Carbon Finance for Reduced Emissions from Deforestation & Degradation at the Forest Frontier

Financial Analysis of Alternate Land Uses in the Amazon, Congo and Papua, Indonesia

Authors:
Marisa Meizlish[1]
Dan Spethmann[2]
Michael Barbara[3]

New Forests
Sydney, Australia and Washington, D.C.

Paper Presented at UNFCCC COP13 and Forest Day
Dec. 3-14, 2007
Bali, Indonesia

[1] Manager, Advisory Services, mmeizlish@newforests.com.au
[2] Manager, Investment Programs, dspethmann@newforests-us.com
[3] Analyst, Environmental Markets, mbarbara@newforests-us.com

New Forests

New Forests (www.newforests.com.au) is a forestry investment management and advisory services firm. The company's investment thesis is unique in seeking investment opportunities that deliver traditional timber returns, as well as returns from emerging environmental markets and preferences, such as certified timber, carbon, biodiversity and water. In addition to world-leading forestry investment expertise in the areas of acquisitions, modeling, operations, silviculture and ecosystem services, New Forests is at the forefront of developing and commercializing environmental products and developing opportunities in emerging environmental markets. The company is based in Sydney, Australia, with offices in Washington, D.C. and San Francisco. New Forests holds an Australian Financial Services License (license #301556).

New Forests Pty Limited
The Zenith Center, Tower A
Level 19, Suite 1905
821 Pacific Highway
Chatswood 2067
Australia
+61-2-9406-4100

New Forests Inc.
1025 Connecticut Ave, NW
Suite 1206
Washington DC 20036
United States
+1-202-715-1700

# # #

Copyright

For citations, please use:

Meizlish, M., Spethmann, D. and Barbara, M. (2007) "Carbon Finance for Reduced Emissions from Deforestation & Degradation at the Forest Frontier" New Forests Inc., Washington, D.C.

Table of Contents

List of Figures

List of Tables

Executive Summary

Background on Carbon Investment & Forest Conservation	Deforestation in tropical rainforests contributes approximately 20% of global greenhouse gas emissions annually. Options for expanding the inclusion of forest conservation in global carbon markets are currently being explored. Policies that support a price mechanism for reducing emissions from deforestation and degradation (REDD) could lead to significant new investment in forest conservation. A key question in designing such market policies is how a carbon price for REDD would impact land use dynamics, in particular whether carbon investment may compete effectively with large-scale activities that are driving deforestation, such as commercial agribusiness expansion.
Scope of Financial Analysis	The objective of this study is to evaluate the viability of carbon finance as a mechanism for forest conservation. This is explored via a generalized framework that compares the net present value (NPV) of carbon-financed forest conservation with the value of land uses resulting in forest degradation and deforestation. The study conducts this analysis from the perspective of a private investor making investment decisions on land use options for existing forested areas.
Current Investment Scenarios	This analysis is conducted across all of the world's largest remaining areas of tropical rainforest. The major drivers of deforestation in each region are the baseline scenarios against which conservation is considered. These are: • Cattle ranching in the Brazilian Amazon • Oil palm plantations and logging in Papua, Indonesia • Logging in the Democratic Republic of Congo
Methodology to Assess Carbon Investment Scenarios	The NPV of the cashflows from these activities are compared to the NPV of carbon revenue generated from a potential REDD regime. A range of carbon prices and crediting periods is applied to consider sensitivities to these variables. The impact of policy uncertainty is also discussed.
Results	Results indicate that carbon-financed forest conservation is generally competitive with current land uses at the forest frontier. More frequent crediting periods and the ability to sell some credits into a voluntary market in the short term improve the ability of carbon-finance scenarios to compete with baseline activities. Policy uncertainty is an important variable that can undermine the ability for carbon investment to compete with alternate land uses. Further analysis of the cost structure associated with carbon investments and refinement at a more localized scale can build on the generalized framework developed here to inform decision making in greater detail.

1 Introduction

The forest frontier – the next area of intact forest to be degraded or converted to a non-forest land use – is the front line of global deforestation. Deforestation of the world's intact tropical forests is driven by many factors. These include the recent price increases in global agribusiness commodities, such as soybeans, palm oil and cattle, and increasing global timber demand. At the same time as the forest frontier is being pushed deeper into previously intact forest areas, the rapid growth in carbon markets is creating new avenues to support forest conservation and rehabilitation.

This paper assesses whether conservation through carbon finance can compete with land uses currently driving large-scale deforestation at the forest frontier. Focusing on the rainforest regions of the Brazilian Amazon, Papua, Indonesia, and the Democratic Republic of Congo, we have sought to develop a generalized financial model of a range of land uses and carbon market scenarios. The focus of this study is on whether carbon investors may compete effectively with the current large-scale actors in deforestation, such as commercial agribusiness ventures. Ultimately, if the price of a forest for carbon conservation is greater than the soil expectation value for other uses, then forest conservation management will be attractive to investors over other land uses.

Private investment flows that currently finance alternate land uses, such as converting forests to oil palm, could shift toward investment in forest conservation if risk adjusted returns are competitive. Consequently, the paper uses a Net Present Value (NPV) methodology to compare the relative attractiveness of forest conservation versus agribusiness from the perspective of a private investor. This analysis is conducted under the assumption that credits generated by reducing emissions from deforestation or degradation (REDD) are eligible in an operational global carbon market. However, a range of crediting scenarios and carbon credit prices are considered to show sensitivity to these factors. A discussion of discount rates and policy uncertainty is also included.

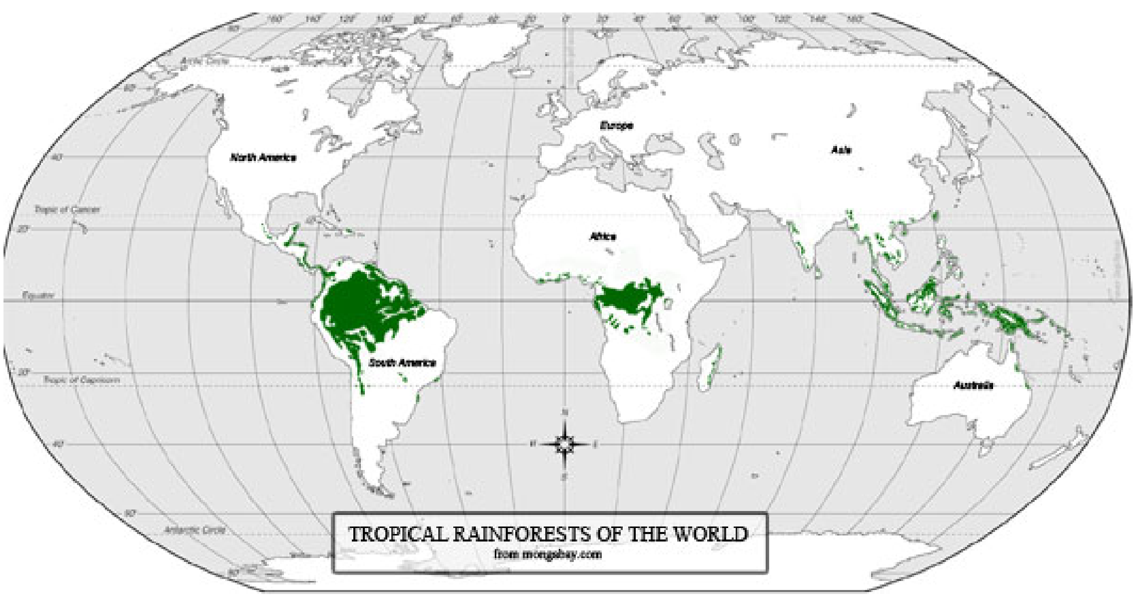
Our findings indicate that there is a case to be made for investment in carbon-financed conservation. The generalized approach developed here suggests that forest conservation can compete with land uses driving deforestation, if policies can provide market certainty around credit eligibility. This paper is intended to serve as a launching point for more detailed economic analysis and debate around forest conservation carbon policy. In particular, further analysis of the cost structure associated with carbon investments and refinement at a more localized scale can build on the generalized framework developed here to inform decision making in greater detail.

Section 2 of this paper provides background on the land use dynamics of the three study regions. Modelling methodologies and assumptions and a discussion of results are presented in the following sections. The paper concludes with a discussion of policy considerations that could generate large-scale investment in carbon-financed forest conservation.

2 Background on Drivers of Deforestation at the Forest Frontier

The three areas considered in this study are the Brazilian Amazon, the Indonesian province of Papua and the Congo Basin in the Democratic Republic of Congo (DRC). These areas represent the largest remaining areas of intact tropical rainforest in the world (Figure 1). This section briefly describes regional land use dynamics as context for the financial analysis in the following sections. The main drivers of deforestation in each region are identified to define the baseline, or "business as usual," activities that are most likely to occur in the frontier regions.

Figure 1 – World's remaining areas of intact rainforest[4]



2.1 The Brazilian Amazon

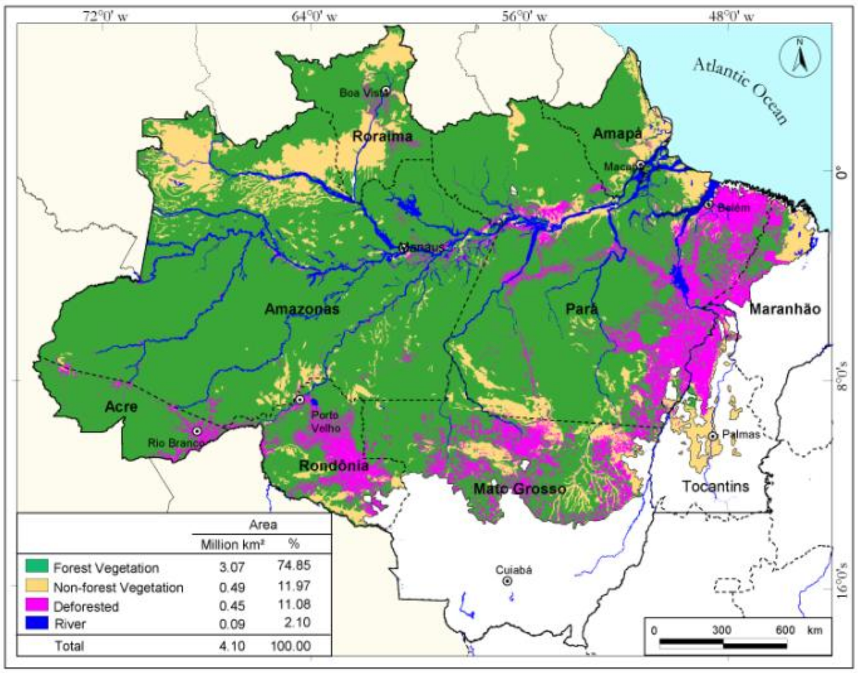
The largest area of remaining intact forest is the Amazon Basin, which covers 5.5 million square kilometers across nine countries in northwest South America. Approximately 60% of the Amazon rainforest is located in Brazil, which is home to 19% of the world's remaining intact forests.[5]

Around 67 million hectares – 17% of the original Amazon area – have been converted to other land uses since the 1970s.[6] Seventy-six percent of deforestation occurs in the

[4] Source: Mongabay.com http://rainforests.mongabay.com/0102.htm
[5] Brazilian Vegetable Oil Industry Association (2006) "Understanding the Moratorium: Responsible Production" http://www.abiove.com.br/english/sustent/ms_cprodutor_24jul07_us.pdf
[6] Ibid

"arc of deforestation" from the Atlantic Ocean through southern Para and Mato Grosso to Acre,[7] which is the frontier area considered in this study (Figure 2). It is estimated that current trends in agribusiness expansion could convert 40% of the Amazon rainforest by 2050.[8] This would result in the release of 32 billion tonnes of carbon to the atmosphere, equivalent to approximately 4 years of global annual greenhouse gas emissions.[9]

Figure 2 – Nine states of the Brazilian Amazon and patterns of deforestation[10]



The annual rate of loss of primary forest in Brazil from 2000-2005 was 0.8%, representing a total loss of 17.3 million hectares over these 5 years. This rate is a 35% increase over the rate of primary forest loss recorded from 1990-2000.[11] Two of the largest deforestation years on record were 2002 and 2003 (23,000 square kilometers

[7] Margulis, S. (2004) "Causes of Deforestation of the Brazilian Amazon" World Bank Working Paper No. 22, Washington, D.C.
[7] Walker, R. and Moran, E. (2000) "Deforestation and Cattle Ranching in the Brazilian Amazon: External Capital and Household Processes" World Development Vol. 28, No. 4, p. 683-699
[8] Soares-Filho, B. et al (2006) "Modelling Conservation in the Amazon Basin" *Nature* Vol. 440, March
[9] Ibid
[10] Global Forest Watch (2007) "Human Pressure on the Brazilian Amazon Forests" (online) http://www.globalforestwatch.org/english/interactive.maps/Brazil_Datasets.htm#Study_area
[11] FAO (2005) "FAO Forest Resource Assessment – Global Tables" http://www.fao.org/forestry/site/28679/en/

and 24,000 square kilometers per year, respectively[12]), and an all-time high of 27,400 square kilometers was cleared in 2004, 50% above the long-term average.[13] Deforestation rates tend to be closely correlated with prices for cattle, timber and crops.[14] With the decline of soy and beef prices in 2005 and 2006 and the strengthening of the Real against the US dollar, deforestation rates slowed to 18,800 and 13,100 square kilometers per annum, respectively[15].

A rise in annual deforestation is expected, as prices increase for these commodities in response to global growth in demand.[16] This reactive variability suggests that land practices could change quickly through the introduction of a price signal for carbon-financed forest conservation. Figure 3 gives one snapshot of how quickly the conversion of the frontier is advancing.

Figure 3 – Deforestation in Rodonia, Brazil from 2000 to 2006 [17]

[12] Woods Hole Research Center (2007a) "Agriculture Frontier Explosion in Brazil" http://www.whrc.org/southamerica/agric_expans.htm
[13] Nepstad, D., Moutinho, P. & Soares-Filho, B. (2005) "The Amazon in a Changing Climate: Large-Scale Reductions of Carbon Emissions from Deforestation and Forest Impoverishment" Amazon Institute for Environmental Research), Woods Hole Research Center (WHRC) and Federal University of Minas Gerais paper released during COP 12, Nairobi
[14] Mongabay.com (2007) "South American development plan could destroy the Amazon" http://news.mongabay.com/2007/1003-ci_amazon.html
[15] Ibid
[16] Martino, D. (2007) "Deforestation in the Amazon: Pressures and Outlook" Third World Resurgence No. 200, April http://www.southdevelopment.org/environment/MartinoAmazonDeforestation.pdf
[17] NASA Earth Observatory http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=17600

The most serious threat to the Amazon forests and the main driver of deforestation is cattle ranching.[18] Government subsidies and tax incentives granted to large-scale ranchers in the 1970s and 1980s spurred the growth of the industry, [19] and the herd size nearly doubled from 26.2 million head of cattle in 1991 to 51.6 million in 2001.[20] It is estimated that as much as 88% of deforested areas are occupied by ranches,[21] and the industry continues to grow.[22]

In general, cattle ranching is not the highest economic land use when compared with other regimes, such as soy or logging. However, landowners tend to favor ranching because it provides a relatively liquid asset that can provide annual cash-flow and is also relatively low risk. Converting land to a cattle ranch is also a way of guaranteeing land possession and securing property rights.[23]

Soybean production, which grew approximately 60% between 1998 and 2002,[24] is contributing to this expansion by moving onto old ranching lands in the southern arc of deforestation, pushing cattle further north into untouched areas. Soybean cultivation is becoming more competitive as soy prices rise, driven by a growing demand for bio-diesel and global food production, and as transportation costs decrease through increased river usage and expanded road networks.[25]

An additional driver of deforestation is selective logging, which occurs over an average area of 15,000 square kilometers a year.[26] Recent studies indicate that rather than contributing to deforestation by providing access to areas that are subsequently converted to agricultural use, selective logging appears to be a driver of deforestation on its own and is accretive to deforestation caused by conversion for cattle and soy.[27] However, 96% of the logging in the Amazon occurs in old and intermediate frontiers (10 –30 years since first selective harvest) with the remaining 4% occurring in new frontiers, principally Novo Progresso and northern Mato Grosso.[28]

There are multiple land uses at the Brazilian forest frontier and the land use dynamics are not fully understood.[29] However, conversion to pasture for cattle ranching is the largest driver and the land use studied here as the baseline scenario in Brazil.

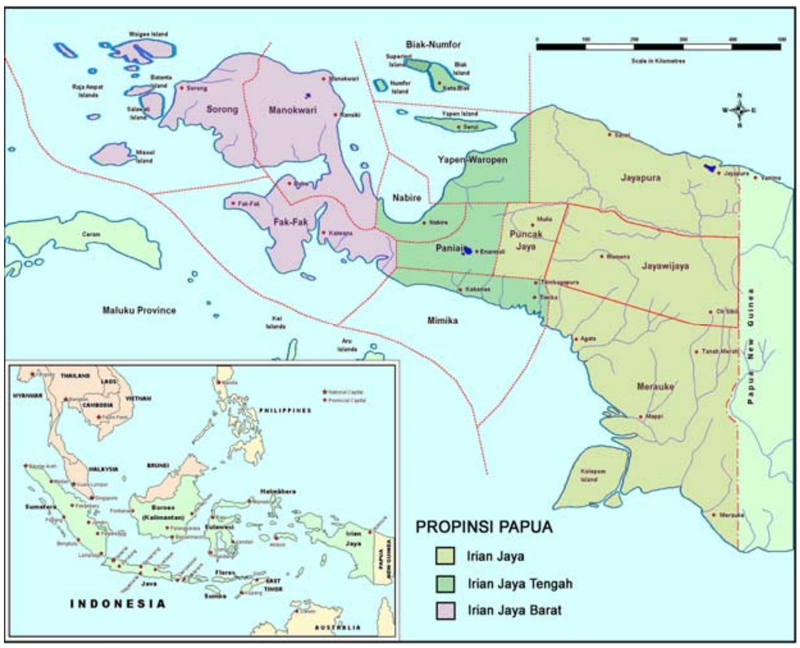
---

[18] Fearnside, P. (2007) "Deforestation in Amazonia" *Encyclopedia of Earth* Eds. Cutler J. Cleveland, Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment http://www.eoearth.org/article/Deforestation_in_Amazonia; Margulis, S. (2004); Woods Hole Research Center (2007)
[19] Walker, R. and Moran, E. (2000)
[20] Woods Hole Research Center (2007)
[21] Margulis, S. (2004)
[22] Walker, R. and Moran, E. (2000)
[23] Margulis, S. (2004)
[24] Woods Hole Research Center (2007)
[25] Ibid
[26] Foley et al (2007) "Amazonia Revealed: Forest Degradation and the loss of ecosystem goods and services in the Amazon Basin" Frontiers in Ecological Environment, Issue 5(1), p. 25-32
[27] Foley et al (2007) citing Nepstad, D. et al (1999) "Large scale impoverishment of Amazonian forests by logging and fire" *Nature* Issue 398, April 8, p. 505-508 and Anser, G. et al (2005) "Selective Logging in the Brazilian Amazon" *Science* Issue 310, p. 480-82
[28] Woods Hole Research Center (2007b) "Logging and Family Forests" http://www.whrc.org/southamerica/logging_fam_forests.htm
[29] Foley et al (2007)

2.2 Papua, Indonesia

Papua is the largest province in Indonesia and accounts for almost a quarter of Indonesia's land area (Figure 4). The percentage of forest cover in Papua and West Papua (now a separate province, shown in pink in Figure 4) was 85% in 1985[30] with satellite imaging analyses reporting an estimated reduction to approximately 73% by 2005.[31] The rate of loss of primary forest in Indonesia from 2000-2005 was 2.6% per annum totalling a loss of 7.2 million hectares over the five-year period.[32] This rate was a 26% increase over the period from 1990-2000. Data specific to Papua is difficult to obtain, but the rate of loss of primary forest for neighbouring Papua New Guinea has been 0.95% annually from 1990-2005. This is a loss of 250,000 hectares per year.[33]

Figure 4 – Papua Province, Indonesia



Timber companies are increasingly turning their attention to Papua's natural forests, and large scale timber extraction concessions have led to significant clearing of the province's primary forests.[34] Forest concessions allowing harvesting of natural

---

[30] Global Forest Watch et al (2001) "The State of the Forest: Indonesia" Global Forest Watch, World resources Institute and Forest watch Indonesia www.globalforestwatch.org
[31] Sumantri, H. and Wijayanto, I. (2005) "Land cover mapping using satellite imagery and GIS in the Mamberamo Basin and Raja Ampat Islands, Papua, Indonesia" www.mapindia.org/2005/papers
[32] FAO (2005)
[33] Ibid
[34] Tokede, M., William, D., Widodo, Gandhi, Y., Imburi, C., Patriahadi, Marwa, J., Yufuai, M. (2005) "The impacts of Special Autonomy in Papua's Forestry sector: Empowering Customary Communities (Masyarakat Adat) in decentralised Forestry Development in Manokwari District" Centre for International Forestry Research, Bogor, Indonesia

forests have been granted over 6.5 million hectares of the province's 42 million hectares.[35] While concession requirements include preparing environmental impact assessments and forest management and monitoring plans, logging practices typically result in over-exploitation and loss of the forest structure.[36] Inventories of harvested areas in Papua found that 58% of the remaining trees with diameters of 20 cm or larger were damaged, compromising the ability of the forest to recover and provide sustainable yields of timber.[37] In addition to these pressures, illegal logging activities are increasing, particularly as forest resources diminish in the Indonesian provinces of Kalimantan, Sulawesi and Sumatra.[38]

Increasing international demand for green energy sources has led to a demand for new land to produce palm oil, a feedstock for bio-diesel. Most of the global expansion of the oil palm plantation estate has occurred in Indonesia and Malaysia.[39] Predictions are that about half of the new plantation land – 3 out of 6 million hectares – needed to supply the global palm oil market by 2020 will be established in Indonesia.[40] National government plans for Papua to absorb much of this expansion would dwarf the province's current plantation estate of 58,000 hectares (as of 2002).[41] The provincial government is actively pursuing alternate investment strategies related to carbon credit generation to avoid this massive land conversion.[42] In Papua New Guinea, the oil palm plantation estate doubled between 1990 and 2000 to 73,000 hectares, and this growth is expected to accelerate.[43]

Irrespective of whether this land use change occurs in Papua or elsewhere in Indonesia, it would represent a significant loss of frontier forest in the Asia Pacific region. The land use pressures in Papua are representative of challenges faced across the region's remaining tropical forests. Unsustainable logging and oil palm plantation establishment are the two activities studied here as the baseline scenarios for Papua. While regional variables will influence the financial viability of logging and palm oil development across the region, the models for Papua can generally be applied elsewhere.

---

[35] Papua Ministry of Forestry (2006) List of Forest Concession Right (Hak Pengusahaan Hutan) and Timber Forest Product Utilisation Permit (Izin Usaha Pemanfaatan Hasil Hutan Kayu) holders, August

[36] Jarvis and Jacobsen (2006) "Working paper – Incentives to promote forest certification in Indonesia" Project: Motivating Sustainability, International Finance Corporation

[37] Tokede et al (2005)

[38] Ibid

[39] Wilkinson, M. (2007) "Green Fuel Gets a Black Name" *Sydney Morning Herald* October 13; Painter, J. (2007) "Losing Land to Palm Oil in Kalimantan" *BBC News*, August 3

[40] WWF Germany (2002) "Oil palm plantations and deforestation in Indonesia: What role to Europe and Germany Play?" http://www.fire.uni-freiburg.de/se_asia/projects/wwf_oil.htm

[41] Friends of the Earth (2005) "Greasy Palms. The social and ecological impacts of large-scale oil palm plantation development in southeast Asia" http://www.foe.co.uk/resource/reports/greasy_palms_impacts.pdf

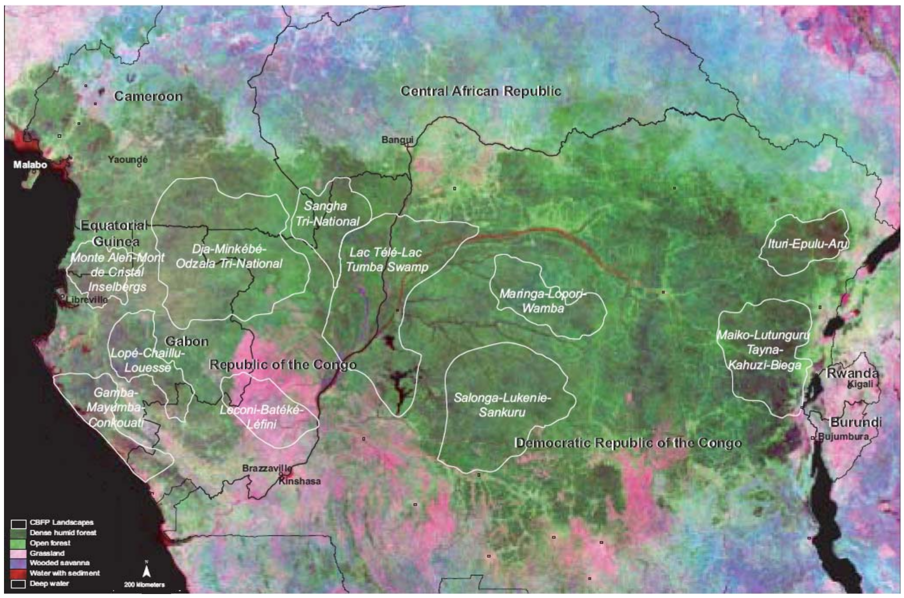
[42] Tedjasukmana, J. (2007) "Heros of the Environment: Leaders & Visionaries" *Time Magazine* http://www.time.com/time/specials/2007/article/0,28804,1663317_1663319_1669895,00.html

[43] Ibid

2.3 Democratic Republic of Congo

The Congo Basin is the world's second largest tropical rainforest covering 2 million square kilometers across the central African nations of the Democratic Republic of Congo (DRC), the Central African Republic, Cameroon, the Republic of Congo, Equatorial Guinea and Gabon (Figure 5). Fifty-three percent of the rainforest is within the DRC, the area of focus in this study.

Figure 5 – Congo Basin spanning five central African nations[44] *



* Encircled areas are priority landscapes based on high biodiversity value and intact forest

Compared to many of the world's tropical rainforests, the Congo Basin is relatively healthy.[45] This is primarily a result of the low population density and limited commercial activity. The annual rate of deforestation from 2000-2005 was 0.24%, which actually represented a 37% decrease from the period of 1990-2000.[46] This may be a result of decreased economic activity during Congo's civil war from 1998-2003, and the country is likely to open to global markets as political stability improves.

Nearly 60% of the DRC's total forest area is thought to be productive or commercially valuable,[47] and logging is currently the main commercial activity contributing to deforestation.[48] Approximately 20 million hectares of the DRC's 145 million hectare forest estate are allocated as timber concessions to about 60 companies, although only

---

[44] Congo Basin Forest Partnership (2005) "The Forests of the Congo Basin: A Preliminary Assessment" (online) http://carpe.umd.edu/products/PDF_Files/FOCB_APrelimAssess.pdf
[45] Congo Basin Forest Partnership (2005)
[46] FAO (2005)
[47] Congo Basin Forest Partnership (2005)
[48] Bavier, J. (2007) "Congo to Cancel Logging Deals to Protect Forests: Reuters, June 21; Congo Basin Forestry Partnership (2005)

about a dozen are in operation.[49] Three main companies – Siforco (owned by Germany's Danzer Group), Sodefor (a Portuguese-owned unit of holding company NST) and Safbois (an American and Belgian owned conglomerate) – account for over two-thirds of the country's current timber production capacity.[50]

The government is currently carrying out a World Bank-led legal review of 156 logging licenses covering 21 million hectares, half of which are in intact forest landscapes. Around three million hectares of illegal logging concessions have already been cancelled, and the government claims it is willing to cancel an additional 12-15 million hectares.[51] The outcome of these processes and the enforcement of government policies remain uncertain.

Currently, logging in the DRC is largely driven by demand from Europe for certified sustainable timber[52] (e.g. Forest Stewardship Council certification). The general practice in the region is selective logging of high-value species for export. One to two trees are removed per hectare (ha)[53] with an average of 75-80% of the canopy cover remaining intact.[54] Felling cycles (in a properly managed tropical forest) rarely exceed 30–40 years.[55] Estimates of production range from 5-6 cubic meters (m^3) /ha[56] to 8-12m^3/ha[57].

Economic drivers such as increased timber demand from Asia, which is more accepting of non-certified wood, and increasing population pressures suggest that there could be an increase in unsustainable logging practices in the near term. For example, the ITTO reported in late 2006 that China has replaced Europe as the price-setter for African timber.[58] With only a dozen of the 60 companies holding logging concessions currently in operation,[59] there is scope for increased production capacity as non-active concession holders become operational or relinquish licenses that are acquired by operational companies.[60] In nearby Ivory Coast, Ghana and Uganda,

---

[49] Forests Monitor (2007) "The Timber Sector in the DRC: A Brief Overview" http://www.forestsmonitor.org/uploads/2e90368e95c9fb4f82d3d562fea6ed8d/Description_of_the_Timber_Sector_in_the_DRC.pdf
[50] Bavier, J. (2007)
[51] Ibid
[52] Forests Monitor (2007)
[53] Karsenty, A., and Gourlet-Fleury, S. (2006) "Assessing sustainability of logging practices in the Congo Basin's managed forests: the issue of commercial species recovery. *Ecology and Society* Issue 11(1), p. 26 (online) http://www.ecologyandsociety.org/vol11/iss1/art26/
[54] Nasi, R. (2005) **"**Potential Methodological Flaw in the Examination of the Effects of Logging" *Ecology and Society* Issue 10(2) (online) http://www.ecologyandsociety.org/vol10/iss2/resp2/
[55] Karsenty, A., and Gourlet-Fleury, S. (2006)
[56] Ruiz-Perez, M. et al (2005) "Logging in the Congo Basin: A Multi-Country Characterization of Timber Companies" *Forest Ecology and Management* Volume 214, Issues 1-3
[57] Karsenty, A. and Gourley-Fleury, S. (2006)
[58] ITTO (2006) "Asia Takes Price Leadership from Europe in Africa" *Tropical Forest Update* Volume 16, No. 4 http://www.itto.or.jp/live/Live_Server/3163/tfu.2006.04.e.pdf
[59] Forests Monitor (2007)
[60] Greenpeace suggests that this could be an outcome of the World Bank led concession review currently underway. (See "Carving Up the Congo" http://www.greenpeace.org/raw/content/international/press/reports/carving-up-the-congo-exec.pdf)

favorable economic markets for both timber and agricultural products, such as cacao, also contributed to the deforestation of old growth forests in those countries.[61]

Should Congo's forests come under greater threat of degradation from increased logging as the country opens to global markets, a price signal for carbon conservation could help the country develop land uses that incorporate a full range of forest values. Studying logging as the main driver of deforestation in this region is therefore more forward looking and hypothetical than the other regions, but it provides an early assessment of how carbon finance could mitigate the rapid expansion of logging activities, as market demand for timber inevitably increases.

3 Methodology and Assumptions

This study evaluates the viability of carbon finance as a mechanism for forest conservation via a comparison of the net present value (NPV) of carbon-financed forest conservation versus the land uses driving deforestation. This analysis is considered from the perspective of private investors making investment decisions on land use options for existing forested areas. This section describes the methodology used to conduct the analysis and outlines assumptions underlying the financial modelling.

3.1 Framework for Analysis

There is no accepted regulated market standard for defining and accrediting avoided deforestation credits. Many ideas are currently being discussed for what is being referred to as reduced emissions for deforestation and degradation (REDD). A position favoured by the UNFCCC, World Bank and others takes a national accounting approach in which countries establish a baseline deforestation scenario and receive credit for reducing emissions below the baseline.[62] Other accounting approaches have taken a more project-level perspective or combined national and project-level mechanisms (the "nested approach"[63]).

The second major question is whether credits from REDD will be fungible with other carbon offsets. Some proponents suggest a completely fungible market. A dual markets approach has also been proposed in which avoided deforestation credits are sold in a parallel market but are not fungible with emission reduction offsets as defined under markets of the Kyoto Protocol.[64]

---

[61] Laporte et al (2004)
[62] World Bank Carbon Finance Unit (2007) "Forest Carbon Partnership Facility" http://carbonfinance.org/Router.cfm?Page=FCPF&FID=34267&ItemID=34267
[63] Pedroni, L. and Streck, C. (2007) "Mobilizing Public and Private Resources for the Protection of Tropical Rainforests" CATIE and Climate Focus http://www.climatefocus.com/newspubs/downloads/PolicyBriefonREDD_000.pdf
[64] Centre for Clean Air Policy (2007) "Reducing Emissions from Deforestation and Degradation: The Dual Markets Approach" http://www.ccap.org/international/FINAL%20REDD%20report.pdf

Defining baseline scenarios is fundamental in all of these policy debates and is the fundamental first step in evaluating activities that are seeking carbon finance.[65] A baseline scenario explains the likely land use in the absence of the emission reduction activities. Avoided deforestation as a general project type assumes that the baseline activity results in forest degradation or conversion to a non-forest activity. The emissions "avoided" by pursuing a forest conservation management strategy rather than the baseline activities represent the volume of saleable carbon.

For this study, a framework for analysis was designed to compare the NPV of baseline activities to the conservation scenario. This framework includes the following steps:

- specify baseline activities for each region
- determine the NPV of the cashflows of the baseline activity
- estimate carbon stock loss associated with the baseline activity
- quantify the NPV of maintaining carbon stock by forgoing the baseline activity

3.2 Definition of Baseline Activities

As discussed in Section 2, the baseline scenarios considered in this study are:

- Cattle ranching in the Amazon
- Unsustainable logging in Papua
- Oil palm plantation development in Papua
- Unsustainable logging in the DRC

Modelling is based on a hypothetical frontier area of 250,000 hectares. This approximately represents the size of logging concessions in Papua and the Congo but is much larger than individual landholdings for ranching in the Amazon and oil palm plantations. This scale is used to approximate land use dynamics across the frontier, whether that is driven by a single landowner or the cumulative impact of multiple landowners.

The entire concession area is assumed to be impacted over a 20-year period. This represents a deforestation rate of 5% per annum, totaling a conversion of 12,500 hectares annually. This rate is reasonable in terms of the operational capabilities of the land uses in the baseline scenarios.

Ideally, each scenario would apply a deforestation rate based on the country's historical and projected rates of deforestation. Although many data points could be used, the best method for determining these baseline loss rates is an important point of

[65] See, for example, the Voluntary Carbon Standard "Guidance for Agriculture, Forestry and Other Land Use Projects" www.v-c-s.org/docs/AFOLU%20Guidance%20Document.pdf and California Climate Action Registry "Forest Sector Protocol" http://www.climateregistry.org/docs/PROTOCOLS/Forestry/Forest_Sector_Protocol_Version_2.1_Sept2007.pdf

debate in policy discussions around the accreditation of REDD activities. FAO deforestation statistics presented for each region in Section 2 suggest lower rates (0.8% in Brazil, 2.6% in Indonesia and 0.24% in Congo), but this data is aggregated nationally and underestimates rates at the forest frontier. Rates of deforestation also appear low when considered over a large intact forest land base, such as those in the Brazilian Amazon and the Congo Basin. A rate of 5% is therefore generalized and is applied as a simplified approach, which would need further investigation for specific areas.

Definitions of baseline activities are as follows:

Cattle Ranching Forested land in the hypothetical 250,000 hectare study area is converted to pasture at a rate of 12,500 hectares per annum. Once a hectare is converted, it is assumed to become productive in the following year and remains productive through the project life (to 2040). It is assumed that the net cashflows per hectare over the project life incorporate start-up costs and operating costs. Any initial revenue from the liquidation timber sales upon conversion is assumed to be included in the average net cashflows per hectare over the project life, although in many cases trees are burned onsite rather than taken to market.[66] Operating costs and cattle prices are assumed to be static over the project life and do not take into account changing market conditions.

Logging Logging scenarios assume that reduced impact logging is not applied, resulting in degradation of logged areas. This results in little or no regrowth of merchantable timber; therefore a hectare is logged only once. At a rate of 12,500 hectares per annum, the 250,000 hectare area is logged over in 20 years. Land uses and revenues post-harvesting, such as conversion to agribusiness, are not included in the model. It can be assumed that population growth would result in small-scale cultivation and urbanization of these areas in the short term, which is beyond the scope of the commercially driven activities considered in this study. The assumed yield of merchantable timber from the initial harvest is 20m^3/ha.

Oil Palm For oil palm, the same rate of conversion (12,500 hectares per annum) is applied, resulting in complete conversion of the study area over 20 years. The model does not factor in the sale of timber from conversion activities under the assumption that plantation development often occurs on degraded secondary forest, where limited timber revenues are available, with remaining timber burned on site. The degradation of the forest for timber as an intermediary process is captured in the land purchase price of the palm oil investment.

3.3 Discount Rates

Discount rates are a crucial component in determining the NPV of cashflows of these baseline activities. A discount rate represents the investors cost of capital over time, or hurdle rate. It ultimately determines the investor's expected financial return over

---

[66] Bowman, M. (2007) *pers comm* Project Assistant, Woods Hole Research Center, November 2

the project life (internal rate of return, IRR) based on the amount of risk ascribed to the activity. Investors will ascribe higher discount rates to projects that are assumed to involve more risk. Risk considers many factors, including market knowledge, market certainty, country sovereign risk (i.e. defensibility of property rights and contracts), currency risk, timing of cash flows and availability of skilled labour and physical capital.

For this study, a 20% real discount rate was used. High performing cattle ranches deliver a real IRR of up to 20%,[67] and 20% real IRR is likely the minimum return forest investors would expect in these countries. Anecdotal evidence suggests that returns from oil palm plantations are currently higher than this and are increasing with the rising price of crude palm oil. This reflects the rationale for the rapid expansion of this land use in many places.

The stability and size of beef, timber and palm oil markets provides investors with a relative level of certainty, although risk remains related to project execution and market volatility. Discount rates applied to current carbon finance projects would likely be higher given the current carbon market uncertainty. Nevertheless, this study is designed to test the impact of establishing a set of rules and market price signals for carbon offsets from REDD. Assuming such a market is established, investors would be increasingly likely to use similar discount rates for carbon-related investments as are applied for agribusiness investments. Carbon investors may even apply lower discount rates, since the relative establishment and operational costs are minimal, involving less project delivery risk.

However, it is acknowledged that there is currently little certainty around how REDD credits will be incorporated into carbon markets. A major outstanding issue is how project-based forest conservation may be incorporated into national baseline accounting policies. National accounting requires countries to adopt a country-level deforestation baseline, and credits would only be saleable if the country as a whole reduces its emissions below the accepted baseline.[68] This creates a problem for investors who may reduce emissions over a project baseline but are then precluded from selling in international markets because of host country non-performance.

With this level of uncertainty, investors need to consider the risk-return profile of carbon projects, and the implications of this are discussed in Section 4.

3.4 Net Present Value of Baseline Activities

The NPV of the cashflows from baseline activities represents the total cashflows over the project lifetime discounted back to today's dollars. This methodology enables a comparison across investment options using a single metric of present value derived from the activity (effectively the current purchase value that the land or forest should

[67] Margulis, S. (2004)
[68] Pedroni, L. and Streck, C. (2007)

be worth to an investor contemplating those activities). All modelling is in real terms (i.e. values are in current dollars and do not account for inflation over time).

A range of approaches was used to determine the NPV per hectare based on available information and market knowledge. Cashflows are modelled through 2040 for cattle ranching and palm oil. Cashflows for logging end in 2028, when the resource is considered to be depleted. (Carbon scenario cashflows are modelled through 2040.)

Cattle Ranching Generalizing the NPV of cattle ranching is difficult because costs and revenues are highly variable. Costs are dependent on whether landowners are converting large forest areas directly or buying smaller plots already converted through intermediary processes. However, as ranching is the final productive activity, it can be said to underwrite all prior costs and revenues, such as speculative land purchases and selling timber from initial clearing (i.e. investors in intermediate logging use land sale to ranching as a "terminal value" for their activities).[69] Income also varies by type of ranch activity (rearing, fattening, etc.) and regional variations, such as soil quality and distance to slaughterhouses.

Published data is sparse but one major World Bank study estimates a NPV of $500/ha applying an 8% discount rate.[70] This is corroborated by another study in which the NPV per hectare is estimated at $567 (6% discount rate) adjusted to $197 per hectare at a 12% discount.[71] These discount rates generally reflect low risk projects involving land that has already been cleared. Projects at the frontier would likely involve higher risk, and therefore discount rates closer to 20% would be reasonable, as discussed.

The World Bank study reports profits per hectare of $77 per year.[72] Using this estimate, the NPV of cashflows from the baseline scenario (12,500 hectares converted to production annually over 20 years with cashflows to 2040) yields a per hectare NPV of $111/ha, applying a 20% discount rate. Preliminary results from a third study indicate that NPVs range from $0-1150/ha across the entire Brazilian Amazon.[73] For the purposes of this study, a median value of this range ($575) was averaged with $111/ha to yield an NPV of $343/ha.

Logging For logging, cashflows were derived from profits per hectare per year based on literature and our access to data from regional forestry consultants. The NPV was then derived based on cashflows over 20 years, at which point the forest is assumed to be degraded and no longer viable for commercial logging.

In Papua, cashflows were based on estimated average log prices (on barge) minus production costs. Based on information from industry sources operating in Papua, log prices are assumed to be $150/m^3, which is an average of prices achieved for high-grade logs, medium-grade logs (i.e. Meranti and Agathis) and mixed species. Costs

[69] Margulis, S. (2004)
[70] Ibid
[71] Mattos, M. and Uhl, C. (1994) "Economic and Ecological Perspectives on Ranching in the Eastern Amazon" World Development Vol. 22, No. 2, p. 145-158
[72] High productivity ranches in the best soil regions yield profits of R$138/hectare (Margulis 2004) multiplied by the conversion rate of 1.76 to convert to US$.
[73] Merry, F. (2007) *pers comm.* Discussing work in review. Woods Hole Research Center

were derived from an International Finance Corporation working paper[74] and incorporate information provided by experienced foresters working in the region in addition to New Forests' operational experience in tropical forests. Total production costs are approximately $120/m^3$ assuming logs are loaded on a barge for transport to Asian markets or to a local processing site near the coast.

This cost estimate represents natural forest management at a level that would meet reputable sustainable forestry certification standards, i.e. reduced impact logging. Concessions managed to these standards are rare. Specifically in Papua, there are no certified natural forest extractive management operations. Therefore, the cost structure was adjusted to remove activities that would likely be forgone in unsustainable management regimes (silviculture treatments, planning, rehabilitation and official taxes). A cost structure of $80m^3$ was used to reflect unsustainable practices. (Line item costs and further discussion are provided in Appendix A.)

Log prices per cubic meter ($150) minus operational costs under an unsustainable logging scenario ($80) yield a profit of $70/m^3$. With $20m^3$ of merchantable timber per hectare and 12,500 hectares logged annually, this generates an annual cashflow of $17.5 million. The NPV of project cashflows over 20 years is $350 per hectare, applying a 20% discount rate.

In the DRC, log prices are reported at $220[75] to $300[76] per cubic meter corroborated by ITTO average log (on barge) prices for Khaya (African mahogany) and Meranti of $300.[77] Taking an average ($260) and using the same operational costs assumed in the Papua scenario, the profit margin is assumed to be $160/m^3$.

Given that increased production in the DRC would necessitate harvesting less valuable species, it was assumed that $160/m^3$ profit was achieved for the first $10m^3$. The remaining $10m^3$ were assumed to yield a profit of $100/m^3$. This resulted in an average profit of $130/m^3$. The NPV of the cashflows over 20 years is $633 per hectare, applying a 20% discount rate.

It is important to note that the availability and value of $20m^3$ of merchantable timber in the Congo requires further investigation. In particular, if market pressures result in a shift toward the unsustainable logging practices assumed here (e.g. shift to Chinese markets), price premiums for certified sustainable timber would be lost. Deriving profits from current prices may over-value actual prices in an unsustainable logging scenario, and this should be taken into consideration.

Palm Oil A discounted cashflow model was built to determine plantation establishment costs and crude palm oil yields over time. (Appendix B provides a full list of cost and revenue assumptions and sources.) In brief, costs include a $300/ha

---

[74] Jarvis, B. and Jacobson, M. (2006)
[75] Forests Monitor (2007)
[76] ITTO (2005) "Annual Review and Assessment of the World Timber Situation" Division of Economic Information and Market Intelligence, Yokohama, Japan http://219.127.136.74/live/Live_Server/2151/E-AR05-Text.pdf
[77] ITTO (2007) "Market Trends" *Tropical Forest Update* Volume 17, No. 1 http://www.itto.or.jp/live/Live_Server/3241/tfu.2007.01.e.pdf

land purchase price and establishment costs of $2555 per hectare, both incurred as establishment occurs (12,500 hectares per annum). Operating costs total $500 per hectare per year, and harvesting costs are priced at $187 per hectare. The model assumes that beginning at year four, each hectare of plantation produces 0.64 tonnes of crude palm oil. In a linear fashion, the palm oil yield increases to 4 tonnes of crude palm oil per hectare at age 7, stays constant to age 12 and steadily declines until age 25, when trees are removed and replanted. Crude palm oil is sold at current market prices of US$886 per tonne over the project life. The net present value of the cashflows to 2040 is $757 per hectare, applying a 20% discount rate.

3.5 Carbon Quantification

In addition to determining the NPV of the baseline activities, a carbon accounting methodology is required to quantify the volume of carbon emissions that are avoided by forgoing the baseline scenario. The assumed change in carbon stock over time between the baseline scenario and the conservation scenario represents the quantity of carbon offsets that can be created and sold. Realistic assumptions are therefore required on the rate of conversion for each land use and associated emissions.

General assumptions are:

- It is assumed that there is an average of 549 tCO_2/ha stored in the standing forest in all three regions. This represents 150 tonnes of carbon (C) per hectare multiplied by the molecular weight conversion factor of 3.66 to estimate metric tonnes of carbon dioxide equivalence (tCO_2e), the standard unit traded in carbon markets. This figure is the average of multiple data sources that report approximately 100-200 tC per hectare for tropical rainforests.[78]

- With regard to cattle ranching, it is assumed that 86% of the biomass is removed from the site immediately upon conversion through burning. Remaining biomass stays on site and decays over time. The minimum residual carbon stock is 50 t CO_2/ha, representing primarily below ground biomass.

- With regard to logging scenarios, it is assumed that after harvesting 10% of stored carbon is immediately lost (i.e. removed in the form of logs[79]); 25% decays over time, either on site or when debris, litter and soil carbon

---

[78] FAO (2005) http://news.mongabay.com/2006/1031-deforestation.html; Gibbs, H.K, S. Brown, J. O. Niles and J. A. Foley (2007) "Monitoring and estimating tropical forest carbon stocks: making REDD a reality" *Environmental Research Letters* (in press); Margulis, S. (2004); Saatchi, S. et al (2005) "Spatial Distribution of Carbon Stock in the Amazon Basin" *American Geophysical Union, Fall Meeting* 2005 http://adsabs.harvard.edu/abs/2005AGUFM.B54B..03S

[79] The standard approach in carbon trading systems is to assume that the carbon stored in logs is released upon harvest. While carbon may remain stored in wood products for years, decaying later in landfills or through other processes, this delay is not currently factored into carbon accounting, and convention is applied here.

is washed into waterways; 65% remains in standing forest with 10% lost each year from fire, illegal logging, mining, agriculture and reclassification for agribusiness, etc. The minimum residual carbon stock is 50tCO_2/ha.

- For palm oil, 100% of the biomass is assumed to be removed from the site immediately with a minimum residual carbon stock of 50tCO_2/ha. The model accounts for the carbon sequestered as the palm plantation grows, which is subtracted from the volume of saleable carbon in the avoided deforestation scenario.

Standing carbon stocks are regionally variable, and the minimum carbon stock of 50tCO_2/ha is an estimate based on the likely percentage of the remaining above and below ground biomass after burning and degradation. Both require refinement to improve accuracy at a local scale.

3.6 Carbon Value

As discussed, there is no accepted regulated market standard for defining and accrediting avoided deforestation credits. For this study, it was necessary to make assumptions about how avoided emissions may be credited and priced. Crediting periods were designed based on general current practices in voluntary and regulated markets. Price points were derived from recent transactions and market data as explained in the notes to Table 1.

Scenario 1 A once only calculation is made of the total credits generated from foregoing the baseline scenario. All credits are sold in the voluntary market from 2008-2012. This is called ex-ante accounting, in which credits are sold before the emission reduction is assumed to have occurred. Products applying ex-ante accounting tend to attract a lower market price.

Scenario 2 Bi-annual calculation of credits representing the carbon that would have been released in the previous 2 years under the baseline scenario. In this scenario credits are issued and sold bi-annually. Credits are assumed to be sold to the voluntary market pre-2012 and then sold through an international regulated market (i.e. Kyoto second commitment period). All accounting is ex-post whereby credits are sold after the emission reduction is assumed to have occurred, generally attracting higher prices.

Scenario 3 Calculation and sale of credits every five years from 2012 onward. The first tranche is sold in an international regulated market (i.e. Kyoto second commitment period) in 2017 and every five years thereafter. No sale of the credits occurs prior to 2017 or in voluntary markets. All accounting is ex-post whereby credits are sold after the emission reduction is assumed to have occurred, generally attracting higher prices.

Table 1 – Carbon trading scenarios and prices

Scenario	Volume	Market	Value
1	1/5 of the total credits generated are sold each year between 2008-2012	Wholesale credits for voluntary markets	US$2.95 *
2	credits are sold bi-annually for the quantity of emissions avoided over the baseline	Voluntary markets to 2012 & international regulated market thereafter	US$10/tCO2 ** US$18/tCO2 after 2012 ***
3	credits sold in 5-year tranches for emissions avoided over the baseline starting with the 2012-2017 tranche	International regulated market	US$18/tCO2 ***

* Average of approximate World Bank Biocarbon fund prices and a recent transaction in which Rio Tinto purchased credits associated with avoided deforestation of farmland in Queensland, Australia.[80] These are voluntary prices for ex-ante products.
** An average price in the voluntary market for ex-post forestry products.[81]
*** The average price for issued Certified Emission Reductions from the Clean Development Mechanism in 2006,[82] representing the approximate value of a project-based offset in a regulated international market.

Investors would likely pursue forward carbon sales, purchase options and other transaction structures to improve the economics of carbon investments. These more sophisticated structures are not included in the modeling, likely understating the value of carbon scenarios. This should be taken into consideration.

It is assumed that REDD credits are permanent and therefore equivalent with other emission reduction credits, trading at comparable per tonne prices.

Ten percent of the total carbon revenue was deducted from carbon sales to account for transaction costs and forest management. Transaction costs include developing a carbon accounting system, project documentation, third-party verification, scheme accreditation or verification to a voluntary standard and management/brokerage fees. Forest management costs include forest protection and monitoring over time and could include payments to local communities for services such as boundary maintenance and collecting inventory data.

---

[80] See http://www.carbonpool.com/
[81] Hamilton, K., Bayon, R., Tunrer, G. and D. Higgins (2007) "State of the Voluntary Carbon Markets 2007: Picking Up Steam" Ecosystem Marketplace & New Carbon Finance www.ecosystemmarketplace.com
[82] Jotzo, F. (2007) "CDM Project Design" Centre for Energy and Environmental Markets, University of New South Wales, Applied CDM Short Course, July 18th

4 Discussion

Table 2 summarizes the NPV of the cashflows for each baseline activity against cashflows from each carbon scenario. Results are reported in NPV per hectare.

Table 2 – NPV per hectare of baseline and carbon scenarios

	Brazil - cattle	Papua - logging	Papua - palm	Congo - logging
Baseline	**$343**	**$350**	**$757**	**$633**
Carbon Scenario 1	$660	$649	$550	$649
Carbon Scenario 2	$1168	$756	$981	$756
Carbon Scenario 3	$521	$402	$386	$402

Results indicate that, assuming carbon rules are adopted and implemented, carbon revenue from avoided deforestation may compete with current alternate land uses at the forest frontier. Carbon appears to effectively compete with logging in Papua and cattle ranching in the Amazon. The case is not as clear for palm oil and logging in the Congo, where high profits make it difficult for carbon to compete in some scenarios. The quantum of saleable carbon associated with the baseline scenarios is approximately 125-145 million tCO^2.

In summary:

- Carbon appears competitive in comparison with cattle ranching in Brazil
- Carbon appears competitive in comparison with unsustainable logging in Papua
- Carbon competes with palm oil revenues in Papua if the project can sell credits regularly (bi-annually) and make initial sales into the voluntary carbon market (carbon scenario 2)
- Carbon can compete with logging in the Congo if crediting occurs regularly (bi-annually) and some sales are made in the near term in voluntary markets (carbon scenario 2) or all credits are sold in the voluntary market in the short term (scenario 1)

These results suggest that under certain policy settings, private financing could flow toward conservation. This is a generalized model, however, and several points need to be addressed in interpreting the results, including differences between regional land use scenarios, variation across carbon scenarios, policy certainty and methodology considerations.

4.1 Land Use Comparisons

Across the regions considered, carbon competes most effectively with cattle ranching in the Amazon. This is based on high carbon values, which reflect the immediate and permanent change in carbon stock when land is cleared for pasture. It is also a result of ranching delivering a relatively low NPV, which is consistent with the fact that cattle ranching is not considered the highest economic use of the land. As discussed, ranchers are motivated by factors other than financial returns, including securing land rights and generating low-risk cash flows. Carbon investments for forest conservation would need to provide for or compete with these preferences in order to be more attractive to investors than ranch development.

In Papua results show that a strong case can be made for carbon-financed forest conservation investment when compared to logging revenue. For palm oil, the case is not as clear. The results that show that only an investment strategy with characteristics of scenario 2 – frequent crediting and initial sales into a voluntary market – can compete with palm oil.

However, it is important to note the impact of discount rates in the case of oil palm production. There are large initial capital costs in establishing an oil palm plantations and cash flow only occurs as plantations grow. The result is that small changes in discount rate have large effects on the net present value and, thus, the relative competitiveness of carbon finance versus oil palm development. More information regarding investors' risk-return expectations is needed to explore this scenario more fully.

In the Congo, high log prices make carbon less competitive that in the Papua logging comparison. Timber from the DRC is primarily sold to European markets, which are prepared to pay higher prices for sustainable, certified wood.[83] The market is increasingly being driven by demand from China and India, which is currently pushing prices of African species such as Khaya (African mahogany) and Meranti to near historical highs.[84] As production increases to meet this demand, less valuable species will be logged, and there will be a move away from sustainable harvesting that meets certification standards. These drivers would result in lower log prices.

The model accounts for these market changes in a simplified way by reducing profits per cubic meter from \$160 for the first $10m^3$ to \$100 for the remaining $10m^3$. This is an approximation for which more detailed market analysis is required. A reduction in timber prices would make carbon more competitive in the region. The availability of $20m^3$ of merchantable timber per hectare also needs to be verified.

[83] Forests Monitor (2007)
[84] ITTO (2007) "African Prices Stable on the Back of Steady Demand" *Tropical Forest Update* Volume 17, No. 2 http://www.itto.or.jp/live/Live_Server/3453/tfu.2007.02.e.pdf

4.2 Carbon Price Scenarios

Scenario 2 is the most competitive of the three scenarios presented. This is the result of a medium to high carbon price (US$10-18/t$CO_2$) delivered every two years. While Scenario 3 has an overall higher price point (US$18), revenue is delayed until 2017 and every 5 years thereafter, which reduces overall value after discounting.

Scenario 1 delivers all of the revenue in the first 5 years. This is a trade off with the low carbon price of US$2.95, as market evidence suggests that a product sold upfront in this way would likely attract a lower price. This scenario is somewhat aggressive in suggesting that the total project carbon volume (approximately 125-145 million tCO_2) would be sold in the voluntary markets before 2012, even at this low price point. Total transactions in the global voluntary market were estimated at 91 million tonnes in 2006.[85] Although this market is posed for growth, transactions of the size suggested by Scenario 1 would likely need to be motivated by future acceptance in a regulatory scheme, where they could be sold in a secondary market at a higher price. Policy uncertainty is likely to prevent this in the short term.

Scenario 3 represents the most conservative point of comparison. Revenue is skewed toward the future, reflecting the reality that it will likely be several years before policies are clear enough to drive investment in conservation carbon. Additionally, the price point of US$18t$CO_2$e, while the highest of the scenarios, may be lower than future carbon prices in regulated markets. This price represents the value of issued Certified Emission Reductions (CER) in the Clean Development Mechanism (CDM) in 2006, a reasonable indicator of the value of project-based offsets. However, CERs traded as high as $25/t$CO_2$e in 2006, and demand for project-based offsets is expected to increase.[86] Comparatively, allowances in the EU Emissions Trading Scheme are currently trading for US$33.10,[87] although forestry credits are not currently eligible in this market. Prices for project-based offsets may be higher in real terms in the future, particularly as low-cost opportunities, such as Chinese projects to reduce HFCs, are no longer available.

Conversely, credits from avoided deforestation may not be equivalent to other project-based offsets, and this would result in lower prices. REDD credits may be treated as temporary, as is current practice with afforestation/reforestation projects under the CDM. There is some discussion of dual markets in which REDD credits are sold in a parallel market and are not fungible with emission reduction offsets as defined under Kyoto.[88] Additionally, the Voluntary Carbon Standard, which is emerging as a leading standard for accrediting voluntary carbon projects, suggests that forestry conservation projects should reduce the amount of saleable carbon by 5-30% (based on a project risk assessment) as a buffer against future carbon stock losses. Policies that result in REDD credits being non-equivalent to other emission reduction credits or require large buffers reduce the value of carbon investments.

---

[85] Hamilton et al (2007)

[86] Carpoor, K. and Ambrosi, P. (2007) "State and Trends of the Carbon Market" World Bank/IETA, Washington D.C.

[87] As of November 15, 2007 according to Point Carbon http://www.pointcarbon.com/

[88] Centre for Clean Air Policy (2007)

4.3 Policy Uncertainty

Investors must determine the required threshold return for each investment by considering a range of risks and uncertainties. In voluntary carbon markets, those uncertainties typically include buyer demand and achievable per tonne prices. In regulatory markets, major risks are associated with project delivery and accreditation. Existing carbon funds seek returns in the order of 35% real IRR, often based on paying a very low price for carbon offsets prior to accreditation and then sharing some of the upside with project developers. For projects where rules are uncertain or untested, IRRs of 40-50% or more would be expected.

These return expectations imply discount rates that are higher than the 20% applied here. However, the objective of this study was to consider whether investment in forest conservation could compete with other land uses under the assumption that a functional carbon market existed that incorporated REDD credits. Nevertheless, it is also useful to consider the impact on investment if policies do not provide investors with adequate levels of certainty. This point is most salient to the current debate around national accounting baselines and project delivery, as discussed.

Two methods can be applied to consider this uncertainty. One is to apply a higher discount rate to carbon projects. Table 3 shows the results for carbon projects when a 35% discount rate is applied. These are still compared to the baseline scenarios at a 20% discount rate because of the greater certainty around the timber, beef and palm oil projects. This results in favouring conversion activities. As Table 3 shows, this adjustment results in carbon being uncompetitive in the Congo and Papua for palm oil and only competes with logging in Papua and ranching in Brazil in certain cases. Figures in red indicate a lower NPV than the baseline scenario.

Table 3 – Carbon scenarios applying a 35% discount rate

	Brazil - cattle	Papua - logging	Papua - palm	Congo - logging
Baseline (at 20% discount)	***$343***	***$350***	***$757***	***$662***
Carbon Scenario 1	$432	$428	$363	$428
Carbon Scenario 2	$521	$286	$440	$286
Carbon Scenario 3	$126	$92	$85	$92

Adjusting the discount rate in this way generally captures uncertainty around project delivery and accreditation, but it is ambiguous in the specific risks that are being considered. It also favours policies that are skewed toward the present, such as carbon scenario 1. The more conservative approach represented in scenario 3 cannot compete financially, as revenues are skewed toward a more heavily discounted future.

Another approach is to assume that there is a 50% chance that credits will be awarded and reduce the NPV by this probability factor. Using the original results in Table 2 and multiplying carbon NPV by 0.50, it can again be seen that carbon only appears attractive in a limited number of cases. Figures in red indicate a lower NPV than the baseline scenario.

Table 4 – Carbon project NPVs assuming 50% chance of accreditation

	Brazil - cattle	Papua - logging	Papua – palm	Congo - logging
Baseline	**$343**	**$350**	**$757**	**$662**
Carbon Scenario 1	$330	$324	$275	$324
Carbon Scenario 2	$584	$378	$490	$378
Carbon Scenario 3	$260	$201	$193	$201

In reality, investors that are only 50% certain that credits will be awarded will factor in the optionality to abandon a carbon project in 5 or 10 years, if credits are not likely to be accredited, and then convert to another land use. From this perspective, the loss in returns is the difference in NPV from converting land today versus converting it in the future, whereas the upside is the opportunity for carbon revenue. An investor would be more likely to consider the original NPV results presented in Table 2 to evaluate this trade-off.

Under either method, it is difficult to fully quantify the investment implications if the fundamental question of whether the carbon credits will be recognized cannot be answered. If it is accepted that private investment can play a major role in land use change at the forest frontier, then fostering an attractive investment environment for forest conservation should be an objective of policy debates.

4.4 Government Fees

Governments generally use a concession licensing system to allocate land use rights, entitling licensees to conduct a particular activity on the land. Fees, ongoing lease payments and tax arrangements tend to be variable based on activities, i.e. logging versus oil palm plantations. For example, an area that is designated as a productive forest may be reclassified for palm oil establishment if it is degraded after a first harvest and there is minimal residual timber value. It is likely that concessions specifically allocated for carbon investments would need to be designed or designated within existing or new concession licensing systems. The structure of fees and other payments to government would need to be considered under such a system.

There are no specific assumptions made here regarding how this structuring could occur. As discussed in Section 3.5, ten percent of carbon revenues are reserved to account for forest management and carbon transaction costs, and a portion of this could also be assumed to be government fees. Investment revenues could be split in any proportion between the commercial enterprise, local communities and the regional or national government, and this will be an important point of negotiation as markets develop. This could be addressed at a national level by governments taking ownership of some or all carbon concessions, thereby receiving all associated revenues, or negotiating with private investors.

This is also an important point in relation to the NPV methodology applied in this study. Investors evaluate investment options in multiple ways. For example, different outcomes would result from an IRR analysis, which focuses on rate of return on invested capital rather than the present value of future cashflows. It is arguable that forest conservation requires a limited outlay of initial capital in comparison to baseline scenarios, so the financial risk to investors is relatively low. This would result in a high IRR, making carbon investment appear even more competitive than under the NPV analysis. (Note: Logging costs may be minimal if concession holders are using old, depreciated machinery, but costs will still include employees, harvesting plans, cutting roads, etc. For oil palm plantations and ranching, in some cases site preparation costs could be offset by selling timber, but the models here assume that the terminal value of timber sales is captured in baseline scenario land prices.)

In both the NPV and IRR analysis, a detailed consideration of the costs associated with developing and managing a carbon forestry project needs to be included. This analysis has used a simple method to account for costs, 10% of revenues. A higher cost structure would decrease the competitiveness of the carbon scenario.

5 Conclusions

This study has determined that conservation projects financed through carbon markets can generally deliver returns that are competitive with current land uses that are driving deforestation. These findings are based on the assumption that carbon market policies will provide certainty to investors that REDD credits will be accepted and creditable in carbon markets. Without this certainty, conservation will remain a high-risk investment that cannot compete with conversion activities, resulting in limited direct private sector investment. This has implications for policies which are considering national baseline accounting approaches that result in high risk at the project level.

This study has developed a framework to bring together a wide scope of information. The generalized models and approach are intended to provide input to investment and policy decision making. Many of the assumptions are necessarily simplified in order to consider implications across the forest frontier. There is now some evidence to consider the opportunities and evaluate carbon conservation investment options at a more localized scale. If it is accepted that private investment can play a major role in land use change at the forest frontier, then fostering an attractive investment environment for forest conservation should be an objective of policy debates.

Key points for these ongoing debates are:

- Certainty around accreditation at the project level is paramount. If stable and predictable policies are in place, investors could apply even lower risk profiles (discount rates) in comparison to baseline activities, since the primary capital investments are limited to project accreditation, forest monitoring and protection and community payments or taxes that provide for local development and non-extractive forest use. This is significantly less than the appreciable start-up costs associated with baseline activities.

- The price of carbon credits is often discussed as the crucial variable for carbon investment. Results presented here suggest that crediting periods and early market sales interact with prices to deliver a range of outcomes. It is not necessarily useful to identify the most significant input factor because policies will rarely be designed with one element in mind. An exception to this may be crediting periods, as our results suggest that more frequent crediting is beneficial to investment returns.

- This study has not assessed how carbon-financed forest conservation projects could provide benefit to communities or governments. This point is central to the success of conservation activities, as forests cannot be simply "locked up" or separated from the interests of communities that rely on forest resources. Investors will want to ensure that local communities dependent on the forests are supportive of conservation activities to reduce project risks associated with illegal logging and other destructive activities. Options may be payments for monitoring and maintaining conservation forests and ensuring community rights to develop forest resources for non-timber forest products and local use. The cost structure of these activities needs to be factored into carbon investments more clearly.

- While carbon investment costs may not be fully captured in this level of analysis, there are additional benefits that have also not been quantified in both the baseline and carbon scenarios. Baseline scenarios presumably have flow-on benefits to communities in the form of employment and social services, which are often provided by large-scale operators. Carbon scenarios, conversely, can sustain non-timber forest product industries and provide continued access for firewood, hunting, small-scale timber, food and medicines. Ecosystem benefits from retaining the forest, e.g. water quality protection, landslide/flood prevention, biodiversity habitat, maintenance of traditional livelihoods and prevention of social dislocation of communities are also not included, would require a total economic assessment and are not included in the financial analysis considered here.

- Although this study was framed as a trade-off between one land use type and the conservation scenario, the impact of carbon-financed conservation will likely be to shift land use economics, rather than replace activities.

For example, if a standing forest is now valued for its carbon, landowners would be motivated to increase the efficiency of existing agribusiness activities or rehabilitate degraded areas rather than move into new forested areas. This could result in more efficient land uses and a wider range of benefits at a landscape scale.

References

Bowman, M. (2007) *pers comm* Project Assistant, Woods Hole Research Center, November 2

Brazilian Vegetable Oil Industry Association (2006) "Understanding the Moratorium: Responsible Production" http://www.abiove.com.br/english/sustent/ms_cprodutor_24jul07_us.pdf

Butler, Rhett A. (2007) "Is peat swamp worth more than palm oil plantations?" www.mongabay.com

Carpoor, K. and Ambrosi, P. (2007) "State and Trends of the Carbon Market" World Bank/IETA, Washington D.C.

Centre for Clean Air Policy (2007) "Reducing Emissions from Deforestation and Degradation: The Dual Markets Approach" http://www.ccap.org/international/FINAL%20REDD%20report.pdf

Congo Basin Forest Partnership (2005) "The Forests of the Congo Basin: A Preliminary Assessment" (online) http://carpe.umd.edu/products/PDF_Files/FOCB_APrelimAssess.pdf

FAO (2005) "FAO Forest Resource Assessment – Global Tables" http://www.fao.org/forestry/site/28679/en/

Fearnside, P. (2007) "Deforestation in Amazonia" *Encyclopedia of Earth* Eds. Cutler J. Cleveland, Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment http://www.eoearth.org/article/Deforestation_in_Amazonia;

Foley et al. (2007) "Amazonia Revealed: Forest Degradation and the loss of ecosystem goods and services in the Amazon Basin" Frontiers in Ecological Environment, Issue 5(1), p. 25-32

Forests Monitor (2007) "The Timber Sector in the DRC: A Brief Overview" http://www.forestsmonitor.org/uploads/2e90368e95c9fb4f82d3d562fea6ed8d/Description_of_the_Timber_Sector_in_the_DRC.pdf

Friends of the Earth (2005) "Greasy Palms. The social and ecological impacts of large-scale oil palm plantation development in southeast Asia" http://www.foe.co.uk/resource/reports/greasy_palms_impacts.pdf

Gibbs, H.K, S. Brown, J. O. Niles and J. A. Foley (2007) "Monitoring and estimating tropical forest carbon stocks: making REDD a reality" *Environmental Research Letters* (in press)

Global Forest Watch et al (2001) "The State of the Forest: Indonesia" Global Forest Watch, World resources Institute and Forest watch Indonesia www.globalforestwatch.org

Global Forest Watch (2007) "Human Pressure on the Brazilian Amazon Forests" (online) http://www.globalforestwatch.org/english/interactive.maps/Brazil_Datasets.htm#Study_area

Hamilton, K., Bayon, R., Tunrer, G. and D. Higgins (2007) "State of the Voluntary Carbon Markets 2007: Picking Up Steam" Ecosystem Marketplace & New Carbon Finance www.ecosystemmarketplace.com

Ismail, A., Simeh, M. and M. Mohd Noor (2003) "The Production Cost of Oil Palm Fresh Fruit Bunches: the Case of Independent Smallholders in Johor" *Oil Palm Industry Economic Journal* Vol. 3(1)

ITTO (2005) "Annual Review and Assessment of the World Timber Situation" Division of Economic Information and Market Intelligence, Yokohama, Japan http://219.127.136.74/live/Live_Server/2151/E-AR05-Text.pdf

ITTO (2006) "Asia Takes Price Leadership from Europe in Africa" *Tropical Forest Update* Volume 16, No. 4 http://www.itto.or.jp/live/Live_Server/3163/tfu.2006.04.e.pdf

ITTO (2007) "Market Trends" *Tropical Forest Update* Volume 17, No. 1 http://www.itto.or.jp/live/Live_Server/3241/tfu.2007.01.e.pdf

ITTO (2007) "African Prices Stable on the Back of Steady Demand" *Tropical Forest Update* Volume 17, No. 2 http://www.itto.or.jp/live/Live_Server/3453/tfu.2007.02.e.pdf

Jarvis, B. and Jacobson, M. (2006) "Working paper – Incentives to promote forest certification in Indonesia" Project: Motivating Sustainability, Prepared for Moray McLeish, International Finance Corporation PENSA. Indonesia, April

Jotzo, F. (2007) "CDM Project Design" Centre for Energy and Environmental Markets, University of New South Wales, Applied CDM Short Course, July 18th

Karsenty, A., and Gourlet-Fleury, S. (2006) "Assessing sustainability of logging practices in the Congo Basin's managed forests: the issue of commercial species recovery. *Ecology and Society* Issue 11(1), p. 26 (online) http://www.ecologyandsociety.org/vol11/iss1/art26/

Laporte, N. T, T. S. Lin, J. LeMoigne, D. Devers, and M. Honzak (2004) "Toward an Integrated Forest Monitoring System for Central Africa" *Land Change Science: Observation, Monitoring, and Understanding Trajectories of Change on the Earth*

Surface, Remote Sensing and Digital Image Processing Vol (6), Ed. G. Gutman, p. 97-110

Laporte, N., J. Stabach, R. Grosch, T. S. Lin, S. Goetz (2007) "Expansion of Industrial Logging in Central Africa" *Science* Vol. 316, No. 5830, p. 1451-1452

Malaysian Palm Oil Board (2007) Palm Oil Weekly Prices, available online http://econ.mpob.gov.my/upk/weekly/bh_wk02nov07.htm (accessed Oct 2007)

Margulis, S. (2004) "Causes of Deforestation of the Brazilian Amazon" World Bank Working Paper No. 22, Washington, D.C.

Martino, D. (2007) "Deforestation in the Amazon: Pressures and Outlook" Third World Resurgence No. 200, April http://www.southdevelopment.org/environment/MartinoAmazonDeforestation.pdf

Mattos, M. and Uhl, C. (1994) "Economic and Ecological Perspectives on Ranching in the Eastern Amazon" World Development Vol. 22, No. 2, p. 145-158

Merry, F. (2007) *pers comm.* Discussing work in review. Woods Hole Research Center

Mongabay.com (2007) "South American development plan could destroy the Amazon" http://news.mongabay.com/2007/1003-ci_amazon.html

Pedroni, L. and Streck, C. (2007) "Mobilizing Public and Private Resources for the Protection of Tropical Rainforests" CATIE and Climate Focus http://www.climatefocus.com/newspubs/downloads/PolicyBriefonREDD_000.pdf

Nasi, R. (2005) **"**Potential Methodological Flaw in the Examination of the Effects of Logging" *Ecology and Society* Issue 10(2) (online) http://www.ecologyandsociety.org/vol10/iss2/resp2/

Nepstad, D., Moutinho, P. & Soares-Filho, B. (2005) "The Amazon in a Changing Climate: Large-Scale Reductions of Carbon Emissions from Deforestation and Forest Impoverishment" Amazon Institute for Environmental Research), Woods Hole Research Center (WHRC) and Federal University of Minas Gerais paper released during COP 12, Nairobi

Ruiz-Perez, M. et al (2005) "Logging in the Congo Basin: A Multi-Country Characterization of Timber Companies" *Forest Ecology and Management* Volume 214, Issues 1-3

Saatchi, S. et al (2005) "Spatial Distribution of Carbon Stock in the Amazon Basin" *American Geophysical Union, Fall Meeting* 2005 http://adsabs.harvard.edu/abs/2005AGUFM.B54B..03S

Soares-Filho, B. et al (2006) "Modelling Conservation in the Amazon Basin" *Nature* Vol. 440, March

Sumantri, H. and Wijayanto, I. (2005) "Land cover mapping using satellite imagery and GIS in the Mamberamo Basin and Raja Ampat Islands, Papua, Indonesia" www.mapindia.org/2005/papers

Tedjasukmana, J. (2007) "Heros of the Environment: Leaders & Visionaries" *Time Magazine* http://www.time.com/time/specials/2007/article/0,28804,1663317_1663319_1669895,00.html

Tokede, M., William, D., Widodo, Gandhi, Y., Imburi, C., Patriahadi, Marwa, J., Yufuai, M. (2005) "The impacts of Special Autonomy in Papua's Forestry sector: Empowering Customary Communities (Masyarakat Adat) in decentralised Forestry Development in Manokwari District" Centre for International Forestry Research, Bogor, Indonesia

Vidal, J. (2007) "World Bank Accused of Razing Congo's Forests" *The Guardian*, October 4 http://www.guardian.co.uk/environment/2007/oct/04/congo.forests?gusrc=rss&feed=12

Woods Hole Research Center (2007a) "Agriculture Frontier Explosion in Brazil" http://www.whrc.org/southamerica/agric_expans.htm

Woods Hole Research Center (2007b) "Logging and Family Forests" http://www.whrc.org/southamerica/logging_fam_forests.htm

World Bank Carbon Finance Unit (2007) "Forest Carbon Partnership Facility" http://carbonfinance.org/Router.cfm?Page=FCPF&FID=34267&ItemID=34267

WWF Germany (2002) "Oil palm plantations and deforestation in Indonesia: What role to Europe and Germany Play?" http://www.fire.uni-freiburg.de/se_asia/projects/wwf_oil.htm

Appendix A – Production cost schedule for natural tropical forest concession

Hypothetical Natural Forest Concession – applying sustainable forest management in line with international certification standards and payment of all official taxes and fees		
	Assumed harvestable area (ha)	
	Number of years cut over	
	Hectares harvested per year	
	Annual production (m3) - 20 m3/ha	
	Activity	**Cost/m3**
		(USD)
I	**PLANNING COSTS**	
1	Block delineation	0.04
2	Pre-harvest inventory	0.22
3	Survey, road planning and construction	3.91
4	Amortisation of concession fee	0.25
5	Amortisation of forest inventory	0.05
6	Amortisation of concession boundary delineation	0.02
7	Amortisation of satellite imagery	0.02
	Subtotal	**4.51**
II	**REHABILITATION PLANTING**	
1	Seedling costs	0.17
2	Planting in logged areas, roadsides and bare soil	0.33
	Subtotal	**0.50**
III	**SILVICULTURAL TREATMENTS**	
1	Post harvest inventory	0.16
2	Plant maintenance	0.12
3	Reserve area maintenance	0.04
4	Permanent sample plots	0.02
5	General facilities	0.08
	Subtotal	**0.42**
IV	**HARVESTING COSTS**	
1	Felling (on contract with equipment provided)	5.05
2	Skidding (on contract with equipment provided)	0.09
3	Rafting/Hauling (on contract with equipment provided)	4.99
4	Maintenance of facilities and equipment	9.15
5	Mechanics workshop	3.70
6	Fuel	6.38
7	Tug boat and pontoon costs	12.00
	Subtotal	**41.37**
V	**OFFICIAL TAXES AND FEES**	
1	Land and buildings tax	1.50
2	Vehicular and heavy equipment tax	0.12
3	Log grading tax	0.26
4	Local government fees and contributions	3.20
6	Rehabilitation Fund (DR)	14.00

7	Forest Resource Provision Tax (PSDH)	7.00
	Subtotal	**26.09**
VI	**SOCIAL AND ENVIRONMENTAL COSTS**	
	Community liaison	4.31
	Community fees	1.24
	Amortisation of Environmental Impact Assessment	0.01
	Subtotal	**5.56**
VII	**PAYMENT TO CUSTOMARY LAND OWNERS**	
	Subtotal	**5.50**
VIII	**GENERAL DEPRECIATION COSTS**	
1	Of field generators, heavy equipment	5.29
2	Of roads and buildings	4.00
3	Of workshop and camp generator and equipment	0.09
	Subtotal	**9.38**
IX	**WAGES, BONUSES, ADMINISTRATION**	
1	Wages and bonus	4.00
2	Field camp consumables and associated costs	3.00
3	Head office and marketing costs	4.00
4	Forest protection and security	0.12
	Subtotal	**11.12**
X	**UNOFFICIAL COSTS**	
	Forest service officials - honorarium, entertainment	5.18
	Forest security and protection	1.96
	NGOs - honorarium. Entertainment	1.02
	Village officials	0.63
	Local government	1.57
	Others	5.00
	Subtotal	**15.36**
	Grand total - Production cost	**120.73**

The following should be noted in relation to this estimate:

- These are the costs that would be necessary if natural forest extractive management was practiced at a level that would meet reputable forest certification standards. There are no certified natural forest extractive management operations in Papua.
- All costs have been divided by total yield. This approach does not take into account the effect of the timing of costs i.e. not all costs will be spread evenly over all the years of harvesting; there will be some up-front costs. There is therefore an underestimation of the cost, but it is not significant for analysis at this level.

Further explanation of costs:

I4 – Amortisation of concession fee

The Iuran Hak Pengusahaan Hutan (IHPH) is a one-off payment to the Department of Forestry for the rights to manage the forest for a set period of time, typically 20 to 50 years. The fee is an area based fee set at $10.00 per hectare.

IV3 – Rafting/Hauling
Note – roading costs are a combination of part of the fuel, mechanics workshop, heavy equipment depreciation and other costs.

Costs are based on a topographic area is largely flat with large sinuous rivers, seasonal wet areas and swamps, reflecting the geographies of Papua and parts of the DRC. Roading intensity has to be higher to allow for these obstructions, and in some places the roads would need to be elevated on causeways. Roading is difficult and, with limited supplies of rock, expensive and difficult to maintain. There are few public roads away from larger centres, most logs will be hauled to large rivers and rafted or barged to the coast.

V. OFFICIAL TAXES AND FEES (in Papua)

V1 – Pajak Bumi Bangunan - Land tax
Paid annually, this is calculated on a fixed percentage of listed government value per ha. Sources quoted a wide range of costs, from $0.25 to $3.00 per m^3 of merchantable logs produced.

V4 – Local government taxes and contributions
This includes 'Retribusi daerah', a local government tax. Local government taxes may vary from region to region.

V5 – Dana Reboisasi – Reforestation Levy
The reforestation levy varies by species grouping and, for Papuan logs is likely to be from $16/m^3$ for merbau (Instia bijuga) and other high grade species to $12/m^2$ for mixed grades.

V6 – PSDH – Forest Resource Provision Tax
This tax is set at 10% of the list price set by the Ministry of Trade. The levey varies between location, diameter and species. It is currently of the order of US$12.30 for the highest grade including merbau; US$6.90 for the meranti group grade and US$4.10 for the mixed grades.

VII – PAYMENT TO CUSTOMARY OWNERS

The benefits received by the community cooperatives vary according to the agreement made with investors, and, in some cases, the volume of timber harvested. Compensation may range from USD3.00/m3 to even USD22.00/m3. Where community cooperatives are in partnership with large scale forest concession holders, the maximum amount of compensation that the concession holders are required to pay is around USD5.75 (Tokede et al 2005).

X. UNOFFICIAL COSTS

X1 – Government officials – honorarium, entertainment

This includes expenses to obtain the concession license. One source estimates the unofficial costs at perhaps USD100,000 although may often be many times that. Getting the annual plan (RKT) accepted may cost between USD12 000 and USD25,000 each year. Signing of the regular log inspection reports by Department of Forestry staff costs at least USD300/month. Signing of transport documents costs around USD per shipment and there are additional charges to be paid to port officials. Companies will frequently respond to a range of requests from the government officials it deals with for air tickets and accommodation not related to the tasks they perform.

Appendix B – Oil Palm Model Assumptions

1. Costs
   - Land costs are $300 per hectare and are assumed to be incurred in the year of establishment.
   - Due diligence costs of $1.25 million ($5 per hectare) based on New Forests' investment experience are incurred in year 1.
   - Establishment costs are $2,555 per hectare, which includes land clearing, site assessment, ripping and mounding, weed control, seedlings, planting, contingencies and refilling.
   - Operating costs total $500 per hectare per year for established plantation areas. Costs include pruning, weed control, roading, labor, fertilizer, equipment and transportation.
   - The model assumes harvesting costs of $187/ha.
   - These establishment costs are is in-line with figures provided by the Oil Palm Research Institute.[89]

2. Productivity and revenue generation
   - Revenue from timber harvests associated with clearing land for plantations are not included in this model.
   - The model assumes that crude palm oil can be sold at current market prices of US$886 per tonne.[90]
   - The model assumes that beginning at year 4, each ha of plantation produces 0.64 tonnes of oil. In a linear fashion, the oil palm yield increase to 4 tonnes of oil per ha at age 7 where it stays consistent to age 12 before steadily declining until age 25. Productivity curves derived from the Oil Palm Research Institute and the World Agroforestry Centre.[91]
   - The applied oil extraction rate is 16%, indicating the volume of crude palm oil extracted from fruit bunches grown on trees. For example, in the first year the model produces 50,000 tonnes of fresh fruit bunches (4 tonnes per hectare) resulting in 8,000 tonnes of crude palm oil (16% of 50,000 tonnes).

---

[89] Ismail, A., Simeh, M. and M. Mohd Noor (2003) "The Production Cost of Oil Palm Fresh Fruit Bunches: the Case of Independent Smallholders in Johor" *Oil Palm Industry Economic Journal* Vol. 3(1)

[90] Malaysian Palm Oil Board (2007) Palm Oil Weekly Prices, available online http://econ.mpob.gov.my/upk/weekly/bh_wk02nov07.htm (accessed Oct 2007)

[91] Butler, Rhett A. (2007) "Is peat swamp worth more than palm oil plantations?" www.mongabay.com