



FEASIBILITY OF STANDARD PROCEDURES FOR
MONITORING ECOSYSTEM SERVICES PROJECTS IN THE
ATLANTIC FOREST

REPORT TO ALCOA FOUNDATION FELLOWSHIP PROGRAM

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LIST OF ACRONYMS

AGB – aboveground biomass

ARVORAR – Arvorar Soluções Florestais Ltd (private company)

BGB – belowground biomass

CDM – Clean Development Mechanism

CER – Certified Emissions Reduction

CO₂ – Carbon dioxide

EEC – Estação Ecológica dos Caetetus (forest reserve)

GHG – greenhouse gas

IPÊ – Instituto de Pesquisas Ecológicas (NGO)

PES – payment for ecosystem services

PDD – project design document

PIN – Project Idea Note

Rio-92 – United Nations Convention on Environment and Development

UNFCCC – United Nations Framework Convention on Climate Change

INTRODUCTION

One of the most threatened biomes in the world is the Atlantic Forest. Historically it covered more than 1 million square kilometres of land in Brazil, but today is reduced to less than 8% of its original distribution (Myers *et al.*, 2000). The current level of habitat loss and fragmentation of ecosystems is a serious threat to the long-term maintenance of biodiversity and to the provision of several ecosystem services, i.e. benefits that forests provide to humans (Millennium Ecosystem Assessment, 2005).

The majority of the Brazilian people can be directly affected by problems related to losses of ecosystem services because they live within the boundaries of the Atlantic Forest. Consequently, efforts to promote forest restoration are urgently needed in this biome.

Systems of payments for ecosystem services (PES) have been developed in several countries owing to increasing belief in the effectiveness of market-based mechanisms for conservation (Pagiola *et al.*, 2002). One of the most relevant examples of PES is the carbon market, which originated from a worldwide concern about impacts of climate change. In 1992, during the United Nations Convention on Environment and Development (Rio-92), representatives of more than 150 countries have discussed about problems and potential solutions related to global warming and climate change. One of the results of this event was the United Nations Framework Convention on Climate Change (UNFCCC), an international treaty that encouraged industrialized countries to reduce their emissions of greenhouse gases (GHG).

Five years latter the discussion about climate change has evolved to an international agreement, the Kyoto Protocol. Through this agreement 37 industrialized countries and the European Community became committed to reduce their emissions of GHG in the period from 2008 to 2012. Their target of reduction of GHG emissions was equivalent to 5% of the level of their emissions in 1990. Some market mechanisms were created for enabling these countries to achieve their targets of emissions reduction. One of these mechanisms is the Clean Development Mechanism (CDM). According to CDM rules the industrialized countries can implement projects to reduce emissions in developing countries. Such projects generate credits or certified reduction emissions (CER) that can be traded for achieving Kyoto's target. One CER unit is equivalent to removing one ton of CO₂ from atmosphere.

There are also several voluntary initiatives of carbon trade being developed simultaneously to CDM. Instead of being related to targets of the Kyoto Protocol these initiatives have been implemented for attending demands of individuals and institutions that are interested in contributing for mitigation of climate change or in compensating their own GHG emissions.

Projects of carbon sequestration that include activities of restoration of native forests in tropical countries are eligible for generating CER if they are submitted to verification, certification and monitoring according to CDM

rules. Alternatively they can be traded through the voluntary market if they are in accordance with rules of the selected voluntary mechanism.

Both CDM and voluntary carbon trade initiatives have been requiring the development of specific methods for quantifying and monitoring results of carbon sequestration projects. These methods should enable project developers and auditors to demonstrate or to verify how much carbon is being removed additionally from atmosphere and stored in forest biomass due to the project. Considering that there is a large variation in the types of forests, habitats, environments and the capacity of forests to remove carbon dioxide from atmosphere, project developers have been facing scientific challenges for defining appropriate methods for monitoring carbon in forest biomass and for obtaining accurate estimates of carbon stock in the forests. The overall objective of this study is to contribute to overcome these challenges through an investigation of carbon storage in fragments of Atlantic Forest in the state of São Paulo, Brazil.

The study considers a real scenario encountered by “Arvorar Soluções Florestais” (cited in this report as “Arvorar”), a private company created by IPÊ – Instituto de Pesquisas Ecológicas, a Brazilian non-governmental organization, for the implementation of projects of forest restoration and carbon sequestration according to rules of voluntary market or CDM.

Arvorar’s team has been prospecting carbon buyers, i.e. institutions and individuals interested in financing carbon-offset projects. Simultaneously, Arvorar has been searching for areas in the state of São Paulo that are available for implementing forest restoration activities that are financed by carbon buyers.

When these areas are detected it is necessary to analyze the economic feasibility of carbon-offset projects. The economic analysis of feasibility of the project requires information about how much CO₂ can be removed from atmosphere in the areas that are being selected. The capacity of forests to remove CO₂ can be determined by analyzing carbon storage in the remaining forest fragments near the selected areas. The specific objectives of the current study are: i) to quantify the amount of carbon stored in forest biomass in fragments of Atlantic Forest that are located in various geographic areas in the State of São Paulo; ii) to determine the maximum threshold values of potential carbon storage in forest biomass, that can be safely considered in the feasibility analysis of carbon-offset projects; iii) to provide recommendations of how to measure and monitor carbon storage in projects of restoration of Atlantic Forest in the State of São Paulo.

METHODS

Guidelines for estimating and monitoring carbon stocks

From the myriad of guidelines and recommendations found in literature for planning activities of estimation and monitoring carbon stocks (Brown et. al, 2008; BioCF, 2008; Pearson et. al, 2005; MacDicken, 1997), the current study has passed through the following steps:

- 1) Analysis of maps, aerial photographs and satellite images for selecting the forest fragments to be sampled;
- 2) Ground truth verification for confirming the existence of the selected fragments and the feasibility of data collection;
- 3) Fieldwork for collecting data of vegetation;
- 4) Analysis of vegetation data for assessing conservation status of the sampled fragments;
- 5) Estimation of carbon stocks in the sampled fragments through inputting vegetation data in biomass regression equations that were found in literature;
- 6) Developing procedures for monitoring forest biomass and the respective carbon stock.

Study area and the selected forest fragments for study

The Atlantic Forest biome is located on the lands where the European colonization begun 500 years ago: coastal areas from south to northeast Brazil and inland areas in the south (figure 1). Since the period of colonization more than 93% of these forests have been cleared (Morellato, 2000). Due to an exceptional concentration of endemic species, the Atlantic Forest is one of 25 world hotspots (Myers *et al.*, 2000) and because of the extraordinary loss of habitat it is a key region for study.

Two main types of vegetation predominate in the Atlantic Forest: entire dense broad-leaved evergreen rainforest in coastal areas and seasonal semi-deciduous forest in inland regions (Veloso *et al.*, 2001).

A few pristine forests composed entirely of the former type of vegetation are still found in relatively large protected areas such as the Serra do Mar State Park in São Paulo State. The second type of vegetation no longer exists in its pristine state (Ditt, 2002). Its occurrence is restricted to small fragments of forests located in the inlands. These fragments were the objects of the current study in two geomorphologic provinces: the “Planalto Ocidental”, in west and the “Planalto Atlântico”, in east of São Paulo State.



Figure 1. Atlantic Forest biome in Brazil

Historical forces of degradation and land use change that predominate in each of these provinces are substantially different. Consequently they differ in terms of the current landscape configuration and status of forest regeneration. Planalto Ocidental contains 40 fragments larger than 400 hectares in a landscape with a relatively low connectivity. Primary forests highly disturbed predominate in these areas. The forest fragments found in the Planalto Atlântico are normally smaller but in a landscape that is relatively more connected. These forests are mostly old secondary forests (Ditt et. al, 2008).

The differences in historical forces of degradation and conservation status may influence the amount of carbon stored in forest biomass. In order to investigate the variations in carbon storage the current study included an assessment of 25 forest fragments in the Planalto Ocidental and 10 forest fragments in the Planalto Atlântico, in the region of Nazaré Paulista. The area of the fragments that were studied varied from 400 to 2,000 hectares in the Planalto Ocidental and from 5 to 40 hectares in the Planalto Atlântico. The fragments investigated in this study are indicated in table 1 with their respective geomorphologic province and location in the state of São Paulo.

Considering that the fragments in Planalto Atlântico are substantially smaller than in the Planalto Ocidental, some of the procedures adopted for collecting data and sampling the fragments varied between the two geomorphologic provinces as described in the next paragraphs.

Table 1. Forest fragments where studies of biomass and carbon storage were developed, with their respective location and geomorphologic province

#	Fragment name	Geomorphologic province	Location in the State of São Paulo
1	TucaRosan	Pl. Ocidental	West
2	Maturi	Pl. Ocidental	West
3	Aguapeao	Pl. Ocidental	West
4	Sta_Marial	Pl. Ocidental	West
5	Sta_MariaIII	Pl. Ocidental	West
6	6R	Pl. Ocidental	West
7	Sta_Maria II	Pl. Ocidental	West
8	Sta Monica	Pl. Ocidental	West
9	Mosquito	Pl. Ocidental	West
10	LuaNova	Pl. Ocidental	West
11	EEC	Pl. Ocidental	Centre
12	Filemaria	Pl. Ocidental	West
13	NovaPontal	Pl. Ocidental	West
14	Pte Branca	Pl. Ocidental	West
15	Queimado	Pl. Ocidental	Centre
16	Macuquinho	Pl. Ocidental	Centre
17	Baugureo	Pl. Ocidental	Centre
18	Fbranca	Pl. Ocidental	Centre
19	Aclaras	Pl. Ocidental	Centre
20	Macauba	Pl. Ocidental	Centre
21	Jacarezinho	Pl. Ocidental	Centre
22	Anhangai	Pl. Ocidental	Centre
23	Pitangueiras	Pl. Ocidental	Centre
24	Corrego Boi	Pl. Ocidental	Centre
25	São Justino	Pl. Ocidental	Centre
26 to 35	NazaréF2	Pl. Atlântico	East

Data collection on vegetation

The quarter point method (Martins, 1993) was used to collect data of vegetation in each of the sampled forests. According to this method several sampling points must be established in the forest and the nearest tree from the sampling point in each quadrant must be sampled. Data were collected for the following variables: distance of the trees from the sampling points of the quadrants; height of trees; and diameter of their trunks at 1.30 metres above ground (Figures 2 and 3).



Figure 2. Measuring distance from quadrant sampling point to the sampled tree.



Figure 3. Measuring trunk's perimeter of sampled tree.

The number of sampling points established in each forest fragment in the Planalto Atlântico and in the Planalto Ocidental was 20 and 25 respectively. Each sampling point was composed of four quadrants, giving 80 and 100 quadrants or 80 and 100 trees measured respectively. The means of the data collected in each of the sampled forests were used for calculating: the average area occupied by each tree, corresponding to the squared distance of the trees from the sampling points; the number of trees per area; and the estimated biomass per tree.

The most appropriate threshold value of trunks' perimeter for sampling trees that compose the canopy in the forests of the study area was considered to be 17 cm in the Planalto Atlântico and 32 cm in the Planalto Ocidental. Definition of these values was based on observation of the canopies during preliminary visits to the forests. Therefore, only trees with circumference higher than these values were measured.

Estimation of forest biomass and carbon stock

In the beginning of the research an approach for estimation of biomass based on individual volume of trees and a database of wood density per species, suggested by Brown (1997) was adopted. The following equation was used:

$AGB = VOB * WD * BEF$, where:

AGB = above-ground biomass;

VOB = volume of biomass;

WD = wood density;

BEF = biomass expansion factor (ratio of aboveground oven-dry biomass of trees to oven-dry biomass of inventoried volume).

This approach has a potential to achieve results with reasonable level of accuracy. However, it requires knowledge to identify species of the sampled trees. This requisite is a potential obstacle for the establishment of feasible guidelines for monitoring carbon stock in projects of carbon offset. Therefore, other approaches were considered as described below.

In a literature review two main studies about estimation of biomass and carbon stock in seasonal semi-deciduous forests in the state of São Paulo were found. The first study, developed by Burger & Delitti (1999), used a destructive method, which consisted of cutting down some sampled trees for further drying and weighting the dry matter. From the weight of the dry matter and the data collected about diameter and height of trees, a biomass regression equation was constructed. This equation was not used in the current study because it is based on data collected in a restricted area, which might not be representative of the 35 fragments under investigation.

The second study, developed by Melo & Durigan (2006), has used the equation suggested by Brown (1997) for tropical forests in dry zones, i.e. in areas where: “i) rainfall is considerably less than evapotranspiration; rainfall is normally less than 1,500 mm per year; and iii) there is a dry season for several months”.

The study carried by Brown (1997) was also used as the main reference in the current research. However, equations that this study recommends for moist zones were used instead of the one suggested for dry zones. The reason is that moist zone fits better with the conditions where the 35 fragments studied are found. The equation is expressed by the following:

$Y = \exp\{-2.134+2.530*\ln(D)\}$, where:

Y = biomass per tree in Kg

D = diameter at 1.3m in centimeters.

In addition, the following equation, published by the World Bank (Pearson et. al, 2005), which is an update of the study carried by Brown (1997), was used:

$Y = \exp(-2.289+2.649x \ln(D)-0.021 x \ln(D)^2)$

Carbon content was assumed to be equivalent to 50% of the estimated biomass.

For estimation of belowground biomass the following equation, suggested by Pearson et. al (2005) for tropical forests, was adopted:

$BGB = \exp(-1.0587 + 0.8836 x \ln AGB)$, where:

BGB = belowground biomass;

AGB = aboveground biomass.

In the Planalto Ocidental the estimates of biomass and carbon stock were obtained individually for each forest fragment whereas the data collected in the 10 fragments in the Planalto Atlântico were analyzed together for obtaining a unique estimate for that geomorphologic province.

RESULTS

The estimates of aboveground and belowground forest biomass and carbon storage in the sampled fragments using the equations of Brown (1997) and Pearson et. al (2005) are indicated in table 2. The obtained values from each of these equations were very similar, as it can be observed.

The values varied from 39 tons of carbon per hectare in Santa Maria III, a fragment that has been severely degraded in the region of Pontal do Paranapanema, western of São Paulo State, to 190 tons of carbon per hectare in Anhangá, a private owned forest fragment near the Tiete river, in the centre of São Paulo.

The other fragments with relatively high values of carbon storage were: Macauba, near Anhangá, with 160 tons of carbon per hectare; EEC (Estação Ecológica dos Caetetus) which is one of the most conserved state owned forest reserves in São Paulo, with 143 tons of carbon per hectare; Macuquinho a private reserve also in the margins of Tiete River, with 129 tons of carbon per hectare; and the fragments of Nazaré region, with 114 tons of carbon per hectare.

Table 1. Estimates of forest biomass and carbon stock using equations suggested by Brown (1997) and Pearson et. al (2005).
 “AGB” = aboveground biomass; “BGB”= belowground biomass.

#	Fragment name	AGB Brown (1997)	BGB Brown (1997)	AGB Pearson (2005)	BGB Pearson (2005)	Biomass/ha Brown (1997)	Biomass/ha Pearson (2005)	Carbon (t/ha) Brown (1997)	Carbon (t/ha) Pearson (2005)
1	TucaRosan	19353,64	3447,75	19508,72	3474,02	181,41	182,86	90,71	91,43
2	Maturi	13004,55	2397,08	13121,76	2416,44	110,85	111,83	55,42	55,92
3	Aguapeao	31336,60	5154,78	31380,48	5168,39	102,13	102,29	51,07	51,15
4	Sta_Marial	32359,53	4999,71	31980,74	4969,69	155,49	153,79	77,75	76,90
5	Sta_MariaIII	20579,25	3612,59	20727,12	3637,58	78,38	78,94	39,19	39,47
6	6R	13504,64	2460,42	13608,33	2478,03	85,48	86,13	42,74	43,06
7	Sta_Maria II	16803,30	3053,02	16957,00	3078,73	87,68	88,47	43,84	44,23
8	Sta Monica	20423,40	3480,03	20471,52	3492,14	122,40	122,71	61,20	61,36
9	Mosquito	30130,39	4940,92	30136,26	4950,44	182,69	182,77	91,34	91,38
10	LuaNova	23906,15	3920,95	23836,61	3920,52	178,56	178,12	89,28	89,06
11	EEC	42198,16	6520,63	41935,88	6499,16	289,30	287,61	144,65	143,81
12	Filemaria	28043,09	4737,37	28184,48	4761,90	140,90	141,61	70,45	70,81
13	NovaPontal	36734,09	5794,44	36596,91	5786,79	127,25	126,82	63,63	63,41
14	Pte Branca	24262,81	4015,74	24224,19	4019,98	160,92	160,72	80,46	80,36
15	Queimado	26773,84	4461,84	26826,43	4475,65	177,86	178,23	88,93	89,12
16	Macuquinho	35332,07	5438,85	34934,65	5407,58	261,85	259,09	130,92	129,55
17	Baugureo	31533,99	5059,60	31413,39	5055,89	212,87	212,14	106,43	106,07
18	Fbranca	43898,02	6336,61	42968,38	6250,17	224,05	219,52	112,03	109,76
19	Aclaras	17895,11	3211,08	18029,34	3234,94	113,43	114,28	56,71	57,14
20	Macauba	104803,97	14236,07	102355,57	13981,45	327,08	319,66	163,54	159,83
21	Jacarezinho	25120,63	4230,96	25190,88	4246,85	159,14	159,61	79,57	79,80
22	Anhangai	77393,01	11054,41	76264,94	10933,78	386,31	380,85	193,15	190,43
23	Pitangueiras	43725,02	6269,97	42805,82	6180,58	126,58	124,03	63,29	62,02
24	Corrego Boi	38734,38	6000,09	38437,09	5977,05	178,10	176,82	89,05	88,41
25	São Justino	18399,08	3251,91	18522,73	3273,31	115,64	116,42	57,82	58,21
26 to 35	NazaréF2	77108,78	13689,60	77684,82	13786,09	226,86	228,54	113,43	114,27

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

The estimates obtained of carbon storage in the fragments, expressed in table 1, constitute a useful reference for predicting the potential of projects of forest restoration to contribute to carbon offsetting. For using it as a guide it is also necessary to consider other variables that may influence the forests' potential of carbon sequestration as discussed in the following paragraphs.

The distinction of geomorphological provinces is a first step towards controlling these variables. The estimate of carbon storage in Nazaré, i.e. 113 to 114 tons per hectare, can be a proper reference value for projects being developed in the Planalto Atlântico.

Results of this study enabled a deeper description of carbon storage in the Planalto Ocidental, revealing variations across this geomorphologic province due to variations in soil fertility and on the status of forest regeneration. The forest fragments containing the highest values of biomass and carbon storage were found in areas that contain very fertile soils. Some of these areas are relevant for agriculture. For instance, the fragment EEC is located in one of the most important regions for coffee crops in Brazil. The estimated values of carbon storage in fragments like EEC would not be proper references for fragments in the Planalto Ocidental with lower fertility.

Thus, before going straight through the highest values of table 1 for predicting carbon storage at any site of Planalto Ocidental, it is recommended to observe the soils and the agricultural systems that predominate in the landscape. After interpreting the characteristics of the landscape the tables 1 and 2 should be consulted in order to determine which of the studied fragments fits better with the local conditions of the project.

For instance, in the extreme west of the State of São Paulo, in the region known as Pontal do Paranapanema, the soils are considered “poor” in terms of fertility and the landscape is characterized by the presence of pastures with cattle ranching of low productivity and sugar-cane plantations. Therefore the fragments that can be used as a reference for predicting the potential of carbon sequestration are those with the highest values of carbon storage located in Pontal do Paranapanema region, such as “Tucano”, with 89 tons of carbon per hectare.

Even when a determined forest fragment is properly chosen as a reference it is recommended to be conservative in the prediction of carbon storage in projects of forest restoration. The reason is that forest development is a process that occurs in a long term and is suitable to several sources of interference, such as fires, invasive species, and predation by ants or cattle. These interferences may affect negatively the removal of CO₂ from atmosphere. Project developers and carbon buyers must acknowledge this issue for establishing feasible targets of carbon offset.

On the other hand all the 35 fragments that were investigated are not in their pristine status. They are expected to continue accumulating more biomass over some years until they achieve a status similar to pristine forests. Therefore, predictions of biomass accumulation and carbon storage that use values of table 1 as a reference are expected to be sufficiently conservative. They are not extremely optimistic.

The reference values in table 1 represent an important contribution for filling gaps of information that is required by projects of carbon sequestration. For instance, IPÊ and Arvorar's team have been planning several projects of carbon offset both in the Planalto Ocidental and in the Planalto Atlântico. For one of these projects, in the region of Nazaré, the value of 113 tons of carbon per hectare is considered appropriate for predicting costs and benefits of the project. In other words, from these data it is possible to demonstrate to investors how much the project will cost, as well as how much costs offsetting one ton of carbon.

The document in annex I is a project idea note (PIN) of the project in Nazaré. This document was prepared using the information obtained in the current study. It can be used for describing the project for potential sponsors, i.e. carbon buyers. Furthermore, it is a reference for project developers to prepare a project design document (PDD), which is a document that describes the project in more details and can be submitted to some standard of certification.

CONTINUATION AND NEXT STEPS

There are a number of issues in this study that should be explored in more details for expanding the contribution to development of projects of forest restoration and carbon offset in the Atlantic Forest. The following activities are planned for a continuation of this study:

- 1) Survey of additional areas for expanding the database of capacity of carbon storage within the Atlantic Forest biome;
- 2) Development of mosaic maps of potential carbon storage through the use of geographic information system for integrating information of vegetation, climate, geomorphology and soils;
- 3) Elaboration and publication of a reference guide for project developers, containing all the lessons learned through this study.

These activities require additional funds for being implemented. They could be developed, for instance, if Alcoa offers the opportunity for fellows to apply for continuation grants of the fellowship program.

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ANNEX I

PROJECT IDEA NOTE

**CARBON OFFSET PROJECT IN THE LANDS AROUND THE ATIBAINHA
RESERVOIR IN NAZARÉ PAULISTA**



Arvorar Soluções Florestais

**Nazaré Paulista – SP
2009**

GENERAL PROJECT DESCRIPTION

General project purpose

This Project aims at restoring 288 hectares of Atlantic Forest around the Atibainha reservoir in the region of Nazaré Paulista, in priority areas for the provision of ecosystem services. The goal is to offset 93,888 tons of CO₂ offset.

Forest restoration and provision of ecosystem services in the Cantareira System

The Cantareira System, one of the most important water supply systems in the world, is formed by 5 interconnected lakes that attend demand of water of 10% of the Brazilian population (figure A). The current Project Will be developed around one of these lakes, the Atibainha reservoir.

During the past 6 decades pastures and eucalyptus plantations have replaced most native forests in this region. Such type of landscape conversion is a threat to the provision of water in a long term due to losses of ecosystem services provided by native forests such as production and purification of water.

In order to ensure provision of ecosystem services in a long term it is necessary to restore native forests. Forest restoration in large scale is a complex, slow and expensive process. Therefore, it is recommended to develop forest restoration in areas where it is possible to aggregate co-benefits such as carbon offsetting and water purification, among others, for optimizing investments.

The lands around Atibainha reservoir in Nazaré Paulista have high potential to aggregate such co-benefits. A research supported by the Alcoa Foundation Fellowship Program demonstrated that beyond the role of conserving biodiversity and water resources the forests in that region are able to remove carbon dioxide from atmosphere and to store approximately 113 to 114 tons of carbon in forest biomass.

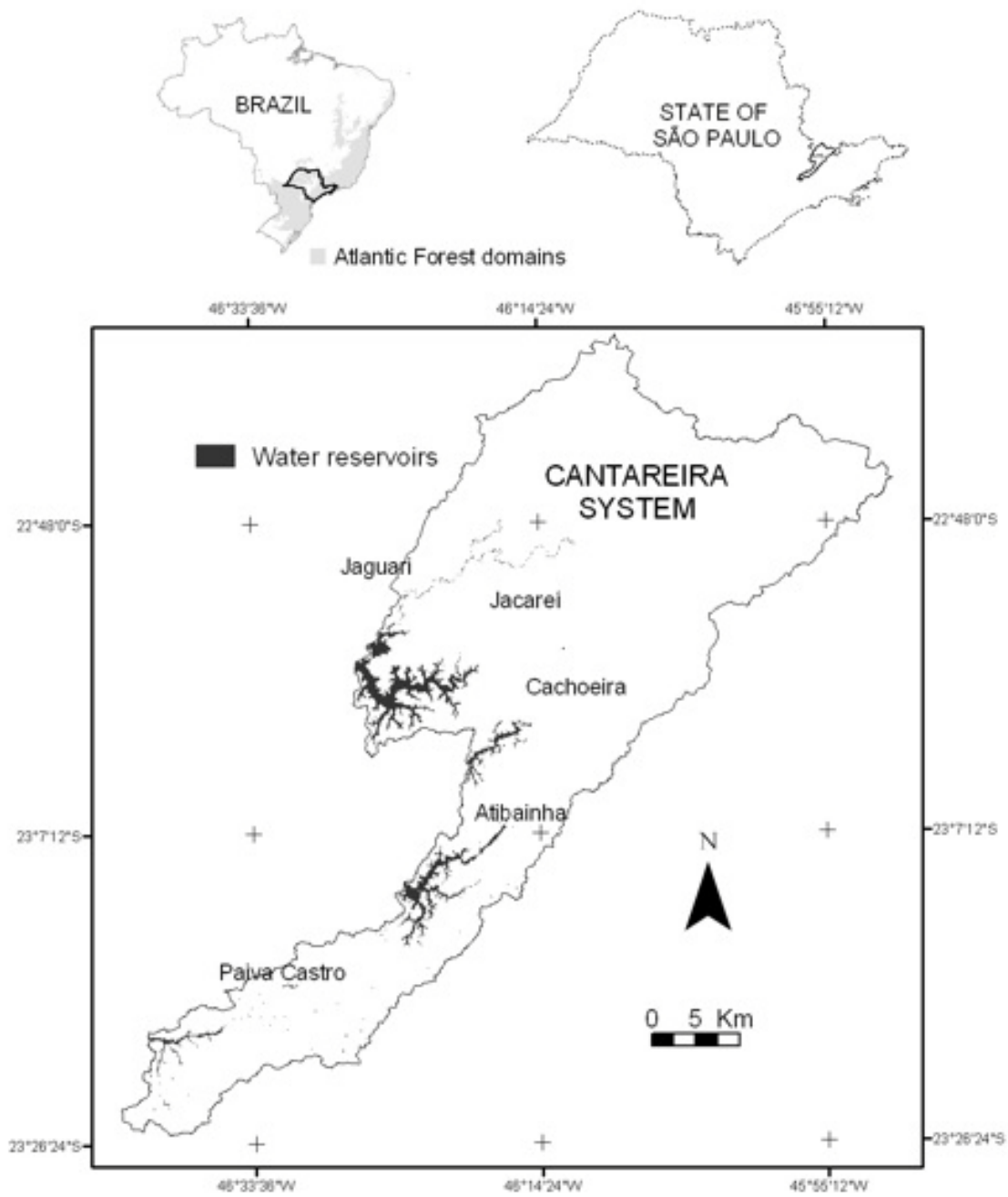


Figure A. Cantareira System (source: Ditt, 2008).

Areas of Project implementation

Approximately 40% of the lands in the watersheds around the Atibainha reservoir belong to Sabesp, the water company of the state of São Paulo. There are 288 hectares of Sabesp's lands without forests for more than 20 years. These lands are available for Arvorar Soluções Florestais and IPÊ – Instituto de Pesquisas Ecológicas to implement projects of forest restoration and carbon offsetting (Figure B).

These areas have been previously indicated by researchers from IPÊ as relevant due to provision of ecosystem services (Ditt, 2008).

Several work in collaboration among Arvorar, IPÊ and Sabesp have been developed in this region. Recently a cooperation agreement was signed by these institutions with the purpose to facilitate the development of projects of forest restoration.

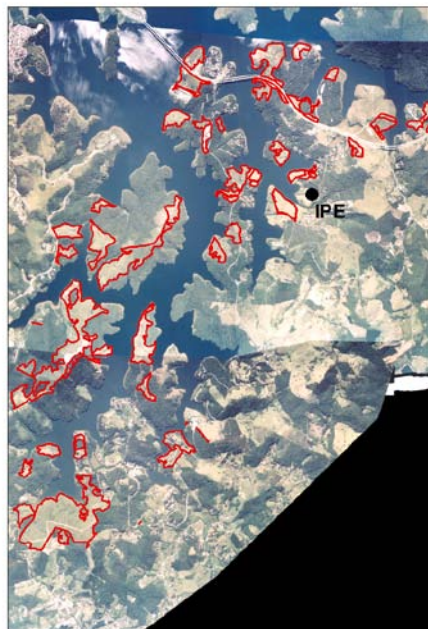


Figure B. Areas that will be restored through the project.

BASELINE SCENARIO

Eucalyptus and cattle ranching are the economic activities that predominate in the municipality of Nazaré Paulista. Analysis of past and current forces of landscape transformation indicate a strong tendency of these activities to be maintained in the region in a without project future scenario. The current project fosters changes in land use through restoration of degraded areas.

The project will rely on an approved methodology of CDM for determining baseline. Considering that the majority of the areas of the project are currently occupied by pastures the forest biomass and their respective carbon stock will be considered irrelevant. Therefore, they will be discarded in the calculations of carbon additionality.

ESTIMATION OF CO2 REMOVAL

The current project will consider only two carbon pools: living biomass above ground and living biomass below ground. Other carbon pools such as litter and soils will not be considered because they are not expected to affect substantially the estimates of variation in the total amount of carbon stored due to project activities.

According to the results of studies supported by the Alcoa Foundation fellowship Program, this project will consider that forests in the region of Nazaré Paulista have the capacity to store 113 tons of carbon per hectare over a period of 30 years. Therefore, the expected amount of carbon removal from atmosphere by this project is: 288 hectares X 113 = 32,544 tons of carbon, which is equivalent to 119,436 tons of CO₂.

LEAKAGE

The leakage considered in this project refers to CO₂ emissions originated from operations of transport during project implementation and development. The calculation will be based on estimates of distance travelled by each vehicle involved in all project activities. The GHG Protocol will also be consulted for these calculations.

MONITORING

The following monitoring activities will be developed in this project:

- 1) Stratification of the area according to variations in soils, slope and date of reforestation activities;
- 2) Definition of sampling sites;
- 3) Use of quarter-point method for collecting data of vegetation;
- 4) Use of biomass regression equations for estimating living biomass aboveground and belowground;
- 5) Reporting results in appropriate format for verification and certification;
- 6) Developing activities 3, 4 and 5 every 5 years to demonstrate project results.

EXTERNAL VERIFICATION AND CERTIFICATION

Considering the activities and procedures being proposed this project can be submitted to external auditing with the purpose of generation of credits of carbon through CDM or through voluntary standards such as VCS-Voluntary Carbon Standard. The choice of the standard or mechanism of verification and certification will depend on the sponsor's preference and on the funds available for the operational costs of the mechanism.