Cover design by Nancy Gelband

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"Such a Tide as Moving Seems Asleep"

Angelo A. Calvello, PhD
Editor in Chief

When we started the *JEI,* our plan was to ride the wave of change. Instead, we have swum against the tide. But necessarily so. The demand for environmental investments remains greater than ever, especially as governments are distracted by the struggle to meet "more pressing" economic and social agendas. This is particularly resonant for the United States. As recently as a year ago, President Obama talked about a "Sputnik moment," when we would commit ourselves to creating critical technologies that would give the U.S. a leadership role in the mitigation of and adaptation to greenhouse gas emissions. While this moment seems to have passed unfulfilled, the temporal imperative for change in our energy mix and energy policies remains. "This is a critical moment both for cutting carbon dioxide emissions and for the U.S. economy," says Letha Tawney of the World Resources Institute.

My discussions with asset owners and managers, corporate and NGO leaders, and academics continue to reveal robust environmental investment ideas and opportunities that offer a competitive return per unit of risk. But these ideas and opportunities are discrete and typically driven by the will of a small group or an individual. (The Global Canopy Programme's work on forest bonds is one such example.) There is no broad programmatic environmental investing. Scalable market-based solutions to our most pressing environmental challenges require the commitment of substantial investment capital and significant patience. They also require "loud, long, and legal" governmental policies and the political will to consider the needs of future generations (see Norway as an example of such will). So for now, we continue to swim on, buoyed by the work and actions of a dedicated, thoughtful group and hopeful that the tide will soon turn.

Thanks for your continued support,

Point of View

The Energy Equation

William H. Page
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The hurdles for clean technology (clean tech) equities have been steep and numerous lately. A continued lack of global climate change legislation with associated low carbon prices has been a clean tech headwind, as have decreased government incentive structures in the European Union. As the United States continues with election year antics and limited Washington comity, hope for any substantial U.S. energy policy has been vanquished. The term *climate change*, while common parlance in most regions of the world, is now treated with disgust in some developed markets by those with interests in incumbent fossil fuel extraction and distribution. Despite these hurdles, I remain not only constructive on the near- and long-term prospects for clean technology investing, but believe clean tech will be the key solution for global economic expansion.

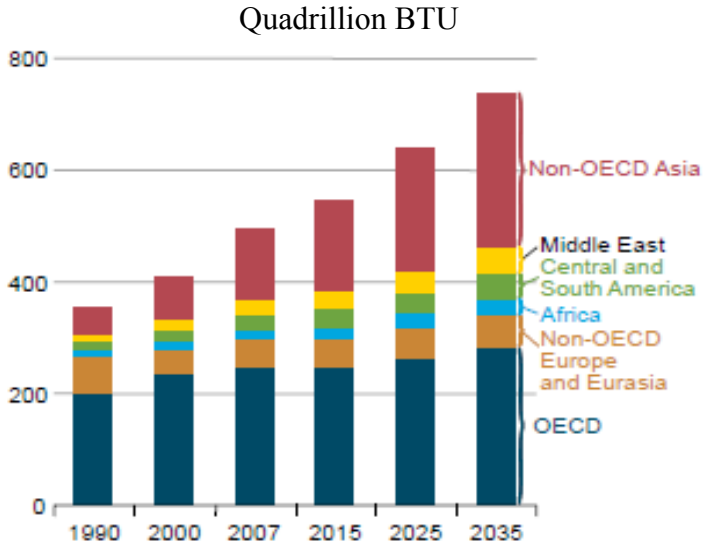
In managing the Essex Global Environmental Opportunities Strategy (GEOS), we utilize a broad thematic approach and believe that listed equity companies that recognize the opportunities and costs associated with de-carbonization and resource scarcity will deliver strong shareholder returns over time. Our thematic approach, modeled after findings such as the Stern Review and the Intergovernmental Panel on Climate Change, invests across commercially viable leading technologies that increase the efficient use of scarce resources. While politicians and bureaucrats bicker about climate change policy, I believe our world is experiencing a secular shift greater than that of the Industrial Revolution. The case for clean-technology equity investing is based on our observation that as the economic baton is passed from the established Organisation for Economic Co-operation and Development (OECD) economies to the emerging growth *establishing economies*, the global economic levers are increasingly being pulled by the non-OECD regions. I agree with IMF projections that by 2014 the emerging markets will have overtaken the OECD countries in total share of global gross domestic product (GDP).

This economic shift is compounded by demographics and climate change, as well as by associated trends such as the global rise of the middle class and urbanization. Many of these trends have been manifesting for years, yet are now rising to the fore in concert and providing ample boosts to newfound supply-demand imbalances. In the end, I believe the main driver for clean tech can be summarized by a short yet complex equation:

$$GDP = BTU;$$

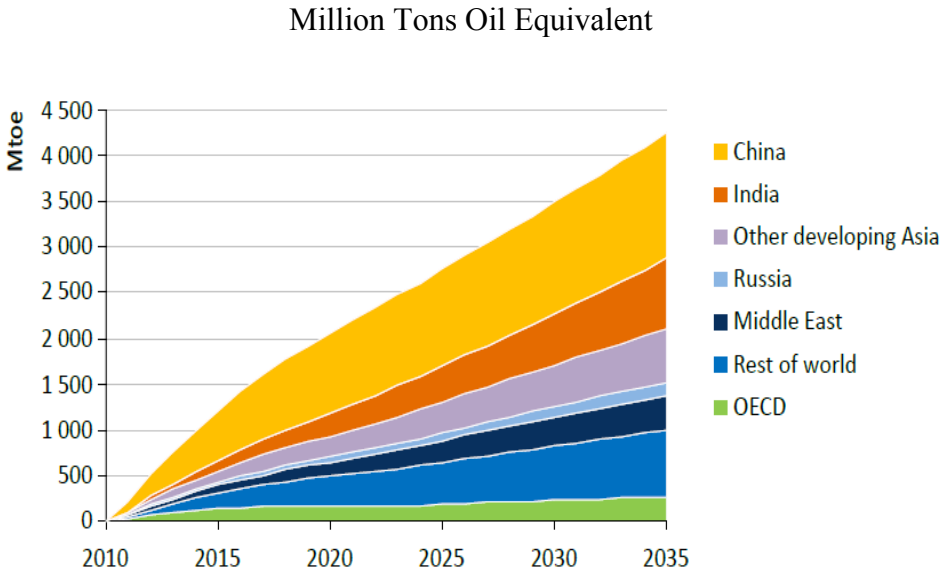
Without British Thermal Units (BTUs) of energy, and the expansion of those units, there can be no growth in GDP. Energy is the key ingredient for economic expansion, and the superior economic growth experienced in non-OECD regions is the reason their energy appetite surpassed that of the OECD countries back in 2006. The Energy Information Administration (EIA) projects a 50% increase in global energy consumption from 2009 to 2035, with over 84% of growth in world energy use coming from non-OECD regions and driven by the economic trajectories of China and India (Figure 1). International Energy Agency (IEA) models concur, projecting an increase in global energy demand by one-third over the next twenty years, with China and India accounting for 50% of said growth (Figure 2).

Figure 1: World Energy Consumption by Region



Source*: EIA Annual Energy Outlook 2011.*

Figure 2: Growth in Primary Energy Demand



Source*: IEA World Energy Outlook 2011.*

While this shift in energy demand is driven by economic growth, the trend is secular in nature since these establishing economies develop middle-class domestic consumption bases. In China, domestic consumption contributed to over 50% of overall GDP growth in 2011, very close to the record-high 53% in 2009. As China's economy transitions, the labor surplus is declining and wages are rising. This astonishing trend can be summarized in a recent Ernst & Young study (*Growing Beyond: Innovating for the Next Three Billion*) addressing the rise of the consumer class in the emerging economies, which is projected to increase from almost two billion middle class consumers today, to five billion by 2030.

The economic growth trends in these developing economies, coupled with secular catalysts such as the rise of the middle class, have exacerbated demand for resources beyond energy. A supply and demand imbalance in total grain production, which has not kept pace with global consumption, has been present since 2000. The USDA is projecting that global food demand could rise up to 50% over the next twenty years, largely driven by heightened protein consumption by the *next three billion*. This consumption shift could be exacerbated by declining agricultural yields since many regions with high agricultural productivity are at risk of long-term drought from global climate changes. We view water scarcity as an investment opportunity, since irrigation and other agricultural productivity technologies are applied to areas experiencing long-term drought and decreased water tables.

De-carbonization and resource scarcity technologies exist across our economy and can be applied with commercial viability now in the absence of climate change legislation,

government incentives, or energy policy. GEOS invests in global growth equity companies that provide solutions to the world's challenges through the efficient use of scarce resources. These solutions include: improvements in agricultural productivity, increased energy efficiency, water conservation and reuse, greater use of renewable energy, sustainable living, and more efficient transportation. Applied broadly and across economic sectors and industries, clean technologies can assist in lowering energy and other operating costs. Most of the revenue growth generated by GEOS portfolio holdings stems from leveraging the hunger for energy sources and efficiencies in China and other emerging regions. China is aggressively scaling and deploying energy technology in every form since it desperately needs BTUs and natural resources for energy deployment. The well-reported solar dominance of China, leveraging what was initially Western technology, has allowed China a growth export and distributed energy source for domestic consumption. The same holds true for Chinese wind turbine manufacturers, who are rapidly encroaching on European and U.S. technological leadership.

Many multinational corporations are also developing, purchasing, and leveraging clean technologies as they seek to limit operating costs and risks stemming from these trends. Natural gas is rapidly becoming a complementary transport fuel to diesel for commercial fleets, as shipping companies move to hedge against higher oil prices. Light emitting diode (LED) technologies are being deployed in industrial settings with 24-hour, 7-day-a-week lighting usage, given paybacks that average less than 18 months before any potential energy efficiency incentives.

The establishing economies are transforming the global economic landscape and are now driving demand for energy and natural resources. To meet this demand shift, hedge this risk, and benefit from this great long-term opportunity, clean technology will be a well-positioned beneficiary. Clean tech is broadly adaptable and commercially viable for solving an extremely complex equation: GDP = BTU.

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UNLOCKING FOREST BONDS

A HIGH-LEVEL WORKSHOP ON INNOVATIVE FINANCE FOR TROPICAL FORESTS

Workshop Report

Hosts

WWF

GCP GLOBAL CANOPY PROGRAMME

Climate Bonds INITIATIVE

Financial Partners

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Disclaimer

This document reports on the discussion that took place during the workshop and does not necessarily represent the views of the workshop hosts or financial partners. It reports on the broad variety of presentations, experience and views put forward by workshop participants. Some additional background research was carried out to fill gaps in information and provide a coherent synthesis of the workshop. The workshop took place under the Chatham House Rule.

Note on terminology

The term "forest preservation" is used throughout this document to collectively refer to the five types of activity to sustain forests: forest enhancement, avoided deforestation, avoided forest degradation, sustainable management of forests and conservation of forest stocks.

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SCALING UP FOREST FINANCE
STATEMENT FROM THE WORKSHOP HOSTS

Tropical forests contain more than half of all terrestrial life on Earth. [1] The biodiversity and ecosystem services these forests support are economically valued in the order of *trillions of dollars annually* [2] and underpin climate, food, energy, water, health and livelihood security for millions of people across the globe. Yet the rate of forest loss "is still alarmingly high". [3]

The importance of forests has received increased attention in recent years, particularly through international climate change negotiations and efforts to develop a mechanism for reducing emissions from deforestation and forest degradation and conserving, sustainably managing and enhancing forest carbon stocks (collectively referred to as REDD+). One recent estimate suggests that the scale of financing required to halve deforestation will increase over the current decade, reaching US$30 billion annually by 2020. [4] Forest finance therefore must increase dramatically to achieve the goals of the UN Framework Convention on Climate Change (UNFCCC) as well as those of the UN Convention on Biological Diversity (CBD), Millennium Development Goals (MDGs), and other national and international agreements. Donor countries are unlikely to have the resources or political will to act alone and provide the full level of finance required. Because of this, new strategies are urgently needed to use the limited public funds available to the greatest effect possible.

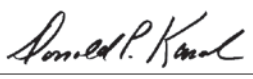
One such strategy could be the use of bonds to help finance forest preservation. With large-scale investments in critical services, such as energy or transport infrastructure, a public-private partnership is often established to balance the risks and rewards between the public and private sector and finance the investment at least in part with a bond. There are many common characteristics between these types of built infrastructure investments and investments in ecological infrastructure such as tropical forests. In particular, both require large upfront capital expenditures.

Recognising these similarities, for half a decade the forest finance community has been developing the concept of forest bonds as a tool for financing forest preservation. Lessons have been drawn from precedents set in other sectors that face similar funding challenges, such as healthcare, where bonds have been successfully used to raise billions of dollars. [5] Although the idea has faced many hurdles, the first rainforest bond is poised to be issued soon. [6] If forest bonds prove successful, an urgent focus on further developing this financing strategy will be required to increase the scale of financing for REDD+.

Unlocking Forest Bonds was a high-level workshop held to discuss the necessary conditions for bonds to become a useful large-scale financing mechanism in the effort to save tropical forests. Hosted by WWF's Forest & Climate Initiative, the Global Canopy Programme and the Climate Bonds Initiative, the workshop brought together international experts in forest finance and related areas including government representatives, NGOs, forest project developers, forest financiers and consultants.

Unlocking Forest Bonds set out to identify the issues, obstacles and critical steps to making forest bonds work for all stakeholders. This report synthesises the discussion that took place at the workshop. Although bonds were the core topic, a wide range of issues related to scaling up forest finance was discussed. Accordingly, the workshop outcomes are not limited to forest bonds alone but are broadly relevant to efforts to leverage private-sector finance for forests.

The need to scale up forest finance is unequivocally urgent, not only to combat climate change and provide a host of ecosystem services the world depends on, but also to secure a prosperous future for the world's forested countries. We hope that this report helps communicate some of the remaining obstacles and how to deal with them. Though the challenges are great, they can be overcome, and it is in all our interests to do so.



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EXECUTIVE SUMMARY

To reach the scale of finance needed to combat climate change, protect and manage forests, and maintain the world's natural capital, increasing engagement with the private sector is necessary. That engagement can come in many forms, and bonds are one option. By using public funds to support private-sector investment in forests, bonds could leverage additional finance from global capital markets. Although forest bonds alone are not the solution to saving the world's tropical forests, they could play an important role in catalysing the scale of financing needed to tackle global forest loss.

Time is fleeting, scale is essential

Two fundamental issues for financing forest preservation are time and scale. Time is a concern because the longer we wait, the more forest we lose. This increases greenhouse gas emissions and biodiversity loss while degrading the livelihoods of forest-dependent communities and reducing the provision of other ecosystem services, vital on local to global scales. All of these effects reduce the resilience of forests and the broader economic-ecological systems that depend on them, increasing the risk of irreversible forest loss and long-term damage to the global economy.

The scale of financing is important for three reasons. First, the challenge itself is large and requires significant levels of finance to overcome. Second, investing at scale can reduce the risk of investing in one place and simply displacing forest degradation across a given forest landscape. Investing at scale can also target multiple types of investment: multiple sectors that directly and indirectly impact forests must be improved to protect forests from within and reduce the external drivers of deforestation. Third, the investment proposition needs to be large and liquid in order to attract the largest investors.

Why bonds?

Forest bonds can play a powerful role in financing forest preservation as the policy landscape, globally and within countries, takes shape. The issuance of bonds directly addresses the concerns of time and scale, enabling issuers to raise large-scale finance now that will be repaid by existing and anticipated future income. Importantly, bonds are also a familiar and proven mechanism for leveraging private-sector finance; they have been used to finance public-private partnerships around the world that have invested in infrastructure, development and health.

Carbon finance is a key opportunity, but demand is weak

Prospective issuers of forest bonds will need to convince investors that the cash flows they plan to pay the bond back with are sufficiently secure and predictable. Carbon markets are an important source of cash flows that could be used to back a bond, but they are not yet reliable enough. Lack of regulatory certainty within the UNFCCC and the absence of demand from large compliance markets such as the European Union's Emissions Trading Scheme (EU ETS) cast doubt on future income from regional or global compliance carbon markets. Demand for forest carbon through smaller markets, such as the California cap-and-trade programme or the voluntary carbon market, offers some potential for return on forest investments now and is useful in the context of a broader range of income streams.

A range of income streams could support a forest bond

Forest bonds should not rely solely on forest carbon revenue and could potentially be linked to income from other ecosystem service markets (e.g. water, biodiversity), sustainable timber and agricultural markets, regulation (e.g. taxes, liability regulation), and forest-friendly lending (e.g. to ecosystem-dependent small- and medium-sized enterprises). Although some of these cash flows could come through voluntary markets and actions, support from the public sector through regulation or other commitments will be needed to ensure that these cash flows materialise, making forest preservation an attractive investment.

The investment proposition must be attractive to investors…

Impact investors and other socially responsible financiers target clear social and/or environmental returns alongside financial returns. They may be willing to sacrifice financial returns for social and environmental returns and potentially compromise in other areas, like secondary market liquidity. This could make these investors the ideal pioneers in a new asset class like forest bonds. Larger insti-

tutional investors such as pension funds will generally not be able to sacrifice financial returns for other forms of return due to their fiduciary duty. Yet, under the right conditions, larger institutional investors could be interested in forest bonds. Forest bonds should target impact and socially responsible investors initially, while the market develops, then begin to target institutional investors as the forest bond market deepens. A tranche structure with different risk/return profiles could also be used to simultaneously appeal to both groups.

...and equitable for all stakeholders

Forest preservation involves multiple stakeholders, including private investors, public-sector funders, regulated businesses and, importantly, the people whose livelihoods and well-being depend on forests. To be successful, a forest-financing strategy that leverages private-sector finance must ensure that benefits are equitably shared amongst all stakeholders, rather than accruing as profits to the private sector alone. Private investors that provide capital deserve an appropriate return for the risk to which they are exposed, but if they receive a disproportionate return, the entire approach to forest finance could be undermined, particularly in the eyes of forest countries and communities.

Balancing risks and rewards among different actors is only feasible with political will and a strong policy framework in place. Examples of these conditions are beginning to emerge, particularly at the sub-national level. Amazonian states, such as the State of Acre, have developed or are developing strong statewide frameworks to recognise the multiple values of their forests and to establish the policies, institutions and public-private partnerships to secure that value by investing in both forest protection and reducing the drivers of deforestation.

Improved access to finance for eco-entrepreneurs may be needed

In some cases, the first issue to resolve will be how to make it possible for enterprises, communities and households to access the finance they need to shift towards more forest-friendly livelihoods and land uses. Such activities often require greater upfront expenditures than non-sustainable activities. So actors in forest countries that want to adopt more sustainable land uses and access the associated cash flows will not be able to if they do not have access to affordable financing first. Forest bonds provide one avenue through which the public sector could support the provision of affordable financing to forest-friendly activities.

Risk mitigation is paramount

Potential investors are concerned about a number of risks, including security of future cash flows and failure of enterprises, but they are particularly concerned about political risk. Public-sector funds could ease such risk through a variety of actions, including paying for or providing political risk guarantees. However it is achieved, mitigating risk will be a crucial factor in attracting potential investors to a forest bond.

Assurance of environmental and social benefits is essential

As with any form of forest finance, safeguards will be required to ensure the environmental and social integrity of forest bonds. All potential stakeholders in a forest bond require this, even potential bond investors, since they are motivated to invest (and potentially take lower returns) because they want to make an investment that has environmental and social returns. Standards that are currently under development for forest and other green bonds will provide assurance of these sustainability benefits.

International donor finance has a catalytic role to play

A primary role of the public sector is to find the appropriate leverage point to make large-scale forest finance attractive to both the investors that will provide finance and to the enterprises and communities that will carry out activities to preserve forests. To do this, international donors and multilateral institutions can support a bond by acting to:

1 Ensure cash flows arise to reward investment in forest preservation;
2 Make finance or capital expenditure more affordable for forest-friendly enterprises; and
3 Become directly involved in structuring the bond by, for example, providing credit enhancement.

The relative effectiveness of these strategies will depend upon the context of the forest landscape or country where the finance is to be delivered, but in all cases a combination of approaches is likely to be needed. Multilateral institutions could play an additional catalytic role by issuing a forest bond themselves and helping to pump-prime the forest bond market.

Demonstrations and dialogue will improve understanding

A disconnect remains between the international investor community, from which finance would be leveraged, and the projects on the ground that would use that finance. The greatest catalyst to stimulating continued work in this area would be the issuance of a forest bond to demonstrate how capital from international markets can be funnelled down to forest-level actions. Lessons from that experience would highlight how to continue improving on the mechanism and how to scale up forest finance in the future.

At the same time, dialogue between private- and public-sector actors must also be increased. There is currently a lack of understanding of each sector's expectations and needs for working together to leverage finance. Communication between the private and public sectors must be increased if public funding is ever going to catalyse a much larger scale of forest preservation than it can achieve on its own.

INTRODUCTION

The State of REDD+

The UNFCCC's 15th Conference of the Parties (COP-15) held in Copenhagen in 2009 was largely seen as a political and diplomatic failure, which raised serious questions about the appropriateness of this forum for dealing with climate change negotiations. As a result, many observers and participants entered COP-16 in Cancún the following year with low expectations and the perception that Cancún was the last chance for the UNFCCC negotiating process to prove its worth. Heading into the negotiations, agreement on mitigating climate change through forest protection (i.e. REDD+) was believed to be the issue on which there was greatest consensus. Agreement on REDD+ was thus seen as a litmus test for climate change diplomacy; it was the last great hope of the last great hope. And with strong leadership in Cancún, some agreement was achieved.

For forests, the Cancún agreement was generally considered successful, although there is much left to be decided. [7] Cancún did not specify what exactly is being paid for under a REDD+ mechanism, how to pay for it or how to measure results. The metric of forest preservation under the UNFCCC has been established as carbon emissions (or their absence), but while this commodification of forests has benefits for scaling up efforts to combat climate change, there is concern that negative effects may arise if forests are valued only for their carbon. Debate continues on the safeguards that must be put in place to prevent negative impacts on biodiversity and people, respectively the foci of the CBD, and MDGs and UN Declaration on the Rights of Indigenous Peoples. Some progress was made, however, on safeguards, reference levels, and monitoring, reporting, and verification (MRV) protocol during the Climate Change Conference in Bonn in June 2011.[8]

Carbon Markets and Forest Carbon

The existing market for forest carbon is largely driven by demand from voluntary buyers of carbon offsets and is small, opaque and illiquid compared to compliance markets for carbon. As a result, compliance markets attract much more capital. Although compliance markets have the potential to generate large demand for forest carbon, significant growth in trading volumes of forest carbon in these markets appears unlikely in the near term.

The EU ETS, the world's largest compliance market, is not planning to accept international forest carbon credits for compliance in Phase III (2013-2020). Current rhetoric in Brussels implies it is unlikely that forest carbon credits will be accepted in Phase IV either. That implication is supported by increasing requirements for the quality of all international carbon offsets and a tightening of the limits on their use for compliance in the EU ETS. In contrast, the State of California looks set to become the first compliance market in the world to accept international forest carbon credits. Based on current proposals, however, California's entire annual demand could be satisfied by the supply from just one of the states with which it is partnered (e.g. the State of Acre in Brazil).

There is still potential for the US to establish a compliance carbon market. If the US were to establish a compliance trading-scheme that includes international forest carbon credits, it is likely that significant demand would be created and that other major economies, such as the EU and Japan, would be pushed to include international forest carbon credits as well. There is no expectation, however, of any movement by the US until after the next presidential term begins (in January 2013) at the earliest.

So, in the short to medium term, REDD+ faces a sizeable finance gap [9] with no imminent market or other mechanism that could generate large-scale demand for forest carbon and provide a meaningful price signal for investors to fill that gap. Even if such a proposal were to emerge, uncertainties exist as to how long it might take for a REDD+ mechanism to become fully operational. [10] If progress is to be made at the scale required and within the time required, alternative, complementary approaches to forest finance are needed.

Securing Forest Friendly Development

While demand for forest carbon is slow to grow, donor countries are looking for ways to stimulate forest preservation now, particularly by reducing the drivers of deforestation. In addition to payments for forest carbon, other payments for reductions in deforestation and unsustainable land use are emerging. Achieving sustainable land uses, however, requires transitioning of livelihoods to more sustainable activities, which in turn requires significant upfront investment to make that shift. In many tropical forest countries, the cost of capital and difficulty accessing it is a significant barrier to that transition.

In these circumstances, catalysing successful preser-

vation of tropical forests will first require support for developing and financing alternatives to forest-degrading activities. Once a strong platform for a forest-friendly, low-carbon development is in place, a pay-for-performance mechanism can then be used to enhance and sustain a country's trajectory along that path. To do this on the scale of a country requires large-scale upfront investments. Similar investments are familiar to those involved in infrastructure and economic development finance, which use financing mechanisms such as bonds and public-private partnerships. Under the right enabling conditions, these mechanisms could also be used for financing forest-friendly development, offering a significant opportunity for donor countries—looking for new ways to deliver official development assistance (ODA) in a catalytic approach—to leverage private-sector financing and ensure the large-scale investment that is needed is delivered.

Photo by Olivier H, Creative Commons on Flickr

TOPIC 1
BUY-SIDE PERSPECTIVE

Key Points

To access the deepest pools of capital managed by institutional investors, forest bonds will need to be simple, transparent, comparable and liquid, and must hold an investment-grade credit rating.

The first forest bonds should target investors with a socially responsible investment mandate that may be willing to compromise on some financial aspects of the investment in return for assured environmental and social returns.

Adopting a tranche (i.e. segmented) structure would enable forest bonds to attract multiple types of investors at the same time, each with different requirements for risk, financial returns, and social and environmental returns.

Governments of donor countries can incentivise investors by providing tax breaks on forest-friendly investments such as forest bonds.

Looking to Capital Markets

The bond markets are a large pool of finance that forest bond issuers could potentially tap into: outstanding global bond issuance totals around US$100 trillion. Some multilateral institutions investing in sustainable development have already begun to target that source of finance, with US$3.5 billion of green bonds issued in 2010.[11] The green bonds issued so far help finance climate change mitigation and adaptation, including renewable energy and water infrastructure. Whilst they can include forest investments in the portfolio of projects they finance, to date, forests represent only a small portion of such a portfolio and are included only for their value in mitigating and adapting to climate change. A forest bond would focus specifically on forests and recognise the multiple benefits of forests in securing climate, food, water, energy, health and livelihoods.

Core considerations for prospective investors in forest bonds will mirror those for any other bond: returns, risk and liquidity. Different types of investors, however, will have different requirements in relation to those considerations, and some will include requirements for social and environmental returns on their investment in forest bonds. Ultimately, forest bonds should be mainstream and attractive to institutional investors. The early forest bonds, however, will need to target more niche investors.

Impact Investing

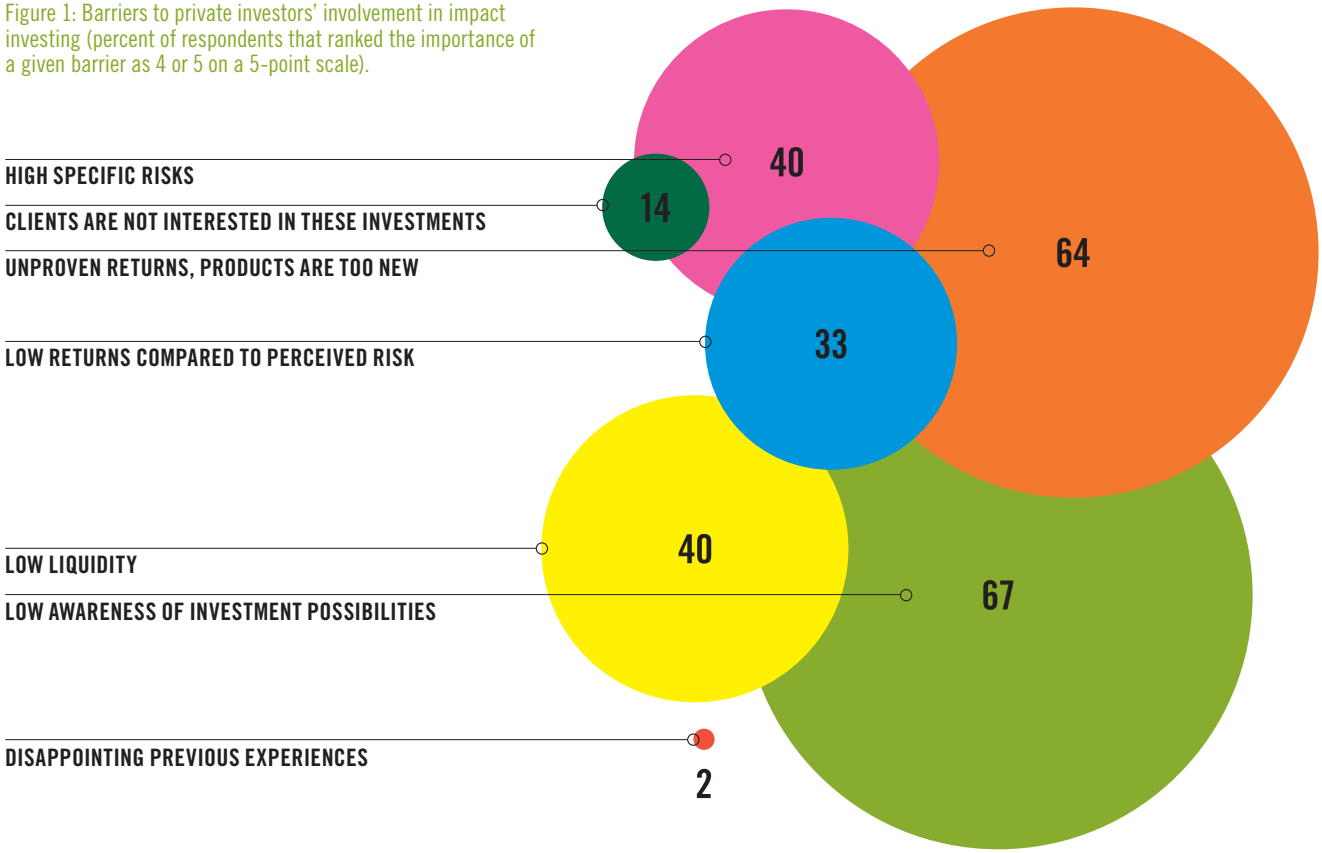
Impact investing is an emerging asset class that describes investors seeking to create positive social and/or environmental impact beyond financial returns.[12] There are around 100 active impact investment funds,[13] catalysing a market that could grow to US$500 billion or more of assets under management (AuM) in the current decade,[14] which would provide a significant pool of finance that forest bonds could attract. As opposed to other investors, impact investors are often willing to compromise on the financial attributes of an investment in return for the social or environmental return they seek to create.

A brief survey[15] of private investors' perceptions of green bonds indicated that when considering investing in such bonds, they might be willing to compromise on the return, risk and liquidity of that investment compared to a benchmark (Table 1). They are not willing to compromise on their preferred maturity or the assurance of environmental benefits. Reaching this type of investor will require overcoming some barriers (Figure 1). The two most important barriers for private investors' involvement in impact investing are low awareness of the investment opportunities and the short track-record of such products,

Table 1: Private investors' desired features of a green bond and willingness to compromise on those features.

FEATURE	PREFERENCE	COMPROMISE?
Maturity	≤ 10 years	No
Credit Rating	≥ A–	Yes
Interest Rate	Comparable to benchmark	Yes
Liquidity	Narrow daily spreads	Yes
Environmental Benefits	Assured	No

Figure 1: Barriers to private investors' involvement in impact investing (percent of respondents that ranked the importance of a given barrier as 4 or 5 on a 5-point scale).



meaning the asset class is unproven in their eyes. The third most important barrier is high specific risks, such as emerging market risk.

Socially Responsible Investment

Not far removed from impact investing, the socially responsible investment (SRI) market is composed of a heterogeneous collection of investors that have all agreed to uphold certain principles for responsible investing, and they are another class of investor to which forest bonds could cater. If the SRI market is defined by asset managers that are signatories to the UN Principles of Responsible Investment (UN PRI), globally there are approximately US$20 trillion of SRI AuM, [16] of which nearly US$10 trillion is allocated to fixed income. Although some SRI asset managers may act like impact investors by being willing to compromise on the financial aspects of their investment, 73% of SRI AuM are held by pension funds, which are strict institutional investors that cannot make that compromise.

Institutional Investors

Institutional investors hold roughly US$70 trillion in assets under management. [17] As opposed to impact and some socially responsible investors, institutional investors generally operate under a strict fiduciary duty to maximise risk-adjusted financial returns and are not typically in a position to sacrifice financial performance for social or environmental returns. Institutional investors are similarly unlikely to compromise

on other characteristics of a product—such as credit rating or liquidity—even if the risk-adjusted returns are comparable to other investments in their portfolio. [18]

Institutional investors with long-term liabilities could, however, be attracted to long-dated forest bonds, provided they are relatively easy for investors to understand, compare, trade and book into their risk management systems. The more standardised and commoditised a forest bond is, the more attractive it will be to institutional investors.

A forest bond must also be transparent in its environmental integrity to attract institutional investors that rarely have the time or sector-specific expertise to carry out due diligence on the environmental benefits associated with an investment product. To address this need, the Climate Bonds Initiative launched the International Standards and Certification Scheme for Climate Bonds in December 2010. By adhering to a known and agreed set of standards, the process of certification outsources the responsibility of environmental due diligence to a third party, which gives investors greater certainty of the environmental integrity of green bonds.

Conclusion: Targeting Multiple Types of Investors

To reach institutional investors and the deep pools of capital they manage, forest bonds must be simple, transparent, comparable and liquid and hold an investment-grade credit rating. As with most new environmental markets, however, forest bond markets will need something to pump-prime the market and help reach a critical mass before it can become mainstream and easily accessible to those investors. The first forest bond issuances should target impact and socially responsible investors that have a specific interest in environmental returns and may be willing to compromise on the financial aspects of an investment in return for tangible and assured environmental returns. Multilateral development banks could also become more active in stimulating the market, not only through their capacity to guarantee or issue [19] green bonds, but also in their own role as investors through their own treasury.

Early forest bonds could offer a lower-than-benchmark guaranteed return, but with a carbon or ecosystem service upside should the proper policy framework be put into place. [20] Such products could possibly raise a few hundred million dollars and, importantly, get the market started. To continue pushing the market to scale, other strategies could also be implemented. Policymakers could incentivise investors through, for example, tax breaks on forest-friendly investments. [21] Forest bonds could initially be designed in partnership with the governments of donor countries that have relatively high tax rates but are motivated to undertake environmentally friendly actions.

Although it is likely that impact and socially responsible investors would be the pioneers in a new market for forest bonds, as the market developed, the use of a tranche (i.e. segmented) structure could be used to appeal to multiple types of investors at one time. Impact investors, for example, could invest in a riskier tranche of the bond in order to support the overall funding structure. An institutional investor could in turn invest in a different tranche offering lower returns but increased security. Through tranching, the pool of investors for any given bond issuance can be spread across multiple investor classes (the tranche structure is revisited below in Table 3).

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TOPIC 2
SELL-SIDE PERSPECTIVE

Key Points

Policymakers and financiers should avoid relying solely on future carbon market revenues and consider a mix of cash flows to back a forest bond. A broader range of cash flows potentially makes a forest bond more feasible to structure and more attractive to potential investors.

Funding multiple initiatives inside and outside the forest enhances a forest protection strategy by both increasing forest resilience and reducing the pressures on them.

Public policy can create a price signal to stimulate early investment in forest preservation through demand-pull mechanisms such as advanced market commitments or through supply-push mechanisms such as subsidising the cost of capital for forest-friendly enterprises. The choice of the proper mechanism will be context specific, but either type of support should be reduced as forest preservation becomes familiar to investors and the economy.

A first forest bond is urgently needed to demonstrate how to link on-the-ground activities in forest preservation with international capital markets and also to demonstrate what types of policies are needed in the given context.

Structuring and Issuing a Forest Bond

Forest bonds allow an issuer to borrow from the international markets to fund forest preservation and a transition to sustainable livelihoods. There are a number of organisations that could do this, including private-sector financial institutions; supranational institutions and multilateral development banks; and state-, regional- or national-level governments. The challenge for any potential issuer of a forest bond is to generate cash flows that will repay the bond's principal and interest, manage associated risk (see Topic 3), and ensure social and environmental integrity (see Topic 1).

The first component of structuring a forest bond will be to determine how to pay it back. A bond could be issued on the basis of future cash flows from a suitable forest preservation project or programme. Alternatively, a forest bond could be issued to refinance loans made by local institutions to forest-friendly projects or activities carried out by individuals, communities or businesses. In this case, the cash flow required to pay back the bond would come from future repayment of these loans. Finally, if the issuer were a public-sector entity, a forest bond could be structured on the basis of cash flows generated through policy-based mechanisms such as natural capital taxes, user fees or environmental liability legislation. [22] Although these formats are presented as separate, a bond could be developed that integrates these models (depending on who the issuer is).

In addition to generating cash flows, the issuer will have to decide how best to manage forest bonds. That could be done through an earmarking procedure, in which revenues flow back into the issuing entity and are kept on the issuer's balance sheet before being used to pay back the bond. If for any reason those earmarked cash flows did not arise, the issuer would draw on other financial resources to meet its obligations. In this case, potential investors would primarily consider the balance sheet and risk level of the issuing institution before deciding to invest in the bond.

Alternatively, cash flows could be ring-fenced by having them flow into a separate legal entity [23] that would be responsible for paying back the bond using those cash flows. In this case, if the cash flows failed, there would be limited recourse on the sponsoring institution, so potential investors would primarily be concerned with the risk inherent in the cash flows before deciding whether to buy a forest bond.

A key issue in attempting to structure and issue a forest bond is that whatever structure is used, cash flows that would pay it back are often variable and/or difficult to access. In many cases, forest preservation is competing with destructive land uses, such as palm oil, cocoa, soya, biofuels and cattle ranching, all of which have less variable and/or more easily accessible cash flows and so are often considered less risky and attract more investment. Public-sector support is needed to reduce the risks related to cash flows for forest preservation, making the investment proposition more attractive. How exactly to do that, however, is still under discussion.

Demand-Side Policies for REDD+

The clearest way to secure investment in forests is to implement regulation that ensures significant demand for the outputs of forest preservation, such as forest carbon services or sustainable timber. The REDD+ mechanism

under the UNFCCC is the largest attempt to do this, and although progress has been made to pay for forest preservation on a global scale, the mechanism is not yet established. In the interim, lack of demand for forest preservation, such as seen with compliance carbon markets, means that crucial near-term investment in forest preservation is not occurring. To scale up forest finance earlier, potential suppliers of REDD+ credits (or other outputs of forest preservation) need to be encouraged to invest now, whilst regulation is still being designed and implemented.

One way for public-sector entities to do this is via advanced market commitments (AMCs) that would provide sales or price support for REDD+ credits whilst the UNFCCC mechanism takes shape. AMCs have been successfully used in other sectors such as health and energy and come in four basic forms, namely those that increase sales, increase price, improve certainty of sales or improve certainty of price. [24] In the context of tropical forests, such an approach should focus on states or nations that are further along in their development of REDD+ supply. In these places, a relatively small amount of public-sector funding could support a carefully designed AMC, which should be scaled back as the REDD+ mechanism develops.

Three types of AMC are receiving particular attention for use with REDD+ credits:

1 *Performance Agreement*: The public sector agrees to purchase a predetermined volume of verified REDD+ credits. At its core, a performance agreement is intended to increase quantity of sales. The price can, however, be fixed, indexed (against e.g. a carbon price or other economic variable) or indexed with a combination of a price floor and ceiling, and each option would provide a different level of price certainty. A REDD+ performance agreement would be a variation of an Emissions Reduction Purchase Agreement (ERPA) commonly used in the broader carbon markets.
2 *REDD-Credit Option*: The public sector sells (or allocates) the right, but not the obligation, to sell credits at a minimum price to the public sector (i.e. a forest carbon put option), thus improving price certainty. The option would be exercised when the market price was below the price designated by the option. As with a performance agreement, the price promised by the public sector could be fixed, indexed or indexed with a floor, each providing a different level of price certainty.
3 *Subsidy*: The public sector would pay a guaranteed price subsidy for every REDD+ credit generated, not necessarily improving price certainty, but aimed at increasing the price.

Advocates of forest carbon markets and the interim use of AMCs argue that providing direct payments and public-sector demand-pull mechanisms are the most effective ways to stimulate private-sector investment in preserving tropical forests. It is also the approach that most easily aligns with the concept of payments based on performance.

Supply-Side Policies for Forest-Friendly Development

A direct approach that pays for delivery of forest preservation *ex post* is clearly a useful policy tool. Yet questions remain around how to bring that approach to scale and how to make forest preservation sustained in the long term, such as:

– What policy support can be provided in the absence of forest carbon or other ecosystem-service compliance markets?
– How can the high transition costs to establish forest-friendly development and deliver forest preservation be overcome?
– How does the public sector ensure that the next generation does not convert forest that a previous generation has invested in preserving?

One possible answer to these questions is the use of supply-push policies. These interventions make it easier and/or cheaper to start a forest-friendly enterprise. For example, the public sector could lower the cost of financing forest projects. Shifting to more sustainable livelihoods and activities, generally involves high upfront capital expenditure (capex), [25] and there may be a significant time lag before positive returns are generated. In contrast, unsustainable uses of land often require less capex and generate short-term cash flow more rapidly, [26] meaning they are easier to finance. Access to a relatively cheap source of long-term funding is therefore important for sustainable development.

Generally speaking, supply-push policies may be preferred over demand push-policies (e.g. AMCs) when there are constraints that do not allow firms or households to access the start-up resources they require. [27] That scenario often exists in tropical forest countries where demand for affordable capital from individuals, communities and businesses in those countries that want to act sustainably is not satisfied. The projects are often too small to be attractive to investors, and a lack of access to financial and business expertise can also be a

hindrance. There are three primary strategies to dealing with this mismatch:

1 Provide cheaper capital directly at ground level.
2 Help aggregate projects so that combined they reach a scale that is of interest to larger investors that provide cheaper capital.
3 Reduce capex costs through subsidy or technology/ services transfer.

The barriers to cheap capital for forest-preservation capex in forest countries have significant implications. In the extreme, activities that could potentially help preserve forests either do not take place or are financed by institutions or individuals in industrialised countries that do have access to financial expertise and cheaper funding from capital markets. Thus, even with robust demand for forest preservation in place, the combination of high capex costs and high cost of capital could keep actors in tropical forest countries from being able to capitalise on the full benefits of a forest carbon (or other ecosystem service) market or interim guarantee mechanism. Therefore, reducing the initial financing barrier should be considered alongside any pay-for-performance mechanism.

Advocates of supply-side interventions also point out that forests will come under increasing pressure as the populations of forest countries grow and increasingly demand higher standards of living. The approach of supporting the finance of forest-friendly enterprises could not only support enterprises that are directly forest related (e.g. sustainable forest management, ecotourism, non-timber forest products, etc.), but could also reach outside of the forest. It could help ensure that as forest countries develop, people have opportunities for work that do not depend on unsustainable forest extraction and that outdated enterprises transform and new enterprises emerge that are based on sustainable use of forest resources, reducing the external pressures that forests face. Although forests can be preserved in this generation, without the concurrent improvement in people's livelihoods and opportunities for work that do not depend on unsustainable forest extraction, there will always be pressure in the future to return to short-term thinking that leads to conversion of natural capital (i.e. tropical forests) into financial capital.

Conclusion: Diverse Policies and Diverse Cash Flows

Since interest in forest bonds began, it has been argued that they can and should draw on a mix of forest-friendly cash flows. [28] Although carbon markets can provide a source of revenue for forest preservation, the scale of the opportunity remains uncertain. Given the current policy landscape, it is clear that more forest needs preserving than carbon markets appear willing to pay for.

Forest bonds could in theory be structured around cash flows from a wide range of forest-friendly activities and policies including mechanisms for ecosystem service and biodiversity provision, sustainable forest management, sustainable agricultural commodities and in some cases revenues from fiscal policies. Creating forest bonds in this way enables prospective issuers to develop larger deals and to reduce reliance on future carbon revenues alone to pay the bond back. The ability to evaluate and potentially blend different forest-friendly cash flows enables institutions structuring forest bonds to manage overall risk more effectively, making the bond increasingly attractive to potential investors. It also inherently means that the bond is used to finance a broad forest protection strategy, both increasing forest resilience and reducing the pressures on them.

Work to understand how cash flows related to ecosystem services might link to forest bonds is nascent. A demonstration is urgently needed to show how capital from international markets could be funnelled down to forest-level actions. Similarly, more thinking and demonstration activities are needed to understand how other cash flows that do not depend on carbon credits could be used to incentivise forest preservation and even back a forest bond. With water scarcity poised as the next great global environmental challenge, there is particular interest in developing models where long-term support for forest preservation is connected to the water, food and energy sectors that are currently benefiting from water services provided by large areas of intact forests.

Finally, it is clear that some form of public support is needed to stimulate investment in forest preservation. Whilst regulation that values the ecosystem services provided by forests is still being negotiated, public funding can be used to foster the foundation for the private sector to finance forest projects and forest-friendly development. Whether that support is best provided through demand-side mechanisms, such as securing a minimum price for REDD+ credits, or through supply-side mechanisms, such as reducing the costs of capital, is a context-specific question. In some cases, the answer may be that both are needed.

TOPIC 3
RISK MITIGATION

Key Points

Forest preservation in the tropics entails high market and commercial risk, but political risk is the dominant concern for potential investors; forest bonds will require some degree of political risk insurance (PRI).

The Multilateral Investment Guarantee Agency (MIGA) is a logical provider of PRI and, with recent changes to its convention, is in a strong position to take on that role. Even if MIGA does not provide PRI for forest bonds, evaluating its case provides lessons on what characteristics a PRI provider for forest bonds needs to have.

Insurance and other external risk mitigation measures, for all types of risk, will not make a bad deal good; it will only make a good deal better. Existence of external enabling conditions and a strong underlying bond structure that is designed to mitigate risk are equally important to the success of a forest bond.

Risk Mitigation Tools

The first step in mitigating risks inherent in a forest bond should be to fully understand risks associated with the underlying assets and/or relevant cash flows. That will determine the best risk mitigation strategy. There are three primary categories of risk in forest investment that need to be addressed: commercial risk (e.g. natural hazard or theft), market risk (e.g. currency exchange risk or interest rate risk) and political risk (e.g. expropriation risk). [29]

Two key approaches that can be used to mitigate risk, or at least to apportion it appropriately, have been discussed earlier in this report. First, diversifying cash flows by type (e.g. carbon or other ecosystem service credits, forest-friendly loan repayments, natural capital taxes, etc.) and geography is the best way to lower overall risk. Second, a tranche structure can be used to allocate more or less risk to different target investors.

There are a number of other mechanisms, however, for reducing various risks associated with a forest bond (Table 2). Unfortunately, awareness of some of the mechanisms is low, and the total cost of mitigating relevant risks can often be prohibitive. Innovative ways of the public sector raising awareness, subsidising the costs or otherwise supporting

Table 2. Overview of risk mitigation mechanisms that could be used for tropical forest investment, and the risks they mitigate. Mechanisms are qualitatively ranked first by their level of effectiveness, then breadth of usefulness. C = Commercial Risk, M = Market Risk, P = Political Risk (adapted from Gaines & Grayson, 2010).

MECHANISM	DESCRIPTION	C	M	P
Diversification	Invest in a portfolio that includes diverse cash flows and projects	+++	+++	+++
Credit Guarantees	Guarantors insure against default of a bond (or other debt payback) for any reason	+++	+++	+++
Commercial Insurance	Insure against losses due to specific risk events, such as natural hazard	+++	–	–
Political Insurance	Insure against losses due to specific risk events, such as expropriation	–	–	+++
Securitisation and Tranching	Revenues are isolated from the original entity, so less risk of mismanagement, and tranching allows different investors to take different levels of risk.	++	++	++
Technical Assistance	Provide business or financial management expertise to actively manage risks that arise	++	++	–
Due Diligence	In-depth research to ensure project risk is known	++	–	–
Derivatives	Financial products used to minimise volatility of cash flows	–	++	–
Fund Enhancement	An 'enhancing' institution takes the first loss on any business failure	+	+	+

the use of risk mitigation should be explored.

Political Risk and Tropical Forest Investment

Even with all of these risk mitigation tools, in the context of forest bonds, country risk—specifically political risk—remains the dominant concern for potential investors. Under the Clean Development Mechanism, country risk was reduced because a letter of approval from the host country was required and the UNFCCC was intimately involved. For now, it does not appear that a REDD+ mechanism would follow the same path, so other avenues must be explored.

It is no surprise that potential investors in tropical forests are concerned about political risk; investors perceive such risk as the greatest constraint to foreign direct investment generally. [30] What is surprising is that one of the simplest means of addressing that risk, political risk insurance (PRI), is only used by 21% of investors that invest in developing countries (Figure 2). Although PRI will clearly not hedge every risk and other methods of reducing political risk are more popular, PRI is broadly considered a necessary feature of a successful forest bond. The Multilateral Investment Guarantee Agency (MIGA, a member of the World Bank Group) is often recommended as the most logical provider of PRI when investing in tropical forest countries, [31] due to its remit to support sustainable development.

PRI and Forest Bonds: The Case of MIGA

MIGA provides insurance for investors investing across borders into developing countries. The Agency's coverage insures against currency transfer restrictions and inconvertibility, expropriation, war and civil disturbance, breach of contract, and non-honouring of sovereign obligations. Breach of contract is particularly important when considering REDD+: one envisioned structure of REDD+ is a nested approach that would involve project developers or states/regions generating forest carbon credits for which the national government would reward them. Failure of the national government to pay could be considered a breach of contract, the resolution of which would require involvement by a PRI provider such as MIGA. Similarly, if a national government offered an AMC (see Topic 2), but was unable or unwilling to honour it, that would also constitute a breach of contract that PRI could insure against.

MIGA has a strong record of success in resolving issues of political risk. [32] Based on this history, MIGA's political leverage with host countries and a strong capital position, the Agency has an implied triple-A credit rating and is named in the Basel II framework as a highly rated multilateral. Thus, PRI from MIGA enhances the credit rating of the investments insured against, often from just below investment grade to potentially as high as MIGA's triple-A rating. Further, PRI through MIGA is affordable, equivalent on average to approximately a 1% annual premium on investments, depending on the risk of the host country.

MIGA has experience with forestry as an insurer of equity investments and loans for timber and some re- and afforestation investments, but the opportunity for MIGA to become involved in forest bonds has only just opened up. Changes to MIGA's convention in late 2010 now allow it to insure 1) stand-alone debt and 2) existing assets. MIGA's insurance of capital market bond issuance or asset securitisation is done on a case-by-case basis. The changes in the Agency's convention, however, mean that MIGA is now technically allowed to insure a stand-alone forest bond that would invest, at least in part, in already existing forests.

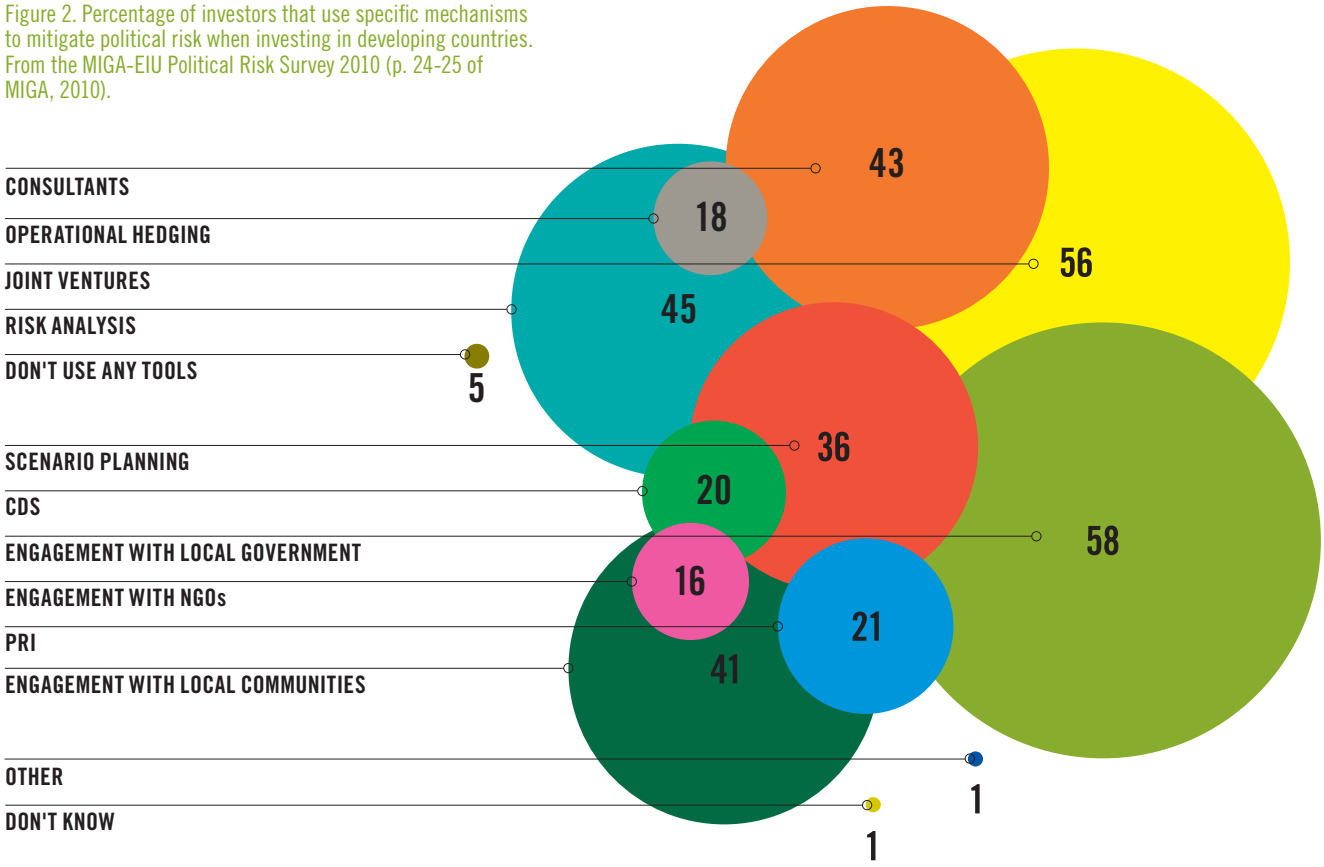
Importantly, beyond these technical necessities, MIGA is suited to insure forest bonds. The Agency has the financial scope to insure large amounts of forest investment [33] and can offer insurance up to 15-20 years maturity, matching the long-term nature of forest investment. The Agency also applies a comprehensive set of social and environmental performance standards to all projects, which at minimum provides a baseline from which to build in safeguards and assurance of the environmental integrity of a bond. Perhaps most importantly, there is good alignment between tropical forest countries and MIGA's focus countries.

Conclusion: PRI and More

As often suggested, MIGA could be a strong project partner in structuring and issuing a forest bond. MIGA's global diversification and strong record of resolving issues to avoid the need for claims permit the Agency to offer strong leverage. MIGA also has good partnerships and can work with other public- and private-sector entities to jointly insure and bring attention to an investment. Together, these points mean MIGA could insure investment on the scale of forest bonds.

MIGA is also now in a good position to engage with all types of forest intervention, not only new forest assets

Figure 2. Percentage of investors that use specific mechanisms to mitigate political risk when investing in developing countries. From the MIGA-EIU Political Risk Survey 2010 (p. 24-25 of MIGA, 2010).



generated under reforastion and afforestation projects, since its new convention permits the Agency to insure pre-existing assets. The Agency is also well placed to insure the mechanism of a bond, particularly a forest bond, since it is now able to insure stand-alone debt and has always offered long-term insurance. Further, the Agency's social and environmental performance standards could help in the implementation of safeguards and assurance of the environmental integrity of a forest bond. Finally, and perhaps most importantly, there is good alignment between tropical forest countries and MIGA's focus countries.

Exploring the case of MIGA does not mean that it should be the sole provider of PRI for forest bonds, but understanding the potential of the organisation helps clarify the qualities that a forest bond issuer should look for in a PRI provider. The costs of PRI and any other external risk mitigation mechanisms will vary, and subsidising these costs could be a role the public sector can play in encouraging investment. Although external risk mitigation is an important component, it alone is not sufficient to ensure the success of forest bonds. Insurance will not make a bad investment good; it can only make a commercially viable proposition better. Portfolio diversification, a tranche structure, proper *ex ante* risk analysis, and engagement with government and local communities are all internal risk mitigation measures that will be necessary to help make forest bonds work.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TOPIC 4
FOREST COUNTRY PERSPECTIVE

Key Points

The burdens and benefits of forest preservation must be appropriately balanced among all stakeholders, from international investors to rural communities.

Only if that balance is achieved can forest bonds, or any effort to leverage private-sector finance for forest preservation, be deemed legitimate.

Sub-national experiences are demonstrating how to establish effective policy frameworks and public-private institutions that strike this balance.

These experiences demonstrate that a key strength of sub-national action is strong ground-level engagement and governance, whilst a key weakness is lack of expertise.

With appropriate technical support, sub-national governments could be early issuers of forest bonds.

Engaging the Private Sector

Donor countries are seeking ways to engage the private sector in forest preservation, and the private sector is willing to invest, provided returns on those investments are commensurate with the associated risk. How to catalyse such investment, however, is still under debate.

Tropical forest countries have a mixed view of the way forward for financing forest preservation: some forest-country governments are wary of linking it to international carbon markets. The concern is that finance will be highly uncertain and risky if it is primarily dependent on the single commodity value of carbon, which some worry could be volatile. Additionally, some forest-country governments do not like the idea of depending on the private sector to save their forests, which could result in the associated benefits of that investment (i.e. profitability, rents) flowing out of the country to wealthy outside investors. Understandably, forest countries want to maintain sovereign control over how forest finance is used within their borders and want to ensure that a good portion of the potential profitability goes to support their economic development. In short, if the onus of saving forests falls on forest countries, they should receive an equitable share of the bonus too.

The solution is to ensure that the burdens and benefits of forest preservation are distributed appropriately between the forest countries and forest-dependent peoples attempting to balance development and forest preservation and the donor countries and private-sector providing finance. Public-private partnerships can be established to deal with such investments and ensure that burdens and benefits are appropriately allocated between different entities.

A Sub-National Case: The State of Acre, Brazil

While national governments are still working out the details of international agreements on climate change and forest finance, sub-national governments are developing their own policies for maintaining their natural capital. These state-level initiatives provide lessons and models upon which national and international policymakers can build.

The State of Acre in Brazil is a forested state in the Amazon basin that has already developed a policy framework for recognising the value of ecosystem services provided by the forest and incentivising land practices to maintain those services. Acre's framework is increasingly recognised as an example to be followed and expanded upon. The state's efforts to foster its carbon programme include establishing the necessary institutions, particularly an ecosystem service regulatory agency and a public-private partnership agency. The role of the latter is to attract direct investments in forest-friendly activities and facilitate the purchase of ecosystem service credits issued by the regulatory agency.

An important aspect of the Acre policy, as well as other similar policies in the Brazilian Amazon States, [34] is that they recognise the multiple ecosystem services provided by forests. The carbon value is the starting point because it is the most readily monetisable value, but these policies also explicitly recognise the forest's contribution to the regulation of water resources, conservation of biodiversity and regulation of local climate, and importance to traditional and local livelihoods. Acre's policy is thus designed to foster the development of multiple funding sources related to those different values, including state and federal government resources, philanthropy (e.g. through Sky Rainforest Rescue), private investment, and carbon credit trades (for which they have already secured some

demand through an agreement with the State of California). That is the first step to aggregating diverse cash flows that the state could then use to back a forest bond.

Acre has also been hailed as a strong model because of its broad engagement with all relevant government, community and private-sector organisations and representatives throughout the development of the policy framework. That engagement led to these groups having a real stake in the success of the policy and indicates one of the potentially large benefits of sub-national programmes: better ground-level engagement and governance. With years of engagement and structural policy development to support their ecosystem services policy, Acre is in a strong position to effectively implement a sustainable development path.

The Acre experience also highlights one major difficulty at the sub-national level: the need for more expertise. Compliance markets and increased demand for certification of voluntary ecosystem service credits or sustainable products mean that environmental and social standards are increasingly strict and more expertise is needed to meet those requirements. Financial and private-sector expertise is also needed to ensure that the strong policy framework, which includes economic incentives and a public-private investment agency, is used most effectively to stimulate investments in forest-friendly development in the state.

Conclusion: Balancing Burdens and Benefits

In one sense, the discussion on tropical forest preservation is primarily about who should pay. But whether investors, businesses, national governments or any other parties pay, it is important to make sure that those that take on the burden of forest preservation — financial, economic, social or political — also reap their fair share of the benefits. The problem of forest finance is not so much about choosing which policy is best (e.g. REDD+ credit price subsidy vs. lowering the cost of capital), but about implementing a framework that permits a mix of policies to support different groups contributing to sustainable development. For example, this could include domestic governments implementing a tax on forest-degrading activities to raise finance for co-investment in forest-friendly enterprises, which profit in part from ecosystem service credits for which donor countries have provided a price floor.

For any policy mix, a bond could provide a method to raise large-scale financing up front. Domestic governments could potentially use it to overcome the transitional costs of establishing governance structures and investing in forest-friendly enterprises and pay it back from cash flows based on forest-extraction tax revenues, sales of forest carbon credits, or any number of other regulatory or normal market cash flows.

The experience in the State of Acre is one of a small but growing number of sub-national models that are leading the way in establishing a policy framework on which forest-friendly development can be built. In addition to demonstrating how to design the policy framework, these experiences are also illustrating that sub-national governments are generally willing to engage with the private sector. Action by sub-national governments is likely only to strengthen under initiatives such as the Governor's Climate and Forests Taskforce. [35] Considering their potential strength in ground-level governance and the movement to develop multiple revenue streams for multiple forest values, state governments could be prime candidates for issuing forest bonds.

TOPIC 5
DONOR COUNTRY PERSPECTIVE

Key Points

Donor countries are increasingly exploring bilateral arrangements to use climate, biodiversity and development aid as catalytic finance, leveraging private-sector investment in forest preservation.

There are three basic approaches to doing this for a forest bond: 1) Use demand-side mechanisms to secure the cash flows that pay back investment in forest preservation; 2) Use supply-side mechanisms to reduce the costs of that investment; and 3) Provide direct risk mitigation in the structuring of a forest bond.

To understand how best to leverage private-sector finance, more dialogue between the public and private sectors is required to understand what each expects from and is willing to do to support such a public-private partnership.

Dialogue needs to expand to other public-sector actors as well, specifically to treasury departments and finance ministries that are familiar with private-sector engagement. This dialogue will be essential to the success of forest bonds, particularly if issued by the public sector.

Catalysing Forest Preservation

Approximately US$7.2 billion in forest finance has been or is imminently expected to be pledged from donor countries. [36] As donor countries increase their pledges, they have growing concerns about how to use that finance effectively. Although dominant in the history of ODA, the project-based approach appears to have failed in many cases. That has led donor countries to look for more careful uses of aid that can catalyse systemic changes needed for development.

Although there is a role for funnelling ODA through multilateral institutions, those institutions are not the only means of managing and delivering international finance for tropical forest preservation. Countries trying to move fast on forest preservation and climate change are starting to look at bilateral deals whereby public funds can catalyse a sustainable development path and leverage private-sector finance to support it. Forest bonds offer a mechanism for doing just that: using donor country funds to leverage private finance and reach a large scale of funds that can be used to invest in a forest country's economic transition.

Many Potential Roles

There are three basic roles that donor countries can take to leverage private-sector finance:

1. *Demand-side*: Secure the cash flows that pay back investments in forest preservation.
2. *Supply-side:* Reduce the costs of investing in forest preservation.
3. *Structuring:* Become directly involved in forest investment through, for example, providing third-party risk mitigation.

An argument could be made that the second option, supply-side interventions, should be slightly prioritised above the other options. The goods and services that donors expect forest-friendly activities and development to produce will simply not be produced on a large scale if there are constraints on financing the upfront transition costs [37] which may occur in some contexts in tropical forest countries. Further, providing finance can play some role towards that transition in the absence of certain regulatory changes to boost demand for forest preservation (e.g. through compliance carbon markets). Cash flows for forest-friendly activities can come from a number of sources without regulatory intervention, such as cash flows arising from increasing global demand for green commodities such as sustainable timber or cash flows from activities that locally make economic sense, such as paying for watershed services or intensifying beef production, both of which are seeing increased implementation globally. Policy support for these types of activities is needed to stimulate broader and larger economic shifts, but at least there is a starting point to profit from forest preservation without much policy intervention.

Assuming no constraints to investment exist, donor countries should focus on implementing policies to promote demand for forest preservation and secure cash flows that would pay back a forest bond. Although AMCs for REDD+ have received a lot of attention, other demand-side interventions to help secure other cash flows are already in effect and should not be forgotten, specifically interventions promoting sustainable products (e.g. laws combating illegal timber, such as the US Lacey Act or EU's FLEGT). A range of demand-side policies could be linked to forest bonds or

Table 3: Stylised comparison of a normal tranche structure (top)to a potential forest bond tranche structure (bottom) where public sector finance is used to leverage private sector investment.

INVESTOR	INVESTMENT	RETURN	RISK
Investor 1	Debt: Senior Tranche	$	+
Investor 2	Debt: Junior Tranche	$$	++
Investor 3	Equity Investment	$$$	+++

INVESTOR	INVESTMENT	FINANCIAL RETURN	SUSTAINABILITY RETURN	RISK
Institutional	Debt: Senior Tranche	$$		+
Impact	Debt: Junior Tranche	$$		++
Public Sector	Equity / Concessional Debt	Maybe $		+++

countries from which a forest bond is issued, reducing risk associated with the cash flows that would pay back the bond and improving investor demand for it.

Donor countries can also become more directly involved in the structuring and issuing of a bond. One way is to reduce the risk associated with the bond by underwriting the bond directly, paying insurance premiums (e.g. for PRI) or providing some other mechanism that directly improves the bond's credit rating.

A similar role would be to design the bond with donor countries taking a stake in the bond and providing a first-loss facility. [38] In some ways, this is like the donor taking an equity stake in the forest investment but with a return in the form of public goods rather than a financial return, although some financial return may be realised (Table 3). That structure deploys public funds to provide public goods, the primary purpose of those funds, but in a manner that leverages much larger amounts of finance.

Conclusion: Dialogue and Engagement

A great challenge left for donor countries and the private sector is that they do not yet speak the same language and do not understand one another's needs and motivations. Policymakers that support carbon markets have usually done so on the basis that providing a price signal for the output of an environmental externality would change the economic landscape and force the private sector to change its behaviour. That logic works in some cases, specifically when the externality is one-dimensional, there is an easy technological fix and financing that fix is relatively cheap. The case of forests is different. A price signal from carbon markets, or other markets such as biodiversity and watershed markets, can be a strong policy tool. The loss of tropical forests, however, is a multidimensional issue in which some fixes may be simple, but in many cases donors are asking households to transition to alternative livelihoods and that transition can be costly, or even unaffordable for many poor people living in forests and rural areas in tropical countries. The process is more complex and requires much greater engagement with those that will finance this process.

Engagement with the private sector is also different for the global issues of forests, biodiversity and climate change. It is not simply a matter of making the polluters pay, as was the case with many environmental issues in the past. Instead, it is also about engaging the private sector to help finance the large shift to sustainability that economies need to undertake.

If donor countries expect to leverage private-sector finance, the two sides need to speak the same language to begin better understanding one another. That engagement can be difficult in international forums where ideological opposition to markets has disproportionate power. As a result, that engagement is starting to emerge at the level of national governments between like-minded countries and private-sector organisations. Moving forward, it would also be useful to engage treasury departments and finance ministries. These government groups are not only familiar with private-sector engagement, but are essential to the success of any large-scale financing strategy, including forest bonds and the role they may play in stimulating forest-friendly development.

END NOTES

1 The Royal Society, 2003
2 TEEB, 2009
3 FRA, 2010, pp. 3
4 The Commission on Climate and Tropical Forests, 2010
5 The IFFIm has raised more than US$ 3 billion for the GAVI Alliance's immunisation programmes. Read more online at: www.iff-immunisation.org
6 A multilateral finance institution seems poised to issue the first 'rainforest bond', which is being structured by Bank of America Merrill Lynch. Reported in Carbon Finance (4 May, 2011) and Environmental Finance (6 May, 2011) with the article '"Rainforest bond" aiming to monetise REDD+ credits' (subscription required).
7 To read more on REDD+ under the Cancun Agreement, go to The REDD Desk and follow links to many major NGOs' analyses: www.theredddesk.org/conference/cop16/news/blogcop_16_and_the_cancun_agreements_agreements_what_did_it_all_mean_for_forests
8 For more on progress in Bonn see Parker and Almassy, 2011.
9 It was recently estimated that financing needed to reduce deforestation will increase over the current decade, reaching US$30 billion annually by 2020, averaging US$16 billion during that period (The Commission on Climate and Forests, 2010). Current and imminent pledges of REDD+ financing total about US$7.2 billion (Simula, 2010), but these are *multi-year* amounts; forest finance remains far short of the *annual* sums required.
10 Under the Kyoto Protocol, it took seven years from agreement of the Protocol before the first issuance of carbon credits under the Clean Development Mechanism—the portion of the carbon market that developing countries could participate in.
11 Wood & Grace, 2011
12 O'Donohoe et al., 2010
13 GIIN, 2011
14 Monitor Institute, 2009
15 Lombard Odier surveyed 47 private banking clients about their views on green bonds.
16 PRI, 2010
17 The City UK, 2010
18 E.g. the need for a liquid secondary market in any product included in their portfolio. Ensuring enough liquidity to attract institutional investors would probably require a forest bond issuance of at least several hundreds of millions of US$.
19 International financial institutions have issued over US$5 billion in green bonds as of early 2011. For more information on green bond issuance see www.climatebonds.net/resources/bonds-issued
20 This structure is similar to the "Green Sectoral Bond" proposal of the International Emissions Trading Association (IETA), whereby if emissions reductions were achieved, part of the payback to investors would be in the form of carbon credits, which the bondholders could likely sell on.
21 A popular example is the Dutch Groenregeling, a set of tax incentives designed to stimulate investments that are important for the environment, including nature and forests.
22 See Parker & Cranford, 2010.
23 i.e. a special purpose vehicle
24 Vivid Economics, 2009
25 E.g. securing land tenure, legal fees, etc.
26 In some cases this may be due to environmentally harmful subsidies.
27 Vivid Economics, 2009
28 Forum for the Future & EnviroMarket, 2007
29 Gaines & Grayson, 2010
30 MIGA, 2010
31 Forum for the Future & EnviroMarket, 2007; Gaines & Grayson, 2009; O'Sullivan et al., 2010
32 Of over 600 projects insured, more than 80 cases of possible claims have arisen with only five resulting in actual claim payments.
33 MIGA is currently only directly exposed to US$4.8 billion, but its capacity is in excess of US$9 billion before reinsurance. There is a current limit of US$180 million of exposure MIGA can take on its own books for any one investment project, and US$600 million in any one country, but those amounts can be leveraged by as much as 10 times with the help of reinsurance and coinsurance. The limits are reviewed annually.
34 E.g. the recently approved Ecosystem Service law in the State of Amazonas.
35 A collaboration between 15 states and provinces in Brazil, Indonesia, Mexico, Nigeria, and the US, on implementing REDD. See www.gcftaskforce.org
36 Building on Simula, 2010
37 Demand-pull interventions are ineffective if the market is restricted and cannot supply what the intervention is demanding (Vivid Economics, 2009)
38 For further discussion on a first-loss facility see Forum for the Future & EnviroMarket, 2007

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PARTICIPATING ORGANISATIONS

- Bloomberg New Energy Finance
- BNP Paribas
- Canopy Capital
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- GLOBE International
- Goldman Sachs
- Eco System Services Limited
- Harvard Law School Program on International Financial Systems
- Lombard Odier Investment Management
- London School of Economics
- Multilateral Investment Guarantee Agency
- Norton Rose
- Norwegian Environment Ministry
- PwC
- SEB
- State Street Global Advisors
- Terrestrial Carbon Group
- UK Committee on Climate Change
- UK Department for International Development
- UNEP Finance Initiative
- Vivid Economics
- WWF Forest & Climate Initiative
- WWF-International
- WWF-UK

www.panda.org/forestclimate
www.globalcanopy.org
www.climatebonds.net

UNDERSTANDING FOREST BONDS

A GUIDE TO RAISING UP-FRONT FINANCE FOR TROPICAL FORESTS

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Global Canopy Programme

The Global Canopy Programme (GCP) is a small and dynamic tropical forest think tank based in Oxford, acting through our global networks of experts in science, policy, business, finance and forest communities. We gather their tropical forest intelligence to spark insight, convene research and design projects that can help leverage future large-scale systemic change, demonstrating the value of forests as natural capital and communicating it to the world.

Visit **www.globalcanopy.org** for more information.

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More on forest bonds

For those readers that are interested to learn more, particularly key steps to making a forest bond work, we recommend reading the report on *Unlocking Forest Bonds: A High-Level Workshop on Innovative Finance for Tropical Forests*. That report presents a more in-depth, technical view of the specific challenges and concerns of using bonds in the context of forest finance. Both *Understanding* and *Unlocking Forest Bonds*, as well as links to other relevant materials, can be found at:

www.globalcanopy.org/projects/understanding-forest-bonds

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FOREWORD

As the world navigates through an unprecedented financial crisis, the opportunity to transition to a fairer and greener economy is emerging. But to achieve that transition, what is misvalued needs to be properly valued, and we need to be more open to business as *un*-usual. It is starkly obvious that the costs of degrading natural capital, such as forests, are undervalued and unrepresented in the price of goods profitably made from ecosystem conversion. The new green economy should recognise the full value of forests, including all of its ecosystem services worth trillions of dollars, and push business to act more sustainably in relation to this vital natural capital.

A transition to a forest-friendly economy could cost upwards of tens of billions of dollars annually and is unlikely to be achieved without public sector leveraging of private sector finance. That is precisely where forest bonds can help. As part of a broad financial approach, forest bonds would tap into global capital markets to deliver up-front finance at the scale and with the urgency required to maintain forests and their ecosystem services before they are lost.

Predicating this intervention solely on a forest carbon market, which is yet to exist at the necessary scale, has so far stalled private sector interest in forest bonds. This could be overcome by taking a broader Proactive Investment in Natural Capital (PINC) approach to these bonds. PINC is a complementary approach to REDD+ that draws on sources of revenue beyond carbon markets. A PINC forest bond could be paid back, for example, by green commodity revenue streams, with carbon viewed not as the primary revenue stream, but as a potential future upside.

Such an approach is particularly useful to help finance more sustainable agriculture. Agribusiness is the fastest growing cause of deforestation globally. To save forests, we need to stop degradation at the forest frontier, move agricultural production onto restored land and increase agricultural efficiency. A bond with a PINC approach could be key to financing that transition.

Understanding Forest Bonds is the Global Canopy Programme's contribution to demystifying forest bonds and bridging the communication gap between policy-makers and the investment community. Different contexts call for different bonds, which this publication addresses. Whichever type is used, however, to be successful, the benefits to forests and forest communities must be absolutely ensured and the bond must be carefully designed to ensure fair and equitable sharing of risks and rewards among all stakeholders.

As the Rio+20 Earth Summit approaches, defining a 'roadmap to a green economy' will be essential. Forest bonds should be on that map. They offer a giant opportunity to help finance a significant part of the transition to a new economy, where natural capital is valued alongside human and financial capital, and is not simply plundered at will.

Andrew W. Mitchell
Founder and Executive Director,
Global Canopy Programme

EXECUTIVE SUMMARY

Why do we need to frontload forest finance?

Every year around 13 million hectares of forest around the world are cleared (FAO, 2010) for purposes such as crop cultivation, pastures, logging and mining. Although the rate of loss has declined in some countries in recent years, the global deforestation rate is still "alarmingly high" and it remains particularly high in the world's main tropical forest regions (FAO, 2010). As forests are degraded, so are the ecosystem services they provide to humanity. These services are valued in the order of USD trillions per year (TEEB, 2009) for their role in underpinning livelihoods and supporting climate, food, energy and water security across the globe.

Conserving forests for the benefit of both current and future generations requires significant up-front investment. It requires investment:

1 To plan, including undertaking consultations and developing policies;
2 To strengthen institutions, such as land tenure and forest governance; and
3 To monitor, report and verify that forest conservation has actually taken place.

All the while, incentives that drive deforestation must decline and sustainable livelihoods must become more accessible and prosperous for current and future generations.

It is estimated that to do all of this and halve the rate of deforestation by 2020, investment in the conservation and sustainable use of forests will have to increase from less than USD 10 billion *total* that has been pledged now, to approximately USD 30 billion *annually* by 2020 (Commission on Climate and Tropical Forests, 2010). A number of mechanisms exist to generate the needed funding, such as increasing the market share of forest-friendly agricultural products, implementing green fiscal reform, and increasing the use of ecosystem service markets (see Parker and Cranford, 2010), but it will take time to implement these mechanisms at the scale needed. Forest bonds offer an opportunity to raise the needed large-scale finance for forests, and to raise it now.

What is a forest bond?

Public or private institutions that need to raise large-scale, up-front finance often do so by selling bonds in to the global bond markets worth nearly USD 100 trillion. A bond is a tradable financial security representing a promise that the organisation that sold it will pay whomever holds the security a pre-specified interest payment at defined intervals over the bond's lifetime, and also pay the full face value of the bond upon maturity. The amount raised by selling the bond will be the amount investors are willing to pay based on the interest and face value payments that are being promised. Essentially, selling a bond is a way to borrow large amounts of finance from the global financial markets.

Bonds are a familiar financing mechanism in sectors such as water, energy, development and even health. Climate bonds have seen increasing use in recent years to finance investments in climate change mitigation and adaptation, and in some cases forest projects have been included in the portfolio of investments underlying climate bonds. Considering the nature of the financing needs described above, however, bonds specifically dedicated to forest investment, i.e. *forest bonds*, could also be a key component of a strategy to sustain the world's forests.

Who would invest in a forest bond?

Two particular types of investors have been identified that may be interested in a forest bond. The first type is impact investors who, when comparing a forest bond to a normal corporate or government bond, are willing to take a slightly lower return on investment and compromise on other financial qualities of the bond as long as the environmental and social benefits are absolutely assured. The second type of investor is institutional investors, who control the majority of funds invested in global bond markets. These investors would not compromise on the financial aspects of the bond, but would be very attracted to a forest bond if it could be structured to suit their needs.

How would a forest bond work?

As with any bond, in return for borrowing money from global bond markets, the issuer must pay back a pre-specified amount of interest plus the face value of the bond once it has reached maturity. To do so, the issuer must generate revenues. As noted above, there are many mechanisms that can be used to generate revenues for forest

finance. In general these revenues can be forest-based (e.g. price premiums on sustainable timber) or non-forest based [e.g. official development assistance (ODA)], depending on the forest investment needs. The choice between these two types of revenue will have important implications for the type of activity that can be supported: ranging from capacity building activities and land tenure reform to investments in forest-friendly enterprises and projects that generate ecosystem service credits.

The finance raised from selling a bond and the revenue generated to pay it back can either be held on the financial accounts of the issuing institution (on balance sheet) or in a legally independent entity (off balance sheet). Combined with the choice of revenue generating mechanism, the choice of institutional arrangements has important implications for the risk to both the bond investor and the bond issuer. Generally if the bond is on balance sheet, the bondholder will be concerned with the risk of the bond issuer making repayments, while the issuer will be taking on risks associated with revenue generation. If the bond is off balance sheet, the bondholder will be directly exposed to the risks associated with revenue streams. In either case, measures will be required to mitigate some of the risks that are present in order to make a forest bond viable.

Where would forest bonds work?

The type of forest bond that could work in a given country depends on the financial stability, level of political risk and current (and likely future) shape of forest policy in that country. Before purchasing a bond, potential bondholders would analyse these characteristics and the specific structure of the bond to determine which characteristics directly present a risk if they invest in the bond. Policy-makers must also consider these characteristics—particularly the shape of forest policy—to determine which type of bond would be useful for their country to issue or support.

Although no type of forest bond is off limits to any particular tropical forest region, an initial evaluation indicates which type of bond could be most useful and/or successful in each of the world's three major tropical forest regions. A forest bond issued by a forest nation or backed by commitments from one or more forest nations could be successful in Latin America, particularly the Amazon region. In contrast, Africa would likely get the most use out of a bond issued by a relevant multilateral development bank or backed by commitments from donor countries. Finally, in Eastern and Southern Asia, an off-balance-sheet forest bond backed by forest-based revenues currently seems the most viable option.

INTRODUCTION

The challenge

Tropical forests cover about 15% of the world's land surface (FAO, 2010) and provide a multitude of ecosystem services from local to global scales. At the global level, through their interactions with the atmosphere, tropical forests are fundamental to the cycling of water and heat around the planet. They also absorb vast quantities of carbon from the atmosphere, helping to reduce the build-up of greenhouse gases, whilst returning oxygen to the atmosphere in the process. Regionally, they filter and regulate the flow of water in river basins. At more local scales, forests provide a resource base upon which the livelihoods of over a billion of the world's poor depend (The World Bank, 2004). In many ways, we can consider tropical forests to be *ecological infrastructure* that provides a suite of ecosystem services underpinning livelihoods and climate, food, energy and water security. The value of this ecological infrastructure is in the order of USD trillions annually (TEEB, 2009).

In spite of these immense societal benefits, the global rate of deforestation is still "alarmingly high" according to the United Nations Food and Agricultural Organization (FAO, 2010). It is estimated that around 13 million hectares of forest are cleared every year (FAO, 2010) for uses such as agriculture, pasture, logging and mining. Although forest conversion can bring economic prosperity, it also brings increasing costs in the form of lost ecosystem services (Braat & ten Brink, 2008). Comparing those costs and benefits, it is unlikely that deforestation at its current rate will bring improvements to human wellbeing that are sustained for future generations to enjoy. As such, many tropical forest countries are seeking to undertake a new forest-friendly mode of development.

A role for forest bonds

The transformation from business-as-usual to more sustainable ecosystem management requires a broad strategy of policy and institutional reform along with capacity building and on-the-ground implementation. Amongst other actions, this will require a significant scaling up of funding in the immediate future. As an indication of the scale of finance needed, a recent study estimated that the funds needed to halve the current rate of deforestation will have to increase from less than USD 10 billion total that has been pledged now, to approximately USD 30 billion annually by 2020 (Commission on Climate and Tropical Forests, 2010). Although estimates of the financing needed vary, there is increasing consensus that the public sector alone does not have the means to raise these funds and therefore engagement with the private sector is imperative.

Bonds started receiving more attention from the environmental community after the successful issuance of bonds to fund immunisation and vaccination in less developed countries (IFFIm, 2011). Since bonds have historically been used to raise the finance needed to construct physical infrastructure and finance many other actions in a country's development process, it is not surprising they are now being used to finance green and climate-friendly development. Since 2008, development banks and other financial institutions have increasingly used *green bonds* or *climate bonds* to raise money for their investments in renewable energy and water infrastructure. The World Bank, for example, has issued over USD 2 billion in such bonds to finance its climate-change-related investments (World Bank, 2011) and green bond issuances totalled around USD 3.5 billion in 2010 alone (Wood & Grace, 2011).

Whilst green and climate bonds have been used to finance a portfolio of projects that can include forest-related investments (e.g. World Bank Green Bonds), a forest bond has not yet been issued that would specifically finance the ecological infrastructure of tropical forests and related forest-friendly development. Several proposals have, however, been put forward for the creation of a forest bond (see e.g. The Prince's Rainforests Project, 2009). Further, a bamboo bond has recently been issued that follows one potential structure a forest bond might take [1] and the first forest bond is expected to be issued soon [2].

What is a bond?

Bonds are a way of borrowing finance from private capital markets. As with other debt-based mechanisms, bond issuers must repay the capital they borrowed plus interest (see **Figure 2** in **Framework** section). A public or private institution can sell (i.e. *issue*) a bond, and it represents a promise that over the bond's lifetime the organisation that sold it (the *issuer*) will pay back a pre-specified amount. Repayment usually includes an interest payment (i.e. *coupon payment*) that occurs every 6 or 12 months, plus full repayment of the initial value of the bond (called the *principal*) at the end of the bond's life (upon its *maturity*). Since bonds are tradable, the interest payments and principal repayment will be given to whomever owns the bond (known as the *bondholder*) at the time that payment is due.

The terms of a bond are defined mainly by the cash flows the borrower plans to use to pay back the bond (the bond's *collateral*), and the level of confidence that the issuer will have the ability and willingness to collect those cash flows and use them to pay back the bond. The terms relevant to potential bondholders include:

- **Return:** The value of coupon and principal payments
- **Credit Rating:** Indicates the level of confidence that the bond will be repaid; a risk measure
- **Maturity:** The number of years until the principal is paid back
- **Liquidity:** The ability to trade the bond in a secondary market
- **Covenants:** Any specific requirements the issuer must adhere to

These terms are made clear when the bond is issued, so the bondholder has a reasonable expectation of the timing and scale of the return on their investment in the bond. Bonds are therefore often referred to as a fixed-income investment, and because they provide relatively predictable long-term returns, they are a key component of any diversified investment portfolio. That is also why the global bond market is three times larger than the global equity market, which on average provides higher returns to investors, but offers more volatile returns and hence more risky investments.

Frontloading forest finance

When considering using bonds to finance the conservation and sustainable use of tropical forests, policy-makers might consider the potential benefits and liabilities of doing so. The main benefits are that bonds engage the private sector to frontload and lock-in large-scale financing. Doing so, however, creates a future liability to pay back the investors from whom finance was initially raised. As such, before attempting to create a forest bond, policy-makers and potential forest bond issuers should ask the vital question: is there a strong case to frontload finance and create that liability?

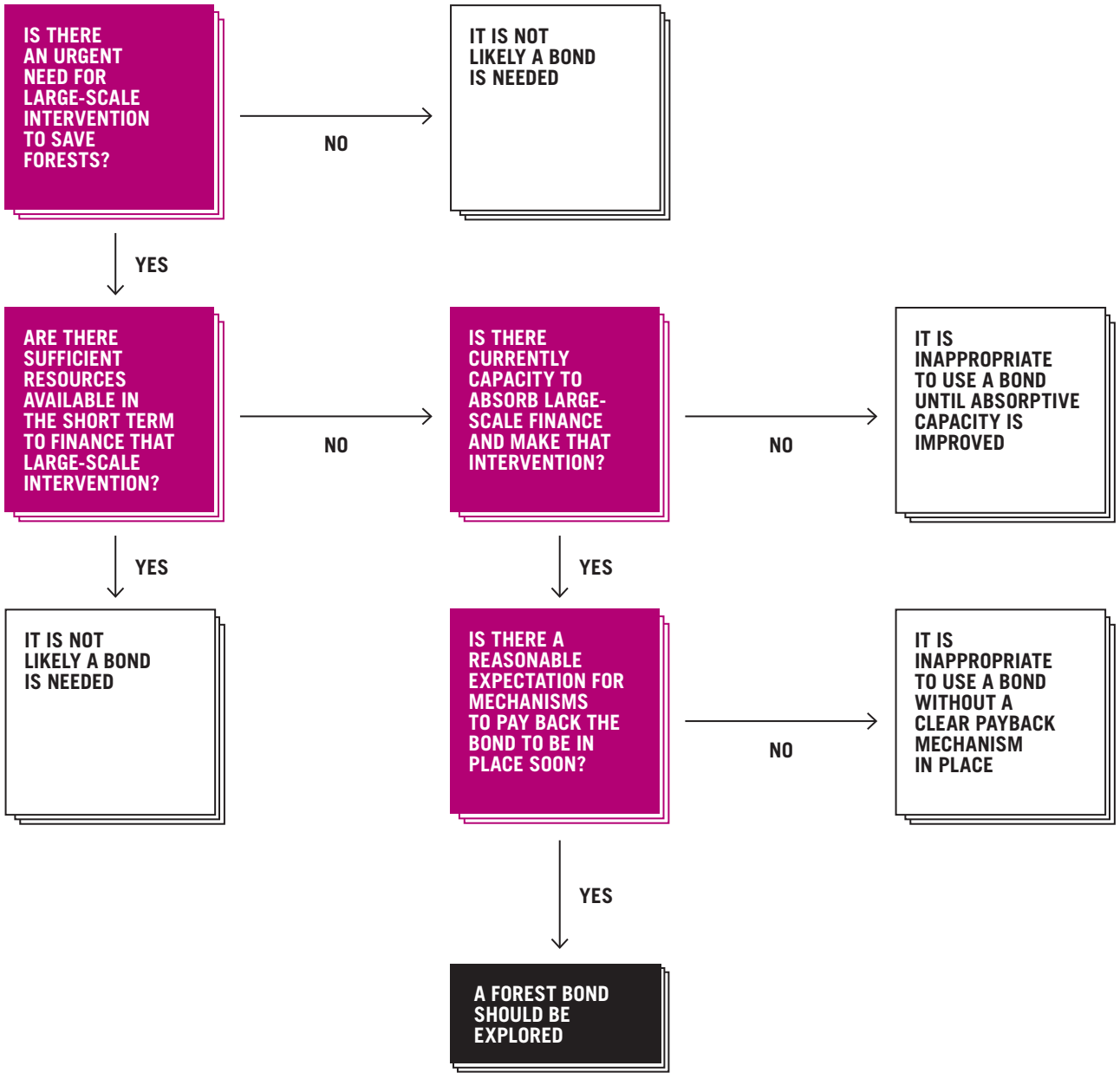
This question has both political and institutional dimensions. First, from a political perspective, policy inaction on deforestation will result in continued emissions of harmful greenhouse gases, further loss of biodiversity, and a reduction in the provision of other vital ecosystem services. All of these changes will continue to degrade the livelihoods of those living in and around forests, as well as those that live far beyond them. Many of the mechanisms to generate revenue that can be used to finance forests will take time to implement at the scale needed (Parker et al., 2009; Parker and Cranford, 2010), and forest bonds could offer a bridging mechanism whilst these other sources of finance are scaled up (The Prince's Rainforests Project, 2009).

Second, from an institutional perspective, forest-owning nations vary in their ability to absorb finance effectively at scale. Large amounts of frontloaded finance are only useful if the recipient has the capacity to use it effectively in the short term. A related concern will be the type of mechanism that the issuer will use to pay back bondholders as well as the choice of how the mechanism will be managed. This will be important in defining the types of actions that can be carried out on the ground. These issues are discussed in more detail in the **Generation** and **Delivery** sections.

The decision process that a policymaker might go through before exploring whether to issue, or support the issue of, a forest bond is shown in **Figure 1**.

Photo by D J Rosen, Creative Commons on Flickr

Figure 1: Decision tree for policy-makers on whether or not to explore using a forest bond



WHO WOULD INVEST?

Research on forest bonds (e.g. Forum for the Future and EnviroMarket, 2007; Forum for the Future, 2009; Prince's Rainforests Project, 2009; Flensborg, 2010; Cranford et al., 2011) has identified two specific groups of potential forest bond investors and their preferences for the five terms of a bond outlined above. By understanding those preferences and each group's motivation for investing in forest bonds, policy-makers can be more targeted and thus more effective in their design and use of forest bonds.

Impact investors

Impact investing is an investment strategy where investors proactively seek investments with positive social and/or environmental benefits in addition to financial returns. There are over a hundred active impact investment funds (GIIN, 2011) underpinning a market that could grow to more than USD 500 billion by 2020 (Monitor Institute, 2009). Impact investors (and some socially responsible investors) are often willing to compromise on their preferred investment characteristics in exchange for assurance that the investment provides broader environmental or social benefits.

Currently, most impact investing has been implemented in community health, energy, or microfinance projects, but there is strong potential to extend impact investing into forest and other natural capital projects. A brief survey of private investors' preferences for green bonds (see Cranford et al., 2011) showed that impact investors would prefer a forest bond if it had an upper-medium to high *investment grade credit rating* (i.e. a credit rating of A3/A- or better), a return comparable to other bonds with a similar level of risk, and high liquidity (**Table 1**). Impact investors would be willing to compromise on these three requirements, however, if the environmental benefits of the investment were significant and assured.

Impact investors would make good early investors in forest bonds when the market is not yet well known, is smaller (and therefore has lower liquidity) and is perceived as being riskier. This is particularly true for forest bonds that are more difficult for investors to evaluate, such as forest-backed bonds.

Table 1. Comparing impact and institutional investors' preferred characteristics of a forest bond.

IMPACT INVESTORS	PREFERENCE	COMPROMISE?
Return	Better returns than government bond	Yes
Credit Rating	≥ A–	Yes
Maturity	≤ 10 years	No
Liquidity	High	Yes
Environmental Benefits	Assured	No
INSTITUTIONAL INVESTORS	**PREFERENCE**	**COMPROMISE?**
Return	Better or similar returns to government bonds	No
Credit Rating	AAA or close to	No
Maturity	≤ 10 years	No
Liquidity	High	No
Environmental Benefits	Assured	No

Institutional investors

Institutional investors manage the largest proportion of private sector finance globally–roughly US$70 trillion (The City UK, 2010). These investors act on behalf of large groups of people (e.g. managing pension funds and insurance funds) and therefore have a responsibility (called *fiduciary duty*) to ensure the highest standard of care is taken to meet the investment needs of their clients, who are relying on the investment returns for their retirement or to pay insurance claims.

Institutional investors are therefore often more constrained in how they can invest and a forest bond would have to meet their requirements to be attractive.

A forest bond would only attract institutional investors if it had a high investment grade credit rating (i.e. AAA or close to) and assured high liquidity (see **Table 1**). Despite these constraints, however, institutional investors are increasingly interested in green bonds to improve the long-term performance of their portfolio (Flensborg, 2010) because they recognise that:

- Environmental risk increases the uncertainty of future investment performance;
- Investments may be exposed to future constraints in natural resources; and
- Environmental regulation is beginning to impact investment performance.

Institutional investors are likely to become increasingly interested in forest bonds as the market grows (improving liquidity) and risks are better known and managed.

Credibility of forest bonds

The most important attribute for any forest bond is that its environmental credibility must be assured. The environmental (and potentially social) outcomes of a forest bond are the motivation for it in the first place. Investors will prefer a forest bond, or other green or climate bond, to a non-green bond with the same financial characteristics if and only if the environmental benefits of the forest bond are assured. No investors—nor any other stakeholders in a forest bond—are willing to compromise on that.

Environmental credibility of a forest bond will be influenced by how finance is managed and delivered, which can vary depending on bond structure, particularly the institutional arrangements. To support the growth and legitimacy of a forest bonds market, standardised criteria to judge credibility are needed to generate confidence and allow comparability between different bonds. Development of standards for climate bonds is already underway, and a similar initiative to devise standards specific to forests bonds is being developed. For more information on that process see www.climatebonds.net/proposals/standards.

FRAMEWORK

Underlying the basic outline of a forest bond described so far are multiple ways in which a forest bond can be structured. **Figure 2** presents a framework to assess the various structures a forest bond can have [3] and is comprised of four basic modules:

Generation: How is revenue generated to pay back bond investors?
Institutional Arrangements: How is finance managed and by whom?
Delivery: How is finance delivered to support forest activities?
Risk: What are the primary risks of the bond and who holds those risks?

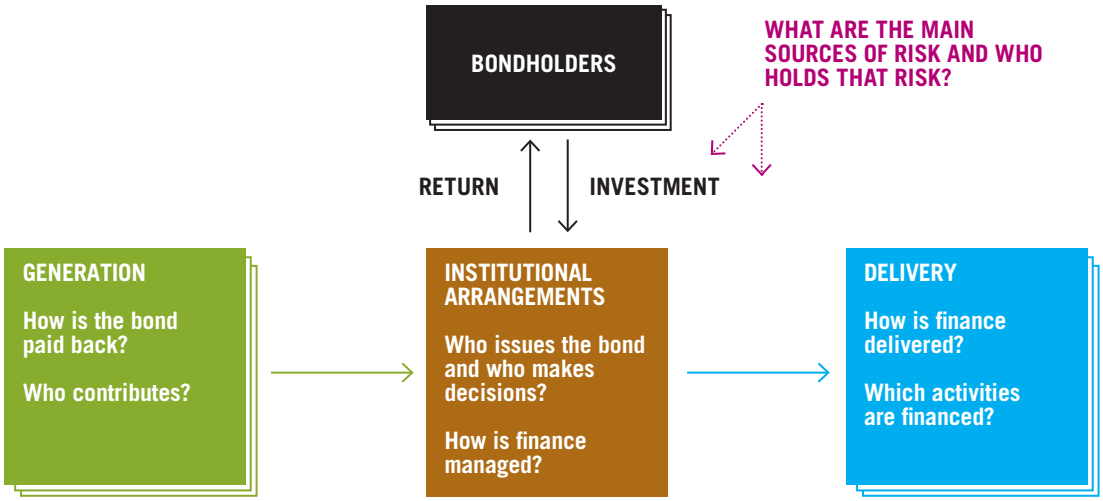
These modules represent individual components of a forest bond and when combined they describe the forest bond mechanism as a whole. It is important to note two things. First, bondholders do not define the structure of the bond and would sit outside of these four modules.

Bondholders would provide the issuing institution with up-front finance, which that institution would then deliver to forest-based activities in the short term. In the medium to long term, bondholders would be repaid through the revenue generation mechanism.

Second, the bond structure is primarily defined by the first two modules of the framework: Generation and Institutional Arrangements. The delivery mechanisms used and risks associated with the bond are heavily influenced by the choices made in terms of generation and institutional arrangements.

For each of these components there are one or two key characteristics that can vary, and this will have important implications for the overall bond structure. For example, in generating revenue the choice of generation mechanism affects *who will contribute*, whereas in delivering finance the choice of mechanism impacts *which types of activity* will be financed. The following sections will explore these four modules in detail, focusing on the key options for each module.

Figure 2. Framework for understanding a forest bond. Boxes represent actors and solid arrows represent flows of finance.



GENERATION

The issue of how to generate revenues is often the first question when considering any forest finance strategy. Whilst forest bonds are at times presented alongside revenue generation mechanisms, it is important to note that a bond does not itself generate revenue. Bonds are a way of raising finance from private capital markets, and as with other debt-based mechanisms, bond issuers must repay the capital they borrowed plus interest. As such, a forest bond creates a net liability on the balance sheet of a bond issuer and a key question is how revenue will be generated in the medium to long term to repay the bondholder.

There are many mechanisms through which revenue can be generated to pay back a forest bond (see Parker and Cranford, 2010), but for better understanding we discuss here the two broad categories of revenue generation mechanisms separately. There are mechanisms that generate revenues from the underlying forest asset, which we call here **forest-based revenues**, and those that generate revenues from some other source, which we call **non-forest-based revenues** (see **Table 2**). Forest bonds could easily use a blend of revenue generation mechanisms within each category and, although it would be more complex, could also be structured to use a blend of mechanisms across these two categories.

Forest-based revenues

Revenue can be generated from the underlying forest investment through **direct markets** for forest biodiversity and ecosystem services (e.g. forest carbon markets) or **indirect markets** where the value of forest biodiversity and ecosystem services is linked to other types of markets (e.g. forest-friendly agriculture).

Forest-based revenues are politically attractive because they incorporate the value of forest biodiversity and ecosystem services into normal economic activities. Direct market mechanisms place the burden of payment (or in this case, repayment of the bond) either on actors that have to mitigate their direct, negative impacts on the environment (e.g. mining companies could use biodiversity offsets) or on actors that are not paying the full value of the natural resources they directly use (e.g. bottling companies could pay for watershed protection). Indirect market mechanisms, in contrast, place the burden of payment on the consumer. Whilst indirect mechanisms may be less politically palatable in developed or non-forest countries where high consumption occurs, such mechanisms can help create a more equitable distribution of the burden of repayment among forest and non-forest countries, or more accurately, among nations with relatively high and relatively low levels of consumption that negatively impacts forests.

Non-forest-based revenues

The second option is for revenues to be generated through mechanisms not related to forests, either from **other markets** not specifically linked to forest biodiversity or ecosystem services (e.g. aviation levy) or from **non-market** mechanisms (e.g. ODA).

Generally speaking, non-forest-based revenues are less politically attractive because they generate revenue either from consumers or firms that are not directly impacting forests (e.g. through an aviation or maritime levy) or from general citizens or individuals (e.g. through general budget allocation). They do, however, have benefits. First, they can be used to redistribute the burden of payment if the mechanism involves an international financial transfer such as a debt-for-nature swap [4] or auctioning of carbon emission allowances in a non-forest country. Second, while direct and indirect markets for biodiversity and ecosystem services are still growing and maturing, non-forest-based revenues provide a larger and potentially more stable revenue base to draw from in the short and medium term.

Table 2. Mechanisms that could be used to pay back a forest bond (based on Parker and Cranford, 2010).

REVENUE	MECHANISM	MECHANISM EXAMPLES
Forest-based	Direct Markets	Forest carbon market Biodiversity offsets Watershed payments
	Indirect Markets	Certified timber Green commodities User fees (e.g. ecotourism)
Non-forest-based	Other Markets	Aviation or maritime levy Financial transaction tax Levy on insurance premiums
	Non-market	General budget allocation ODA Debt-for-nature swaps

INSTITUTIONAL ARRANGEMENTS

The second issue to address in relation to a forest bond is what the institutional arrangements will be. For a forest bond, this means first understanding which organisation is trying to use a bond to finance forest investment (e.g. a government, multilateral development bank, private bank, etc.). Second, this means understanding how both the finance raised by issuing the bond and particularly how the revenue generated to repay the bondholder will be managed. The link between revenue generation and bond payback can either be weak, but allow flexibility in paying the bond back, if it is **on balance sheet**, or it can be strong and legally binding if the bond is **off balance sheet**.

On balance sheet

When revenues to pay back a bond are held *on balance sheet*, they pass through the financial accounts of the issuing institution before paying back bondholders. This means that the link between revenue generation and bond payback is weak, giving the issuing institution flexibility over how to pay back the bond. Payback can either be based on a specific (or set of) generation mechanism(s) or on general budgetary revenues. In the case where repayment is backed by a specific mechanism, the revenues can be *earmarked* to pay back the bond. Earmarking, however, is a political decision and there is therefore a risk that the revenues could be re-appropriated for other spending needs in the future.

Because the bond is on balance sheet, if either the revenue generation mechanism or earmarking procedure fails, bondholders have recourse to claim repayment from other sources from which the issuer receives revenue. Since this places the burden of debt squarely on the issuing institution, the risk profile of an on-balance-sheet forest bond would primarily be defined by the risk profile of the issuer.

Off balance sheet

The alternative arrangement is that revenues are held *off balance sheet* in a separate legal entity called a special purpose entity (SPE), which then becomes the bond issuer. Under this structure a stronger link is maintained between the revenue generation mechanism and bond payback, since the revenue raised to pay back the bond essentially side-steps the financial accounts of the organisation that wants to use a bond (called the *originator*) and so moves more directly from the revenue generation mechanism to the bondholder. This type of bond is referred to as an asset-backed security (ABS) and is used when originating institutions want to distribute some or most of the risk of the underlying revenue generating mechanism to other institutions such as the bondholders themselves. It is also used when these institutions do not want to hold the debt of the bond on their accounts, thus allowing the originator to maintain low debt levels and the ability to borrow finance for different activities in other sectors.

Because the revenues used to pay back an off-balance-sheet bond are kept legally separate from the originator (i.e. are *ring-fenced*), the risk-return profile is directly related to the underlying revenue generation mechanism. For example, under the immunisation bond (see IFFIm, 2011), which uses future ODA commitments to repay bondholders, the return is based on the commitments from donor countries and the risk is defined by the ability and willingness of those countries to honour their commitments.

DELIVERY

The third consideration for the structure of a forest bond is how finance will be delivered to the organisations and communities that carry out forest-friendly activities. As discussed above, the choice of delivery mechanism is strongly influenced by the choice of revenue generation mechanism and the type of institutional arrangement being used.

As with revenue generation mechanisms a mix of delivery mechanisms will probably be used in a forest bond. For purposes of understanding, however, delivery mechanisms can be viewed as falling into two classes, those that are expected to generate a direct **financial return** and those that will have little or **no financial return**.

Financial return

Where revenue generation depends on the underlying forest asset (see **Forest-Based Revenues** in the **Generation** section) the delivery mechanism will often align with the need to generate some financial return on forest investment. Examples of delivery mechanisms in this "closed-loop" system include normal or *concessional* lending to forest-friendly enterprises or households, direct investment (i.e. taking an equity stake) in those enterprises, or creating performance-based payments/incentives at the local level (e.g. through a forest carbon market) assuming the bond issuer would receive performance-based payments from another party at the national or international level (e.g. through REDD or biodiversity payments).

No financial return

Where revenue generation is independent of the underlying investment (see **Non-Forest-Based Revenues** in the **Generation** section) there will be much more flexibility in how finance can be delivered. These bonds could use any of the mechanisms outlined above in addition to other mechanisms that generate no financial return, such as grants or non-financial incentives. In one or two cases (as will be described in later sections on different bond structures), generation mechanisms that depend on forest-based revenues can also use delivery mechanisms with no financial return. Activities that have no financial return, such as capacity building and technology transfer, are vital to the overall efforts to sustain the world's forests. For some countries or regions, being able to fund those types of efforts will be a more immediate need and so it is important to understand which types of forest bonds could include delivery mechanisms to support such activities.

RISK

The final consideration for the structure of a forest bond is risk; specifically what the primary risks associated with the bond are and who faces those risks. Risk is heavily defined by the generation mechanisms and institutional arrangements of a forest bond and risk mitigation will be included in any bond structure (see opposite).

Before investing, potential investors in forest bonds will consider all of the risks normally relevant to bonds. Under certain forest bond structures they will also consider the risks relevant to forest-level investments (see e.g. Gaines and Grayson, 2009), many of which are similar for investments in any asset class (e.g. currency risk if investing from abroad). There is, however, a set of risks that are either specific to or particularly relevant for forest bonds that potential bondholders will focus on.

Commercial risk

Commercial risk is the risk of failure of the underlying asset to produce the goods or services expected (e.g. not producing as many ecosystem service credits as expected). In the case of forest bonds, commercial risk is only relevant for bonds backed by forest-based revenues, but to whom this type of risk falls is dependent on the institutional arrangements of the bond. There are two types of commercial risk that are particularly important for bonds paid back with forest-based revenues.

First, **natural hazard risk** is the risk of commercial failure of an enterprise due to natural events. In the case of forests, such events could include forest fires, disease, drought and weather. Most potential investors in forest bonds do not have much experience in the forest sector, so are not familiar with these risks and measures to mitigate such risks are needed.

Second, **political risk** is the risk of commercial failure due to action (or inaction) by the government where a forest investment is made. That can include expropriation of assets, cancellation of forest concessions, or non-enforcement of forest law. Political risk is a primary constraint on foreign direct investment in all sectors (MIGA, 2010) and is often cited as the greatest concern among potential investors in REDD+ projects in developing countries (Clinton Foundation, 2008 as cited in Forum for the Future, 2010). Thus, political risk would be a primary concern for bonds dependent on forest-based revenues.

Market risk

Market risk arises when the prevailing economic environment causes an investment to generate less revenue than expected. There are two specific market risks related to forest investments generally and therefore to forest bonds.

The first, **ecosystem market risk**, is the risk that either the demand or price in markets for ecosystem goods and services (e.g. certified timber and carbon credits respectively) will be lower than expected.

Ecosystem market risk is inherently linked to the second type of risk: the **regulatory risk** that governments will not implement the appropriate legislation to establish or support direct and indirect markets for forest-based ecosystem goods and services. As with commercial risk, market risk is only relevant for bonds dependent on forest-based revenues, but to whom it falls depends on the institutional arrangements of the bond.

Default risk

Default risk is the risk that institutions responsible for paying back a forest bond will fail to meet their obligation. Default risk is not specific to forest bonds, but is important to highlight because it depends on which organisation is responsible for paying back the bond, which in turn is a function of the revenue generation mechanism and institutional arrangements of the forest bond structure. For example, if a bond is repaid by developed country ODA commitments, the default risk is defined by those developed country governments and their willingness and ability to honour those commitments. For almost every forest bond structure, bondholders will hold default risk.

Risk mitigation

The financial sector has various strategies to mitigate risk, four of which are commonly discussed for forest bonds, particularly in relation to commercial and market risks associated with forest-based revenue generation mechanisms. Two of these strategies, insurance and guarantees, provide compensation in the case of commercial failure. The other two strategies, portfolio diversification and investment tranching, mitigate various risks through the structure of the bond.

Insurance could be purchased to cover a range of risks, and is the most likely method of mitigating natural hazard risk, as seen in the emergence of specialised forest insurance products provided by private-sector insurers (Gaines and Grayson, 2009). A guarantee is a type of insurance used to mitigate risks that are difficult to quantify and in the context of forest bonds might be used to mitigate political risk. Guarantees are more likely to be provided by the public sector through a sovereign or supranational guarantee agency. For example, in mid-2011 the US Government's private-sector development finance institution (the Overseas Private Investment Corporation) agreed to provide what is believed to be the first guarantee against political risk for a REDD project (Terra Global Capital, 2011).

Portfolio diversification can be implemented by ensuring that any cash flows backing a forest bond come from sources that range across geography and/or market sectors. This mitigates risk because underperformance of investment in one place can be offset by overperformance elsewhere. A tranche structure would divide a forest bond into different segments, each with a different risk-return profile. The *senior tranche* would be paid before the more *junior tranches*, and thus be exposed to less risk, but in return for taking lower risk would receive a lower return. In contrast, *junior tranches* would accept first loss if there were any problem with repaying the bond, and so accept more risk, but also expect a higher return assuming all runs smoothly. Both diversification and tranching are crucial to mitigate multiple risks, particularly those associated with nascent ecosystem markets.

The financial sector also has various strategies to deal with the risk of default by issuing institutions, and failure to pay by backing institutions, including mono-line insurance and credit-default swaps. The risk of default, however, is the primary risk that bondholders take on when purchasing a bond of any type, and forest bonds would be no different. Further discussion of mitigation of commercial, market and default risk is included in the section on **Forest Bond Structures**.

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FOREST BOND STRUCTURES

Using the framework outlined above, the following section presents six basic structures that a forest bond can take. Whilst a forest bond would not be limited to these six structures (i.e. hybrids could be developed), examining these structures allows us to understand the way in which forest bonds can be used to finance the conservation and sustainable use of tropical forests.

As discussed previously, the structure of a forest bond is defined primarily by two key factors: whether the bond is repaid through forest-based or non-forest-based revenues; and whether finance is kept on or off the balance sheet of the institute using the finance raised (i.e. the strength of the link between pledged revenues and bond payback). Within a matrix of these two variables, **Figure 3** presents the six basic structures of a forest bond with a brief description of each.

The following pages will discuss each of the structures based on the framework outlined in the previous pages. The discussion of each structure includes a diagram similar to that presented in the Framework section above (**Figure 2**) where boxes represent actors and solid arrows represent flows of finance. Each discussion also includes a summary of the key characteristics of each bond structure as they pertain to the four components of that framework.

Figure 3. The matrix of forest bonds based on the types of revenues used to payback the bond and whether the bond is held on or off the balance sheet of the organisation that developed it.

	ON BALANCE SHEET	OFF BALANCE SHEET
NON-FOREST-BASED	**GOVERNMENT FOREST BOND (TAX-BACKED)** A sovereign bond that specifically raises finance for forests.	**COMMITMENT-BACKED FOREST BOND** Uses a forest finance facility and adapts the model of immunisation bonds.
	CORPORATE FOREST BOND Similar to green bonds issued by multilateral development banks.	
FOREST-BASED		**FOREST-BACKED BONDS (DEBT-BASED)** Adapts the model of a microfinance-backed security, but with forest-friendly loans.
	GOVERNMENT FOREST BOND (REVENUE-BACKED) Like bonds issued by sub-national governments to construct infrastructure.	**FOREST-BACKED BONDS (EQUITY-BASED)** An asset-backed security backed by revenues such as forest carbon, certified timber, etc.

GOVERNMENT FOREST BOND (TAX-BACKED)

GENERATION	INSTITUTIONAL ARRANGEMENTS	DELIVERY	RISK
Non-forest-based revenues.	On balance sheet; issued by government.	Can finance activities without financial return.	Bondholder faces risk of default by government. Issuing government faces risk in terms of its ability to raise taxes to pay back the bond.

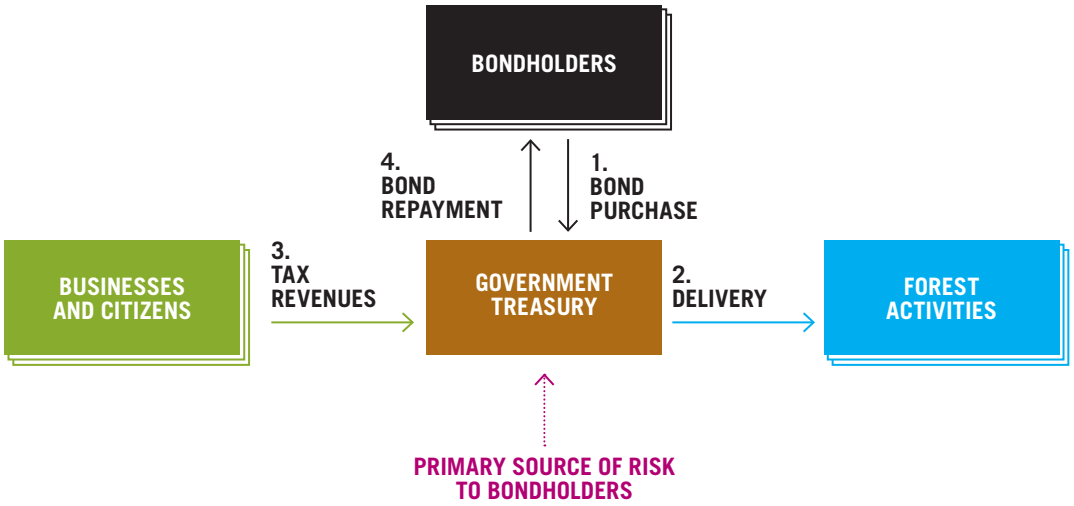
The most basic form of forest bond would be a government-issued bond repaid by tax revenues. There are historical examples of governments issuing themed bonds that are backed by general tax revenues, specifically war bonds. The aim of a forest-themed bond is to tap into a new class of investors that may not normally purchase bonds from the given issuer, but are more interested in financing specific social or environmental initiatives. A national government or sub-national government of a forest or non-forest country could issue this style of bond. Having a smaller tax base, sub-national governments may be more likely to issue a government bond backed by revenues [see **Government Forest Bond (Revenue-Backed)**].

As shown in **Figure 4**, a tax-backed government forest bond follows a simple structure. The government issues a bond to raise finance (**1**), uses that finance to fund forest activities (**2**), collects taxes as normal (**3**) and uses tax revenues to pay back the bond (**4**). A key feature of a government bond is that it is held on the balance sheet of the issuing government. As such, the primary risk to the bondholder is the ability and willingness of the issuing government to raise and use taxes to pay back the bond. Investors would be most attracted to a tax-backed government forest bond issued by a country with an investment grade credit rating or higher (i.e. minimum rating of BBB-) and they may even require credit enhancement for those with a low investment grade credit rating (i.e. above, but close to BBB-).

There are two major concerns with a tax-backed government forest bond. First, from the issuing government's perspective they will be taking on more debt. To satisfy both the potential bondholders who are deciding whether to invest in the bond and politicians who are deciding whether debt should be issued, an issuing government would need to show clearly that they would be in a strong financial position to repay the bond, which would mean showing that sufficient taxes can be raised from businesses and citizens. Second, governments can change and finance raised by the bond can be reallocated to finance activities in non-forest sectors, so credibility in accounting for how finance is delivered will be crucial.

There are also two major benefits to a tax-backed government forest bond. First, since it is essentially a typical government bond it would be fairly easy for investors to compare it to other government bonds and therefore evaluate as a potential investment. This would make the bond more attractive to many types of investors. Second, because the bond would not depend on forest-based revenues to repay bondholders, the bond could fund forest activities with no financial return.

Figure 4. Structure of a tax-backed government forest bond.



GOVERNMENT FOREST BOND (REVENUE-BACKED)

GENERATION	INSTITUTIONAL ARRANGEMENTS	DELIVERY	RISK
Revenues are largely forest-based, but could be mixed.	On balance sheet with earmarked revenues; issued by government.	Can finance activities without financial return.	Bondholder faces risk of default by government. Issuing government faces ecosystem market and natural hazard risk (not regulatory or political risk).

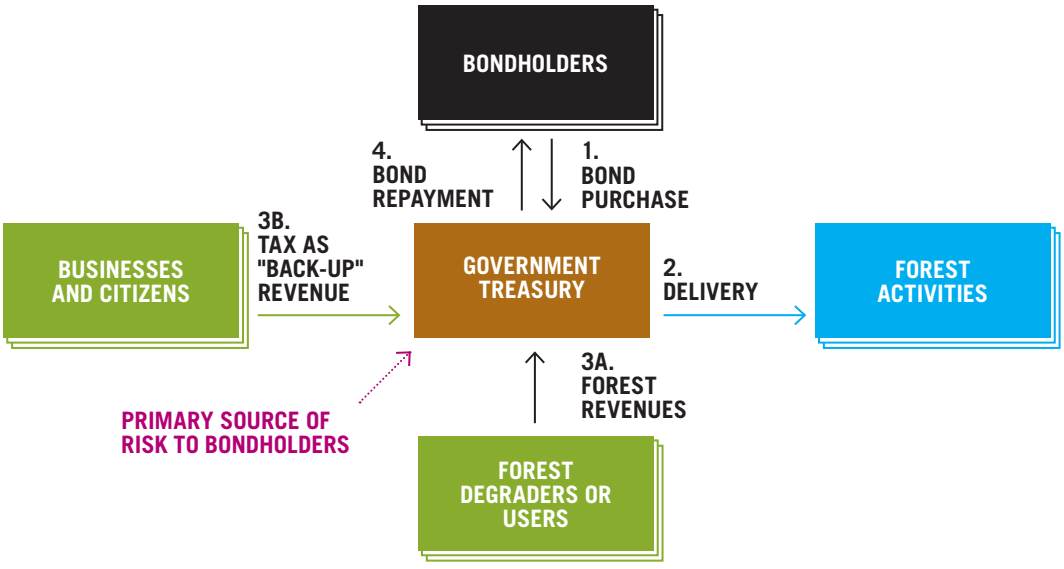
A government forest bond can also be repaid using forest-based revenues. There are many examples of governments issuing revenue-backed bonds in other sectors, particularly at the state or municipal level to raise finance for infrastructure projects such as railways and toll roads. While municipal, state and federal governments could all issue a bond of this type, sub-national governments would probably favour this type of bond over a tax-backed bond due to their relatively smaller tax base.

As illustrated in **Figure 5**, a revenue-backed government forest bond is similar in many ways to a tax-backed forest bond. The main difference is that the revenues used to pay back the bond are primarily generated from policies the government implements to generate forest-based revenues (**3a**). Although the bond is on balance sheet, the government can earmark these forest-based revenues, thereby giving bondholders and policy-makers some confidence that there are specific revenues of a known scale available to pay back the bond. The link between those revenues and the bond payback, however, is still dependent on political decisions in annual budget allocations, leaving the possibility that in future years the government could reallocate the generated revenues to another cause.

Since the bond is held on balance sheet, if forest-based revenues fail to materialise, the bond will still need to be paid back from other revenues, such as general taxes (**3b**). With tax revenues as the "back-up" option for paying back this type of forest bond, from the bondholder's perspective, a revenue-backed government forest bond would have a similar risk profile to a tax-backed bond.

From the issuing government's perspective a revenue bond would alleviate the political difficulty associated with a tax-backed bond, namely that local businesses or citizens not associated with forest degradation would pay back the bond. Instead, the government could institute policies, or use policies already in place, to generate revenues from forest-degrading or forest-using actors (e.g. through stumpage fees, biodiversity offsetting, or user fees), thus following the more politically palatable polluter (or user) pays principal. Further, because the government has the power to institute revenue-raising policies, the funds raised through the bond would not have to be invested in forest activities with a financial return.

Figure 5. Structure of a revenue-backed government forest bond.



CORPORATE FOREST BOND

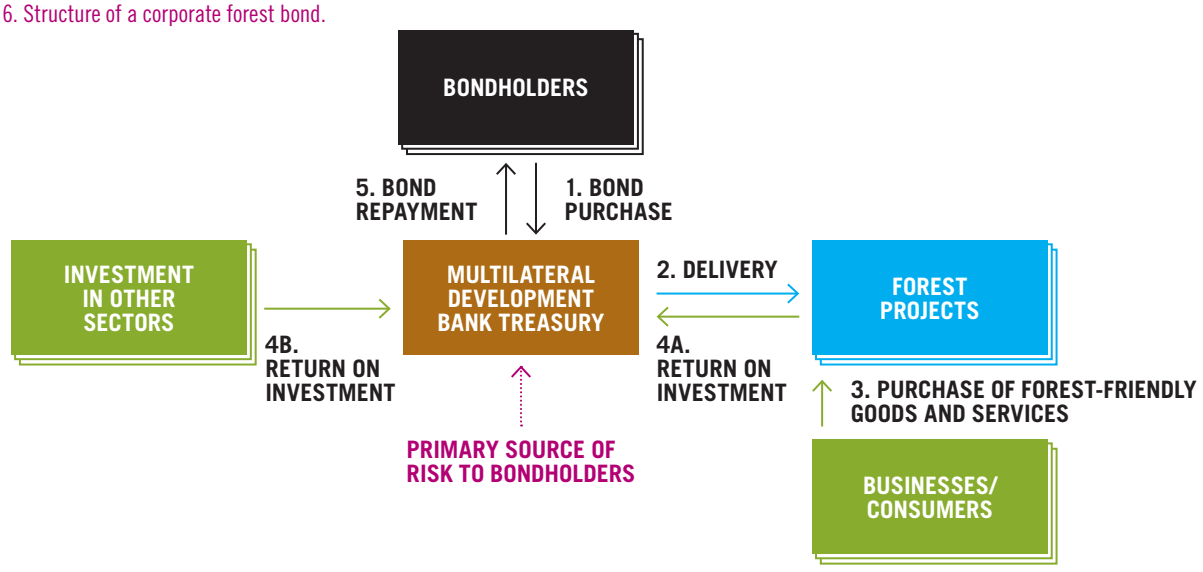
GENERATION	INSTITUTIONAL ARRANGEMENTS	DELIVERY	RISK
Mixed.	On balance sheet; likely to be issued by multilateral development bank.	Would finance activities with at least a small financial return.	Bondholder faces risk of default by issuer. Issuer faces either default or commercial and market risks.

A bank would issue a corporate forest bond to finance its investment in a portfolio of forest projects. As indicated in **Figure 6**, the issuer would raise finance through a bond (**1**) and invest that in forest projects (**2**). Those projects would generate at least some revenue through direct and indirect markets for forest ecosystem services, such as the sale of forest carbon credits or sustainable agricultural commodities (**3**). The bond issuer would then receive a portion of those revenues (**4a**) but would also receive revenues from investments in other sectors (**4b**). Revenue streams from all the issuer's investments in every sector would flow into its treasury, the treasury in turn would pay back the bond from its total available resources (**5**). So as with all forest bonds, a corporate forest bond can be defined as a forest bond not by how it is paid back, but because the money it raises is delivered to forest-friendly activities.

Like a government forest bond, a corporate forest bond is on balance sheet so the primary risk to bondholders is default by the issuer. Unlike a government forest bond, however, the issuer does not have the power to implement policies that support forest-based revenue generation. If returns on investment in forest-friendly activities are lower than expected, the issuer will have to depend more on returns from investments in other sectors to pay back the bond. Due to the perceived nascent nature of direct and indirect markets for forest ecosystem services, private banks are unlikely to want to take on the direct risk of paying back a forest bond with revenues from other investments and would probably prefer to issue a forest-backed bond (described later) rather than a corporate forest bond.

Consequently, a corporate forest bond might be most appropriate for a multilateral development bank (MDB), which has both the remit to support sustainable development objectives through concessional investments and the political leverage to promote policies that support forest-based revenues within the countries they invest in. Repayment of the MDB's forest investments could be concessional and based on non-forest-based revenues while the relevant policies to support forest-based revenues were being implemented. A MDB would thus most likely deliver finance through (concessional) lending following the model of World Bank Green Bonds (World Bank, 2011) or through an equity-like arrangement similar to, for example, Emissions Reduction Purchase Agreements (ERPAs) used by the World Bank in its carbon funds (see www.wbcarbonfinance.org for more information). Whatever the delivery mechanism, an issuing MDB would still need to take risk mitigation measures, by for example investing in a diverse portfolio of projects varying by country and revenue source.

Figure 6. Structure of a corporate forest bond.



COMMITMENT-BACKED FOREST BOND

GENERATION	INSTITUTIONAL ARRANGEMENTS	DELIVERY	RISK
Non-forest-based revenues.	Off balance sheet; sponsored by public or civil sector.	Would finance activities with no financial return.	Bondholder faces risk of default by backing governments. Backing governments face risk in generating revenues.

Commitment-backed forest bonds have received significant attention in forest policy discussions that cite the immunisation bonds issued by the International Finance Facility for Immunisation (IFFIm) as a succesful model [5] (IFFIm, 2011). Following that model, and as indicated in **Figure 7**, a commitment-backed forest bond would be issued by an SPE—called a *forest finance facility*—to raise finance (**1**) that is used to fund forest activities (**2**). Revenues would be generated through commitments made by one or a group of governments (**3**) and used to pay back the bondholders (**4**).

An ODA-backed bond is the most frequently discussed option for a commitment-backed forest bond (see The Prince's Rainforests Project, 2009), but the repayment mechanism for this type of forest bond could be any of the other market or non-market mechanisms outlined in **Table 2**. Since the revenue generation is decoupled from the underlying forest investment, the finance raised through this type of bond could be delivered to forest activities that do not have a financial return.

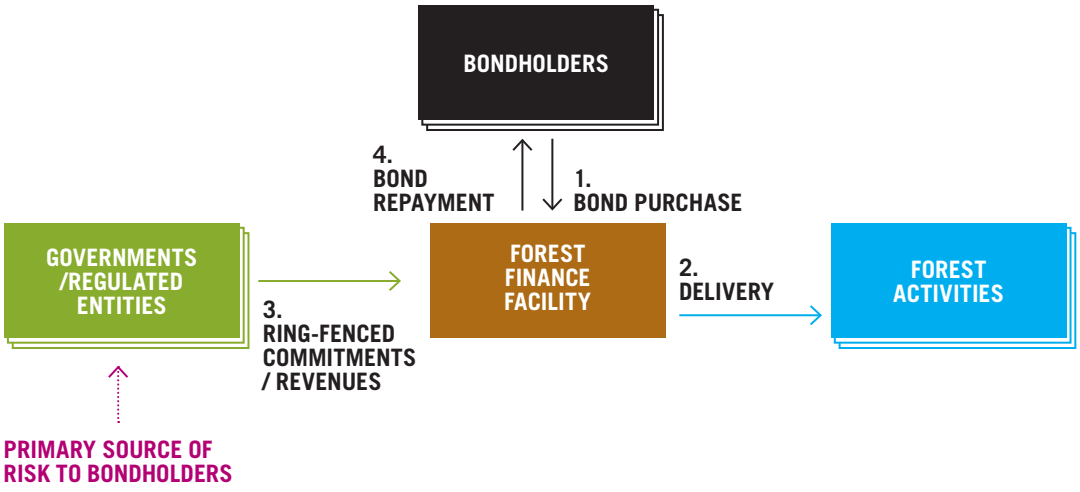
A commitment-backed bond is held off balance sheet, so the primary risk to bondholders will reside in the ability and willingness of countries that have backed the bond to honour their commitments (i.e. default risk). Learning from the IFFIm there are three main requirements for a commitment-backed bond to be low risk (FitchRatings, 2010; Standard and Poor's, 2009):

- A politically compelling mandate and strong commitment from backing countries;
- Strong credit ratings of backing countries; and
- Conservative financial management within the finance facility.

A growing body of evidence coupled with a high degree of political support has led to a politically compelling mandate for forests and it is assumed that any forest finance facility would be conservative in its financial management of a forest bond. The greatest concern, therefore, for potential investors in a commitment-backed forest bond will be the risk associated with the countries backing it. The majority of countries funding forest conservation either through bilateral or multilateral channels have high investment grade credit ratings, so an ODA-backed bond would be considered low-risk.

There is also potential for developing countries to fund investment by making commitments from their general budget, but due to their generally lower credit ratings, increased risk mitigation would likely be needed.

Figure 7. Structure of a commitment-backed forest bond.



FOREST-BACKED BOND (EQUITY-BASED)

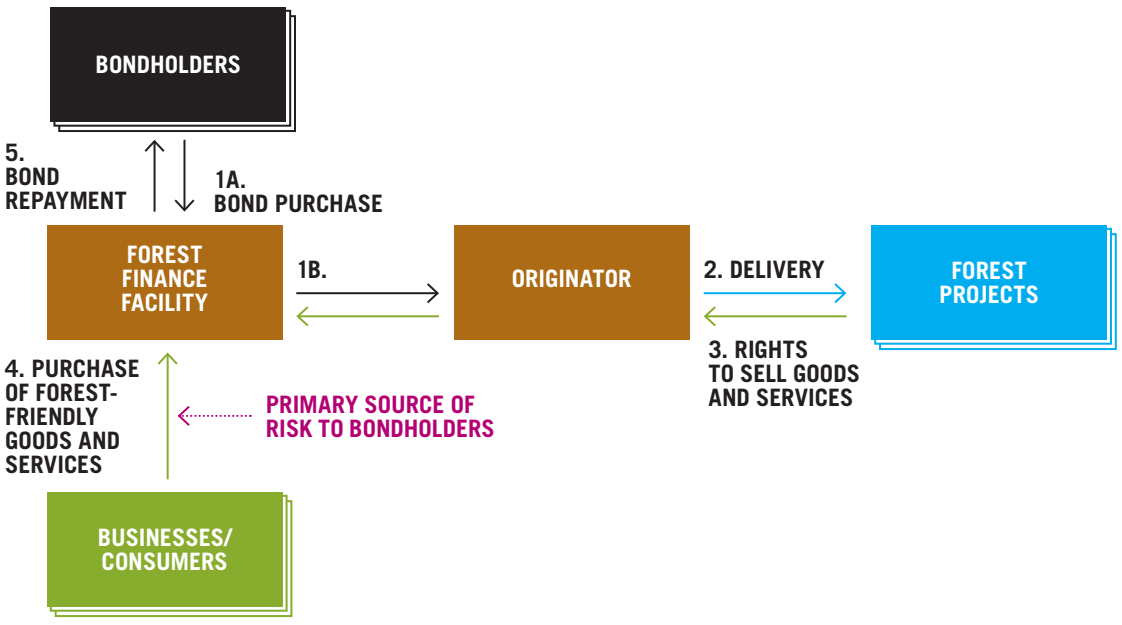
GENERATION	INSTITUTIONAL ARRANGEMENTS	DELIVERY	RISK
Exclusively forest-based revenues.	Off balance sheet, sponsored by private sector.	Would finance activities with financial return.	Bondholder faces commercial and market risks.

An equity-based forest-backed bond was the first type of forest bond structure to be envisioned (see Forum for the Future and EnviroMarket, 2007; Lambe, 2007). Whilst a forest-backed bond has not yet been issued, this model is currently being developed by several organisations [6] and examples in related sectors are emerging [7]. A forest-backed bond is the most likely structure that a private financial institution would choose to use.

As illustrated in **Figure 8**, the bond would be issued by a forest finance facility (**1a**). The originator would then receive those funds (**1b**) and use them to invest in forest activities through an equity investment or performance-based payments (**2**). In return, the rights to some or all of the ecosystem goods and/or services would be passed back to the forest finance facility (**3**). The facility would generate revenues by selling those goods and services into regional or global markets (**4**) and those revenues would be used to pay back the bond (**5**). For example, in return for investing in activities that produce carbon credits, the forest finance facility would receive the rights to (some of) those credits, and would generate revenue by selling them in carbon markets.

As the only sources of revenue from such a bond are those from ecosystem goods and services, strong financial management will be a key function of the facility to manage market risks such as commodity price fluctuations, particularly as forest-friendly goods and services still have relatively small market share. Further, without proper measures, a forest-backed bond directly exposes bondholders to the commercial risks of forest investment. The bond structure would need to adopt strategies to mitigate risks the bondholder faces and distribute risks to those best able to deal with them. Among these risks, regulatory and political risk of the countries the bond is used to invest in will be a key concern for investors considering an equity-based forest-backed bond.

Figure 8. Structure of an equity-based forest-backed bond.



FOREST-BACKED BOND (DEBT-BASED)

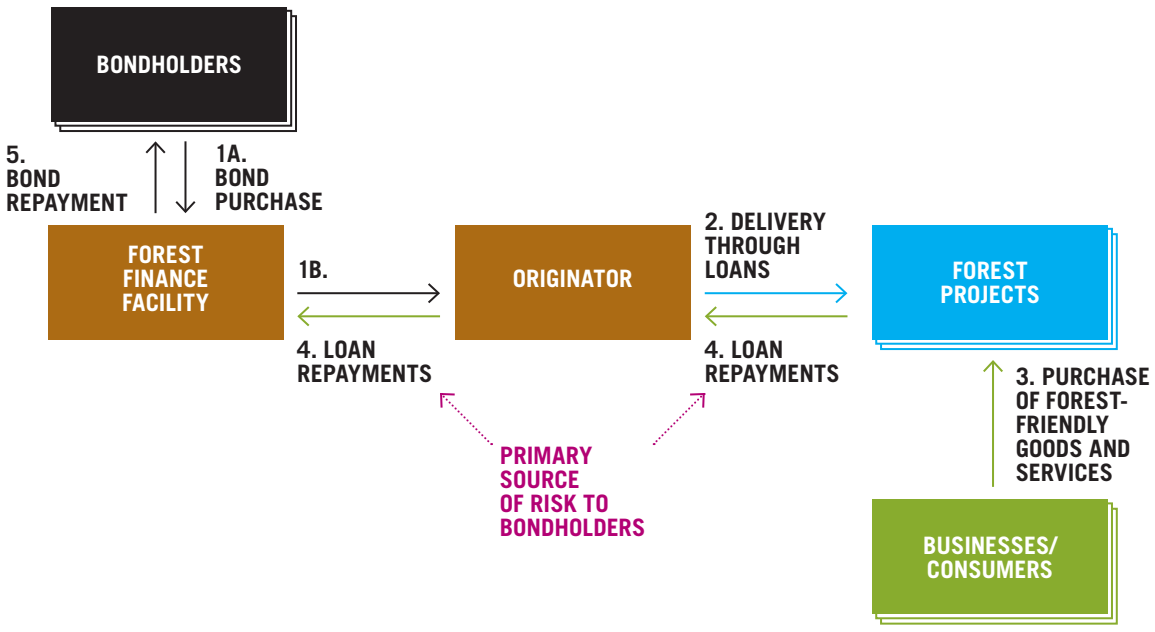
GENERATION	INSTITUTIONAL ARRANGEMENTS	DELIVERY	RISK
Non-forest-based revenues.	Off balance sheet; sponsored by public or civil sector.	Would finance activities with no financial return.	Bondholder faces risk of default by backing governments. Backing governments face risk in generating revenues.

A debt-based forest-backed bond would build on the growing body of experience with microfinance-backed securities—often referred to as a *microfinance-backed security* (MFBS) or *microcredit-backed security* (MCBS). The first security backed by loans to microfinance institutions (MFIs) was issued in 2004 (BlueOrchard, 2006) and 2006 saw issuance of two securities that directly pooled microfinance loans (e.g. securitisations by ProCredit Bulgaria and BRAC; see Hüttenrauch and Schneider, 2009).

As shown in **Figure 9**, the institutional arrangements of debt-based forest-backed bonds are very similar to that of equity-based bonds, but the generation and delivery mechanisms are different. Finance is delivered through loans to households or small- and medium-sized enterprises (SMEs) that want to undertake forest-friendly activities (**2**). The institutions implementing these activities would maintain the rights to the forest-friendly goods (e.g. certified timber) and/or ecosystem services (e.g. forest carbon credits) they produced and generate revenues from selling them into local, regional, or potentially global markets (**3**). Sales of those goods and services would be used to repay the loan (**4**) and those loan repayments would be used to pay back the bond (**5**).

As with the previous structure, a debt-based forest-backed bond directly exposes bondholders to the underlying investment risk. In the case of a debt-based bond, however, the risk to bondholders is institutional in nature and would be the risk that borrowers default on their loan repayments. As such, the commercial and market risks would fall mainly to borrowers who would need to ensure that their investment generates sufficient revenue to repay any loans they have received. Innovation may therefore be needed in the bond structure to ensure that the forest-level borrowers do not have a disproportionate amount of risk placed on them. That is particularly true where the borrowers are rural communities or low-income households. Further care should also be taken to ensure that these borrowers have support to manage the risks that they do face.

Figure 9. Structure of a debt-based forest-backed bond.



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ADDING PERSPECTIVE

Policy perspective

Forest-owning countries [8] have vastly different developmental, political and institutional contexts, and therefore have different capacities to implement forest policy reform. Within international climate change negotiations, recognition of these different contexts has led to the development of what has been called a phased approach to REDD (Meridian Institute, 2009). Under the phased approach, countries will progress from capacity-building activities toward national approaches that deliver emissions reductions through forest activities in a measurable, reportable and verifiable way.

While the phased approach has been developed in the context of an emissions reduction framework under the United Nations Framework Convention on Climate Change (UNFCCC), conceptually it can also apply to other activities to conserve and sustainably use tropical forests, including certified timber production and green commodities. As under the development of REDD, **Phase 1** would be the planning phase and include strategy development, capacity building and demonstration activities. **Phase 2** would include implementation of policies addressing deforestation and degradation, and processes for monitoring, reporting and verifying improvements in forest management would be established. **Phase 3** is when the ability to deliver measurable and environmentally sustainable ecosystem goods and services at the national or sub-national level would be fully established and rewarded.

For each phase, different bond mechanisms will be more appropriate to use than others (see **Table 3**). In **Phase 1**, a commitment-backed or tax-backed government forest bond could be used, as they do not depend on forest-based revenues to pay back bondholders. Furthermore, since the issue of capacity building is often framed as an international responsibility (e.g. for REDD under the UNFCCC), a commitment-backed bond that generates revenue from donor countries (as suggested in e.g. Prince's Rainforest Project, 2009) might be the most appropriate structure to use. **Phase 2** activities would begin to generate some forest-based revenues, but more importantly they would pave the way for the generation of significant forest-based revenues in the future. As such, a government or corporate forest bond could be used to support these activities. A bond that depends wholly on forest-based revenues could only be used to finance **Phase 3** activities. A forest-backed bond (equity- or debt-based) would therefore only be an appropriate choice for countries implementing the final phase, although other bonds backed by forest-based revenues (i.e. corporate or government) could also be used to finance this phase.

With good financial planning, a sequential issuance of different types of forest bond could be used to build an end-to-end forest financing strategy. For example, a forest-owning nation could finance capacity-building activities using revenue raised from a forest bond backed by ODA commitments from donor countries. After several years that country could issue its own government forest bond, for example, a 5-10 year tax-backed forest bond to finance Phase 2 activities. After several more years the country would hopefully be entering Phase 3 and have mechanisms in place to reward measurable and verifiable forest conservation and sustainable use. At this time, it could issue a revenue-backed forest bond. Critically, if the timing is set up appropriately, the capital from the second government issued forest bond could be used to pay back part of the first.

Following such a strategy, the tropical forest country would only maintain the additional debt on its accounts for a few years. While that debt is on its accounts, however, it provides a clear incentive to ensure that policies are in place in good time to support a revenue-backed government forest bond with direct and indirect markets for forest biodiversity and ecosystem services.

Investment perspective

Each of the bond structures discussed in the previous section will present different risks to bondholders. The risk associated with a **government forest bond** (tax- or revenue-backed) will primarily be determined by the riskiness of the issuing forest nation. Sovereign credit ratings provide a direct measure of the financial stability of a country and as a result are a good indicator of the level of risk associated with a government forest bond depending on which country issues it (see **Figure 10**). Generally speaking, countries with an investment grade credit rating (i.e. BBB- or above) have the best potential to issue a sovereign forest bond. The 12 tropical forest countries [9] that fall into this category, listed from highest to lowest credit rating, are: Australia, China, Taiwan, Chile, Malaysia, Thailand, Mexico, Brazil, Colombia, India,

Table 3. The phases of implementing policies to reward the provision of ecosystem services, and the forest bond structures that could be used to finance each phase.

	PHASE 1	PHASE 2	PHASE 3
AIMS Bond type	**STRATEGY DESIGN**	**IMPLEMENTATION**	**PERFORMANCE**
Commitment-backed			
Government (tax)			
Government (revenue)			
Corporate			
Forest-backed (debt)			
Forest-backed (equity)			

Panama and Peru.

A **commitment-backed bond** is off balance sheet, and the risk will therefore be dependent on the type of mechanism that will be used to repay the forest bond. In the case of an ODA-backed bond, the associated risk can be estimated from donor countries' sovereign credit ratings. Most donor countries have a high investment grade credit rating and recognise the politically compelling issue of tropical forest conservation. Assuming that conservative fiscal management was employed by the forest finance facility, a bond backed by ODA should have a sufficiently high credit rating to interest investors. Bonds that are backed by other financial mechanisms such as auctioning of emissions allowances in the EU, or an aviation or maritime levy, would be assessed based on the performance of those mechanisms and the surety of the regulation supporting them. For bonds backed by commitments from tropical forest countries, the list of most likely backers will be limited to the same 12 with the greatest potential to issue a government forest bond.

The risk associated with **forest-backed bonds** and **corporate bonds** that are dependent on forest-based revenues would be less influenced by sovereign credit rating and more influenced by the political risk of the tropical forest country in which those revenues were generated. Political risk is not the only risk associated with tropical forest investment, but is consistently noted as the risk of greatest concern for potential investors, and so provides the primary filter to understand where it may be feasible to use forest-backed and corporate forest bonds (**Figure 11**).

Political risk is most clearly important for forest-backed bonds. For an equity-based forest-backed bond, if this risk is not mitigated, potential bondholders will be directly exposed to the level of political risk the project-level forest investments face. For a debt-based forest-backed bond, the borrowers would face some of the political risk, and so the bondholders indirectly face this risk through higher risk of default on forest-friendly loans. As such a forest-backed bond is most likely to be successful to finance forest activities in countries with low political risk.

With a corporate forest bond, bondholders would only be exposed to the risk of the balance sheet of the issuing institution. As such the risk that bondholders will face would probably be low, since institutions that would issue a corporate bond (e.g. international finance institutions and private investment banks) would have a high credit rating. Nevertheless, political and other risks still have an impact on where this type of bond structure could be useful, because the issuing institution would be taking on those risks. As with a forest-backed bond, therefore, a corporate forest bond would most likely be issued in countries with low political risk unless significant risk mitigation was included in the bond structuring.

CREDIT RATINGS OF FOREST COUNTRIES

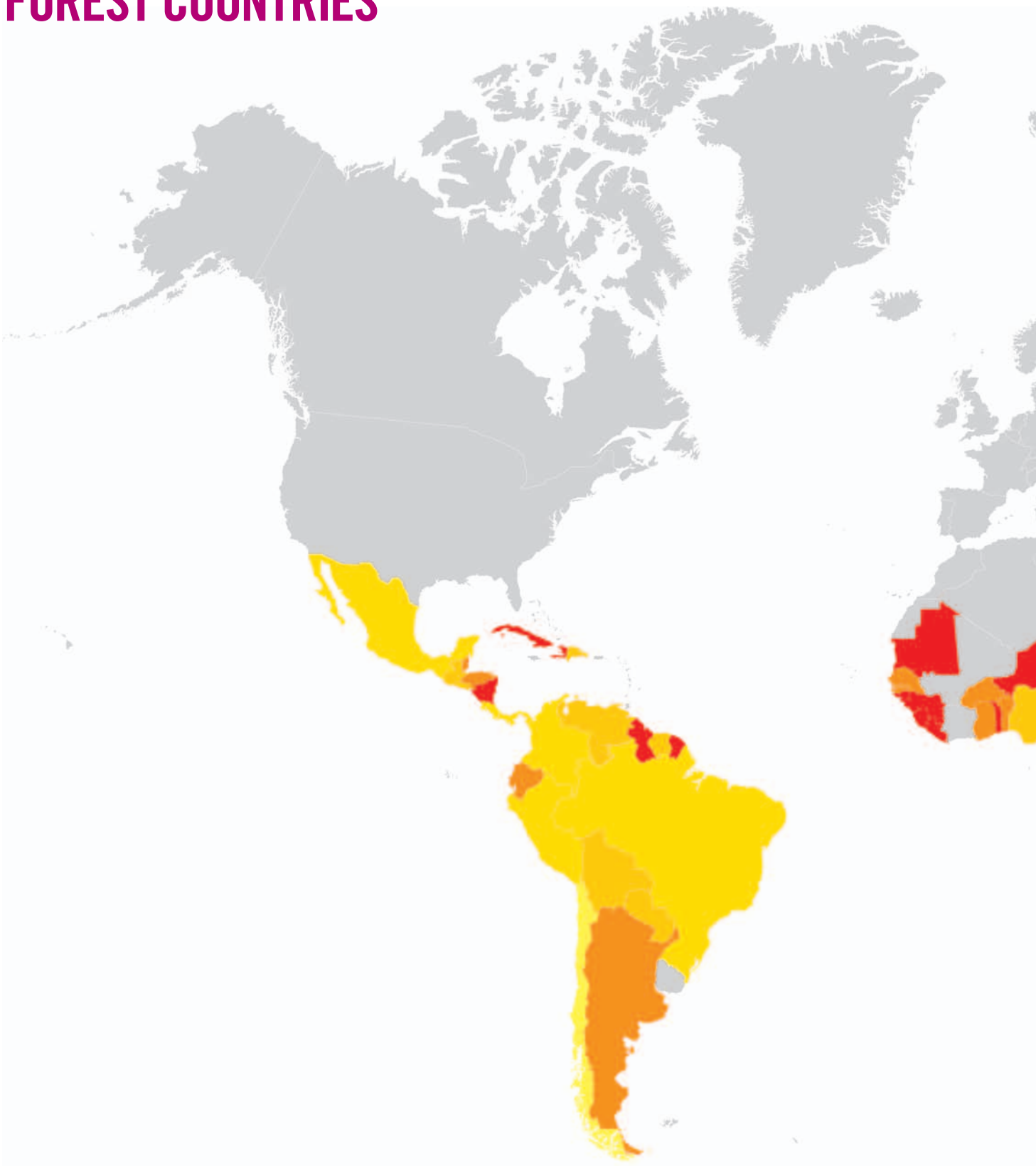
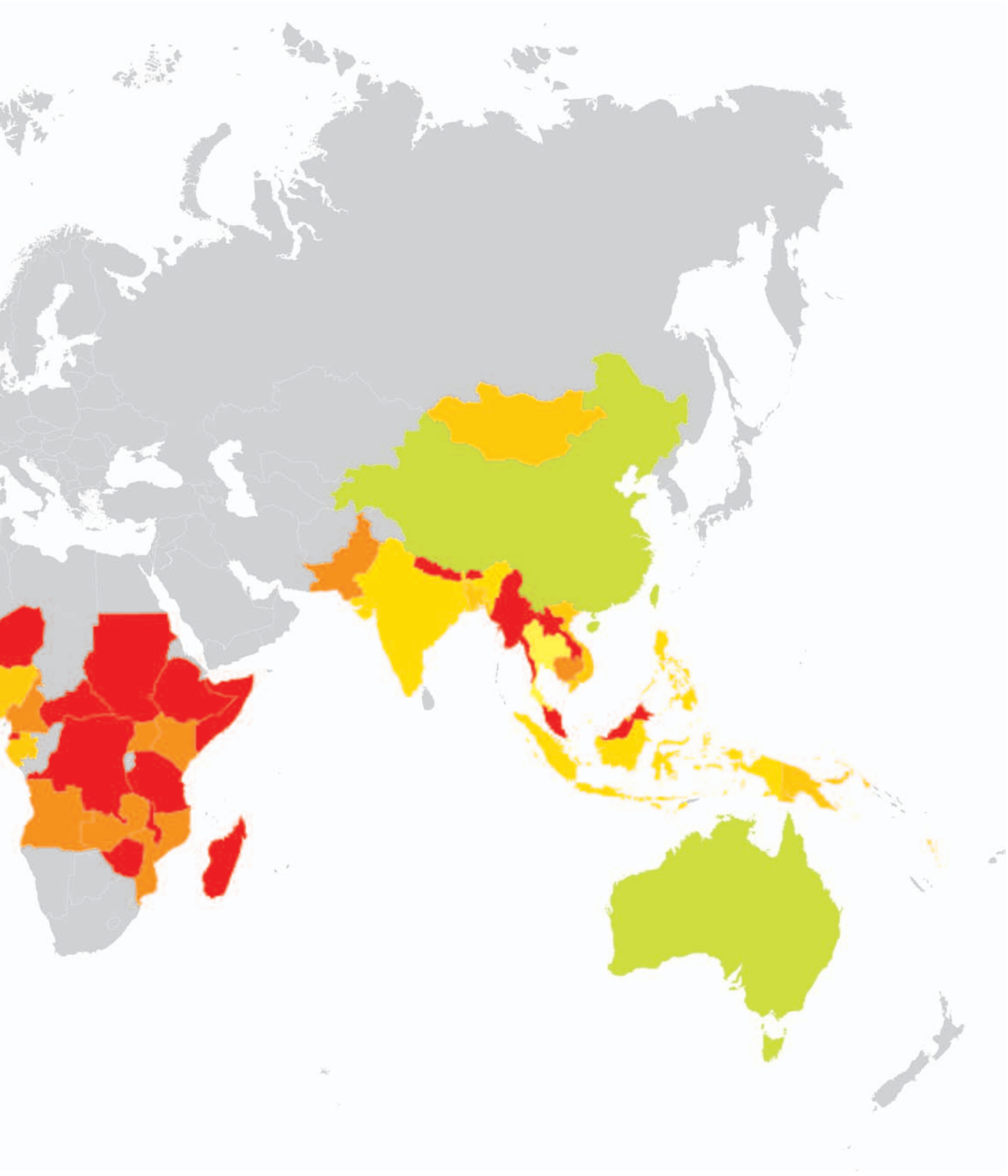


Figure 10. Sovereign credit ratings of 85 tropical forest and REDD countries, based on Standard and Poor's (S&P) ratings in June 2011. Countries with investment grade credit ratings are categorised as High (S&P rating AAA to AA-), Upper Medium (A+ to A-) and Lower Medium (BBB+ to BBB-). Countries without investment grade credit ratings are categorised as Speculative (BB+ to BB-), Highly Speculative (B+ to B-) or Not Rated.



HIGH | UPPER MEDIUM | LOWER MEDIUM | SPECULATIVE | HIGHLY SPECULATIVE | NOT RATED

POLITICAL RISK OF FOREST COUNTRIES

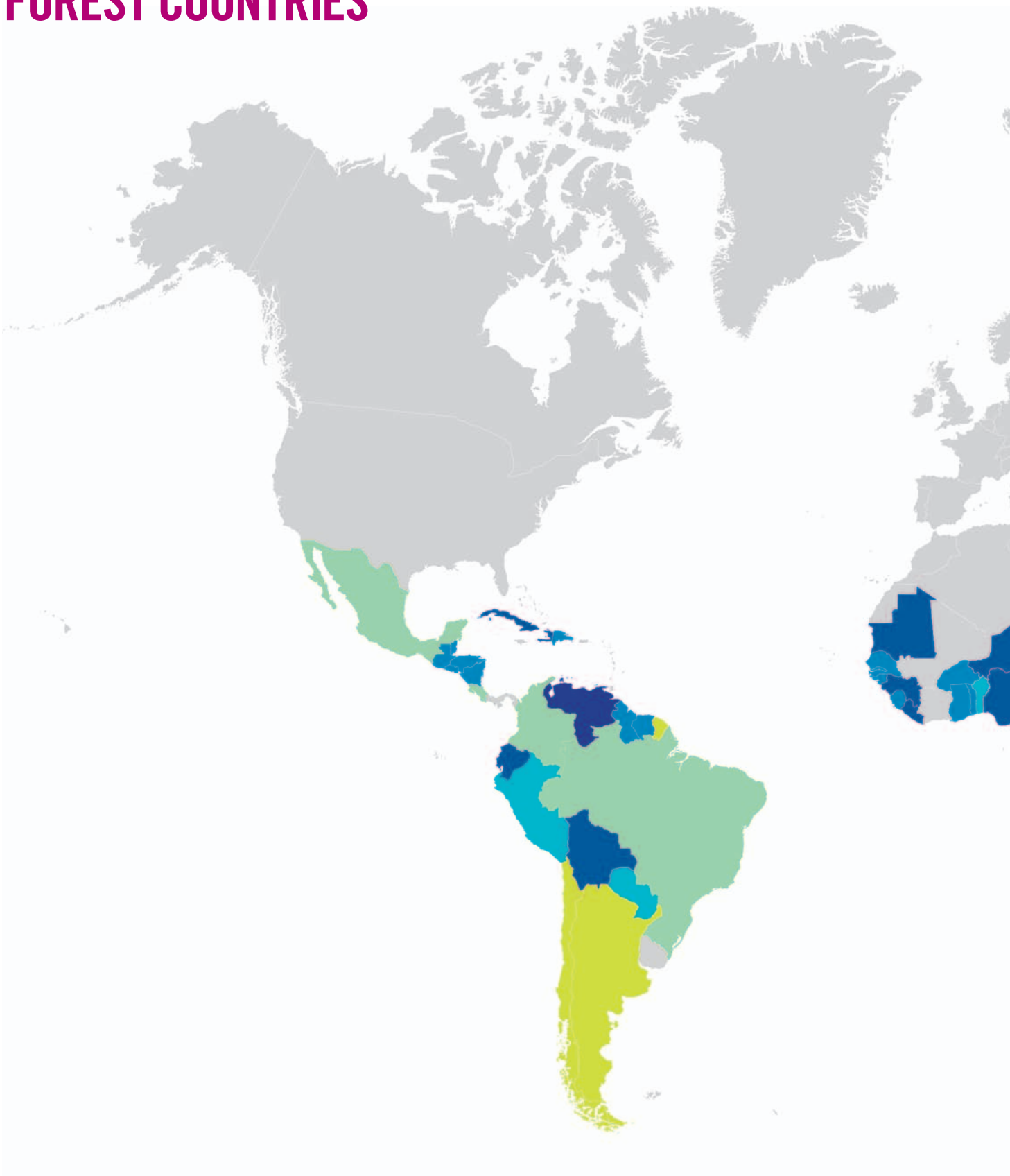
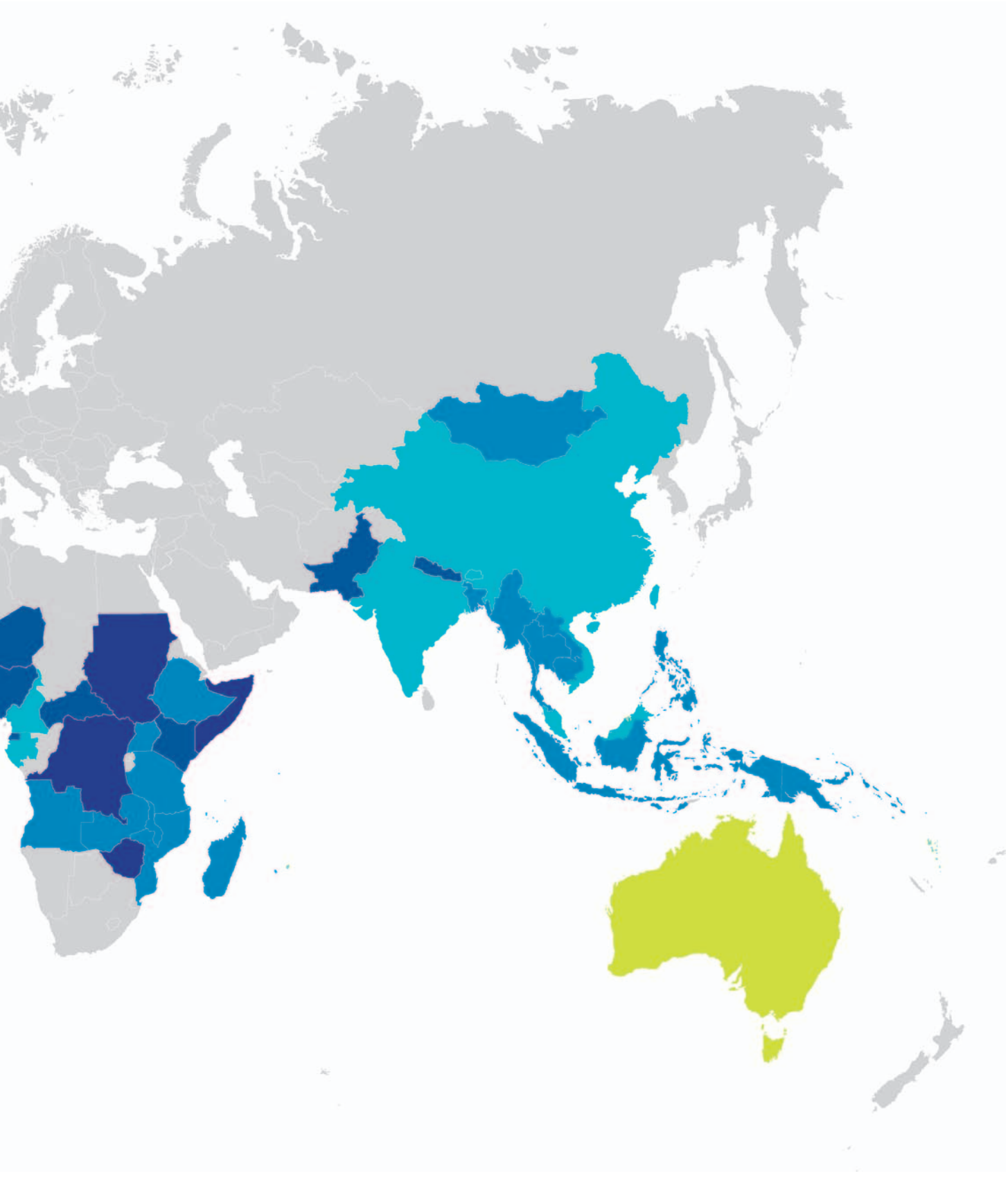


Figure 11. Political risk ratings of 85 tropical forest and REDD countries, based on Aon's political risk map 2010. Countries are categorised following Aon's categorisation.



LOW | MEDIUM LOW | MEDIUM | MEDIUM HIGH | HIGH | VERY HIGH

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WHICH FOREST BONDS WHERE?

Building on the information presented about forest bond structures, and overlaying the policy and investor perspectives, a picture emerges of which forest bonds might work in different tropical forest regions.

Latin America

Of the 12 tropical forest countries with an investment grade credit rating, six are in Latin America: Chile, Mexico, Brazil, Colombia, Panama and Peru. Latin America is therefore a region in which government bonds backed by individual countries could be particularly useful. All of these countries also have a strong or rapidly growing economy, which means that not only are they more able to pay back a bond, but are also facing increasing threats to their forests from increasing levels of growth and consumption.

There is also potential to develop a regional bond in South America, in which for example, Brazil, Colombia and Peru could work together to issue forest bonds that support conservation and sustainable use of the majority of the area of Amazonia and protect the Amazon's major headwaters. The credit rating of these countries is sufficient and their economies are growing at such a pace that they would not necessarily need to depend on donor country support. Extending beyond the Amazon and across South America, Chile would be a potentially welcome addition to such a facility from an investor's perspective.

The Latin American countries in this list also have relatively high levels of participation in markets for ecosystem goods, such as certified timber or sustainable agricultural commodities. Those with low political risk—Brazil, Chile, Colombia and Mexico—are therefore prime candidates to be the focus of a bond backed by forest-based revenues that is issued by either the government or a private institution. Perhaps the most obvious country in which to develop a forest-backed bond is Brazil, which has arguably the best capacity for monitoring, reporting and verification (MRV) of emissions reductions and has already established a reference level for GHG emissions from tropical forests.

Africa

The majority of African nations have a lower than investment grade credit rating (or are unrated) and also have a high level of political risk. Many African countries are also either only in Phase 1 or have not yet begun their national REDD strategy and have little access to markets for ecosystem goods and services. As such, an ODA-backed bond following the model of the IFFIm would be the most viable option from the investor perspective and most useful from a policy perspective to fund a broad strategy of forest governance improvement across the region.

That said, there are some notable private-sector forest investments already taking place in some African nations (e.g. Wildlife Works Carbon, the first Verified Carbon Standard REDD project in the world) and a few other African nations stand out as having low political risk (e.g. Gabon). It is feasible, therefore, that a forest-backed or corporate forest bond could be used to invest in a portfolio of carefully selected projects in the region. With a remit to support (sustainable) development through the private sector, the International Finance Corporation (IFC) is a strong candidate to issue a corporate forest bond to finance African forest investments. If ecological infrastructure could be considered within its remit, the African Finance Corporation (AFC) may be even better situated to issue a corporate forest bond that invests in well-selected private investments in forests across the continent.

Eastern and Southern Asia

Eastern and Southern Asia have a greater diversity of sovereign credit rating than either Africa or Latin America and similarly a much greater diversity of political risk than Africa. The diversity of risk across Asia's tropical forest countries means that a regional forest-backed bond could be developed that uses portfolio diversification to mitigate risk and a tranching structure to sell different levels of risk and return to different types of potential bondholders.

In the short term, any forest-backed bond in this region may have to focus on markets for forest-friendly goods rather than the sale of ecosystem services directly. Conversion of tropical forests, and broader land degradation in this region are dominated by market-based activities, such as timber, palm oil, and rice cultivation across forests, peatland and other ecosystems. From a policy and investor perspective, rather than a forest-specific bond, a broader natural capital or green growth bond that includes forests at its core may be more viable (and potentially more useful) to tackle the direct and indirect drivers of forest loss and land degradation in the region.

MAKING FOREST BONDS WORK

Although bonds are commonly used in many sectors, there are still barriers to their use in the forest sector. Overcoming these barriers was the focus of *Unlocking Forest Bonds*, a workshop held by WWF's Forest and Climate Initiative, the Global Canopy Programme and the Climate Bonds Initiative. The workshop brought together a group of international experts in forest policy and finance to explore how to make a forest bond work. A summary of the workshop results is presented in **Table 4** (the full report can be found at www.globalcanopy.org/projects/understanding-forest-bonds)

A key issue raised during the workshop is the need to improve understanding of what forest bonds can be and increase the level of dialogue and engagement between investors, policy-makers and forest-level stakeholders. All sides use different language to describe their needs and expectations of forest finance, and without clear understanding of how forest bonds work and what they are intended to do, suspicion and mistrust can easily build up. Bridges of communication must be forged and confidence building must take place between these communities before we can realise the full potential of forest finance mechanisms such as bonds to sustain forests and enhance human livelihoods.

Understanding Forest Bonds is part of that process. To truly secure the world's natural capital, much of which is forests or located near forests, financing needs to increase from the USD tens of billions per year to USD hundreds of billions a year. To reach that scale we cannot argue about which mechanism is best; we need all mechanisms. And whilst those mechanisms are being put in place, bonds can be used to frontload finance and start acting to save the world's forests now.

Table 4. Key findings from the *Unlocking Forest Bonds* report. The full report and other relevant documents can be found at www.globalcanopy.org/projects/understanding-forest-bonds.

ATTRACTING INVESTORS	To attract the biggest investors, forest bonds will need to be simple, transparent, comparable and liquid, and must hold an investment grade credit rating	The first forest bonds, however, should target investors with a socially responsible investment mandate who may be willing to compromise on those characteristics.	Adopting a tranche (i.e. segmented) structure would enable forest bonds to attract multiple types of investors at the same time.
CREATING A BOND	Policy-makers and financiers should consider not just carbon revenues, but a mix of cash flows to back a forest bond.	A forest bond can fund multiple initiatives inside and outside the forest to both increase forest resilience and reduce the pressures on them.	Public policy can create a price signal to stimulate early investment in forest preservation.
DEALING WITH RISK	Political risk is the dominant concern for potential investors; forest bonds will require some degree of political risk insurance (PRI).	The external policy environment must also be supportive. Risk mitigation measures like PRI will not make a bad deal good; it will only make a good deal better.	
FOREST COUNTRY POTENTIAL	The burdens and benefits of forest preservation must be appropriately balanced among all stakeholders for forest bonds to be deemed legitimate.	It's worth looking to sub-national experiences in forest countries for lessons on how to strike this balance.	With appropriate technical support, sub-national governments could actually be early issuers of forest bonds.
DONOR COUNTRY SUPPORT	Increasing demand for ecosystem goods and services would secure the cash flows that pay back investments in forest conservation and sustainable use.	Reducing financing costs would help stimulate forest friendly investments.	Donor countries can become more directly involved in the structuring and issuing of a bond by for example underwriting the bond directly.
DIALOGUE AND ENGAGEMENT	More dialogue between the public and private sectors is needed to understand what each expects, and is willing to do, to support public-private partnerships.	Dialogue needs to expand to other public-sector actors including treasury departments and finance ministries that are familiar with private-sector engagement.	

GLOSSARY OF TERMS

- **Asset-backed Security**
  A financial security that is backed by a future flow of revenues that are held legally separate from the originating institution.
- **Bond**
  A debt-based financial instrument that a government or private institution can sell into private capital markets to raise up-front finance.
- **Bondholder**
  A public or private sector entity that purchases a bond.
- **Collateral**
  The assets used to secure a loan. In the case of forests bonds, refers to what is promised to pay the bond back.
- **Concessional Lending**
  The lending of money at a cheaper interest rate (sometimes zero) and at times longer maturity than typical lending in normal credit markets. Multilateral development banks typically carry out concessional lending to support developing countries.
- **Coupon Payment**
  A detachable portion of a bond that is given up in return for a payment of interest (*versus principal*).
- **Climate Bond**
  A bond issued to finance investment in climate change mitigation and adaptation.
- **Credit Default Swap (CDS)**
  Credit default swaps (CDSs) are a form of insurance on a loan or bond. The purchaser of a CDS pays the seller a pre-agreed amount at regular intervals. If certain conditions are met, usually that the borrower or bond issuer defaults, then the CDS seller will compensate the CDS purchaser for their loss and in return will receive the rights to the defaulted loan or bond.
- **Credit Enhancement**
  Credit enhancement describes the process of a bond issuer implementing risk mitigation measures so that the bond they issue receives a higher credit rating.
- **Debt-for-nature Swap**
  When a portion of a developing country's foreign debt is forgiven in exchange for that country making local investments in environmental conservation.
- **Diversification**
  A risk-management practice that involves investing in a group of projects that are heterogeneous by geography, sector, and/or type of expected revenues.
- **Ecological Infrastructure**
  Ecosystems and landscapes that provide ecosystem services to humanity.
- **Ecosystem Service Credits**
  A tradable certificate or permit either 1) representing the right to use or emit a specified amount of an ecosystem service, or 2) recognising the provision of an ecosystem service.
- **Equity Stake**
  The portion of ownership of an asset that is based on an equity investment
- **Equity Investment**
  An investment that results in the investor owning a portion of the underlying asset (company, land, etc.). Equity investments receive the lowest priority regarding returns arising from the asset. Generally equity investments are realised when the share of equity owned is sold on, although equity dividends may also be received.
- **Fiduciary Duty**
  Responsibility of managers of institutional investment funds (such as pension funds and insurance funds) to act in the best interest of the fund beneficiaries.
- **Fixed-income Investment**
  An investment with the terms of the return on that investment outlined from the outset.
- **Forest Bond**
  A bond that is issued to solely finance investments that support the conservation and sustainable use of forests.
- **Forest Finance Facility**
  A special legal entity that would manage finance raised through *off-balance-sheet* forest bonds and the revenues generated to pay them back. A type of *special purpose* entity.
- **Green Bond**
  A bond issued to finance investments with an environmental focus; often used as a synonym for climate bonds.
- **Guarantees**
  Insurance for risks that are difficult to quantify.
- **Impact Investing**
  An investing practice whereby investors are willing to compromise on their preferred financial qualities of an investment (e.g. expected return, risk) as long as positive social or environmental benefits of that investment are assured.

- **Institutional Investors**
  A non-bank person or organisation that trades in very large volumes; often synonymous with pension and insurance funds.
- **Investment Grade Credit Rating**
  A credit rating of Baa3/BBB- or greater. Bonds with lower credit ratings are considered speculative investments.
- **Issuer**
  The organisation that sells a bond to raise finance.
- **Insurance**
  A contract whereby an individual or organisation receives financial compensation if the terms of the insurance contract are met; usually those terms are an unlikely negative event such as a forest fire destroying a plantation.
- **Liquidity**
  The degree or ease to which a financial asset can be bought or sold without affecting that asset's price.
- **Maturity**
  The age at which a bond expires and the principal value must be repaid.
- **Microfinance- or Microcredit-backed Security (MFBS, MCBS)**
  An asset-backed security that is backed by repayment on microfinance/microcredit loans.
- **Monoline Insurance**
  A type of credit enhancement where an insurer will guarantee that if a bond defaults the insurer will pay back the bondholders.
- **Off-balance-sheet Bond**
  A bond where the finance raised and the revenues generated to pay back the bond are not held on the financial accounts of the originator. Instead those financial flows are ring-fenced and held off-balance-sheet in a special purpose entity (SPE).
- **On-balance-sheet Bond**
  A bond where the finance raised and the revenues generated to pay back the bond are held on the financial accounts of the bond issuer.
- **Originator**
  The organisation that structures an asset-backed security and is responsible for determining what the finance raised by that security is invested in.
- **Principal**
  The face value of a bond that is promised to be paid the bond issuer on maturity of the bond (*versus coupon*).
- **REDD and REDD+**
  REDD stands for Reducing Emissions from Deforestation and forest Degradation and refers to the reduction of greenhouse gas emissions through the reduction of forest loss. REDD+ incorporates three additional activities, the conservation, sustainable management, and enhancement of forest carbon stocks, all of which help to mitigate climate change.
- **Ring-fencing**
  When a company or set of cash flows is made legally separate from the parent company.
- **Socially Responsible Investing**
  Investments in organisations or assets that are believed to have a positive benefit for society; often involves screening out socially negative investments such as alcohol or arms production.
- **Special Purpose Entity (SPE)**
  A legal entity whose operations are limited to dealing with specific assets, such as future cash flows.
- **Tranche (incl. Senior and Junior Tranches)**
  A "slice" of an investment deal or structured finance where payments/returns are prioritised. That is, the senior tranche receives returns in preference to junior tranches, meaning the senior tranche is taking less risk, and so receives a smaller return than more junior tranches.

END NOTES

1 In mid-2011, EcoPlanet Bamboo (a subsidiary of the US-based EcoPlanet Group) issued what is believed to be the world's first asset-backed bamboo bond in mid-2011. More information at http://www.ecoplanetbamboo.net/news/asset-backed-bamboo-bond

2 A multilateral finance institution seems poised to issue the first "rainforest bond", which is being structured by Bank of America Merrill Lynch. Reported in Carbon Finance (4 May 2011) and Environmental Finance (6 May 2011) with the article "'Rainforest bond' aiming to monetise REDD credits" (subscription required).

3 The framework is based on Parker et al. 2009 and Parker and Cranford, 2010

4 An arrangement where a portion of a developing country's foreign debt is written off by the lender in exchange for the developing country making local investments in environmental conservation.

5 The International Finance Facility for Immunisation (IFFIm) is a special purpose entity that was established in 2006 to finance the delivery of vaccines in developing countries through the work of the Global Alliance for Vaccines and Immunisation (GAVI Alliance). The IFFIm, which has issued over USD 3 billion in bonds to date, is financed solely through future ODA commitments from donor countries.

6 E.g. A forest bond is being explored by Canopy Capital as a source of finance for ecosystem services provided by the Iwokrama reserve in Guyana (see www.canopycapital.co.uk)

7 E.g. The bamboo ABS issued by EcoPlanet (EcoPlanet, 2011)

8 We define "forest-owning nations" as the 80 countries traditionally considered "tropical forest countries" plus 5 REDD countries not in that original 80. REDD countries are defined as those participating in the Forest Carbon Partnership Facility (http://www.forestcarbonpartnership.org/fcpnode/203) or UN-REDD Programme (http://www.un-redd.org/AboutUNREDDProgramme/tabid/583/Default.aspx).

9 Singapore also falls into this category, but has very little rainforest and is unlikely to issue a forest bond.

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GCP
GLOBAL CANOPY PROGRAMME

Bonds for Trees: A Good Idea Hoping to Become Real

A Commentary on *Unlocking Forest Bonds: A High-Level Workshop on Innovative Finance for Tropical Forests* and *Understanding Forest Bonds: A Guide to Raising Up-Front Finance for Tropical Forests*

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The two reports spearheaded by the Global Canopy Programme (GCP), *Unlocking Forest Bonds: A High-Level Workshop on Innovative Finance for Tropical Forests* and *Understanding Forest Bonds: A Guide to Raising Up-Front Finance for Tropical Forests,* provide an excellent introduction to forest bonds on a conceptual level. While there is significant overlap in content between the two articles, they complement each other and serve as a working proposition that forest bonds—which do not currently exist in the market—could serve a role in financing rainforest protection and conservation efforts. The articles should not, however, be considered a manual or "blueprint" for how to structure and issue forest bonds. The mechanical details of issuing forest bonds, such as fees, choice of distribution channels, securities filings, and road shows are not included. Rather, the two reports serve more as high-level guides to familiarize forest stakeholders with forest bonds as a financing option and to generate interest among potential investors in such instruments.

The underlying thesis behind *Understanding Forest Bonds* and *Unlocking Forest Bonds* is that forest stakeholders can draw upon the large global pool of private debt capital to provide the financing needed to support forest-friendly projects and efforts. In that regard, *forest bonds,* as conceived by the authors, should not be confused with *timber or timberland bonds*. The impetus of a *forest bond*, as put forward by the two reports, is to pursue a greater social good—such as reducing deforestation, maintaining water quality, promoting biodiversity, and sequestering atmospheric carbon. In contrast, *timber or timberland bonds* are issued in pursuit of generating a financial return for the private timberland owner. A standout example of a timber bond is the $800 million timber-backed commercial mortgage pass-through certificates issued by Timber Star in October of 2006—an effort undertaken in conjunction with the firm's acquisition of 900,000 acres of timberland in the United States from International Paper Company.

What is commendable about the two reports is that they provide a clear and well-reasoned explanation and assessment of the functional and theoretical underpinnings of forest

bonds. The advantages and disadvantages of the various types of forest bonds for different needs and scenarios are explained in easily understood language that is devoid of confusing Wall Street lingo. In short, one does not need to be a finance professional to grasp the content of the reports.

Extending Beyond the Rainforest

While the Global Canopy Programme's reports target tropical forests, there is a great deal of transferability to other types of forests and even non-forest ecosystems. Many of the topics addressed in reference to employing fixed income instruments to fund "green" projects are not exclusive to tropical forests, but have broad applicability to virtually any natural system or asset. Why not a fishery bond? Or a wetlands bond? Any natural environment that benefits from an infusion of capital to support sustainable development or conservation values can take advantage of bond financing. From that standpoint, readers who are interested in *green bonds* and *impact investments* in general can stand to benefit from reading these reports.

It Is Not All Green: A Dose of Reality about Forest Bonds

Since the goal of *Unlocking Forest Bonds* and *Understanding Forest Bonds* is to promote and raise the awareness of forest bonds, the reports are, by nature, positive in tone. While there are many good ideas promoted in both works, a dose of realism is recommended.

First, the market potential for forest bonds would likely be limited for quite a number of years. Timberland bonds (which we refer to as bonds issued from private entities owning industrial timberland) take up a very small segment of the global fixed-income market. In the United States, which is the world's largest timber market, total public debt issuance by timberland-based real estate investment trusts (REITS) is less than $8.5 billion. Aside from timber REITs, there are virtually no other timber or timberland-based bonds in the U.S. market today. However, the authors of the reports cited an estimate from the Commission on Climate and Tropical Rainforests of the need for US$30 billion annually for funding just to halve the deforestation rate (*Unlocking Forest Bonds,* 5, 25). If timberland bonds covering the world's most valuable timber resource amount to less than $9 billion, it would be a challenge to raise capital on the scale of tens of billions of dollars annually from the issuance of forest bonds in developing economies.

The second issue that would temper the potential of forest bonds is that many tropical forest nations face a dilemma. These emerging nations need financing from forest bonds to finance the infrastructure needed for preserving and protecting a sustainable forest system. Yet, it is that lack of infrastructure, as well as a lack of markets, that prevents a

developing tropical forest economy from generating the type of stable revenues that bond investors demand. In other words, forest stakeholders can claim that the bonds they issue can be paid through, for instance, eco-tourism, agro-forestry crops, micro-lending to forest communities, biodiversity payments, or credits from Reducing Emissions from Deforestation and Forest Degradation programs (REDD+), but such assurances cannot be demonstrated without the needed funds that the bonds can bring. The irony is that cases that would benefit most from forest bonds are cases that entail high levels of risk—which is anathema to bond investors.

A third and final concern that could limit the appeal of forest bonds is the dearth of quality funding options to support bond payments in the current global economic environment. Many industrialized nations face tight budgets, which will most likely affect their global aid programs. Official development assistance (ODA) from developed countries may therefore not be as enthusiastic about backing forest bonds. Furthermore, internal funding by tropical forest nations also poses challenges. On page 23 of *Understanding Forest Bonds*, the authors propose that "government could institute policies, or use policies in place to generate revenues from forest-degrading or forest-using actors (e.g., through stumpage fees, biodiversity, or user fees)." However, such policies could be politically unpopular, as they would result in cash being pulled from the local economy to pay mainly foreign investors.

The other option is to pay the bond with forest-based revenue sources, such as markets for ecosystem services. On page 15 of *Understanding Forest Bonds*, the authors write, "Revenue can be generated from the underlying forest investment through direct markets for forest diversity and ecosystem services or indirect markets where the value of biodiversity and ecosystem services is linked to other types of markets." However, ecosystem services, while attractive in theory, are hard to effectively monetize in emerging markets. They commonly lack the depth and dependability that would be the basis of a quality credit rating that such bonds need. To place this in context, the total value of biodiversity offset and compensation markets in the United States, including wetlands mitigating banking and species habitat banking, total $1.5 to $2.5 billion per year. This is the lion's share of the $1.8 to $2.9 billion of known annual biodiversity payments made globally (Becca Madsen, Nathaniel Carroll, and Kelly Moore Brands, State of Biodiversity Markets Report: Offset and Compensation Programs Worldwide. 2010). If biodiversity offset markets amount to less than half a billion a year outside of the United States, one must have very modest expectations for emerging nations interested in monetizing ecosystem services to generate enough revenue to finance forest bonds in the range of hundreds of millions or billions of dollars.

A Future for Forest Bonds

For these reasons, it is no surprise that forest bonds have yet to emerge within the fixed income asset space. Nevertheless, momentum has been generated in the last few years for *green* bonds and there is a growing interest in *impact investments.* It is only a matter of time before forest bonds become a reality. I agree with the core message GCP shares in their two reports: bonds have a pertinent and valuable role to play in recruiting private capital to fund environmental forest projects. Chosen wisely in the right situations, forest bonds can advance the social, economic and environmental goals of the forest bond issuer and offer profit (and green credentials) to the investor.

Biography

Chung-Hong Fu is a founding member and partner of Timberland Investment Resources, a timberland investment management organization based in Atlanta, Georgia. He leads the firm's economic research efforts and helps set investment strategy and analysis. He began his career at Temple-Inland Forest Products Corporation, serving as a forest economist. Before his current role at Timberland Investment Resources, Hong served as Senior Investment Analyst for Global Forest Partners.

Hong received a master of business administration from Columbia University. In addition, Hong received a PhD in forest economics from North Carolina State University. He can be reached at mailto:Fu@tirllc.com.

Forest Bonds—Understanding How Debt and Forest Conservation Are One

A Commentary on *Unlocking Forest Bonds: A High-Level Workshop on Innovative Finance for Tropical Forests* and *Understanding Forest Bonds: A Guide to Raising Up-Front Finance for Tropical Forests*

E. Thomas Tuchmann
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Unlocking Forest Bonds: A High Level Workshop on Innovative Finance for Tropical Forests and *Understanding Forest Bonds: A Guide to Raising Up-Front Finance for Tropical Forests* are two reports that provide a succinct, easily understood, and persuasive case for creating an independent class of bonds that would focus on tropical forest preservation. The reports are a great summary read for conservation finance professionals or those who are interested in raising private capital for conservation purposes. The reader may come away with a series of "what ifs" but therein is the value. If forest bonds can be made to work, implementation can be structured in many different ways to address the particular circumstances of individual transactions.

Unlocking Forest Bonds

Unlocking Forest Bonds is the result of a workshop in which public, finance, academic, and business leaders held discussions to determine the necessary conditions under which bonds could become a useful financing mechanism in the effort to conserve tropical forests. The report is organized in five sections to address the following significant topics: buy-side perspectives, sell-side perspectives, risk mitigation, forest country perspectives and country donor perspectives. Each section begins with key points and contains helpful figures and graphics to better understand those points.

The report does a good job of outlining how bonds can best be used to raise large sums of private capital to preserve forests. Of equal importance, it helps to explain what will be expected from investors in exchange for their loans and what will be expected from countries that are the recipients of these funds. The takeaway is that numerous compromises are inherent in borrowing money for forest preservation, and it is important for all parties who enter into such relationships to have a very clear understanding of the terms.

As one who works in the area of conservation debt, I find that perhaps the report's most important information surrounds the discussion of risk. As the authors point out "risk

mitigation is paramount." By *risk*, the authors mean commercial risk, market risk, and political risk. Assigning and managing the risks associated with these factors in the case of default often makes or breaks a debt transaction. The report identifies an array of risk management mechanisms and how they can be used to help lenders and borrowers achieve the comfort they need to move forward with a debt transaction.

Understanding Forest Bonds

Understanding Forest Bonds, published by the Global Canopy Programme, is focused on the nuts and bolts associated with bond financing. The report makes the case for using bonds to finance forest preservation and then addresses the question of who would invest in these bonds; outlines different frameworks for generating cash that is essential for debt service; outlines various institutional arrangements and delivery mechanisms that might be used; and describes different forest bond structures. The report closes with discussions about which countries might best take advantage of forest bonds and how to make a forest bond program work. A glossary included at the end of the report is a valuable resource for those who are new to bond discussions and unfamiliar with the highly specialized language associated with debt financing.

Addressing the Issues

The report highlights a number of important issues associated with financing forest acquisitions with bond proceeds.

Tried and True Financing. Bond programs allow interested parties to tap into a well-established private capital market to raise large levels of capital necessary to preserve forests at scale. Successfully structuring a bond and servicing its debt over time will attract more capital and larger sums than will federal appropriations and/or philanthropic mechanisms.

Financing Flexibility. The great thing about debt financing is its flexibility. Individual transactions can be structured in many different ways and leveraged with different sources of equity and public/philanthropic capital to match a project's biological and cash-flow characteristics, lender return expectations, risk and timing requirements, and borrowers' sustainability objectives among other objectives. While the options are numerous, the report provides a summary of six structures that could be used by lenders and borrowers to structure bond financing.

Structural Flexibility. Bonds can be structured flexibly to address individual country capabilities. Said differently, some countries' investment-grade rating would be conducive

to government-backed bonds whereas other countries' lower-than-investment-grade ratings would be more conducive to a commitment-based bond structure.

Some Closing Thoughts

These reports are excellent primers on bonds and the ways in which they can be structured to fund large-scale forest conservation. Yet there are a number of difficult issues that our firm has experienced in trying to use debt to finance forest conservation. Perhaps some of these issues could serve as the basis for a follow-up study and to further build support for a forest bond program.

To begin with, federal and local institutions are not in a place right now where they can or want to fund or guarantee what they see as new and potentially risky forest conservation transactions. Moreover, the learning curve is steep for anyone who wants a full understanding of the forest asset class. Finally, though an international effort is afoot to create ecosystem service markets, they are generally not bankable. An oversimplified conclusion is that forest bonds are not viable because investors are not confidant that projected cash flows under a conservation regime will service debt associated with a commercial purchase price.

However, and in addition to the reports' recommendations on this topic, there may be ways around this dilemma. First, an appropriate level of sustainable harvest should be assumed. Meaning that bonds and debt are probably not conducive to properties for which no harvest is contemplated. Second, federal and local governments can play an important role by authorizing municipal bond structures in a way that lowers the cost-of-capital in exchange for conservation commitments; for example, by structuring a bond so that a lender country will lower its capital cost by 100 basis point in exchange for the borrower prohibiting fragmentation or accepting limits on certain harvest activities. Third, forest bond users might think about how forest ownership and governance can be structured in a way that provides comfort to investors, forested countries, and local citizens. One way to do this is to create private nonprofit forestry companies that have economic objectives in terms of debt service but that also maintain agreed-upon levels of forest conservation. Fourth, to the extent that bond terms can be extended to 20, 30, or ideally 40 years, significant pressure will be taken off forests to produce returns at the expense of conservation in the short term or in difficult markets.

Finally—and this is more philosophical than substantive—when looking at bonds and associated debt service, it is important to look at the actual forest and not just individual trees. Forest bonds will require debt service, and debt service may require harvesting trees at a rate that some view as unacceptable; however, harvesting trees at accelerated rates would be temporary, and once that debt was serviced, conservation would grow over time

and any ongoing proceeds could be funneled back to local communities. In the authors' viewpoint and mine as well, the alternative actions (or inaction) lead to more fragmentation and more deforestation that will be difficult to manage. The great thing about forests and forestry is that we can manage at various intensities to achieve different goals. When one lines that concept up with bond financing, it is likely that large sums can be raised to reach various environmental, social, and economic objectives.

I share the authors' perspective that tapping into private capital bond markets can go a very long way in helping to preserve forests. Time is too short, traditional public and philanthropic financing programs are too limited and the scale is so large that failure to do so will certainly mean that conservation at a meaningful scale will be difficult if not impossible to achieve.

Biography

Mr. Tuchmann is President of US Forest Capital, LLC, an advisory services company based in Portland, Oregon. US Forest Capital assists clients in identifying, managing, and financing natural resource transactions; creating and improving governance structures; and resolving public policy and communication challenges. In this role, Mr. Tuchmann helped to raise $240 million in conservation funding that conserved 110,000 acres of private working forestland.

In his previous role as Western Director and Special Assistant to the U.S. Secretary of Agriculture, Mr. Tuchmann successfully directed negotiations and implementation of the $480 million Headwaters Forest Agreement and arranged President Clinton's Forum, resulting in a $50 million plan for Lake Tahoe. Before joining the Department of Agriculture, Mr. Tuchmann served as the Director of the U.S. Office of Forestry and Economic Development.

Mr. Tuchmann is a forestry graduate of Northern Arizona University and earned a Masters degree in natural resource policy from Pennsylvania State University. He has written and spoken widely on natural resource issues. He served on the Society of American Foresters' Committee on Forest Policy and as an adjunct professor at the Northwestern School of Law at Lewis and Clark College. Mr. Tuchmann currently serves on the boards of Sustainable Northwest and the Forest Park Conservancy. He can be reached at mailto:tuchmann@usforestcapital.com

The Stoves Are Also Stacked: Evaluating the Energy Ladder, Cookstove Swap-Out Programs, and Social Adoption Preferences in the Cookstove Literature

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Abstract

The Stoves Are Also Stacked: Evaluating the Energy Ladder, Cookstove Swap-Out Programs, and Social Adoption Preferences in the Cookstove Literature

The distribution of fuel-efficient cookstoves, whether via aid, subsidies, carbon finance, or public programs, has undergone an international renaissance since the establishment of the "Global Alliance for Clean Cookstoves" (GACC) in September 2010, a high profile private-public partnership including the United Nations, the United States' Environmental Protection Agency, and the Shell Foundation. The dominant discourse within the GACC mission and project strategy is the conviction that cookstoves can attract sufficient carbon finance to completely offset project costs, resulting in highly leveraged returns on donor contributions. Much of the literature has focused on the many positive contributions of cookstove technology including improving public health, decreasing the burden on women, and reducing deforestation. Ample policy publications present recommendations for practitioners regarding cookstove design and project development, though these publications often underreport project failure. Cookstove technology is not a new intervention but with the entrance of innovative financing streams, it is essential to contextualize its past performance within the academic and policy literature. This survey of existing knowledge synthesizes current understanding of fuel-efficient cookstove interventions while also revealing literature gaps and potentially fruitful lines of inquiry for future scholarship.

The Stoves Are Also Stacked: Evaluating the Energy Ladder, Cookstove Swap-Out Programs and Social Adoption Preferences in the Cookstove Literature

The distribution of fuel-efficient cookstoves, whether via aid, subsidies, carbon finance, or public programs, has undergone an international renaissance since the establishment of the "Global Alliance for Clean Cookstoves" (GACC) in September 2010, a high profile private-public partnership championed by United States Secretary of State Hilary Clinton, and which includes the United Nations, the United States' Environmental Protection Agency, and the Shell Foundation. The alliance aims to reduce black carbon (soot) from the atmosphere, improve family respiratory health, provide women with timesaving technologies, and reduce burns and injuries in the home. Yet beyond the public fanfare for the cookstove solution, previous attempts at distributing fuel-efficient cookstoves and liquid cooking fuels in rural communities in developing countries have achieved mixed results and are understudied. Today, there is a proliferation of gray literature on cherry-picked cookstove programs and a robust literature on the technicalities of cookstove performance in reducing indoor pollution and increasing the efficiency of fuel combustion. Yet after thirty years of international attempts at distributing fuel-efficient cookstoves to households in developing countries, adoption and implementation patterns remain enigmatic. The ability to determine project performance is further complicated by new factors—such as the proliferation of carbon finance projects.

This literature review draws upon scholarly and policy-papers from 1987 to the present to outline key debates in the production, dissemination, and continued utilization of efficient cookstove technologies in order to identify gaps in the research. The first section is a catalogue of the social and environmental benefits frequently attributed to improved cookstoves. In the second section, we investigate the spectrum of stove program types and financing models, from purely public to commercial distribution models in an effort to identify research gaps in terms of understanding adoption patterns in varying institutional contexts. In the third section we shift the examination to the household level to survey the landscape of theories and scholarly work responding to a question famously posed by Barnes et al. at the World Bank: *"Why, in the face of all the benefits, have so many potential beneficiaries of improved stoves decided not to purchase or use the stoves given the opportunity?"* (1994). The existing theories on fuel preferences, technology adoption, and gender dynamics in determining cookstove adoption rates are addressed, including a critical examination of the "energy ladder" model. In the fourth section we critically examine the vision of cookstove programs more broadly by synthesizing current debates on what "improved" cookstove technologies and fuel types include and by inviting scholars to more rigorously assess the advantages and disadvantages associated with locally produced or imported stove programs. Finally, the literature review concludes with key questions on the edge of the cookstove research frontier.

Meeting International Development Goals through Cookstoves: A Catalogue of Benefits

Cookstoves interest both policy-makers and development scholars given the relevance of improved energy access and modernized energy systems to the Millennium Development Goals (MDG), which have become a proxy for international development targets. While no specific MDG for energy exists, related issues, such as improving access to modern fuels, and reliable electricity and modernizing cooking methods, are required to achieve all eight goals (Foell et al. 2011; Modi et al. 2006). Additionally, growing interest in carbon finance as a mechanism to achieve climate compatible development has also refueled interest in cookstove interventions (Linacre et al. 2011).

Almost three billion people, equal to 40% of the world's population, lack access to modern cooking fuel and technology (IEA2010). Cooking fuel is a basic necessity required for cooking most staple foods, and the world's poor are disproportionately affected by the need to collect or purchase cooking fuel (Sagar 2005). Therefore, improving access to efficient fuel sources and reducing the amount of fuel needed for household heating and cooking is directly correlated with the eradication of extreme poverty and hunger. The majority of cookstove interventions therefore, focus on solid fuel use, although still only 27% of this population has access to fuel efficient cookstoves (Hosgood et al. 2010).

Much current scholarship on cookstoves focuses on specific benefit areas, such as health (Ezzati et al. 2004; Smith 2000), climate change (Bailis et al. 2005; Grieshop et al. 2011; Smith 1994), improved livelihoods for women and children (Parikh 2011), and development (McDade 2004; Sagar and Kartha 2007). Although there is empirical evidence demonstrating the positive impact of cookstoves in each of these areas, it cannot be assumed that cookstove interventions equally benefit each area. Certain projects may favor one benefit area over another, and no project includes a comprehensive benefit package.

Cookstoves and Gender

The burden of fuel collection is customarily a task reserved for women and children, and numerous studies document the work as time intensive (Oparaocha and Dutta 2011); potentially dangerous, particularly in politically unstable regions (Patrick 2007); physically treacherous and associated with a high rate of injury and soreness (Bryceson and Howe 1993; Parikh 2011). Furthermore, the time, risk and injury associated with fuel wood collection is not recognized in the price of wood fuel, rendering invisible both the energy expenditure and the true value of wood fuel within household budget calculations and many policy discussions (Parikh 2005).

It is common practice in rural communities to keep children, particularly girls, out of school for assistance with fuel wood collection and processing given the urgency of meeting household cooking and heating needs (Clancy 2002; Parikh 1995). Thus, while the relationship between cooking fuel options and cookstove options is clearly related to the livelihoods of woman and children, the dynamics of how improved cookstoves will actually improve the lives of women and children is complex, nuanced, and sensitive to social and cultural dynamics such as the woman's ability to authorize how she spends her time and how her work is socially valued.

Cookstoves and Health

The relationship between cookstoves and family health is dramatic. Coined the "killer in the kitchen," indoor smoke from traditional biomass, charcoal, and wood fuel cookstoves is highly correlated with pneumonia and chronic pulmonary disease and accounts for 3.3 million deaths (WHO 2006). By 2030, the number of premature deaths is estimated to reach 9.8 million, demonstrating the significant disease burden (Bailis et al. 2005). Following malnutrition, unsanitary water, and unsafe sex, indoor air pollution is the dominant cause of health risks in developing countries (WHO 2006). This health burden disproportionately impacts women and children, affecting child mortality rates and exacerbating the condition of the immuno-compromised. For children, research has shown that improvements in stove and fuel choices reduce acute respiratory infections equivalent to the delivery of antibiotics through primary health care systems (Ezzati et al. 2004). The potential health benefits of introducing fuel-efficient cookstoves into developing country households provides one of the fundamental justifications for international donor interest and support (Goldemberg et al. 2004; Smith 2010). While the correlation between increasing access to modern efficient fuels and health is well documented (WHO 2006), increasing health in the kitchen is not a simple technocratic task. Scholarship on the cost-effectiveness of fuel-switch interventions implies that cookstove interventions coupled with education on the importance of ventilation in the kitchen can reduce indoor air pollution 25% more effectively than fuel-switch interventions alone (Mehta and Shahpar 2004).

Cookstoves and the Environment

Initial attempts at fuel-efficient cookstove dissemination focused on ending deforestation, the underlying assumption being that wood fuel demand from the rural poor was driving the destruction of primary forests (Arnold et al. 2006, Foell et al. 2011). Further scholarship dismantled this development narrative, demonstrating that forest cover change is often driven by timber extraction or pasture and agricultural demand (G. Leach and Mearns 1988; M. Leach and Mearns 1996). Also, in some cases, village wood collection has actually been shown to stimulate forest cover growth (Forsyth 2003).

Currently, the debate has shifted to a focus on the local and global environmental impacts resulting from fuel-use emissions. Household fuel usage accounts for 18% of global black carbon emissions (Foell et al. 2011). Between 25% and 35% of black carbon in the atmosphere comes from China and India, emitted from the burning of wood and cow dung for household cooking and through the use of coal-based household heating systems (Ramanathan and Carmichael 2008). Notably, burning biomass results in a much higher global warming potential than more "modern" fossil fuels such as kerosene and liquefied petroleum gas (LPG) due to incomplete combustion and the release of other emissions such as methane and black carbon (WHO 2006).

Fuel-efficient stoves are estimated to reduce greenhouse gas emissions by 1–3 tons of carbon equivalent per annum (Bailis and Hyman 2011). Therefore, expanding fuel-efficient cookstove dissemination programs to their full breadth could reduce global greenhouse gas emissions from 2.19 to 6.57 million tons of carbon dioxide equivalent per annum. In addition, an alternative stove system such as an efficient biodigester, a type of cookstove that introduces a localized, household-level biogas system utilizing animal waste for cooking fuel, emits 99% less methane than a rudimentary cookstove that heats with dung (WHO 2006). Envirofit, a lead stove manufacturer for the developing country market, has recently launched its CH-2200 stove model which promises a 50% reduction in charcoal consumption and 37.3% reduction in carbon emissions (Envirofit 2012).

The Spectrum of Stove Program Types, from Public to Private Institutions

Underlying the potential for a cookstove program to make a development impact is the issue of ensuring cookstove adoption and sustained use (Ruiz-Mercado et al. 2011). Open debates in the literature regarding successful and prolonged cookstove dissemination and acceptance center around the appropriate role of governments, the private sector, and NGOs in facilitating the production, dissemination, and adoption of new cookstoves (Gaul 2009; Goldemberg et al. 2004; Kees and Feldmann 2011; Shrimali et al. 2011).

The spectrum of cookstove financing options includes purely commercial models, such as venture financing, as well as soft loans and public grants. Cookstove programs typically rely on intermediate options that seek to leverage public support for the social benefits associated with stoves while attracting market actors to the developing country energy market (Cox 2011; Shrimali et al. 2011). Hybrid programs evaluated in the literature utilize public, NGO, or donor financing, at least at the outset of the initiative in order to support the development of technologies, the creation of research and testing centers, and to begin stove promotion and training (Kees and Feldmann 2011). Public support for start-up costs reflects the simultaneous public and private benefits associated with the new stoves (Bailis et al. 2009).

State-Driven Programs

The two largest cookstove programs, in India and China, have been state run. China's National Improved Stove Program (NISP), which introduced 200 million improved biomass cookstoves to rural households within 10 years, is often cited as the most successful national intervention (Smith et al. 1993). This far exceeds the penetration of other national cookstove programs, and China accounts for the largest number of efficient cookstove users in the world (Smith et al. 1993). Sustained government support was one of the key factors for the program's success, leading to widespread adoption, the development of local markets, and the dissemination of technical stove innovations (Edwards et al. 2004; Sinton et al. 2004; Smith et al. 1993). The utilization of "institutions stacking," or the phasing in and out of varying forms of support for the NISP has received praise from the cookstove epistemic community, though the literature is thin on comprehensive studies on local user preferences for improved biomass stoves or access to other fuel types. Meanwhile, the Chinese government is preparing for the second round of the program to disseminate new efficient stove technologies, given the improvements in the technology and rural energy infrastructure (Smith and Deng 2010).

India's program, the National Program on Improved Cookstoves (NPIC), was initiated during the same period as China's program. According to government estimates, the NPIC disseminated 28 million stoves (Kishore and Ramana 2002). In contrast to China's success, NPIC is characterized by low adoption rates due largely to a lack of maintenance and criticism that its "improved" stoves have high emissions and limited increases in efficiency rates (Kishore and Ramana 2002; Smith 1989). In 2009, India began the National Biomass Cookstove Initiative, which focuses on disseminating more advanced combustion technology stoves and has loftier goals to reduce pollution, rather than just transferring smoke outside the kitchen (Venkataraman et al. 2010).

Non-Governmental and Commercial Stove Programs

In areas with less proactive government intervention, NGOs have frequently initiated stove programs with mixed success due to internal fragmentation or sporadic funding; in particular, NGO-led programs have been less successful in scaling up (Barnes et al. 1994; Kees and Feldmann 2011; Uvin et al. 2000). Although NGOs have limited resources and reach, often they focus efforts on populations that lack financial capacity to purchase stoves or with insufficient energy demand to support market development (Bailis et al. 2009). These projects often target users who have no economic incentive to purchase new stoves because they gather fuel wood for household usage (Troncoso et al. 2011). It follows that the private sector has also taken an interest in cookstove substitution programs, though commercialization efforts by the private sector prior to the carbon market are understudied (Bailis et al. 2009). Private sector involvement, particularly in

Asia, reflects the large market potential for energy services among the poor (Barnes et al. 1994). The private sector may bring management, marketing, research and development, and sales skills to the cookstove market, in addition to the ability to raise capital at scale. Notably, there are few examples in the literature of self-sustaining commercial enterprises distributing improved cookstoves outside the carbon market (Shrimali et al. 2011).

Commercial stove programs tend to incorporate more advanced tracking, monitoring, and certification schemes than public programs (Adler 2010; Gaul 2009; Kees and Feldmann 2011), particularly in the carbon market. While some productive imbrications can be expected between private sector actions and project performance (that is, market-based interventions often focus heavily on adoption and usage in order to guarantee that carbon credits will be generated), the private sector may be less attuned to the stoves' ability to promote health and improve the lives of women and children, and may target users not on the basis of need but on the basis of current fuel-use consumption in order to maximize the credits generated. Thus, private-sector driven cookstove projects provide both advantages and disadvantages to public-sector oriented interventions; whereas the private sector will likely monitor usage more accurately, the public sector may be more willing to invest in populations that are able to demand very limited energy services.

Understanding Adoption Patterns in Varying Institutional Contexts

Current studies on public and private institutional frameworks for cookstove dissemination are inconclusive, and it is unlikely that there is a single best model given the wide variation in local conditions within which cookstove programs are implemented. The launch of GACC is injecting ambition into cookstove distribution efforts, although it is too early to analyze its effectiveness (Goldemberg et al. 2004; Smith 2010). However, the literature does point to the need for a model that can offer sustained support to network building, production, education, and extension services over time, given the significant development efforts associated with technology deployment to poor urban and rural households. Further research would be instructive on how varying institutional models impact a program's ability to deliver some development goods over others. In particular, there is a research gap on the role that the public and private sector can play in building institutions that support cookstove production and dissemination over the long term.

Consumer Pricing, Microfinance, and Other Models

An early debate in the cookstove literature focused on whether and how households should contribute to the cost of cookstoves (Barnes et al. 1994). Experience indicated that households did not value free goods; and indeed, survey studies of cookstove dissemination failures suggested that giveaway cookstoves "soured" the intervention, resulting in families either not valuing the stove or expecting the stove to be free in

perpetuity (Barnes et al. 1994; Krugman 1998). Thus, almost all cookstove programs today charge at least some of the cost of the stove to the household. In the Chinese NISP, county agencies covered the cost of cookstove design and dissemination while households covered the cost of their own installation (Sinton et al. 2004). In Cambodia, the "fixed subsidy" model utilized by the National Biodigester Program (NBP) provides an elegant solution to the question of public versus private cost burden, whereby all farmers seeking biodigester-cooking technologies are offered a flat rate subsidy from the government: for smallholders the flat rate covers a substantial portion of the biodigester cost, whereas for larger installations the subsidy is much less significant. In this way, poorer families benefit more from the subsidy while administrative processes are streamlined (van Mansvelt, 2010).

Other forms of assistance include microfinance and public contracts arranged through local commercial banks for soft loans for cookstove programs (van Mansvelt 2010; Rao et al. 2009). Integrating private sector-driven carbon finance with soft loan arrangements at the national level appears promising, as evidenced in the NBP, which uses both nationally sponsored support for lending facilities and external carbon finance to underwrite a national biodigester program that reaches over 10,645 families in twelve provinces (NBP 2012; Sundar and Shakya 2005).

Direct versus Indirect Subsidies and Their Usefulness

For a development intervention, cookstoves offer a considerable suite of development benefits for a low donor price tag. The cost of disseminating improved stoves to half of the three billion solid fuel users would cost US$34 billion per year while generating a return on the stoves themselves of US$105 billion per year in terms of fuel savings at the household level (WHO 2006). While the private sector offers an efficient means to distribute goods to paying populations, markets historically underserve the most indigent populations (Bailis et al. 2009), thus indicating a need for some subsidies or public assistance to reach development goals (Alvarez et al. 2004; Kremer and Miguel 2007; Shrimali et al. 2011).

Direct subsidies are usually required for imported stoves, given that the cost is prohibitive for rural households without some direct assistance from governments, NGOs, or microfinance institutions. Gaul (2009) argues that there is no clear answer to whether direct subsidies are useful and forwards the concept of "smart subsidies" that are appropriate for local conditions, while Barnes et al. (1994) conclude that subsidies are useless. Instead, Barnes et al. champion indirect subsidies, that is, subsidies that support cookstove dissemination infrastructure, stove production, and education. Regardless of

subsidy type, there is consensus that subsidies cannot compete with other fuel and energy policies, such as putting improved biomass stoves in direct competition with subsidized LPG (Gaul 2009).

Innovative Subsidies: Carbon Finance

Since the launch of the carbon market in tandem with the ratification of the Kyoto Protocol in 2005, the private sector has been developing accounting methodologies to earn certified emissions reductions, or carbon credits. The Gold Standard Foundation, a certification scheme for both the international and voluntary carbon market, launched a methodology for cookstoves in 2008 that was revised in 2010. The Clean Development Mechanism (CDM) also introduced its own cookstove-appropriate methodology "AMS II.G" in 2008 and approved it in 2009 (Blunck 2011). The carbon finance model is a public-private partnership; the public sector sets a cap on global greenhouse gas emissions and the private sector creates emission-reducing projects that earn "credit" towards the cap. The subsidy aspect of the carbon market is that funds generated by selling credits can be used to reduce the cost of the stove or to cover program costs.

Carbon finance appears to be a powerful financing mechanism that effectively utilizes the strengths of the private sector, including the ability to attract capital at scale, use effective management techniques, create self-sustaining markets and support innovation. One benefit of carbon finance to the cookstove project is in helping it achieve long-term financial sustainability without relying on donor or government support. Indeed, the Kyoto Protocol's carbon market has been extended through 2020, as per the recent decision at the 17th Conference of the Parties to the United Nations Framework Convention on Climate Change in Durban in December 2012 (UNFCCC 2011). Prior to this decision, however, the European Union independently committed to honor the value of carbon credits sourced from Least Developed Countries (LDCs) through 2012–2020 (European Commission 2011).[1] Given the relevance of the technology for least developed populations, the EU's actions effectively stimulated private sector interest in developing methodologies for quantifying and monitoring the carbon reductions associated with cookstoves.

Carbon offsets from cookstove interventions now exist in both regulated and voluntary markets. The regulated markets are dominated by the CDM, which has a lengthy registration and credit issuance process that can pose barriers for project developers. The voluntary market presents an alternative to the CDM. Regulations vary in voluntary

[1] The definition of "LDC," according to the United Nations High Commissioner on Least Development and Land-locked States includes a low-income criterion, and low rankings on the human assets index and Economic Vulnerability Index. The LDCs comprise 12% of the world population but account for only 2% of world GDP. There are currently 48 LDCs: 33 in Africa, 14 in Asia, and one, Haiti, in Latin America (UNOHRLLS 2011). Given that the EU/ETS accounts for 80% of the demand for carbon offsets, the African cookstoves carbon market is expected to expand significantly in 2012. (European Commission 2011.)

markets: some market segments allow less burdensome verification processes than the CDM; others, like the NGO-created Gold Standard certification scheme, claim to be stricter (The Gold Standard 2011). While such claims may be contested, it appears that the Gold Standard offers the only carbon accounting methodology within the voluntary markets that specifically addresses cookstoves.

As this article was being written, 19 cookstove projects were in the CDM pipeline (Fenhann 2011), while 70 cookstove projects in 27 countries in CDM and voluntary markets were currently seeking carbon credits (Cox 2011). Another study that is currently underway estimates that 14 cookstove projects have been issued credits, 2 through the CDM and 12 through Gold Standard. There were another 24 projects that have been registered and 32 at the validation stage (Hill and Bailis 2012). A recent analysis from REN21 (2010) noted that 160 cookstove projects are currently active worldwide. If correct, this implies that roughly 30% of stove projects are engaged in carbon markets through the CDM or the Gold Standard.

Carbon finance differs from standard subsidies in that a formal monetization process transforms the cookstove project into a fungible asset representing climate change benefits. A number of criticisms have been raised about the merit of carbon markets in theoretical terms, questioning whether globally harmonized metrics can be relevant to local patterns of resource use (Robertson 2006) and whether decarbonization via geographically displaced offsetting is an ethical approach to carbon abatement (Bumpus and Cole 2010). There is also concern that the carbon market's dual goals of promoting sustainable development and achieving emission reductions for the lowest cost are incompatible (Schneider 2007). Others doubt the environmental integrity of the reductions themselves, claiming that many projects do not result in reduced emissions, nor are they cost effective (Wara and Victor 2008).

In addition to scholarly debate on the merits of the carbon finance idea per se*,* the impact of carbon finance on cookstove projects, specifically, merits more rigorous scholarship. Kyoto-type accounting does not capture the climate benefits associated with reducing black carbon (Grieshop et al. 2011) and as such may undervalue cookstove enterprises. While carbon finance projects are regularly monitored and third-party verified as part of the carbon offset accreditation process, there is little incentive to comprehensively assess whether or not full cookstove substitution is taking place given the negative impact such findings would have on credit issuance and the time constraints of the validators. Despite repeated efforts from market regulators to improve the quality of project validation, including the Gold Standard requirements that auditors walk into the homes of a random cross-section of users, project developers and buyers alike frequently cite inadequately trained and poorly informed validation as a primary bottleneck in the carbon market (Cosbey et al. 2006; Hyman 2009). Thus, while the carbon finance model simultaneously

presents a rare opportunity for regular, annual monitoring of cookstove adoption and usage, this opportunity is hampered by a likely blindness towards the social and cultural preferences that might engender multiple stove-use strategies that are evidenced in academic research (Masera et al. 2000).

Despite considerable focus in the literature on the merits and drawbacks of direct and indirect subsidies, the relatively recent onset of carbon finance as an alternative subsidy model merits further query, particularly as the carbon market's own priorities predetermine and influence cookstove program design. In particular, the interface between user needs and the carbon market's priorities is underexplored.

Household Preferences, Social Adoption Literature

Households base their fuel use and cookstove technology preferences on highly personal, localized factors that are the key component to a public or private model's success. Several studies have attempted to explain adoption by using diffusion of innovation theory (Rogers 2003), technology adoption theories, and social-psychology based approaches, including the theory of planned behavior (Ajzen 1991). Although these theories allow for a better understanding of household energy decision making, the multifaceted behavioral, cognitive, and social processes applied in these decisions are still not well understood (Wilhite et al. 2003).

In practice, studies have demonstrated a range of barriers to transitioning from biomass fuel or to improved cookstove technology. The assessment by Barnes et al. (1994) finds that cookstoves are adopted when there are clear advantages for users, including fuel economy, durability, ease of use, low price, and cleanliness. Households are more likely to adopt stoves when there is a lack of access to fuel wood sources, which divides interventions based in rural and urban areas. Energy decision-making within the household is gendered and provides another dynamic that obfuscates decision-making. Often, financial decisions are within the realm of male household members, while women are in charge of the kitchen (El Tayeb Muneer et al. 2003). A stove purchase therefore requires both household heads to agree, which complicates marketing tactics. Women may not prioritize timesaving over traditional cooking practices, but this pattern often changes as women are earning income outside the home (Foell et al. 2011). Women are also aware that time savings in one area could bring more work in another area, providing less incentive for a timesaving technology transfer (Clancy 2002). Taste is also a significant cultural barrier since the ability to cook traditional foods on improved stoves can be difficult or impossible (Ruiz-Mercado et al. 2011; Taylor et al. 2011). A study in Mexico found that women did not like LPG stoves because they were not appropriate for making tortillas (Troncoso et al. 2007).

Although few studies have directly examined cognition bias within cookstove interventions, some studies seem to find that source agents, that is, the source of the recommendation to buy a new stove, matter (Bailis and Hyman 2011; Kishore and Ramana 2002). Therefore, the cultural and social barriers to introducing a new technology matter as much as the technology itself (Troncoso et al. 2011; Simon 2010). Finally, involving users—especially women who are the main cooks in the home (Ahmad 2001)—in the development and dissemination of cookstoves is also essential (El Tayeb Muneer et al. 2003).

The Energy Ladder and Energy Stacking

The energy ladder is a model of household fuel preference based on empirical evidence that households in urban areas and the wealthier households in rural areas prefer modern fuels, such as LPG and electricity (Masera et al. 2000). A defining feature of the energy ladder model is the assumption that *all good things go together*, that increased income paves a development path (Smith 1987, 452) to decreased wood fuel demand, increased fuel-use efficiency, decreased air particulate levels, and more modern energy consumption (Hosier and Dowd 1987). Critics of the energy ladder point to the complicated and unpredictable relationship between income and fuel choice, in large part because fuel choices are not perfect substitutes for one another (Masera and Navia 1997; Pachauri and Spreng 2004).

Kowsari and Zerriffi (2011) propose that households use a combination of fuel types depending on three drivers, which they label a "Three Conceptual Framework" whereby fuel choice is determined by the energy services, devices, and carrier. The energy stacking model, forwarded by Elias and Victor (2005), adds nuance to the energy ladder by demonstrating how external factors such as fuel subsidies and accessibility, fluctuating budgets, and secondary-fuel-use benefits (for example, using wood fuel smoke to repel mosquitoes in tropical areas) often lead to multiple-fuel use patterns whereby households maintain both traditional and modern cookstoves. According to the energy-stacking model, increased income simply increases fuel use choice, but does not guarantee increased fuel-use efficiency.

While the linearity of the energy ladder has been robustly critiqued, energy-stacking models remain poorly defined and unable to predict household behavior in terms of fuel-efficient cookstove adoption. If households do not necessarily view fuel types as perfect substitutes or adopt "improved" cookstoves to the exclusion of the old models as research suggests, then it is also possible that cookstove users do not define success in the same way as policy designers define it. Further research is needed on the types of cookstoves that local communities prefer and the highly probable phenomenon of "cookstove stacking," whereby households maintain multiple stoves even as their income increases.

Thus, the final section of the review critically examines how "success" in cookstove program interventions is defined. What type of development results from introducing advanced biomass combustion stoves versus programs that leapfrog the poor from biomass to LPG models? How does the decision to import or locally produce stoves create and limit possibilities for local and climate compatible development? These questions often play a secondary role in the technical, health, and economic studies of cookstove programs, which is unfortunate given their salience for the global cookstove industry.

Are Cookstoves a Crutch or a Tool? How Far Can Cookstoves Really Take the Poor?

A key debate that is rarely discussed in the literature revolves around the definition of what an "improved" cookstove entails. Efforts to disseminate advanced biomass combustion stoves (Venkataraman et al. 2010) are critiqued by scholars who claim such programs should focus instead on elevating rural populations to more modern and efficient stoves that run on LPG (Smith 2002). Issues of access and availability limit the potential of the fuel-switch option, but underlying the discussion of feasibility is an ethical and development debate as to whether promoting petroleum products adheres to global development goals (Foell et al. 2011).

An inherent tension in discussions about climate compatible development derives from the simple fact that poor people emit very little greenhouse gas, and thus, interventions aimed at responding to their suppressed energy demand will almost always increase their contribution to global greenhouse emissions. Those that favor the distribution of LPG-based stoves point to the relatively small impact of their use in light of developed country petroleum use (Foell et al. 2011; McDade 2004; Smith 2002). According to an assessment by Smith, if the 2 billion biomass and wood fuel users switched to LPG, the additional impact would not even reach a 2% increase in global greenhouse gas emissions (2002), while the health and greenhouse gas benefit from reductions in black carbon would annul this already negligible environmental externality. The recent report of the International Energy Agency (IEA) comes to a similar conclusion, arguing that transitioning 1.2 billion people to LPG by 2030 would only increase global demand by 5% of the oil demand in the United States today (IEA 2010).

Furthermore, renewable biomass and the utilization of bioenergy—while avoiding the taboo of fossil fuel promotion—are not necessarily less harmful to the natural environment. Bioenergy and its production can positively contribute to climate goals and rural livelihoods; however, if not implemented carefully, they could exacerbate degradation of land, water bodies, and ecosystems; reduce food security; and increase greenhouse gas emissions (Sagar and Kartha 2007). Every fuel type has its deleterious impacts and potential advantages; thus greater attention is required to fully understand who defines "improved" in "improved cookstove" programs.

Beyond the distributional justice arguments for bringing modern fuels to developing country kitchens, and the cultural preferences already outlined in the "energy stacking" discussion, practical debates on fuel costs and access also underpin the literature. Depending on geographical region and local policies, LPG may be prohibitively expensive (Venkataraman et al. 2010) or highly feasible (Bazilian et al. 2011). Frequently, the barriers to LPG are related to the infrastructure surrounding fuel access, such as the delivery of LPG in large canisters (high upfront costs versus the small incremental costs associated with charcoal and wood collection or purchases) and access to the fuel. Barnes et al. (1994) propose that improved biomass stoves should be a "stepping stone" between traditional biomass stoves and modern cooking fuel technologies. This compromise, however, is also subject to the criticism that incremental improvements are just as costly as the leap to modern fuel, and thus beg the question, why delay access for the poor? (McDade 2004).

Imported versus Locally Produced Stoves

The development potential of cookstove programs is significantly interrelated with their reliance on imported or locally produced technologies. The merits of imported versus locally designed or hybrid produced stoves are highly debated (Adkins et al. 2010; Adler 2010; Bailis et al. 2009). Locally manufactured stoves, while less vulnerable to accessibility issues associated with interrupted subsidies or public funding and cross border taxation and controls, are more vulnerable to "design drift" wherein local manufacturers adapt the cookstove design, possibly resulting in less efficient combustion chambers and lower performing stoves (Sinton et al. 2004). Hybrid models are frequently favored in the literature: Barnes et al. describe successful local assembly techniques that mass produce critical stove components off-site and enable other stove parts to arrive at the household through local supply chains (1994).

The Possibility of Imported or Locally Produced Enterprises

Issues of material availability determine whether or not stoves can be produced by artisans or whether they must be manufactured abroad (Adkins et al. 2010). Stoves are usually based on clay, metal, or concrete and masonry and can employ a suite of fuels from biomass and charcoal to LPG (Sagar and Kartha 2007).

Dissemination practices also determine whether or not stoves can be imported or locally produced. The prevalence of ox-cart transportation for household goods in LDCs such as Cambodia, favors locally produced clay stoves that are easily stackable and can withstand long journeys on rough roads unlike their higher efficiency counterparts. Other cookstove interventions are only available through in-situ construction, such as the Dutch-supported

biodigester programs throughout Asia, where the biodigester itself must be built in-situ, but specialized parts such as the gas measurement valve are sourced from abroad (van Mansvelt, 2010). Other hybrid approaches to technology transfer include importing the stove, but relying on only local engineers to maintain and monitor their performance (van Mansvelt, 2010).

Imported stoves are more expensive and may also be associated with higher performance levels in terms of combustion efficiency and reductions in particulate matter in the home (MacCarty et al. 2010). According to a survey of stove users in Uganda and Tanzania, the imported stoves were preferred because of their improved performance and because they brought greater social status (Adkins et al. 2010). The merits of locally produced stoves include the stove production networks (often trained by NGOs and aid organizations) whereby local artisans become fuel-efficient cookstove builders, able to supply and repair the stoves on demand (Kees and Feldmann 2011). Despite the assumption that local networks strengthen a program's durability, it is noteworthy that the Indian national cookstove program failed, in part, because its local production model did not produce stoves of high enough quality (Adler 2010).

The implications of locally producing, importing, or hybrid-producing cookstoves for local development are significant for the formation and long-term viability of projects. To illustrate, carbon finance projects that use revenues from the credits to subsidize imported stoves are dependent on the carbon market for the viability of the program, whereas projects that utilize carbon finance for local capacity building and the monitoring of artisan stove performance merely rely on the carbon market to grease the wheels of a new enterprise. There is no denying, however, that stove performance is paramount to a cookstove program's ability to forward development goals. Further research and empirical clarity is needed to assess how imported stoves can remain reliably accessible for the poor, as well as the conditions within which locally produced stove enterprises can perform at par and adjust to changing market conditions.

Conclusions

The Global Alliance for Clean Cookstoves is tasked with disseminating 100 million stoves to developing countries by 2020 in an attempt to increase energy access for the poor, and with calling on public-private partnerships for the production and distribution of the stoves. Given the potential benefits surveyed in the literature, the goal is worthy of international focus. However, in order to successfully design, distribute, and sustain fuel-efficient cookstove adoption in developing countries, significant advances are required in research fields. Progress could include a closer look at areas ranging from the social dynamics of household preferences to more nuanced findings on technology adoption, as well as a clearer understanding of how and under what conditions subsidies and innovative

finance tools, such as the carbon market, can distribute benefits to the poor. Our synthetic literature review from 1987 to the present identifies key findings in the cookstove field to date. In addition, our landscape assessment of the field clarifies its frontier, pointing to areas for future scholarship and experimentation. Each bullet, below, synthesizes a key finding as well as a knowledge gap.

Academic research confirms that the public goods associated with improved cookstoves are significant. As such, there is an empirically supported justification for public sector involvement in promoting improved cookstoves to poor populations. However, knowledge gaps regarding the efficacy of improved cookstoves versus encouraging behavioral changes (such as increased ventilation; fuel switch; soaking legumes; and using pressure cookers) are understudied and further work in this area could lead to better use of public funds.

Carbon finance, while understudied in terms of its impact on the very poor in the cookstove sector, appears to be a powerful financing mechanism that effectively utilizes the strengths of the private sector: namely, in its ability to attract capital at scale; utilize effective management techniques; create self-sustaining markets; and support innovation. However, given the private sector's historic weakness in reaching indigent populations that command limited demand for goods, policy makers and academics should seek further insight into how combined public-private dissemination techniques can perform in Least Developed Countries.

Multiple benefits associated with cookstove interventions are both an opportunity and, notably, a pitfall for policy designers. Those who attempt to achieve everything within a single program (health benefits; gender empowerment; self-financing mechanisms; environmental impacts) appear to be less successful than those who concentrate their efforts on a few, targeted goals within a program, such as the NISP does in China. However, the many benefits of cookstoves mask confusion within the literature on the definition of an "improved" stove. How much donor and commercial effort is justified for advanced biomass combustion stoves versus fuel-switch programs that leapfrog developing country households to more advanced cooking models? Are cookstoves on the international agenda as an aid mechanism, whereby installing a stove in every home will suffice, or a development mechanism, whereby developing country households are empowered to source, select, and profit from a more advanced stove industry? Further examination is required from both academics and practitioners as to the purpose and reach of an improved cookstove program.

A debate regarding the advantages of utilizing imported stove technologies versus relying on local stove assembly remains unresolved, and further highlights tensions within the stove community as to the ultimate purpose of the stove intervention. Further exploration

of these themes is a priority for the stove community. In addition, initial insights into the social factors leading to stove adoption point to the importance of source recommendations (that is, locals promoting stoves to locals), gender dynamics, and a nuanced interpretation of "timesaving" as a marketing incentive.

While questions about stove adoption practices certainly remain, it is noteworthy that the research frontier is no longer defined by a new series of questions, but instead by a new population of respondents. Barnes et al. famously asked the development community, nearly a generation ago, *"Why don't they buy the improved stoves?"* stimulating a field of scholarship on household preferences, the power of social networks and local marketing channels, the energy ladder and energy stacking, cookstove utilization (and cookstove stacking), and the ambivalence of women in accepting "timesaving" improvements. Today, questions on low adoption rates of the early cookstove days are no longer the sole purview of the development expert but instead are also directed at the cook herself: "What is an improved cookstove for you?" There is a need for more finely grained data. The GACC and its attendant wave of research, if done humbly, may indeed forward development through the kitchen.

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Biographies

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From 2001 to 2005, Jasmine worked on climate and sustainable agriculture issues at the Food and Agriculture Organization of the United Nations. She was the head writer and correspondent for the International Year of Rice in 2004, where she wrote speeches for the Food and Agriculture Director General and varying representatives to ASEAN.

Jasmine began her study of greenhouse gas emission markets in earnest while earning a Masters of Science at the London School of Economics in Environment and Development in 2005. She earned an honors BA in Urban Studies at Columbia University in 2001. Jasmine's current research is supported by the National Science Foundation Graduate Research Fellowship; the Yale Center for Environmental Law & Policy; and the Center for Business and the Environment at Yale. She can be reached at mailto:jasmine.hyman@yale.edu

Emissions Abatement in a Production Economy: Cost-Minimization versus Investment-Consumption Optimization

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Abstract

Emissions Abatement in a Production Economy: Cost-Minimization versus Investment-Consumption Optimization

This article proposes a baseline-and-credit emission abatement system in the CIR production economy settings by Cox, Ingersoll, and Ross (1985a, 1985b). Under the CIR production economy, individuals can invest directly or indirectly in a set of abatement technologies through firms. In this production economy, the investments pay physical dividends in the form of a capital-consumption good, that is, greenhouse gas (GHG) reduction credits, that can be used to reinvest in the abatement technologies or consumed to offset actual GHG emissions. The mechanism improves the cap-and-trade system in three respects: (1) Instead of free-of-charge emission allowances, carbon credits are produced via physical reductions; therefore, the over-supply of emission allowances in a cap-and-trade system can be avoided. Moreover, the amount of emission reductions is proportional to the GHG emission baseline. (2) By featuring growth of the investments in abatement technologies, the mechanism provides an incentive for further investments in abatement technologies. (3) The risk of changing demands in baseline GHG emissions is hedged via a zero-coupon bond, which provides an ideal fixed-interest-debt financing instrument so that individuals can borrow and lend capitals at a risk-free interest rate r.

By adjusting the risk-free interest rate *r*, in equilibrium, all the resources and wealth within the economy are invested in the abatement technologies. Compared to the emission-reduction-cost minimizing cap-and-trade system, the proposed mechanism maximizes the total benefits in different aspects and provides an alternative mechanism for fighting global warming.

Emissions Abatement in a Production Economy: Cost-Minimization versus Investment-Consumption Optimization

A climate policy to reduce CO_2 emissions includes benefits such as improving the unemployment rate and prior tax distortions and recycling revenue, as well as bringing about the secondary benefits of reducing greenhouse gas (GHG) emissions (Ekins 1995). For example, the benefits of the green tax policy are examined in the double dividend hypothesis, either in its weak form, in which revenues from green tax can be used to cut distorting taxes, or in its strong form, in which green tax improves both the environment and non-environmental welfare (Schob 2003). Bustamante et al. (2009) show that if a tax were imposed on CO_2 emissions and the resulting revenues were used to cut labor taxes, then employment would rise by 0.5 per cent by 2014. The aggregate net benefits of climate policies also include the even larger gains due to technological changes, for example, the adoption of more efficient environmental technologies, the growth of energy-saving technology innovations, and production expansions (Jackson 1995; Buchner and Carraro 2006; Aldy, Barrett, and Stavins 2003).

Considered the largest international instrument with wide support, the Kyoto Protocol, aimed at stabilizing and reducing GHG emissions. It was adopted on 11 December 1997 in Kyoto, Japan, and the commitments it set up became enforceable on 16 February 2005. As of September 2011, 191 states have signed and ratified the protocol. On Dec. 12, 2011, the United Nations climate summit in Durban had extended the current Kyoto Protocol—originally set to expire at the end of 2012—to 2017.

Under the Kyoto treaty, the Annex 1 countries must meet their greenhouse gas (GHG) emission targets of an average 5.2% reduction of their 1990 level in the period 2008–2012. Nevertheless, the failure to secure agreements from countries such as the United States, thus far, has made progress toward the emission reduction commitments insignificant (Buchner and Carraro 2006). In the Annex I non-Economies-in-Transition (non-EIT) Parties, emissions in 2005 were 5% higher than 1990 levels (World Bank 2008), while their Kyoto target for 2008–2012 is for a 6% reduction in emissions. For Annex I non–Kyoto Protocol Parties, including Turkey and the United States, emissions were 18% above their 1990 levels in 2005. According to the International Energy Agency (IEA), energy-related GHG emissions reached 30.6 giga metric tons in 2010, which is five percent higher than the 2008 level and is the highest level ever since, making it "extremely challenging" to prevent global temperatures from rising to dangerous levels (*World Energy Outlook* 2011).

In summary, the success of the Kyoto Protocol as a climate change policy for solving the climate problem is inconclusive (Prins and Rayner 2007; Gupta et al. 2007). A major criticism is centered on the Kyoto Protocol's International Emissions Trading (IET)

mechanism that allows Annex I countries to trade their assigned units (AAUs or emission allowances) to achieve their countries' GHG emission reduction targets over the 2008–2012 commitment period, and in which one unit of AAU corresponds to the right to emit one ton of GHG into the atmosphere. The economic basis for International Emissions Trading (IET) is that the marginal emission abatement cost differs among countries, and trade allows emissions to be abated first in countries where the marginal costs of abatement are lowest. With a trading system, it is expected that the Annex I countries can meet their emission reduction commitments at a reduced cost.

As the negotiations leading up to the Kyoto Protocol had focused only on cost-effectiveness, they failed to account for the aggregate net benefits that can be achieved compared to other global climate policies, for example, a Research and Development Protocol (Barrett 2001; Buchner and Carraro, 2006) or a Hybrid of International Trading Program (Aldy et al. 2003). Early literature (Woerdman 2000) expected that through the other two mechanisms of the Kyoto Protocol, the Clean Development Mechanism (CDM) and Joint Implementation (JI), investors could increase their value via the export potential of advanced emission abatement technologies. In a survey of nine respondents composed of executives linked to the environment (with three of them from banks, five from consulting companies, and one belonging to a NGO), the hypothesis that companies developing CDM projects can generate higher profit margins was not rejected (Kerr et al. 2009). In a comprehensive analysis of technology transfer in the CDM to-date, covering 3,296 registered and proposed projects (Seres 2009), it is claimed that roughly 36% of the projects accounting for 59% of the annual emission reductions claim to involve technology transfer. In this respect, emission abatement projects in CDM or JI yield not only emission savings but also potentially generated revenues that can be used to pay back the investments of the projects.

Under the Kyoto Protocol's IET, emissions trading schemes may also be established as climate policy instruments at the regional or domestic level. Under such schemes, governments set emissions obligations to be reached by the participating entities. In Europe, the European Union's Emissions Trading Scheme (EU ETS) is the world's largest regional emission trading system and is a cornerstone of the EU's efforts to meet its obligation under the Kyoto Protocol. Under the EU ETS, a cap-and-trade system is adopted in which an allowable overall cap of GHG emissions is established and allocated among installations in the form of permits or allowances (with one EU allowance unit of one metric ton of CO_2 or EUA, which is equivalent to the AAU of CO_2 defined under the Kyoto Protocol). With a cap-and-trade system, yearly EUAs can be freely allocated on the basis of the National Allocation Plan (NAPs) made for the trading period by responsible governments to mandatory participating installations, such as businesses or entities with operations that are responsible for significant GHG emissions, or through sale via auction by the government. Installations with surplus EUAs are allowed to sell to the market,

although they are not obliged to do so. Those with surplus EUAs may also choose to abate emissions in order to have even more EUAs to sell. On the other hand, when the volume of emissions exceeds installations' allocated EUAs, they will either abate some of their emissions or buy the EUAs from the market. If the participating installations fail to comply, penalties will be imposed on them.

The challenge in a cap-and-trade system is to determine the appropriate level of the cap, which should be stringent enough to induce the desired level of reduction, and the subsequent allocation of the EUAs. On this ground, EU ETS also allows for a certain number of offsets to come from emissions reductions that are generated by projects from baseline and-credit systems, for example, credits from CDM and JI can be used interchangeably with EUAs. Although allowing credits from CDM and JI will increase the number of compliance units, it makes achieving reductions potentially more cost effective.

Nevertheless, a cap-and-trade system still suffers the critique that it provides insufficient incentives for investment in technology development because it does not address two interacting market failures, namely, the negative externality by GHG emissions and the positive externality by new technology (Jaffe, Newell, and Stavins 2005). Given that the development of environmentally beneficial technology is subject to two interacting market failures, it is unlikely that environmental policy alone creates sufficient incentives (Jaffe, Newell, and Stavins 2005). To the contrary, both theory and empirical evidence suggest that the rate and direction of technological advance can be cost-effectively harnessed through the use of economic-incentive based policy (Jaffe, Newell, and Stavins 2005).

Additional policies may be necessary to increase government funding or incentives for private funding of the investments in emission abatement technologies. The optimal public policies portfolio should also include instruments designed explicitly to foster environmentally beneficial technologies. Because of this, a baseline-and-credit system based on a CIR production economy setting (Cox, Ingersoll, and Ross 1985a; 1985b), aimed directly at the stimulation of environmentally beneficial technological changes in an investment-consumption prospect, is proposed. In a baseline-and-credit system, each firm has an emission baseline, which is derived by multiplying a measure of a firm's scale, for example, energy input or product output, by a performance standard specifying a required ratio of emissions to input or output (Fischer 2001, 2003). Firms create reduction credits by emitting fewer than their baseline emissions, which can be sold to firms who exceed their baselines. The variable emission baseline introduces a critical difference between a baseline-and-credit system and a cap-and-trade system. In addition, in a baseline-and-credit system, credits can only be traded before they are certified and registered. Usually, credits cannot be registered until the emission reductions have actually occurred (Buckley 2005).

The outline of the paper is as follows: The next section introduces the two emission reduction mechanisms: the cap-and-trade mechanism versus the baseline-and-credit mechanism in the CIR production economy settings by Cox, Ingersoll, and Ross (1985a, 1985b). The section following that gives a simulation study that compares the two mechanisms, and the final section is devoted to concluding remarks.

Mechanism of GHG Emission Abatement Based on a Cap-and-Trade System

Cap-and-trade systems have been used in the United States for regulations such as the reduction in the use of CFCs and halons to comply with the Montreal Protocol, an international agreement aimed at slowing the rate of stratospheric ozone depletion. They have also been used to reduce the emission of SO_2 and NO_X, the primary precursors of acid rain, to comply with the U.S. Clean Air Act Amendments of 1990. Under a cap-and-trade system, SO_2 emissions from the electric power sector decreased from 15.7 million tons in 1990 to 10.2 million tons in 2005, and a robust market in SO_2 allowances emerged, resulting in cost savings on the order of $1 billion annually compared with some command-and-control alternatives (Carlson et al. 2000). Nevertheless, cap-and-trade systems have a very limited history as a method of reducing CO_2 emissions.

Two of the main objectives of a cap-and-trade system are to fulfill environmental targets and, on the other hand, to achieve these targets at the lowest costs for the regulated installations by the regulatory authority. The two objectives can be attained by making use of differentiated marginal abatement costs among different regions as well as different sectors. Countries or installations with higher marginal abatement costs can upload their obligation for emission reduction commitment by purchasing emission allowances from parties with lower marginal abatement costs. By making optimal use of these marginal abatement cost differences, it is hoped that the overall abatement costs can be greatly reduced (Richels et al. 1996; Seifert 2009). Rubin (1996) shows that in a cap-and-trade system, joint cost is minimized when each firm individually minimizes its abatement costs

and emission allowances' purchased expenses. In Fehr and Hinz (2006), it was shown that an optimal reduction policy that minimizes the global abatement and penalty costs exists and, if that policy is followed, the equilibrium allowance's price equals to the penalty per ton of emission times the probability that the actual emissions exceeding the targets. Overall, a well-designed cap-and-trade system thus minimizes the costs of achieving any given emissions target and provides certainty regarding emissions from the regulated installations as a group, because aggregate emissions from all regulated installations cannot exceed the emission cap.

General Critique of a Cap-and-Trade System

The difficulty in setting the emission cap due to uncertainty in the baseline CO_2 emission demand year by year has become the major source of risks in a cap-and-trade system. In addition to the difficulty of setting an appropriate cap level, two other issues—the subsequent allocations of AAUs to various installations (Burtraw, Palmer, and Kahn 2005; Fowlie 2009) and the efforts in administering and ensuring compliance with the system—show the difficulty of implementing an effective cap-and-trade program while avoiding the so called "carbon bubble" (Daskalakis and Markellos 2008).

If free-of-charge AAUs are oversupplied, no efforts on the emission abatements will be made. Russia, for example, had a tremendous surplus in its free-of-charge AAUs because the targets under the Kyoto Protocol were based on 1990's emission levels, but emissions in Russia dropped dramatically as a result of its economic declines after the 1990s. In this case, instead of making any abatement efforts, Russia was able to sell the surplus AAUs or "hot air" with no actual emission reductions (Victor et al., 1998; Woerdman 2005). The oversupply of AAUs also occurred within the Regional Greenhouse Gas Initiative (RGGI) program designed to cap the CO_2 emissions from 250 power plants in ten Northeastern and Mid-Atlantic states in the United States for the years 2009 through 2014. In 2009, because the projected goal was 188 million tons but the actual emissions from the power plants were only 124 million tons, less than one third of the allowances offered were bid on and sold. This results in a huge oversupply of allowances.

In Seifert, Uhrig-Homburg, and Wagner (2008) and Fehr and Hinz (2006), it was shown that under conditions in which allowances are not bankable (see EU ETS phase 1) and there is no minimum auction reserve price, and provided that a sufficient number of the allowances are auctioned, if the baseline GHG emission is below the emission target, then the allowance's price will drop to zero. The price collapse of the EUAs in EU ETS in 2006 (it was halved by May 2, 2006), was a manifestation of the excess allocation of emission permits (Paolella et al. 2006). In light of the ongoing eurozone sovereign debt woes and the fears of a second, deeper, recession, the price expectations for EUAs continue to be in flux and dependent on uncertain policies. The recent situation has also created a surplus of EUAs: Their price has fallen by 40% since June of 2011 and is expected to fall to €3 in 2012–2013. The collapse of the EUA price due to the financial crisis in Europe is expected to take until 2025 to disappear, which can dramatically weaken the efficiency of a cap-and-trade system as an economic-incentive-based environmental policy.

Nevertheless, to create incentives for firms to invest in the development and deployment of low- or non-emitting technologies, a cap-and-trade system must provide commitments to meeting long-run emission targets. A lack of commitments makes the payoff from

investments in the new technologies highly uncertain and the investments in those emission abatement technologies will lag (Montgomery and Smith 2007). On the other hand, policymakers also need to maintain flexibility to adjust long-term emission targets as new information is obtained regarding the economic environment as well as the costs of mitigating GHG emissions. Managing the trade-off between the commitments and the flexibility of long-run targets has made the success of a cap-and-trade system more difficult (Stavins 2007). In the following section, a baseline-and-credit system in the CIR production economy settings is developed.

Emission Reduction via Benefits Maximization: CIR Production Economy

The continuous-time optimal consumption and portfolio choice problem was first formulated by Merton (1969, 1971, 1972). Later, Cox, Ingersoll, and Ross (1985a, 1985b) proposed a production economy in which a single capital-consumption good, which can be either consumed or transformed to capital to invest, in perfectly elastic supply is produced by *n* different technologies available in the system. The framework is characterized by the growth of the *n* technologies in a changing investment environment. Individuals within the economy can either consume the outputs or invest the *n* technologies with their wealth and part of the produced outputs so that their consumption utilities are maximized. That is, the output of the *n* technologies, the single capital-consumption good, is both the input and output of the production process. In Prieto (2010), the relationship between innovation and risky investments in research and development (R&D), productivity growth, consumption, and asset price in equilibrium is analyzed based on the CIR production economy.

In this study, the capital-consumption good specifically refers to the carbon credits that are produced by the *n* abatement technologies via physical emission abatement, which can be consumed to offset GHG emissions with one unit of reduction credit equivalent to one ton of GHG emissions. Or, by selling the reduction credits to firms who exceed their baselines, the produced outputs can be transformed into capital to re-invest in the *n* abatement technologies.

Under the CIR production economy, there are a fixed number of individuals, identical in their initial endowment and preferences for the consumption of the capital-consumption good. Each individual seeks to maximize his or her lifetime expected utility of consumption in the form

$$E_t\left[\int_t^T U(C_s, t)ds\right] \tag{1}$$

where C_s is the consumption rate at time s, U is the twice-differentiable utility function

that is increasing and strictly concave. This study specifically considers logarithmic utility function

$$U(C, t)=e^{-\rho t}\, ln(C_t) \qquad (2)$$

To describe the growth of the n technologies, let S_i represents amounts of the capital-consumption good invested in the ith abatement technology. The instantaneous return rate of the ith technology is

$$dS_i(t)/S_i(t)=\mu_i x(t)dt+\sigma_i\sqrt{x(t)}\,dZ_i(t), \qquad i=1,..., n \qquad (3)$$

where $\mu_1,\ldots, \mu_n$ are the mean return rate coefficients, and $Z_1(t),\ldots, Z_n(t)$ are Brownian motions representing n sources of risks associated with the production processes. Define the variance-covariance matrix $\Omega=[\sigma_{ij}]$, where $\sigma_{ij}dt=\sigma_i\sigma_j dZ_i(t)dZ_j(t)$.

In Equation 3, the growth of the investments in the n abatement technologies depends on the state variable $x(t)$ that describes the changing production opportunities of the economy over time. In the case of GHG emission abatement technologies, the apparent key state variable is the baseline GHG emission rate. In Equation 3, it is assumed that the mean return rate increases as the baseline GHG emission rate $x(t)$ increases. This is due to the fact that as more GHG is emitted, the more GHG emission reductions are in demand and the more emission reductions are produced.

In general, the baseline GHG emission depends on the weather and fuel prices, as well as economic growth (Benz and Truck 2009). All these factors show mean reversion behaviors in that high (low) factor levels induce supply and demand adjustments that gradually pull down (raise up) the factor levels to their long-run means. Therefore it is assumed here that the aggregate baseline GHG emission rate $x(t)$ follows a nonnegative stochastic mean-reversion process in the form

$$dx(t)=\{a_0-a_1x(t)\}dt+b\sqrt{x(t)}\,dY(t) \qquad (4)$$

where $a_0>0$, $a_1>0$, and $b>0$, $Y(t)$ is a Brownian motion representing uncertainty (risks) associated with the emission rate (Wachter 2002).

In Equations 3 and 4, there are total (n+1) sources of uncertainties (risks) in the system. Under such uncertainties, an investment basis of (n+1) opportunities is required (Cox, Ingersoll, and Ross, 1985a). In Cox et al. (1985a), the (n+1) opportunities consist of the n abatement technologies and a contingent claim, that is, a zero-coupon bond that guarantees payoffs on a specific date in the future. In the CIR production economy, it is assumed that a market exists for the zero-coupon bond, which is in zero-net-supply, that is, the number of long and short positions held by the individuals in the economy are the

same. With this assumption, in equilibrium, all the resources or wealth within the system are allocated among the technologies. With the zero-coupon bond, individuals can borrow or lend capitals at a risk-free interest rate *r*. To complete the description of the CIR production economy, it is also assumed that physical investment and trading in securities, either the stocks of the firms for the *n* abatement technologies or the zero-coupon bond, take place continuously with no adjustment or transaction costs.

The existence of the zero-coupon bond guarantees that the risk associated with the changing baseline GHG emission can be hedged since the equilibrium price of the zero-coupon bond is negatively associated with the baseline GHG emission. According to Cox, Ingersoll, and Ross (1985a,b), the equilibrium price of the zero-coupon bond, or the equilibrium risk-free interest rate *r*, will depend on the individuals' preferences for the consumption of the capital-consumption good. This determines individuals' decisions about how much of their wealth is to be consumed versus invested in the *n* abatement technologies so as to maximize their expected lifetime utility of consumptions in (1) subject to the budget constrain

$$\mathrm{d}W_t = W_t\left(\sum_{i=1}^{n} w_i \mu_i x(t)\right)\mathrm{d}t - C_t dt + W_t\left(\sum_{i=1}^{n} w_i \sigma_i \sqrt{x(t)}\right)' d\boldsymbol{Z} \tag{5}$$

where W_t is the time-t aggregate wealth, C_t is the time-t consumption rate, the vector of Brownian motions $\mathrm{d}\boldsymbol{Z}=(Z_1(t),\ldots, Z_n(t))$, $w_1,\ldots, w_n$ are proportions of aggregate wealth W invested in the n technologies, respectively.

As shown by Cox et al. (1985b), subject to the market equilibrium constraint, the optimal consumption rate C^* and proportions $\boldsymbol{w}^* = (w_1^*, \ldots, w_n^*)'$ of aggregate wealth W invested in the n technologies, subject to $\sum_{i=1}^{n} w_i^* = 1$, are

$$\boldsymbol{w}^* = \Omega^{-1}(\mu - \alpha \mathbf{1}) \tag{6}$$

$$C_t^* = \frac{\rho}{1-(1-\rho)e^{-\rho(T-t)}} W_t \tag{7}$$

where $\mathbf{1}$ is a $n\times 1$ vector with all elements ones. The vector $\boldsymbol{\mu}=(\mu_1, \ldots, \mu_n)'$ and the covariance coefficient matrix $\Omega=[\sigma_{ij}]_{1\le i,j\le n}$ with $(\sigma_i\sqrt{x}\,\mathrm{d}Z_i)(\sigma_j\sqrt{x}\,\mathrm{d}Z_j)=\sigma_{ij}x\mathrm{d}t$, where $\mu_1, \ldots, \mu_n$ and $\sigma_1,\ldots, \sigma_n$ are constants given in (3). The coefficient

$$\alpha = \left(\frac{1'\Omega^{-1}\mu - 1}{1'\Omega^{-1}1}\right) \tag{8}$$

Given the optimal consumption rate C^* and portfolio weights $\boldsymbol{w}^*$, the market's risk-free interest rate $r(t)$ can be derived as the constant α multiplying the aggregate baseline GHG emission rate $x(t)$, that is,

$$r(t)=\alpha x(t)$$

Plugging in the stochastic mean-reversion process of $x(t)$ in (1), the risk-free interest rate r is

$$\mathrm{d}r=a_1(p-r)\mathrm{d}t+\nu\sqrt{r}\,\mathrm{d}Y \tag{9}$$

where $\nu=b\sqrt{\alpha}$, $p=\alpha a_0/a_1$. The price of the bond that matures at time $T>t$ follows as

$$P(t, Y)=\exp\{A(t, T)-B(t, T)r(t)\} \tag{10}$$

where

$$A(t, T)=\frac{2a_1\pi}{\nu^2}\log\left(\frac{2\gamma e^{(\gamma+a_1)(T-t)/2}}{(\gamma+a_1)\left(e^{\gamma(T-t)}-1\right)+2\gamma}\right)$$

$$\gamma=\sqrt{a_1^2+2\nu^2}$$

$$B(t, T)=\frac{2e^{\gamma(T-t)}-2}{(\gamma+a_1)\left(e^{\gamma(T-t)}-1\right)+2\gamma}$$

Simulation Study

In this Section, a simulation study is given to compare the proposed baseline-and-credit system in a CIR production economy framework with a cap-and-trade system. The parameters have been chosen to reflect some stylized facts in the EU ETS for the three-year period between 2005 and 2007. The amount of capital-consumption goods are measured in units of carbon credits, with one unit of carbon credit corresponding to one metric ton of CO_2 emission reduction. The annual fossil fuel CO_2 emission data of Germany from 1960 to 2006 is used for calibration of the mean-reversion process of the "baseline" GHG emission rate $x(t)$ in Equation 4. The annual CO_2 emission data are from the Carbon Dioxide Information Analysis Center (CDIAC). Given the annual CO_2 emissions $x(1)$, …, $x(T)$, T=47, from 1960 to 2006, the log-likelihood of $x(1)$, …, $x(T)$ is

$$\frac{T}{2}\log\left(\frac{b^2}{2a_1}\right)-\frac{T}{2}\log\left(1-e^{-2a_1}\right)-\frac{b^2}{a_1}\sum_{t=1}^{T}\frac{\left[\left(x(t)-\frac{a_0}{a_1}\right)-e^{-a_1}\left(x(t-1)-\frac{a_0}{a_1}\right)\right]^2}{1-e^{-2a_1}} \quad (11)$$

Maximum likelihood estimates of the parameters a_0, a_1, and b of the mean-reversion process in Equation 4 are a_0=1.1625×10^5, a_1= 0.4536, and b=174.381, respectively. The estimated total GHG emission for the period between 2005 and 2007 is therefore 7.7125×10^5 thousand metric tons.

In a cap-and-trade system, if assuming an emission reduction target of 5% during the period between 2005 and 2007, then 3.856×10^4 thousand metric tons of CO_2 emission needs to be reduced, and 7.327×10^5 thousand metric tons of CO_2 emission allowances will be allocated into the system at the beginning of the 2005–2007 period. Simulations of 10^4 sample paths of the cumulated CO_2 emission from 2005 to 2007 show that the proportion of over-supply of the emission allowances is 16.43%. In such cases, no incentives are provided for the investments of abatement technologies. Even if the emission allowances are under-supply, a cap-and-trade system tends to provide a transference of wealth from firms with high abatement costs to those with low abatement costs. Without considering the growth of the investments in the abatement technologies and the corresponding benefits other than emission abatement, the incentives for the investments are still insufficient.

Instead, consider a baseline-and-credit system based on the CIR production economy settings, in which carbon reduction credits are considered as capital-consumption goods that can be either consumed or reinvested in abatement technologies. Suppose there are five different abatement technologies (n=5), each of which can produce the capital-consumption goods in terms of carbon credits that can be consumed or used to re-invest in the n=5 abatement technologies.

To describe the growth of the n=5 abatement technologies in Equation (3), consider four scenarios with different return rates and risks associated with the 5th abatement technology. In the first scenario, low mean return coefficient μ_5, and low risk (variance) σ_{55} but high covariance coefficients σ_{5j}, $j\neq5$, i.e., variance-covariance matrix Ω_1, are adopted. In the second scenario, high mean return coefficient μ_5 and variance-covariance coefficient matrix Ω_1 are adopted. In the third scenario, high mean return coefficient μ_5, and high risk (variance) σ_{55} and high covariance coefficients σ_{5j}, $j\neq5$, i.e., covariance coefficient matrix Ω_2, are adopted. In the fourth scenario, a high mean return coefficient μ_5 and covariance coefficient matrix Ω_3 with high risk (variance) σ_{55} but zero covariance coefficients σ_{5j}, $j\neq5$, are adopted. The mean return rate coefficients and variance-

covariance coefficient matrix of the four different scenarios are exhibited in Figure 1.

Figure 1: Coefficients of Return Rates in Equation (3) of Five Abatement Technologies

Coefficients of Mean Return Rates $\mu_1,\ldots,\mu_5$

	μ_1	μ_2	μ_3	μ_4	μ_5
Low	0.521×10^{-7}	0.781×10^{-7}	1.042×10^{-7}	1.302×10^{-7}	1.563×10^{-7}
High	0.521×10^{-7}	0.781×10^{-7}	1.042×10^{-7}	1.302×10^{-7}	3.125×10^{-7}

Coefficients of Variance-covariance Matrix Ω

Ω_1

$$10^{-7}\times\begin{pmatrix} 0.3960 & 0.1727 & 0.2087 & 0.1790 & 0.1540 \\ 0.1727 & 0.4153 & 0.1957 & 0.1737 & 0.1367 \\ 0.2087 & 0.1957 & 0.4513 & 0.2453 & 0.1927 \\ 0.1790 & 0.1737 & 0.2453 & 0.4753 & 0.1777 \\ 0.1540 & 0.1367 & 0.1927 & 0.1777 & 0.5507 \end{pmatrix}$$

Ω_2

$$10^{-7}\times\begin{pmatrix} 0.3960 & 0.1727 & 0.2087 & 0.1790 & 0.1540 \\ 0.1727 & 0.4153 & 0.1957 & 0.1737 & 0.1367 \\ 0.2087 & 0.1957 & 0.4513 & 0.2453 & 0.1927 \\ 0.1790 & 0.1737 & 0.2453 & 0.4753 & 0.1777 \\ 0.1540 & 0.1367 & 0.1927 & 0.1777 & 1.2845 \end{pmatrix}$$

Ω_3

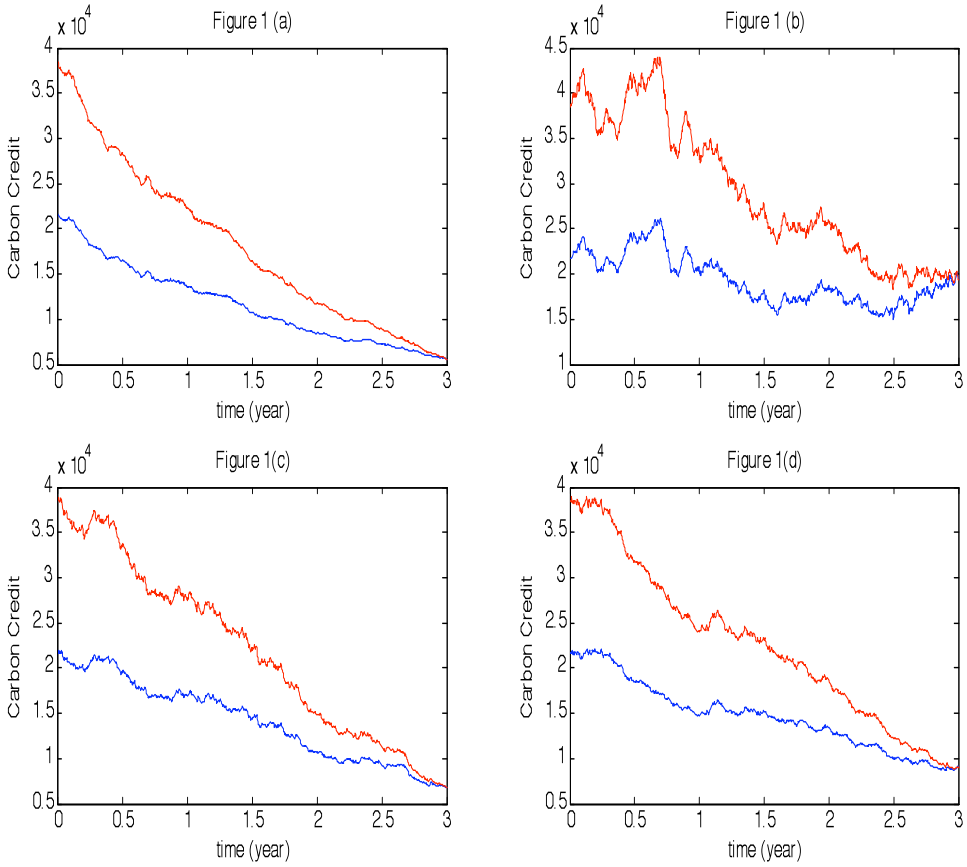
$$10^{-7}\times\begin{pmatrix} 0.3960 & 0.1727 & 0.2087 & 0.1790 & 0. \\ 0.1727 & 0.4153 & 0.1957 & 0.1737 & 0. \\ 0.2087 & 0.1957 & 0.4513 & 0.2453 & 0. \\ 0.1790 & 0.1737 & 0.2453 & 0.4753 & 0. \\ 0. & 0. & 0. & 0. & 1.2845 \end{pmatrix}$$

Figure 2: Summary of Simulated Emission, Emission Reduction, and Final Wealth in Four Scenarios of Baseline-and-Credit System in CIR Production Economy Settings

Scenario	Mean	Covar-iance	Initial Wealth	Emission	Emission Reduction	Final wealth
1	Low	Ω_1	3.856×10^4	7.688×10^5	3.496×10^4	5.570×10^3
2	High	Ω_1	3.856×10^4	7.613×10^5	5.806×10^4	1.930×10^4
3	High	Ω_2	3.856×10^4	7.660×10^5	4.250×10^4	6.776×10^3
4	High	Ω_3	3.856×10^4	7.691×10^5	4.398×10^4	9.017×10^3
Note: All values are in units of carbon credit.						

For each scenario, 10^4 simulation runs with initial wealth $W_0=3.856\times10^4$ thousand metric tons of carbon credits are implemented. The averages of the 10^4 simulation runs are given (Figure 2). Also exhibited is the annual emission consumption rate C_t of Equation 7, or the annual emission reduction rate, versus the evolution of the total wealth in the system (Figure 3). As can be seen, the annual emission reduction rate exhibits the same pattern as the total wealth in the system (Figure 3). The second scenario, with higher mean return rate and low risk technology, generates not only the highest total emission reduction of 5.806×10^4 units of reduction credits, but also the highest final wealth of 1.930×10^4 units of reduction credits (Figure 2). Not only that, but as can be seen, the second scenario generates the highest annual emission reduction rate during the period 2005–2007 (Figure3(b)). On the other hand, the first scenario, with low mean return rate and low risk, generates the lowest

Figures 3a–d: Realization of the Averages of 10^4 Simulation Runs



Note: Figures 3(a)- (d) illustrate the time paths of emission reduction rate (in blue) versus total wealth (in red) for scenarios one through four, respectively.

emission reduction and final wealth of 3.496×10^4 and 5.570×10^3 units of reduction credits, respectively. For the third and fourth scenarios, with higher mean return rate but higher risk technology, the final wealth and total emission reduction are all lower than those of the second scenario. However, compared to the third scenario with highly positively correlated technologies, the fourth scenario generates higher final wealth as well as higher total emission reduction. The simulation result exemplifies the advantage of investment in a diversified portfolio of technologies.

In either scenario, as credits can be registered only until the emission reductions have actually occurred, the over-supply of the emission allowances can be avoided. In addition, as the growth of the investments in the abatement technologies are taken into consideration, the emission reduction together with final wealth exceed the initial wealth $W_0=3.856\times10^4$ in all scenarios. The simulation result highlights the largest difference between a cap-and-trade and a baseline-and-credit system.

Concluding Remarks

To avoid global warming, simultaneous and rapid industry growth across all mitigation opportunities is required (Mackenzie and Ascui 2009). On this ground, this study provides a different mechanism for emission reduction, namely, in the context of a CIR production economy, instituting a baseline-and-credit system instead of a cap-and-trade system. The rationale behind the mechanism is that investments in emission abatement technologies should be considered as "carbon assets," rather than "liabilities." In addition, the growth of these investments is taken into consideration. Emission reduction credits are produced via physical emission abatement by the technologies instead of via free-of-charges assigned emission allowances under a fixed cap in a cap-and-trade system, in which the largest risk is the changing "baseline" GHG emission.

The advantages of the proposed mechanism are threefold. First, as the credits can only be registered and traded until physical reductions have actually occurred, the over-supply of free-of-charges emission allowances in a cap-and-trade system can be avoided. In addition, by assuming that the productivities of the abatement technologies increase as the "baseline" GHG emission increases, it can be expected that the more GHG is emitted, the more emission reductions are produced. Second, the growth of the investments in abatement technologies is taken into consideration, which provides an incentive for further investments in abatement technologies. Third, a zero-coupon bond that pays its principle plus interests with a risk-free rate r at the maturity date can hedge the risk associated with the fluctuated "baseline" GHG emission. In the case of climate change mitigation, zero-coupon bonds provide an ideal fixed-interest-debt financing instrument since investments typically involve long payback periods and large capital costs but relatively secure operating margins. Not only that, but by adjusting the price of the zero-coupon bond and the risk-free interest rate r, the market equilibrium can be achieved—an equilibrium in which all the resources or wealth within the economy are invested in the n abatement technologies, that is, investment opportunities other than the n abatement technologies have zero net supply.

By aiming directly at the stimulation of environmentally beneficial technological changes in an investment-consumption prospect, it is possible that the proposed baseline-and-credit system can provide a better mechanism to resolve the global warming issue rapidly.

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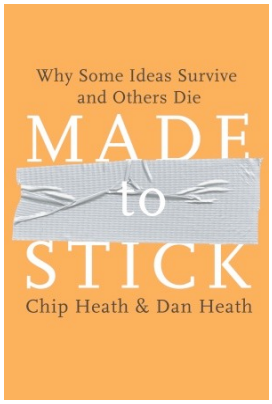
Book Review



Why Some Ideas Survive and Others Die: Made to Stick, by Chip Heath and Dan Heath; New York: Random House, 2007, 2008, 336 pp., $26.00 (hardcover), $14.99 (eBook), $29.95 (audiobook)

Reviewed by Sarah Cleveland

When was the last time you attended a presentation and were gripped by the presenter, so much so that you found yourself immediately sharing it with others? Reading *Made to Stick: Why Some Ideas Survive and Others Die* by Chip Heath and Dan Heath (Random House, 2008) had that effect on me.

I was introduced to the book by a climatologist I happened to meet on a plane. He referred me to it when I asked him how people reacted to his presentations, given the controversy around his topic. He said he had struggled with alternative framing and messaging in his presentations. His most difficult challenge had been communicating impact—translating metrics such as greenhouse gas emissions into something tangible the audience could understand. In environmental investing, clear messages are particularly critical because this is a relatively new field, and misconceptions cause decision makers to close themselves off to new ideas.

In their book, Chip and Dan Heath help sort out how to communicate what matters. The authors identify six principles of sticky ideas and combine them into the acronym SUCCESs:

S = Simplicity
U = Unexpectedness
C = Concreteness
C = Credibility
E = Emotions
S = Stories

This simple memory tool (SUCCESs) has allowed me to describe the book's key concepts by remembering only a few letters in a memorable order, and building off knowledge I already have (for example, knowing the word "success," which allowed me to recall the acronym). The process *sounds* easy. All we need to do is create simple, unexpected, concrete, credible, emotional stories, and we'll be able to have people listen to us, remember what we say, and act on our advice. The process may be "simple," but it's not easy.

Made to Stick feels like a cross between a how-to guide and a reference book. The main chapters "show," rather than describe, each of the principles. At the end of the book, the authors include a handy reference guide and some advice based on their consulting experiences with many companies. I found three sections especially useful: the epilogue "What Sticks," the chapter "Sticky Advice," and the "Easy Reference Guide."

Here is a very brief synopsis of the principles.

Principle	My Simple Takeaway
Simple. In order to be effective communicators, we need to find the core of our message. Simple = core + compact. Proverbs exemplify the idea: "A bird in the hand is worth two in the bush." Finding the core of your message and communicating it in one compact statement is very difficult.	Simple does not equal easy.
Unexpected. Our challenge is to get someone's attention (surprise) and keep it (interest). Have you noticed how Southwest Airlines flight attendants carry out the routine safety announcement? Mundane descriptions of the dos and don'ts for buckling your seat belt are peppered with outrageous statements that catch our attention and make us laugh.	Boring is deadly.
Concrete. We get lost in abstraction unless it's based on concrete ideas. Fables like "The Boy Who Cried Wolf" and "The Goose That Laid the Golden Egg" pull all this together. We create a memorable message by grounding it in concrete examples and including visual, sensory representation. Case studies are an effective example of this idea.	Come down out of the clouds and walk with the humans.
Credible. We believe because of family (our parents told us), personal experience, or faith. To get others to believe our ideas, we need to have a credible source to draw upon: authorities, celebrities, and anti-authorities. Also, don't discount the power of details. Statistics are best used to illustrate a relationship or context, rather than only units of measure.	Believing is seeing and connecting.

Emotional. To take action, we have to care. Feelings inspire us to act. Self-interest is a motivator for action ("What's in it for me?"). Our analytical filter can stifle our ability to feel and can cause us to react differently to emotional requests.	Trust your gut.
Story. Stories are part entertainment and part instruction. They provide the context for abstractions and make them real, or concrete. The following are three basic plot templates for inspirational stories: the Challenge Plot (David and Goliath), the Connection Plot (good Samaritan), and the Creativity Plot (apple falls on Newton's head). Stories take information and make it more relevant to our day-to-day existence.	Stories stimulate and inspire action.

The summary in the epilogue brings the most important concepts neatly together in a checklist framework. For an audience to take up an idea and have it last, we need to make the audience:

1. Pay attention: UNEXPECTED
2. Understand and remember it: CONCRETE
3. Agree/Believe: CREDIBLE
4. Care: EMOTIONAL
5. Be able to act on it: STORY

I can't think of a situation involving communication where these principles *wouldn't* be relevant. For many years I worked as an investment consultant advising corporate retirement plans and other institutional investors. Clients typically structure quarterly investment committee meetings around communicating and assessing information (for example, finding out how their fund performed) and making a decision based on the detailed information provided. Even though the information format tends to be the same from quarter to quarter, we have the opportunity to create more "stories" that illustrate what is happening in the markets. The appeal of the story depends on its relevance, simplicity, and emotional content. Its power is educational and persuasive, but it is also a vehicle for developing a personal relationship with the client that goes far beyond the information in the presentation.

This is all easier said than done. Every time we present information to institutional clients, we are overwhelmed by data—in the authors' words, the "Curse of Knowledge." Data. Data. Data. The numbers alone do not communicate *the* core message. As consultants, our job is to synthesize the data, boil it down to a few key points, and show the relevance to the client. It's a skill and it takes practice.

I'm sure we all share the experience of attending a presentation or meeting where the presenter lost the audience. It doesn't take much to alienate them: industry jargon, too many abstractions, a monotone reading of material, or just generally not engaging the audience. People don't have the patience to sit through your talk and figure it out for themselves. Blackberries and iPhones will command their attention, and you'll wonder whether anyone is listening. One of my clients had all-day meetings that included quarterly updates from several money managers. Besides the pension trustees, one key staff member and two legal counsels attended. The key staff member was continuously using his Blackberry *and* laptop. I was embarrassed for the staff member because of his blatant disrespect for the presenters, and I wondered how much he was absorbing. One time I was surprised to find that he was exchanging emails on a completely different topic with the legal counsel who was sitting at the opposite end of the conference table!

Since reading *Made to Stick,* I listen differently to presentations and am challenging myself to be clear and more focused. I find myself asking: What's the core message? Where is the excitement and urgency? Is this translated into everyday language? Where's the emotional appeal? How do I communicate with a compelling story? I am constantly fighting the Curse of Knowledge. I see that the SUCCESs approach can help all of us become more effective communicators.

In *Made to Stick,* Chip and Dan Heath offer a valuable tool to help improve communication. Investment professionals in the environmental investing field would be well served to adopt the authors' approach. Communicating to institutional investors in *their* language will help build the bridge necessary to have environmental, social, and corporate governance issues routinely considered throughout the investment process. Just imagine what our world would be like if we were able to move the topic of climate change from "important" to "urgent." We would all be in action, working to improve the chances of having a habitable planet for future generations.

Sarah Cleveland is an independent investment consultant serving in an unconventional role. Through Sarah Cleveland Consulting, she is working to further industry efforts to incorporate sustainability in all elements of institutional investment decision making. She may be reached at mailto:sarah@sarahcleveland.com or 503.816.5203.