DONALD BREN SCHOOL OF ENVIRONMENTAL SCIENCE & MANAGEMENT
UNIVERSITY OF CALIFORNIA, SANTA BARBARA

Reducing Emissions from Deforestation and Degradation (REDD) in the Cofán Bermejo Reserve, Ecuador:

An assessment of forest carbon sequestration capability and potential entry into an emerging carbon market

A Group Project submitted in partial satisfaction of the requirements for the degree of Master's in Environmental Science and Management

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March 2009

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The Group Project is required of all students in the Master's of Environmental Science and Management (MESM) Program. It is a three-quarter activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Final Group Project Report is authored by MESM students and has been reviewed and approved by:

Christina Tague
March 2009

ACKNOWLEDGEMENTS

We are grateful for the support we have received from our advisor Christina Tague, professor at the Donald Bren School of Environmental Science and Management, UC Santa Barbara. We appreciate her vision for our project and guidance. Without her support, our project would not be as successful.

We greatly appreciate the financial support and interest in our project from Nature and Culture International and especially the enthusiasm from Ivan Gayler.

We would like to thank our client, the FSC, including Sadie Siviter and Randy Borman, not only for the opportunity to complete this project, but also their continuous support of knowledge and information. We also want to thank those that made our summer field work possible and successful: Mateo Espinosa (FSC); Park Guards Roberto, Eduardo, Alejandro, and Edison; the Cofán; Paulina Arroyo (The Nature Conservancy); and Gosia Bryja (Wildlife Conservation Society).

We value all the input we have received from the following individuals who have guided our project along the way: Lee Hannah, Hallie Eakin, Christopher Still, Frank Davis, Jacob Olander, Nikki Virgilio, and Erin Myers.

Lastly, we want to thank mothers, fathers, brothers, sisters, wife, fiancée, friends, and lovers; especially Julia for her delicious homemade cakes which we faithfully taste-tested, and Nacho for his late-night entertainment.

ABSTRACT

Deforestation and degradation in tropical forests creates approximately twenty percent of annual global carbon emissions through the burning or decomposition of biomass (IPCC 2007). The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) does not currently recognize any carbon-trading mechanisms that provide incentive for reducing emissions from deforestation and degradation (REDD). However, REDD may be recognized by the UNFCCC as a carbon-trading mechanism in the future, and existing voluntary carbon markets already accept REDD-based carbon offsets. This project assesses the feasibility of creating a REDD project within the 55,451-hectare Cofán Bermejo Reserve, located in northwest Ecuador and stewarded by the indigenous Cofán people. To facilitate this assessment, we consider the current political context of REDD, compare the project against voluntary REDD standards, and calculate the amount of potentially salable carbon credits held within the Reserve. Overall, our analysis demonstrates that a REDD project is conceptually feasible within the Reserve, provided the Cofán find a willing buyer and gain Ecuadorian government support. Furthermore, based on our carbon loss estimate, historic market rates, and expected implementation costs, a REDD project in the Reserve can be economically viable. Should the Cofán pursue a REDD project, we recommend advocating for UNFCCC acceptance of REDD-based carbon projects to increase their carbon asset value.

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ABBREVIATIONS

AFOLU	Agriculture, Forestry and Other Land Use
ALOS	Advanced Land Observing Satellite
CBA	Cost-Benefit Analysis
CCB	Climate, Community, and Biodiversity Standard
CCBA	Climate, Community, and Biodiversity Alliance
CCX	Chicago Climate Exchange
CDM	Clean Development Mechanism
CER	certified emissions reduction credit
CI	Conservation International
CONIAE	Confederation of the Indigenous Nationalities of Ecuador
COP-14	fourteenth session of the Conference of Parties
COP-15	fifteenth session of the Conference of Parties
DBH	diameter-breast height
DEM	Digital Elevation Map
EU ETS	European Union Emissions Trading Scheme
FAO	Food and Agriculture Organization of the United Nations
FCPF	The World Bank Forest Carbon Partnership Facility
FEINCE	Indigenous Federation of the Cofán Nation of Ecuador (Federación Indígena de la Nacionalidad Cofán del Ecuador)
FSC	Foundation for the Survival of the Cofán (Fundación para la Sobrevivencia del Pueblo Cofán)
GEF	Global Environment Facility
GHG	greenhouse gas
GPP	gross primary production
IFCI	Australia International Forest Carbon Fund
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
JI	join implementation
LAI	leaf area index
LBA	Large-scale Biosphere-Atmosphere Experiment
LBA-Eco	Large-scale Biosphere-Atmosphere studies
LULUCF	Land Use, Land-Use Change and Forestry
MAE	Ministry of Environment of Ecuador (Ministerio del Ambiente de Ecuador)
NEP	net ecosystem production
NPP	net primary production
PDD	Project Design and Document
RAINFOR	Amazon Forest Inventory Network
REDD	Reducing emissions from deforestation and degradation
RGGI	Regional Greenhouse Gas Initiative

SNAP	National System of Protected Areas (Sistema Nacional de Areas Protegidas)
TNC	The Nature Conservancy
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollars
VCF	Vegetation Continuous Fields
VCS	Voluntary Carbon Standard
VCU	Voluntary Carbon Unit
VER	Voluntary Emission Reduction

EXECUTIVE SUMMARY

The Cofán Bermejo Reserve is a 55,451-hectare tract of primary Amazon rainforest located in northeastern Ecuador, bordering Colombia. Cofán Bermejo was established in 2002 by the Ministry of Environment of Ecuador as an ecological reserve under the condition that it would be sustainably managed and stewarded by the indigenous Cofán people. The Cofán have sustainably subsisted in the Amazonian rainforests of Ecuador and Colombia for centuries. The establishment of the Cofán Bermejo Reserve marked the first instance in Ecuador in which an indigenous group was granted the rights to manage, administer, and control their ancestral territories. Despite the Cofán Bermejo status as an ecological reserve, the Cofán receive no funding from the Ecuadorian government for its protection.

Throughout Ecuador, activities such as road construction, government infrastructure projects, oil, mining, mono-cultivation plantations, timber extraction, weak land tenure, and poverty have led to significant land use changes, and ultimately deforestation (Mena et al. 2006). Between 2000 and 2005, Ecuador lost 1.7 percent of its forested area per year, constituting the highest deforestation rate within South America (Mena et al. 2006, FAO 2006). Reserve status does not always protect areas from deforestation, as governments often grant concessions and illegal deforestation is widespread. The Sucumbíos Province, where the Reserve is located, has a historic deforestation rate of approximately 1.1 percent per year (Viña et al. 2004). Similarly, the pressure of deforestation on the Cofán Bermejo Reserve is high and likely to increase in the future.

Tropical rainforests provide one of the greatest vegetative carbon stores on the planet; consequently, deforestation results in a significant loss of carbon into the atmosphere (FAO 2006). According to the Intergovernmental Panel on Climate Change (IPCC) (2007), land use change, including deforestation, accounts for 20 percent of global annual greenhouse gas emissions. In December 2007, the United Nations Framework Convention on Climate Change (UNFCCC) acknowledged the considerable contribution of emissions from deforestation and forest degradation activities to climate change. Subsequently, the UNFCCC has requested further research into developing a mechanism for reducing emissions from deforestation and forest degradation (REDD) and using such a mechanism in an international carbon emissions trading scheme. In the absence of an UNFCCC sanctioned REDD trading mechanism, voluntary markets have emerged to allow for the trading of carbon emissions credits generated from REDD projects.

The Cofán are interested in creating a REDD project for the Cofán Bermejo Reserve to generate a sustainable income for maintaining effective stewardship of their territories. Much of the funding generated by a REDD project would be directed to the Cofán Park Guard Program. Cofán park guards provide on-the-ground surveillance, biological research, and long-term monitoring of changes within the forest. This program operates through inconsistent grant funding. In its current capacity, the Park Guard Program lacks the resources to sufficiently protect the Reserve from deforestation. REDD-based carbon market funding can provide the consistent funds necessary to improve the Park Guard Program in order to preserve both the Cofán Bermejo Reserve and the Cofán way-of-life.

This project analyzes the feasibility of entering the Cofán Bermejo Reserve into a REDD-based carbon market by considering criteria used in existing voluntary market standards. Highlights from this analysis include:

<u>REDD Standards</u> - Currently, REDD projects are not recognized by the UNFCCC. However, voluntary market standards can be used to develop certifiable, REDD-based carbon emissions reduction credits. Should the UNFCCC adopt REDD, these voluntary market standards will influence the shape of future regulations.

<u>Political Climate of Ecuador</u> - Recently, Ecuador adopted a new Constitution, which provides additional rights to nature and indigenous groups, and developed Socio Bosque, a program that provides incentives for forest protection. These recent developments highlight Ecuador's recognition of the value of its ecological resources and interest in developing national-based programs that utilize market mechanisms to protect them. A REDD project in the Cofán Bermejo Reserve would likely gain government support, but uncertainty surrounds the distribution of benefits.

<u>Carbon Stock and the Potential for Loss</u> – Based on a literature review of comparative forests in South America and a limited field study. We estimate a potential deforestation rate of 0.5 percent per year; leading to a loss of 200 to 300 metric tons of carbon per hectare (Houghton 1999; DeFries et al. 2002; IPCC 2006; Butler 2007b). A REDD project would be designed to prevent the loss of this carbon stock.

<u>Additionality</u> – Most REDD standards require that a project can demonstrate emission reduction benefits in addition to a business-as-usual scenario. Reserves typically do not qualify because the forest and its carbon stocks are already protected. However, we argue that a case can be made for REDD projects for reserves in developing nations, including the Cofán Bermejo Reserve. These reserves are often subject to forest loss through illegal deforestation and development within protected areas because of government concessions. Considering this potential for carbon loss, a REDD project for the Reserve would reduce emissions beyond a business-as-usual scenario.

Indigenous Culture Considerations – A REDD project and the Cofán lifestyle are compatible because both depend on protecting the forest in perpetuity. Such a project can be designed to accommodate existing Cofán cultural practices.

Cost-Benefit Analysis – We analyzed the financial viability based on conservative carbon stock and deforestation rate estimates. A medium risk REDD project, which prevents only half of the estimated deforestation, would be viable considering expected, long-term carbon market rates. Such a project would generate the funds necessary to sufficiently protect the Reserve by covering the cost of expanding the Park Guard Program.

Overall, the implementation of a REDD project for the Cofán Bermejo Reserve is feasible, but contingent on external factors. Given the conditions stated above, the Cofán would need to find a buyer that is interested in purchasing the carbon emissions credits generated from a REDD project for the Reserve. Additionally, the Cofán need Ecuadorian government support because the government owns the title to the Reserve and has developed the foundation to implement a national program. Both of these factors highlight the potential for the government to control the funds generated from a REDD project. Finally, there is uncertainty around whether REDD standards will recognize carbon emission reductions generated from protecting threatened reserves as additional to business-as-usual. This uncertainty arises because the UN does not yet recognize REDD as a mechanism to reduce carbon emissions. Adoption of a REDD mechanism within the UN could potentially change the entire shade of the REDD landscape.

1.0 PROBLEM STATEMENT

1.1 Problem

Global climate change, driven largely by increased greenhouse gas (GHG) concentrations in the atmosphere, poses a serious threat to society (IPCC 2007). A key strategy in the fight against global warming is to reduce the amount of carbon dioxide (CO_2) emissions being released into the atmosphere. One obvious approach to reducing CO_2 concentrations in the atmosphere is to limit emissions from stationary and mobile fossil fuel combustion sources. A less obvious, and arguably less expensive, approach to reducing carbon emissions is to decrease deforestation and forest degradation, both of which are activities that release significant stores of carbon to the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC) (2007), forest conversion accounts for 20 percent of global annual carbon emissions. A large proportion of the land area in the tropics is comprised of forests, and tropical forests have a high rate of net primary production and thus carbon sequestration (Butler 2007b). As a result, deforestation in this region has the potential to significantly impact the growing climate change problem (Butler 2007b).

The Cofán Bermejo Reserve, located in northeastern Ecuador along the border of Colombia (Figure 1), is a large tract of primary Amazon rainforest threatened by deforestation. Tropical rainforests provide one of the greatest vegetative carbon stores on the planet, sequestering approximately 200 to 400 metric tons of carbon per hectare (Houghton 1999; DeFries et al. 2002; IPCC 2006; Butler 2007b). Unfortunately, economic and social pressures to cut, burn, and convert land for development are driving deforestation (Bumpus and Liverman 2008). The threats of ongoing development, the struggle against poverty in many

Figure 1: Map of the Ecuadorian-Colombian border. The Cofán territories are shaded in dark green. The Cofán Bermejo Reserve is circled in red.

developing tropical nations, and most importantly, concerns over climate change, are driving the search for economic incentives to combat deforestation and degradation.

Currently, global policies under the United Nations Kyoto Protocol clean development mechanism (CDM) award carbon emissions credits for afforestation and reforestation activities. However there is no mechanism that provides economic incentive to avoid deforestation and forest degradation activities. The United Nations Framework Convention on Climate Change (UNFCCC) is currently exploring such policies for reducing emissions from deforestation and degradation (REDD). In particular, the UNFCCC is working to address the issue of additionality as well as three other methodological concerns—leakage, non-permanence, and establishing a carbon emissions baseline. In order to address these aspects, a REDD project must to show that a forest would not be protected without leveraging carbon-trading resources, does not push emissions-generating activities into other forests, and has a long-term carbon sequestration potential. Furthermore, it is important to ensure that a REDD project would not significantly affect the current practices of indigenous people.

Because the REDD policies are still being debated and developed, there is high uncertainty surrounding the instruments that will be used for implementing and regulating an emerging carbon market. Despite these uncertainties, voluntary partnerships are forming to leverage private funds to purchase carbon credits from nations or groups to reduce deforestation in previously unprotected forests (Niles 2007). Voluntary carbon market standards have developed to give these agreements more credibility (CCBA 2008b, VCS 2008, Plan Vivo 2008).

In 1999, the Foundation for the Survival of the Cofán Nation (Fundación para la Sobrevivencia del Pueblo Cofán, FSC) was formed to ensure the survival of the Cofán indigenous people and their culture. The non-profit organization works to raise awareness and gain funding for the Cofán, while simultaneously protecting the rainforest environment (FSC 2008). The FSC is located in Ecuador’s capital of Quito and is committed to an integral approach to conservation that incorporates researching and conserving biodiversity, procuring legal rights and protection for ancestral Cofán territories, developing environmentally-sound income alternatives, and educating their youngest generations (FSC 2008).

The Indigenous Federation of the Cofán Nation of Ecuador (Federación Indígena de la Nacionalidad Cofán del Ecuador, FEINCE) is the political representative of the Ecuadorian Cofán and was developed to defend their human rights. FEINCE is a member of the larger umbrella group, Confederation of the Indigenous Nationalities of Ecuador (CONIAE), and is comprised of members from the different Cofán indigenous communities. The FSC and FEINCE are interested in entering the Cofán Bermejo Reserve into a REDD-based carbon market to generate sustainable income to supplement the existing Park Guard Program to protect the forest and the Cofán way-of-life.

A regulated carbon market that accepts REDD credits does not currently exist. Given the uncertainty of how and when these markets might form, implementing such a project in the Cofán Bermejo Reserve must be done cautiously. Due to the lack of a regulated market, voluntary markets have formed that do currently accept REDD credits. At least three organizations[1] have developed guidelines that outline specific criteria required for REDD projects to establish credibility for REDD-based carbon credits. Before the Cofán pursue implementation of a REDD project for the Cofán Bermejo Reserve, we must determine whether a REDD project would meet criteria outlined by current voluntary guidelines for two reasons: 1) it would be difficult to find a willing voluntary market buyer without voluntary project certification, and 2) these standards will likely influence regulated market adoption of REDD projects, should REDD project carbon offsets be recognized by the UNFCCC. Even if a REDD project for the Reserve can be developed, the benefits from generating carbon emissions credits must offset the cost of implementation.

1.2 Purpose

This project seeks to inform the FSC and FEINCE as to whether it is feasible for the Cofán to enter the Cofán Bermejo Reserve into a REDD-based carbon market. The goal of these organizations is to find a sustainable source of funding to strengthen the Park Guard Program, guarantee long-term protection of the forest in this Reserve, and allow the Cofán to continue to live sustainably within the forest. Through the generation of carbon credits in a REDD-based carbon market, all three of these goals may be fulfilled. However, it is first necessary to determine whether the Cofán Bermejo Reserve would likely meet criteria outlined in the voluntary market standards for entering a carbon market and whether such a project would be economically viable. This study provides the Cofán with the information necessary to decide whether or not to implement a REDD project for the Reserve, and highlights how the Cofán can participate in current or future carbon markets by identifying barriers to entry.

1.3 Research Question

Is it feasible and economically viable for the Cofán to develop a REDD project for the Cofán Bermejo Reserve? In order to determine feasibility, this project must assess or address the following issues:

a. the current status of REDD projects with regard to the UNFCCC,
b. existing voluntary REDD standards and their applicability to a Cofán Bermejo REDD project,

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[1] Voluntary Carbon Standard, Climate Community and Biodiversity Alliance, and Plan Vivo

c. carbon stored within the reserve and the potential for carbon loss in the absence of a REDD project,
d. monetary benefits from the value of carbon assets held within the Reserve,
e. REDD project design and implementation costs, and
f. the overall feasibility of building a credible REDD project to successfully attract carbon market funds

1.4 Project Significance

Assessing the feasibility and potential economic benefits of implementing a REDD project within the Cofán Bermejo Reserve will:

- Compliment the efforts of organizations such as the Large-scale Biosphere-Atmosphere Experiment (LBA), the Amazon Forest Inventory Network (RAINFOR), The Nature Conservancy (TNC), and Conservation International (CI) in emphasizing the carbon sequestration capabilities of South American rainforests.
- Inform the Cofán about participating in carbon markets, while serving as an example for other indigenous groups in similar rainforest areas.
- Potentially help the Cofán gain a sustainable source of income to fund the Park Guard Program and manage the Cofán Bermejo Reserve.

2.0 BACKGROUND

2.1 Cofán People and the Cofán Bermejo Reserve

The Cofán people have lived in the Amazonian rainforests of Ecuador and Colombia for many centuries. It was not until the 1500's that they came in contact with other people, most notably the Spanish. This initial contact and the events that followed threatened their culture, land, livelihood, and health (FSC 2008).

The next major invasion did not occur until the late 1900's with the arrival of oil companies for oil exploration. Traditionally, the Cofán lived in small populations surrounded by abundant natural resources. Their livelihood depended heavily on hunting, fishing, and subsistence agriculture. With the arrival of oil companies, such as Shell, Texaco, Gulf, and PetroEcuador, throughout the late 1900's, their culture, land, livelihood, and health were threatened once again. The oil exploration activities that followed did not consider the welfare of the indigenous tribes, which resulted in cultural degradation, crime, increased rates of cancer and illness, and even murder and rape. As a result of oil exploration, many roads were built that subsequently allowed and resulted in further development of the surrounding areas. Typical tribal activity slowly began to deteriorate, local water quality was extremely degraded, and the forest they depended on was threatened by road construction and the resulting development and deforestation (FSC 2008).

The Cofán currently live in ten different communities scattered throughout northeastern Ecuador and Colombia including Dureno, Duvuno, Zábalo, Cayambe-Coca and Cofán Bermejo. Many of the Cofán, as well as the surrounding Ecuadorian communities, rely on Cofán Bermejo for their subsistence. According to Agreement No 016 from the Ministry of Environment, the 55,451 hectares of natural land located in Provincia de Sucumbíos, Cantón Cáscales, Parroquia Cáscales, was created as the Cofán Bermejo Reserve on 30 January 2002 (MAE 2002a). This was the first instance in Ecuador where an indigenous group received stewardship over their ancestral territories in federally protected land by Ecuador's Ministry of the Environment (Ministerio del Ambiente, MAE) (FSC 2008). The Cofán people were granted stewardship because of their demonstrated long-term sustainable use of the forest (MAE 2002a).

Although the Cofán do not actually own the land in the Cofán Bermejo Reserve, they have been granted the rights to administration, management, and control of the Reserve and are given the unique responsibility of guarding this area and other ancestral territories through agreements between the MAE and FEINCE (MAE 2002a). The FSC, in coordination with the onsite Institute for Training and Environmental Conservation (Instituto para la Capacitación y Conservación Ambiental), has built an extensive Park Guard training program, educating Cofán Park Guards in all elements of protection, maintenance, and monitoring of their lands. There are currently 54 professionally trained Cofán men and women working as park guards in the Cofán territories (FSC 2008, Virgilio 2008). However, these practices and the resources available for these programs are not sufficient enough to prevent activities such as road construction, agriculture, development, and oil exploration that continue to threaten the Reserve's forests with deforestation.

Despite these threats, the Cofán people have been able to mostly maintain their traditional indigenous practices of living off the land. The deep conservation ethic instilled in their practices will continue to help maintain the existence of the Cofán Bermejo Reserve and allow them to maintain their sustainable way-of-life that has been central to their culture for hundreds of years (Borman 1999). Environmental groups striving to preserve the Amazonian forest ecosystem direct much of their support to indigenous groups similar to the Cofán, whose skills and knowledge play an integral role in preserving the forest (Selverston 1999). Consequently, their cultural practices and needs must be considered in future conservation plans and in developing guidelines for entry into the carbon market to ensure the Cofán people's continued survival in the forest.

Currently, the Cofán people have legal rights to about 405,000 hectares of ancestral territory, including the Cofán Bermejo Reserve in the northeastern region of Ecuador, bordering Colombia.

2.2 Geographic Scope

The specific geographic scope of the Cofán Bermejo Reserve, as shown in Figure 2, is designated in Agreement No 016 between FEINCE and the MAE for the establishment of the Reserve (MAE 2002a). Agreement No 016 outlines the border of the reserve complete with latitude and longitude points. In the North, the Reserve follows the Ecuador-Colombia border and the San Miguel River. In the South, the Reserve follows several rivers including the Bermejo River, Boca Chico River, Chandia Na'e River, and la Quebrada Rayo. These borders, along with the East and West borders further described in Appendix A, comprise the Cofán Bermejo Reserve. Additionally, Agreement No 016 designates a "buffer" surrounding the Reserve that is subject to the same requirements of the Management Plan as the Reserve, but this buffer is not clearly defined (MAE 2002a).

For further specifics of the geographic region, refer to Appendix A.

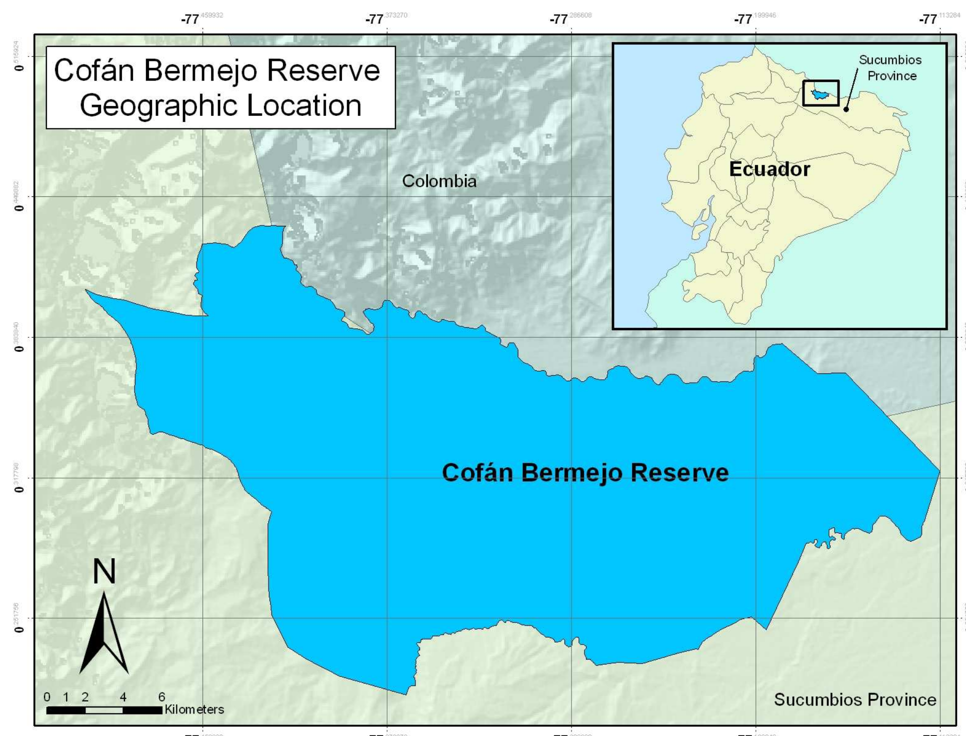

Figure 2: The Cofan Bermejo Reserve is located in the north of Ecuador along the Colombia-Ecuadorian border.

2.3 World Forest Carbon Storage and the Cofán Bermejo Reserve

In addition to the social significance of the Cofán Bermejo Reserve, its geographic location in the lush tropical Amazon provides high carbon storage potential within its forested areas. The 55,451-hectare Reserve comprises a small relative area of the total global forests, but in terms of per-area carbon stores, Amazonian rainforests are among the most productive in the world. The Amazon basin accounts for about 10 percent of the world's carbon stored in terrestrial ecosystems due to high rates of primary productivity (Tian et al. 1998).

In 2005 the total world forest area was estimated to be less than 4 billion hectares, or 30 percent of total land area (FA0 2006). The Food and Agriculture Organization of the United Nations (FAO) estimates that the world's forests can store 283 gigatons of carbon (1 GtC = 1 billion metric tons of carbon) in its biomass (2006). Even more impressively, including the top 30 centimeters of soil, 638 GtC can be stored in all the forest ecosystems of the world (FAO 2006). Global net primary production on land sequesters an estimated total of 60 GtC per year (Schlesinger 1997).

Photosynthesis is the primary driver of the carbon stored within these forested ecosystems. Through the photosynthetic process, plant matter uptakes CO_2 and converts it, in the presence of other nutrients, into biomass, thus sequestering carbon from the atmosphere (Schlesinger 1997). This process can be further explained by considering the processes of net primary production (NPP) and net ecosystem production (NEP) that occur within a vegetated landscape. NPP is the difference between the gross primary production (GPP) (total photosynthesis) and the total plant respiration (NPP = GPP – plant respiration). NEP measures carbon accumulation and accounts for changes in ecosystem carbon storage by accounting for the difference between NPP and the respiration from the decomposing leaf litter and soil carbon pools (heterotrophic respiration) (NEP = NPP –heterotrophic respiration). Few attempts have been made to estimate net ecosystem productivity (NEP), since this requires estimation of soil respiration and litter decomposition in addition to NPP, none of which can be directly measured effectively (Kergoat et al. 2005). Within a forest, NEP is primarily dependent on the forest perturbations, like fires and clear-cuts, and on the resulting stand age and stand history (Kergoat et al. 2005).

Deforestation and degradation of forested land leads to the release of carbon to atmosphere through the burning and decomposition of biomass. The scale of this forest loss presents a tremendous problem: deforestation and degradation contribute to approximately 18 to 20 percent of the annual carbon emissions entering the atmosphere (IPCC 2007; CAIT 2009). From 1990 to 2005, the global deforestation rate was estimated at 13 million hectares per year (FAO 2006). Between 2000 and 2005, deforestation in South America was the highest worldwide at 4.3 million hectares per year (equivalent to the loss of 23 Cofán Bermejo Reserves per year) (FAO 2006). Recent studies have suggested that future deforestation within the Amazon could have significant impacts on the climate (Butler 2007b). The remaining intact tropical forests have been shown to store more carbon than previously thought and also have other substantial climate regulation attributes (i.e. protection from storms, erosion, extreme temperatures, and desiccation) both locally and globally. Researchers estimate that the Amazon stores approximately 86 GtC within the landscape (by comparison, approximately 7.9 billion metric tons of carbon dioxide (CO_2) were emitted globally in 2005) and has the ability to store approximately 11 years worth of recent CO_2 emissions within the entire Amazon Basin alone, illustrating the importance of preservation of this area under REDD carbon project standards or other rigorous conservation measures (Butler 2007b).

Between 2000 and 2005, Ecuador had the highest rate of deforestation within the entire South American continent at 1.7 percent per year (FAO 2006). In comparison, Brazil had a deforestation rate of 0.6 percent over the same time period (FAO 2006).[2] The province of Sucumbíos, which includes the Cofán Bermejo Reserve, is among the three provinces in Ecuador with the highest proportion of deforested land (Mena et al. 2006). Between 1973 and 1996, approximately 22 percent of the overall forest cover was lost from within the state of Sucumbíos (Viña et al. 2004).

In addition to carbon storage potential, forests are sources of timber, help regulate local and regional rainfall, are crucial sources of food, medicine, clean drinking water and offer recreational, aesthetic and spiritual benefits. Unfortunately, communities and governments of developing countries have little incentive to protect standing forests and prevent deforestation because the potential economic gain from deforestation and land-use change activities is perceived as higher than the benefits gained from forest conservation (Bumpus and Liverman 2008).

2.4 Deforestation and Degradation Activities Threatening the Reserve

Deforestation drivers in Ecuador include colonization and agricultural expansion facilitated by road construction, government infrastructure projects, oil, mining, mono-cultivation plantations, timber extraction, weak land tenure, and poverty, with the first four being the most significant (Mena et al. 2006). Additionally, while the presence of indigenous inhabitants has been shown to have an inhibitory effect on deforestation, the Nepstad el al. (2006) study found that

[2] Of note is the significant difference in size between Ecuador and Brazil. Whereas Ecuador may have an overall higher rate of deforestation, Brazil has significantly more deforestation in terms of area deforested.

indigenous lands that were either located near urban areas, like the Cofán Bermejo Reserve, or contained roads, similar to those likely to be built for oil exploration, experienced the highest rate of deforestation amongst indigenous lands. A recent global study by DeFries et al. (2005) found that approximately 25 percent of the protected areas in their study experienced deforestation. Additionally, they found that within Latin America, the mean forest area decreased from 88 to 86.9 percent over the same time period. Likewise, a recent report issued by the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC) (2008) showed that although protected areas appear to have been effective in reducing deforestation in the humid tropics between 2000 and 2005, deforestation rates within protected areas of the Neotropics were still around 0.8 percent (compared to 1.9 percent outside the protected areas). It was estimated that over 1.7 million hectares of forest were cleared in tropical protected areas during this time period (UNEP-WCMC 2008). The protected area designation and the presence of the indigenous Cofán people within the Cofán Bermejo Reserve may deter some deforestation. However, the above studies show that protected areas and indigenous lands, such as the Cofán Bermejo Reserve, still face deforestation threats and are being actively deforested.

Within Ecuador, mining has the potential to become a major threat in the near future. While mining is currently not common or frequent enough to cause wide-scale deforestation within the Cofán Bermejo Reserve, the Ecuadorian government has revised its mining laws to stimulate the mining sector within the country (Anderson 2004). These laws, in addition to higher prices for minerals worldwide, led to a significantly increased amount of exploration projects within Ecuador in 2005 and early 2006. More recently, Ecuadorian President Correa introduced new mining laws that increase state control over mining and allows mining to take place within protected areas (Denvir 2009). Therefore, a large discovery of mineral deposits near the Cofán Bermejo Reserve could increase interest in the area from large commercial mining companies and lead to deforestation within the Reserve (Pitman at al. 2002).

In addition to the threat from mining activities, the Cofán Bermejo Reserve is vulnerable to deforestation as a result of government infrastructure projects such as the Interoceanic Highway. This highway, completed in August 2000, connects the Andean Ecuador and lowland Amazonia and has allowed colonists to illegally clear forests for cattle ranching, crop land, and small scale timber harvesting. Additionally, the development of roads has allowed logging companies to enter the surrounding area and harvest high-value hardwoods in the adjacent forests (Pitman et al. 2002).

There are oil concessions within and immediately surrounding the Cofán Bermejo Reserve. Development of infrastructure for oil extraction still continues outside the borders of the Cofán Bermejo Reserve and concessions within the

Reserve pose a direct threat to the integrity of the area. In 1999 Tecpetrol, an Argentinean oil company, was granted rights to the Bermejo area for exploration and production (Tecpetrol 2007). This included a concession to explore and develop petroleum resources within the Cofán Bermejo Reserve (Pitman et al. 2002). With the addition of the Oleoducto de Crudos Pesados oil pipeline in 2003, which mostly parallels the route of the older Sistema de Oleoductos Trans Ecuador pipeline, the Ecuadorian Government doubled its pipeline capacity. This provided Ecuador with the capacity to expand oil exploration within the Reserve (Anderson 2004). In 2008, approximately 40 percent of Ecuador's National Budget was funded through oil exploration and production (Lee 2009). As such, the government has a high incentive to find more sources of oil in Ecuador. The Oriente Region of Ecuador, which includes the Cofán Bermejo Reserve, provides a large portion of the nation's oil wealth. During the 1960s, when a large oil field was discovered in the Ecuadorian Amazon Rainforest, significant portions of forest, including Cofán ancestral lands, were cleared to make way for roads, pipelines, and oil facilities (Jochnick 1994). As long as our society depends on oil for energy, pressure for oil exploration in the Cofán Bermejo Reserve area can only be expected to increase.

The Cofán Bermejo Reserve's designation as a reserve does not exempt its lands from development. Indeed, the Ecuadorian government has already drilled in several of its national parks, including the Sumaco National Park, the Cuyabeno Wildlife Reserve, and the Limoncocha Biological Reserve. As recently as January 2009, the Mining and Oil Minster of Ecuador announced that it would soon begin accepting tenders to drill within the Ishpingo-Tambococha-Tiputini oil field located within the Yasuni National Park. This move comes in spite of Yasuni National Park's designation as one of the countries largest natural reserves, its function as one of the most biologically diverse forests on the planet, and its role as home to numerous indigenous people (Dow Jones Newswires 2009).

Oil exploration is occurring at significant levels throughout the country and does contribute to deforestation; however, the most significant threat to the Cofán Bermejo Reserve is the colonization that follows oil exploration. This is because the construction of roads for oil exploration facilitates colonization (Messina et al. 2006, Viña et al. 2004). This is illustrated in the region immediately outside the Cofán Bermejo Reserve, where a study by Viña et al. (2004) study found that 22 percent of the forest cover in the Sucumbíos study region was lost from 1973 to 1996, with 90 percent of the deforestation occurring within 5 km of the road (92.6 percent from 1973 to 1985 and 87.9 percent from 1985 to 1996). Due to the development of these roads, the Sucumbíos Province had the highest rate of population increase in the country (6.7 percent) during the height of the oil production (1974 to 1990) (Viña et al. 2004). Additionally, a study by Nepstad et al. (2006) noted that in cases of high deforestation rates within indigenous lands, resource exploitation and invasions from non-indigenous populations were often the cause. As can be seen in Figure 3, urban expansion is approaching the Cofán Bermejo Reserve. If a more robust Park Guard Program is not established, the development of roads outside the Cofán Bermejo Reserve is likely to facilitate the intrusion of colonists through urban expansion into the Reserve. In addition, the development of roads within the Reserve for oil extraction would further ease the illegal intrusion of colonists and subsequent deforestation within the Cofán Bermejo Reserve.

Figure 3: Urban expansion can be seen approaching the Cofán Bermejo Reserve in a fishbone pattern associated with deforestation along roads in this Google Earth Image (2009).

In general, when colonists settle in a tropical forest area the land is initially cleared for subsistence farming, followed by cash crops, and ultimately ends up being used as pastureland. The conversion to pastureland requires more land and therefore results in further deforestation (Messina et al. 2006). Within the Sucumbíos region, which again includes the Cofán Bermejo Reserve, the Viña et al. (2004) study concluded that over a 23 year period (1973 – 1996) government sponsored construction of thousands of kilometers of roads for the oil industry led a high influx of colonists who then settled along these roads. As a result, the area experienced a five-fold increase in population between 1950 and 1982, and by the mid-1970s half the region's population consisted of migrants (Country-data 1989). This influx of population resulted in widespread deforestation along the Ecuadorian-Colombia border. Therefore, development of roads within or near the Cofán Bermejo Reserve is likely to facilitate colonist movement into the region. Thus, without the implementation of a REDD project within the Reserve, deforestation due to colonization is likely to occur.

Therefore, based on historic events, government priorities, and economic drivers, there is high likelihood that deforestation will occur within the Reserve in the future. Thus, it is necessary to find a means to prevent future deforestation activity within the Reserve.

2.5 International Political Climate

Because tropical deforestation contributes to approximately 18 to 20 percent of GHG emissions, and existing systems do not sufficiently protect forested areas in developing nations, the international community has been called on to consider REDD as a mechanism for achieving global emissions reduction targets (COP 11 2005; IPCC 2007; CAIT 2009).

2.5.1 United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty, which was adopted in 1992 and implemented in 1994, that considers various courses of action to reduce global warming and strategies to cope with increasing global temperatures (UNFCCC 2008a). The Convention sets a framework for intergovernmental efforts to undertake the challenges posed by climate change, including but not limited to, gathering and sharing information on GHG emissions and developing strategies for addressing and adapting to climate change (UNFCCC 2008a). In particular, the Convention *encourages* countries to stabilize GHG emissions (UNFCCC 2008a). Today, there are 192 parties to the UNFCCC (Akanle et al. 2008).

In 1997, the delegates to the third Conference of Parties (COP) convened in Kyoto, Japan and agreed to a protocol to the UNFCCC, which was adopted shortly thereafter. The Kyoto Protocol set binding targets for industrialized countries and countries in transition aimed at stabilizing GHG emissions (UNFCCC 2008a). The Kyoto signatories agreed to reduce emissions of six GHGs on average of 5.2 percent below a 1990 baseline by 2012, the end of the first commitment period which began in 2008. The Kyoto Protocol entered into force in 2005 and today has 180 signatory parties (Akanle et al. 2008).

The Protocol acknowledges that developed countries are primarily responsible for the current levels of GHG emissions in the atmosphere and subsequently, in accordance with the principle of "common but differentiated responsibilities", places a larger burden on developed countries to reduce emissions (Bumpus and Liverman 2008, UNFCCC 2008a). It was recognized that emissions reductions for developed countries would be more expensive than emissions reductions for developing countries (Bumpus and Liverman 2008). Furthermore, developing countries would face economic difficulties because of the high marginal costs of reducing emissions. Because of these difficulties, the Kyoto Protocol developed flexible trading mechanisms for treaty signatories to meet carbon emission reduction targets (i.e. emissions trading, joint implementation, and the clean development mechanism) (UNFCCC 1998, Hepburn 2007). The clean development mechanism (CDM) was established in 1997 with the purpose of achieving sustainable development in developing countries and economically viable emissions reductions in developed countries (Ellis et al. 2007, Olsen 2007). The CDM allows emission reduction projects in developing countries to earn emission reduction credits, which can be traded or sold, so that industrialized countries can meet a portion of their emission reduction targets (UNFCCC 2008).

2.5.2 Emerging Carbon Markets

Ideally, market-based mechanisms such as the CDM would minimize the economic sacrifice associated with reducing GHG emissions and maximize net GHG emission reductions. As currently structured, carbon transactions can be grouped into two main categories: allowance-based transactions and project-based transactions.

Allowance-Based Transactions: Allowance-based transactions are based on cap-and-trade systems in which a GHG emitter either purchases or is allocated emission allowances. An emitting party can do one of two things with their allowance: they can emit the authorized levels of GHG or they can sell unused allowances to another party in need of additional emission allowance. This design allows mandated participants to meet compliance requirements for the lowest cost (Capoor and Ambrosis 2008). Three primary allowance-based transaction markets currently exist:

1) The European Emissions Trading Scheme (EU ETS) was launched as the primary mechanism to facilitate compliance with European Kyoto commitments (the EU-15[3] committed to average emission levels of 8 percent below the Kyoto baseline for the first commitment period of 2008-2012[4]) (Europa 2007). This market covers over 11,500 energy intensive installations[5] across the EU, which represent close to half of Europe's CO_2 emissions (Europa 2005). The EU ETS is by far the largest allowance-based carbon market (Hepburn 2007). In 2007, during the trial market period, nearly $50.1 billion United States Dollars (USD) in credits were exchanged on the EU ETS, up from $25 billion USD in 2006 and $8 billion USD in 2005 (Capoor and Ambrosis 2008).

2) The New South Wales, Australia, allowance-based scheme is not currently structured to meet Kyoto Protocol requirements, but its design and purpose parallels the EU ETS. The system allows power suppliers to

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[3] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom

[4] The baseline emissions year is 1990 for most countries and gases

[5] These installations include combustion plants, oil refineries, coke ovens, iron and steel plants, and factories making cement, glass, lime, brick, ceramics, pulp, and paper.

reach a mandatory cap; but does not allow credit for offset projects outside of Australia (Hepburn 2007). This scheme traded $225 million USD in 2007, or less than 0.5 percent of the EU ETS (Capoor and Ambrosis 2008).

3) The Regional Greenhouse Gas Initiative (RGGI) is the first mandatory, market based effort in the United States to reduce GHG emissions. Ten Northeastern and Mid-Atlantic[6] states have committed to cap and then reduce CO_2 emissions from the power sector by 10 percent by 2018. So far, two quarterly CO_2 emission auctions have been held (on September 25 and December 17, 2008), leading to the exchange of $164 million USD (RGGI 2009).

Although the New South Wales scheme does not currently allow credit from out-of-country projects, EU ETS does by virtue of the "Linking Directive" (2004/101/EC), which came into force November 13, 2004. This directive allows for the use of credits from project-based transactions, and opens the door for outside projects to benefit from EU carbon trading (Hepburn 2007). Similarly, RGGI allows regulated parties to reach emissions reductions targets using mandatory programs outside the United States (e.g. the CDM) (RGGI 2009). Some member nations of the Kyoto Protocol are interested in allowance-based transactions for their entire country; such instances are referred to as national-based programs.

Project-Based Transactions: Project-based transactions allow a buyer to purchase emission credits from outside of the allowance transaction market. These credits must come from a certified project that can demonstrate GHG emission reductions that are additional to the status quo. The Kyoto Protocol established two project-based transaction mechanisms: the CDM, and joint implementation (JI). JI allows for transactions to occur between Annex I countries and economies in transition (i.e. Russia, Ukraine, and Bulgaria) (Capoor and Ambrosis 2007).

In addition to the Kyoto Protocol based EU ETS and the non-Kyoto-based New South Wales and RGGI markets, voluntary carbon trading markets have evolved. In 2007, the Chicago Climate Exchange (CCX), a voluntary market that facilitates the trade of legally binding emissions reductions and offsets for six GHGs, traded $72 million USD of carbon credits (Capoor and Ambrosis 2008). In addition to these markets, thriving consumer-led markets for voluntary offsets by individuals and corporations have captured continually increasing interest. By all accounts, carbon markets are expanding rapidly: the market grew from $14.1 billion USD in 2005 to a $33.3 billion USD market in 2006 and a $64 billion USD

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[6] Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

market in 2007 (Hepburn 2007, Capoor and Ambrosis 2007 and 2008, Ebeling et al. 2008).

Currently, REDD-based carbon credit can only be traded in voluntary carbon markets, or through voluntary buyer and seller agreements (i.e. a voluntary agreement does not necessarily need to be facilitated through the CCX or similar market). Within in the context of the Kyoto Protocol, should the UNFCCC recognize REDD as a legitimate climate change mitigation strategy, REDD projects would most likely be included as CDM projects.

2.5.3 REDD to address Climate Change

Originally, the Kyoto Protocol encouraged emissions trading for afforestation and reforestation activities and explicitly excluded a system to assign carbon credits for avoiding or reducing deforestation (UNFCCC 1998). Opponents of avoided deforestation credits feared that wealthy nations would use the mechanism to gain profit from continuing to operate business-as-usual, and consequently the policies would create perverse incentives to displace deforestation to another location (also known as leakage). In addition, opponents feared that avoided deforestation credits would minimize the sovereign rights of developing tropical countries (Laurance 2007).

Since the original signing of the Protocol, however, the concept of applying the economic power of carbon trading to reducing deforestation has garnered increased support (Olsen 2007). The same Parties who originally opposed the strategy have since recognized the importance of addressing the tropical deforestation problem (Laurance 2007).

At the thirteenth session of the Conference of Parties (COP-13) held in Bali, Indonesia in December 2007, Parties acknowledged that the contribution of emissions from deforestation and forest degradation activities to global anthropogenic GHG emissions is considerable (UNFCCC 2008a). Since a significant portion of carbon enters the atmosphere as a direct result of deforestation, a global carbon emissions cap-and-trade market has been proposed to provide economic incentives to reduce deforestation (Bumpus and Liverman 2008). The COP has requested further research into developing a robust policy for reducing emissions from deforestation and forest degradation (REDD) and potentially establishing a global carbon-trading scheme. Specifically, decision 2 from the COP-13 (decision 2/CP.13) invites Parties to the Kyoto Protocol to strengthen and support voluntary efforts to reduce emissions from deforestation and degradation, and encourages Parties to address the technical needs of developing countries to track and reduce emissions from deforestation (UNFCCC 2008b).

In an effort to continue discussion on REDD and in anticipation of the approach of the fourteenth session of the Conference of Parties (COP-14), UN Secretary-

General Ban Ki-moon along with leaders from Indonesia, Poland and Denmark convened meetings with leaders from the US, China, Japan and the European Union in the months preceding the COP-14 meeting. Secretary-General Ban hoped to bridge the mistrust between developing and developed countries in order to make significant strides toward a post-Kyoto agreement in Poznan. Furthermore, on September 24, 2008, Secretary-General Ban and Prime Minister of Norway Jens Stoltenberg announced a plan to pioneer a new initiative called the UN-REDD Programme. The program, financed by the country of Norway, is implemented by the Food and Agriculture Organization (FAO), the UN Development Programme (UNDP), and the UN Environment Programme (UNEP). The UN-REDD Programme will support developing countries (such as Bolivia, Democratic Republic of Congo, Indonesia, Panama, Papua New Guinea, Paraguay, Tanzania, Viet Nam, and Zambia) as part of an international move to elevate the visibility of REDD and include REDD in new and more comprehensive UN climate change arrangements post-2012.

The UN-REDD Programme lays the framework for negotiations for the second commitment period under the Kyoto Protocol and opens the door for early action (UN-REDD Program Fund 2008). The immediate goal of the UN-REDD Programme is to assess whether a REDD-based finance program can create incentives to ensure emissions reductions while maintaining other forest-based ecosystem services (UN-REDD Program Fund 2008). The Programme will help developing countries and the international community gain experience with various REDD risk management and payment structures, aid developing countries in devising national REDD strategies, and help facilitate development of REDD-centric technical and scientific resources. These efforts will focus on contributing to the final UNFCCC negotiations on a post-2012 framework (FAO, UNDP, UNEP 2007).

Parties will convene in December 2009 in Copenhagen, Denmark for the COP-15 to reach a consensus on a post-2012 framework agreement. In order to gain as much information and insight as possible prior to these negotiations, the UN-REDD Programme is working closely with the following programs (FAO, UNDP, UNEP 2007):

- The World Bank Forest Carbon Partnership Facility (FCPF): The World Bank launched the FCPF at the Bali COP-13 Climate Meeting to assist developing countries in their efforts to engage in current and future REDD-based funding opportunities. Nine industrialized countries and The Nature Conservancy7 have pledged a total of $155 million USD to

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[7] Germany ($59 million USD), the United Kingdom ($30 million USD), the Netherlands ($22 million USD), Australia and Japan ($10 million USD each), France and Switzerland ($7 million USD each), and Denmark and Finland ($5million USD each). The Nature Conservancy pledged $5 million USD.

kick-start the 10-year initiative, which will help countries monitor their forests and sell emission reductions to a designated Carbon Fund (World Bank 2007). This parallels the Bank's $92 million USD BioCarbon Fund, which can consider purchasing carbon credits from a variety of land use and forestry projects, including REDD projects (Carbon Finance Unit 2008).

- Global Environment Facility (GEF) Tropical Forest Account: The GEF is the world's largest environmental funding body. It announced plans to launch the Tropical Forest Account Initiative at the Bali COP-13 meeting. Through this initiative, GEF would fund projects to stop deforestation in seventeen countries of the Amazon, Congo Basin, New Guinea and Borneo (GEF 2008).
- Australia International Forest Carbon Fund (IFCI): The IFCI aims to demonstrate that REDD can be an effective and equitable way to combat climate change, with a special focus on developing practical demonstration activities in Indonesia and Papua New Guinea (Australian Government Department of Climate Change 2008).

Although the above funding and exploratory efforts highlight significant international interest in REDD, it remains to be seen whether REDD-projects will gain the political backing as an UN-recognized emission reduction tool. As mentioned above, the Kyoto Protocol currently excludes REDD projects from inclusion under the CDM. No official UNFCCC REDD-based certified emission reduction credits (CERs) are issued during the first commitment period (2008-2012) (CRN 2008). The lack of UNFCCC sanctioned REDD carbon credit trading may exclude Protocol Parties from meeting reduction commitments using REDD-based carbon credits, but it does not preclude the use of REDD credits on the voluntary market.

2.5.4 REDD to Address Deforestation

In addition to providing a mechanism for addressing climate change and GHG emissions, REDD is a tool to address deforestation. Without a monetary value on intact forests, individuals, governments, and industries are motivated to extract forest resources in order to generate an income or to sustain their livelihood. Extractive activities, such as drilling for oil, mining for minerals, harvesting timber or fuel wood, and developing agriculture, directly or indirectly result in deforestation. The REDD mechanism attempts to reverse the incentive structure. With a REDD mechanism, forest stewards are incentivized to protect the carbon stores within a standing forest. This is a means to generate an alternative livelihood for individuals, thereby addressing a driver of deforestation and ultimately protecting intact forests.

2.5.5 Voluntary REDD Standards

In the absence of a UNFCCC sanctioned REDD finance mechanism, growing interest and support in using REDD as a climate change mitigation strategy has led to voluntary REDD agreements backed by certification standards developed by non-governmental organizations. Three sets of voluntary standards incorporate the ability to certify and/or bolster REDD-based carbon credits for voluntary markets: the Climate, Community, and Biodiversity Standard (CCB), the Voluntary Carbon Standard (VCS), and the Plan Vivo System and Standards (Merger 2008). Due to the voluntary nature of the REDD market, none of these standards are required for a REDD project. In fact, a REDD-based bilateral agreement between a forest steward and carbon investor can be made on the voluntary carbon market without any of these standards. However, without the backing of at least one set of standards, such an agreement is unlikely. Use of these standards builds credibility into a REDD-based project argument, which provides investors with some level of certainty that the project will provide long-term, additional carbon benefits. This certainty warrants higher carbon prices.

In order to command the greatest benefit from a project (i.e. the highest possible carbon price, at the lowest investment level, with the most co-benefits), a project proponent must build the most credible case possible given the size of the project and level of initial investment. In the context of REDD, two practical standard levels exist. Plan Vivo offers the most accessible set of standards: the system is designed to provide poor, rural communities with access to the carbon market by delaying third-party verification of certified projects until the project has generated enough experience and money to support verification (Plan Vivo Standards 2008, Merger 2008). Larger projects stand to attract price premiums by utilizing both the CCB and VCS, which require up front third-party verification (Merger 2008). While the required independent verification required under both CCB and VCS increases immediate project credibility, the associated costs can be prohibitive for smaller projects (Merger 2008).

The Cofán Bermejo Reserve could utilize the Plan Vivo System and Standards, VCS, CCB or the combination of CCB and VCS. The following sections introduce the three voluntary standards, highlight relevant CDM related guidance, and explain how these standards and guidance will be employed within the context of the feasibility analysis for this project. The voluntary standards are presented in order of general recognition by carbon project developers.[8] Should the Cofán

[8] In effort to inform carbon project developers, carbon offset purchasers and other carbon market participants about the selection and use of these standards, Carbon Positive (2008) published "*Forest Carbon Standards 2008, A comparison of the leading standards in the voluntary carbon market and the state of climate forestation projects*". The report examines these three standards, along with the CarbonFix Standard (which does not apply to REDD projects). Seventy-one carbon project developers were surveyed in July 2008. Of the 71 participants, 82

decide to pursue a REDD-based project, any of these standards could be used to build a credible project.

Climate, Community, and Biodiversity Standard (CCB)

CCB standards focus on identifying land-based projects that deliver credible GHG reductions and net positive benefits to local communities and biodiversity. The goal is to catalyze "a robust carbon market for multiple-benefit forest carbon projects" (CCBA 2008b). Applicable projects either focus on or include elements of REDD, such as reforestation, afforestation, revegetation, forest restoration, agroforestry, and sustainable agriculture (CCBA 2008b). These standards are put forth by the Climate, Community, and Biodiversity Alliance (CCBA), whose members include both non-governmental organizations, such as The Nature Conservancy, Conservation International, and the Rainforest Alliance and corporations including BP, SC Johnson, and Intel (Gunther 2008, CCBA 2008b). The CCB standards incorporate solicited public comments and have been field tested and verified in various countries. The first edition of the standards, which was released in May 2005, incorporated the outside perspective of three well-respected advising institutions.[9] CCBA launched the second edition of the CCB standards on December 6, 2008 at Forest Day 2 of the COP-14 meeting in Poznan, Poland. The revisions implemented in the second edition spawn from an inclusive and participatory process that solicited comments from a diverse range of interested parties (CCBA 2008b).

As of December 2008, sixteen projects had received or were in the process of receiving, CCB validation. Around 43 percent of these projects involve REDD components (CCBA 2008a). To date, two specifically REDD-based projects have attained CCB approval:

- The Juma Sustainable Development Reserve Project (Juma Project): Reducing Greenhouse Gas Emissions from Deforestation in the State of Amazonas, Brazil, was approved with a gold rating on September 30, 2008 (CCBA 2008a). This project also seeks VCS validation, which will lead to the creation of tradable Voluntary Carbon Units (Schroder and Medina 2008, Viana and Ribenboim 2008). To drive the project, the Amazonas Sustainable Foundation (Fundacão Amazonas Sustentável) partnered with the State Secretariat for the Environment and Sustainable Development of Amazonas with technical assistance from the Institute for Conservation and Sustainable Development of Amazonas. Marriott

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percent knew about the CCB Standard (66 percent had read the Standard), 75 percent knew the VCS (61 percent had read it), and 61 percent recognized Plan Vivo (read by 38 percent) (Merger 2008).

[9] Advising Institutions: World Agroforestry Centre, Centro Agronómico Tropical de Investigatión y Enseñanza and Center for International Forestry Research.

International is providing funding for rights to the carbon credits (Viana and Ribenboim 2008).

- Reducing Carbon Emissions from Deforestation in the Ulu Masen Ecosystem, Aceh, Indonesia (Aceh Project) received a CCB silver rating on February 6, 2008 (CCBA 2008a). This project sought to have independently verified Voluntary Emission Reductions (VERs) by mid 2008 (Carbon Conservation 2008). Carbon Conservation partnered with the Province of Aceh and Fauna & Flora International to push the project. Merrill Lynch invested $9 million USD in the project in return for carbon credits it will be able to sell on the carbon market (Gunther 2008).

CCB validation and verification costs are expected to range between $5,000 and $40,000 USD depending on the size and complexity of the project, and whether or not the auditor simultaneously validates the project under a carbon accounting standard, such as the VCS (Merger 2008). Projects that gain CCB certification can expect to retrieve "premium prices" over other forestry projects, as CCB Standards ensure "premium quality" of carbon credits (Merger 2008).

<u>Voluntary Carbon Standard (VCS)</u>

Voluntary Carbon Units (VCUs), which are certified and created using the VCS, represent approximately one-third of the voluntary carbon market, making it the most widely used carbon offset standard (VCS APX Registry 2008; Hamilton et. al. 2008). As of December 2008, the VCS had not made its project registry available, but at the very least, one REDD project, the Juma Project listed above, is currently seeking VCS validation. This validation will lead to the creation of VCUs, which can be traded on the voluntary carbon market.

The Climate Group, the International Emissions Trading Association and the World Economic Forum initiated the VCS in late 2005. Since that time, three versions of the standards have been released; the most recent of which is VCS 2007.1, which was released on November 18, 2008. In addition to the overarching VCS 2007.1 standards, the VCS has produced three land use specific guidelines, which are of particular interest to the REDD projects. The latest versions of these documents were released on November 18, 2008:

- Tool for Agriculture, Forestry and Other Land Use (AFOLU) Methodological Issues
- Tool for AFOLU Risk Analysis and Buffer Determination
- Guidance for AFLOU Projects

As of February 2009, no forestry projects had been validated and verified under the VCS, but per-audit verification costs are not expected to vary much from the other standards. It should be highlighted, however, that the VCS requires two independent audits before Voluntary Carbon Units (VCUs) can be issued (VCS

Projects 2009, Merger 2008). As such, a project proponent can expect validation and verification costs of $30,000 to $60,000 USD (Merger 2008). The VCS anticipates a price range of $12 to $18 USD per metric ton of CO_2 in 2009, and charges $0.04 for every metric ton CO_2 certificate generated (Merger 2008).

CCB and VCS Together

From the REDD voluntary market perspective, the projects most likely to gain funding are those that build the strongest case for additionality, reliability, and permanence. Both the VCS and CCB were created to provide a sense of regulation and instill investor confidence in an otherwise voluntary market. As alluded to above, the CCB and VCS approach land use issues from different angles: CCB standards are designed to ensure multiple project benefits and the VCS focuses on creating certified carbon units. Within the context of REDD projects, the two standards are strongest when used in tandem (Merger 2008).

Both the VCS and CCB standards point out that the weakness inherent to the respective standard is filled by the strength of the other. For instance, the CCB standards rely on a carbon accounting standard (i.e. VCS and/or CDM based, if available) to generate quantified emissions reductions certificates, while the VCS stresses the importance of reaching beyond climate change mitigation by generating social and environmental benefits (CCBA 2008b, VCS AFOLU 2008). Specifically, the CCB standards state that the standards "can be combined very effectively with a carbon accounting standard such as…the Clean Development Mechanism (CDM) or the Voluntary Carbon Standard (VCS)". REDD projects are not currently recognized by the CDM, leaving the VCS as the recommended REDD project carbon standard. In similar light, the VCS requires all AFOLU projects to identify and take steps to mitigate potential negative environmental and/or socioeconomic impacts prior to generating VCUs. The VCS suggests that independent CCB validation can be used to demonstrate project quality across multiple dimensions (VCS AFOLU 2008).

Plan Vivo System and Standards

The Plan Vivo System and Standards includes aspects of both the CCB and VCS. It was developed in 1994 to enable communities in developing countries to access payments for ecosystem services. Under Plan Vivo, an individual farmer or community designs a 'living plan' for long-term land management that includes carbon sequestration or conservation activities. The plan is developed with training and guidance from local technicians; special interest is placed on transferring knowledge and learning to the community. Once a Plan Vivo Project is approved, expected carbon benefits are calculated to create verifiable emission reductions sold in the form of Plan Vivo Certificates (Plan Vivo 2008).

A Plan Vivo Certificate represents the long-term sequestration of one metric ton of CO_2, plus the additional ecosystem and livelihood benefits quoted below:

- "Biodiversity conservation through expansion and strengthening of protected areas and native species;
- Poverty reduction and sustainable livelihoods through sustainable agriculture and micro-enterprises;
- Restoration of degraded and degrading ecosystems;
- Adaptation of natural and managed ecosystems to climate change (watershed protection, soil stabilization, regulation of regional micro-climates);
- Increased resilience to climate change and decreased dependence on aid through capacity building, knowledge and skills transfer and community development." (Plan Vivo 2008)

Eligible lands include small-holder owned or leased farmland, community owned land, and state lands where communities have forest use-rights. Much like the CCB, projects are required to promote sustainable land-use practices that benefit the local rural communities through agroforestry, afforestation, restoration, reforestation, or avoided deforestation activities (Plan Vivo 2008). Furthermore, Plan Vivo encourages project coordination by a non-governmental community-based organization with strong links to local groups and, ideally, experience working with target communities (Plan Vivo 2008).

As of December 2008, no REDD or avoided deforestation projects had been implemented under Plan Vivo (Merger 2008). However, as highlighted above, the capacity exists. Plan Vivo differs from CCB and VCS in that project validation and verification are two separate processes. Expert reviewers conduct initial validation at the beginning of the project, and issue the relevant Plan Vivo Certificates (Plan Vivo 2008). This initial verification can cost between $5,000 and $12,000 USD (Merger 2008). Third party verification is delayed until the community can gain the greatest benefit: the $15,000 to $30,000 USD process takes place after the project has built up sufficient information (through experience) and money (through carbon finance) to both fund and learn from the verification (Plan Vivo 2008, Merger 2008). Plan Vivo expects to sell Plan Vivo Certificates (equivalent to one metric ton of CO_2) for $8 to $30 USD in 2009, and charges $0.30 USD for every certificate sold (Merger 2008).

<u>Developing Project Methodologies Using Existing Standards</u>

Within the UNFCCC Land Use, Land-Use Change and Forestry (LULUCF) policy context, the Kyoto Protocol only authorizes afforestation and reforestation activities for use in emissions mitigation (Capoor and Ambrosis 2006). Some parallels, such as carbon accounting, local stewardship, and sustainable forestry practices, can be drawn between afforestation, reforestation projects, and REDD projects. Two documents produced by the IPCC, listed below, have been published to guide these LULUCF projects and provide necessary methodological foundation for estimating land based GHG emissions. This project utilizes the logic behind the methods within the following documents to help estimate emissions from the Cofán Bermejo Reserve for scenarios with and without a REDD project:

- The *IPCC 2006 Guidelines for National GHG Inventories for Agriculture Forestry and Other Land Use* provides details on how to account for emissions from managed lands
- The *IPCC 2003 Good Practice Guidance on LULUCF* provides methods and guidance for estimating, measuring, monitoring, and reporting on carbon stocks and GHG emissions from LULUCF activities.

These documents will likely be important in the development of internationally sanctioned REDD standards because they were developed and reviewed by numerous experts, and they have already been accepted by the UNFCCC. They have been tested during the initial phase of the Kyoto Protocol and provide a tiered system that provides flexibility for differences in technical capabilities amongst target countries (Olander et al. 2008).

CCB, VCS, and Plan Vivo all refer to these documents for carbon accounting methodology. For the sake of clarification, methodologies under the CDM and Joint Implementation (JI) are accepted under both the VCS and CCB Standards (VCS AFOLU 2008, CCBA 2008b). Plan Vivo, VCS and CCB standards all address afforestation and reforestation projects, which can theoretically qualify as CDM projects (UNFCCC 2005). However, LULUCF projects comprised only 1 percent of the total carbon asset transactions in 2006 and 2007 because the EU ETS, the largest carbon market by far, denied access to LULUCF carbon assets during Phase I (2005-2007) of its trading, and is currently denying access for Phase II (2008-2012) (Capoor and Ambrosis 2006, 2007; Garside 2008). Hence, based on the current situation, voluntary standards play a critical roll in LULUCF projects.

CCB Standards, VCS, and Plan Vivo System and Standards all provide plausible routes to certify REDD project implementation. They do not necessarily provide step-by-step methodology for how to prepare and implement a project. Instead, the standards outline what components need to be proven or addressed, and it generally remains up to the project proponent to justify the specific methodologies used to determine and report the carbon, climate and biodiversity benefits of a given project. Critical methodological issues, and guidance available to address them for this analysis, are addressed below.

<u>Methodological Guidelines for Measuring Deforestation</u>

Within the voluntary market, the VCS *Standard Tool for AFOLU Methodological Issues* establishes basic guidelines for determining land eligibility, project boundaries, carbon pools, and project baselines, as well as procedures for assessing and managing leakage, and estimating and monitoring net project GHG benefits. However, it currently fails to provide a detailed methodology to identify and address the measurement of deforestation.

To address this, several groups have begun work to develop methods that may be accepted by the VCS or other standards. Avoided Deforestation Partners announced in the summer of 2008 that they had launched a REDD Methodology Project. The project's goal is to develop a series of free methodology modules to help advance Avoided Deforestation projects. These methodologies will be submitted to the VCS and should be ready for use during the first half of 2009 (ADP 2008). However, at the time of this writing, these documents are not available for review.

In addition to the efforts by the Avoided Deforestation Partners, the World Bank's BioCarbon Fund released an updated draft of their own methodologies entitled *Methodology for Estimating Reductions of GHG Emissions from Mosaic Deforestation* on December 15th for public comments (The BioCarbon Fund 2008). This methodology is still incomplete. It does not fully address all three types of avoided deforestation determined eligible by the VCS in their *Standard Tool for AFOLU Methodological* document, it does not address forest degradation, and has yet to be certified by the VCS or any other standards agency. This document does, however, provide a window into how future methodologies for measuring deforestation under REDD may develop. Therefore, despite the incomplete nature of the BioCarbon Fund's methodology, it may be useful for helping determine the rate of deforestation within the Cofán Bermejo Reserve.

<u>Defining Forests, Deforestation, and Degradation</u>

In order to quantify the amount of deforestation and degradation occurring within the Cofán Bermejo Reserve for entry into a REDD market, it is necessary to establish which definition of forest, deforestation, and degradation the REDD project will use. The choice of an appropriate definition is important because it can have a large effect on a project's computed rate of deforestation. For example, the FAO redefined 'forest' in their 1990 and 2000 Forest Resource Assessments. The change in definition included decreasing the minimum forest height from 7 meters to 5 meters, decreasing the minimum forest area from 1 hectare to 0.5 hectares, and reducing the crown cover requirement from 20 percent to 10 percent. With the new definition, global forest cover increased by 10 percent, or 300 million hectares (Neeff 2006). The VCS's *Standard Tool for AFOLU Methodological* recommends the use of UNFCCC host-country thresholds or FAO definitions for forest, deforestation, and degradation. The FAO defines forests as containing:

> a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 meters at maturity in situ. A

> forest may consist either of closed forest formations where trees of various stories and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10-30 percent or tree height of 2-5 meters are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest. For the Clean Development Mechanism (CDM), developing countries must choose a parameter within the above ranges. (Neeff 2006)

Although REDD projects do not currently qualify under the CDM, it is suggested that this project use the minimum indicators associated with the CDM to define forests for a REDD project (e.g. 10 percent tree cover, 2 meter tree height, and 0.05 hectares forest area) for two reasons: First, Ecuador became a ratified member of the Kyoto protocol January 13, 2000; the country would likely need to use this definition to qualify its forests for CDM certified activities. Second, the Cofán should be prepared for the chance that REDD could be accepted under CDM.

Similar to the need to define forests, defining deforestation and degradation is critical to establishing reliable deforestation estimates and projections that can be addressed by a REDD project. This project employs the World Bank's BioCarbon Fund *Methodology for Estimating Reductions of GHG Emissions from Mosaic Deforestation* definition for deforestation. This definition defines deforestation as

> direct, human-induced and long-term (or permanent) conversion of forest land to non-forest land. It occurs when at least one of the parameter values used to define 'forest land' is reduced from above the threshold for defining 'forest' to below this threshold for a period of time that is longer than the period of time used to define 'temporarily un-stocked'. (The BioCarbon Fund 2008)

The BioCarbon Fund further goes on to define forest degradation as "forest land remaining forest land but gradually losing carbon stocks as a consequence of direct-human intervention (e.g. logging, fuel-wood collection, fire, grazing, etc.)" (The BioCarbon Fund 2008). For the purposes of this project, both potential deforestation and degradation are considered in the Cofán Bermejo Reserve.

<u>The Use of the Standards within the Feasibility Framework</u>

Absent UNFCCC recognition of REDD, the most credible, tradable REDD-based carbon credits would be represented as Plan Vivo Certificates or VCUs (from the VCS) backed with CCB verification. Again, a project certified using CCB standards would rely upon VCS verification to create certified, tradable VCUs. Carbon stocks, deforestation rates, and the potential loss of carbon to the atmosphere should be estimated using the most widely accepted guidelines, as described above. However, before taking the Cofán Bermejo Reserve through an expensive Plan Vivo or CCB and VCS verification process, it is necessary to determine the likelihood that a REDD project can be successfully being implemented in the Reserve, which is the focus of the remainder of this report.

3.0 FEASIBILITY ANALYSIS

The Cofán Bermejo Reserve could potentially benefit from implementing a REDD project. In order to determine eligibility, this project developed a feasibility framework. This framework incorporates the following critical elements taken from the Plan Vivo System and Standards, VCS, CCB standards, and relevant IPCC GHG and land use project guidance: political climate; additionality, which includes determining carbon storage estimates and potential carbon benefits; permanence; leakage; and indigenous and cultural considerations. These critical elements must be addressed in order to develop and design a verifiable REDD project. Based on the requirements of the UNFCCC, Kyoto Protocol, and CDM, these components will likely be critical in the development of an UN-sanctioned REDD program, should one develop. Our analysis references three REDD projects that are currently seeking, or have sought, VCS and/or CCB verification, the Juma Project in Brazil, the Aceh project in Indonesia, and the Noel Kempff Project in Bolivia, as case studies.

Each component, identified in the Table 1 below, is explained and analyzed throughout the following feasibility analysis.

Table 1

Component	Explanation
International Political Climate	Where does the UNFCCC stand with regard to REDD?
Political Climate of Ecuador	Does the structure of the government support or act against development of REDD projects?
Additionality	Will the project provide carbon emission reductions in addition to business-as-usual?
Permanence	What is the risk of unexpected carbon loss if a REDD project is implemented?
Leakage	Will the project displace deforestation into other areas and negate any project benefits?
Indigenous and Cultural Aspects	How would a REDD project impact the Cofán people?

3.1 International REDD Policy and Political Climate of Ecuador

The first step in our feasibility analysis is to examine the political climate of the international community and Ecuador. The international political climate sets the stage for the development of a carbon trading scheme which could include REDD projects. Through the development of policies, programs, or guidelines, the international community establishes which actors will be able to participate in a carbon trading scheme and in what capacity. This, in turn, can influence the development of projects within countries. Subsequently, it is necessary to determine if the structure of the government within Ecuador supports, or acts against, the attempts of the Cofán to enter a REDD-based carbon market.

For this project, the political climate was analyzed by looking at what the global community has put forward in terms of trading schemes and the characteristics of those schemes. Likewise, the political climate of Ecuador is assessed by researching regulations which support or act against a carbon emissions trading scheme.

3.1.1 International Political Climate

The international political climate is unfolding in a manner that is paving the road for potential mandatory REDD policies (or voluntary REDD regimes) that could significantly protect forests from deforestation and land-use change while also providing economic incentives for carbon sequestration values. Furthermore, REDD-based policies have the potential to promote sustainable development within developing countries, which is inline with the original intentions of the CDM (Olsen 2007). The results of the most recent COP are opening the possibility of expanding the role of indigenous peoples in the conservation of forests and subsequently reduction of carbon emissions from deforestation.

In December 2008, COP-14 convened in Poznan, Poland to continue talks on climate change. Among a variety of issues, Parties continued discussing the need for furthering the work towards developing methodological guidance for REDD (Akanle et al. 2008). Areas of progress for the REDD discussion include both recognition of the role of conservation and sustainable forest management in the enhancement of forest carbon stocks and subsequently, reduction of carbon emissions from deforestation (Akanle et al. 2008). COP-14 also acknowledged the integral role of indigenous peoples in the conservation of forests (Akanle et al. 2008). Both issues will be further addressed in future discussions of a REDD mechanism (Akanle et al. 2008). At the COP-15 meeting, which is set to convene in Copenhagen, Denmark in December 2009, members are expected to reach a decision about a post-Kyoto treaty. The results of this meeting should reveal whether REDD is included in the agreement.

There is still uncertainty in regards to the establishment of a robust REDD scheme within the CDM of the Kyoto Protocol or in subsequent climate treaties, which creates a moving target for the Cofán Bermejo Reserve for a variety of reasons. The first is uncertainty surrounding the requirements for a project under the CDM. It is difficult at this point to develop a project which could meet the demands of a potential REDD scheme, since currently the only way to create a REDD project is to use the existing voluntary market standards. It is not clear how voluntary standards will translate into a regulated market; however, key concepts and lessons learned from voluntary REDD projects will undoubtedly be incorporated into any UNFCCC REDD regime.

The second uncertainty surrounds the price of carbon on the market. Based on the 2007 market value for carbon (which varies considerably around the world), a hectare of intact rainforest could be worth anywhere from $400 to $8,000 USD or more, depending on the political structure of avoided deforestation projects (Laurance 2007). For countries with a net loss of forest between 1990 and 2005, Ebeling et al. (2008) estimate that a 10 percent reduction in the rate of deforestation could generate between $2.2 and $13.5 billion USD in annual carbon finance. These numbers were determined using country specific values of average carbon content from the IPCC 2003 report and a range of carbon prices ($8 to $47 USD per metric ton of CO_2) (Ebeling et al. 2008). It is important to note that the market value for carbon tends to be higher for regulated carbon trading schemes such as the EU ETS; whereas, the value for carbon tends to be lower for voluntary markets such as the CCX. If international support for REDD projects continue to grow along with the carbon markets, REDD projects could generate significant revenue. According to one projection, Indonesia has the potential to be compensated $1 billion USD per year if its deforestation rate was reduced to 1 million hectares annually[10] (Fogarty 2009).

Maintaining the Cofán Bermejo Reserve as an intact rainforest under a REDD project could generate a significant amount of revenue, as demonstrated in our Cost Benefit Analysis (see Section 4.0). However, without an UN-sanctioned REDD market, the Cofán would need to sell carbon credits on a voluntary market, through which they would command lower relative carbon prices. If the Cofán wait and a regulated REDD market evolves, the value of carbon emissions credits would likely increase but the requirements for REDD projects may change in a manner that excludes the Cofán Bermejo Reserve from participating.

Given the financial turmoil seen in late 2008 and early 2009, the carbon market is increasingly feeling the effects of the economic crisis. In October 2008, EU ETS Certified Emission Reductions (CERs) were holding up in comparison to other assets, but prices dropped in February 2009 (New Carbon Finance 2009). In the context of global financial struggles, voluntary markets and carbon project development are expected to be hit the hardest: financing for new carbon reduction projects is basically linked to the rest of the credit market (Gronewold 2008). This reality could slow the development and implementation of a voluntary REDD project in the Cofán Bermejo Reserve.

Despite the global economic crisis, leaders are calling to keep climate change issues at the top of priority lists. Many leaders are even calling the crisis an

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[10] Between 2000 and 2005 deforestation in Indonesia was occurring at a rate of 1.8 million hectares per year, equivalent to a loss of 2 percent of its forests each year (Guinness World Records 2009)

opportunity. In his opening speech of the High-Level Segment of the COP-14, UN Secretary General Ban remarked that the climate change and global economy crisis create an opportunity for sustainable green growth (UNFCCC 2008 – SG Opening Statement). Upcoming UNFCCC climate change negotiations and the overall health of the global economy will have a profound impact on the value and salability of carbon assets held within the Cofán Bermejo Reserve. We cannot predict what will happen on either front; however, the rhetoric surrounding REDD appears to be positive and consensus surrounding the climate change problem is undeniable: the need to mitigate emissions, is not expected to go away. At the very least, REDD should remain a viable voluntary offset strategy.

3.1.2 Political Climate of Ecuador

Just as the international political climate determines the place of REDD within the global climate mitigation strategy, national policies and strategy determines the ability of an area or group to sell its carbon assets. Although the Cofán people remain the official stewards of the Cofán Bermejo Reserve, the government of Ecuador owns the land itself. Rights to the carbon assets in the forest are not clearly defined, especially with the newly adopted Ecuadorian Constitution and any associated rule changes. However, an emerging program called Socio Bosque suggests Ecuador might support REDD-based carbon projects. In order for the Cofán to sell REDD-based carbon credits from the Cofán Bermejo Reserve, they will likely need support and approval for such activity from the Ecuadorian government. From the perspective of the Cofán, an ideal national government would both support the ability of the Cofán to restrict deforestation from occurring and allow them to directly receive all monetary benefits associated with carbon market entry.

<u>The New Constitution</u>

On September 28, 2008, Ecuador passed a new Constitution (Revkin 2008). This new Constitution granted many more rights to nature and indigenous cultures in some respects, but it still guarantees sovereign rights to the government regarding these entities.

Nature is given more rights and protection with the 2008 Constitution. For example, according to Article 10, "Nature will be subject to those rights that the Constitution recognizes." According to the Constitution, nature has fundamental rights to protection, restoration, and prevention of destruction as well as other rights typically given to humans. It gives nature the right to protection, restoration, and prevention of destruction (Ediciones Legales 2008). However, the State still has power to overrule these rights. The Constitution states that extractive activity of nonrenewable resources is prohibited in protected areas unless given permission by the President of the Republic (Ediciones Legales

2008, Article 407-408). This article gives the State ultimate power over nature and its resources.

The updated constitution of Ecuador demonstrates some promise for indigenous cultures of Ecuador. For example, in Article 57, indigenous nationalities are given the right to maintain possession of ancestral lands. In addition, they are guaranteed the right to transparent information regarding exploitation and commercialization of any goods found on their land, and any decisions that could affect the environment or ancestral lands must be communicated to these groups (Ediciones Legales 2008, Article 57). While their opinion will be heard and valued, the ultimate decision will be made by the government (Ediciones Legales 2008, Article 57). Even though this article gives indigenous groups the rights to possess land and receive information regarding activity on their lands, it gives the government sovereign rights to decisions of land use within their territories.

While these additional rights for nature and indigenous rights can be beneficial, Article 378 could prevent the Cofán Bermejo Reserve from benefiting from payments for ecosystem services. This article states that any indigenous culture that receives public funds will be subject to control and surrender of funds, however, it does not specify what constitutes public funds (Ediciones Legales 2008, Article 378). This article demonstrates the power of the government to regulate funding received by the Cofán even though the article does not specify funds received from carbon markets or other ecosystem services. The implications of this article depend on the government's future actions and could have severe implications on the success of a REDD project in the Cofán Bermejo Reserve. Therefore, it is crucial that the Cofán receive government support before implementing such a program. The Constitution does not clearly define the Ecuadorian government's stance regarding indigenous groups and what specific rights they are guaranteed, so it is difficult to predict how likely it is that the government will actually seize funding the Cofán might receive through a REDD project.

Socio Bosque

Despite the uncertainty regarding the rights of the Cofán in the Ecuadorian Constitution, the establishment of the Socio Bosque program by the Ecuadorian government provides evidence that the government is supportive of REDD projects within the country. Ecuador committed to the UNFCCC in 1993 and the Kyoto Protocol in 2000. In line with this commitment to address climate change, the Socio Bosque program was designed to address climate change while also generating funding to combat poverty and protect native forests. Socio Bosque provides an incentive to peasants and indigenous communities to voluntarily participate in the conservation and protection of their native forests through payments based on land area (MAE 2008a).

The government has recognized the important role that indigenous groups can play in combating climate change, reducing GHG emissions, and preserving the forests and biodiversity of Ecuador (MAE 2008a). The overall goals of this program include conserving native forests, especially those in danger of deforestation; protecting environmental services provided by native forests; providing income for rural people that own native forests; and positioning Ecuador as a pioneer for reducing carbon emissions by avoided deforestation (MAE 2008b). More specifically, Ecuador aims to conserve 3 million hectares of native forest by 2015, reduce GHG emissions from deforestation, and alleviate poverty for 500,000 to 1,500,000 people in Ecuador (MAE 2008a).

Groups that own native forest and want to receive funding through Socio Bosque must apply for participation through assembling a portfolio that demonstrates their qualifications according to specific criteria. If they qualify, a client may be awarded up to $30 USD per year for each hectare of forest protected (MAE 2008b), but the exact amount depends on the total size of the forested area (MAE 2008a). The Cofán only steward the Cofán Bermejo Reserve and do not own it, so this could potentially inhibit them from directly benefiting from Socio Bosque in the Cofán Bermejo Reserve.

Despite inability of the Reserve to qualify for Socio Bosque, this program still offers some insight as to Ecuador's interest in carbon markets, forest preservation, and improving quality of life for indigenous people (MAE 2008b). The program has also demonstrated the government's recognition that increasing conservation can simultaneously help alleviate poverty (MAE 2008a).

Additionally, other forests within Cofán territories may qualify for Socio Bosque and thus be able to generate funding for the Cofán overall. As of January 2009, a Socio Bosque agreement was reached between the Ecuadorian government and the Cofán people to protect Rio Cofánes, another Cofán territory. This agreement will conserve 30,000 hectares and provide the Cofán with $49,000 USD per year over 20 years (equivalent to $1.63/ha/yr). Likewise, a Socio Bosque agreement for the Dureno territory is currently being negotiated, and it is projected that the Cofán will receive $29,000 USD per year for this project (Siviter, In litt. 2008a).

<u>REDD Projects in Ecuador</u>

Should Ecuador support a REDD project in the Cofán Bermejo Reserve, there are a variety of paths it can choose. These paths will depend upon the national strategy the government wants to pursue. They can either organize a national-based program and funnel benefits through the government or they can allow individual projects to develop on their own and proceed with little to no government interference (project-based). The type of REDD projects that Ecuador supports will determine the nature of carbon markets within the country. Project-based REDD agreements allow investors more control and involvement in the project while national-based REDD projects establish standards for all projects in that country and are designed by the government (Myers 2007). A project-level REDD project would allow the Cofán to prevent deforestation, manage resources independently, and directly benefit from funds generated. Without a clearly defined national strategy or UN-sanctioned framework for REDD standards, REDD carbon projects will likely be managed on the project level. However, in Ecuador, a project-based REDD program could be difficult to implement because of the government's ability to seize payments to indigenous groups according to Article 378.

According to Ecuador's actions, we predict the country will approach REDD markets with a national-based approach. More specifically, Ecuador's efforts with Socio Bosque demonstrate the nation's interest in payments for ecosystem services through protecting forests and compliance with the Kyoto Protocol. With a national-based REDD program in Ecuador, the government will be able to invest in any local forest for preservation and reduced deforestation including the Cofán Bermejo Reserve.

Participation of the Cofán Bermejo Reserve in a REDD-based carbon market will likely only be successful with support from the Ecuadorian government. Whereas it is possible that the Ecuadorian government will support such a project as demonstrated above, its success is highly contingent on such government support.

3.2 Additionality

According to the CCB standards, additionality is where projects demonstrate real, measureable, and long-term results in reducing or preventing carbon emissions, when that reduction or prevention would not have occurred in the absence of project activities (CCBA 2008b). Proof of additionality is critical because many developing countries do not have legally binding reduction commitments under the Kyoto Protocol (CCBA 2008b). Without legally binding reductions, some developing countries do not have national baseline carbon emissions. Without a baseline, it is difficult to quantify if a country is reducing emissions by implementing projects.

Demonstrating additionality is important for REDD projects because if a forest already has adequate protection from deforestation and degradation (herein referred to as deforestation unless otherwise specified), additional protection would not be necessary. In order to legitimize a REDD project in the Cofán Bermejo Reserve, project proponents need to be able to demonstrate that REDD-based protection of forest carbon stores and prevention of deforestation activity would be in addition to business-as-usual.

In the context of a REDD project, the first step to address additionality involves establishing the amount of carbon stored within a defined area of the Reserve (i.e. carbon stored per hectare of primary forest), followed by determining the rate of deforestation that is currently occurring (the baseline) and the amount of deforestation that might reasonably be expected if deforestation and degradation activities were to occur within the Reserve. As is further discussed below in Section 3.2.5, this project applied additionality standards from current voluntary markets to prove that a REDD project in the Cofán Bermejo Reserve would be in addition to business-as-usual.

3.2.1 Linking Carbon Storage and Deforestation Estimates to REDD

According to the VCS standards, the primary concern for REDD is the carbon stored within the aboveground biomass within the project area (VCS 2008). We quantified the approximate carbon storage within the aboveground biomass of the Reserve using limited field measurements and comparative studies; both are further discussed in the following sections.

Once the amount of carbon stored per hectare is approximated, deforestation rate estimates can be used to estimate the relative amount of carbon that is emitted to the atmosphere through the loss of biomass per unit area (Gibbs et al. 2007). Difficulties associated with taking direct and accurate measurements of the rate or amount of overall deforestation and potential amount of carbon lost from activities stem from the complexity of deforestation activity. For instance, agriculture expansion, oil exploration, and mining activities can often result in indirect and subsequent deforestation that occurs slowly over time (FAO 2006, Gibbs et al. 2007). In-depth comparative studies conducted in geographic locations similar to the Cofán Bermejo Reserve can be used to estimate baseline levels of carbon storage and deforestation rates (FAO 2006, Gibbs et al. 2007). Coupling current carbon storage with the amount of probable carbon loss gives the quantity of carbon that could be sequestered if the forest is preserved in perpetuity.

In the next two sections, we discuss the estimation of the amount of carbon stored in the Cofán Bermejo Reserve and both existing and potential future rates of deforestation.

3.2.2 Methods to Estimate Carbon Storage

Carbon is stored in both aboveground (i.e. in leaves, branches, trunks, detritus etc.) and belowground biomass (i.e. in roots and soil organic matter). A majority of the carbon stored within a tropical forest ecosystem is found within the aboveground living biomass. This is also the portion of carbon storage that is most impacted as a result of deforestation and other land degradation activities. The belowground biomass carbon storage estimates are optional for consideration under a REDD project, although it is strongly recommended that this be included in the total carbon storage estimate for the project area since it typically contains up to 25 percent of the stored carbon pool (Achard et al. 2007, Ramankutty et al. 2007, VCS 2008). Likewise, leaf litter and dead biomass are estimated to be equivalent to approximately 10 to 20 percent of the aboveground carbon stored within the living biomass of a mature forest (Harmon and Sexton 1996, Delaney et al. 1998, Achard et al. 2002). Since it is not possible to directly measure the carbon storage within the landscape, we measured the approximate amount of biomass within a certain area of the forest. We then used allometric equations to translate the amount of biomass into an estimate of the amount of carbon stored (Sala et al. 2000). Figure 4 outlines the methodology employed by this analysis to estimate carbon storage and potential loss for the Cofán Bermejo Reserve.

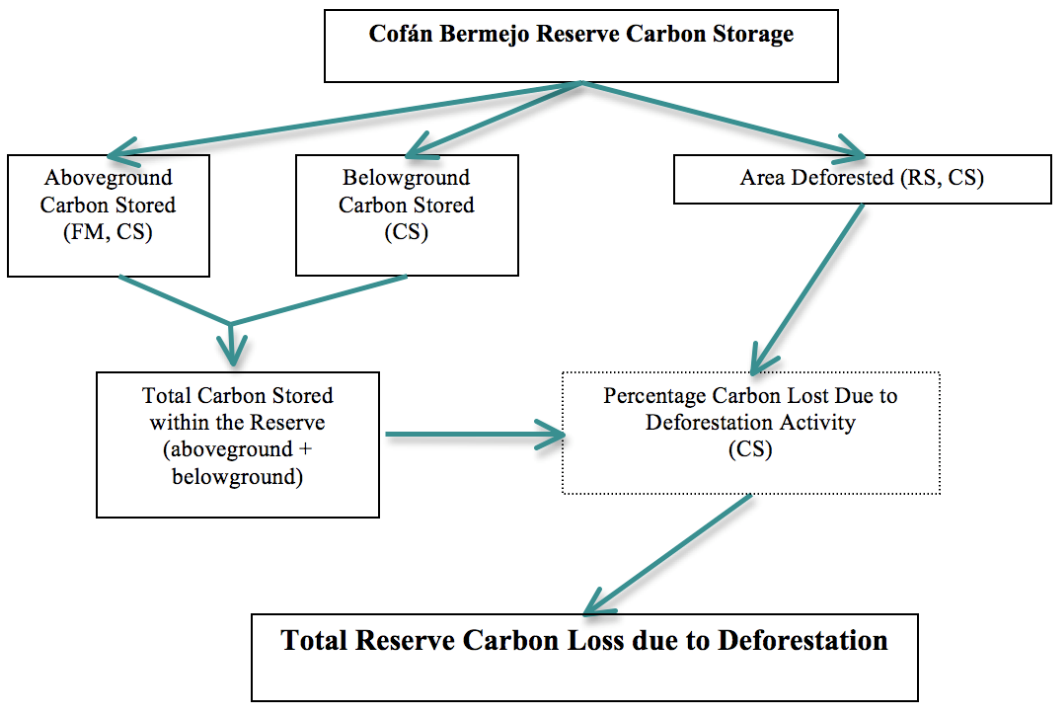


Figure 4: This flow chart shows the methodology used for this project to estimate the carbon loss due to deforestation. FM - field measurements, CS - comparative studies, RS - remote sensing.

<u>Carbon Content from Comparative Studies</u>

A literature review of comparative studies is often the most feasible way to estimate the average carbon storage potential of a forest, especially in areas that are particularly inaccessible and situations where time and resources are limited. Several areas similar to the Cofán Bermejo Reserve in both climate and species content were reviewed in order to establish a range of the amount of carbon stored.

Both aboveground and belowground carbon storage have been estimated through a number of different studies focused in the tropical forests of Ecuador or other similar locations (Gibbs et al. 2007). Although biome averages for certain geographic locations are less region-specific, they are convenient to use since they are readily available, generally globally consistent (which is good for comparison purposes), and useful in establishing a range of approximate amount of carbon stored within the Reserve (Gibbs et al. 2007). It is estimated that wet tropical equatorial forests, such as those found in the Ecuadorian Amazon, may contain anywhere from 193 to 200 metric tons of carbon per hectare (including both aboveground and belowground carbon content) (Houghton 1999; Defries et al. 2002; IPCC 2006).

A region-specific study was conducted in the Amazon by scientists from the Woods Hole Institute, Caltech, and the National Institute for Space Research (Instituto Nacional de Pesquisas Espaciais) using a combination of remote sensing and field plot measurements to determine forest biomass. To estimate the average carbon stored within the region, researchers compiled data from numerous biomass plots in a variety of different forest types and geographic locations randomly distributed over the study area. By overlaying this information with remote sensing data, they were able to extrapolate the data over the entire study region. From this data, they estimated that areas within the lowlands of the Ecuadorian Amazon (i.e. Cofán Bermejo) contain approximately 200 to 300 metric tons of carbon per hectare within the aboveground biomass of the forests (Butler 2007b).

Field Analysis of Carbon Storage within Cofán Bermejo Reserve

In effort to validate the values found in the above studies, two project members traveled to the Cofán Bermejo Reserve in July 2008 to take field measurements. As discussed in Appendix B, to properly estimate the carbon stored within the Cofán Bermejo Reserve, a representative sample of the forest must be collected to allow for accurate extrapolation of the carbon storage. However, due to the limited time frame of the study, weather, and other logistical issues, this was not possible. As shown in Figure 5, eight samples were collected within southeastern corner of the Reserve during the field study.

During these brief field surveys, measurements were taken within the Cofán Bermejo Reserve and used to estimate the average aboveground biomass. We used a diameter-breast height (DBH) tape and hypsometer at the various sample sites to measure aboveground biomass. A hypsometer was used to determine the forest canopy height and the average stem basal area per tree was measured manually using a DBH tape. Trees less than 5 cm in diameter were not sampled because they are insignificant in terms of the overall amount of biomass within the sample site. These measurements were then converted into estimates of the aboveground biomass for each tree within the sample locations using allometric

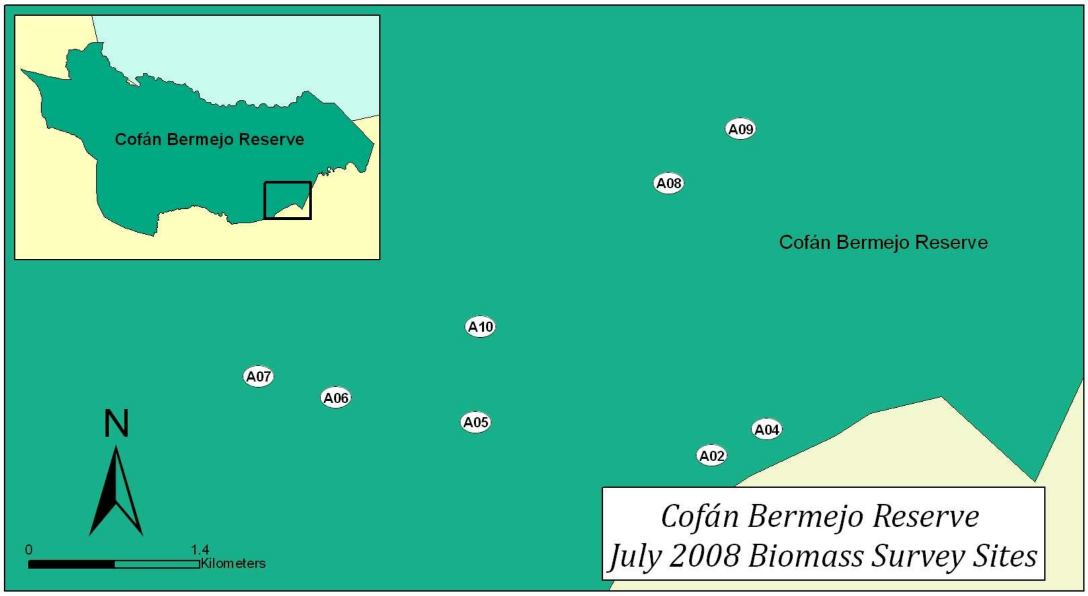


Figure 5: During July 2008, the Cofán Group Project conducted a field study to assess the carbon density within the Cofán Bermejo Reserve. The study assessed the carbon density at 8 field sites.

equations (see Table 2 for the equation used in our analysis) provided in the FAO paper *Estimating Biomass and Biomass Change of Tropical Forests: a Primer* (Brown 1997). Because the Cofán Bermejo Reserve receives approximately 1,500 to 4,000 mm of rain per year, it is classified as a moist tropical forest (Brown 1997, Helminthiasis and Culture Change Among the Cofán of Ecuador 2000). Two equations are provided by the FAO to estimate biomass within a moist tropical forest, but Equation 3.2.4 provides a closer approximation of the actual biomass for trees with a DBH of less than 160 cm (Brown 1997). Due to the difficulty of directly measuring belowground biomass, it was not measured during this field assessment.

The carbon storage potential within the Cofán Bermejo Reserve was calculated using the following steps. First, estimates of the total aboveground biomass per tree were converted into metric tons of carbon using the allometric relationship that approximately 50 percent of the biomass is carbon (Brown 1997). The values for metric tons of carbon per tree within the sample site were then summed, averaged per square meter of the sample site, and extrapolated over a hectare. For a more detailed explanation of the method used to calculate the carbon density, see Appendix B.

For the eight sites sampled during this study, the carbon storage ranged from 90 metric tons per hectare to 644 metric tons per hectare for an average of 351 metric tons per hectare across all eight sites (see Table 2). This estimate is reasonably close to the estimates presented in the comparative studies discussed in the previous section. Similar to the sites examined in the comparative studies, all the samples were collected within an elevation range of 380 to 490 meters above sea level. Samples were not collected from the montane region in the western portion of the Reserve and thus there are no estimates of carbon storage for that area. The field derived carbon values for the lowland plains within the Reserve fall within the expected range Ecuadorian Amazon forests.

Table 2: Estimated Sample Site Carbon Storage
Y = exp{-2.134+2.530*ln(D)} (Eq. 3.2.4, Brown 1997)

Sample Site	**Biomass Sum for each Sample Site** (metric ton)	**Biomass per sample site** (metric tons/sq meter) (Sample site = 530.92 m²)	**Metric tons Carbon / Hectare**
A02	29.59	0.0557	279
A04	9.57	0.0180	90
A05	68.35	0.1287	644
A06	34.17	0.0644	322
A07	24.07	0.0453	227
A08	38.49	0.0725	362
A09	55.00	0.1036	518
A10	38.46	0.0724	362
		Average metric tons of carbon per hectare across all eight sites	351 tons/hectare

Since it was determined that forests similar to the Cofán Bermejo Reserve store approximately 200 to 300 metric tons of carbon per hectare (tons C/ha) in the aboveground biomass alone, for the purpose of further analysis of a REDD project in the Cofán Bermejo Reserve, we conservatively assume the Cofán Bermejo Reserve stores an average of 250 metric tons C/ha in both the aboveground and belowground biomass.

Although these carbon storage estimates from the literature and limited field samples will aid in understanding the significance of the GHG mitigation potential that the Cofán Bermejo Reserve provides, they are only useful when verified by more in-depth field surveys and remote sensing data. Before implementation of a REDD project, we recommend that extensive and focused field surveys be conducted to better estimate the overall biomass and carbon storage potential of the Reserve. This data can then be combined with advanced remote sensing vegetation data to get an accurate representation of the existing carbon stocks within the Cofán Bermejo Reserve (Sala et al. 2000).

3.2.3 Deforestation and Degradation

Analysis of Deforestation within the Cofán Bermejo Reserve and Similar Forests

The VCS *Standard Tool for AFOLU Methodological Issues* states that three different types of deforestation types are eligible for inclusion in REDD projects.

These deforestation types include planned deforestation, frontier deforestation, and mosaic deforestation. Planned deforestation is where forested lands are cleared for extraction of resources (such as logging, mining, oil development), while frontier deforestation is deforestation caused by the development of infrastructure (such as roads, etc.). Finally, mosaic deforestation is where human populations and the associated infrastructure (towns, roads, etc.) and agricultural activities spread into accessible areas, resulting in clearing of forested lands. The VCS requires a REDD project to assess the current rate of mosaic and frontier deforestation occurring within and outside the project area in addition to any planned deforestation that may occur in the future (VCS AFOLU 2008).

In order to determine if deforestation is currently occurring or will likely occur in the future within the Reserve, comparative studies and satellite imagery were used. This allowed us to develop a baseline deforestation rate that would occur within the Reserve without the implementation of a REDD project.

Deforestation Assessment

During a rapid biological assessment of the Cofán Bermejo Reserve in 2002, Pitman et al. (2002) observed that the area was remarkably well preserved. Likewise, during the limited field study conducted within the Cofán Bermejo Reserve in July 2008, it was noted that the Reserve appeared relatively untouched without signs of extensive anthropogenic deforestation. The Reserve is currently home to only approximately 136 residents who have minimal impact on the park. These residents use the park mainly for hunting, fishing, and subsistence agriculture (Borman, In litt. 2009). Overall, of the 55,451 hectares within the Reserve boundary, less than 200 hectares are under direct human use (0.36 percent of the total land area), and it is unlikely that Cofán use will expand significantly (Borman, In litt. 2009).

In order to analyze general trends in vegetative cover and assess the likelihood that anthropogenic deforestation is occurring, satellite imagery was used to assess changes in percent tree cover. This analysis utilized satellite imagery from the MODIS Vegetation Continuous Fields (VCF) annual data product (MOD44B),[11] a base map of the Sucumbíos region,[12] and a digital evaluation map

[11] The VCF product provides global images of percent tree cover at a moderate spatial resolution of 500 meters averaged over a year. By creating a dataset that is an annual average, the VCF product can negate the effect of an obscured image due to cloud cover and reduce the effect of temporary changes in forest cover. However, because this dataset is averaged over the year, it is not possible to distinguish an exact date when the forest cover decreased. Additionally, if the percent tree cover decreases dramatically towards the end of the year, due to the annual averaging of each location within the dataset, the VCF image may understate the severity of the change. Finally, due to the moderate resolution of the VCF product, it is not possible to discern changes in small patches of land. Therefore, while this dataset can provide general trends, it

(DEM) of the Cofán Bermejo Reserve. Using this data, maps were developed showing the change in percent tree cover within the Reserve from 2000 to 2005. Our analysis found that the Cofán Bermejo Reserve experienced a 4 percent increase in percent tree cover over the whole Reserve from 2000 to 2005. Further analysis, however, revealed that the majority of the change occurred within the western montane region of the Reserve (Figure 6). Therefore, for the purpose of analysis the Reserve was split into in two regions; the western montane region and the eastern plains region. The division between the two regions was made roughly along the along the 1,000 meter elevation contour within the Reserve (Figure 7) which includes all areas 1,000 meters above sea level.

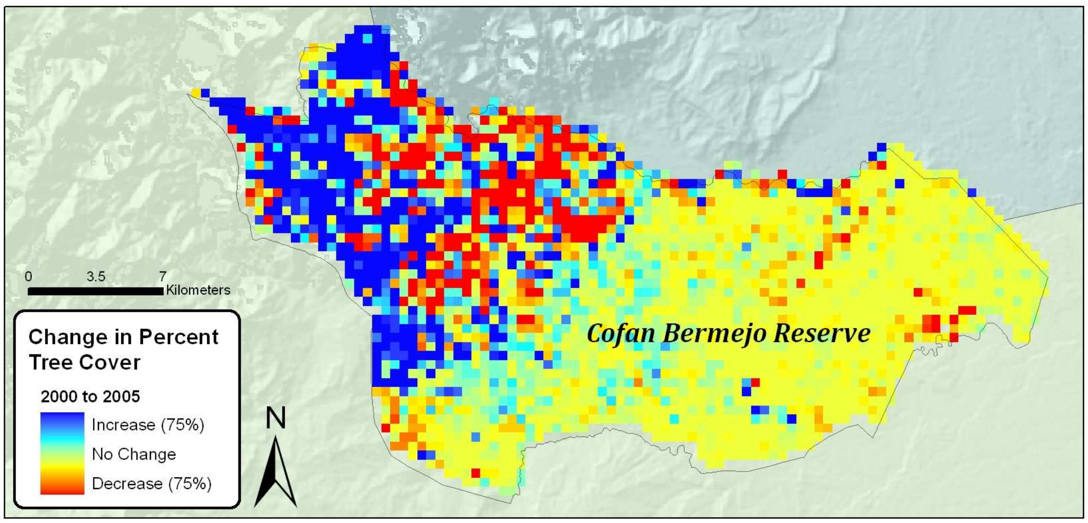


Figure 6: The change in the forest tree cover between 2000 and 2006 is represented in this image. Dark reds represent a decrease in tree cover between the years while dark blues represent an increase. Between 2000 and 2005 there was an overall increase of 4% in the percent tree cover

In evaluating the two regions of the Reserve separately, it was discovered that the eastern lowlands of the Reserve experienced a 1.7 percent increase in tree cover while the western montane region saw a 9.7 percent increase between 2000 and 2005 (Table 3). Furthermore, the montane region experienced large swings in percent tree cover from year to year. Because of the lack of road access and the roughness of the terrain in the montane region, the observed change in percent tree cover within the mountains is unlikely to be anthropogenic in nature. Furthermore, a review of the literature and discussion with experts in the field also suggests that the changes in percent tree cover within this region are likely the result of naturally occurring landslides, which

does not have a high enough spatial or temporal resolution to be used to examine the Reserve at the necessary resolutions for a formal REDD analysis.

[12] The base map consists of international boundary, rivers, roads, cities, and oil and mining concession data files.

are known to occur frequently within the tropical mountains of Ecuador (Ohl 2004; Siviter, In litt. 2009).

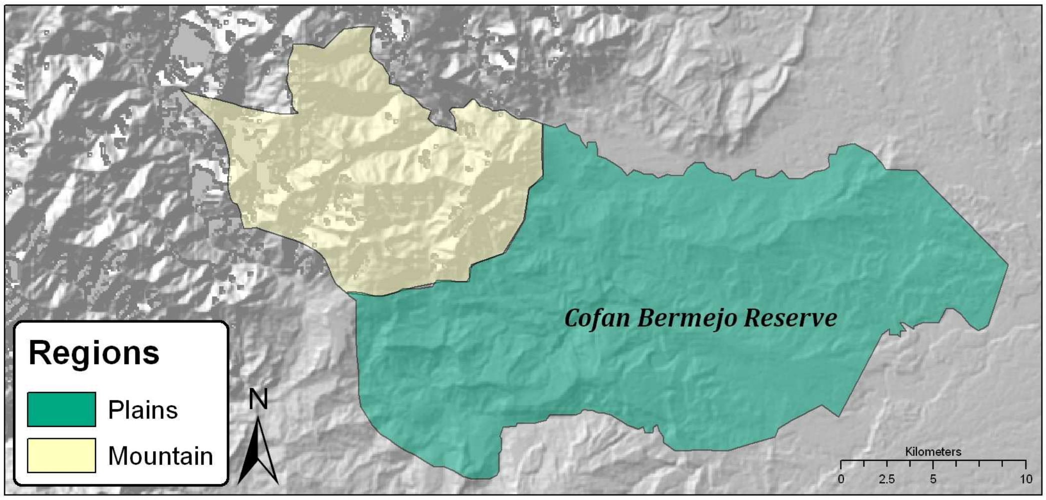


Figure 7: The plains region of the Cofan Bermejo Reserve (gold shaded region) experience much less change in percent tree cover from year to year in comparison to the montane region (grey shaded region).

Analysis of the plains region suggests that anthropogenic deforestation is not occurring on a scale large enough to be detected with medium resolution imagery. This analysis is based upon the relatively small observed change in percent tree cover between each year (Table 3) and the project team's fieldwork conducted during July 2008. Additionally, visual analysis of the unprocessed raw satellite images reveals no noticeable pattern of vegetation change, such as a fish bone pattern of clearing along roads, which is usually associated with anthropogenic deforestation.

Table 3: Average Percent Tree Cover Change From time Period 1 to 2 (+ increase, - decrease)

Years Changed Occurred Between	Cofán Bermejo Reserve	Montane Region	Plains Region
2000 - 2001	1.2	1.9	1.0
2001 – 2002	3.3	13.7	-0.87
2002 – 2003	-2.5	-15.5	2.6
2003 – 2004	4.0	10.8	1.3
2004 – 2005	-2.0	-0.9	-2.3
2000 - 2005	4.0	9.7	1.7

While the satellite imagery and literature indicate that the Cofán Bermejo Reserve is not currently being deforested, the VCS guidelines state that deforestation does not have to be currently occurring within the project boundaries for it to be eligible for entry into a REDD market (VCS AFOLU 2008). In these cases a project must show that planned, frontier, or mosaic deforestation will occur within the Reserve in the future without the implementation of a REDD project. For planned deforestation, a REDD project must include government and landowner documents demonstrating that portions of the forested area will be cleared. For frontier and mosaic deforestation, a REDD project must utilize historical rates of deforestation based upon the rates occurring outside the project area (VCS AFOLU 2008).

The largest threat for planned deforestation within the Cofán Bermejo Reserve is from oil concessions occurring within and immediately outside the Reserve (Figure 8). As mentioned in Section 2.4, the Ecuadorian government has allowed the exploitation of resources within its national reserves and indigenous lands, and approximately 40 percent of Ecuador's economy is based on oil production. While there are no current plans to develop these concessions, there is a large incentive to continue finding and producing additional oil, and the likelihood of future development is high. However, because there are no current plans to develop within the Reserve, an estimate of the rate of deforestation based upon planned deforestation cannot be made at this time.

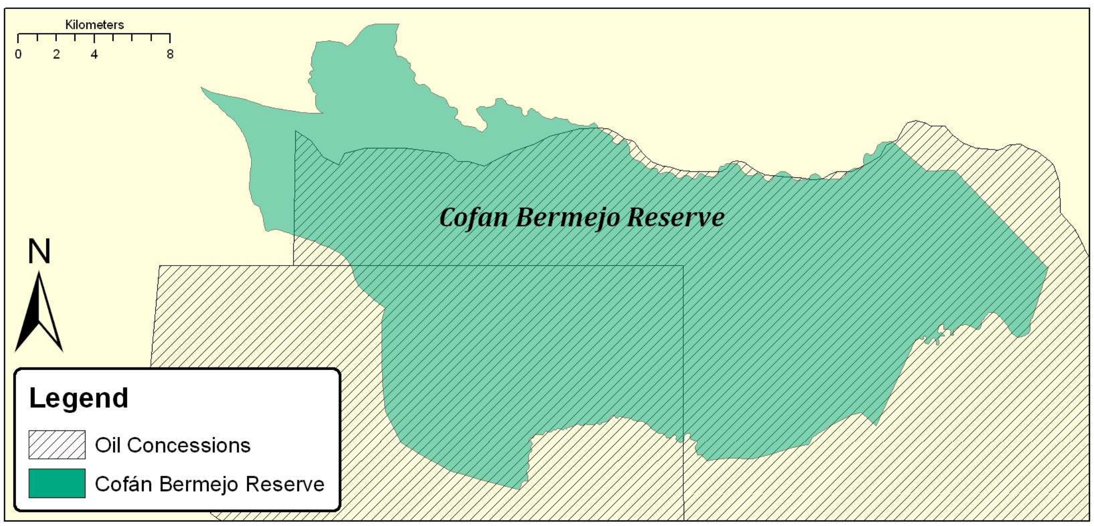


Figure 8: Oil concessions cover a majority of the land within the Cofán Bermejo Reserve.

In order to develop a baseline rate for mosaic and frontier deforestation, the VCS guidelines suggest that an annual rate of deforestation should be based upon the typical rate of deforestation due to a particular activity within a certain area (VCS AFOLU 2008). A literature review for the Neotropics, including Ecuador, revealed that the area experienced a deforestation rate of 2.93 percent per year between 2000 and 2005 (UNEP-WCMC 2008). Protected areas within this region were deforested at a rate of 0.79 percent per year over the same time period (UNEP-WCMC 2008; FAO 2006). At a country level, Ecuador had a deforestation rate of 1.7 percent per year from 2000 to 2005 (FAO 2006). Additionally, a Viña et al. (2004) study revealed that approximately 90 percent of the deforestation in the region followed the road networks associated with oil exploration and the subsequent colonization. Viña et al. (2004) calculated a

1.025 - 1.17 percent rate of deforestation per year (between 1973 and 1996) in the Sucumbíos Province, which includes the Cofán Bermejo Reserve. Studies have shown, however, that deforestation rates are generally lower within protected areas and therefore, mosaic and frontier deforestation within the Cofán Bermejo Reserve would likely occur at a rate lower than the rate observed in the Viña et al. study.

The montane and plains regions are likely to experience significantly different deforestation rates. Because of this, this project will exclude the montane region of the Reserve from the project for three primary reasons:

1. Oil concessions, which constitute the largest threat to the Reserve, are limited to the lower plains region;
2. The steepness of the mountain terrain makes it relatively unattractive to colonists and colonist expansion; and
3. Anthropogenic deforestation would be difficult to monitor in the highlands due to high natural turnover of biomass.

Thus, only the region of the Reserve east of the 1000-meter divider line (as portrayed in Figure 7) was evaluated for this project. This reduces the amount of area analyzed from 55,451 hectares to 37,800 hectares of forest. Additionally, this allows for a more accurate comparison of the deforestation rate to the Viña et al. study, which was conducted in the plains region of the Sucumbíos Province.

From this analysis, we conservatively estimate that a baseline deforestation rate of 0.5 percent would occur within the Reserve each year without the implementation of a REDD project. We believe that a strong case can be built to back up the 0.5 percent baseline estimate based on the following reasoning. This rate is considerably lower than the 1.025 to 1.17 percent deforestation rate observed immediately outside the Cofán Bermejo Reserve, which accounts for the fact that protected areas generally experience a lower deforestation rate than non-protected areas (Viña et al. 2004). Similarly, the 0.5 percent rate is lower than the 0.79 percent loss observed in protected areas in the Neotropics (UNEP-WCMC 2008; FAO 2006). However, it should be noted that this baseline rate is largely dependent upon the amount and extent of resource exploitation authorized by the Ecuadorian government and the rate of expansion of colonists into the region through urban and mosaic development.

3.2.4 Linking Carbon Loss to Deforestation

<u>Carbon Stock Lost due to Land Use Change</u>

The percent of initial carbon stock that is emitted into the atmosphere following deforestation depends on the type of land the forest is converted to. For instance, a study conducted by Houghton et al. (2005) found that an area converted from tropical forest to pasture land resulted in 90 to 100 percent of the vegetative carbon stock lost to the atmosphere while the conversion to secondary forests resulted in only 25 to 50 percent of the carbon being lost.

Within northeastern Ecuador (i.e., the Cofán Bermejo Reserve region), a survey conducted in 1990 found that nearly 90 percent of new settlers adopted a polyculture system that incorporated cash and subsistence crops. Due to the uniform rainfall and temperature year round, these settlers employed a slash and mulch system to clear new land for crops. While a majority of this land was dedicated to agriculture, some of the land also was cleared to provide pastureland (Pichon 1996). Houghton et al. (2005) found that forests converted to degraded croplands and pastures lose 60 to 90 percent of their carbon stocks to the atmosphere. If a REDD project was not implemented within the Cofán Bermejo Reserve, we assume that the most significant deforestation would result from the colonization and conversion to agriculture following roads constructed for oil access and exploration. Considering this expected land change pattern, we conservatively estimate that 60 percent of the total carbon stock would be lost to the atmosphere following deforestation within the Cofán Bermejo Reserve.

<u>Cofán Bermejo Reserve Carbon Storage & Expected Carbon Loses</u>

As noted in Section 3.2.3, this project will only examine the plains region for inclusion into a REDD based carbon trading scheme and as explained in Section 3.2.2, we conservatively assume the Cofán Bermejo Reserve stores an average of 250 metric tons C/ha in both the aboveground and belowground biomass.

Equation 1:

$$\begin{matrix}\text{Plains Region}\\ \text{Carbon Storage}\end{matrix} = \left[\begin{matrix}\text{Forest carbon}\\ \text{density}\end{matrix}\right] \times \left[\begin{matrix}\text{Available}\\ \text{Forested Land}\end{matrix}\right]$$

From this, it is estimated that carbon storage for the plains region of the Cofán Bermejo Reserve is 19.7 million metric tons of CO_2 equivalent (tCO_2eq).

Table 4: Cofán Bermejo Total Carbon Storage

Parameter	**Value**
Conservative forest carbon density (above and belowground carbon)	250 tC/ha (521 $tC0_2eq$/ha)
Available forested land (montane region only)	37,800 ha
Plains region carbon storage	19.7 million tCO_2eq

After the total carbon stored within the plains region has been estimated, it is then possible to examine the expected carbon losses if a REDD project is not implemented within the Reserve. With a baseline deforestation rate of 0.5 percent per year, 3,609 hectares of forest would be lost over twenty years. To calculate the expected carbon losses this project utilized Equation 2 below and the input parameters from Table 5.

Equation 2:

$$\left[\text{Expected carbon losses after 20 years}\right] = \left[\text{Forest Carbon Density}\right] \times \left[\text{Land deforested after 20 years w/o REDD}\right] \times \left[\text{Percent carbon stock lost from land use change}\right] \times \left[\text{Expected carbon losses after 20 years}\right]$$

Using Equation 2, this project estimated that the Cofán Bermejo Reserve would emit approximately 2 million tCO_2eq over twenty years as a result of a 0.5 percent baseline deforestation rate. This corresponds to approximately 10 percent of the total carbon stored within the plains region of the Cofán Bermejo Reserve and is equivalent to the carbon emissions of approximately 300,000 cars on the road for one year (USEPA 2000).

Table 5: Parameters for carbon losses without the Implementation of a REDD project

Parameter	**Value**
Conservative forest carbon density (above and belowground carbon stored within the biomass)	250 tC/ha (521 $tC0_2eq$/ha)
Land deforested after 20 years without a REDD project	3,609 ha
Percent carbon stock lost due to land use change (Houghton 2005)	60%
Baseline deforestation rate (Expected deforestation rate without a REDD project)	0.5%
Expected carbon losses after 20 years	2 million tCO_2eq

Avoided Deforestation Scenarios for the Cofán Bermejo Reserve

To determine the amount of carbon emissions that can be avoided with the implementation of a REDD project, three avoided deforestation scenarios were analyzed for this project, where 100 percent, 50 percent, or none of the expected baseline deforestation is avoided. These scenarios are discussed in further detail below:

Scenario 1 (No Deforestation): In the no deforestation scenario, the project is able to prevent 100 percent of the expected deforestation within the Reserve that would have occurred without the implementation of a REDD project. The project would avoid the emission of 2 million tons of carbon dioxide equivalent over the life of a 20-year project. This scenario depends on the ability of the Cofán people to develop an agreement with the Ecuadorian government to prevent the development of the oil concessions within the Cofán Bermejo Reserve during the twenty-year crediting period. As part of this agreement, we assume that no new roads are built in the vicinity of the Reserve and that the fortified Park Guard Program is able to prevent urban expansion, and the resultant frontier or mosaic deforestation, from encroaching into the Reserve.

Scenario 2 (Moderate Deforestation): In the moderate deforestation scenario we assume that a REDD project is implemented but only able to effectively prevent 50 percent of the expected deforestation. This reduces the expected annual deforestation rate (0.5 percent) to 0.25 percent area lost per year, resulting in 1 million tons of avoided carbon dioxide equivalent emissions. The deforestation in this scenario may have occurred because:

a) The project was unable to prevent frontier and/or mosaic expansion along the Reserve's borders but was able to completely prevent development of concessions within the Reserve;
b) The project was unable to prevent legal development of oil concessions but prevented illegal deforestation within the Reserve; or
c) The project was able to prevent some combination of Scenario 2a and 2b.

Scenario 3 (Business-As-Usual): In this without-project scenario, a REDD project is not implemented within the Reserve, and all of the expected deforestation occurs. This would result resulting in no avoided carbon dioxide equivalent emissions.

Table 6 summarizes the three scenarios considered in this feasibility analysis.

Table 6: Avoided carbon dioxide equivalent emissions under each scenario

Scenario	Avoided Emissions Over a 20 Year Project Period (tC02eq)
100% of the expected deforestation prevented	2 million
50% of the expected deforestation prevented	1 million
0% of the expected deforestation prevented	0

Potential Deforestation Scenario

Under the Cofán's stewardship agreement with the MAE, the Cofán people do not have the legal power to prevent the government from exploiting oil concessions within the Reserve (MAE 2002a, Ediciones Legales, Article 407-408). While the Cofán cannot prevent the government from developing the oil concessions, they can attempt to leverage international pressure to prevent the government from developing within the Reserve or negotiate an agreement with the government to not exploit the concessions during the twenty-year lifetime of a REDD project. It is entirely possible for the Cofán to negotiate an agreement with the Ecuadorian government to prevent oil exploration within the Reserve (Scenario 1, no deforestation), just as it is possible for the government to refuse to concede use of their oil concessions (Scenario 2, moderate deforestation). In actuality, hybrid agreements are entirely possible (i.e., the government would develop some of the Reserve area).

In effort to consider the range of options, we employ both Scenario 1 and 2 in our analysis of the overall feasibility of implementing a REDD project in the Cofán Bermejo Reserve. These scenarios represent best and worst case with REDD project scenarios.

3.2.5 Demonstrating Additionality

The discussion on the potential for carbon loss due to deforestation, leads to the analysis of whether protecting carbon stores within the Cofán Bermejo Reserve meets the requirements of additionality. Under the CDM, projects must demonstrate that a project activity provides carbon storage in addition to a business-as-usual scenario. CDM methodological guidelines exist for demonstrating additionality for afforestation and reforestation activities but do not exist for REDD projects. VCS, CCB and Plan Vivo standards require that REDD projects demonstrate additionality. Both the VCS and Plan Vivo standards provide guidelines that are similar in purpose and outcome. This additionality analysis was developed based on information provided in the step-by-step guidelines of the VCS standards.

The VCS guidelines have three possible tests (Project Test, Performance Test, Technology Test) to demonstrate that a project is in addition to business-as-usual. The Project Test is relevant to our project. The Performance Test and Technology Test are not relevant to the project as carbon sequestration through avoided deforestation is not an improvement of performance or technology. This feasibility analysis will go through the three steps of the Project Test which are 1) Regulatory Surplus, 2) Implementation Barriers, and 3) Common Practice.

Regulatory Surplus - Step 1 of the Test is titled Regulatory Surplus, where it is necessary to demonstrate that this project is not mandated by any regulatory framework (VCS 2008). While the Cofán Bermejo Reserve is recognized as an ecological reserve by Ecuador, status designated by SNAP (previously discussed in Section 3.1.2), the reserve status does not mean that the forest is truly protected from threats of deforestation.

SNAP claims to be a "special and irreplaceable form of protecting ecosystems, biodiversity, and ecosystem services" (MAE 2002a). However, there is evidence of downfalls in this system. It has been accused of lacking ownership, leadership, and vision, and there are conflicting opinions within the program in regards to restricting or developing resource extraction within forests (World Bank Operations Evaluation Department 2002). More specifically, there are several categories of protected areas that determine the main objectives of the area and what activities are allowed. Many ecological reserves have a significant human presence and they will most closely correspond to a protected area which includes the exploitation of resources. And, areas that are considered to be a national strategic resource can be taken out of the SNAP system (Siviter, In litt. 2008b). The Cofán Bermejo Reserve is an ecological reserve, so it could also experience such resource exploitation (MAE 2002a).

In fact, oil concessions exist in the Reserve and mining concessions exist just outside the western border of the Reserve. The government of Ecuador has a history of allowing extractive activities to occur within reserves. The government has already drilled in several of its national parks, including the Sumaco National Park, the Cuyabeno Wildlife Reserve, and the Limoncocha Biological Reserve (Oilwatch 2000). Also, Los Ilinizas Reserve and Manglares Cayapas-Mataje Reserve experience serious threats despite their recognition as ecological reserves. Parts of the Manglares Cayapas-Mataje Reserve have been strongly altered by logging and the substitution of forest for crops and pasture (MAE 2007).

In Los Ilinizas Reserve, there is a noted lack of legal structure resulting in illegal extraction of timber and subsequent transformation of the natural ecosystem. Additionally, 109,278 ha of mining concessions exist within Los Ilinizas and mineral extraction continues. Mining can result in a wide range of negative impacts depending on the type of technology used (MAE 2007). These extractive activities within other ecological reserves throughout Ecuador demonstrate that the Cofán Bermejo Reserve is not immune to threats despite its status as an ecological reserve.

Furthermore, a lack of implementation of forest protection from governments throughout Latin America has been noticed and somewhat mitigated but from outside parties. Parks in Peril was a result of a partnership with The Nature Conservancy and various Latin American partners. This program was started because partners felt there was inadequate framework and lack of environmental legislation to safeguard protected areas. Because of the lack of framework and legislation, protected areas in South America were still being deforested and destroyed (The Nature Conservancy 2008b). World Land Trust is a US-based organization dedicated to providing resources internationally to conserve biodiversity. World Land Trust found it difficult to persuade the Ecuadorian government to protect habitat, so instead they purchased the Tapichalaca Reserve and hired park guards in 1998 (World Land Trust 2008). These two instances demonstrate a lack of government preservation of areas with high biodiversity, and protection does not occur until international efforts are made.

In addition to the loose definition of an ecological reserve, the government of Ecuador has a limited budget for protected areas. To guarantee the conservation and sustainable use of the Reserve, the administration, management, and control of the Reserve are the charge of FEINCE (MAE 2002a). For the Cofán Bermejo Reserve, this includes raising the funds necessary to protect the Reserve (the budget constraints of FEINCE are further discussed below in Implementation

Barriers). Conversely, in the United States, the government maintains reserves and national forests and the annual budget for the US National Park Service for 2009 is estimated to be $2.4 billion USD (NPS 2009).

While the Cofán Bermejo Reserve is protected under the SNAP program in an agreement with the Ministry of Environment, its protection is not guaranteed by the status. The Aceh Project in Indonesia is similarly positioned. A portion of the forest in that REDD program is recognized as a reserve by the national government (Aceh 2007). However, local governments of Indonesia have the authority to take the land out of reserve status and have a record of doing so (Aceh 2007). Because of the instability in the government, the Aceh forest is still considered regulatory surplus (Aceh 2007). Similarly, even though the Cofán Bermejo Reserve is mandated by the Ministry of Environment, the status of the Reserve could change at any moment. Because the reserve status of can be removed, it is arguable that the Cofán Bermejo Reserve does meet the requirements of Test 1: Regulatory Surplus.

Implementation Barriers - Test 2 of the Project Test requires demonstrating that there are barriers to implementing a robust forest protection system and such barriers could be overcome with REDD funding. In order to fully protect the Cofán Bermejo Reserve, there are investment, technological, and institutional barriers that must be overcome.

The first barrier to implementation is investment. Administration, management and control of the reserve are the responsibility of FEINCE. This includes running and operating the Cofán Park Guard Program which is recognized by the Ministry of Environment as a functioning body for the control and management of the protected area (MAE 2002b).

The Park Guard Program was established in 2002, with the purpose of providing surveillance and protection of the Reserve (MAE 2002b). Each month, 54 Park Guards, Cofán men and women, enter the forest to provide on-the-ground protection and management of all the Cofán territories (Dureno, Cayambe Coca, Zabalo, Rio Cofánes, and Cofán Bermejo) (FSC 2008, Virgilio 2008). Six permanent guard station teams and three five-person ranger teams perform a range of tasks including: clearing boundary trails, approaching would-be-invaders, and monitoring soil, groundwater and key species (FSC 2008). The Park Guards also have GPS and map reading skills (Siviter, In litt. 2008c). With these skills, the Park Guards cover by foot 400,000 hectares of land. The men and women receive refresher training courses annually (FSC 2008). In order to operate, the Park Guards are supplied with boots, sleeping bags, GPS systems, rain gear, machetes, and walkie-talkies (Siviter, In litt. 2008c). The current capacity of the Park Guard Program is not sufficient to effectively patrol the Reserve. It takes one Park Guard about one month to completely walk around the perimeter of the Reserve (Abbey 2008). Six guards can thoroughly complete all the tasks which are required of them and protect the forest.

The FSC has been responsible for recording and facilitating funding for all the costs of the Park Guard Program, and since 2007 has also been responsible for overseeing the costs of two MAE Park Guards in the Cayambe Coca Reserve. The Park Guard Program has an annual budget of approximately $400,000 USD (Siviter, In litt. 2008c). The funding to run the Park Guard Program comes mainly from applying for grants and requesting funding from international donors. The stream of funding is not consistent. However, consistent funding from a REDD project could help provide the extra financing necessary to have a robust program with sufficient supplies as well as human capital.

A robust monitoring program would include more Park Guards. This would not only create more jobs for Cofán men and women, but would help improve on-the-ground surveillance as well as remote sensing monitoring. An increase in funds could provide more supplies as well as provide more training for individuals. Furthermore, long-term monitoring of the forest would include detecting changes in the forest via remote sensing. Such monitoring would require regularly obtained, high quality, satellite images as well as the computer hardware and software to process the images.

A robust monitoring program would also have sufficient human capital. Human resources would be able to efficiently and effectively manage, administer and operate the forest protection program. By receiving payments for REDD carbon credits, the FSC and FEINCE could overcome a variety of investment, technological and institutional barriers.

Common Practice - The third step to demonstrating additionality is demonstrating that the project is not common practice in comparison with projects that have not received carbon finance. The Cofán Bermejo Reserve is the first instance in Ecuador where an indigenous group received stewardship over their ancestral territories (FSC 2008). While many areas in Ecuador are protected because the lands are ancestral territories of indigenous people, there are only a few areas in which the indigenous people have stewardship over the land. For example, the US Agency for International Development (USAID) is currently funding a two-year project which is helping the Cofán, Awa, and Waorani people of Ecuador establish conservation programs to manage and maintain their respective ancestral territories (USAID 2007). Funding from a REDD project would help maintain the project started by USAID as well as provide the investment necessary for long-term conservation strategies.

Even though this forest is a Reserve and the establishment of reserves is common practice in Ecuador, this case is exceptional because the reserve is stewarded by the Cofán people, who are financially responsible for the management of the Reserve. The development of a REDD project for the Cofán

Bermejo Reserve provides direct funding to an indigenous group to sustainably manage their ancestral territories. Other forestry projects are not so intricately linked between sustainable development, indigenous culture and ancestral lands. Therefore, this project and the establishment of reserves stewarded by indigenous people is not common practice in comparison with other forestry projects or reserves in the tropics.

Based on this analysis the Cofán Bermejo Reserve meets the requirements of the three steps (Regulatory Surplus, Implementation Barriers, Common Practices) of the Performance Test as outlined in the VCS. Based on the amount of carbon stored within the pools of the Reserve, the potential for deforestation and the subsequent loss of carbon, and VCS additionality guideline documents, it could be argued that the implementation of a REDD project for the Cofán Bermejo Reserve is in addition to a business-as-usual scenario. However, if an UN-sanctioned REDD program were established today, the Cofán Bermejo Reserve would not be considered Regulatory Surplus under the strict definition of additionality, because of its ecological reserve status.

3.3 Permanence

This section will analyze the longevity of the Cofán Bermejo Reserve as a carbon pool and the stability of its stocks, given the management and disturbance environment in which it occurs. Addressing permanence is an acknowledgement of the possibility of a reversal of carbon benefits from either natural disturbances such as fires, disease, pests, and unusual weather events; or from the lack of reliable guarantees that the original land use activities will not return after the project concludes (CCBA 2008b). Permanence is an important component to a REDD-based carbon project because without guaranteeing longevity of forest protection, exploitative activity could follow shortly after establishment of a REDD project. Thusly, the project is unsuccessful in protecting forests and their carbon stores.

3.3.1 Non Permanence Risk Assessment

One of the primary difficulties surrounding REDD projects is the potential for unexpected carbon loss. Paying to implement programs to stop or slow deforestation does not guarantee permanent storage of carbon in the forest: an unexpected forest fire can lead to an inadvertent loss of carbon stores, illegal logging can denude an area without approval from the land steward, or changing climate could alter the habitat structure for various project areas. Should carbon storage be lost inadvertently, both the investor and the carbon payment recipient could loose access to the carbon asset.

In an effort to mitigate for the risk of losing carbon storage, the VCS developed their *Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination*, which is designed to create a risk profile for each project. This tool, which is also recommended in the CCB Standards, takes a project through a step-by-step risk classification exercise to determine the likelihood of losing carbon assets. A higher-risk project would be asked to deposit a larger percentage of carbon credits into the AFOLU Pooled Buffer Account to cover potential losses.

For REDD Projects, the VCS AFOLU Risk Analysis Tool assesses the factors shown in Table 7 below, which has been filled out for the Cofán Bermejo Reserve (for more information please refer to the AFOLU Non-Permanence Tool, Tables 1 and 8). The assumptions behind each category are described below Table 7:

Table 7: Non-Permanence Risk Factors

Risk Category	Risk Level
General Project Risk	Low
Economic Risk	Low
Regulatory and social risk	Low
Natural disturbance risk	Low
Land Ownership/Land Management Type	Low
Technical Capability of Project Developer/Implementer	Unknown
Expected Net Revenue/Financial Returns	Low
Infrastructure and Natural Resources	Medium
Population Surrounding the Area	Low
Incidence of Crop Failure	Low
Project Financial Plan	Unknown
Overall Project Risk	**Low-Medium**

General Project Risk surrounds the potential for land disputes, and financial, technical or management failure, none of which are expected to pose significant problems should a Cofán Bermejo Reserve REDD project be implemented. As such, low general project risk is expected.

Economic Risk considers the risk of rising opportunity costs that cause reversal of sequestration and/or protection (VCS AFOLU 2008). Unless illegal logging pressure proved to be more than the enhanced Park Guard could handle, rising opportunity costs are not expected to impact a Cofán Bermejo Reserve REDD project. The fundamental tenants of REDD projects fall in line with the cultural desires of the Cofán people to manage their land for generations of long term security. As such, economic drivers are expected to create minimal project risk.

Regulatory and social risk addresses the risk of political and social instability. As with many Latin American governments, Ecuador has had its share of both. For example, the government has established ecological reserves, yet overtime, has allowed for the extraction of resources from those reserves (Section 2.4) It is not possible to predict how the government will act in the future. However, the contemporary government appears to be stable and amenable to environmentally based projects. Additionally, a REDD project would likely generate significant international notoriety with high potential to be sustained through potential political shifts. Thusly, regulatory and social risks have a low rating.

Natural disturbance risk considers the likelihood of a devastating fire, the risk of pest and disease attacks, risk of extreme weather events (e.g., floods, drought, winds) and geologic risk (e.g. volcanoes, earthquakes, landslides). No natural disturbance is expected to create a significant risk to the carbon stored within the Reserve. Recent studies indicate that increasing global temperatures associated with climate change may lead to decreased growth rates in tropical rainforest trees (Butler 2007a). This finding is contrary to the hypothesis that increases in atmospheric CO_2 will lead to higher net primary production and growth rates. In cases such as these, increased temperatures lead to a higher respiration rate for the vegetation and this subsequently may lead to decreased growth rates. For example, there could be as much as a 24 to 71 percent decrease in the growth rates for the vegetation in Panama and 54 to 95 percent decrease in the vegetation growth rates within Malaysia (Butler 2007a). However, like the future political situation, this component is difficult to predict and substantial analysis should be conducted to make a more strongly substantiated claim. Overall, the risk of carbon loss from all natural disturbances is low.

In addition to the general risk categories, the VCS AFOLU Risk Tool defines REDD specific risk factors in the Risk factors and risk ratings applicable to REDD projects table. Within the table, risk factor scoring is divided by project type: 1) avoided deforestation and 2) frontier deforestation or mosaic deforestation. As discussed in the deforestation Section (3.2.3), no deforestation is planned for Cofán Bermejo Reserve. Risk ratings for the Reserve are therefore carried in accordance with the frontier deforestation and mosaic deforestation ratings.

Land ownership/land management type. According to the Risk Tool, legally protected lands, such as the Cofán Bermejo Reserve, carry low to medium permanence risk. Because the Ecuadorian government owns the Reserve land, it has the power to rescind their agreement with the Cofán. This possibility expands the potential project risk from low to low-medium. However, the likelihood of the government rescinding their agreement with the Cofán appears to be low. The new Ecuadorian constitution highlights the inherent rights of nature and the environment and establishes the importance of allowing indigenous groups to maintain possession of their ancestral lands. In addition, the FSC and FEINCE have the institutional capacity to keep pressure on the government to ensure Cofán rights are maintained, and a REDD project would bring international recognition to the Reserve. With these factors in mind, there is a low risk of carbon loss from unstable land ownership.

Should a REDD project be established in the Reserve, there would be a very low risk of unexpected carbon loss from poor management, as the Reserve is stewarded by indigenous people with an expressed interest in the long term sustainability of the forest. The Cofán have successfully managed the forest and its resources for hundreds of years, and there is no reason to doubt that this success will continue with proper funding. Thus, considering the land ownership and management realities surrounding the Cofán Bermejo Reserve, there is a low risk of losing carbon to uncertain ownership and management.

The *Technical capability of project developer/implementer* is currently unknown, however, it is expected that experienced project developers would be included in the REDD project design phase. As such, this section raises no red flags.

Net revenues/financial returns to ALL relevant stakeholders. As a whole, net revenue and financial returns from a REDD project would be higher than the current situation. At the very least, REDD funds would pay for an expanded Park Guard Program which would fund more Cofán workers. Although Cofán living within the Reserve may not see an increased income if a REDD project were implemented, they would directly benefit from additional security for their ancestral territories, which may be considered more useful; the Cofán living within the Reserve only engage in limited trade with the outside world. As such, the expected finances from a REDD project would help to create a low risk environment.

Infrastructure and natural resources. There is a possibility of new roads or rails being built near the REDD project boundary to facilitate oil exploration. The Cofán have no interest tied to oil: they do not own the rights to the oil resources within the Reserve, the government does. Even though the Cofán steward the Reserve, the government controls whether or not oil exploration occurs within Reserve boundaries. As discussed in the deforestation Section (3.2.3), oil related revenue provides for approximately 40 percent of Ecuador's economy, and in the past Ecuador has allowed oil drilling to occur within Reserves.

The fact that Ecuador controls oil exploration and has allowed drilling to occur within Reserves in the past creates a potentially tenuous situation. At least three lines of reasoning may be used to address this potential problem. First of all, should an internationally recognized REDD project be implemented in the Reserve, Ecuador may be less likely to pursue oil within its borders. Second, Ecuador could become an active participant in the project and agree to forgo any drilling or exploration within REDD project boundaries. Third, the Park Guard Program can be used to prevent colonist expansion should oil exploration roads open access to the Reserve. As discussed earlier, when considering oil exploration in the Sucumbíos region of Ecuador, colonist expansion serves as the primary deforestation driver. Of these scenarios, the Cofán only have potentially direct control over colonist expansion. An effective Park Guard Program can reasonably be expected to prevent this expansion, and therefore the majority of deforestation related to oil explorations and exploitation. Considering this, along with the potential for increased access to the Reserve, infrastructure and natural resources creates a medium risk to long-term carbon security.

Population surrounding the project area: Currently, the area directly surrounding the project area supports low population density as defined by the Risk Tool (e.g., <50 people/km^2). This qualifies as low risk. However, as oil exploration expands, population, densities around the Reserve may increase. As such, this component may need to be revisited in the future.

Incidence of crop failure on surrounding lands from severe droughts, flooding and/or pests/diseases. Crop failure on surrounding lands is generally expected to increase pressure on the project area. However, the lands surrounding the Reserve are under only minimal, if any, cultivation. Thus, at this point in time, even if crop failure occurred, other, non-Reserve areas could serve to buffer against increased agricultural pressure. Regardless, crop failures are expected to be infrequent (<1 in 10 years as defined by the Risk Tool), which qualifies as low risk.

Project financial plan. The financial plan is unknown but is expected to be designed as a low risk project with a comprehensive long-term financial strategy.

In order to earn full VCS certification, a more in depth risk analysis would need to be created to defend these qualitative, judgment-based assessments. The above analysis utilizes a back-of-the-envelope type assessment to show that if a REDD-based project were designed properly in the Cofán Bermejo Reserve, it could potentially be rated as a low risk project. If a Cofán Bermejo Reserve project were to receive VCS validation and verification, two independent project reviewers would need to agree on an appropriate risk rating. As such, substantial effort would need to be made to convince the reviewers of a low risk rating so that the maximum amount of carbon credits would be available to sell.

The VCS recommends a 10 percent buffer pool for low risk projects, and a 10 to 30 percent buffer for medium risk projects (Table 9, VCS AFOLU Non-Permanence Tool 2008). In other words, should a project qualify as low risk, 90 percent of the generated carbon credits would be available for sale and 10 percent would be placed into the VCS AFOLU Pooled Buffer, which serves as a carbon insurance pool. Thus, at best, the Cofán Bermejo Reserve would bank 10 percent of the carbon credits in the Reserve in the AFOLU Pooled Buffer to protect against potential unexpected losses. For the purposes of this feasibility study, it is assumed that a Cofán Bermejo Reserve REDD project would be a *low to medium risk* project.

3.3.2 Long term Monitoring

The success, or permanence, of a REDD project can only be measured if effective long term monitoring is implemented and maintained. This monitoring comprises a critical component of any REDD project: recorded carbon stores within the forest need to be continually updated and verified to ensure that any REDD-based carbon credits sold on a carbon market are backed by actual carbon. Should forest area be lost to natural or human causes, available carbon credits would be adjusted accordingly.

Necessary monitoring falls into two categories: remote sensing and field measurements. With additional funding and training, the existing Cofán Park Guard Program can easily be adapted to incorporate carbon related field measurements and observations. Until refined REDD-specific field guidance manuals are published, the techniques introduced in Section 3.2.2 and further described in Appendix B are most likely to be employed. Similarly, the remote sensing methods outlined in Section 3.2.3 and further described in Appendix C would be utilized on a semiannual, annual, or biannual basis to observe general forest trends.

Monitoring requirements vary by standard, and monitoring plans can generally be tailored to meet the needs of each project. The VCS requires a plan for the frequency of monitoring and reporting based on the standards outlined in the International Organization for Standardization (ISO)Greenhouse Gases code, which were not purchased for the purpose of this report[13] (VCS 2008). The CCB Standard states that a project should develop a full monitoring plan within six months of the project start date, or within twelve months of validation against the Standards, and should be re-verified at least every five years (CCBA 2008b). The Plan Vivo Standard requires projects to submit reports each year before November 5th (Plan Vivo 2008).

Changes in carbon stocks and emissions can be monitored using remote sensing data and field measurements (Gibbs et al. 2007). Using a stratified spatial design that combines extensive field measurements with remote sensing for deforestation and carbon stock estimates, it is possible to estimate both past, present, and future changes and carbon emissions within the project area.

Regardless of the monitoring plan, should a REDD project be pursued, stewards of the Cofán Bermejo Reserve should expect to perform regular monitoring functions, which will be used to ensure ongoing project value.

3.3.3 Strategies to Mitigate Potential Reversals

Land-based carbon projects often face the threat of potential reversals of carbon benefits either during the project or following completion. These projects have a goal of reducing deforestation, but the threat of increased deforestation is still possible, and could reach even higher levels without mitigating potential reversals or developing a monitoring system to guarantee prevention of deforestation. Such activity would result in impermanence of this project and

[13] Please refer to ISO 14064-2:2006 for further detail

needs to be handled in order to address the permanence requirement of the CCB guidelines for carbon projects. Sources of possible reversals include an increase in deforestation through natural disturbances or through human activity. Some mitigation strategies to prevent such reversals have been identified in the CCB Project Design Standards and include non-permanence risk assessments, establishing contingency carbon credits, and conservation easements (CCBA 2008b).

As previously mentioned, *non-permanence risk assessments* are used to create a risk profile for proposed REDD projects. The results from this assessment determine how many carbon credits must be designated to compensate for potential carbon losses over time.

Contingency carbon credits would only allow parties to possess carbon credits if certain requirements were followed. This could be a powerful tool in limiting permitted activity while still benefiting from carbon credits.

Conservation easements are legal agreements between landowners and the government that limit the possible uses of the land while still guaranteeing ownership and ecological value of the land. This agreement often limits the types of development allowed on the land. In the United States, conservation easements have proven successful in protecting millions of acres of wildlife habitat and open space while maintaining private ownership of the land (The Nature Conservancy 2008a). In this case, conservation easements could guarantee ownership of the forested land but restrict certain land-use activities including deforestation and development.

The Aceh Project implemented an adaptive management program to ensure success of the project as certain elements including climate change and political situation may change over time. The project also implemented various monitoring techniques, including use of GIS and a joint community-ranger forest monitoring program among others (Aceh 2007). Similar efforts, including those described previously, could be utilized in the Cofán Bermejo Reserve to further ensure permanence of this project.

Based on our analysis of the non-permanence risk factors, this component is not expected to hinder REDD participation. The risk of non-permanence is low to medium. Furthermore, this risk can be addressed in the development of a PDD.

3.4 Assessing and Managing Leakage

Leakage occurs when REDD project activities result in the displacement of deforestation to areas outside the project area (VCS 2008). Analysis for addressing leakage examines if the implementation of a REDD project in the Cofán Bermejo Reserve results in carbon emissions from alternative areas or other forests (protected or unprotected). To avoid leakage, the project design should consider where potential sources of leakage might originate from and design accordingly. Furthermore, if there is an increase in CO_2 emissions as a result of implementing a REDD project, these potential sources of emissions should be assessed, minimized, monitored and accounted for when estimating net emission reductions (VCS 2008, CCBA 2008b).

3.4.1 Sources of Leakage

For this leakage analysis, there are two paths of consideration: the threats of deforestation and activities that result in deforestation. In this analysis these two aspects of leakage are evaluated separately. The Leakage Tree, found in the Sourcebook for Land Use, Land-Use Change, and Forestry Projects published by the BioCarbon Fund and Winrock International, was used to address deforestation activities that result in leakage. According to the Sourcebook, there are three types of activities that cause leakage: activity shifting, market effects, and super-acceptance.

Activity Shifting occurs when an activity is restricted from occurring within a project area to reduce emissions. However, if this activity is simply displaced to an area outside the project boundary, emissions are not actually reduced and the benefits of the REDD project are not realized. Potential drivers of activity shifting are illegal logging, illegal grazing, land grabbing, and mining (Juma PDD 2008). Currently, the Cofán primarily use the forest for subsistence and have not participated in these activities. And, the Cofán have demonstrated long-term sustainable use of the forest. Similar to the Juma Project, activity shifting of the Cofán people is not expected to occur within the Cofán Bermejo Reserve because these drivers are not occurring.

Market effects occur when restricting an extractive activity to reduce emissions causes a decrease in supply of a product. As a result, the market price for the product increases and encourages other suppliers to increase their rate of extraction. Ultimately emissions occur in an area outside the project boundaries and can negate additional emissions generated from the implementation of a REDD project. Market effects are associated with the extraction of forest products and provision of forest services such as timber harvesting. Extractive activities are not currently occurring within the Reserve as the Cofán are sustainable users of the land. A market effect is not expected to occur for the Cofán Bermejo Reserve.

Super-acceptance occurs when an alternative livelihood is created for the REDD project which is so successful that it draws in individuals from surrounding regions. This can result in either positive or negative emissions. Positive leakage occurs if the migrants adopt the new livelihood which is less carbon intensive than their former livelihoods and overall emissions further decrease. Negative leakage occurs when the migrants consume resources from the land and further emissions result.

Super-acceptance is a potential problem which should be addressed. A REDD project for the Cofán Bermejo Reserve could create new livelihoods for the Cofán people. An improved and more robust Park Guard Program would create more jobs resulting in a migration of additional Cofán into the Reserve. More people in the Reserve mean more reliance on the resources of the forest. This potential source of leakage can easily be addressed by creating guidelines to monitor and regulate migration into the Reserve. Additionally, the Park Guard Program typically employs Cofán from all the Cofán territories and migration may prove to be a minimal problem.

Conversely, job creation from the augmentation of the Park Guard Program within the Reserve would provide incentive for Cofán to continue living and providing stewardship for the forest. This will prevent the migration of Cofán seeking alternative livelihoods in areas where forest conservation is not a priority. Therefore, this project could result in positive leakage. Juma Project in Brazil, represents a similar situation where the project activities were expected to not only avoid offsite increases in carbon emissions, but actually add to carbon stocks by reducing deforestation outside the boundaries of the project. This observation of protected areas supporting reduced deforestation in surrounding areas has been observed in many parts of the Brazilian Amazon (Juma PDD 2008).

Emissions generated from the implementation of a REDD project is the final form of leakage to consider. This aspect is not listed in the Sourcebook but is necessary to consider in accordance with the CDM. The implementation of a REDD program in the Cofán Bermejo Reserve could result in additional carbon emissions generated. For example, if monitoring and surveillance activities require the use of vehicles or other activities that generate emissions, these emissions must be considered in the carbon accounting of a REDD project (CCBA 2008b).

The above analysis examined the deforestation activities that result in leakage. Below, the analysis is directed toward the threats of deforestation. While deforestation activities are not currently occurring within the Reserve, there are threats of deforestation to the Reserve. We want to examine if restricting the threats of deforestation will result in leakage. As previously mentioned (Section 3.2.3), oil concessions exist throughout the Reserve, posing a significant threat to the integrity of the forest. Additionally, deforestation as a result of encroachment on the Reserve would be prevented by a more stringent Park Guard Program with funding from a REDD project.

Restricting the threat of deforestation in the Reserve will not displace the threats elsewhere as the threats are already high throughout the country. If concession exploration is allowed, and the Reserve is not included, the threat of actual exploration will not increase elsewhere, rather it will prevent the entire area from being explored and thus carbon emissions are less than if the Reserve was open to oil exploration.

Pursuit of oil concessions and encroachment activity already occur at high rates and more easily outside the Reserve, so by preventing these activities within the Reserve, these pressures outside would not increase and activity shifting would not occur.

Ultimately, a REDD project for the Cofán Bermejo Reserve would focus on sustainable development and therefore would not overlook the need for sustainable livelihoods for the Cofán people as well as the long-term sustainability of the forest. Leakage will likely not be a significant concern for this project, and it may even result in positive leakage because of super-acceptance.

Many of these leakage concerns can be addressed through implementing specific policies and regulations. The Cofán themselves could address super-acceptance, but national policies would be necessary to address activity shifting and market effects. The science of evaluating leakage is not well developed and therefore a REDD Project Design Document for the Cofán Bermejo Reserve should carefully evaluate the impacts identified above (Pearson et al. 2005).

Leakage will likely not be a significant concern for this project because the Cofán have demonstrated long-term sustainable land-use practices within the Cofán Bermejo Reserve (MAE 2002a). There is little risk of the Cofán people leaking carbon benefits outside the project boundaries.

3.4.2 Managing the Leakage Zones

The development of a project design according to the current VCS RED standards includes establishing baselines for three geographic areas: a Reference Region, a Project Area, and a Leakage Belt. These three geographic areas would be used in a Project Design Document to address areas of leakage. According to the VCS RED Guidelines:

- The project area is the area delineated by the project's boundaries within the reference region where the project participants will implement activities to reduce deforestation;
- The leakage belt is the land surrounding the project area in which leakage is likely to occur. The leakage belt defines the area outside the project's boundary where project activities influence deforestation;
- The reference region includes the project area and the leakage belt. It is the analytic domain from which information about deforestation agents, drivers, and rates is obtained. (VCS 2008)

After defining these three geographic areas, a REDD project would thoroughly affect leakage.

3.5 Indigenous Cultural Consideration

The Cofán subsist off agricultural activity, fishing, native fruit trees, and various handicrafts from material found in the forest. Participation of the Cofán Bermejo Reserve in a REDD-based carbon market could lead to prohibition of certain extractive activity within the forest. If this restriction affects the Cofán way-of-life and their subsistence off the land, this could have a negative impact on the community and the preservation of Cofán culture.

3.5.1 Impact of Entering REDD Market on Life and Culture of Cofán

The VCS encourages appropriately designed projects that consider benefits beyond carbon sequestration and GHG mitigation (VCS 2008) including preservation of indigenous and cultural practices. ENCOFOR is an organization that is dedicated to maximizing the ability to create benefits for local environments and stakeholders through various carbon sequestration projects and other such benefits (a goal similar to this project) and can be used as a model in preserving Cofán culture. One case study within ENCOFOR is from the Ecuadorian Highlands region. This specific project was designed to reforest eroded areas and degraded grasslands from abandoned agricultural areas in the highland area. This reforestation endeavor depends on labor from the local indigenous Qichua tribe in return for income with the goal of alleviating poverty and increasing their quality of life. If successful, the positive results from this project for the Qichua will be four-fold: poverty alleviation, improved knowledge of forestry products, and more outside representation and acknowledgement, and eliminating threats to the forest (ENCOFOR 2008). ENCOFOR is making many efforts aimed at using carbon sequestration projects to alleviate poverty among local indigenous groups in Bolivia, Ecuador, Kenya, and Uganda (ENCOFOR 2008). However, policies to support these programs and ensure positive local impacts are necessary. Whereas this project has not yet reported on their results, their methodology can be a model for preserving the Cofán culture should a REDD project be implemented in the Cofán Bermejo Reserve.

REDD projects offer significant opportunities for habitat conservation by preserving the integrity of the forest and protecting ecosystem services available in the area (Brown et al. 2000). A REDD project for the Cofán Bermejo Reserve aligns well with Cofán priorities of protecting their ancestral lands. The funding generated from a REDD project would enhance the existing Park Guard Program and provide an economic incentive to continue the conservation efforts within Cofán territories. The benefits received would contribute to improved reserve management. A REDD project can also provide assurance that natural resources will remain available for subsistence and provision of essential ecosystem services (Brown et al. 2000).

Furthermore, an increase in economic opportunities for local communities is another co-benefit of implementing a REDD project. One of the goals of the FSC is to provide opportunities for education and employment of the Cofán people which allow the Cofán to continue their traditions and culture and provide for the basic needs of their families (FSC 2008). Well-designed projects must consider the economic viability of communities and they must contribute to sustainable long-term, locally driven economic development in and around the REDD project area (CCBA 2008b). Consideration of the economic incentives for local communities, at the very least, can serve as a means to better ensure a long-term protection of forests. Local communities, in many cases, have a tradition of living off the forest resources. If access to these lands is restricted in some way, projects must address the economic needs of communities to avoid negative impacts and to minimize the risk that local people will impact the forests outside the project boundary. In many cases, rural communities are subject to boom-and-bust forest exploitation cycles. Implementation of a REDD project can offer a steadier economic base for these communities. REDD projects have the potential to directly benefit local communities in comparison to international development assistance.

3.5.2 Potential Opportunity Costs

Opportunity costs, or opportunities forgone by choosing a specific action, would be implicit to any REDD agreement to maintain the carbon stores held within the Cofán Bermejo Reserve. If a REDD agreement were implemented, the Cofán would not be able to allow any activity that would result in a rise in deforestation. The potential opportunity cost associated with this restriction needs to be accounted for as the Cofán decide whether or not to pursue a REDD project. Foregone opportunities could potentially be more valuable than funding generated through REDD: the Cofán could loose the opportunity to harvest valuable resources from the forest, or their lifestyle may need to be altered to implement a project. It is however, unlikely that the Cofán would loose any significant opportunities with a REDD project in the Cofán Bermejo Reserve.

The Cofán already lead a lifestyle that is highly consistent with what may be required under a REDD agreement. Currently, tree harvest in the Reserve can be attributed to canoe and housing construction and small-scale agriculture for local consumption. This harvest takes place in and around the primary housing areas within the Reserve and is conducted to sustain the approximately 140 Cofán people living within the Reserve. A REDD project could be implemented so that no major lifestyle changes (with the exception of carbon monitoring activities) would need to be made. The Juma Project, introduced in Section 2.5.5 offers a salient example: resident areas necessary to sustain the indigenous tribes within the Juma Reserve are excluded from REDD accounting (Juma PDD 2008,). A Cofán Bermejo Reserve project could implement the same principles.

Two primary constructs prevent the Cofán from harvesting substantial material from the Cofán Bermejo Reserve. First of all, a deep conservation underlines the

Cofán tradition. The Cofán way of life encapsulates sustainable livelihood with a focus on preserving culture and resources for future generations. As long as the Cofán lineage (biologically and/or culturally related Cofán people) continues to exist and steward the Reserve, it is extremely unlikely they would choose to unsustainably harvest wood from the Reserve. Second, the Cofán do not own the Cofán Bermejo Reserve; they steward it. As such, in the event that oil is discovered, the Ecuadorian government would likely be the benefactor of any generated rents.

Nevertheless, if a REDD project is pursued, special attention should be paid to any potential lost opportunities that could be associated with the project. Reasonable sustainable population areas should be excluded from the REDD areas, just as the door should remain open to promote ecotourism, if possible. All of this should be weighed against the potential income generated through REDD carbon credits. Potential project income is estimated in the Cost Benefit Analysis in Section 4.0.

3.6 Conclusions of the Feasibility Analysis

Based on the analysis of the components within the feasibility framework, it is feasible to develop a REDD project for the Cofán Bermejo Reserve. However, participation in a carbon market is contingent on three main unknowns or factors. The first is the acceptance of a REDD program under the Kyoto Protocol, or a post-Kyoto agreement. If REDD is included in either climate treaty, the requirements to participate are unknown. If the current definition of additionality is used, the Cofán Bermejo Reserve would be excluded as its reserve status would not be considered regulatory surplus. This leads to the second factor; a voluntary market is more flexible and would be an agreement between two parties. On the voluntary market, a buyer could see the merits of protecting reserves in developing countries and could consider the Reserve in addition to business-as-usual. However, carbon emissions credits do not draw as high a price as carbon emission credits in a regulated market. Finally, the third factor that could restrict participation in a carbon market with a REDD project is the Ecuadorian government. It appears that the government is setting the political foundation to support a national-based system for the implementation of REDD projects and the trading of REDD carbon credits. However, the Ecuadorian government's actions have not clearly identified the potential for the Cofán to benefit from such a system. Support from the government that allows the Cofán to limit deforestation within the Cofán Bermejo Reserve and allows them to directly receive funds generated from participation in a REDD project would strengthen the feasibility of participation. Otherwise, without this government support, this project would likely not succeed. The Cofán should negotiate an agreement with the government should they choose to develop a REDD project for the Reserve.

It is important to note that if any of the components of the feasibility analysis—Ecuador's political climate, additionality, leakage, permanence, and indigenous and cultural considerations—are not fulfilled and/or would not promote a REDD-based carbon project in the Cofán Bermejo Reserve, then such a project could not be successfully implemented.

4.0 COST BENEFIT ANALYSIS

Assuming a properly designed Cofán Bermejo Reserve REDD project could gain the support of the Ecuadorian government, conceptually pass the requirements for additionality, permanence, and leakage, and allow the Cofán people to continue their way-of-life; one fundamental question remains: would pursuing a REDD project within the Cofán Bermejo Reserve make economic sense for the Cofán? To answer this question, it is necessary to estimate both the costs of implementing a REDD project and the potential revenue such a project would generate.

In what follows, this group project evaluates expected project implementation costs, quantifies the amount of carbon credits that could be created within the Reserve, and establishes baseline carbon market prices that would be necessary for the Cofán to break even on the project. To clarify, 'breaking even' includes paying for a fortified Cofán Park Guard Program, which would be a substantial improvement over the status quo and would sufficiently accomplish the goal of further protecting the forest. The Cofán are not necessarily looking to profit from a REDD-based project.

Before examining expected project costs and benefits, it is important to outline the fundamental assumptions relevant to this analysis. First, this group project assumes that the Cofán would pursue both CCB and VCS validation and verification for a REDD project within the Cofán Bermejo Reserve, in effort to signal to potential buyers that the project would be considered under the most robust and rigorous standard suite available. This would help establish high project credibility. Second, it is assumed that the project would take place over a 20-year project timeline, which is the minimum project length accepted under the VCS (VCS 2008). The minimum time commitment would allow the Cofán to potentially pursue greater returns in the future should regulated carbon markets accept REDD based carbon credits. Finally, for reasons described below, project costs were discounted annually at a rate of two percent per year and project benefits annually at a rate of six percent.

<u>Discount Rate Selection</u>

For a long-term study, discounting future costs and benefits allows one to consider and compare costs and benefits throughout the project life span in present day terms. In other words, a dollar today might be worth more than a dollar ten years from now and discounting the future value of money associated with a potential Cofán Bermejo Reserve REDD project allows us to compare future costs and benefits to present day money. As such, a high discount rate reduces the future value of money more than a low discount rate (Pearce et. al. 2006). The discount rate can have a significant impact on a study outcome.

Unfortunately, no discreet formula for determining an appropriate discount rate exists. Discount rates are justified on a case-by-case basis, generally using past project analyses to establish a reputable foundation. For starters, discount rates can be classified in two categories: private and social. Social discount rates, or discount rates used to represent the time preference of money for social projects, are generally lower than private discount rates (Ninan and Jyothis 2003). REDD projects, by nature, are long-term socially beneficial projects. As such, discount rates should fall in line with those used for other socially beneficial projects.

A number of social forestry projects, which account for benefits realized by both society and forest stewards for at least 20 years, have employed 3 to 6 percent discount rates in real terms to evaluate afforestation and conservation projects (Bojo 1990; Pearce 1992; Nadkarni et al., 1994 as cited in Ninan and Jyothis 2003). In particular, the Nadkarni et al. social forestry study incorporated discount rates of 3 and 5 percent (1994). Lykke E. Andersen (1997) conducted a close analogue to a Cofán REDD project by completing a CBA of Deforestation in the Brazilian Amazon. Discount rates of both 2 and 6 percent were used to compare the potential economic benefits of deforestation to the expected costs (Andersen 1997).

Based on the above-mentioned studies, discount rates of 2 and 6 percent for the Cofán Bermejo Reserve fall in line with existing social forestry projects. However, in effort to ensure robust results, this analysis uses two different discount rates at the same time. The relative low discount rate for costs (2 percent) conservatively estimates higher costs throughout the project. Conversely, the relative high discount rate for benefits (6 percent) conservatively reduces the value of expected future revenue. These different discount rates are chosen to provide a conservative overall estimate of both costs and benefits.

Project Implementation Costs

Many variables come into play when scoping project design and implementation costs, making it difficult to arrive at a reliable cost estimate. This analysis uses information from an existing REDD project, along with information from current practitioners and listed certification costs, to develop a plausible Cofán Bermejo Reserve REDD project cost estimate.

Selecting an Existing REDD Project as a Cost Estimate Foundation: As of February 2008, at least three projects had entered into voluntary, legally binding REDD based carbon trading agreements: the Noel Kempff Mercado Climate Action Project in Bolivia (2008), the Reducing Carbon Emissions from Deforestation in the Ulu Masen Ecosystem project, in Aceh, Indonesia, and the Juma Sustainable Development Reserve Project in Brazil. Noel Kempff, the largest of the three, was established in 1997; prior to the creation of voluntary REDD standards. Juma (2008) and Aceh (2007) were both designed for CCB approval, while Juma is seeking VCS verification.

Unfortunately, for the sake of quantifying expected project study and implementation costs, the time and money invested in each project varies widely, making it difficult to integrate all of the existing project costs into a reliable REDD project estimate. Each of the example REDD projects faced its own unique set of circumstances: political systems, local attitudes, socioeconomics, deforestation threats and REDD program knowledge vary from project to project. Rather than integrating costs associated with each project, this analysis incorporates costs from the project most similar to a potential Cofán Bermejo Reserve REDD project: The Juma Project in the Brazilian Amazon.

The Juma Project is used as the primary cost reference for a Cofán Bermejo Reserve REDD project for a number of reasons. First, like the Cofán Bermejo Reserve, the Juma Project is located in the Amazon. Second, the Juma Project was designed to obtain both CCB and VCS approval, similar to what is recommended for a potential the Cofán Bermejo REDD project. Third, Juma is the most recent project and the project documentation was completed and accepted by CCB in 2008 (VCS approval is pending). Fourth, similar to the Cofán Bermejo Reserve, the Juma Reserve supports resident indigenous people who depend on the forest for survival. Finally, although the Juma Reserve is over 10 times the size of the Cofán Bermejo Reserve at 589,000 ha versus 55,000 ha, it is the smallest of the example projects (Aceh = 750,000 ha; Noel Kempff = 1.5 million ha). Therefore, Juma Project costs and components, taken from the Juma Reserve Project Design Document (PDD), serve as the backdrop for Cofán Bermejo Reserve estimates.

In addition to cost estimates provided by the Juma PDD, this analysis relies on project design cost information provided by current practitioners, listed certification costs, and information provided directly by the FSC. Table 8 below presents the information used to establish expected 20-year Cofán Bermejo Reserve REDD project design and implementation costs. Unless otherwise noted, estimates are based on information provided by the Juma Project. Further information, focused on estimates that vary from the Juma Project is provided below the table.

Table 8: Estimated 20-year Project Design and Implementation for a Cofán Bermejo Reserve REDD Project

Category	One Time Cost (in USD)	Projected 20 yr Cost (in USD)	Notes
Planning and Implementation Costs			
Project Design and Development (PDD)	300,000		The PDD was based upon conversations with various practitioners. See PDD Cost **Table 9**.
Partnership Agreement Cost	30,000		Cost to find and develop a buyer.
Definition and regularization of land titles	12,000		Land Tenure Analysis, development of buffer zones, etc.
Verification/Certification Costs			
CCB Third Party Verification/Certification Costs	20,000		Current certification ranges from $5,000 to $40,000. Prices depend on project complexity and size (Merger 2008). This project choose $20,000 for the verification cost because the Cofan Bermejo Reserve is relatively small compared to existing REDD projects
CCB Third Party Re-verification Cost Year 5	18,115		See above. Verification costs assumed to equal certification costs. The verification cost of $20,000 was discounted at a rate of 2% over 5 years.
CCB Third Party Re-verification Cost Year 10	16,407		See above. The verification cost of $20,000 was discounted at a rate of 2% over 10 years.
CCB Third Party Re-verification Cost Year 15	14,860		See above. The verification cost of $20,000 was discounted at a rate of 2% over 15 years.
VCS Third Party Verification	30,000		Current certification ranges from $15,000 to $30,000 (Merger 2008). This project chooses $30,000 as a conservative estimate of cost.
VCS 2nd Third Party Verification	30,000		See above. VCS Requires two third party verifications.

Table 8 Continued

Category	One Time Cost (in USD)	Projected 20 yr Cost (in USD)	Notes
VCS Verified Emission Reduction Cost for Years 1 through 5	19,473		The VCS charges $0.04 per Verified Emission Reduction (VER) Unit (Merger 2008). There is a one to one ratio of VERs to each tCO2 emitted. The estimated number of VERs was based upon a low risk scenario, with an annual deforestation rate of 0.5%, where half of the deforestation was prevented.
VCS Verified Emission Reduction Cost Year 6	17,201		See Above. The cost was then discounted at a rate of 2%.
VCS Verified Emission Reduction Cost Year 11	15,194		See Above.
VCS Verified Emission Reduction Cost Year 16	13,421		See Above.
VCS Third Party Re-verification Cost Year 5	27,172		The verification cost of $30,000 was discounted at a rate of 2% over 5 years.
VCS Third Party 2nd Verification Year 5	27,172		See Above.
VCS Third Party Re-verification Cost Year 10	24,610		The verification cost of $30,000 was discounted at a rate of 2% over 10 years.
VCS Third Party 2nd Verification Year 10	24,610		See Above.
VCS Third Party Re-verification Cost Year 15	22,290		The verification cost of $30,000 was discounted at a rate of 2% over 15 years.
VCS Third Party 2nd Verification Year 15	22,290		See Above.

Table 8 Continued

Category	One Time Cost (in USD)	Projected 20 yr Cost (in USD)	Notes
Various Field Activities			
Stakeholder Meeting – Public Consultation	18,000		
Field Activities: on-site visits and social mobilization	18,000		
Workshop to introduce Program	21,000		
Community Meeting Year 5 (Present Value Cost)	5,434		Determine community needs; emphasize REDD goals. The initial cost estimate of $6000 is discounted at a rate of 2%.
Community Meeting Year 10 (Present Value cost)	4,922		Determine community needs; emphasize REDD goals. The initial cost estimate of $6000 is discounted at a rate of 2%.
Community Meeting Year 15 (Present Value cost)	4,458		Determine community needs; emphasize REDD goals. The initial cost estimate of $6000 is discounted at a rate of 2%.
CBR Reserve Mgmt Council Creation	12,000		The cost for the creation of the Cofan Bermejo Reserve Management Council was based upon the development of a similar council for the Juma Reserve.
Operational Costs			
Monitoring Costs			
Carbon Monitoring		588,650	Costs were based on Juma Project Costs . The cost of carbon monitoring for the Juma Reserve per year is likely to be cheaper because the Cofan Bermejo Reserve is 1/10 the size of the Juma Reserve. These costs were assumed to occur for each year of the project, but were discounted at 2%.
Deforestation Monitoring		524,392	Costs were based on Juma Project Costs . The cost of carbon monitoring for the Juma Reserve per year is likely to be cheaper because the Cofan Bermejo Reserve is 1/10 the size of the Juma Reserve. These costs were assumed to occur for each year of the project, but were discounted at 2%.

Table 8 Continued

Category	**One Time Cost (in USD)**	**Projected 20 yr Cost (in USD)**	**Notes**
Operational & Coordination Staff			
Park Guard Program		4,428,809	This estimate doubles the existing number of station park guards and team leaders and quadruples the number of patrol guards. Includes 8 stationary park guards, 16 patrolling park guards, 2 guard leaders, reoccurring infrastructure costs, equipment, uniforms, training, and Individual Park Guard Costs (salary, insurance, mobilization, medicine, and food).
Project Coordinator		200,142	Based on $1K/month salary
Project Assistant		120,085	Based on $500/month salary
Field Coordinator		200,142	Based on $1K/month salary
Field Assistant		120,085	Based on $500/month salary
GIS Technician		400,283	Based on $2K/month salary
Consultancies		196,217	Consultancy estimate taken directly from Juma Project Costs
Government Liaison		200,142	Cost for an additional part time employee to liaison with the Ecuadorian government. Based on $1K/month salary

	One Time Cost	Projected 20 Year Cost	**Total 20-year Project Cost (in USD)**
VCS Certification Only	699,248	6,978,945	7,678,193
CCB Certification Only	495,196	6,978,945	7,474,141
CCB & VCS Certification	768,630	6,978,945	**7,747,575**

Planning and Implementation Costs

A PDD defines the baseline, strategy, and merit of a REDD project. Because PDD preparation costs can vary significantly, we contacted four REDD practitioners to assess general project design document costs, in addition to reviewing the costs of the PDD for the Juma and Aceh Reserves. Table 9 below shows potential PDD costs based on VCS certification (Olander, In litt. 2009). The addition of CCB certification for added project benefits or developing new methodologies to establish a project case requires more work, and therefore expense.

Table 9: Potential PDD Cost (in thousands of US Dollars)

Baseline Cost Element	Low Estimate	High Estimate	Notes
VCS Certification	40	300	Range varies based on project complexity, available data, etc.
CCB Certification when developed jointly with a VCS Certification	10	20	Includes need to gather and account for additional social and biodiversity data
New Methodology		100	Considers need to new carbon counting methodology
Total Potential Cost	50	420	

A REDD project PDD for both VCS and CCB certification may cost between $50,000 USD and $420,000 USD. Table 10 lists available resources considered in this analysis that may reduce the total expected PDD cost. These resources are subtracted from the maximum PDD estimate of $420,000 USD to arrive at a Cofan REDD project PDD cost of $300,000 USD. Considering the fact that the Juma Reserve REDD project PDD cost $167,647, $300,000 USD can be considered a conservatively high estimate. In reality, a PDD for the Cofán Bermejo Reserve may cost much less.

Table 10: Estimating Potential PDD Cost

PDD Cost Estimate - Starting from Maximum Expected Cost (in thousands of US Dollars)		
Cost Element	**Cost**	**Notes**
Maximum PDD Cost	420	See Table 9
Subtract New Methodology Cost	90	Minimal methodology development anticipated
Subtract CCB Data Collection	10	CBR has a wealth of available biodiversity and social data
Subtract Need to Establish New Park Guard	40	Foundation for Park Guard scale up already exists
Subtract for Small Project Size	20	CBR is relatively small compared to existing REDD projects
Subtract for Relatively Static Baseline Carbon Estimate	10	Slightly less effort to quantify baseline carbon
Subtotal	250	Estimate aligns with other developing PDDs
Add Buffer for Unexpected Design Costs	50	
Total	300	

Validation/Verification Costs

This analysis assumes that a Cofán Bermejo Reserve REDD project would be designed for VCS and CCB certification and verification. Of course, the project could choose either set of standards in solidarity, utilize Plan Vivo Standards (which are discussed in the REDD Standards Section), or avoid certification altogether with the backing of a willing buyer. Avoiding certification is highly unlikely, as these certifications lend credibility to the project.

Two components comprise project approval: validation and verification. VCS and CCB treat project approval nomenclature slightly differently. For the sake of simplicity, validation takes place at onset of the project to ensure the project design lines up with the defined carbon, climate, community, and biodiversity standards. Verification occurs in subsequent years to ensure that the project meets its prescribed goals and expectations. Both standards require verification to take place at least every five years (VCS Program Guidelines 2008, CCBA 2008b). Each validation and verification costs money. Table 8 above presents both the price range and study assumptions associated with each component. It is important to note that the VCS requires two independent audits for every validation or verification conducted. Further, VCS charges 0.04 USD for every metric ton of CO_2 offset (VCS Program Guidelines 2008, Merger 2008). For the purpose of establishing a conservative project cost, it is assumed for this analysis that the maximum potential number CO_2 offsets would be issued.

Operational Costs

The Cofán Bermejo Reserve Park Guard Program costs are taken directly from the FSC Park Guard Program funding request submitted to the Ecuadorian Ministry of the Environment (MAE) for the Reserve. As of February 2009 this request for funding to support four station-based guards, four patrolling guards, and one team leader, was still awaiting a response (Siviter, In litt. 2008c). For the purposes of a REDD project, the following assumptions are made:

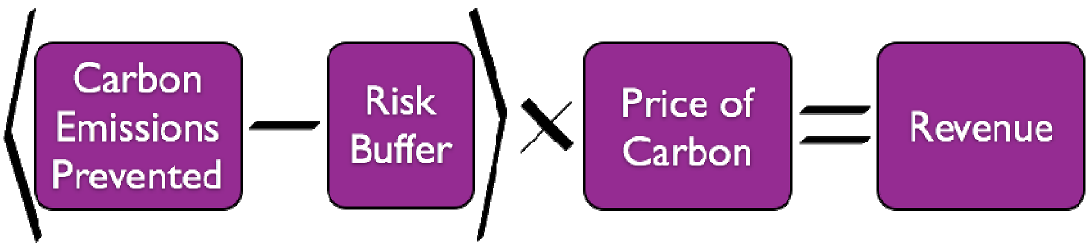
- Station based guard numbers would be doubled from 4 to 8 guards
- Patrol based guard numbers would be quadrupled 4 to 16 guards
- A park guard leader would be added, making a total of 2 guard leaders

All told, these additions would raise the number of park guards within the Cofán Bermejo Reserve from 9 to 26. Expenses are adjusted to include additional training and infrastructure costs, all of which are carried over the 20-year life of the project.

Additionally, this project recognized the need for additional personnel to provide administrative, logistical, and technical support. The costs to employ these positions were based upon likely salaries for employees in these positions according to Ecuadorian standards. As shown in Table 8, the total expected twenty-year project cost, with both CCB and VCS certification, is approximately 7.75million USD. It should be noted that this represents a conservative estimate, as many areas may prove to be less expensive.

<u>Benefits – Potential Carbon Market Revenue</u>

In order for the Cofán to sensibly enter into a REDD based carbon trading agreement, the money generated by the carbon credits would at least need to match the expected project costs to ensure that the expanded Park Guard Program and all REDD related expenses are met. To determine the revenue from the sale of carbon credits the following equation is used:



Carbon Emissions Prevented: Calculation of the amount of carbon emissions prevented by a project provides for the greatest amount of uncertainty in the above revenue equation. In an effort to deal with this uncertainty, conservative estimates are used for every value included in the analysis. Table 11 presents the calculated per hectare carbon emissions associated with deforestation in the Amazon. As discussed in Section 3.2.2, this calculation is based on the assumption that the Cofán Bermejo Reserve stores an average of 250 metric tons of carbon in each hectare of forest.

Table 11: Carbon Emission Assumptions

Potential Per Hectare Carbon Emissions	
Metric Tons Carbon/ha stored in biomass	250
Percent of biomass carbon stock lost to conversion of forest to degraded croplands and pastures (Houghton 2005)	60%
Avoided Carbon Emissions (tC/ha)	150
Avoided CO2 Emissions (tCO_2/ha) [Conversion Factor = 3.667 tCO_2/tC]	550
Avoided non-CO2 trace gas emissions* (tCO_2eq/ha)	27.5
Total avoided GHG emissions (tCO_2eq/ha)	578

***Emissions from deforestation include CO_2 and trace gases (such as CH_4 and N_20). Trace gas emissions account for an additional 5 to 9 percent above the direct CO_2 emissions from forest conversion. These numbers are based on deforestation and land use change in the Brazilian Amazon (Fearnside 1997). This analysis utilized the conservative 5 percent estimate.**

Section 3.2.3 of this document established the assumption that without a REDD project, deforestation would occur at a rate of 0.5 percent per year in the lowlands. The montane region of the Reserve is excluded from this CBA for three primary reasons: 1) oil concessions, which constitute the largest threat to the Reserve, are limited to lower areas; 2) anthropogenic deforestation would be difficult to monitor in the highlands due to high natural turnover of biomass; and 3) the steepness of the terrain make it relatively unattractive to colonists and colonist expansion. Thus, instead of including carbon values from all 55,451 ha of the Reserve, this analysis considers potential carbon loss from approximately 37,800 ha of forest. All told, if deforestation occurred at a rate of 0.5 percent year for 20 years, approximately 3,600 ha of forest, or almost 10 percent of available forested land, would be lost. This equates to approximately two million metric tons of CO_2eq emissions.

This CBA considers two REDD project deforestation scenarios: one in which the Cofán are able to stop half (Scenario 2 from Section 3.2.4) of the potential deforestation and the second in which the Cofán stop all of the potential deforestation (Scenario 1 from Section 3.2.4). These scenarios are combined with two risk scenarios to determine the quantity of carbon credits that would be available for sale.

Risk Buffer: A risk buffer basically serves as an insurance policy against unexpected carbon loss. The VCS maintains an AFOLU Pooled Buffer Account in which projects deposit credits to insure against any unexpected carbon loss. In other words, these credits are withheld from sale so that should an unexpected event, such as a fire, affect a defined REDD project, real carbon backed credits would still available for climate mitigation. The amount of credits each project sets aside for a risk buffer directly corresponds to the project risk rating. Projects with a high-risk rating are required to deposit a larger quantity of credits into the AFOLU Pooled Account to buffer for potential carbon loss when compared to a low risk project.

Based on the preliminary permanence assessment conducted in the feasibility analysis, it was determined that a Cofán Bermejo Reserve REDD project would likely qualify as a low to medium risk project (Section 3.3.1). Under the VCS, two independent reviewers would need to verify the risk rating and confirm the amount of credits that must be deposited in the AFOLU Pooled Buffer Account (VCS Program Guidelines 2008). The qualitative nature of the risk assessment presents an element of uncertainty. As such, both the low risk and medium risk rating scenarios are considered within this analysis. Low risk REDD projects must withhold 10 percent of available carbon credits from sale, while a medium risk REDD project is required to withhold 10 to 30 percent (VCS AFOLU 2008). For this analysis, risk buffers of 10 and 30 percent are considered.

Price of Carbon: Rather than speculate on the potential future price of carbon, this analysis highlights the break-even price point for a Cofán Bermejo Reserve REDD project. In other words, based on the revenue equation above, what price per metric ton of CO_2eq would be required to meet the projects expected twenty-year costs? Table 12 presents four scenarios that combine both low and medium risk ratings with the project preventing either 100 or 50 percent of the expected without REDD project deforestation.

Table 12: Break Even Price Points

Carbon Emissions Prevented				
Potential Carbon lost due to Deforestation	**Percent Carbon Loss Prevented**	**Risk Buffer**	**Break Even Carbon Offset Price ($/t$CO_2$eq)**	**20-year Revenue (in millions of USD)**
2 million tons of CO_2eq (0.5% deforestation per year)	100	Low (10%)	6.73	7.75
	50	Low (10%)	13.46	
	100	Medium (30%)	8.65	
	50	Medium (30%)	17.30	

Again, the break-even price would meet all of the operational expenses associated with implementing and maintaining a Cofán Bermejo Reserve REDD project. Any price above the break-even point would provide additional revenue to the Cofán. As shown in Table 12, the best-case scenario for the Cofán includes obtaining a low risk rating and the prevention of 100 percent of the potential deforestation, as this would maximize the amount of carbon available for sale.

Having developed the potential break-even prices points, it is now possible to consider the likelihood of retrieving such prices on the carbon market. As a general statement, carbon market prices have been volatile. Kollmus et. al (2008) provide a range of likely prices in their WWF Germany published "Making Sense of the Voluntary Carbon Market: A Comparison of Carbon Offset Standards" report. The report states that Voluntary Carbon Units (VCUs) issued by the VCS should trade anywhere from $6.50 to $19.50 USD per t$CO_2$eq and that offsets from CCB projects range between $6.50 to $13 USD per t$CO_2$eq (Kollmus et. al 2008). Additionally, a project with both VCS and CCB certification is likely to retrieve a price premium (Merger 2008). It should be noted that forestry projects tend to command prices on the higher end of the voluntary market price range (Hamilton et al. 2008 as cited in UNEP 2007).

As another point of comparison, the Chicago Climate Exchange (CCX), a voluntary U.S. based carbon market, has traded anywhere from $0.71 to $7.40 USD per t$CO_2$eq since the beginning of trading in December 2003 through February 2009 (CCX 2009). The EU ETS is most prominent existing regulated market that may open up to REDD credits in the future. Should REDD credits be accepted, they would likely trade as Certified Emissions Reductions (CERs), as defined by the Kyoto Protocol's Clean Development Mechanism. CERs are sold in the area of $18.20 to $39 USD per t$CO_2$eq (Kollmus et. al 2008).

As stated above, carbon market prices have been volatile over their short lifespan. For example, the CCX saw all time highs ($7.40 per tCO_2eq) in June 2008 and by November of the same year, was trading below $1 per tCO_2eq (CCX 2009). A wealth of creative solutions can be designed to protect the interests of both carbon sellers (i.e. the Cofán) and carbon credit buyers from potential price volatility pitfalls. One potential solution would establish both minimum and maximum prices can up front so that the Cofán are protected from the bottom end of price swings, and the buyer is protected from the top end of the market. These details would need to be worked out with any prospective buyer.

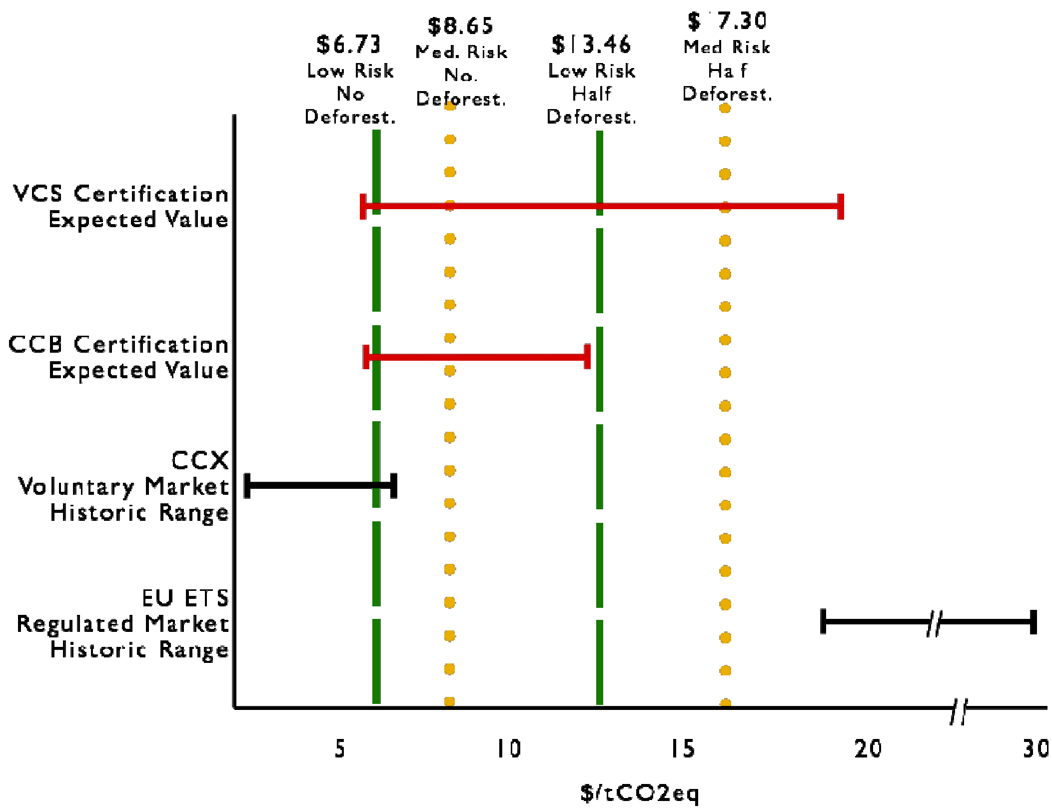


Figure 9: Expected and historic price ranges (dollars per metric ton of carbon dioxide equivalent) are represented with red lines for certification schemes (VCS & CCB) and black lines for existing carbon markets (CCX & EU ETS). Green dashed lines represent low risk scenario break-even price points; yellow dotted lines represent medium risk scenario break-even price points.

Figure 9 combines the range of expected and realized carbon market rates with the Cofán. This figure demonstrates that even a medium risk project that prevents only 50 percent of the expected deforestation may be financially viable in a voluntary market arrangement, and would almost certainly be viable within a regulated market context. Therefore, according to current rates, it is likely that a REDD-based carbon project does make economic sense and the Cofán could at least break even to support a more robust Park Guard Program. However, this is still highly contingent on external factors that determine the actual feasibility of implementing such a project. If a REDD project is in fact not feasible, the Cofán still have other options for generating a sustainable source of funding.

5.0 RECOMMENDATIONS AND ALTERNATIVES

5.1 Recommendations for Pursuing Carbon Market Participation

Based on the feasibility study and cost benefit analysis, it is potentially both feasible and economically beneficial for the Cofán to implement a REDD project for the Cofán Bermejo Reserve. Should the Cofán decide to pursue a REDD project, two options remain. First, they can wait for a regulated market recognized by the UNFCCC to accept REDD-based carbon credits, which would ostensibly increase the value of their carbon assets. Second, the Cofán can pursue immediate entry into the voluntary market rather than wait for an internationally mandated set of standards to be approved. There are both advantages and disadvantages to the two options.

If the Cofán decide to wait for a regulated market to accept REDD credits, the opportunity to gain more funding needs to be considered against the uncertainty of the specific regulations that would be constructed into an UN-sanctioned market. Furthermore, since these markets could take years to form, the Cofán would have to seek out other sources of funding until a regulated REDD project could be implemented to protect their forest and culture. All the while, threats and extractive activities would likely increase and continue both outside, and potentially inside, the Reserve boundary. With this decision, it is recommended that the Cofán align with organizations with similar interests for the upcoming climate change negotiations (December 2009 COP-15 in Copenhagen, Denmark) to help ensure REDD is included in post-Kyoto agreements. Specifically, the Cofán and allies should work to make sure that the definition of additionality, as applied to REDD projects, is adjusted to include the threatened reserves and protected areas of the developing world.

If the Cofán decide to enter into current voluntary markets, increased protection of the Cofán Bermejo Reserve could be realized sooner. However, they would likely not generate as much funding as they could from a regulated market. If the Cofán decide to pursue voluntary markets, they should design a project according to one or more of the three most widely accepted voluntary carbon market standards: VCS, CCB, or Plan Vivo. As noted earlier, the use of both VCS and CCB currently provides the most rigorous project review process, which would likely maximize both investor confidence and the carbon asset sale price (Merger 2008).

Whereas Plan Vivo is less recognized, it is nevertheless an option worth exploring for several reasons. First, it is a more accessible and less expensive option as initial certification costs are low. Unlike the VCS and CCB, verification costs are defrayed until the project is able to accumulate sufficient capital from carbon asset sales (Plan Vivo 2008). Second, the verification process allows a few years of flexibility because it is more of a learning process and information is passed on to the local indigenous people. Additionally, this set of standards is geared more toward small-scale projects within developing countries and looks at both biodiversity and carbon values, while empowering the locals to implement and receive payments directly for the project. Finally, Plan Vivo standards are one of the few that specifically offer the option for indigenous people to receive credits for the land in which they steward, even if they do not own the actual title to the land.

All things being equal, should the Cofán decide to pursue a voluntary REDD project, we recommend combining VCS and CCB certification over the use of Plan Vivo. Compared to Plan Vivo, the design and verification costs necessary to carry a project through VCS and CCB certification are high. However, the relative gains in carbon price could be substantial. That being said, carrying a project through VCS and CCB certification relies on significant upfront resources, which would most likely depend on the Cofán's ability to find a willing buyer. In the Noel Kempff project case, three energy companies invested upfront over the course of the first 10 years of the project in exchange for 51 percent of the future verified emissions reductions for the project lifetime (Virgilio, In litt. 2009). The Cofán could either aim to establish a similar relationship or apply for grant funding to get the project off the ground. If the Cofán are not able to find a willing upfront buyer or find sufficient grant funding to cover project development costs, Plan Vivo remains a viable option. Regardless, Plan Vivo should be explored in more depth before deciding on a final plan of attack.

There are a few factors that could potentially help or hinder the possibility for the Cofán to enter into a REDD-based carbon market, including the direction that the government decides to take economically, environmentally, and morally. There are some key factors that will have a large impact on the government's support for releasing the oil concessions within the Reserve in order to allow implementation of a REDD-based project within the Cofán Bermejo Reserve. These include whether or not the global economy continues toward crisis and how quickly our existing oil supply is depleted and how quickly alternative energy replaces the existing global oil and coal-based energy system.

If the Cofán decide to pursue either of these markets, support from the Ecuadorian government is crucial. The government both owns the title to the land and controls the oil and mining concessions within the Reserve, which presents a series of complications. First off, the fact that the government owns the Cofán Bermejo Reserve, but the Cofán have stewardship rights, raises questions about which institution owns the rights to the Reserve's carbon resources. The Ecuadorian government may or may not allow the Cofán to sell the Reserves carbon assets, or they may require a cut of the profits. Our review of the new Ecuadorian Constitution and other related government documents provided no answer to carbon asset ownership question. As discussed earlier, the primary threat to the Reserve stems from the potential for the government to allow oil concessionaires to explore either within, or up to, Reserve borders. While an improved Park Guard Program could prevent colonial expansion from the oil roads, the carbon stores within the Reserve would be much more secure with an agreement from the government to prohibit drilling within the Reserve. The government may require a cut of the carbon asset money in exchange for releasing the right to drill within the oil concessions in the Cofán Bermejo Reserve, which may prove to be expensive. Considering these complications, before proceeding with a REDD project, the Cofán need to gain government support prior to attempting to implement a REDD project within the Reserve and should establish an agreement with the Ecuadorian government as to how these matters will be handled.

5.2 Alternatives for Generating Funding

Should the Cofán decide to refrain from pursuing carbon market entry, there are other options available for generating funding to support their way-of-life and protect the Cofán Bermejo Reserve.

<u>Business as Usual</u>

Under the business as usual scenario, the FSC and FEINCE would continue to apply for grant funding to implement and maintain the existing Park Guard Program. As discussed in the Indigenous and Cultural Considerations section (Section 3.5), the current Cofán lifestyle remains in line with forest preservation. However, regardless of what the Cofán do within the Reserve borders, deforestation pressure is likely to increase in the future. Assuming fundraising can be maintained at current levels, this increased deforestation pressure would add stress to an already constrained budget.

<u>Carbon Based Alternatives:</u>

Bundling REDD Projects - The Cofán may be able to build a stronger case for a REDD project by bundling multiple territories (most likely the territories that may not qualify for Socio Bosque payments) into a bigger REDD project. Such an approach could potentially help the Cofán overcome potential shortfalls of the additionality argument for the Cofán Bermejo Reserve, as outlined in Section 3.2.5. Namely, under the strictest definition of additionality protecting carbon resources within a "reserve" would not qualify as additional to business-as-usual. In addition to having significant rates of anthropogenic deforestation, many of the other Cofán ancestral territories have not been granted reserve status within Ecuador, which could also aid the additionality argument, if necessary.

Socio Bosque - As previously noted, the Cofán Bermejo Reserve specifically does not qualify for Socio Bosque. However, the Cofán can maximize entry into the Socio Bosque program for other ancestral territories. As outlined in Section 3.1.2, Socio Bosque can provide *up to* $30/ha/year to a qualifying forest. So far, Socio Bosque prices are much less: the Rio Cofánes contract is worth what amounts to $1.63/ha/year. How does this compare to potential income from the carbon market?

Considering the assumptions made in the Cost Benefit Analysis (Section4.0), in the worst case scenario (i.e. no deforestation prevented in the lowlands) the Cofán Bermejo Reserve would lose an average of up to 1.54 tons of CO_2eq per hectare per year if no project were implemented. Assuming a REDD project in the Reserve stopped 100 percent of this deforestation (and earned credit for stopping 1.54tCO_2eq/ha) carbon would have to sell at a price of $19.42/t$CO_2$eq for the Cofán to earn the equivalent of $30/ha/year from Socio Bosque. To earn the equivalent of $1.63/ha, carbon credits would need to sell at $1.05/ t$CO_2$eq. While these numbers are not directly transferrable to other reserves, they can be used to make a ballpark comparison of a REDD project to Socio Bosque as the Cofán decide how to proceed with the management of their territories.

Afforestation or Reforestation - Although there is not currently a high rate of anthropogenic deforestation or a large amount of degraded land within the Cofán Bermejo Reserve, some of the other ancestral territories have large swaths of deforested or degraded lands that could be eligible for an afforestation or reforestation project. These forestry projects are currently accepted under the CDM of the Kyoto Protocol and as such, this could be an option for the Cofán to implement a lucrative UN-sanctioned project in the near future.

Biochar - The Cofán could also look into using biochar as an efficient active carbon sequestration technique that is compatible with other uses of the Cofán Bermejo Reserve. Biochar is emerging in the world climate change discussions as a potential solution to mitigating CO_2 emissions. Biochar is an ancient technology that has enormous potential to be used in sequestering carbon. Thousands of years ago, indigenous Amazonians used charcoal created through low-temperature pyrolysis (burning of plant biomass in the absence of oxygen) (Marris 2006). This process of pyrolysis converts the biomass into biochar, locking the carbon into a more stable, durable form with a mean residence time of 1,000 years (UNCCD 2008). Adopting the use of biochar into environmental management regimes has the double benefit of improving agricultural performance of the soil by improving the water and nutrient holding capacity of the soil (Marris 2006). Like REDD, biochar is not yet recognized under the UNFCCC but may soon become a viable climate change mitigation strategy.

Biodiversity and Other Ecosystem Services

Another alternative for generating income is to receive payments for ecosystem services. Ecosystem services are defined as ecological functions that sustain and improve human life (Daily 1997). There are four general categories of ecosystem services: provisioning, supporting, regulating, and cultural. Humans rely on ecosystems for many economically important and essential goods, including food, wood, clean water, and medicine. They can be considered life-support systems that purify our air and water, regulate the climate, and regenerate the soil fertility (Daily 1997). The Cofán Bermejo Reserve provides many critical ecosystem services, benefiting the indigenous Cofán people living in its proximity with food, medicine, clean water, and shelter. Furthermore, Ecuadorians as far away as Quito receive a large portion of their fresh water from the Cofán Bermejo Reserve and the adjacent Cayambe-Coca Reserve (The Nature Conservancy 2008b).

Norman Myers, a scientist known for his studies of biological hotspots, claims that Western Amazonia, including the Cofán Bermejo Reserve, "is surely the richest biotic zone on Earth" and "deserves to rank as a kind of global epicenter of bio-diversity" (Myers 1988, pp194). This area has been previously recognized as among the highest priorities for worldwide biodiversity conservation.

In 2001, a Rapid Biological Inventory of the Reserve was conducted by the Chicago Field Museum, in conjunction with the Cofán. The inventory estimates that the Cofán Bermejo Reserve contains a total vascular flora of 2,000 to 3,000 species, 150 of which are endemic to Ecuador alone (Pitman et al. 2002). It was estimated that this region has over 85 species of reptile and amphibian, 399 species of bird and 46 species of large mammal (Pitman et al. 2002). The Napo rainforest south of the Cofán Bermejo Reserve is considered "among the most biologically diverse and unique environments" (Mena et al. 2006, pp803).

With the significant biodiversity, climate-regulation contribution, and water provision services that the Cofán Bermejo Reserve provides, there is a good chance that there may also be opportunities for the Cofán to receive payments in exchange for conservation of these ecosystem services that are provided by this unique area (i.e. similar to a conservation easement). Such a payment system would ensure that these services are continuously provided. However, this concept has proven difficult to implement.

Marketing Sustainable Forest Goods

Lastly, it may be worthwhile for the Cofán to look into expanding their existing ecotourism programs and sustainable jewelry and craft sales to foreign markets in order to bolster more funding for the Park Guard Program. For example, with distribution to U.S. and European boutique stores, Cofán jewelry and other artisan products could fetch premium prices.

Concluding Thoughts

Land is threatened worldwide by development as a result of technological, political, and climate changes. Sustainable development is a great challenge as population, density, productivity, income, and consumption increase. As population grows worldwide, urban areas demand more resources for the increased health and well-being of many, but at the cost of land-use changes and degradation that negatively impact biodiversity and biophysical cycles (UNEP 2007). The integrity of the Cofán and other indigenous tribes depends on intact ancestral land with a healthy amount of biodiversity and intact biophysical cycles. As outlined in the GEO4 report, forests support local livelihoods by providing firewood, traditional medicines, and food (UNEP 2007). Urban populations also depend on these forest goods and services in even larger amounts and the increased demand of such goods and services results in land-use changes (UNEP 2007). Threats to the Cofán and their ancestral lands represent a microcosm of a greater societal tension: human quality of life throughout the world depends on both the extraction from, and preservation of, forested lands. The Cofán are in the position to both limit extraction and enjoy the quality of life they desire; they just need the resources to dissuade extraction. Regardless of the actions taken, threats to the Cofán way of life and their ancestral lands can only be expected to increase in the future.

The Cofán have many options for generating funding to protect their forest and sustain their way-of-life. Of the options mentioned above, a REDD project would likely generate the most funding considering a) the generally increasing value of carbon emissions, and b) the expected increased demand for viable carbon offset credits. However, of the options, a REDD project carries the greatest uncertainty and requires the most forethought, preparation, time, and initial investment. Considering the potential pay-off, we believe the Cofán have a strong enough case to warrant pursuit of a REDD project.

6.0 REFERENCES

[Aceh] The Provincial Government of Naggroe Aceh Darussalam. 2007. Reducing Carbon Emissions from Deforestation in the Ulu Masen Ecosystem, Aceh, Indonesia. In *A Triple-Benefit Project Design Note for CCBA Audit*, edited by F. F. International and C. C. P. Ltd.

Achard, F, R DeFries, H Eva, M Hansen, P Mayaux, and H-J Stibig. 2007. Pan-tropical monitoring of deforestation. In *Environmental Research Letters*.

Akanle, Tomilola, Asheline Appleton, Douglas Bushey, Kati Kulovesi, Chris Spence, and Yulia Yamineva. 2008. Summary of the Fourtheenth Conference of Parties to the UN Framework Convention on Climate Change and Fourth Meeting of Parties to the Kyoto Protocol: 1-12 December 2008. *Earth Negotiations Bulletin* (395).

Anderson, Lykke E. 1997. A Cost Benefit Analysis of Deforestation in the Brazilian Amazon. Rio de Janeiro, Brazil: Institudo de Pesquisa Economica Aplicada.

Anderson, Steven. 2004. The Mineral Industry of Ecuador. In *U.S. Geological Survey Minerals*: U.S. Geological Survey.

Australian Government Department of Climate Change. 2008. International Forest Carbon Initiative, March 9, 2009 2008 [cited November 11 2008]. Available from http://www.climatechange.gov.au/international/publications/fs-ifci.html.

Avery, Eugene Thomas, and E. Harold Burkhart. 2002. *Forest Measurements*. 5th Edition ed. New York, NY: McGraw-Hill Higher Education.

[ADP] Avoided Deforestation Partners. 2008. The REDD Methodology Project 2008 [cited 12/1/08. Available from http://www.adpartners.org/initiatives_redd.html.

The BioCarbon Fund. 2008. Methodology for Estimating Reductions of GHG Emissions from Mosaic Deforestation.

Bojo, Jan, ed. 1990. *Benefit-cost analysis of the farm improvement with soil conservation project in Maphutseng, Mohale's district, Lesothio; in Dixon*.

Edited by J. Dixon, D. E. James and P. B. Sherman, *Dryland Management: Economic Case Studies*. London: Earthscan Publications Ltd.

Bonham, Charles D. 1989. *Measurements for Terrestrial Vegetation*: John Wiley and Sons, Inc.

Borman, Randy. 1999. Cofán: Story of the Forest People and the Outsiders. *Cultural Survival Quarterly* 23 (2):1.

Borman, Randy. In litt. 2009. Email: More Questions from the Cofán. January 12, 2009.

Brewer, K. R. W., and Muhammad Hanif. 1983. *Lecture Notes in Statistics*. Edited by D. Brillinger, S. Fienberg, J. Gani, J. Hartigan and K. Krickeberg. Vol. 15, *Sampling With Unequal Probabilities*. New York-Heidelberg-Berlin: Springer-Verlag.

Brown, S. 1997. Estimating Biomass and Biomass Change of Tropical Forests: a Primer. In *FAO FORESTRY PAPER*: Forest and Agriculture Organization of the United Nations.

Brown, S., M. Burnham, M. Delaney, R. Vaca, M. Powell, and A. Moreno. 2000. Issues and challenges for forest-based carbon-offset projects: a case study of the Noel Kempff Climate Action Project in Bolivia. *Mitigation and Adaptation Strategies for Global Change* 5:99-121.

BSI Group. 2008. What is a standard? [cited December 22, 2008. Available from http://www.bsi-global.com/en/Standards-and-Publications/About-standards/What-is-a-standard/.

Bumpus, Adam G., and Diana M. Liverman. 2008. Accumulation by decarbonization and the governance of carbon offsets. *Economic Geography* 84 (2):127-155.

Burns, R.M., and B.H. Honkala. 1990. *Silvics of North America*. Vol. 1 and 2, *Agricultural Handbook 654*: USDA Forest Service.

Butler, R. A. 2007a. Higher temperatures slow tropical tree growth, global warming mitigation. http://www.mongobay.com.

Butler, R.A. 2007b. Amazon rainforest locks up 11 years of CO2 emissions. http://www.mongabay.com.

Capoor, Karan, and Philippe Ambrosis. 2006. State and Trends of the Carbon Market 2006. Washington, D.C.: International Emissions Trading Association and The World Bank.

Capoor, K., and P. Ambrosis. 2007. The State and Trends of the Carbon Market 2007. Washington, D.C.: The World Bank Institute.

Capoor, K., and P. Ambrosis. 2008. The State and Trends of the Carbon Market 2008. Washington, D.C.: The World Bank Institute.

Carbon Finance Unit. 2008. BioCarbon Fund. The World Bank 2008 [cited May 24 2008]. Available from http://carbonfinance.org/Router.cfm?Page=BioCF&ItemID=9708&FID=9708.

Carbon Positive. 2008. VCS Releases Forestry Carbon Rules (November 20, 2008) [cited December 1, 2008. Available from http://www.carbonpositive.net/viewarticle.aspx?articleID=1318.

[CCBA] Climate, Community and Biodiversity Alliance. 2008a. CCBA Projects. [cited November 11 2008]. Available from http://www.climate-standards.org/projects/index.html.

[CCBA] Climate, Community and Biodiversity Alliance. 2008b. Climate, Community and Biodiversity Project Design Standards Second Edition. Arlington, VA: CCBA.

[CCX] Chicago Climate Exchange. 2009. Chicago Climate Exchange "CCX CFI Market Data Charting Tool". Chicago Climate Exchange 2009 [cited February 19 2009]. Available from http://www.chicagoclimatex.com/market/data/summary.jsf.

Clark, Deborah A., Sandra Brown, David W. Kicklighter, Jeffrey Q. Chambers, John R. Thomlinson, and Jian and Ni. 2001a. Measuring Net Primary Production In Forests: Concepts. *Ecological Applications* 11 (2):356–370.

Clark, D., S. Brown, D. Kicklighter, J. Chambers, J. Thomlinson, Ni, and E. Holland. 2001b. Net Primary Production In Tropical Forests: An Evaluation and Synthesis of Existing Field Data. *Ecological Applications* 11 (2):371–384.

[CRN] Coalition for Rainforest Nations. 2008. Initiative: Carbon Emissions 2008 [cited May 24, 2008 2008]. Available from http://www.rainforestcoalition.org/eng/initiatives/carbon_emissions.php.

Country-data. 1989. Migration and Urbanization. [cited December 17, 2008]. Available from http://www.country-data.com/cgi-bin/query/r-3920.html.

Daily, G.C. 1997. Introduction: what are ecosystem services? In *Nature's Services: Societal Dependence on Natural Ecosystems*, edited by G. Daily. Washington, DC: Island Press.

DeFries, R.S., R.A. Houghton, M.C. Hansen, C.B. Field, D. Skole, and J. Townshend. 2002. Carbon emissions from tropical deforestation and regrowth based on satellite observations for the 1980s and 1990s. *Proceedings of the National Academy of Sciences of the United States of America* 99:14256–14261.

Denvir, Daniel. 2009. Indigenous anti-mining protests hit Ecuador. Indian Country Today 2009 [cited 1/6/09 2009]. Available from http://www.indiancountrytoday.com/global/latin/36998464.html.

Dow Jones Newswires. 2009. Ecuador Prepares Bid For ITT Oil Field - Minister. Dowjones Business News 2009 [cited 1/14/2009 2009]. Available from http://www.easybourse.com/bourse-actualite/marches/ecuador-prepares-bid-for-itt-oil-field-minister-593747.

Ebeling, Johannes, and Mai Yasue. 2008. Generating carbon finance through avoided deforestation and its potential to create climatic conservation and human development benefits. Philosophical Transactions of the Royal Society.

Ediciones Legales. 2008. División de Investigación y Técnica Jurídica: La respuesta justa a su necesidad de información.

Ellis, Jane, Harald Winkler, Jan Corfee-Morlot, and Frédéric Gagnon-Lebrun. 2007. CDM: Taking stock and looking forward. *Energy Policy* 35:15-28.

ENCOFOR. 2008. Environment and community based framework for designing afforestation, reforestation, and revegetation projects 2008 [cited December 12 2008]. Available from http://www.joanneum.at/encofor/.

Europa. 2008. Questions & Answers on Emissions Trading and National Allocation Plans, MEMO/05/84. The European Union, March 3, 2005

2005 [cited May 24 2008]. Available from http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/05/84&format=HTML&aged=1&language=EN&guiLanguage=en.

[FAO] Food and Agriculture Organization of the United Nations. 2006. Global Forest Resources Assessment 2005. In *Progress towards sustainable forest management*. Rome: Food and Agriculture Organization.

Fearnside, P. 1997. Greenhouse Gases From Deforestation In Brazilian Amazonia: Net Committed Emissions. Climatic Change.

Fogarty, David. 2009. Indonesia delays forest-carbon rules. *Reuters*.

FSC. 2008. The Fundación para la Sobrevivencia del Pueblo Cofán 2008 [cited December 1 2008]. Available from http://www.cofan.org/.

Garside, Ben. 2008. EU climate deal could open door for forestry credits. London: Point Carbon.

[GEF] Global Environment Facility. 2008. GEF to Launch Tropical Forest Account For World's Last Great Tropical Forests. Global Environmental Facility 2008 [cited November 11 2008]. Available from http://www.gefweb.org/interior.aspx?id=21210.

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* 2.

Gunther, Marc. 2008. Merrill Lynch's carbon bet: why a Wall Street firm wants to save a forest in Sumatra. CNNMoney.com.

Hamilton, Katherine, Milo Sjardin, Thomas Marcello, and Gordon Xu. 2008. Forging a Frontier: State of the Voluntary Carbon Markets 2008. In *A report by Ecosystem Marketplace & New Carbon Finance*. New York and Washington D.C.

Hepburn, Cameron. 2007. Carbon Trading: A Review of the Kyoto Mechanisms. The Annual Review of Environment and Resources.

Houghton, R.A. 1999. The annual net flux of carbon to the atmosphere from changes in land use 1850–1990. *Tellus Series B: Chemical and Physical Meteorology* 51:298–313.

Houghton, R.A. 2005. Tropical Deforestation and Climate Change. In *Tropical Deforestation as a Source of Greenhouse Gas Emissions*, ed P. Moutinho and S. Schwartzman: Amazon Institute for Environmental Research.

[IPCC] Intergovernmental Panel on Climate Change; Eggleston, H.S., L. Buendia, K. Miwa, T. Ngara, and K. Tanabe. 2006. IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme. In *Agriculture, Forestry and Other Land Use*, edited by K. Paustian, N. H. Ravindranath and A. van Amstel. Japan: IGES.

[IPCC] Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: The Physical Science Basis. In *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by S. [Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

Irish, R. R. 2008. Landsat 7 science data user's handbook. National Aeronautics and Space Administration 2008 [cited 5/12/08. Available from http://ltpwww.gsfc.nasa.gov/IAS/handbook/handbook_toc.html.

Jochnick, C. 1994. Rights violations in the Ecuadorian Amazon: the human consequences of oil development. *Health and Human Rights* 1 (1):83.

[Juma PDD] Ribenboim, Gabriel, Marina Campos, Domingos Macedo, Cenamo, Mariano, David Mann, and project contributors. 2008. The Juma Sustainable Development Reserve Project: Reducing Greenhouse Gas Emissions from Deforestation in the State of Amazonas, Brazil. Project Design Document. In *For validation at "Climate, Community & Biodiversity Alliance (CCBA)". Version 5.0.*

Kollmus, Anja, Helge Zink, and Polycarp. 2008. Making Sense of the Voluntary Carbon Market: A Comparison of Carbon Offset Standards. WWF Germany.

Laurance, William F. 2007. A new initiative to use carbon trading for tropical forest conservation. Biotropica.

LBA-Eco. LBA-Eco highlights 2008. Available from http://www.lbaeco.org/lbaeco/index.html.

Lee, Morgan. 2009. *President says Ecuador will default on debt*. The Associated Press 2008 [cited 1/1/09 2009].

Lindsey, Rebecca. Tropical Deforestation. NASA Earth Observatory 2007. Available from http://earthobservatory.nasa.gov/Library/Deforestation/deforestation_update.html.

Google Earth Image. 2009. Location: 0º19'57.56" N, 77º18'39.44" W 4.3, Mountain view.

Lu, D. 2005. Land-cover binary change detection methods for use in the moist tropical region of the Amazon: a comparative study. *International journal of remote sensing* 26 (2005):101-114.

Mas, J. 1999. Monitoring land-cover changes: a comparison of change detection techniques. *International journal of remote sensing* 20 (1):139.

[MAE] Ministerio del Ambiente Republica del Ecuador. 2002a. Agreement No 016. edited by M. d. Ambiente.

[MAE] Ministerio del Ambiente Republica del Ecuador. 2002b. Agreement No 138. edited by M. d. Ambiente.

[MAE] Ministerio del Ambiente, Ecuador. 2007. Guía del Patrimonio de Áreas Naturales Protegidas del Ecuador. Instituto Geográfico Militar, IGM.

[MAE] Ministerio del Ambiente Republica del Ecuador. 2008a. Ministerio del Ambiente Lanza el Programa Socio Bosque. *El Nuevo Empresario: El Periodico de Negocios del Ecuador*.

[MAE] Ministerio del Ambiente Republica del Ecuador. 2008b. Acuerdo Numero X. edited by M. d. Ambiente.

Means, J., H. Hansen, G. Koerper, P. Alaback, and M. Klopsch. 1994. *Software for Computing Plant Biomass: BIOPAK User's Guide*. Portland, Oregon: Gen. Tech. Rep. PNW-GTR-340. : U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Mena, Carlos F., Richard E. Bilsborrow, and Michael E. McClain. 2006. Socioeconomic drivers of deforestation in the Northern Ecuadorian Amazon. *Environmental Management* 37 (6):14.

Merger, Eduard. 2008. Forest Carbon Standards 2008, A comparison of the leading standards in the voluntary carbon market and the state of climate forestation projects. Carbon Positive.

Messina, Joseph P., Stephen J. Walsh, Carlos F. Mena, and Paul L. Delamater. 2006. Land tenure and deforestation patterns in the Ecuadorian Amazon: Conflicts in land conservation in frontier settings. *Applied Geography* 26:16.

Myers, Norman. 1988. Threatened Biotas: 'Hot Spots' in Tropical Forests. *The Environmentalist* 8 (3):22.

Myers, Erin. 2007. Policies to reduce emissions from deforestation and degradation (REDD) in tropical forests. Discussion Paper. Resources for the Future (RFF) DP 07-50. 83 pp.

Nadkarni, M.V., K.N. Ninan, and S.A. Pasha. 1994. Economic and Financial Viability of Social Forestry Projects: A Study of Selected Projects in Karnataka, India, Working Paper No 16. New Delhi: Society for Promotion of Wastelansds Development and the Ford Foundation.

Neeff, Till, Heiner von Luepke, and Dieter Schoene. 2006. Choosing A Forest Definition for the Clean Development Mechanism. In *Forests and Climate Change Working Paper 4*. Rome, Italy: FAO.

Nepstad, D., P. Moutinho, and B. Soares-Filho. 2006. The Amazon in a Changing Climate: Large-Scale Reductions of Carbon Emissions from Deforestation and Forest Improverishment. Amazon Institute for Environmental Research; the Woods Hole Research Center, and the Federal University of Minas Gerias.

New Carbon Finance. 2009. ECX CFI Futures Contracts: Price and Volume. [Cited March 18, 2009]. Available from http://www.newcarbonfinance.com/?gclid=COKi-7Koq5gCFRFMagodlCJsbA

Niles, John-O. 2007. It's Not Easy Being Green in Aceh, Indonesia. The Katoomba Group, Ecosystem Marketplace.

Ninan, K.N., and S. Jyothis. 2003. Social Forestry – Case Study from Karnataka in Gopal Kadekodi (ed) Environmental Economics in Practice- a Case Study Book. New Delhi: Oxford University Press.

Noel Kempff Mercado Climate Action Project. 2008. Noel Kempff Mercado Climate Action Project.

[NPS] National Park Service. 2008. National Park Service budget emphasizes park operations to prepare for NPS Centennial. National Park Service 2008 [cited December 15, 2008 2008]. Available from http://home.nps.gov/applications/release/Detail.cfm?ID=782.

Ohl, C, and R. Bussmann. 2004. Recolonisation of natural landslides in tropical mountain forests of Southern Ecuador. In *Feddes Repertorium*.

Olander, L.P., H.K. Gibbs, M. Steininger, J. Swenson, and B. C. Murray. 2008. Reference scenarios for deforestation and forest degradation in support of REDD: a review of data and methods. In *Environmental Research Letters*.

Olander, Jacob, In litt. 2009. Email regarding REDD project design costs, Jan. 14, 2009.

Pearce, David, Giles Atkinson, and Susan Mourato. 2006. Cost Benefit Analysis and the Environment, Recent Developments. Organization for Economic Co-operation and Development.

Pearce, David. 1992. Assessing the Social Rate of Return for Investment in Temperate Zone Forestry, GEC 92-07. London: Centre for Social and Economic Research on Global Environment, University College.

Pearson, Timothy, Sarah Walker, and Sandra Brown. 2005. Sourcebook for Land Use, Land-Use Change and Forestry Projects. Eds. Bernhard Schlamadinger, et al.: BioCarbon Fund; Winrock International.

Pitman, Nigel, Debra K. Msokovits, William S. Alverson, and Randall A. Borman. 2002. Rapid Biological Inventories 03: Ecuador: Serranías Cofán–Bermejo, Sinangoe. The Field Museum; Fundacion para la Sobrevivencia del Pueblo Cofan/Cofan Survival Fund; Fderacion Indigena de la Nacionalidad Cofan del Ecuador (FEINCE).

Plan Vivo. 2008. The Plan Vivo Standards: Carbon management and rural livelihoods. Edinburgh: Plan Vivo Foundation.

RAINFOR Amazon Forest Inventory Network. 2008. RAINFOR 2008. Available from http://www.geog.leeds.ac.uk/projects/rainfor/.

Revkin, Andrew. 2008. Ecuador Constitution Grants Rights to Nature. The New York Times, http://dotearth.blogs.nytimes.com/2008/09/29/ecuador-constitution-grants-nature-rights/.

[RGGI] Regional Greenhouse Gas Initiative. 2009. An Initiative of the Northeast and Mid-Atlantic States of the U.S. 2009. February 16 2009. <http://www.rggi.org/home>.

Rosin, P. 1998. Thresholding for change detection. In *Computer Vision - Sixth International Conference*.

Sala, O., R Jackson, H.A. Mooney, and R.W. Howarth. 2000. *Methods in Ecosystem Science*. San Diego: Springer.

Schlesinger, William H. 1997. *Biogeochemistry: An Analysis of Global Change*. Amsterdam: Academic Press.

Schroder, Martin, and Gabriel Medina. 2008. The Juma Sustainable Development Reserve Project: Reducing Greenhouse Gas Emissions from Deforestation in the State of Amazonias, Brazil. Munich, Germany: TUV SUD Industrie Service GmbH.

Siviter, Sadie. In litt. 2009. Email: Landslides in Mountains. January 20 2009.

Siviter, Sadie. In litt. 2008a. Email: Socio Bosque and Other Cofán Territories. December 1, 2008.

Siviter, Sadie. In litt. 2008b. Email: Questions for the Cofán Bren School Group Project. November 4, 2008.

Siviter, Sadie. In litt. 2008c. Email: Questions, Excel Spreadsheet titled "propuesta a MAE y sus aliados.xls". November 4, 2008.

Tecpetrol Inc. 2007. Tecpetrol Operational Area 2007 [cited 5/4/08. Available from http://www.tecpetrol.com/eng/empresas/tecpetrol/cuenca_oriental.html.

The Nature Conservancy. 2008a. Conservation Easements: Conserving Land, Water, and a Way of Life 2008 [cited December 11 2008]. Available from http://www.nature.org/aboutus/howwework/conservationmethods/privatelands/conservationeasements/.

The Nature Conservancy. 2008b. Going to the Source: Quito pays for Water 2008 [cited January 8 2009]. Available from http://www.parksinperil.org/howwework/operations/art23110.html.

[UNEP] United Nations Environment Programme. 2007. GEO4: Global Environmental Outlook, environment for development. United Nations Environment Programme.

[UNEP-WCMC] Campbell, Allison, Valerie Kapos, Igor Lysenko, Jörn Scharlemann, Barney Dickson, Holly Gibbs, Matthew Hansen, and Lera Miles. 2008. Carbon emissions from forest loss in protected areas. In *A report commissioned by The Nature Conservancy as part of the PACT 2020 Innovation Initiative in collaboration with UNEP-WCMC and the IUCN World Commission on Protected Areas*: UNEP World Conservation Monitoring Centre.

[UNFCCC] United Nations Framework Convention on Climate Change. 1998. Kyoto Protocol to the United Nations Framework Convention on Climate Change. United Nations.

[UNFCCC] United Nations Framework Convention on Climate Change. 2008a. United Nations Framework Convention on Climate Change 2008 [cited May 15, 2008 2008]. Available from http://unfccc.int.

[UNFCCC] United Nations Framework Convention on Climate Change. 2008b. Report of the Conference of the Parties on its thirteenth session, held in Bali from 3 to 15 December 2007. United Nations.

[UN-REDD Program Fund] FAO, UNDP, and UNEP. 2008. UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD). In *Framework Document*.

[USAID] US Agency for International Development. 2008. Conservation of Indigenous Territories 2007 [cited December 16, 2008 2008]. Available from http://ecuador.usaid.gov/portal/content/view/203/175/.

[VCS APX Registry] Voluntary Carbon Standard. 2008. APX VCS Registry 2008 [cited November 11 2008]. Available from http://vcsregistry.apx.com/.

[VCS] Voluntary Carbon Standard. About the VCS 2008 [cited 11/20/08. Available from http://v-c-s.org/about.html.

[VCS] Voluntary Carbon Standard. 2008. Voluntary Carbon Standard 2007.1 - Specification for the project level quantification, monitoring and reporting as well as validation and verification of greenhouse gas emission reductions or removals.

[VCS AFOLU] VCS Association. 2008. Voluntary Carbon Standard: Guidance for Agriculture, Forestry and Other Land Use Projects.

VCS Program Guidelines. 2008. Voluntary Carbon Standard Program Guidelines 2007.1. VCS Association.

VCS Projects. 2009. VCS Projects and Registries.

Viña, Andrés, Fernando Echavarria, and Donald C. Rudquist. 2004. Satellite change detection analysis of deforestation rates and patterns along the Columbia-Ecuador border. *Ambio* 33 (3):8.

Virgilio, Nicole. 2008. The Cofán and the FSC: An inside scoop... The Donald Bren School of Environmental Science and Management, University of California, Santa Barbara.

Virgilio, Nikki, In litt. 2008. Carbon Research Associate, TNC, December 17, 2008.

World Bank. 2007. Forest Carbon Partnership Facility Takes Aim at Deforestation. The World Bank, December 11, 2007 2007 [cited May 24, 2008 2008]. Available from http://go.worldbank.org/1ELJCN2F60.

World Bank Operations Evaluation Department. Building Biodiversity Governance Through Stakeholder Participation. Précis. Number 228, Fall 2002.

World Land Trust. 2008. Tapichalaca Reserve, Ecuador. [cited November 17, 2008]. Available from http://worldlandtrust-us.org/projects/tapichalaca.html.

APPENDIX A — Agreement No. 016

Translation of: Agreement Number 016 with the Ministry of Environment for the Establishment of the Cofán Bermejo Reserve.

No 016
The Minister of Environment
Considers

That which takes effect the agreement OIT regarding indigenous tribes and towns published in the Official Registry 206 on June 7, 1999 in whose article 7 number 4 consecrates that the government will have to take measures in cooperation with the interested towns to protect and preserve the environment and the lands they inhabit;

That, the article 84 of the Magna Carta of the State, recognizing and guarantees to indigenous towns, conforming with the constitution and the law, respect to the public order and to human rights and to conserve and to promote management practices of biodiversity and its half open nature;

That, Article 248 of the Political Constitution of the Republic is manifested in that the State has sovereign right over biological diversity, nature reserves, protected areas and national parks. Its conservation and sustainable use will be carried out through the participation of involved populations beyond the case and the private initiative according to the programs, plans, and policies that are considered as factors of development and quality of life and of conformity to the agreements and international treaties; [right to carry out practices that conserves and sustainably uses the lands in accordance with agreement and international treaties]

That, the article 69 second point of the Forestry and Conservation Law of Natural Areas and Wildlife and 198 of the mentioned law of the Applied Ruling is manifested in that the person that declares natural areas will be fulfilled through the Ministry Agreement, previous technical report from the Ministry of the Environment or the corresponding branch office of the Ministry, upholding the study of management alternatives and their financing;

That, through Resolution 19 published in the Official Registry 324 of 25 May 1999, the area El Bermejo was declared protected vegetation and forest, located in the Province of Sucumbíos, Cantón Cáscales, Parroquia Cáscales, sector Bermejo with an area of 12,700 hectares;

That, through Ministry Agreement 202 published in the Official Registry 962 of 22 June 1988, of Political Bloc *Unidad Cuatro – Napo* del Patrimonio Forestal del Estado;

That, through memorandum No 0650 DBAP/MA of 25 May 2002, the Direction of Biodiversity and Protected Areas examined the study of Management Alternative of the Zone called El Bermejo and recommended that this protected area to be included in SNAP because of its high biodiversity and endemism, determined the scientific studies completed by the Field Museum of Chicago and others;

That, the area of El Bermejo is a recognized ancestral Cofán territory. The ancestral Cofán communities have used the natural resources in a sustainable manner in this zone, which has allowed this area to be found in very good conservation condition.

In use of its constitutional and legal attributions,
Agreement

Article 1 – To declare Cofán Bermejo Reserve, and to incorporate the National Patrimony of Natural Areas of the State, the remaining tropical forest of 55,451 hectares located in the Povencia de Sucumbíos, Cantón Cáscales, Parroquia Cáscales, between the following limits of coordinates UTM, Province SAD-56, zone 18

North
Dividing the point P1 with coordinates 226716 longitude west and 43964 latitude north and altitude of 2560 msnm, continuing north toward the edge of the mountain until arriving at Cerro Pax in the point P2 with coordinates 226401 longitude west and 47700 latitude north and altitude 3381 msnm, limits the border between Colombia and Ecuador; the limit continues toward the east following the gorge of the birth of below waters of San Miguel River until arriving at point P3 with coordinates 230800 longitude west and 48500 latitude north place of confluence of the two rivers, then the limit continues along the below waters of the San Miguel River until arriving at point P4 with coordinates 256770 longitude west and 42506 latitude north.

East
Dividing the previous point and continuing southeast, the limit continues until arriving at point P5 with coordinates 258593 longitude W and 40953 latitude N, then the limit continues in that direction until arriving at point P6 with coordinates 260085 longitude W and 40988 latitude N, then the limit continues in the same direction until arriving at point P7 with coordinates 265041

longitude W and 35886 latitude N, the limit continues in southwest direction until arriving at point P8 with coordinates 264197 longitude W and 33230 latitude N in the Bermejo River.

South

From the previous point, the limit continues above water of the Bermejo River until arriving at the confluence of the Boca Chico River at point P9 with coordinates 25997 longitude W and 32406 latitude N; then continues above water of Boca Chico River until point P10 with coordinates 258055 longitude W and 32120 latitude N. From this point in the southwest direction toward point P11 with coordinates 255937 longitude W and 27607 latitude N, from this point the limit travels approximately 1000 meters in the northwest direction to change again to the southwest direction until arriving at Chandia Na'e River at point P12 with coordinates 252365 longitude W and 26601 latitude N, the limit continues in the same direction until arriving at point P13 with coordinates 249429 longitude W and 25880 latitude N, continue the same direction until intersecting the Bermejo River of O 14 with coordinates 247014 longitude W and 25787 latitude N, then it continues above water of Bermejo River until the confluence with la Quebrada Rayo at point P15 with coordinates 237939 longitude W and 257150 latitude N; it continues above water of la Quebrada Rayo until point P16 with coordinates 237037 longitude W and 24261 latitude N. From this point in the west direction the path made by the Cofán continues and passes through point P17 with coordinates 233531 longitude W and 25221 latitude N, point P18 with coordinates 230859 longitude W and 26729 latitude N and point P19 with coordinates 230026 longitude W and 28412 latitude N.

West

From the last point, the limit continues through the path of the Cofán towards the north until arriving at point P20 with coordinates 230034 longitude W and 33775 latitude N; then the limit continues following the northwest limit of the Patrimonio Forestal del Estado until arriving at point P21 with coordinates 220292 longitude W and 45335 latitude N, and finally from this point towards the east in a straight line until point P1 where the limit of the Reserve started.

Article 2 – To guarantee its conservation and sustainable use, the administration, management, and control of the Cofán Bermejo Reserve will be the charge of FEINCE in coordination with la National Direction of Biodiversity and Protected Natural Areas of the Ministry of Environment, and they will formally establish the conditions and coordination in the respective administration and management agreements of the Reserve, with the participation of local Cofán communities and FSC, subject to the Law and Regulations of the matter and in particular the respective Management Plan.

Article 3 – The areas covered by native forest the surround the Cofán Bermejo Reserve will be considered buffer zones below the Régimen Forestal and its conservation and sustainable use will be carried out in agreement to that which the Management Plan of this natural area indicates. [how big?? Is this area being deforested]

Article 4 – All those activities that are not compatible with the purpose of the Cofán Bermejo Reserve remain expressly prohibited, especially those related to bio-prospection and access of genetic resources without the express authorization and supervision of the Ministry of Environment.

Final Article – Director of Biodiversity and Protected Areas will take charge, with support from the Regional Direct of Subumbios-Orellana, of the execution of the present ministry agreement that will enter into operation from the date of his subscription without prejudice of its publication in the Official Registry

Published and Completed,
Given in the city of Quito, 30 January 2002
Signed by:
Lourdes Luque de Jaramillo
Minister of Environment

APPENDIX B — Methods to Estimate Carbon Storage

Measurement of the carbon stored within a forest requires measuring aboveground vegetative biomass, utilizing models to re-create canopy structure and composition, and measuring or estimating the belowground biomass (roots and carbon stored within the soil) (Sala et al. 2000). There are direct and indirect in-situ measurement methods. Direct methods include those that require actual hands-on contact with the vegetation and soil in order to take a measurement. In contrast, indirect measurements, which do not require direct contact with the biomass, are often referred to as remote sensing techniques and may be acquired from the ground or from the air (Sala et al. 2000). Additionally, comparative study data and statistical extrapolation methods may be used to estimate the amount of carbon stored within a tropical rainforest area. This study will use both direct and indirect field measurements to determine the carbon storage within the Cofán Bermejo Reserve to verify estimates generated from a literature review of Amazonian tropical forest carbon storage capacity.

In tropical forests there are some difficulties and limitations in estimating biomass. Tropical forests often contain high amounts of diversity and are highly stratified, making many sampling methods difficult or even impossible to carry out. Additionally, the amount of biomass changes rapidly from day to day in a tropical environment due to high rates of decomposition, growth, and high amounts of herbivory and leaching (Clark et al. 2001b).

a) Comparative Studies of Forest Carbon Storage

Several potential sources of information exist regarding similar studies that have been conducted in Ecuador and the Amazon in general, including the Amazon Forest Inventory Network RAINFOR project, the Large-scale Biosphere-Atmosphere (LBA-Eco) studies, and some other smaller scale projects that have been recently completed. The RAINFOR project surveyed nine sites in northeastern Ecuador and many more in surrounding Amazon countries (RAINFOR 2008). The database from RAINFOR includes tree-by-tree data and tree functional traits that could potentially serve as a growth model for the Cofán Bermejo Reserve and to obtain forest carbon data. In addition, the on-going LBA-Eco study in Brazil has vast databases and wikis that could be used to obtain helpful forest carbon data (LBA-Eco 2008). The IPCC Tables for Carbon and Deforestation are another potential source for gathering information on the amount of carbon stored in the forest. A review of this literature will create a credible working knowledge of expected forest carbon stores and will help guide field verification of the carbon storage estimates.

b) Field Methods

Various field methods provide powerful tools to estimate the amount of carbon that is being stored within a landscape. On-the-ground measurement methods, such as those further discussed below, can be employed to accurately analyze the carbon content of a forest, but can be very time consuming and labor intensive if used exclusively (Sala et al. 2000). A forest inventory can be used to directly measure biomass (Avery and Burkhardt 2002). However, it is not feasible to conduct a forest-wide inventory across the entire Reserve, since it is impossible to sample every piece of plant matter within the forest. Instead, direct forest measurements can be made and this data can be extrapolated to the remainder of the Reserve using statistical estimation methods. One indirect method for measuring biomass involves using allometric equations to covert other more easily obtainable measurements (LAI, cover, basal area, etc.) into biomass (Bonham 1989). Means et al. (1994) compiled over 1,150 allometric equations that are useful for estimating biomass using this method for tropical forests. Field measurements can also be used as a calibration method in conjunction with other methods, such as remote sensing and comparative studies.

Before using field measurement methods to estimate the carbon that is stored within the Cofán Bermejo Reserve, it is beneficial to develop an explicit sampling design plan. This includes examining an aerial photo of the study site and plotting random sample sites from widely diversified locations to provide a representative sample of the overall reserve. A widely diversified sample should include sites located at different elevations, slope aspects, dominant vegetative types, and soil types. A practical, user-friendly sampling design for this project would be a multistage unequal probability sampling method of analysis. Multistage unequal probability sampling is useful in these large-scale applications, in order to reduce travel cost and the time required to gather many samples. This sampling method allows the collection of representative samples and subsequently, this data can be accurately extrapolated to the entire Reserve. In addition, this method reduces the sampling error and allows for efficient sampling design (Brewer and Hanif 1983).

Direct field measurement methods include hands-on measurements of characteristics such as diameter breast height (DBH), tree core samples, and vegetative clippings. In general, indirect on-the-ground methods may prove to be more practical in the case of this project, due to the highly stratified and dense vegetative characteristics of tropical rainforests in the Amazon. Indirect methods are measured by canopy-light interactions, using optical tools (such as gridded mirrors, prisms, and radar scatterometers) (Bonham 1989, Sala et al. 2000). This approach makes data acquisition faster, but estimation methods are often more complex (Sala et al. 2000).

Stand structure includes the composition and arrangement of stems, braches, twigs, and leaves. Certain elements of stand structure can be used to estimate the amount of biomass within an area of forest, which can then be converted to carbon stored using allometric equations. Exact reconstruction of three-dimensional stand structure is virtually impossible and unnecessary for this project. Instead, stand structure is broken down into several vertical and horizontal components that are measurable. The vertical components are canopy height and stratification. Some of the horizontal components include canopy cover, leaf area, and stem basal area (Sala et al. 2000).

There are several common, low-cost methods for measuring the vertical and horizontal components of stand structure, in order to estimate biomass. For example, a hypsometer can be used to determine the forest canopy height by measuring the angle to the reference height in the canopy for a known distance from the base of a tree. Trigonometry can then be used to convert this information into the canopy height. Additionally, canopy cover and leaf area index (LAI) can be measured by several methods including canopy gap analysis using photography and/or gridded mirrors. LAI is the measurement of the amount of leaf surface area per unit of ground surface area (Burns and Honkala 1990). Stem basal area can be measured manually using a DBH tape. There are sophisticated methods for determining stratification and foliar profile; however, a rough estimate can be made through visual analysis.

A wedge prism is a relatively inexpensive, easy to use, portable instrument that measures the basal area of a stand. A wedge prism is used to sight trees at diameter breast height at a fixed viewing angle. The tree trunks that are close to the sample point and significant in size will cause the angle of deflection to be enough so that the trees are touching or will be overlapping within the field of view of the prism. These trees are counted and included in the sample. A tree whose trunk has no overlap is not included in the tally, as this indicates that the stems are too small or the tree is too far away and thus should be ignored (Avery and Burkhardt 2002). Additionally, tree core samples are often used in conjunction with basal diameter and height measurements (using a DBH tape, hypsometer, and/or wedge prism) in order to estimate the biomass of a tree (Bonham 1989). Tree core samples can be taken in species that form distinguishable annual rings and then be measured over a time period of interest. This data can be converted to approximate biomass using allometric equations (Clark et al. 2001a).

Belowground biomass is sometimes measured using a volumetric approach by taking cores of soil samples and then analyzing the soil contents for root and other vegetative biomass. It can also be measured by taking in-growth cores, using isotope analysis methods, and analyzing the carbon or nitrogen balance (Sala et al. 2000). Because of the high cost involved with analysis of these soil samples, a more commonly used and practical approach is to estimate belowground carbon amounts from comparative studies and the proportional relationship between aboveground and belowground biomass outlined in the literature (Clark et al. 2001a).

The above discussed horizontal and vertical vegetation measurements can be used to generate estimates of the aboveground biomass of individual trees at chosen field sample sites. This information can be used in conjunction with the average estimated belowground biomass for an individual tree from the sample and stand density to extrapolate the total biomass within a forest stand. Stand density is a measurement of the number of individuals per area and can be measured directly by point and line intercepts, or visually from a distance (Sala et al. 2000). Estimates of aboveground and belowground biomass from stand structure and density can then be converted into the amount of carbon stored in the Reserve using the allometric relationship of how much carbon is stored in a certain amount of biomass.

Literature cited:

Avery, Eugene Thomas, and E. Harold Burkhart. 2002. *Forest Measurements*. 5th Edition ed. New York, NY: McGraw-Hill Higher Education.

Bonham, Charles D. 1989. *Measurements for Terrestrial Vegetation*: John Wiley and Sons, Inc.

Brewer, K. R. W., and Muhammad Hanif. 1983. *Lecture Notes in Statistics*. Edited by D. Brillinger, S. Fienberg, J. Gani, J. Hartigan and K. Krickeberg. Vol. 15, *Sampling With Unequal Probabilities*. New York-Heidelberg-Berlin: Springer-Verlag.

Burns, R.M., and B.H. Honkala. 1990. *Silvics of North America*. Vol. 1 and 2, *Agricultural Handbook 654*: USDA Forest Service.

Clark, D., S. Brown, D. Kicklighter, J. Chambers, J. Thomlinson, Ni, and E. Holland. 2001b. Net Primary Production In Tropical Forests: An Evaluation and Synthesis of Existing Field Data. *Ecological Applications* 11 (2):371–384.

LBA-Eco. LBA-Eco highlights 2008. Available from http://www.lbaeco.org/lbaeco/index.html.

Means, J., H. Hansen, G. Koerper, P. Alaback, and M. Klopsch. 1994. *Software for Computing Plant Biomass: BIOPAK User's Guide*. Portland, Oregon: Gen. Tech. Rep. PNW-GTR-340. : U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

RAINFOR Amazon Forest Inventory Network. 2008. RAINFOR 2008. Available from http://www.geog.leeds.ac.uk/projects/rainfor/.

Sala, O., R Jackson, H.A. Mooney, and R.W. Howarth. 2000. *Methods in Ecosystem Science*. San Diego: Springer.

APPENDIX C — Standards, Data, and Methods for Detecting Deforestation

Methods to Estimate Deforestation

To measure the carbon emissions from a forest due to degradation for a REDD project, it is necessary to know the extent of deforestation and degradation (which includes the baseline rate of deforestation within the study area in hectares per year), the type of forest that is being deforested, the carbon content of each type of forest (in metric tons of carbon per hectare), and the type of deforestation (Olander et al. 2008, Harold 2007). Additionally, REDD projects generally require that deforestation/degradation of the forest continue to be monitored throughout the crediting period. The following section will discuss the standards, data, and methods necessary to determine the baseline deforestation and degradation of a forest.

Standards

To ensure that the baseline deforestation rate calculated for a REDD project is credible, the use of standard methods to determine this rate are recommended. Standards are generally published documents containing technical specifications, criteria, and methodologies to be used as a guideline or definition. Furthermore, standards are usually developed by experienced parties such as sellers, buyers, regulators, and users of the product or service (BSI Group 2008). The establishment of these standards is important; as they allow for consistent application of a process, while generally increasing the credibility of projects associated with the standard.

Standards also help ensure the creditability of the project. A good standard and methodology for determining deforestation and degradation rates should help provide accuracy and precision to the project, be comprehensive, have environmental integrity, the methodologies should be compatible for integration with other sections of the REDD project, and finally the standards should provide transparency (Olander et al. 2008).

REDD projects require a precise and accurate baseline deforestation determination to ensure that errors & uncertainty are quantified. This helps determine how much confidence can be placed in the REDD Credits. A standard for determining a deforestation and degradation rate must also be comprehensive to account for all included sources of deforestation and degradation. Environmental integrity is important and should work in favor of providing climate protection. Therefore, to ensure project integrity, the amount of reported deforestation must be precise and reference scenarios must be conservative to guard against diminishing GHG mitigation efforts. Finally, the standards should be compatible with methods used to calculate carbon stocks in order to calculate emissions (Olander et al. 2008).

Data Requirements to Calculate Deforestation and Degradation

To accurately measure deforestation and degradation for a REDD project, the data used to measure the project must be of high spatial and temporal resolution and be of consistent quality. According to the VCS *Tool for AFOLU Methodological Issues,* baseline net emissions and removals of green house gases (and thus the rate of deforestation) must be estimated for each year of the proposed crediting period. Additionally, a historical record of maximum carbon stocks must be computed for the project area within the previous ten years of the project-crediting period. Thus, the Cofán Bermejo Reserve will require historical data of deforestation for ten years. Additionally, deforestation data will be needed every year of the crediting period (VCS 2008). Trends should be measured over multiple years because this reduces the impact of anomalous (high or low) years (Olander et al. 2008).

Data spatial resolution is also very important for determining accurate deforestation and degradation rates, as a higher resolution provides the ability to more clearly identify small patches of deforestation. Spatial monitoring is generally conducted at medium, high, or very high resolutions. Medium resolution data usually has a pixel size from 250 meters to 1 km. This data is useful for conducting annual monitoring of large events or for monitoring large clearings/hotspots. Because deforestation often occurs in small patches of 100 meters or less, high-resolution data, which has a pixel size of 10 – 60 meters, is often more useful to indentify small patches of deforestation. Additionally, high-resolution data is often used to estimate land change estimates over a period of 5 to 10 years. Finally, very high-resolution data, with a pixel value of 1 to 5 meters, is mostly used for limited verification of deforestation due to the excessive processing time and often-high cost to utilize this data (Achard et al. 2007).

Available Data to Measure Deforestation and Degradation

Currently there are a variety of sources available that can be used to determine deforestation and/or degradation rates, but two main sources are FAO Assessments and remote sensing data. The FAO has conducted global assessments every 5 to 10 years since 1947, thus providing a long historical database of deforestation globally. These assessments are largely based upon forest inventory data, models, and expert opinion. For the purposes of this study, however, FAO documentation alone will likely not be sufficient for determining the rates of deforestation within the Cofán Bermejo Reserve. The FAO data often lacks consistency between assessments and regions it is conducted in. Additionally, due to the changing definition of forests over the years, it may prove to be difficult to interpret and convert the results into a standard dataset. Also, the FAO data is often hard to validate, is of low resolution, and often the assessments contain missing data, and can be unreliable (Olander et al. 2008, pg 3). Therefore, this historical data is not recommended for use in determining deforestation and degradation rates within Cofán Bermejo Reserve.

Remote sensing data, which is data collected from a distance via airplane, satellite or another means, may provide a better assessment of the deforestation/degradation rates occurring within the reserve. While remote sensing data usually cannot provide a historical record as comprehensive as the FAO Assessments, data is generally is available from the 1970s forward (depending on the dataset chosen). The data is reliable over large areas and the data is generally of a consistent quality. Remote sensing, however, can be expensive to acquire, is technically challenging to analyze, and has an error and uncertainty in the data/analysis that is not always well characterized (Olander et al. 2008).

Satellite imagery has been used to identify deforestation in tropical forests since the launch of the Landsat series of satellites in the 1970s (Lindsey 2007). Remote sensing imagery has provided a relatively inexpensive and efficient method for monitoring changes in forest cover due to the ability for repetitive coverage and consistent image quality (Mas 1999). There are numerous remote sensors that can provide data for the Cofán Bermejo Reserve. The table below reviews some of these sensors and provides a brief description of their positives and negatives.

Available Remote Sensing Data (Olander et al. 2008)		
Sensor	**Positives**	**Negatives**
Aerial Photography	- High Spatial Resolution Data Available	- Historical data usually limited - Costly
RADAR - ALOS (Advanced Land Observing Satellite) sensor	- RADAR technology can see through clouds, smoke, and haze from fires into forest canopy - Full pan-tropical data for the Amazon is available	- Data only available from January 2006 onwards - Costly
IKONOS/Quick Bird	- Very High Spatial Resolution data (50 cm), which is useful for verification of deforestation/degradation - Over nine years of available data, providing data for short term trends	- Data only available from September 1999 onwards, limiting the analysis of long term deforestation/degradation trends
MODIS	- Medium Resolution Data (250 meters)	- Medium resolution data does not allow for

	- High temporal data availability (2 times daily) - Freely available - Data Available for nearly 10 years, providing data for short tend trends	differentiation of small patches of deforestation/degradation - Data only available from 1999 onwards, limited the analysis of long term deforestation/degradation trends
LANDSAT	- Available from 1972 till the present - Provides the only satellite data for estimating forest change scenarios from the 1970's, 1980's and 1990's - High resolution data (30 m) may be used to detect small patches of deforestation/degradation - Full Landsat dataset is freely available beginning early 2009	- Landsat 7 satellite has technical issues which reduce image quality without further processing, thus requiring additional technical knowledge and skills - A moderate temporal resolution (16 day repeat cycle) may not provide enough cloud free data to detect deforestation/degradation within the project area

Recommended Data to Measure Deforestation and Degradation

To properly identify deforestation/degradation within the Cofán Bermejo Reserve, the use of both Landsat and MODIS satellites images can provide good coverage of the project area within the Cofán Bermejo Reserve, the leakage belt, and the broader reference region. Landsat imagery is suggested due to its 30-meter resolution, which provides a high enough resolution to identify small patches of deforestation/degradation. Additionally, because this dataset is available beginning in 1972, it is possible to develop a long historical trend of deforestation/degradation within the reference region surrounding the Cofán Bermejo Reserve. Using Landsat Imagery, it is possible to detect deforestation in 1-hectare patches with an accuracy of 90 to 95 percent (Olander et al. 2008).

However, because the Landsat sensor has moderate temporal resolution of 16 days between satellite passes, the cloudiness of the Reserve and the immediate region may make it difficult to collect cloud free data needed to detect deforestation/degradation. The MODIS sensor, however, has a high temporal resolution (two passes over the Cofán Bermejo Reserve daily), increasing the availability of cloud free data. Therefore, the Landsat data is recommended to detect small patch deforestation, while MODIS data can be used to provide less precise but more frequent measurements to detect high rates of change. Using

MODIS data, deforestation can be detected from annual composites of 250 or 500-meter resolution imagery with as low an error as 7 to 11 percent (Olander et al. 2008). Finally, for verification of deforestation, very high-resolution data from sensors such as the IKONOS sensor or aerial photography may be used. Ground based inventories are also useful in verifying the accuracy of the sensors (Olander et al. 2008).

Sensor	**Data for Cofán Bermejo Reserve**
Landsat	Full Landsat Archive became freely available December 30th, 2008 Landsat sensor website: http://landsat.gsfc.nasa.gov/ Data acquisition website: http://edcsns17.cr.usgs.gov/EarthExplorer/ World Reference System Path/Row for Cofán Bermejo Reserve[1]: Path 9/ Row 60
MODIS	MODIS raw data archive currently freely available MODIS sensor website: http://modis.gsfc.nasa.gov/ Data Acquisition Website: http://glovis.usgs.gov/ MODIS Sinusoidal Tiling coordinate for Cofán Bermejo Reserve[2]: (10, 08)
NOTES 1. World Reference System Path/Row: is a grid system, similar to a latitude and longitude, that is used to identify each scene, or image that the Landsat sensor captures, on the globe. The path represents the vertical location and the row represents the horizontal location. 2. MODIS Sinusoidal Tiling System: Most standard MODIS land products use a sinusoidal grid tiling system to identify each scene, or image that the MODIS sensor captures, of the globe. At the equator, the tiles are 10 degrees by 10 degrees in size. The tiling coordinate system starts at (0,0) (horizontal tile number, vertical tile number) ends at tile (35,17) (Global Land Remote Sensing 2009).	

Methods to Measure Forest Change

The use of remote sensing data to detect deforestation is based upon the premise that changes in land cover will result in changes of the radiance value (the amount of light that is emitted or reflected from a particular area) that is greater than other variables such as differences in atmospheric conditions, soil moisture, and sun angles. This premise does not always hold, however, as it may be difficult to discriminate between different successional forest classes and pastures containing trees. Higher spectral and spatial resolutions are often used to overcome this problem. Additionally, cloud cover may make it difficult to determine deforestation rates from year to year (Mas 1999). To overcome this limitation, it may be possible to select satellite imagery from a prior or successive pass over the same region. The repeat cycle for the Landsat satellite is every 16 days (Irish 2008) and twice daily for the MODIS sensor.

There are two main categories of change detection methods. Currently no single method of detection has been identified as applicable to all study areas due to variations in the imagery characteristics of different land cover types. The first category utilizes remotely sensed imagery to detect land cover change from one ground cover type to another (Mas 1999). The second category of methods only detects the presence of change or no-change between two time periods. This method includes but is not limited to image differencing, modified image differencing, principal component differencing, vegetation index differencing, image ratioing, and modified image ratioing. While there is some variation in these methods, most involve comparing an image from one time period with an image from a second time period on a pixel-by-pixel basis. Each pixel in the image represents a square plot of land. It is then necessary to develop change thresholds between the pixels within the two images to determine when only a minor change has occurred, such as the loss of leaves in the dry season, and a major change, such as the occurrence of deforestation. Common methods used to determine thresholds include examining the distribution within the images' histogram, using the standard deviation from the image's mean, or using a training dataset of objects that are known to have, or have not, undergone change (Lu 2005). This training dataset may be from observed field data of changed or unchanged objects.

To understand the output of the change detection analysis, it is important that valid threshold parameters be applied. Applying too low a threshold value will result in a type I error (false positive), while too high a threshold value will result in a type II error (false negative) (Rosin 1998). Therefore, identifying a proper threshold value is crucial in determining the actual deforestation rates of a region. Furthermore, field verification or very high-resolution imagery, can be used to create a reference set of known deforested and non-deforested sites.

<u>Literature Cited</u>:

Achard, F, R DeFries, H Eva, M Hansen, P Mayaux, and H-J Stibig. 2007. Pan-tropical monitoring of deforestation. In *Environmental Research Letters*.

BSI Group. What is a standard? 2008 [cited 12/22/08. Available from http://www.bsi-global.com/en/Standards-and-Publications/About-standards/What-is-a-standard/.

Herold, Martin, and Tracy Johns. 2007. Linking requirements with capabilities for deforestation monitoring in the context of the UNFCCC-REDD process. In *Environmental Research Letters*.

Irish, R. R. Landsat 7 science data user's handbook. National Aeronautics and Space Administration 2008 [cited 5/12/08. Available from http://ltpwww.gsfc.nasa.gov/IAS/handbook/handbook_toc.html.

Lindsey, Rebecca. Tropical Deforestation. NASA Earth Observatory 2007. Available from http://earthobservatory.nasa.gov/Library/Deforestation/deforestation_update.html.

Lu, D. 2005. Land-cover binary change detection methods for use in the moist tropical region of the Amazon: a comparative study. *International journal of remote sensing* 26 (2005):101-114.

Mas, J. 1999. Monitoring land-cover changes: a comparison of change detection techniques. *International journal of remote sensing* 20 (1):139.

Olander, L.P., H.K. Gibbs, M. Steininger, J. Swenson, and B. C. Murray. 2008. Reference scenarios for deforestation and forest degradation in support of REDD: a review of data and methods. In *Environmental Research Letters*.

Rosin, P. 1998. Thresholding for change detection. In *Computer Vision - Sixth International Conference*.

[VCS] Voluntary Carbon Standard. About the VCS 2008 [cited 11/20/08. Available from http://v-c-s.org/about.html.