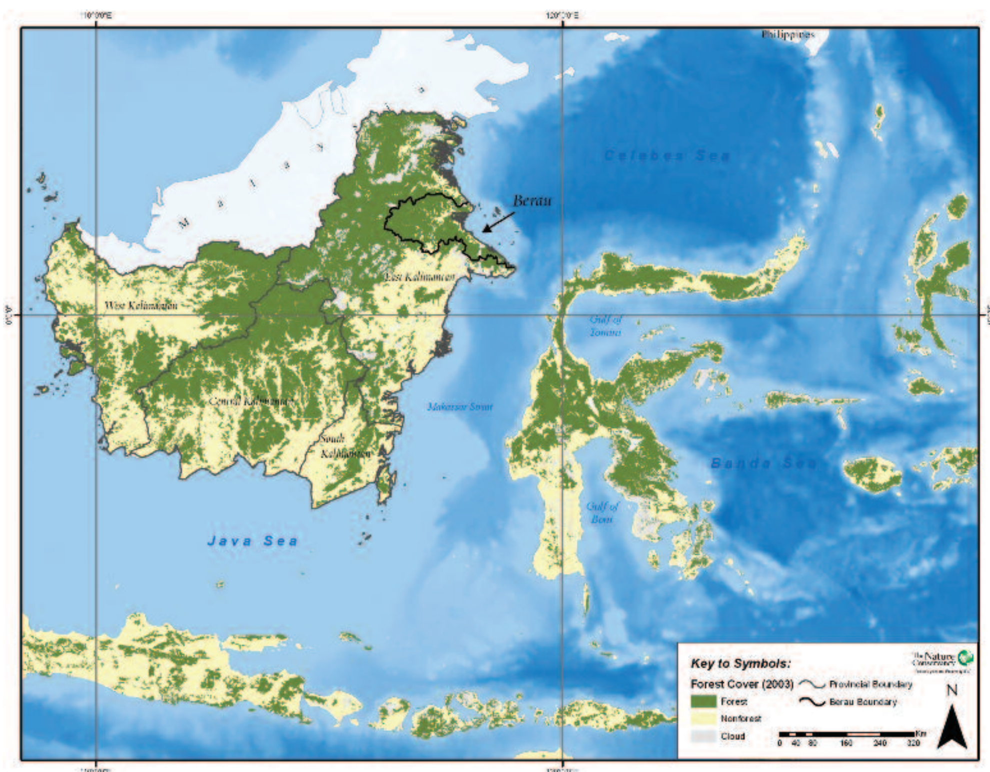


FIGURE 20 » The district of Berau is located just adjacent to areas of high deforestation. Cartography: J. Kerkering.

programs and new governance structures to bring at least 800,000 hectares of forest under effective management while reducing carbon emissions by some 10 million tons over five years. The hope is that the success of Berau's program may also spur other districts in Indonesia and other tropical forest nations to do the same.

To stop the growing threat deforestation poses to Berau's economy, communities, and the climate in general, the Berau Forest Carbon Program will work at two levels. On the one hand, the program will build the capacity of local government and local communities to engage in and support sustainable land use planning, including enhanced information management and decision-making processes. These cross-cutting efforts will be paired with specific site-level activities to reduce forest loss and emissions from certain types of land use.

First, the project will expand upon existing work with eight of Berau's 13 timber concessions to implement improved forest management (IFM) practices—such as directional felling, logging trail siting and cutting of vines which connect trees—that reduce forest degradation and carbon emissions while also maintaining jobs and wood production. The program will develop a model approach for redirecting planned oil palm plantations away from healthy and undisturbed forests to already degraded areas. Strengthened management of existing, but weakly enforced protected areas will help reduce carbon losses from illegal activities while ensuring the long-term health of critical habitat for key species such as orangutans, and the maintenance of ecosystem services such as flood prevention and clean drinking water. The measurement of impact from all of these efforts will be linked in an integrated carbon accounting and carbon monitoring framework that spans the entire district. Finally, a benefit sharing mechanism is envisioned to equitably distribute income to key stakeholders in the project, including communities and governments.

It is hoped that the successful implementation of the strategies undertaken in Berau will set the stage for larger-scale programs in other tropical developing nations. The project is being designed with every effort to allow it to dovetail with international climate change policies and crediting mechanisms as they develop. Programs such as this, which employ multiple forest carbon strategies across a large political unit, hold significant potential to achieve widespread and lasting carbon benefits from the forest sector.

Definitions and Jargon

Activity-Shifting Leakage—Occurs when a project directly causes carbon-emitting activities to be shifted to another location, cancelling out some or all of the project's carbon benefits. See "Leakage."

Additionality—Reduction in emissions by sources or enhancement of removals by sinks that is above and beyond any that would occur in the absence of a project.[38]

Afforestation—The establishment of forest on land that has been without forests for at least 50 years.[21]

Allowance—An authorization to emit a fixed amount of a pollutant (e.g. one ton of CO_2e).[22]

Annex I—38 industrialized countries and economies in transition, as well as the European Union, listed in the Kyoto Protocol, which were committed return their greenhouse-gas emissions to 1990 levels by the year 2000.[23]

Baseline—The baseline (or reference scenario) is the state against which change is measured. It might be a 'current baseline', in which case it represents observable, present-day conditions. It might also be a 'future baseline', which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines.[39]

Biodiversity—The total diversity of all organisms and ecosystems at various spatial scales (from genes to entire biomes).[39]

Biomass—The total mass of living organisms in a given area or volume; dead plant material can be included as dead biomass.[39]

Bioprospecting—The methodical search for novel pharmaceutical (and other) products from plants and microorganisms.

[21] Land Use, Land-Use Change and Forestry. IPCC, 2000—Robert T. Watson, Ian R. Noble, Bert Bolin, N. H. Ravindranath, David J. Verardo and David J. Dokken (Eds.) Cambridge University Press, UK. pp 375.
[22] U.S. Environmental Protection Agency. "Allowance Trading Basics." Clean Air Markets. 14 Apr. 2009. 2 July 2009. <http://www.epa.gov/airmarkt/trading/basics.html>.
[23] "Glossary of Climate Change Acronyms." UNFCC. 2 July 2008. <http://unfccc.int/essential_background/glossary/items/3666. php>.

Biotrade—Those activities of collection/production, transformation, and commercialization of goods and services derived from native biodiversity (genetic resources, species and ecosystems), under criteria of environmental, social and economic sustainability.[24]

Buffer—The amount of carbon credits, determined by risk analysis or the rules of a particular standard, which are set aside and not commercialized to ensure validity of carbon credits from a project in the event of leakage or impermanence.

Business-as-usual ("BAU")—The pre-intervention land use and emissions profile for a forest carbon project area. Also referred to as "baseline".

Cap and Trade—A system which involves the buying and selling of emission allowances, in which the total number of allowances is strictly limited or 'capped' by a regulatory authority at the desired level of emissions.

Carbon Accounting—The tracking of changes in carbon pools associated with human-induced sources and sinks of greenhouse gas emissions.

Carbon Pools—Carbon-containing parts of a forest ecosystem, including aboveground biomass, belowground biomass, dead wood, litter and soil.

Carbon Stocks—The quantity of carbon in a carbon pool.[25]

Carbon Benefits—The quantity of emissions avoided or carbon sequestered above the business-as-usual scenario, after appropriate deductions are made for leakage and impermanence. Usually measured in tons of carbon dioxide equivalent (tCO_2e).

Carbon Carrying Capacity—Carbon carrying capacity (CCC) is defined as the mass of carbon able to be stored in a forest ecosystem under prevailing environmental conditions and natural disturbance regimes, but excluding human induced disturbance.[26]

Compliance (Regulatory) Market—The market for carbon credits used to reach emissions targets under a regulatory regime.

Conservation Easement—A legal agreement between a landowner and a conservation organization or government agency that permanently limits a property's uses in order to protect the property's conservation values.[27]

Decompose—The breaking down of substances into constituent elements or parts.

Deforestation—Conversion of forest to non-forest (below 10% crown cover).[28]

Driver—The cause of an action (in this particular case, deforestation).

Ecosystem—The interactive system formed from all living organisms and their physical and chemical environment within a given area. Ecosystems cover a hierarchy of spatial scales and can comprise the entire globe, *biomes* at the continental scale or small, well-circumscribed systems such as a small pond.[39]

Forest—Land spanning more that 0.5 hectares with trees higher than five meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominately under agriculture or urban land use.[21]

Forest Carbon—Generally refers to the carbon stored in forests; usually in reference to climate change mitigation projects which aim to increase carbon sequestration in or decrease carbon dioxide emissions from forests.

Forest Degradation—Occurs when a forest is reduced below its natural capacity, but not below the 10 percent crown cover threshold that qualifies as deforestation.[29]

Forest Type—Refers to a discrete forested area and the species that make up that area (e.g., redwood, evergreen, etc.).

Greenhouse Gases—Gaseous constituents of the atmosphere, both natural and human caused, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor, carbon dioxide, nitrous oxide, methane, and

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[24] Biotrade Website- Definitions and Concepts: <http://www.biotrade.org/docs/biotrade-definitions.pdf>

[25] Food and Agriculture Organization of the United Nations. "Terms and Definitions for the National Reporting Tables for FRA 2005." 2005. FAO Corporate Document Repository. 2 July 2009. <http://www.fao.org/docrep/007/ae156e/AE156E03.htm#P236_10121>.

[26] Gupta, R.K. & Rao, D.L.N. 1994. Potential of wastelands for sequestering carbon by reforestation. Current Science, 66, 378–380.

[27] Triangle Land Conservancy. "Glossary of Land Conservation Terms and Techniques." Triangle Land Conservancy. 24 Nov. 2008. 2 July 2009. <http://www.triangleland.org/landowner/glossary.shtml>.

[28] Baede, A.P.M. "Annex I Glossary." IPCC Fourth Assessment Report. 2007. <http://www.ipcc.ch/pdf/glossary/ar4-wg1.pdf>.

[29] In the context of the Kyoto Protocol, as stipulated by the Marrakesh Accords, cf. paragraph 1 of the Annex to draft decision-/CMP.1 (Land Use, Land-use Change and Forestry)- contained in document FCCC/CP/2001/13/Add.1, p.58.

ozone are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human made greenhouse gases in the atmosphere, such as the halocarbons and other chlorine and bromine containing substances.[28]

High Grading—A harvesting technique that removes only the biggest and most valuable trees from a stand and provides high returns at the expense of future growth potential.[30]

Hot Air—Refers to the crediting of carbon benefits which did not actually occur.

Improved Forest Management—Forest management activities which result in increased carbon stocks within forests and/or reduce GHG emissions from forestry activities when compared to business-as-usual forestry practices.

Landsat—The world's longest continuously acquired collection of space-based moderate-resolution (30 meter) land remote sensing data.[31]

Leakage—The unexpected loss of anticipated carbon benefits due to the displacement of activities in the project area to areas outside the project, resulting in carbon emissions. Leakage can negate some or all of the carbon benefits generated by a project. Although not often acknowledged, leakage can also be positive, if best practices are adopted outside of the project area and gain widespread use.[32]

Lidar—Lidar (Light Detecting and Ranging) is a remote sensing technology that uses laser scanning to collect height or elevation data.[33]

Litter –Plant residues on the soil surface that have not yet decomposed (e.g. fallen leaves).[34]

Market Leakage—Occurs when a project changes the supply-and-demand equilibrium, causing other market actors to shift their activities. See "Leakage."

Non-Annex I—Refers to countries, mainly developing nations, that have ratified or acceded to the United Nations Framework Convention on Climate Change and are not included in Annex I of the Kyoto Protocol.[35]

Performance Period—Period of time in a regulatory greenhouse gas mitigation scheme during which countries are required to reduce emissions by a specific amount. For example, the Kyoto Protocol has a performance period of 2008-2012 during which signatories to the Protocol must reduce emissions by 5 percent against 1990 emissions levels.

Permanence—Refers to how robust a project is to potential changes that could reverse the carbon benefits of the project at a future date.

Photosynthesis—The process by which plants take carbon dioxide from the air to build carbohydrates, releasing oxygen in the process.[28]

Pixel—The smallest discrete component of an image or picture.

Radar—Short for 'radio detection and ranging,' radar sends out short pulses of microwave energy and records the returned signal's strength and time of arrival.[36]

Real—With regard to carbon markets, the assurance that credited carbon benefits actually occurred.

Reduced Impact Logging (RIL)—Logging techniques that result in significantly less damage to the surrounding forest and the forest ecosystem. Examples of RIL include directional felling, trimming of inter-crown vines, and careful road planning.

Reducing Emissions from Deforestation and Degradation—Activities that reduce the conversion of native or natural forests to non-forest land, which are often coupled with activities that reduce forest degradation and enhance carbon stocks of degraded and/or secondary forests that would be deforested in absence of the project activity.[37]

Reference Period—see "Baseline".

Reforestation—The establishment of forest on land that has not had tree cover for at least 10 years.[21]

[30] North Carolina Forestry Association Website: <www.ncforestry.org/docs/Glossary/term.htm>.
[31] USGS Website: <http://landsat.usgs.gov/about_project_descriptions.php>.
[32] IUFRO. "Carbon in Forests Multilingual Glossary of carbon-related forest terminology." 2 July 2009. <http://iufro-archive.boku.ac.at/silvavoc/carbonglossary/main.php?type=aph >.
[33] "Glossary of Terms." Ordnance Survey Ireland. 2009. 2 July 2009. <http://www.osi.ie/en/alist/glossary-of-terms.aspx>.
[34] U.S, Environmental Protection Agency. "Glossary of Climate Change Terms." Global Warming. 2000. 2 July 2009. <http://yosemite.epa.gov/oar/globalwarming.nsf/content/glossary.html>.
[35] IPCC Glossary of Climate Change Acronyms: <http://unfccc.int/essential_background/glossary/items/3666. php#N>
[36] USGS Online Glossary: <http://landsat.usgs.gov/tools_glossary_R.php>
[37] "Voluntary Carbon Standard—Guidance for Agriculture, Forestry and Other Land Use Projects (VCS 2007.1, 2008)." VCS Association. Available at: www.vc-s.org

Remote Sensing—Instruments that record characteristics of objects at a distance, sometimes forming an image by gathering, focusing, and recording reflected light from the Sun, or reflected radio waves emitted by the spacecraft.[36]

Resolution—A measure of the amount of detail that can be seen in an image.[36]

Scale—The relative physical size/reach of forest carbon activities.

Scope—The range of forest carbon activities included in a project.

Source—Any process, activity, or mechanism that releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol into the atmosphere.[28]

Sequestration—The process of increasing the carbon content of a reservoir/pool other than the atmosphere (in this case specifically referring to uptake by trees and soil).[39]

Standard—Rule or code mandating or defining product performance. In this particular case, referring to sets of rules set forth for projects within the voluntary carbon market.[38]

Sink—Any process, activity or mechanism that removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol from the atmosphere.[28]

Verification—The periodic independent review and ex-post determination of the monitored reductions in anthropogenic emissions by sources of greenhouse gases or increases in carbon stocks (carbon benefits) that have occurred as a result of a project activity during the verification period.[39]

Voluntary Carbon Market—Unregulated market for carbon credits.[40]

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[38] Verbruggen, Aviel. "Annex I Glossary". IPCC Fourth Assessment Report. 2007. <http://www.ipcc.ch/pdf/glossary/ar4-wg3.pdf>.
[39] "Appendix I: Glossary". IPCC Fourth Assessment Report. 2007. <http://www.ipcc.ch/pdf/glossary/ar4-wg2.pdf>.
[40] "Glossary." Carbon Counter. 2007. 2 July 2009. <http://www.epaw.co.uk/carbon/glossary.html>.

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PHOTOGRAPHY—COVER (top to bottom): Aerial view of a logged forest area (logging) in the area of the Paiva Castro Reservoir and adjacent towns whick expand out from Sao Paulo. The reservoir is part of the Cantareira system which provides fifty percent of Sao Paulo's drinking water. Photo Credit: © Scott Warren; A Bolivian forester measures a tree trunk as part of the sustainable logging process near Cururu. Photo Credit: © Ami Vitale; Seedlings grow at a large, state-owned, tree nursery near the city of Guarapuava, Parana state, Brazil. Photo Credit: © Scott Warren INSIDE COVER: Using conventional logging methods, the P.T. Inhutani Timber company harvests timber in the Inhutani conventional logging concession situated in the tropical forest of East Kalimantan, Borneo, Indonesia. Photo Credit: © Bridget Besaw PAGE 1: Aerial view of timber cutting near Cachoeira Reservoir. The watershed and reservoir are part of Brazil's Cantareira system (the largest system of public water supplies in Latin America) which provides fifty percent of Sao Paulo's drinking water. Photo Credit: © Scott Warren PAGE 9: Palms at Corcovado National Park in Costa Rica in Central America. Photo Credit: © Janie M. Mertz PAGE 15: istock.com PAGE 51: Harvest timber in East Kalimantan. Using conventional logging methods, the P.T. Inhutani Timber company harvests timber in the Inhutani conventional logging concession situated in the tropical forest of East Kalimantan, Borneo, Indonesia. Photo Credit: © Bridget Besaw PAGE 55: Visitors explore the tropical rainforest (el bosque tropical) located in the Osa Peninsula of Costa Rica. Photo Credit: © Sergio Pucci/TNC BACK COVER: Abandoned logs in log yard fills a large field near the village of Long Gi, East Kalimantan. Photo credit: © Mark Godfrey/TNC

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