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ISSUES AND CHALLENGES FOR FOREST-BASED CARBON-OFFSET PROJECTS: A CASE STUDY OF THE NOEL KEMPFF CLIMATE ACTION PROJECT IN BOLIVIA

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Abstract

The Noel Kempff Climate Action Project in Bolivia, now in its third year, is breaking ground to establish credible and verifiable methods to quantify greenhouse gas benefits of land-use change and forestry (LUCF) projects. Developed under the Activities Implemented Jointly pilot phase, the project conserves natural forests that would otherwise have been subjected to continued logging and future agricultural conversion. Carbon monitoring began with a C inventory of the project area in 1997; the total amount of C in the project area was 118 Tg (Tg = 10^{12}g) ± 4% (95% confidence interval). Periodic monitoring of relevant C pools (occurring in 1999 and every 5 yr thereafter) occurs over the 30-year life of the project to establish the difference between the with-project and projected without-project scenarios. Permanent sample plots were established both inside the project area to monitor changes in C pools over time; and in a proxy logging concession near the project area to determine changes in C pools in forests that have been impacted by logging. Ground-based monitoring is complemented by data collection on forest industry trends and land-use change patterns. Remote sensing was used to develop a vegetation stratification map of the area, and work is ongoing to investigate the potential application of dual-camera aerial videography to improve the efficiency of monitoring over time.

Keywords: Bolivia, carbon cycle, carbon offsets, land-use change and forestry, climate change, emission trading, Kyoto Protocol

1. Introduction

The global carbon cycle is recognized as one of the major biogeochemical cycles because of its role in regulating the concentration of carbon dioxide (CO_2), the most important greenhouse gas (GHG), in the atmosphere. Increasing concentrations of CO_2 in the atmosphere are a major contributor to climate change (Schimel et al., 1995). Forests play an important role in the global C cycle because they store large quantities of C in vegetation and soil, exchange C with the atmosphere through photosynthesis and respiration, are sources of atmospheric C when they are disturbed by human or natural causes (e.g., use of poor harvesting practices, cleared and burned for conversion to non-forest uses, wildfires, and the like), and become atmospheric C sinks (i.e., net transfer of CO_2 from the atmosphere to the land) during land abandonment and regrowth after disturbance (Brown et al., 1996). Changes in forest land use have been and are currently a significant source of atmospheric CO_2, up to about 20% of current fossil fuel CO_2 emissions (Dixon et al., 1994; Brown et al., 1996). Humans have the potential through forest management to change the magnitude and direction of forest C pools and flux, and thus alter their role in the C cycle and their potential to impact change climate.

In this paper, we present a general overview of: the types of forest management activities that can be implemented to mitigate carbon emissions and thus serve as potential carbon-offset projects, key aspects of the Kyoto Protocol that relate to forests and land-use change activities, the environmental and socio-economic benefits that accrue in addition to mitigating carbon emissions, and the key technical and scientific challenges involved with designing and implementing carbon-offset projects. We then describe the approaches and activities that are being implemented to address the various technical and scientific challenges as they pertain to the Noel Kempff Climate Action Project. We first provide a brief background on the Noel Kempff Climate Action Project and site, then discuss how each technical challenge is being addressed, and finally address what we consider to be some of the future challenges facing forest-based offset projects.

2. Forest Management Activities for Mitigating Carbon Emissions and the Kyoto Protocol

Land-use change and forestry (LUCF) activities can mitigate C emissions by (1) emission avoidance or conserving existing C pools on the land (e.g., by slowing deforestation, preventing logging, or improved forest harvesting practices), (2) C sequestration or expanding the storage of C in forest ecosystems by increasing the area and/or C density of forests (e.g., by establishing plantations and agroforests, allowing for natural regeneration, or improved soil management, and to increase storage in durable wood products), and (3) substitute sustainably grown wood for energy intensive and cement-based products (e.g., biofuels, construction materials) (Brown et al., 1996). Several projects that include such LUCF activities just described have been developed in the pilot phase of Activities Implemented Jointly (AIJ), established under the Berlin Mandate in 1995 (Trexler et al., 1999.

The recognition that LUCF activities could be both sources and sinks of C led to their inclusion in the Kyoto Protocol. There are five articles in the Protocol that refer to LUCF activities, two of which pertain to project-level activities and emissions trading (Articles 6 and 12). Under the not-yet-ratified Kyoto Protocol, joint implementation projects can be developed only between Annex I (industrialized) countries that are party to the Protocol (Article 6). Article 12 defines the Clean Development Mechanism (CDM), whose purpose is to assist non-Annex 1 (developing) countries achieve sustainable development, while at the same time assist Annex 1 countries in achieving compliance with their commitments. Under the CDM, non-Annex 1 countries will benefit from project activities resulting in certified emission reductions (CERs) and Annex 1 countries may use the CERs accruing from such project activities to contribute to their commitments. Thus in essence, Article 12 allows for emission-offset trading between developed and developing countries. Further, emission reductions resulting from such project activities must be real, measurable, long-term benefits related to mitigation of climate change, and additional to any that would occur without the project. Although LUCF projects are not explicitly mentioned in Article 12, they are not explicitly rejected either. Pilot forest-based C-offset projects are being designed and implemented in developing countries with the support of or investment from an industrialized country participant with the expectation that they will be accepted under the CDM proposed in the Kyoto Protocol.

3. Potential Co-Benefits of Forest-Based Projects

Forest-based climate change mitigation projects can offer substantial benefits in addition to GHG emissions reductions, avoidance, or sequestration (Frumhoff et al., 1998; Goldberg, 1998; Trexler et al., 1999). Forest-based projects may protect existing primary or secondary forests and other ecosystems that house the diversity of these natural systems. In most regions of the tropics, high rates of deforestation, on the order of 13 million hectares per year, are continuing (UN Food and Agriculture Organization, 1997). Climate change mitigation projects offer an economic incentive to conserve existing natural forests, afforest degraded lands, or implement sustainable forest management. All these activities can enhance or conserve existing biodiversity, protect watersheds and soil resources, reduce local air pollution, enhance food production, transfer technology, and contribute to the sustainable development of the host nations (Goldberg, 1998;Trexler et al., 1999).

Increase in economic opportunities for local communities is another co-benefit of forest-based projects. 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 forest projects (Goldberg, 1998). Consideration of the economic incentives for local communities, at the very least, can serve as a means to better ensure a long-term climate benefit as it reduces the likelihood that, for instance, protected forests are not encroached or are not harvested. Local communities, in many cases, have a tradition of living off the forest resources around their communities. If access to these lands is restricted in some way, projects must address the economic needs of communities to avoid negative impacts on the community, and to minimize risks that local people will impact the project's forests resulting in leakage. In many cases, rural communities are subject to boom-and-bust forest exploitation cycles. Conserving forests and forest resources, or establishing long-term sustainable forest growth and management projects, can offer a steadier economic base for these communities and greater security that natural resources will be available for subsistence and sustainable management as well. Forest-based carbon-offset projects have the potential to direct benefits to local communities than has past international development assistance.

Finally, as with all climate change projects in developing countries, governments and landowners can negotiate equitable project benefits sharing. Options for benefits sharing may include dividing GHG offsets, charging a premium for developing projects in the country or on offsets sold from their country's projects, and negotiating support for other climate change mitigation activities in the country that can benefit the national economy, environment and communities. Governments will have the opportunity to determine the types of climate change mitigation projects that are a priority for them. Countries with degraded lands or diminishing forests may target forest-based project developers, while others may choose energy efficiency or fuel-switching projects as their top priorities.

4. Technical and Scientific Challenges in Forest-Based Offset Projects

There are several technical and scientific issues related to the use of LUCF activities as mechanisms for countries to meet their obligations under the Kyoto Protocol (Brown, 1998; Trexler et al., 1999; and other papers in this volume). Many of these issues are considered to be threats to the implementation of LUCF projects for C trading; however most of these concerns apply equally to energy-sector projects. The key challenges are (Brown, 1998; Trexler et al., 1999):

- **Additionality**—Projects must demonstrate that project's activities must lead to C benefits that are additional to a "business-as-usual" scenario. In other words, an additional project is one that would have had little chance of being implemented but for the mechanisms covered by Article 12 of the Kyoto Protocol and the GHG emissions would be higher but for the carbon-offsets from the project (Swisher, 1998). A number of tests have been proposed by the US Initiative of Joint Implementation to provide evidence for additionality of a project. These include: financial additionality—evidence that project activities are stimulated by investments or funding beyond that normally available; technological additionality—evidence that project activities have resulted from the removal of technological barriers; and institutional additionality—evidence that project activities go beyond the scope of national programs or regulations.
- **Leakage**—Projects must demonstrate that anticipated C benefits do not suffer an unexpected loss due to the displacement of activities in the project area to areas outside the project that result in C emissions. For example, preventing deforestation in the project area may cause the displaced persons to move elsewhere and deforest, thus there is little to no additional C savings—referred to as activity shifting. Or, stopping or reducing forest harvesting may cause harvesting to increase in another region or another country to satisfy the demand—

referred to as market effects. Leakage is commonly thought of as a loss in carbon, but in some cases leakage can be positive where project activities inadvertently lead to more carbon benefits than originally estimated. Leakage can often be anticipated and prevented as part of the project design by addressing the demands for products or resources (e.g., agricultural land, timber, fuelwood) contributing to the land-use change.

- **Permanence**—A unique feature of LUCF projects is the possibility of a reversal of C benefits from either natural disturbances such as fires and unusual weather events; or from the lack of reliable guarantees that the original LUCF activities and emissions will not return. However, strategies have been identified that could guard against such reversals such as establishment of contingency carbon credits, insurance, and mixed portfolios of projects. LUCF carbon-offset projects should be viewed not as a permanent solution, but rather to postpone emissions to buy time to develop and implement policies and measures requiring longer lead times. For further discussion on issues related to permanence see Moura Costa et al. (this issue).
- **Baselines or without-project case**—Quantifying the additional C benefits from LUCF projects requires the development of a baseline scenario against which changes in C pools in the with-project case can be compared, in other words, what would have happened on the land without the project. For example, in a project aimed at avoiding emissions by preventing deforestation, the baseline would be based on predicting how deforestation in the project area would have occurred without the project over the life of the project.
- **Carbon inventorying, monitoring and verification**—To demonstrate verifiable C benefits, projects must design and implement an initial C inventory, ongoing C monitoring, and a verification program that provides the data necessary to complete the with- and without-project scenario in transparent and verifiable ways.

5. Noel Kempff Climate Action Project

In 1996, the Government of Bolivia, the Bolivian conservation organization Fundación Amigos de la Naturaleza (FAN), American Electric Power and The Nature Conservancy designed a forest-based joint implementation pilot project to allow for the expansion of Noel Kempff Mercado National Park, now totaling approximately 1.5 million hectares. The duration of this \$9.5 million project is 30 years. Industry investors PacifiCorp and British Petroleum America (now BP Amoco) joined the project in 1997. This is the largest pilot LUCF project to date to be implemented in terms of its area, funds invested, and projected carbon offsets. Project funds were used to compensate three forest concessionaires for giving up their logging rights on government-owned forest lands to the west of the previously existing park. The Government of Bolivia then retired the logging rights on this land and expanded the national park to encompass these former forest concessions, thus launching the Noel Kempff Climate Action Project. The project area includes only those lands now within the national park for which the former concessionaires were compensated using project funds.

5.1. Description of Project Area

The project is located in northeastern Bolivia in the Department of Santa Cruz in Noel Kempff Mercado National Park. The project area of approximately 634,000 ha is located within the newly expanded western region of the park that was added in 1996 (latitude 14.775^{o} S to 13.485^{o} S and longitude 61.850^{o} W to 60.640^{o} W). The park is bounded on one side by the Bolivia-Brazil border formed by the Itenez River that drains into the Amazon Basin (Fig. 1). Prior to the initiation of the Noel Kempff Climate Action Project (NKCAP), the forest in the expansion area had been high-graded over a period of about 15 years for several commercial species by three concessionaires. The forests in the expansion area are made up of six basic types (from interpretation of Landsat TM satellite data): tall evergreen, liana, tall inundated, short inundated, mixed liana and burned forest. The elevation of the project area is about 200 m or less with gentle to flat topography, with a mean annual rainfall of about 1,500 mm and a dry season (< 50 mm/mo) of about 2-3 months.

5.2. Project Overview

The two threats to the project area were continued forest logging by the concessionaires and deforestation for agricultural expansion from communities on the Bolivian and Brazilian boundaries of the area. The NKCAP generates C offsets by permanently halting forestry operations in the park expansion area, and protecting these lands from future agricultural encroachment. One of the first activities in this project was to use the funds to indemnify the forest concessionaires, including retirement of their logging equipment. The concessions were then retired by the Government of Bolivia thus ensuring that no legal logging would occur in the area. The NKCAP incorporates several other project components designed to ensure long-term park protection and C-offsets generation. The NKCAP provides funds to establish protection activities in the expansion area of the park in the short-term, and establishes three long-term financing mechanisms as well.

The NKCAP also funds ongoing C monitoring to calculate real benefits over the life of the project. Funds also support leakage prevention activities that are being undertaken in conjunction with the former forest concessionaires and the local communities in and around the park (see below for further details). Finally, the project also supports the Government of Bolivia's efforts to participate in the project and to expand its programs in climate change mitigation policy and implementation at a national level.

Carbon offsets are calculated by determining the C emissions that would have occurred within the project area on the subset of lands that would have been impacted by logging or conversion to agriculture if the project had not occurred. The analysis of C losses avoided incorporates historical data and assumptions about long-term forest management and settlement patterns in this area, and will be revisited and adjusted as the project proceeds.

5.3 Addressing Technical Challenges

5.3.1. Additionality

Project participants may only claim C offsets that result from the prevention or reduction of emissions that are additional to those that would have been registered without the project funds and activities. As part of the feasibility study, it was shown that the Government of Bolivia did not have access to the necessary resources nor the political will to terminate the forest concessions and expand the park without the NKCAP's funds and activities. Without the NKCAP, the concessionaires would have continued exploiting the forest for the remainder of the concession period. And, these concessions would likely have been renewed as they had been in the past.

Deforestation rates in Bolvia are not well known as there has been no national inventory since the 1970s (Food and Agriculture Organization, 1993). Estimates for the 1990-95 period range from about 200 thousand ha/yr (Killeen, 1999) to about 580 thousand ha/yr (Food and Agriculture Organization, 1997). Much of the deforestation occurs in areas zoned for agriculture, forest reserves, and forest production (Killeen, 1999). Evidence from these national trends and from a study of deforestation rates and patterns around a forest reserve in the northeast of Santa Cruz State (Killeen, 199), encroachment and deforestation would likely have continued as people moved into the Noel Kempff area .

5.3.2. Leakage

The concern for leakage from preventing timber harvesting in the project area is that the shortfall in timber production from the project area will be made up by increased harvesting in other concessions. The concern for leakage from preventing deforestation and conversion to agriculture arises because people in the area who were engaged in forest conversion could move these activities to another area outside the project. The NKCAP has implemented many activities to minimize leakage at the 'source" and to monitor any potential sources of leakage (see next sections). To date and to the best of our knowledge, no leakage has occurred. There has been no migration of people from the communities adjacent to the project area to other areas to deforest, and there has been no increase in timber output from other concessions. Since the inception of the project, Bolivia enacted a new forestry law which has had several repercussions: it reduced the size of a concession because tax is based on area under concession not volume extracted as in the past, detailed management plans are prepared and implemented by concessionaires, timber production and damage decreased, and many concessions are becoming certified as producers of sustainably produced timber (Nittler and Nash, 1999). As describe below, the enactment of the new forestry law had implications for the without-project baseline scenario which is presently undergoing revision.

5.3.2.1. Leakage prevention with communities

The NKCAP is supporting a community program designed to improve the standard of living and initiate economic activities in the communities located around the park. These activities are in the process of being implemented and are intended to avoid deforesting activities that might have been transferred to lands outside the project area. The Community Leakage Prevention Program focuses principally on the following activities to prevent leakage and support sustainable community development:

- Provide technical and financial support to assist indigenous communities to legally obtain territories large enough for sustainable resource management through the Original Community Territory Act (TCO). Acquiring title is still an ongoing activity. Land title is being sought to benefit three communities totalling about 1,000 inhabitants of the area; they are seeking lands contiguous to the park that also encompasses the communities. Obtaining legal title to lands diminishes the colonization pressure on the project area and reduces the risk that these people will convert land in the project area to agriculture. In effect, the community lands would become another type of protected area if managed sustainably.
- Diversify the productive activities of the community members in accordance with a land-use plan and the nutritional needs of the community members, putting greater emphasis on sustainable land uses, principally for establisment of heart-of-palm plantations and agroforestry on degraded lands, growing of nutritious crops, improved animal husbandry techniques, forest management, and on ecotourism. For example, grazing lands are incorporating include nitrogen-fixing species to improve fodder and increase carrying capacity of animals per unit of land. Agroforest systems are being established and are incorporating new vegetable crops with fruit trees. Tree nurseries have also been established and these are now being privatized as microenterprises managed by members of the community. The project has also leveraged funds from the local municipalities to pay for teachers and other public works.
- Improve agricultural production and reduce soil degradation and thus reduce the need to clear new areas for agriculture.
- Within the area requested for the TCO, forest management plans have been completed to develop wood and non-wood products. For example, one community has been given legal rights to harvest hearts-of-palm on some of the targetted lands to process in the existing canning factory.

5.3.2.2. Leakage agreement and leakage prevention with ex-concessionaires

The NKCAP tracks the activities of former forest concessionaires with respect to how the indemnification funds are used. The NKCAP also works with one of the ex-concessionaires who went into partnership with another concessionaire to incorporate sustainable forestry practices.

The legally binding Agreement to Prevent the Displacement of the Environmental Benefits achieved by the NKCAP was signed on January 16, 1997, by the indemnified logging companies' representatives and FAN acting as the project manager of the NKCAP. In the agreement, the parties agreed upon measures to preserve and protect the environmental benefits resulting from project implementation, and to provide guarantees and commitments to present and allow review of reports on the concessionaires' activities outside the park expansion area. This will allow project participants to evaluate, prevent and, if necessary, mitigate any GHG leakage. The responsibilities for assuring leakage prevention with the indemnified concessionaires are shared by both the Ministry of Sustainable Development and Planning of the Government of Bolivia, and by FAN.

The Government of Bolivia, through specialized institutions, will provide technical support for the development and implementation of plans and practices for sustainable forest management in the remaining concessions. Such sustainable forest management plans and practices should be sufficient to comply with the applicable requirements of the new Bolivian forest law and corresponding rules and regulations. FAN is charged with tracking the concessionaires' activities, verifying that the concessionaires comply with the commitments made in the Leakage Agreement which the concessionaires signed. FAN will primarily review the annual management plans and reports submitted by the concessionaires to the Bolivian Forest Superintendent; will review and verify reports on the use of indemnification funds; and will verify and document any changes in concessionaire activities that might affect C emissions. With this information, FAN or any other institution will be able to evaluate the potential or actual occurrence of leakage.

5.3.2.3 Activities to monitor and evaluate leakage

A protocol has been developed that considers two levels for monitoring and evaluating leakage: (1) the micro level, in which rates of harvesting from the ex-concessionaires as well as indicators of community development are monitored, and (2) the macro level, in which the trends in logging and timber production and in land-use/land-cover change in other parts of Bolivia are tracked and analyzed.

At the micro-scale, the following tasks are being implemented:

- Data from the activities of the only ex-concessionaire, currently a majority shareholder of a logging company that is still harvesting, will be used to calculate and track potential leakage. With the strengthening of the company by the infusion of new funds, the company's production may have increased. We plan to investigate what the logging company produced before the NKCAP. By reviewing the past annual reports we will compare past rates of extraction to how much they now produce and anticipate producing in the future--any difference could be due to leakage. However, other issues would need to be investigated such as the species being logged, how the current harvesting rates compare with other concessions in the area, and how prices may have changed and how this affected harvesting rates. Furthermore, the implementation and enforcement of the new Bolivian forestry law requires detailed management plans that must be used for the logging operations; these are subject to random checks by the Superintendent of Forests.
- Indicators of community development will be identified and monitored. These indicators will show whether the communities are improving their health and welfare, changing their land-use practices such as by clearing more or less land, planting more trees than cutting, establishing palm plantations, and establishing ecotourism activities. Indicators of these activities will include area of palm plantations, production of such plantations, changes in income, availability of health care and education, and changes in forest cover and other land uses in the surrounding area since the beginning of the NKCAP monitored by remote sensing technology.

At the macro-scale, the following activities are being implemented:

- We have obtained a copy of the long-term plan for the forestry sector in the Department of Santa Cruz. This plan, including maps, has the location and status of new forest concessions. We will also document the likely tree species that will be harvested and the expected rates of harvest under Bolivia's new forestry law. Such information about the future plans for use of the forest areas in the Department of Santa Cruz can be a useful indicator for understanding the projected logging rates and to assess trend in logging for addressing leakage.

- National, regional, and local reliable statistics on wood production by major species (in units of volume), and, if possible, the end use of the wood, from logging for the 10 year (annual) period prior to the initiation of the NKCAP and through time (every 5 years or so) for the duration of the project will be compiled from all available sources (Government of Bolivia, Superintendent of Forestry, and the Forest Products Yearbook of the UN Food and Agriculture Organization). Data on trends in prices of harvested timber will also be collected. These data will demonstrate the trend in likely rates of logging and likely rates of damage and thus C emissions. These data will assist the NKCAP in determining the trends and patterns of logging practices and rates of wood production, and ultimately the associated C emissions.
- Information from the Superintendent of Forestry, professional foresters, and concessionaires will be obtained regarding the potential for new species to become commercial and logged over the life of the project. If new species are identified and likely to be logged, the intensity of logging could increase in the concessions. If these new species are present in the NKCAP then it is likely that logging damage and thus emissions would have increased over time without the project. Depending on the data obtained, we may be able to estimate the upper range of potential offsets from the project, which might help compensate for leakage if any is found.
- To monitor for leakage caused by averting deforestation and conversion to agriculture, satellite imagery at periodic intervals will be analyzed to measure changes in land cover and land use in the larger area surrounding the NKCAP. From such data we will be able to determine rates of land-use change.

5.3.3 Permanence

At this stage it is not clear how the potential carbon-offsets from this project will be credited for the duration of the project to the investors and the Government of Bolivia; policy debate is ongoing, especially with respect to issues of pemanence (see Moura Costa et al., this issue for further discussion on permanence issues). We note, however, that the NKCAP provided the means for the Government of Bolivia to permanently transform former logging concessions into National Park lands. The project life is 30 years, and it is expected that after that time the conservation of the area will be firmly established and most of the recuperation from former logging activities would have occurred. After the end of the project, it is likely that the lands will continue to be park lands and will remain as such in perpetuity and will not revert to logging concessions, as stated in the Comprehensive Agreement that all partners signed, including the Government of Bolivia.

The Nature Conservancy has worked hand-in-hand with the Bolivian conservation NGOs and the Government of Bolivia to ensure that what were once "paper parks" are now truly protected areas. Noel Kempff is an example of how the Conservancy's Parks in Peril program was able to provide the much needed initial support (with funding from USAID) to transform this park into a world class site with the needed infrastructure, staff, management plan, and a local Park Management Committee (that includes local residents) to ensure its protection. The NKCAP was the next step that allowed the expansion of the park, thus protecting twice again as much land from logging and agricultural conversion, and establishing permanent funding mechanisms managed privately in perpetuity for the Park. The Government of Bolivia also recently established a National Park Service and has made numerous public statements this year about its support for wider forest conservation in Bolivia, in particular through mechanisms such as climate action projects. Much of this support is based on the success of the Noel Kempff Climate Action Project.

The occurance of natural disturbances, especially fire, is of concern in that disturbances can affecting the permanence of LUCF carbon offsets. Within the NKCAP fire has occured (one of the six strata, cf. Table 1), but this was in an area surrounding a logging camp and sawmill and the evidence suggests that this was of human origin. During the extensive field sampling in the project area no other evidence of fire was noted. Even if fires do occur in the forest area, and parts of the forest are in various stages of recovery, this has been captured in our inventory. Future monitoring plans will also capture this type of disturbance. And, because the project area has extensive wetlands, fire, if initiated, is not likely to spread throughout the park.

5.3.4 Inventorying and Monitoring of Carbon in the NKCAP

A key aspect of forest-based projects for mitigating C emissions and for use in trading is to accurately quantify the project-level C benefits to a know level of precision. The C benefits are calculated as the net differences between selected C pools for the with-project and the projected without-project conditions in the project area over a specified time period. The challenge is to identify what pools need to be quantified in the project, to measure them accurately to a known, and often pre-determined, level of precision, and to monitor them over the length of the project.

We differentiate between the initial C inventory and the subsequent monitoring. In the initial inventory, major C pools are quantified in the with- and without-project situation, but in subsequent monitoring only some of the initial pools may need to be remeasured and even indicators could be used instead. Criteria to consider in the selection of C pools to inventory and monitor include the type of project, the size of the pool, their rates of change, their direction of change, measurement costs, and attainable accuracy and precision (MacDicken, 1997a,b). Basically, an accounting system is used that includes all pools anticipated to decrease and a selection of pools anticipated to increase as a result of the project. Only pools that are measured and monitored are incorporated into the calculation of C benefits.

The C offsets in the NKCAP result from the prevention of logging and conversion of forested lands to agriculture. Avoided C emissions will result from:

1. Averted logging
    - removal of commercial timber will be halted
    - damage to the residual forest will be eliminated
2. Averted conversion of forested lands to agricultural uses
    - loss of C in forest biomass will be halted
    - loss of C from soil will be eliminated

Techniques and methods for measuring the major C pools in forestry-based projects are well established, and based on commonly accepted principles of forest inventory, soil sampling, and ecological surveys (MacDicken, 1997a; Pinard and Putz, 1996,1997; Post et al., 1999). The project design for inventorying and monitoring all C pools in the with-project case is based on the methodology and protocols in MacDicken (1997a). The C inventory of the area was based on data collected from a network of permanent plots, located using a differential global positioning system (DGPS) (Fig. 2). The total number of plots established was 625, with the number of plots sampled in a given strata based on the variance of an initial sample of plots in each strata and the desired precision level (±10%) with 95% confidence (Table 1). A fixed area, nested plot design was used (4 m radius plot for trees with dbh [diameter at breast height] of ≥ 5-20 cm, and 14 m radius for trees with dbh ≥ 20 cm) and the following C pools were measured or calculated for each plot: all trees with dbh ≥ 5cm, understory, fine litter standing stock, standing dead wood, and soil to 30 cm depth (Table 2). Root biomass was estimated from root-to-shoot ratios given in Cairns et al. (1997). Lying dead wood was sampled in about 20% of the plots May 1999 and the data are still being analyzed.

The total amount of C in the above mentioned pools in the park expansion area is about 118 Tg C ± 4 % (95% CI) (Table 2). Most of the C is in aboveground biomass of trees (64%), followed by soil to 30 cm depth (19%) and roots (16%); the understory and fine litter account for about 3% of the total.

The precision of the estimated C pool is based only on the sampling error at this time; work is in progress to include the measurement error and regressions error. Calculations of C pools in US eastern forests demonstrated that the sampling error is the largest source, accounting for up to 80% of the total error (Phillips et al., in press). If we assume a similar situation in the NKCAP, then accounting for regression and measurement error may bring the total error to about ± 5 %, well below the target of ± 10 %.

5.3.5 Estimation of Carbon Offsets

The carbon offsets are estimated as the difference between the with-project case and the projected without-project case. Projecting the without-project case can be problematic because of the need to predict what changes the area would likely have undergone if the project had not been implemented. Such changes in forest management practices and land use are hard to predict because of the many socio-economic, cultural, and political conditions that can affect these changes. We next discuss how we developed the without-project scenarios and how we estimate the C offsets.

5.3.5.1 Averted logging

Estimates of the changes in major C pools per unit area due to logging practices if logging had been allowed to continue over the project life were assessed to generate the without-project baseline. The main C pools considered are aboveground tree biomass, dead biomass, and wood products. Because the new forestry law has been enacted since the project started, the without-project baseline is being re-assessed (analysis ongoing). From a detailed analysis of the project area by an independent team of Bolivian foresters (who estimated how much of the land would be logged and the likely timber extraction rates), data on the minimum diameter classes of harvested trees and how frequently a forest block can be re-harvested, analysis of data provided by nearby logging concessionaires, and an analysis of concessionaire management plans in areas nearby, the likely area harvested each year and the quantity of wood (in cubic meters per hectare) extracted per year will be estimated over the length of the project.

To determine the change in C pools from logging activities, measurements have been and will be made in a nearby proxy forest concession (about 80 km from the western edge of the project area) whose forest types closely resemble those in the project area and who are compliant with the new forestry law. Permanent plots have been established to measure the amount of dead biomass produced during the felling of a tree and associated activities such as yarding and skidding, as well as the rate of regrowth after harvesting. Dead biomass results from the crowns of the felled timber tree and damage to other trees (broken, uprooted, or broken-off large branches from surviving trees). Total production of dead biomass C per unit of harvested biomass C is determined from these plots. Results show that for every 1 Mg C of removed in a log, 2.2 Mg C (SE = 0.14, n=102) of dead wood are produced.

$$\text{C offsets from averted logging} = \underbrace{\Delta\text{live biomass C}}_{(1)} + \underbrace{\Delta\text{dead biomass C}}_{(2)} + \underbrace{\Delta\text{wood product C}}_{(3)} \quad \text{(Eq.1)}$$

where Δ is the quantity of biomass C in the with-project case minus the without-project case (i.e., change in the C pool). The annual offsets are calculated from a carbon accounting model that calculates all of the changes in these pools from a scenario based on annual area logged and log extraction rates. Because field monitoring will conducted every five years (see below) in the proxy area, the model will use five-year averaged data. As logging practices change over the duration of the project, the annual offsets can be recalculated based on these changes.

(1) Δlive biomass C = (biomass C from logging damage + C in timber extracted) x growth factor

To estimate the change in live biomass, one could measure the live biomass in the proxy concession before a block was logged and then again after it was logged; the difference would give the change in the live biomass C. However, the main problem with this approach is that two large C pools are being subtracted, and although the error on each pool could be small, say 5% or so, the error on the difference, expressed as a percent, will be much larger (Phillips et al., in press). One way around this is to measure the change in live biomass directly as we did in the NKCAP. The change in live biomass between the with- and without-project cases is a result of the extraction of timber and damage of residual trees from the logging activities, thus these were the components that were measured in this project.

The quantity in parenthesis in (1) above, expressed on an area basis, multiplied by the area logged per year gives the total change in live biomass without adjustment for logging effects on growth of the residual stand. The growth factor accounts for the impact of logging on the growth of the residual stand. If logging stimulates growth of residual trees, then stopping logging in the project area reduces this increased C uptake. The overall C offset would be reduced by this amount and the growth factor would be less than one. However it is not clear how harvesting affects regrowth in recently logged areas. The removal of large trees due to logging and the damage to residual trees may be enough to actually reduce regrowth of the stand per unit area after logging rather than stimulate it as is often assumed, and the growth factor would be greater than one. Thus for projects that prevent logging, the effect of logging on growth of the residual trees must be determined. Monitoring of paired permanent plots in logged and unlogged areas of the proxy concession is underway to establish the sign and magnitude of the growth factor over the length of the project. Initial estimates of the carbon offsets assumed a growth factor of one.

(2) Δdead biomass C = (dead biomass from logging damage x decomposition factor)

In projects related to preventing or reducing logging impacts, dead wood cannot be ignored because logging increases the size of this pool. Thus stopping logging (with-project case) has the effect of reducing the dead biomass C pool, and the change in the dead biomass C will be negative, i.e., the dead biomass C in the with-project is less than without-project case. Research has shown that dead wood decomposes relatively slowly in tropical forests and it is a pool that has a long turnover time (Delaney et al., 1998). However, the change in the dead biomass pool has to be corrected for decomposition, but only over about half of the rotation time. This is explained by the following example: in a concession that is logged over a 25 year rotation, there would be blocks logged 25 years ago, 24 years ago, etc. to one that was logged 1 year ago. Thus the amount of dead wood caused by logging damage in the concession would, on average, be the initial amount caused by logging reduced by the amount decomposed over about 12 years. At present, estimates of the decomposition correction factor are taken from the literature (Delaney et al. 1998), but plans call for improving this factor from field studies.

(3) Δwood products C = (timber extracted x proportion converted to long-lived products)

Stopping logging reduces the long-term wood product pool because the input of new products is reduced; the change in the wood products pool between the with- and without-project is thus negative. In the NKCAP, the proportion of harvested roundwood that goes into long-term wood products (life of greater than 5 yr, although most products have a longer life than this) was obtained from literature sources for Brazil (Winjum et al., 1998). We assumed that wood waste generated at each stage of the conversion of timber to products was oxidized in the year of harvest; none of the wood waste is used for cogeneration.

We estimate that, depending upon the effects of logging on rates of regrowth and the rate of wood decomposition, the likely area of the former concessions logged each year, and the projected annual harvesting rates, the C offsets from this activity will range between 5 and 6 Tg C. This range will be refined after the 1999 monitoring activities and revision of the without-project baseline.

5.3.5.2 Averted conversion to agriculture

The without-project baseline for this component was established using projected human demographics in the areas adjacent to the project area (Killeen, 1999 and per. comm.). The two factors affecting conversion of forestlands to agriculture are increasing human populations and the resulting demand for farmland. In constructing the deforestation scenario, we assumed that migration into the area will increase population. Such increases are likely, given that only the Bolivian population has been factored in, when in fact a high degree of pressure will come from the Brazilian side also. There is a population close to 40,000 on the Brazilian side of the River Iténez, bordering the Noel Kempff Mercado National Park. Before drastic control measures were initiated by the Park managers, 500 hectares of forests were illegally logged in a single year in the park, and illegal clearings and cattle grazing occurred by Brazilians crossing the international border into Bolivia. Estimates of deforestation around and in a forest reserve in the northeast of Santa Cruz State are about 0.2%/yr (Killeen, 1999).

$$\text{C offsets from averted forest conversion} = \Delta\text{total biomass C} + \Delta\text{soil C} \qquad \text{(Eq.2)}$$

Carbon losses as forests are converted to agriculture come from two sources: loss of forest biomass as land is cleared and burned and soil oxidation. Carbon loss from change in biomass is calculated as the product of the projected area cleared and the difference between C in forest biomass (sum of trees, understory, litter, dead wood, and roots) and agriculture crop biomass (obtained from field measurements in nearby agricultural lands and from Flint and Richards, 1994). Carbon loss from change in soil C is calculated as the product of area cleared, weighted average forest soil C (Table 2), and an average soil oxidation rate for converted tropical forest soils obtained from the literature (Detwiler, 1986). The estimated C offsets from averted conversion to agriculture ranges from 1.5 to 2.5 Tg over the life of the project. However, as with the averted logging, the without-project baseline is currently being revised.

5.3.6. Carbon Monitoring Plan

The monitoring timetable after the initial inventory is planned at year 3, 5, 10, 15, 20, 25 and 30. Future monitoring plans include:

- Analysis of changes in land cover/land use from satellite data;
- Acquiring timber harvest rates in nearby concessions;
- A promising advance to provide cost-efficient means for monitoring is a system that includes dual-camera aerial videography coupled with a pulse laser profiler, and the necessary data

recorders and DGPS (D. Slaymaker, University of Massachusetts, 1999, pers. comm.). Such a system is able to produce indices of crown area, stem density, and canopy height, as well as identify the extent and number of gaps produced by logging; this system is being tested in the Noel Kempff Climate Action Project during 1999;

- Remeasurement of a random selection only of permanent plots in the project area at each monitoring time;
- Remeasurement of the logged and unlogged permanent plots established in the nearby logging concessions to compare rates of regrowth; and
- Measurement of damage from harvesting in a nearby logging concession to monitor trends in logging damage.

Analysis of all data and information from the above monitoring plan will enable revisions to be made to the without-project baseline, and thus produce more accurate and precise estimates of the C offsets over the duration of the project.

5.3.7 Verification

The NKCAP provides internal verification and is currently taking steps towards external verification. Winrock International, the developer of the C inventory and monitoring methodologies, verifies that field data collection and analysis had been done correctly and of adequate quality to justify the analysis. This is considered internal verification. In the future, the project will submit its methods, assumptions, analyses and results to an independent panel consisting of both internal and external experts for review (see section 5.4).

5.4 Technical Operating Protocols and Advisory Panel

Now that the first year of field activities is finished and the data analyzed (1997-98), the team is incorporating lessons learned and finalizing the project's Protocols for measuring, monitoring, accounting for, and reporting on C offsets generated by the project. These Protocols will be submitted in 2000 to the Project Board and to the U.S. Initiative on Joint Implementation for their review and approval. The Protocols present detailed procedures for C monitoring, verification, Bolivian certification, leakage monitoring and evaluation, and C offsets accounting during the life of the project. They describe the roles of each party, deadlines for collecting data and preparing reports, procedures for periodic monitoring, procedures for calculating and certifying C offsets, procedures for approving changes in the monitoring plan, and various other specifics to ensure documentation and external review of C offset claims.

The project partners have agreed that the C analyses and accounting should be reviewed by a Technical Advisory Panel, consisting of experts both internal and external to the project. The Panel, convened by The Nature Conservancy, will review and comment on each C analysis done by the project technical team and will make a recommendation as to whether the analysis should be accepted or revised. The Panel, which also reviews other projects in which The Nature Conservancy participates, will also draw upon the experiences of other project teams and their own expertise to make recommendations for future modifications to the C monitoring regime if necessary. The Panel and the project partners will adapt their analyses and recommendations to be consistent with any future rules established under the Kyoto Protocol for LUCF project-based activities.

6. Future Challenges

In the future, forest-based and other types of offset projects may need to incorporate additional aspects to compete in the market for C offsets. These include the following.

6.1 Project Risk Management

The project is subject to several sources of risk such as political risk of nationalization, complete project failure, other major changes in forest concessions, and that LUCF projects will not be accepted as part of Article 12 of the Kyoto Protocol (CDM). The project parties have not yet assessed in detail the impacts of these types of risks. However, we note that this project was initiated before the Kyoto Protocol and consideration of the CDM was not a factor at that time.

The Government of Bolivia is already a partner in the NKCAP, and the project occurs on national park lands, so nationalization of the project is unlikely as the Government has already agreed to participate and has signed an international legal agreement to uphold its commitments to the Park and to the project. If the Government of Bolivia takes a great role in certifying and marketing offsets from this project, this is likely to be beneficial to the project, the Park and the protected areas of Bolivia in general as they will have a greater stake in the projects and the protected area system.

Currently, the NKCAP provides no insurance or backing for the potential risks and the C offsets it intends to generate. All of the risks of fewer offsets being generated than anticipated are born by the industry participants, the investors in the project who receive C offset distributions in exchange for their up-front investment. The Government of Bolivia does not insure offsets generation. While all parties signed a Comprehensive Agreement in which roles, responsibilities, and events of default are specified, no party guarantees any other party that offsets will be generated. Future projects will need to address these risks. In the example of Costa Rica, the government backs its C offsets, and reserves a "buffer" of all offsets generated that are not sold until project risks can be minimized.

6.2 Third Party Certification

Together, the NKCAP's Protocols and Technical Advisory Panel constitute a solid foundation for future third party project certification. Presently, the project does not contract third party certification, but rather provides rigorous internal verification. Project participants may need to address how to ensure that external verification or third party certification occurs, depending upon potential requirements of the Kyoto Protocol. Few pilot projects are being certified at this point, but this step will be essential to ensuring real greenhouse gas benefits under the Clean Development Mechanism.

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Table 1. Area of forest strata present in the Noel Kempff Climate Action Project and the number of permanent field plots established in each strata.

Vegetation type	**Area (ha)**	**Number of sample plots**
Tall, evergreen forest	226,827	171
Liana forest	95,564	131
Tall, inundated forest	99,317	64
Short, inundated forest	49625	35
Mixed liana forest	159,471	218
Burned forest	3,483	6
Total	**634,287**	**625**

Table 2. Results of the carbon inventory in the Noel Kempff Climate Action Project. The column values are the means per strata based on the number of plots for each strata shown in Table 1. One unit of biomass was assumed to contain 0.5 units of C. All information is from Winrock International (1998).

Strata	Area (ha)	Aboveground tree biomass (Mg/ha)	Understory biomass (Mg/ha)	Belowground biomass (Mg/ha)	Litter (Mg/ha)	Soil (Mg/ha)	Total (Mg/ha)	Total project case (Tg C)
Tall evergreen	226,827	139.6	2.0	34.9	3.6	28.5	208.6	47.3
Liana	95,564	62.4	3.8	15.6	4.0	40.5	126.3	12.1
Tall inundated	99,316	139.1	1.9	34.8	3.1	46.3	225.2	22.4
Short inundated	49,625	120.2	2.1	30.0	2.9	55.5	210.7	10.5
Mixed liana	159,471	101.8	2.6	25.5	4.3	24.5	158.7	25.3
Burned	3,483	66.1	0.9	16.5	4.2	36.0	123.7	0.4
Total C (Tg)		74.2	1.5	18.4	2.3	21.5		117.9
Weighted mean		117	2.4	29	3.7	34	184	
95% CI* (%)		5	10	5	3	5		4

*CI= confidence interval

Figure Legends

Figure 1. (not in this version) The original park (solid gray) had an imaginary line through the forest as its western border. For biodiversity conservation purposes, and to enhance ability to patrol park borders, the Government of Bolivia and Fundación Amigos de la Naturaleza (contracted to manage the park) wanted to expand the park to Paraguá River to the west. Through the Climate Action Project, former logging concessions and reserves to the west (hatched gray, 817,846 hectares) were incorporated into the park that now spans about 1.5 million hectares.

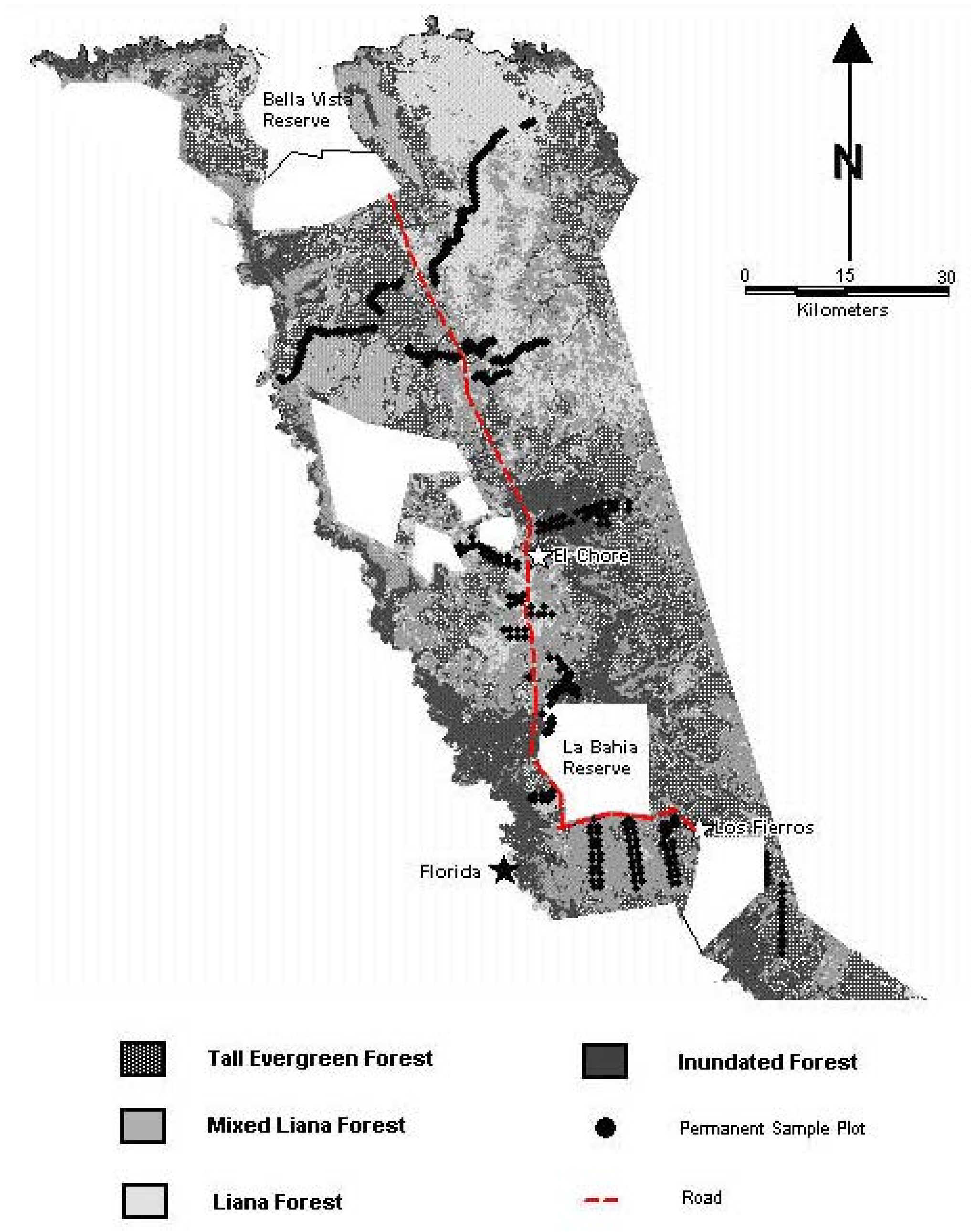

Figure 2. Map of the Noel Kempff Climate Action Project area showing the location of the 625 permanent sample plots. Initially the permanent plots were located systematically with a random start using regularly spaced points along transects. For later installation of permanent plots, transects were laid out to minimize transit time by using secondary logging roads to the extent possible. Road locations and vegetation type was used to determine transect locations to ensure a spatial distribution of plots to sample every major portion of the project area. For simplicity of mapping we have combined the tall and short inundated forest strata into one class; the burned forest strata is too small to show up on this map (it is located to the south of La Bahia Reserve).