Getting carbon value out of the forestry and wood sector in Annex I Countries: The French Example

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GETTING CARBON VALUE OUT OF THE FORESTRY AND WOOD SECTOR IN ANNEX I COUNTRIES: THE FRENCH EXAMPLE

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This study examines the possibilities to monetize on carbon markets four types of actions through which the forestry and wood sector can mitigate climate change:

- Increasing the carbon stock in the forest
- Increasing the carbon stock in wood products
- Using wood as a substitute for fossil fuels (wood for energy)
- Using wood as a substitute for materials more energy intensive (wood as a material)

Actions of the "stock increase" type can theoretically be valued on the voluntary carbon markets. Developments are nevertheless necessary to make these valuations operational. Mechanisms of the "substitution" type can be valued only on the compliance market. They are currently valued at the level of the user (electric power generation, heating etc.); the forestry and timber industry can only participate in this system via agreements such as "supply contracts".

- This report analyses three project types that could be carried out to activate these mechanisms:

- Reforestation / Avoided deforestation
- Improved forest management
- Optimized utilization of products

On the basis of seven hypothetical projects, this study identifies a strong carbon sink potential in France (several million metric tons of CO_2), including afforestation, the conversion of coppice forest into high forest and the changes in the uses of harvested wood.

Carbon certification is expensive and makes sense only above a critical size that enables project developers to recover their expenses. For reforestation projects in metropolitan France, for example, we estimate this size to be around 100 hectares.

Several certification programs coexist on the voluntary carbon market. Their pertinence to the seven hypothetical projects is also analyzed, together with the conditions for carbon credits generated in the French forestry and wood sector to be monetized on carbon markets. To achieve this, two conditions need to be met: methodologies approved by standards should be developed, and the forestry and wood sector should implement a proper organization.

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TABLE OF CONTENTS

INTRODUCTION 4

I. FRENCH FOREST AND CARBON CREDITS 4

A. A young, fragmented and under-exploited forest 4

B. The forestry sector: murky areas in Kyoto accounting 7

C. Voluntary offsets: complementary to the Kyoto Protocol 10

II. THE POTENTIAL OF FRENCH SEQUESTRATION PROJECTS 14

A. Afforestation or reforestation projects 14

B. Improved forest management projects 19

C. "Wood products" projects 26

D. How much carbon in 25 years? 29

III. CERTIFICATION PROSPECTS 31

A. Forestry projects and the "carbon" certification criteria 31

B. Which standard for which project? 33

C. Example of a cost benefit analysis of a project to be certified by a voluntary standard 34

IV. CONCLUSIONS 36

V. ABBREVIATIONS 37

ANNEX 1 - CALCULATIONS PERFORMED FOR EACH PROJECT 38

ANNEX 2– ESTIMATION OF THE NUMBER OF CARBON CREDITS GENERATED 41

ANNEX 3 – CALCULATIONS OF THE NATIONAL AFFORESTATION POTENTIAL 42

ANNEX 4 - ASSUMPTIONS MADE FOR THE ECONOMIC ASSESMENT 43

REFERENCES 45

OTHER CLIMATE REPORTS OF CDC CLIMAT RESEARCH 47

INTRODUCTION

In France, the regulatory framework that resulted from the Kyoto Protocol makes it possible to value only emissions reductions linked to the utilization of wood energy. On the other hand, it does not currently provide any incentive to increase the sequestration of CO_2 in forests or wood products.

While the majority of the participants in the French forestry and wood industry wonder about their opportunities in carbon markets, and in particular about getting carbon value for the increase of carbon sinks such as forests and wood products, the sector remains unfamiliar with carbon markets and their operational requirements.

After a description of the forestry sector and its position in existing carbon pricing frameworks, this study focuses on the extent to which "voluntary" carbon markets might make it possible to value the sequestration of CO_2 in forestry and timber projects carried out in French territory. With an eye towards practical application, it is based on seven hypothetical projects that could apply for carbon certification in the voluntary markets. The study estimates the sequestration potential of these projects and the number of carbon credits they could generate. A cost benefit analysis is also developed for one of these projects.

I. FRENCH FOREST AND CARBON CREDITS

A. A young, fragmented and under-exploited forest

Increasing area and stocks

The French forest occupies 16 million hectares[4], more than one-quarter of the land area of Metropolitan France5. Representing almost one-half of the country's farmland, France's forest area puts this country in fourth place in the EU25 behind Sweden (30.9 million hectares), Finland and Spain (23.3 million hectares each).

Since the mid 19th Century, the loss of farmland, the development of alternative energies other than wood and flood erosion control programs and voluntary efforts of forestry owners have contributed to an increase in the forested area in France, which grew at the rate of +40,000 hectares/year between 1993 and 2004 (Agreste). A forest takes between 50 and 200 years to reach maturity for harvesting. A good part of the current forested area in France is still "young" and growing: estimates of the French Ministry of Agriculture and the National Forest Inventory (IFN) indicate an annual growth of 103 Mm^3 (Figure 1).

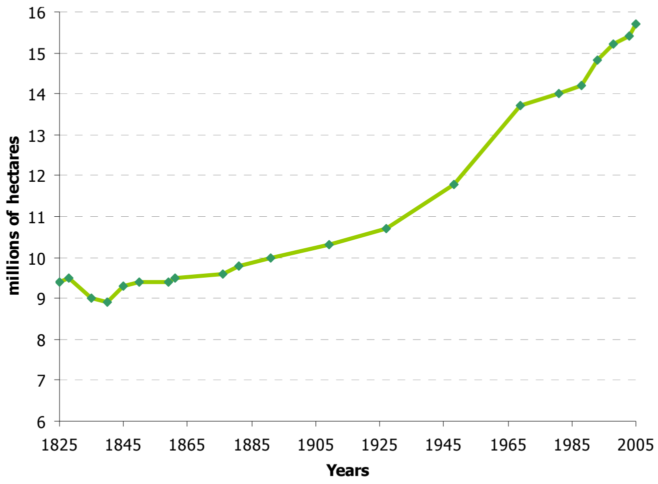
At maturity, a temperate forest, which is representative of the majority of French forests, can store between 550 and 1,200 metric tons of CO_2 per hectare (tCO_2/ha) in its above-ground and underground biomass[6]. Although a large part of the carbon stored in a forest ecosystem, as in the majority of ecosystems, lies in soil, it has been overlooked in most of our calculations, because soil carbon measurement is difficult, time-consuming and expensive to measure.

[4] IFN estimations using the FAO forest's definition - Land areas covering a minimum of 0.5 hectares with tree crown cover of more than 5 meters and a crown density of more than 10%, or with trees capable of reaching a height of more than 20 m.

[5] Adding forests of overseas departments, France's total forest surface reaches more than 23 millions ha which results as approximately 35% of the territory (IFN).

[6] Luyssaert et al. (2007).

Figure 1 – Evolution of the French forested area



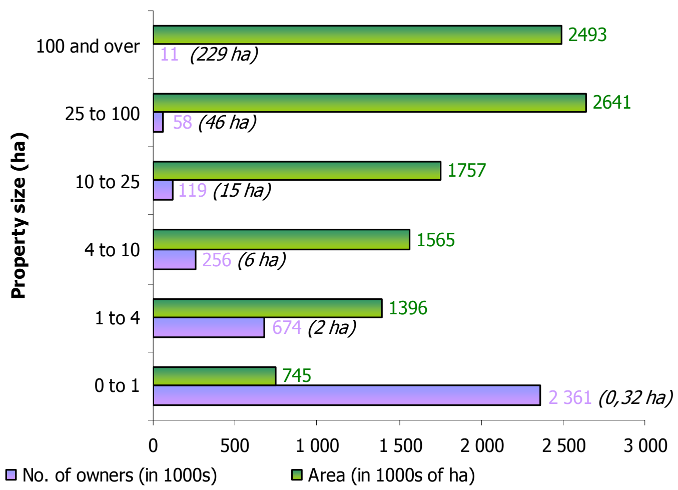
Forested area began to increase in 1850. After the Second World War, this growth was significantly accelerated with the creation of the Fonds Forestier National (FFN), which subsidized forest plantations intended for industrial production. The forested area has continued to increase by 1.7 million hectares over the past two decades, especially in the Mediterranean and Southwestern regions.

Source: MAP, IFN 2005.

French forests are largely privately owned and fragmented

The French forest belongs largely to private owners. Only 26% of the area is publicly owned, 40% of which is owned by the State and the rest by communes. This distribution of ownership varies greatly by region. There is practically no publicly owned forest in the Southwest, although publicly owned forests represent almost one-half of the forested area in the Northeast.

Figure 2 – Structure of private forest ownership



As Figure 2 depicts, privately owned forest is quite heterogeneous: only 25% is owned by individuals or institutions that own more than 100 ha, 83% of the owners own less than 10 ha, 444,000 owners own 77% of the area. Because the exploitation of a forest covering less than 4 ha is seldom profitable, 20% of the privately owned forest is highly fragmented[7]. The fragmentation and young age of the forest explain to a large extent the gap between growth and harvest, although other technical and financial factors such as the difficulty of exploiting certain mountain forests, the shortage of lumberjacks, and the limited production capacity of sawmills also explain part of it.

** The average area per sample is indicated in parentheses.*

Source: CDC Climat Research on the basis of the Structure of Private Forest Ownership Survey, 1999.

[7] Puech (2009).

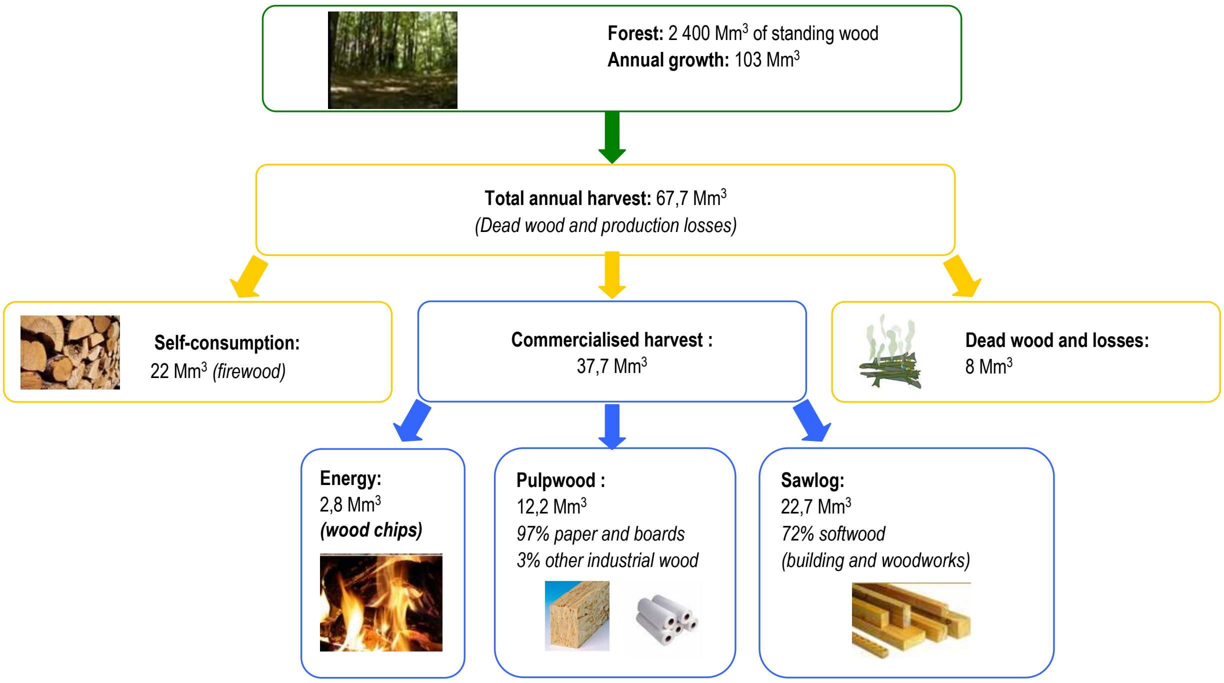
The forestry and timber industry

The forestry and timber industry, from forest management to paper manufacturers, cabinetmakers and other users of the wood, represents a significant economic sector with 33,287 companies8, some 300,000 jobs and total sales of 51.6 billion euros before taxes. By way of comparison, this sales volume is equivalent to 60% of the sales of French automakers and almost 4 times greater than the sales of the winemaking sector. Figure 3 illustrates the different uses of this resource by producers and downstream industries for the primary and secondary transformation processes.

Upstream, the level of the harvest has remained stable in recent decades, although the production of forests is increasing, which generates a net annual growth of approximately 40 Mm3. This unexploited increase is partly contextual: the old plantings made in the framework of the Fonds Forestier National (FFN) in the second half of the 20th century are only beginning to reach an exploitable age. Moreover, some of this unexploited increase lies in forests with strong structural barriers to exploitation, e.g. forests on steep slopes, inadequate transport etc.

When a forest stand is harvested, approximately 10% of the wood (branches, dead wood etc.) remains in the forest. One-third is "self-consumed" by the owners in the form of wood for heating. Only 55% of the exploited volume harvested is sold, essentially as sawlog wood destined to carpenters and furniture makers, and pulpwood which is used for paper and panelling manufacture.

Figure 3 – Diagram of the uses of wood in France, in millions of m^3



60% of the wood harvested is used by the paneling and paper industries and for energy purposes. The remaining 40% is used for the manufacture of veneer or sold in the form of solid wood. Wood used as domestic heating represents the largest utilization of energy wood (22 Mm^3).

Source: CDC Climat Research based on data from the MAP, IFN, INSEE and CNPPF.

This description of the forestry and timber industry points out three possible ways of mitigating climate change: (1) increasing or maintaining the carbon sinks in the forest, which can be done either by reforestation, by avoided deforestation, or by improving forest management practices, (2) increasing the carbon stocks in wood products and (3) reducing carbon emissions in other economic sectors by substitution, such as the utilization of wood energy in place of home heating oil or wood as a replacement for steel in construction.

8 89% of the companies in this economic sector have fewer than 20 employees. Data extracted from the "Mémento FCBA 2008-2009".

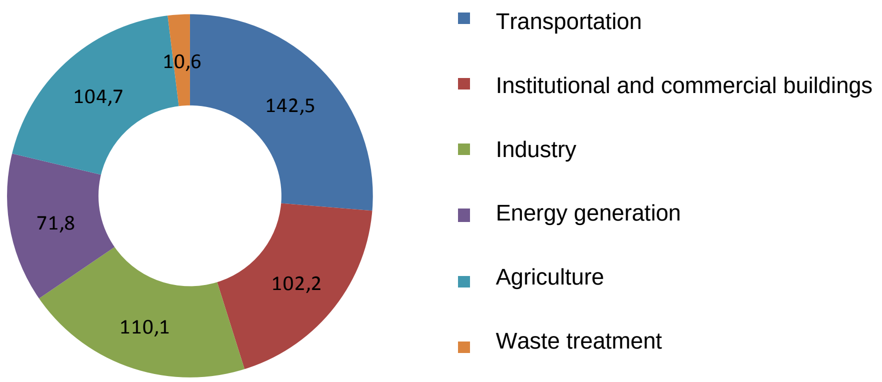
B. The forestry sector: murky areas in Kyoto accounting

To understand how to provide incentives to the forestry and wood industry to optimize its contribution to climate change mitigation, we first have to understand its current position in the French declination of the Kyoto accounting framework. The Kyoto Protocol accounting rules for the forestry and wood industry in fact determine the type of "carbon incentive" that can be provided.

The French forest absorbs 72.3 million tons of CO_2 a year

In 2007, French emissions of greenhouse gases represented 531 million metric tons of CO_2 equivalent (CO_2e) without taking into consideration the emissions and absorptions of CO_2 due to changes in land use and forests. With 141 MtCO_2e, the transportation sector is the largest emitter, followed by manufacturing and agriculture. Changes in land use and forest growth generated a net sequestration of 72 MtCO2, i.e. 13% of French annual emissions.

Figure 4 – French greenhouse gas emissions by sector in 2007 in MtCO_2e (total excluding UTCF: 531 MtCO_2e)



Source: CITEPA / SECTEN Inventory.

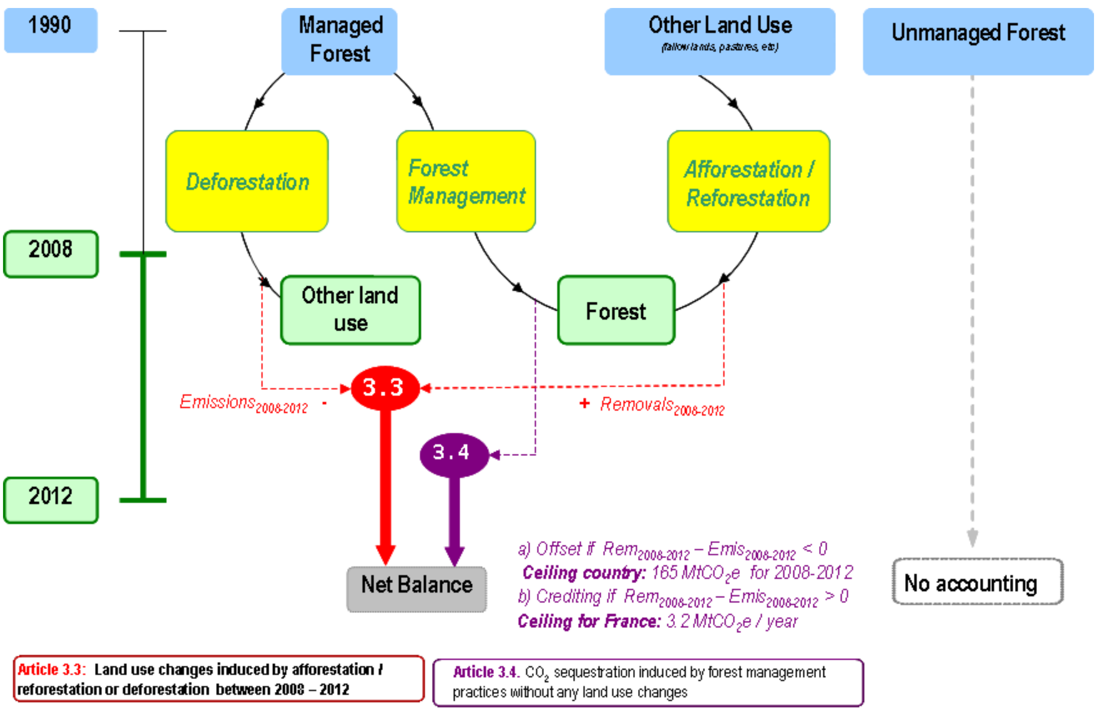
The "Kyoto forestry credits" received by France: 3.2 MtCO_2/year

In the framework of the Kyoto Protocol, signed in 1997, 40 industrialized countries including France have committed to stabilize or reduce their anthropogenic emissions of greenhouse gases. These developed countries, so called "Annex I countries", receive a number of carbon credits - Assigned Amount Units or AAU - corresponding to their emissions objective over the 2008-2012 period. Each year these countries also submit to the United Nations Framework Convention on Climate Change (UNFCCC) an inventory of their emissions of greenhouse gases and are required to ensure that they surrender as many AAUs as the emissions reported in their inventory. To comply, they can reduce the emissions within their borders, purchase AAUs from other countries or invest in emissions reduction projects in the framework of the flexibility mechanisms available under the Protocol. Under certain conditions they can also be awarded another type of carbon credits, namely Removal Units (RMU), which are issued for their forestry and timber sector.

Rules for awarding forestry carbon credits (RMU) for Annex I countries

The rules for the awarding of credits related to Land Use, Land Use Change and Forestry (LULUCF) are set forth in Article 3.3 and 3.4 of the Kyoto Protocol. Article 3.3 applies to afforestation, reforestation and deforestation, and Article 3.4 relates to land that kept being forested since 1990, including clear-cuts followed by regeneration.

Figure 5 – "Kyoto" accounting of emissions and absorptions by the forestry sector



Source: CDC Climat Research.

<u>Managed forest (optional accounting)</u>

Article 3.4 of the Kyoto Protocol allows Annex I countries to optionally include in their national inventories the carbon emissions and sequestration related to the management of forests[9]. In practice, this includes all changes in the carbon stocks of lands that have been forests since 1990. To factor out effects linked to the normal aging of forests and the acceleration of their growth because of climate change, the Kyoto Protocol caps the quantity of RMUs that a country can receive from a positive "3.4 budget".

Over 2008-2012, France, which has opted for the accounting of its "forest management", will therefore receive as many RMUs as it has tons of CO_2e in its "3.4 budget" up to a cap of 3.2 million tons of CO_2 per year[10]. In 2007, the French "3.4 budget" was approximately 80 million tons of CO_2e, i.e. significantly more than the creditable cap. Because this figure is not likely to change significantly over the period 2008-2012, the French State does not have any incentive to impulse the improvement of forest management neither in public nor in private forests. A project that would increase the amount of carbon sequestered in French forests would not increase the 3.2 million RMUs France will receive each year under the terms of Article 3.4.

<u>Afforestation/reforestation/deforestation (mandatory accounting)</u>

Article 3.3 of the Kyoto Protocol requires an accounting for emissions and sinks linked to afforestation, reforestation and deforestation operations resulting in land use changes. The net variation between 2008 and 2012 of the carbon stock of these lands, the use of which has changed since 1990, constitutes the "3.3 budget". For the year 2006, the national inventory shows a slightly positive budget (0.3 $MtCO_2e$/year, Source: MAP-IFN). This actual budget over result 2008-2012 may be different, especially in the event of unforeseen deforestation or changes in the inventory methodology. If the budget becomes negative, France is authorized to offset the deficit using the "inexhaustible" surplus produced by Article 3.4 up to a certain cap limited to 9 $MtCO_2e$/year.

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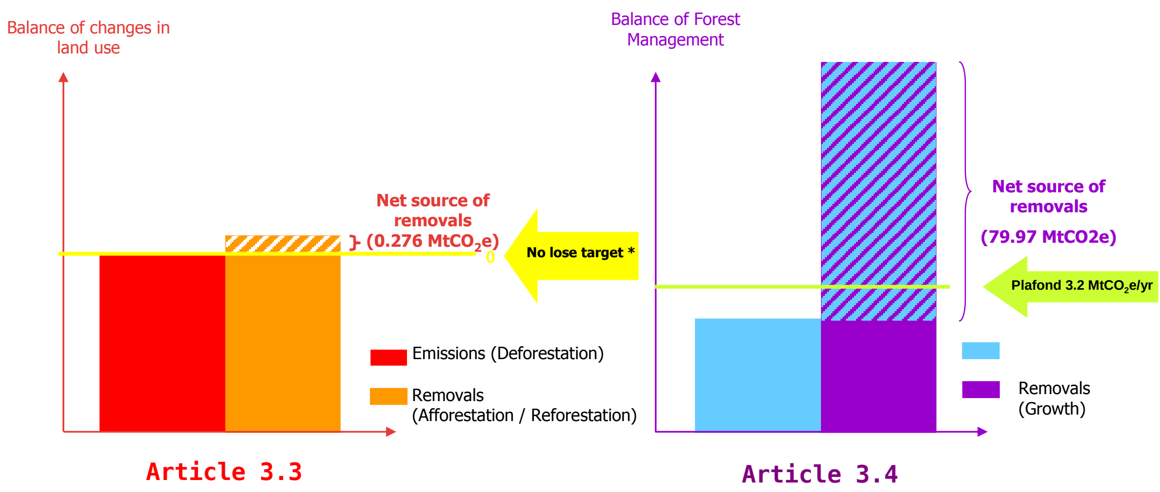
[9] Definition of forest management (Decision 11/COP7): a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner.

[10] This maximum accountable amount, often called “CAP”, agreed by every Annex I country (Decision 16/CMP.11).

An afforestation project that would reduce such a deficit would therefore not have any incidence on the State's "carbon" accounts, which would remain at zero. This risk explains the difficulty of conveying the carbon incentive to forest owners, because such a mechanism would require the State to deliver carbon credits to individual reforestation projects.

Similarly, in the event of a negative balance under Article 3.3, the State would not receive any RMU and therefore could not deliver any units to owners who afforested their land.

Figure 6 – "Kyoto" balances of the French forest in 2006



** Thanks to the large Article 3.4 surplus*

The Article 3.3 balance between reforestation and deforestation activities leaves France with a small surplus. A slight increase in deforestation could change this result before 2012, in which case France would move to a zero balance under Article 3.3. With regard to "forest management", France will receive a maximum of 3.2 million tons of credits annually, significantly less than the "Article 3.4 budget" of 72.6 $MtCO_2e$/year.

Source: CDC Climat Research based on CITEPA data (2006 Inventory).

It is worth pointing out that the numbers described above for France's 3.3 and 3.4 budget positions are aggregated on the national level and conceal regional disparities. Some regions have a high level of net afforestation (Provence/Alpes-Côte d'Azur, Rhône-Alpes). Other regions report net deforestation, such as Guyana, which by itself accounts for 35% of the national emissions from deforestation. Aquitaine is a special region where afforestation and deforestation emissions are balanced, each representing approximately 10% of the nation's total.

The existing incentives for the forestry and wood sector

<u>Sequestration in harvested wood products</u>

The sequestration of carbon in harvested wood products is not taken into consideration in the Kyoto Protocol. All the carbon of harvested wood is considered to be re-emitted immediately.

<u>Wood as a replacement for other energy sources and materials</u>

Another manner in which the forest products industry contributes to climate change mitigation is the use of wood as a lower-emission alternative, either as a fuel for energy generation or as a material to replace concrete or steel in the construction sector.

In both cases, the "carbon" incentive to substitute other materials or fuels with the use of wood is already in place at the national level: a reduction of emissions from the energy or construction materials sector is automatically reported in the French national inventory and consequently releases AAUs.

Two mechanisms transfer this incentive to the local level:

- The largest industrial power generation and construction materials production installations are subject to the European Union Emissions Trading Scheme (EU ETS)[11] for CO_2. At the level of power generation, the EU ETS has in fact driven some power plants to substitute wood for some of the coal they burn. The emissions of the major producers of steel beams are therefore capped, which theoretically gives a competitive advantage to producers of wooden beams. However, it is possible that this "carbon incentive" remains at the level of the producer of the steel beams, if his production of carbon diminishes because of an increase of wood use, he can benefit from exceeding quotas to trade at the market.
- Small installations that are not subject to the EU ETS can develop a domestic offset project[12] to reduce their emissions. This is the case in particular for small heat generating installations. In this framework, the State issues carbon credits (ERU) corresponding to the reduced emissions to the project developer, which are therefore been removed from the national account. The various eligible methods include the use of woody biomass as a replacement for a fossil fuel for the generation of heat. This approach has been operational in France since 2007 and recently three projects of this type have been accepted by the French State which correspond to a total of 0.9 $MtCO_2$ for the period 2008-2012.

The complexity of these accounting rules does not facilitate the creation of mechanisms that correctly value the contribution of the forest products sector to climate change mitigation. Only substitution (wood as an energy source and wood as a substitute for other materials) benefits from two mechanisms derived from the Kyoto protocol. Additional economic incentives may nevertheless be found in the framework of voluntary offsets.

C. Voluntary offsets: complementary to the Kyoto Protocol

More flexible and less developed than Kyoto offsets

Simultaneously to the implementation of the regulatory mechanisms of the Kyoto Protocol, an increasing number of individuals, businesses or public institutions that are not subject to mandatory emission reduction requirements have voluntarily committed to offset their greenhouse gas emissions. These commitments create a demand for "carbon offsets". Carbon offsetting consists in compensating for some or all of a company's emissions by purchasing carbon credits (emissions reduction units or carbon sequestration units generated by carbon projects).

The "voluntary" segment of this market is still relatively small although it is growing rapidly. In 2008, 54 million tons of CO_2 equivalent were traded, 17% of which originated from forestry projects[13]. The average price per ton was close to 4 euros, although the price varied significantly as a function of the perceived quality of the project and the image value that accrued to the buyers. These are modest figures compared to the 600 million tons of CO_2 equivalent traded on the compliance segment of the market coming from mandatory emissions caps, i.e. projects developed within the Kyoto framework (CDM and JI[14]), at the higher average price of 15 euros per ton. Nonetheless, the evolution of the voluntary market depends to some extent on the outcome of the international negotiations which will define the post-Kyoto rules and the emergence of other compliance markets around the globe.

[11] Directive 2003/87/EC, establishing the system which, since 2005, covers 11,000 industrial sites in Europe.

[12] Decree 2006-622 of the French Ministry of Ecology and Sustainable Development, issued March 2, 2007.

[13] Source: Hamilton et at. (2009)

[14] CDM: Clean Development Mechanism which enables Annex 1 countries to obtain emissions credits by investing in reduction projects or projects that prevent greenhouse gas emissions in a developing country. JI: The Joint Implementation mechanism makes possible trades between Annex 1 countries, based on the investment in projects in another Annex 1 country or on the basis of national rules, such as in France, in the context of domestic offset projects.

Forest carbon projects: the major quality principles

The development of the voluntary market has raised concerns on account of scandals reported by the press in which fake offset projects were sold, thereby undermining the credibility of the entire sector. To limit such fraud, quality certification standards have been created in the voluntary market.

Their objective is to guarantee the environmental integrity of the projects they certify, i.e. to ensure that the tons of carbon traded on the voluntary market actually correspond to real emissions reductions. The three principal certification criteria are:

- Additionality: All the voluntary standards follow the United Nations guidelines of additionality. The project developer must demonstrate that the project creates environmental benefits - additional sequestration of carbon compared to a baseline - and that these benefits could not have been achieved in the absence of carbon credits: a project that would have been profitable without obtaining credits is generally ineligible. However, under some conditions this financial demonstration of additionality can be replaced by a demonstration of the existence of technological or cultural barriers to the execution of the project. Certain certification programs also allow the establishment of a performance benchmark as a criterion for the additionality assessment. Proof must be provided that the project goes beyond the regulatory recommendations of the host country.

- Permanence: to cater for the risks of fires or storms and thus the re-emission of the tons of carbon sequestered in the forest, an insurance system has been established by most standards. In the case of the Voluntary Carbon Standard (VCS), an insurance pool, common to all forestry projects, is fed by a buffer that is a percentage of the credits generated by each project. The size of this buffer is determined on a project basis by a risk assessment procedure. If a project is confronted with a natural disaster - fire, disease etc. - the credits that have already been sold are replaced by the credits accumulated in the buffer by other forestry projects already in place, thereby guaranteeing credit buyers the permanence of their offsets.

- Double counting: The ability to track the carbon units traded on the voluntary markets is a necessary condition to ensure credibility of these markets. The standards therefore require that the carbon credits they are certifying have not already been counted in the national inventories of the Annex 1 countries or are not included or utilized in another emissions trading scheme such as the EU ETS. If that was the case, the same emissions reduction would be counted twice: once in the national inventory of the host country and once as a voluntary carbon "credit". To eliminate this risk, proper to countries that have in place reduction commitments, the standards require that the tons that correspond to credits issued for a project be removed from the national inventory. This criterion is very important since it will be the one allowing the sale of voluntary forestry credits.

The different voluntary offset certification programs

Around ten quality certification programs currently coexist on the voluntary offset market. This report concentrates on those that allow forestry projects in the Annex I countries: Voluntary Carbon Standard, Carbon Fix Standard, Climate Community and Biodiversity Standard, as well as the Chicago Climate Exchange Standard, which is included for methodological reasons.

Voluntary Carbon Standard (VCS)

The Voluntary Carbon Standard (www.v-c-s.org) was developed in 2006 by the Climate Group Association, the International Emissions Trading Association and the World Economic Forum Global Greenhouse Register. The VCS created its own carbon credit - the Voluntary Carbon Unit (VCU). VCS aspires to become the reference certification for the voluntary market and is already used by a majority of forest carbon project developers. In 2008, VCS credits were trading at around 4€[15].

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[15] Hamilton et al. (2009).

Chicago Climate Exchange (CCX)

The Chicago Climate Exchange (www.chicagoclimatex.com), created in 2003, is a market that functions as a stock exchange where CO2 units are traded along with five other greenhouse gases among the entities who are voluntarily involved in the system. In cases of forestry projects, the trading asset is called an Exchange Forestry Offset (XFO).

So far, thirteen forestry projects have been registered with the CCX and verified[16]. CCX requirements are generally more flexible than those for VCS or CDM projects, and between 2007 and during the first semester of 2009, its credits were trading between 0.4€ and 4.9€ per metric ton of CO_2[17].

Initially limited to projects originating in countries that were not signatories to the Kyoto Protocol, this market was expanded in 2008 to include greenhouse gas emissions reduction projects anywhere in the world, except for countries that are subject to emissions reduction commitments and that have established an emissions trading mechanism[18]. Although French projects are therefore not eligible, we nevertheless include this standard because of its accounting methodology for carbon in Long Lived Wood Products used in the "Projects" section.

Carbon Fix

The Carbon Fix Standard (www.carbonfix.info) was developed by international scientists specialized in forestry, environment and climate change. This organization sets criteria for afforestation/reforestation projects which are verified by third party certifiers. Projects certified according to the Carbon Fix Standard can gain VER (Voluntary Emission Reductions) credits. This standard is distinguished by the simplicity of its methodologies, which can easily be used by foresters who are not specialists in "carbon" issues. In 2008, these credits traded at around 13 €[19], although the market seems relatively small.

Climate, Community and Biodiversity Standard (CCBS)

The Climate, Community and Biodiversity Standard (www.climate-standards.org) was created by the Climate, Community and Biodiversity Alliance in cooperation with scientific experts and NGOs. The first version of the standard was published in May 2005. The objective of this label is to promote forestry projects (afforestation, avoided deforestation, improved forest management) that combat climate change while benefiting local communities and biodiversity. In contrast to the other three standards, this program certifies a project in its entirety as "good for the climate" but does not issue credits corresponding to a specific quantity of tons of carbon sequestered. Therefore, it is in general used in conjunction with one of the above certification programs.

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[16] Until January 2010.

[17] Hamilton et al. (2010).

[18] http://theccx.com/info/advisories/2008/2008-01.pdf

[19] Hamilton et al. (2009).

Table 1 – Snapshot of the standards that certify forestry projects in Annex 1 countries

Labels	**Voluntary Carbon Standard**	**Chicago Climate Exchange**	**Carbon Fix Standard**	**Climate, Community and Biodiversity Standard**
Credit units	Voluntary Carbon Unit (VCU)	Exchange Forestry Offsets (XFO)	Verified Emission Reduction (VER)	No credits issued, but a dual certification is possible (with CFS or VCS, for example)
Types of forestry projects accepted	Afforestation-Reforestation / Avoided deforestation Improved forest management Sequestration in harvested wood products	Afforestation -Reforestation / Avoided deforestation Improved forest management Sequestration in harvested wood products	Afforestation/Reforestation	Forest projects sequestering carbon that simultaneously produce benefits in terms of biodiversity and sustainable development of local communities
Additionality	Demonstration: • Improvement with respect to existing regulations • Existence of barriers to the implementation of the project (financial related to investment capacity, technical, institutional or those which are related to the uncertainties of the market for wood for example) • Proof that their environmental practices equal or exceed those commonly considered a minimum standard among similar landowners in the area	Sample demonstration: • Improvement with respect to existing regulations • Existence of barriers to the implementation of the project (financial, institutional, cultural)	Demonstration: • Improvement with respect to existing regulations • Projects are designed with a long-term perspective • The project must demonstrate that it would not be viable in the absence of the income generated by the sale of credits.	Demonstration: • Improvement with respect to existing regulations • Existence of barriers to the implementation of the project (financial, institutional, cultural)
Permanence	Insurance with a Non-Permanence Risk Analysis and Buffer Determination (between 5 and 60%, depending on the risk analysis)	Insurance with buffering of 20% of the credits	Insurance with buffering of 30% of the credits for all the projects	The project identifies the potential risks and takes measures to offset them.
Double counting	Present proof that the credits are not already counted in the national inventory	Projects in Annex 1 countries are not accepted.	The standard is verified with the public authorities of the country where the project is developed so that it can be removed from the national inventory.	The project developer must specify why there is no double counting.
Nature and method of credit calculation	Ex-post credits: credits are delivered once the carbon sequestration is verified.	Ex-post credits: credits are delivered once the carbon sequestration is verified.	In its new version, CFS enables project developers to sell their credits in advance (ex ante) and ex post.	No credits
Timetable and details on the awarding of credits	Credits after each verification (at least once every 5 years). The share of the credits placed in the buffer may be reduced with each verification if a project has demonstrated its sustainability and ability to mitigate risks The total of all the credits that will be placed on the market must not exceed the cumulative average of the benefits inventory during the forest rotation period.	80% of the credits received after each annual verification. The 20% placed in reserve are released after the commitment period.	70% of the credits received after certification of the project. The 30% placed in reserve will be returned following subsequent verifications.	No credits
Other pertinent information	The VCS also requires an assessment of the positive and negative impacts that can result from the execution of the project. Projects can and in general search to do joined certification with the CCBS standard. The projects must have duration of at least 20 years.		Project duration must be higher than 30 years. Projects can do joined certification according to the CCBS and the Forest Stewardship Council (FSC) and do not require double documentation.	The projects must generate positive social and economic impacts. The projects are subject to a period of 21 days of public consultation

Source : CDC Climat Research.

II. THE POTENTIAL OF FRENCH SEQUESTRATION PROJECTS

This section presents seven theoretical projects that could qualify as offset projects that sequester, destroy or reduce GHG emissions in the forest and timber sector: two afforestation projects, three improved forest management projects and two projects related to the use of wood. These project ideas emerged from the literature and from initiatives that have been or are projected by representatives of the forestry and wood sector.

For each project, we present:

1) The technical characteristics of the project and the baseline adopted, i.e. the situation that would exist if the project were not carried out;

2) An estimate of the quantities of carbon sequestered or the quantities of the greenhouse gas emissions, in the standard project and in the baseline, over time and over the lifespan of the project;

3) A balance sheet of the carbon sequestration or the reduced emissions at the end of the project;

4) An estimate of the number of credits generated by the project, based on existing VCS methodologies for forest stocks and wood products[20].

The additional carbon sequestration achieved by each project is estimated on the basis of a conservative baseline for the following three compartments: the carbon stock in the forest, the carbon stock in wood products and greenhouse gas emissions avoided by the substitution of the wood for fuels or construction materials that emit greater quantities of greenhouse gases. The coefficients and assumptions used to calculate the sequestration figures are described in detail in Annex 1.

With an eye towards the certification of these tons of sequestered CO_2e[21], which will be explored in Part IV, two compartments of a given project will not necessarily be certified by the same standard. An afforestation project certified by the VCS may produce wood-energy which is valued via domestic offset projects. Finally, the "national potential" of some of these projects is estimated as a function of the land available at the national level (e.g. on the basis of the total area of coppice forest for the coppice forest improvement project).

A. Afforestation or reforestation projects

Definitions of the forest and forestry activities can differ greatly from one country to another. The certification programs for the voluntary market frequently refer to the harmonized definitions adopted in the negotiations for the Kyoto Protocol. Afforestation means "the direct human-induced conversion of land that has not been forested for a period of at least 50 years". Reforestation is "the direct human-induced conversion of non-forested land to forested land on lands that did not contain forest on December 31, 1989"[22].

Interestingly, this rule has some exceptions for the Carbon Fix standard, which in cases of force majeure (forest fires, storms, etc) accepts recently lost forests as eligible for reforestation projects.

Two afforestation projects are studied here: a mature stand of wood to be used for sawlogs and a very short rotation coppice plantation to produce energy wood.

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[20] VCS was chosen because according to Hamilton et al. (2010) it has been historically the third party standard most widely used (44% of all forestry projects) solely or alongside other third party standards.

[21] Conversion: 1 metric ton of wood = 2 m^3 of wood and 1 m^3 of wood = 1 metric ton of CO_2

[22] Decision 16/CMP.1 and LULUCF GPG, Sections 4.2.5.1 and 4.2.6.1.

Example 1: Afforestation project for hardwood sawlog production

An environmental association is looking for partners to transform fallow farmlands into forest in the PACA (Provence - Alpes - Côte d'Azur) region. The general characteristics of the project are presented in Table 2.

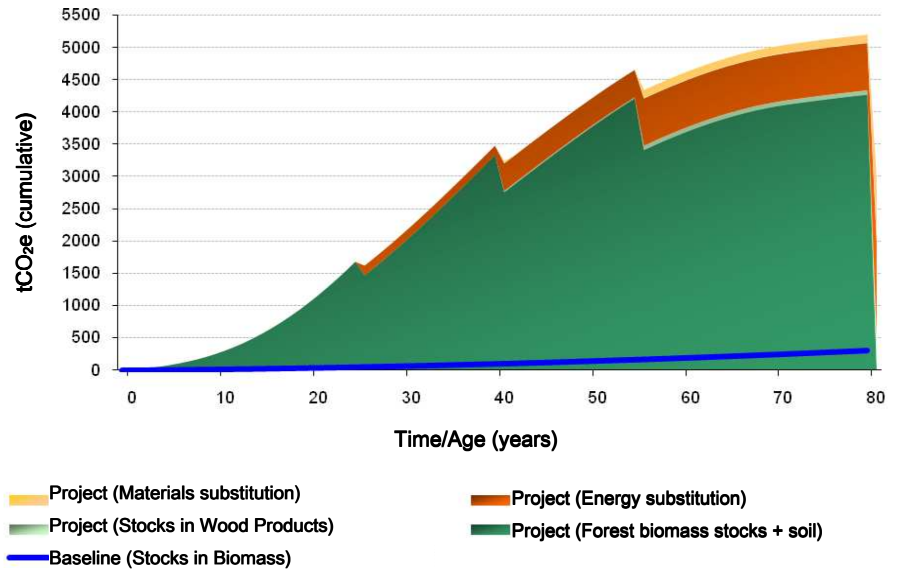
Table 2 – Scenarios of the sawlog afforestation project

	Baseline	Project Scenario
Area	10 ha	10 ha
Type of management	Fallow farmland	Walnut plantation for sawlog production trees for lumber. Management to mature stands.
Production of wood / carbon sequestration	33 tCO_2/ha after 80 years. This figure is hypothetical: we did not model the growth of a fallow farmland	180 metric tons of wood per ha in 80 years, i.e. approximately 360 metric tons of CO_2 per ha.
Co-benefits		Depending on the project, protection of biodiversity by diversifying the species, restoration of the forest landscape, potential utilization as a wildlife corridor. Restoration of a site designed for hiking and leisure. Exploitation of high-quality timber.

Source: CDC Climat Research, after Reverchon (2006).

The calculations of carbon sequestration in the forest and in the wood products in the project cycle, as well as the substitution effects, are presented in the Annexes. A graphic representation of the evolution of these effects over time is shown in Figure 7.

Figure 7 - Carbon sequestration for the sawlog afforestation project

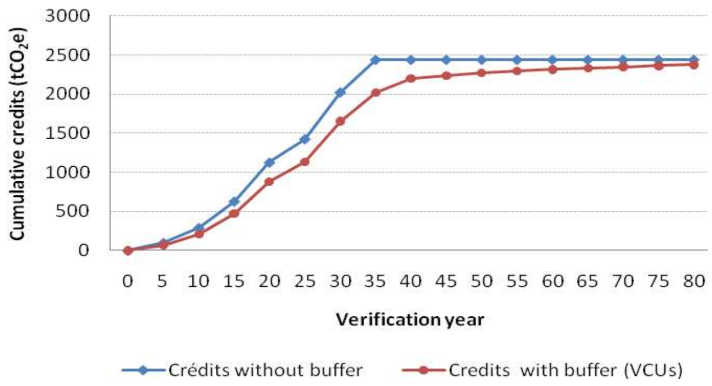


Source: CDC Climat Research.

The estimation of the number of VCU credits generated by the project (see Annex 2) is presented in Figure 8.

The figure shows that beginning in Year 35 the number of credits generated from carbon sequestration (in the forest and harvested wood products) stops increasing. According to VCS guidelines, a project cannot generate more credits than the temporal average of the net sequestration during the rotation period, and this value is reached for this particular project in Year 35. At the end of 40 years the project generates 2,200 VCUs considering the buffer discount.

Figure 8 - Number of VCUs generated by the afforestation project



Project size (ha)	10
Buffer (%)	30%
Release (%)	15%
Verification periodicity (Years)	5
Temporal average of the net carbon sequestration during the rotation period (tCO_2e)	2438,6
Creditable Sequestration rate (tCO_2e)/ha/yr*	5,8

* *computed on a 35 year basis*

Source: CDC Climat Research.

Example 2: Industrial Afforestation project for energy production

The project is developed by a major energy sector company that wants to produce wood for the wood energy sector. The characteristics of the project are presented in Table 3.

Table 3 – Scenarios of the industrial energy afforestation project

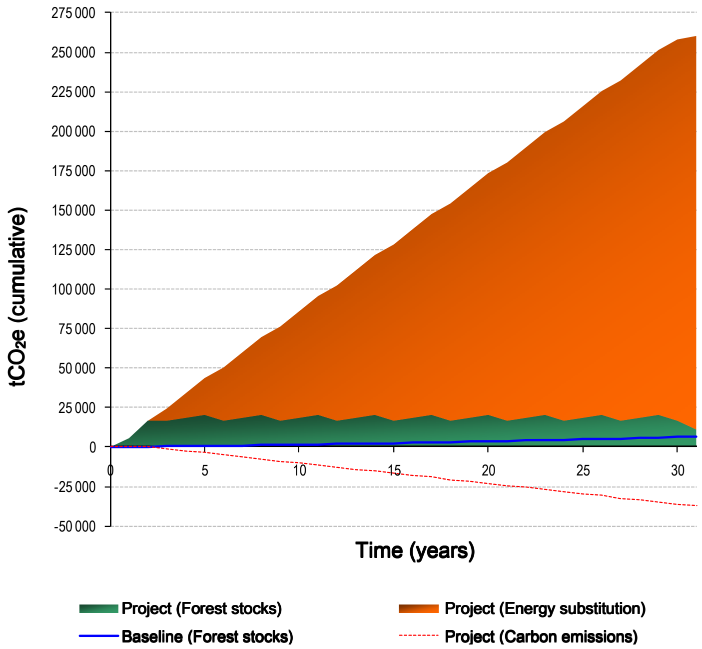
	Baseline	Project Scenario
Area	1000 ha	1000 ha
Species	Fallow farmland	Willow - species selected for its high productivity and ease of planting
Type of management	None	Very dynamic. Low growth in very short rotation, used for the production of small woodchips.
Production of wood / carbon sequestration	We are including this aspect hypothetically because we have not performed the calculations to demonstrate that fallow farmland will store up to 6 tCO_2/ha at the end of 30 years	Production of 24 metric tons of wood per hectare in 3 years, i.e. 48 tCO_2e/ha in 3 years. Significant energy substitution effect.
Carbon emissions	None	Significant emissions during activities between harvests, due in particular to inputs such as fertilizers and soil preparation.
Co-benefits		No consideration for the biodiversity or the landscape function of the forest. If economic additionality is proven, it would come from the carbon captured and the additional revenues resulting from the carbon credits (and the benefit of exploiting wood energy production).

Source: CDC Climat Research.

As shown in Figure 9, the frequency of harvests leaves little forest stocks standing in spite of the large size of the project (1000 ha). The energy substitution effect, on the other hand, is significant.

The project cannot generate VCU credits because, according to our estimations, from the 15th year, greenhouse gas emissions due to fertilization and other forestry operations cancel out the credits that could be generated in the forest stocks. Nevertheless, the substitution effects could be valued under a compliance mechanism but not under a voluntary standard because of the double counting criteria.

Figure 9 - Sequestration of the industrial energy afforestation project



Source: CDC Climat Research

National potential for afforestation projects

Four scenarios of national afforestation objectives are analyzed. Their realism is tested against the total area available for afforestation. Their implication in terms of carbon sequestration is then quantified[23].

- Pol_1 = 10 000 ha/an
- Pol_3 = 30 000 ha/an
- Pol_5 = 50 000 ha/an
- Pol_8 = 80 000 ha/an

Policy Pol_3 corresponds to an objective set in 2000 by the National Program for Tackling Climate Change – Programme National de Lutte contre le Changement Climatique (PNLCCC) for the development of carbon sequestration in the forest, via a boost to the policy of afforestation of fallow farmlands (doubling the annual pace of afforestation up to a level of 30,000 ha/year). Barthod (2001) also indicates that this pace of doubling afforestation is necessary to guarantee the availability of this resource for industrial purposes.

More optimistic policies (Pol_5 and Pol_8) are also tested, as was done by INRA (2002), as well as a very pessimistic one, Pol_1 which considers a pace of only 10,000 ha.

To test the realism of these 4 scenarios, we estimate the quantity of land available for afforestation. This quantity, broken down by region, makes it possible to estimate the regional distribution of the national potential.

The land available for afforestation is determined on the basis of data from Teruti-Lucas, which records land use in France:

- unused fallow farmland
- Grassland not used for livestock or infrastructure purposes.

[23] Since not all the available land will be afforested, our potential estimates indicate the upper boundary.

Table 4 – Estimate of afforestable areas (in hectares)

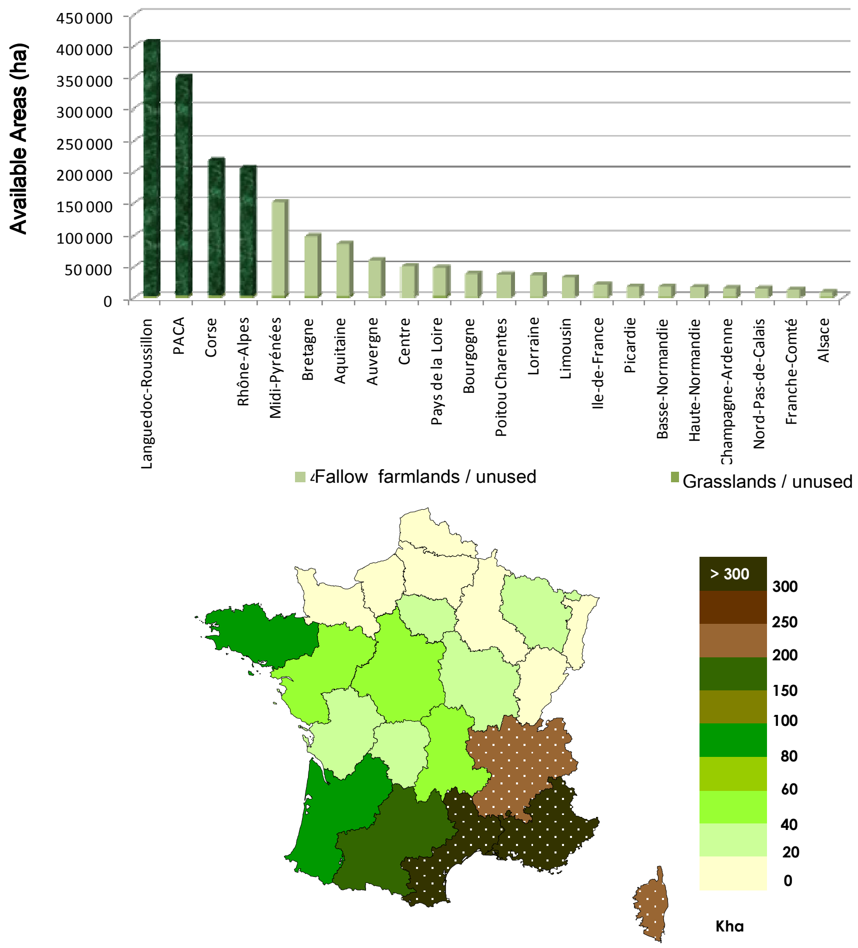
Physical categories / unused	Metropolitan France (in ha)
Surfaces always planted (except mountain pastures) / unused	**39,885**
Permanent productive grassland	11,847
Permanent unproductive grassland	28,038
Scrub land (maquis, garigue) / unused	**1,909,958**
Fallow land, scrubland, maquis, garigue, savannah	1,617,023
Naturally planted areas, unused	292,935
National potential for afforestation - reforestation	**1,949,842**

Among the different eligible types of land we have not included areas that are used in agricultural, industrial, urban development, infrastructure activities and zones of special ecological interest. Our estimates do not take agricultural land set aside into consideration because the plantings that are in direct competition with agricultural uses are generally not eligible for voluntary offset certification, and because it is difficult to make a distinction between land that has been abandoned and that which is part of an agricultural production system.

Source: CDC Climat Research on the basis of SCESS data (TERUTI 2008 Survey).

A distinction is then made between two estimates: "Optimistic" and "Conservative". The "optimistic" estimate considers all land types previously identified. The "conservative" estimate eliminates all of the "fallow land" in the Mediterranean and mountainous regions (Languedoc-Roussillon, Provence-Alpes-Côte d'Azur, Corsica and Rhône-Alpes). In these regions, the terms "fallow land" or "garigues" are applied to many different types of land that cannot physically grow trees and therefore cannot be afforested.

Figure 10 – Regional distribution of areas eligible for afforestation projects



In the histogram, the darker regions correspond to the four regions in which "fallow lands" are excluded for the "conservative" estimate, which are dotted in the map

Source: CDC Climat Research on the basis of SCESS data (TERUTI 2008 Survey).

The national afforestation potential is therefore estimated at between 770,000 ha (conservative) and 1,930,000 ha (optimistic). In Table 5 the realism of the afforestation scenarios (Pol_1 etc.) is estimated via the number of years after which the scenario achieves the quantity of land available for afforestation. The two most ambitious scenarios (Pol_5 and Pol_8) seem to be rapidly limited by the quantity of land available, which makes them doubtfully realistic in the long term.

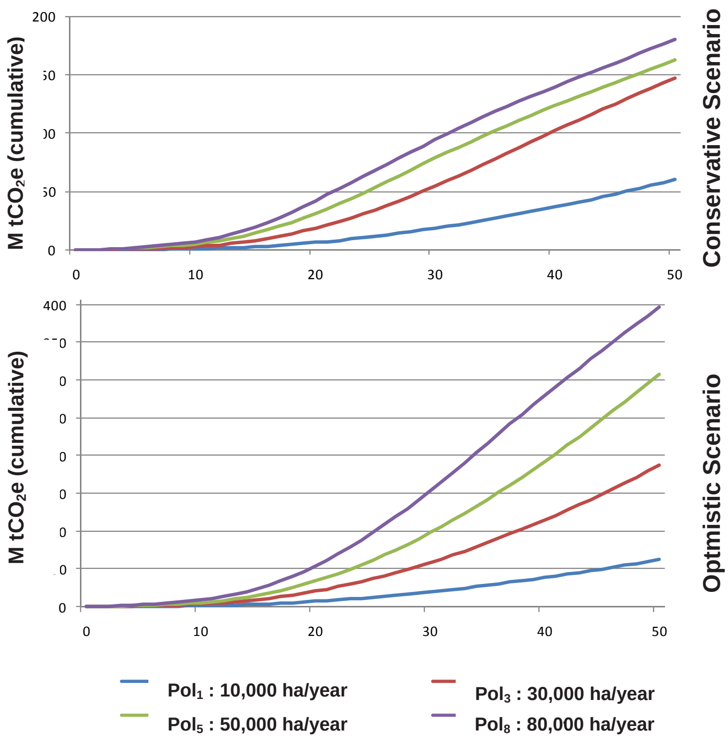
Table 5 – Limit implementation periods of the afforestation scenarios (years)

Afforestation Policies	Optimistic Scenario	Conservative Scenario
Pol_1 10 000 ha/an	195	77
Pol_3 30 000 ha/an	64	26
Pol_5 50 000 ha/an	39	15
Pol_8 80 000 ha/an	24	10

Source: CDC Climat Research

Figure 11 illustrates the national afforestation potential in tonnes of CO_2 that could be sequestered. It is determined using the current age-dependent growth rates of European forests, preserving the ratio between softwood and hardwood species in each region. Our computations show a potential sequestration of 5 million metric tons of CO_2 in 20 years for the most conservative scenario, i.e. 1% of the country's annual emissions. More details on the computations as well as the results are available in Annex 3.

Figure 11 Sequestration potential in time



Source: CDC Climat Research.

B. Improved forest management projects

The objective of forest management projects is to increase the stock of carbon in a managed forest. The carbon benefit of a project is in fact measured jointly to include the inventory of carbon in the forest and products. To use the Kyoto terminology, these types of projects are those implemented in "forests that remain forests".

Several types of forest management projects can be considered: substitution of species, modification of rotation length, densification of stands, conversion of a coppice into an uneven-aged high forest stand, phosphorus fertilization, etc. These projects have an impact on the productivity of forests and therefore on the sequestration capacity in the ecosystem. Three sample projects are analyzed: the conversion of a coppice into an uneven-aged high stand, the densification of a pine plantation and the substitution of species.

Example 3: Conversion of a chestnut coppice into an uneven-aged forest stand

The project consists of moving from a coppice system into an uneven-aged high stand which bears 200 m^3 of wood per hectare. The exploitation objective is set at 80 m3/ha approximately every 7 years, so that 120 m^3 are left standing. This management practice makes it possible to produce more wood than by managing the stand as a coppice (210 m^3/ha in 21 years instead of 160 m^3/ha in 20 years) while preserving a higher forest stock than in the baseline. It is nevertheless more expensive because it requires more frequent and more technical forestry intervention.

Because the wood produced by the "project" scenario has an average diameter greater than the baseline, the project provides more sawlog wood that sequesters more carbon in time.

Table 6 – Project scenarios - conversion of chestnut coppice into an uneven-aged high stand

	Baseline	Project Scenario
Area	800 ha	800 ha
Species	Chestnut coppice	High uneven-aged chestnut forest stand (high forest)
Production of wood / carbon sinks	160 m^3/ha at the end of 20 years with an average long-term sequestration of approximately 80 metric tons of CO_2	200 m^3/ha, exploitation objective: 80 m^3 every 7 years, 120 m^3 are left standing. The average long-term sequestration is 160 metric tons of CO_2. Hence, additional storage of 80 m^3/ha under steady-state conditions.
Carbon emissions	The CO_2 emissions released during forestry activities are considered negligible.	Thinnings. The CO_2 emissions released during forestry activities are considered almost negligible.
Secondary benefits		Limited diversity of species but forest stands encourage the passage of wildlife (corridor). Frequently preferable from a landscape point of view.

Source: CDC Climat Research.

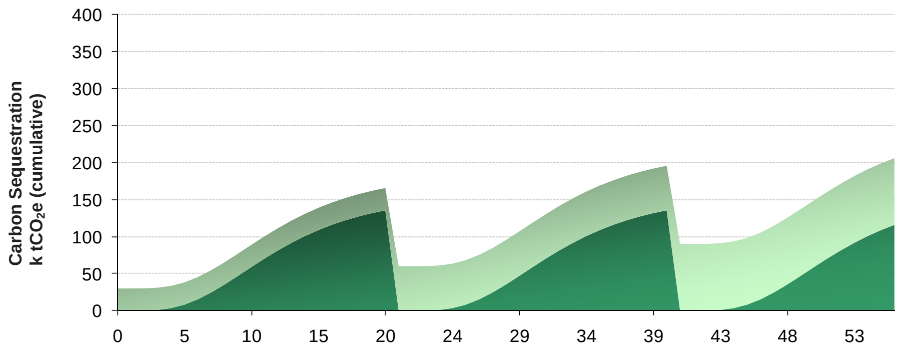
The calculations are performed for the sequestration in the standing wood (forest stocks), the extended carbon storage in wood products and the substitution of materials.

As shown in Figure 12, the forest stock is increased in the project scenario as well as in the wood products stocks. The material substitution effect is taken into consideration for purposes of illustration in the project scenario, because in practice, the chestnut tree is seldom used for the production of beams. Harvested wood from the coppice baseline is considered to be mainly pulpwood not qualified for this purpose.

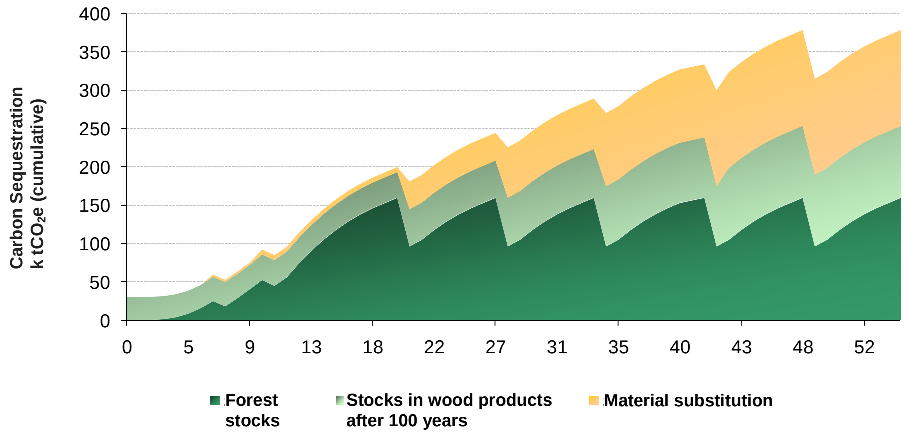
Figure 13 illustrates the quantity of VCS credits generated by the project, which stops increasing at the 20th year, for the same reason as project 1. By year 20, the number of generated credits reaches 56,000 VCUs, once the credits placed in the buffer have been discounted. Moreover, if further verifications take place, confirming that the project's risks have been controlled, the project can earn up to 62,500 VCUs at the end of the 40th year once credits in the buffer have been released.

Figure 12 – Evolution of carbon sequestration of the "coppice to high stand" project

Baseline

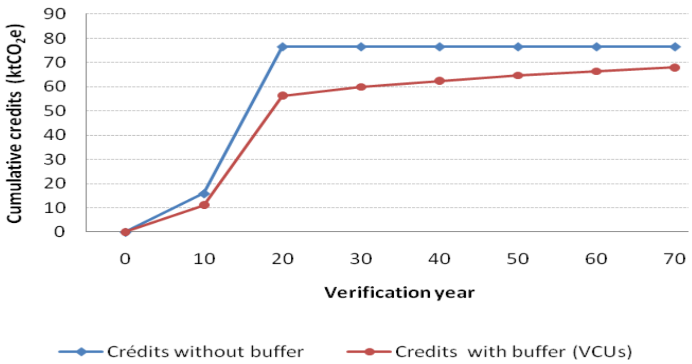


Project scenario



Source: CDC Climat Research.

Figure 13 - Number of VCUs generated by the "coppice to high stand" project



Project size (ha)	800
Buffer (%)	30%
Release (%)	15%
Verification periodicity (Years)	10
Temporal average of the net carbon sequestration during the rotation period (tCO_2e)	76,6
Creditable Sequestration rate (tCO_2e)/ha/yr*	3,5

** computed on a 20 year basis*

Source: CDC Climat Research.

Example 4: Energy densification project

This forest management technique intends to increase the production of energy wood during the initial growth phase of the stand. This theoretical project imagines a partnership between a large power company and a forestry cooperative. The objective is to increase the productivity of maritime pine plantation by adding one row of pines to the planting at the initial stage, which will be cut after eight years to supply the wood-energy industry. More details on the project are provided in Table 7.

Table 7 – Scenarios of the energy densification project

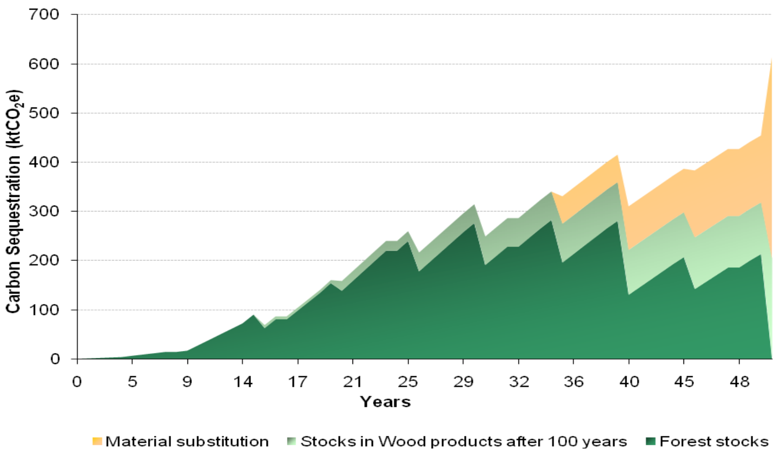
	Baseline	Project Scenario
Area	1000 ha	1000 ha
Species	Maritime pine	Maritime pine
Type of management	Maritime pine plantation	Overstocked maritime pine plantation (during young ages)
Production of wood / carbon sink	Sequestration in the forest by the planting of conifers until clear cutting. Total production of 622 m^3 of wood throughout the project cycle.	Production of 622 m^3 of wood throughout the project cycle, plus 14 m^3 wood/ha at the end of eight years, i.e. 14 t of CO_2/ha.
Carbon emissions	Forestry work (negligible)	Forestry work (negligible)
Secondary benefits		None

Source: CDC Climat Research.

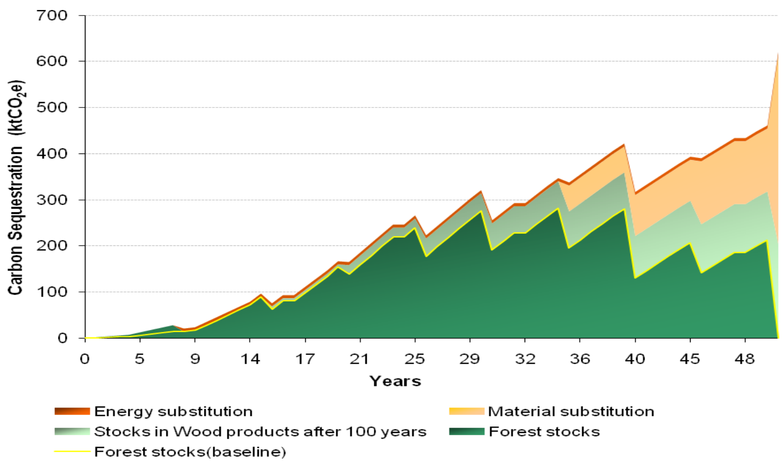
Figure 14 illustrates the evolution of carbon sequestration in the different compartments for the baseline and for the project scenario. We observe a slight increase of the forest stocks as well as a small boost of the energy substitution slot.

Figure 14 – Carbon sequestration in the overstocking project

Baseline



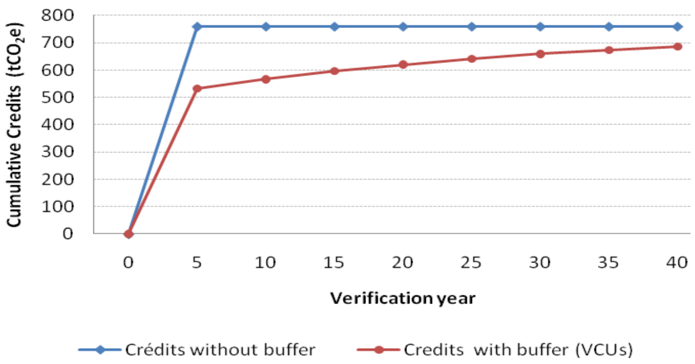
Project scenario



Source: CDC Climat Research.

Figure 15 illustrates the estimated credits generated by project under the hypothesis that the verifications are performed every 5 years. The overall project will generate a total of 700 VCUs (taking into consideration the number of discounted credits placed in the buffer) over a period of 40 years.

Figure 15 – Number of VCUs generated by the densification project



Project size (ha)	1000
Buffer (%)	30%
Release (%)	15%
Verification periodicity (Years)	5
Temporal average of the net carbon sequestration during the rotation period (tCO_2e)	760,1
Creditable Sequestration rate (tCO_2e)/ha/yr*	0,1

**computed on a 5 year basis*

Source: CDC Climat Research.

Example 5: Species change project

In forestry, one of the measures to adapt to climate change will be related to a change in the choice of species. Beech, for example, risks being replaced by oak in the majority of its territory. However, the choice of species can also impact the carbon sequestration capacity of a stand by means of the following factors: 1) Growth speed, 2) Density of the wood, 3) Rooting pattern, 4) Life expectancy and 5) Vulnerability to natural factors.

The hypothetical project scenario here consists of the use of a more productive variety of maritime pine than the one used in the baseline. This substitution of species increases both the forest and wood product stocks, by increasing the amount of saw log wood.

Table 8 – Scenarios of the species change project

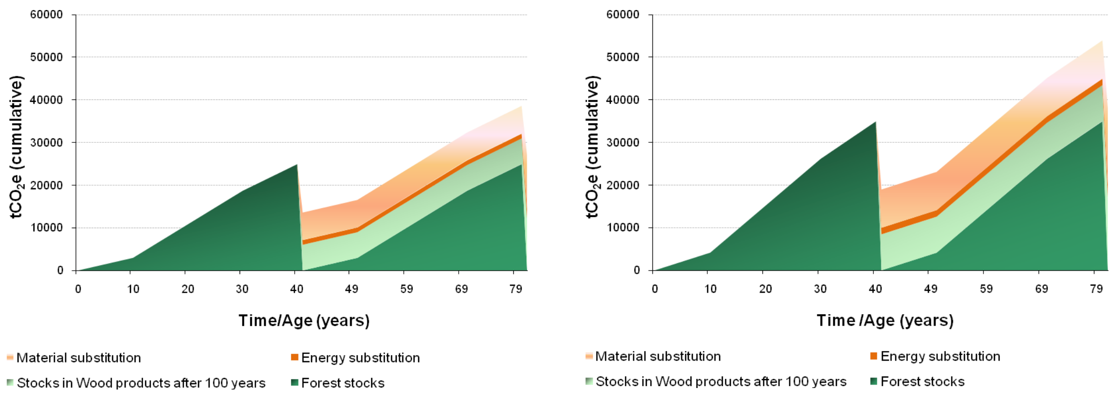
	Baseline	Project scenario
Area	100 ha	100 ha
Species	Maritime pine	More productive maritime pine (genetic improvement)
Type of management	Rotation over 40 years	Rotation over 40 years
Production of wood / carbon sink	Lumber objective: 250 trees/ha 250 m³/ha in 40 years, i.e. 250 tCO_2/ha	Lumber objective: 300 trees/ha 350 m³/ha in 35 years, i.e. 350 t CO_2/ha
Carbon emissions	Considered negligible.	Considered negligible.
Co-benefits		None

Source: CDC Climat Research

Figure 16 illustrates the quantity of CO_2 sequestered by the project in the different compartments.

Figure 16 – Carbon sequestration in the species change project

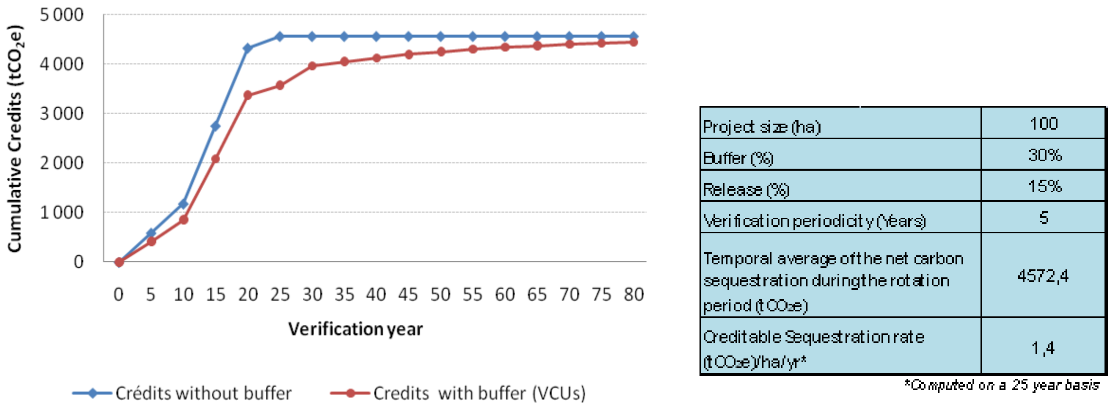
Baseline ***Project scenario***



Source: CDC Climat Research.

Figure 17 illustrates the evolution of the quantity of VCUs generated by the project. At the end of 40 years, the project generates 3,400 VCUs once the credits placed in the buffer have been discounted.

Figure 17 - Number of VCUs generated by the species change project



Source: CDC Climat Research.

National potential for forest management projects

Our estimate of the national potential for the conversion of coppice systems into uneven-aged stands is based on figures by Barthod (Table 9). The categories in question are coppice systems to be transformed, i.e. those that require clear-cutting followed by replanting, and the coppice forests to be improved, i.e. those that can be transformed without clear-cutting.

Table 9 – Areas eligible for upgrading by conversion, transformation and improvement of forest management

Forestry Inter-region	Areas in France [1] in hectares						Areas in coppice forests to be improved, in hectares [2]				
	Hardwood forest stands (A)	Coniferous forest stands (B)	Hardwood coppice (C)	Mixture of hardwood forest stands and coppice (D)	Mixture of coniferous forest stands and coppice (E)	Total (A) + (B) + (C) + (D) + (E)	Conversion to forest stands (C) + (D) + (E)	% conv.	Improv. by planting (C) + (D) + (E)	% Impr.	% total
Massif central and Northern Alps	578 425	976 505	414 632	377 071	172 277	2 518 911	140 000	15%	250 000	26%	15%
Northeast	964 934	768 947	175 057	1 399 383	74 022	3 382 343	340 000	21%	1 130 000	69%	43%
Northwest	925 016	444 790	421 382	904 108	138 744	2 834 040	260 000	18%	860 000	59%	40%
Southeast	223 393	877 358	602 969	68 368	227 120	1 999 208	50 000	6%	130 000	14%	9%
Southwest	632 951	1 093 107	450 964	513 829	139 285	2 830 137	350 000	32%	130 000	12%	17%
Metropolitan France	**3 324 719**	**4 160 708**	**2 065 004**	**3 262 760**	**751 448**	**13 564 638**	**1 140 000**	**19%**	**2 500 000**	**41%**	**27%**

Forestry inter-regions, used by Barthod (2001) and identified by the public authorities and industry federations: Massif central and Northern Alps (Limousin, Auvergne and Rhône Alpes), Northeast (Champagne-Ardenne, Lorraine, Alsace, Bourgogne and Franche Comté) Northwest (Haute Normandie, Basse Normandie, Bretagne, Poitou Charentes, Centre, Nord-Pas de Calais, Picardie and Île de France), Southeast (Provence-Alpes-Côte d'Azur and Languedoc - Roussillon) and Southwest (Aquitaine and Midi-Pyrénées).

Source: CDC Climat Research based on data: (1) Results of Departmental Forestry Inventories between 1989 and 2004 centralized by the IFN and (2) Barthod (2001).

According to Barthod (2001), 3.64 million hectares of forests can be improved via projects that convert and improve coppices and coppice with standard, i.e. 27% of French forests. These estimates are consistent with the potential of 30% of the French forest found by De Galbert (2007). The annual objectives for the transformation and improvement of coppice given by Barthod (Table 10) do not seem unrealistic considering this large potential (Table 11).

Table 10 – Conversion and improvement priorities

	Coppice and micoppice with standard to be transformed (ha/year)	Coppice with standard to be improved (ha/year)	Degraded forest stands to be reforested (ha/year)	Afforestation of fallow farmlands (ha/year)
Northwest	3 500	3 600	200	4 800
Northeast	8 500	8 000	-	800
Massif Central and Northern Alps	3 400	3 300	1 500	1 000
Southeast	1 900	1 100	-	500
Southwest	4 000	1 100	2 500	2 400
Metropolitan France	**21 300**	**17 100**	**4 200**	**9 500**

These objectives were specified by Barthod (2001) as a function of the financial and human resources that can be mobilized, defined after discussions at the regional and local levels. We observe how the objective of afforestation of farmland corresponds to almost 10,000 ha/year, which corresponds to one of the afforestation policies examined in the preceding section.)

Source: Barthod (2001).

Table 11 – Length of inter-regional forest management improvement programs (years)

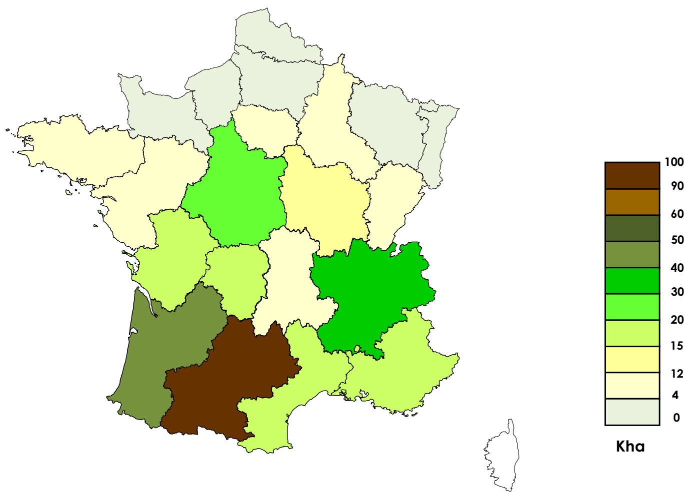
	Conversion to even-aged or uneven aged high forest (years)	Improvement of coppice and coppice with standard (years)
Massif Central and Northern Alps	41	76
Northeast	40	141
Northwest	74	239
Southeast	26	118
Southwest	88	118

Source: CDC Climat Research, from Barthod (2001).

Potential for projects to convert coppice into high forest

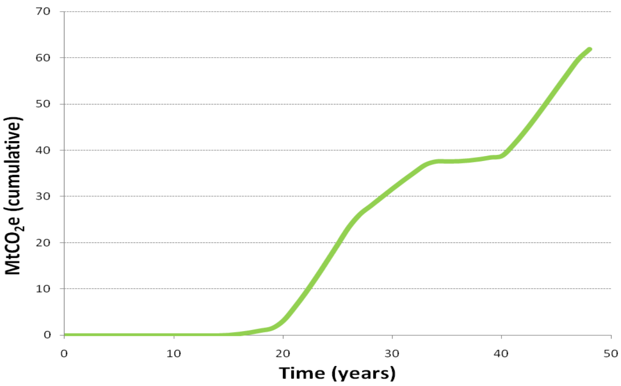
Under the hypothesis of conversion into high forests of 19% of the area in coppice and coppice with standard, the regional distribution of this potential, illustrated in Figure 18, is estimated on the basis of the regional area in coppice.

Figure 18 – Regional distribution of the potential for conversion of coppice into high forest



Source: CDC Climat Research based on data: [(1)] Results of Departmental Forest Inventories between 1989 and 2004 centralized by the IFN and[(2)] Barthod (2001).

Figure 19 – Sequestration potential over time (Additional to the baseline)



Source: CDC Climat Research.

On the basis of an annual rate of conversion of 21,300 ha, the national potential for this type of conversion project is 20 $MtCO_2$ over 25 years. The difference in forest carbon stocks between project and baseline being cyclical, these 20-year cycles also show up in the national potential.

Potential for energy densification projects

The evaluation of the national potential for this type of project is based on the geographic distribution of *Maritime Pine* which is concentrated in the Aquitaine region. According to our information, around 100,000 hectares are potentially available for this type of project, which would allow the sequestration of 70 $ktCO_2e$ in the medium term (under a rhythm of 5,000 ha/year).

Figure 20 – Regional distribution of the Maritime Pine *(Pinus pinaster)* and potential for densification

This species is native to the coasts of the Atlantic Ocean and the Mediterranean. In France, it is found in the forested massif of Les Landes de Gascogne (Landes massif in the Southwest), as well as on the Mediterranean coast, in Brittany and Sologne and in the Loire Valley. This species has the best gross annual production at 11.1 million m^3 per year.

Source: CDC Climat Research based on data from the IFN and from GDF-Suez, COFELY.

C. "Wood products" projects

Example 1: Reallocation of timber uses project

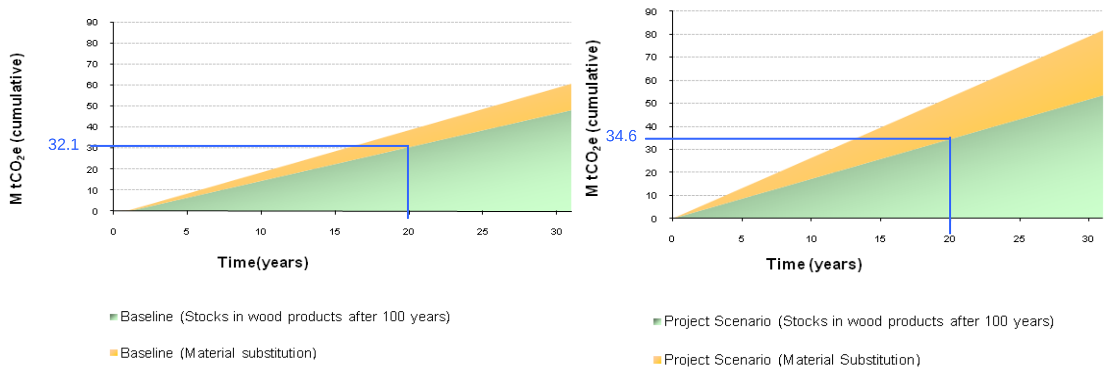
This hypothetical project, inspired by a study published by Malfait et al. in 2008, would involve changing the uses of harvested wood in the Aquitaine region towards products with a longer life span. To simplify the computations, it assumes that the region's forest is in equilibrium, with constant forest stocks and constant harvested volumes. The project characteristics are presented in Table 12.

Table 12 – *Scenario* of the project of reallocation of timber uses[24]

	Baseline	Project scenario
Distribution of wood usage	7.5% of the harvest in the region is to be used as lumber for construction (0.66 Mm3)	20% of the harvest in the region is to be used as lumber for construction (1.76 Mm3). This increase comes at the expense of wood for packaging (industrial timber).
Type of management	Harvested in the region without modifications	Objective: Promote the use of the harvest for wood products that have a long life. Longer carbon sequestration in wood products in construction and modification of the wood-material substitution effect.
Wood production / carbon sequestration	In wood products originating from the harvest in the region: 32.1 MtCO2 (at the end of 20 years)	Sequestration of carbon from the harvest once the redistribution has been completed: 34.6 MtCO2 (at the end of 20 years), i.e. an additional 2.5 MtCO2.
Other Avoided emissions (substitution)	Substitution of materials (use of the wood as a substitute for other materials that emit higher amounts of CO2): 8.1 MtCO2 (at the end of 20 years.	Substitution of materials (use of the wood as a substitute for other materials that emit higher amounts of CO2): 18.2 MtCO2 (at the end of 20 years.
Co-benefits		None

Source: CDC Climat Research from Malfait et al. (2008).

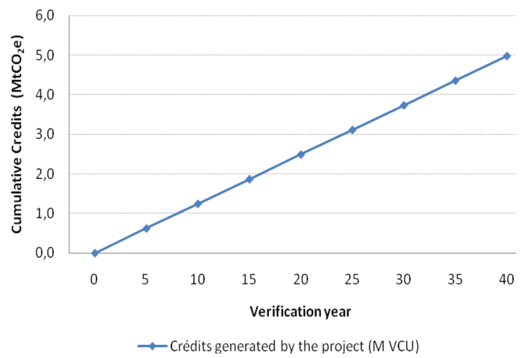
Figure 21 – Evolution of carbon sequestration of the reallocation of timber usages project[25]



Source: CDC Climat Research from Malfait et al. (2008).

Figure 22 illustrates our estimates of VCUs generated by the project. After 40 years, the project generates 4.5 million VCUs. Because this project focuses only on the wood products, we consider the buffer concept not to be applicable.

Figure 22 - Number of VCUs generated by the reallocation of timber usages project



Project size - Annual harvest (Mm^3/an)	8,8
Aiquitaine Forest Size (Mha)	1,77
Verification periodicity (years)	5
Creditable Sequestration rate (tCO_2e)/ha/yr*	0,1

**computed on a 40 year basis*

Source: CDC Climat Research.

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[24] Carbon leakage, which is not considered in our computations, could diminish the number or generated credits as there is no certainty that the material substitutes to wood for packaging would not emit more carbon than the baseline scenario.

[25] Forest stocks and the energy substitution effect are not shown in the figure because they are not modified by the project (Annex 1 - Calculations performed for each project).

Example 2: Regional harvest increase project

A project considering the increase of harvest volumes in the Lorraine region is analyzed, this project has the objective of increasing carbon storage in wood products, based on the exploitation of coniferous stands. This project is inspired by one of the objectives of the Grenelle de l'Environnement which proposes increasing wood harvest by 20 Mm^3/year by 2020. We have adopted a conservative hypothesis; only 70% of this objective will be achieved and the time horizon will be twice as long, which for the Lorraine region[26] would represent an objective of increasing the harvest by 1.1 Mm^3/year in 20 years.

Calculations are made with the simplifying assumption that a portion of the Lorraine forest remains unexploited, while the rest is at equilibrium between natural growth and harvesting. Once the project is under way, a new equilibrium is reached in which the exploited part is increased by 0.8 million hectares, which makes it possible to meet the annual harvesting objective (see Annex). The characteristics of this project are presented in Table 13:

Table 13 – Scenarios of the regional harvest increase project

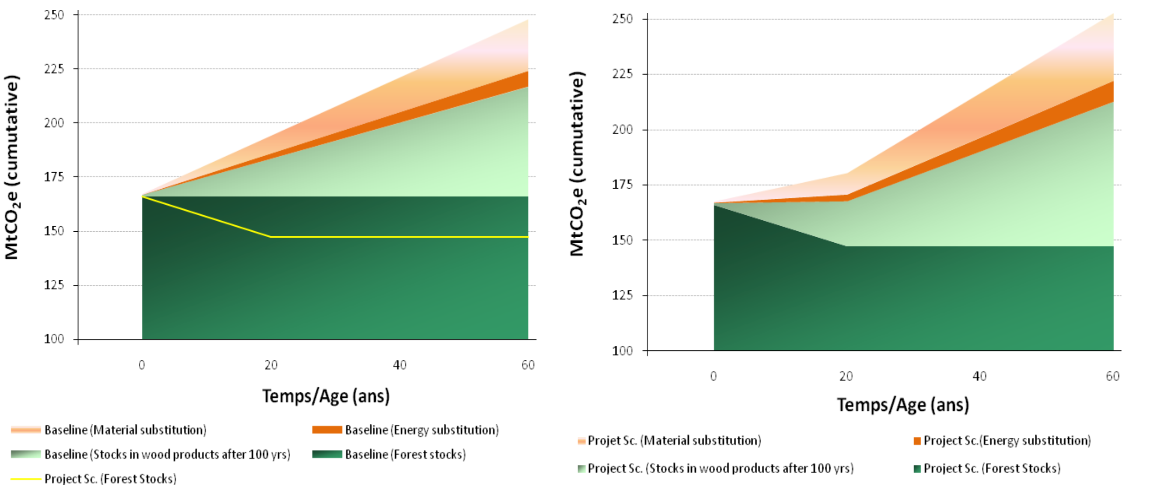
	Baseline	Project scenario
Level of harvesting	Annual harvesting in the region: 3.2 Mm3 Forest stocks 166 Mm3	Gradual increase of regional harvesting to an annual level of 4.3 Mm3 in 2030.
Type of management	Harvesting in the region without modifications	Objective: Mobilization of the forest (mature softwood trees) and extended period of storage of carbon in the wood products.
Wood production / carbon sequestration	In the forest and the wood products originating from the harvest in the region.	Reduced inventory in the forest and increased inventory in the wood products. Increased substitution effects (materials and energy)
Co-benefits		None

Source: CDC Climat Research.

Figure 23 illustrates the impact of the project on the different aspects. The increase in harvest drives an increase in the carbon stored in wood products and in the energy and material substitution effects. These increases are not sufficient to offset the reduction of the forest inventory in the short term. The aggregated mitigation of these four effects over 20 years in the project scenario is 7% lower than the baseline, and 2% lower over 40 years. Nevertheless, over the long term (60 years), the wood products and substitution effects overcome the forest stock effect, leading to a 1.8% higher mitigation effect in the project.

Figure 23 – Stock variations and substitution effects from the regional harvest increase project

Baseline ***Project scenario***

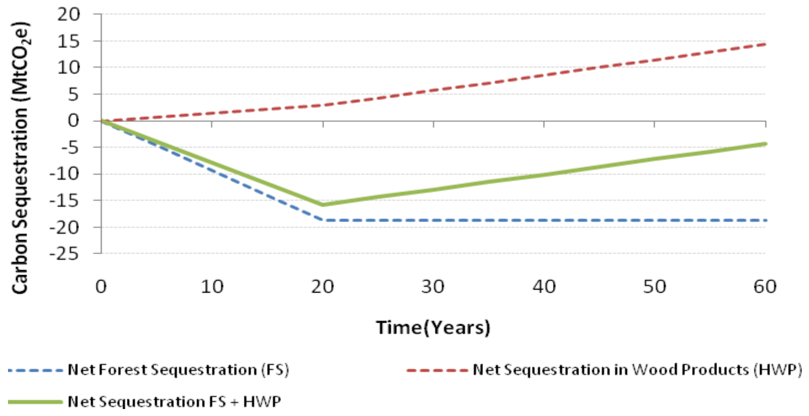


Source: CDC Climat Research.

[26] The harvest in Lorraine represents 8% of the national harvest.

The project cannot claim the benefits linked to the sale of the VCS credits because the aggregate result of the net accounts (project scenario - baseline) of the forest stocks and wood products is negative for the entire project cycle, as illustrated in Figure 24.

Figure 24 - Net sequestration of the project in the forest and wood products compartments



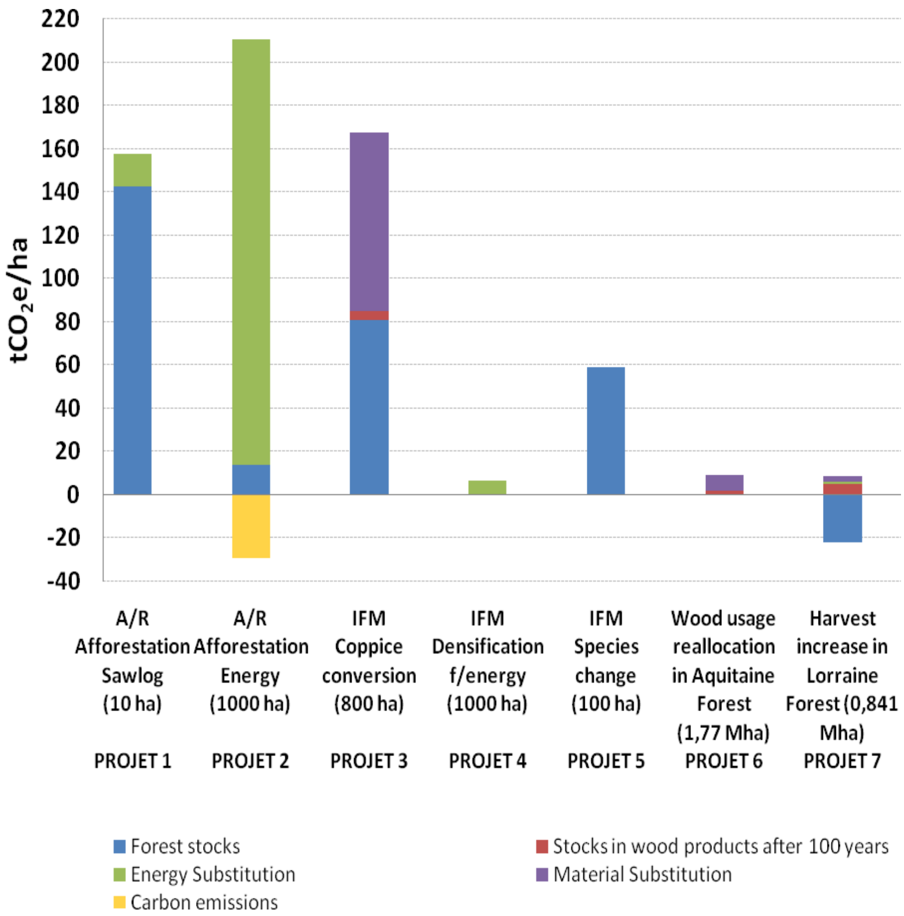
Source: CDC Climat Research.

D. How much carbon in 25 years?

Figure 25 summarizes the net carbon sequestration and substitution effects per hectare of each project by the 25th year.

Figure 25 - Comparison of carbon sequestration / substitution at 25 years

Net effect = Project Scenario (PS) – Baseline (BAU)



Source: CDC Climat Research.

It should be noted that the 7 analyzed projects vary in terms of their size, location, productive purposes and type of forest management, involving different investment costs, organizational measures, and economic arbitrages in terms of land and harvest use.

With regard to the effects that can be valued in the voluntary market (i.e. Forest and Harvested Wood Product stocks), projects 1, 3 and 5 have the most beneficial effects in terms of increasing the forest stocks and projects 3 and 6 in terms of carbon stocks in wood products.

Project 1 achieves a net increase in the forest stock which is greater than that of projects 3 and 5 (+62 tCO_2e/ha and +83.5 tCO_2e/ha respectively). On the other hand, it may require higher investments and operating costs than project 3.

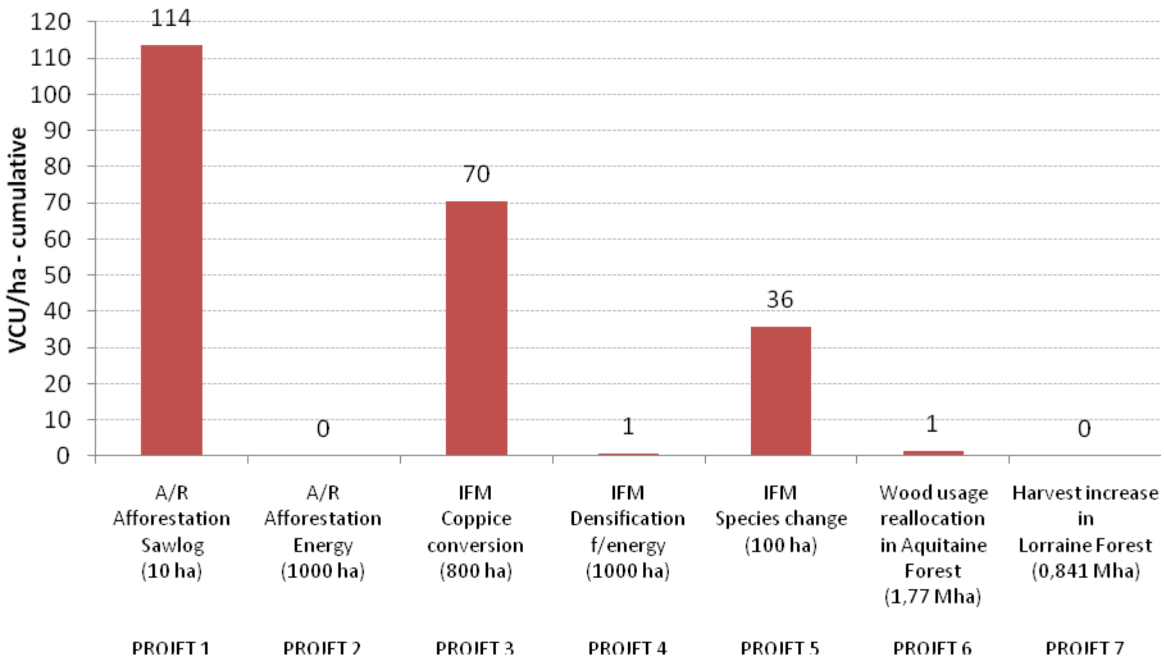
The second project achieves the highest aggregate effect. Nevertheless, the latter is reduced by 15% because of greenhouse gas emissions resulting from management practices and fertilizing. This project is also difficult to value under a voluntary standard. The major effect of energy substitution cannot be valued in the voluntary market, and the increase in the carbon stored in the forest does not offset the greenhouse gas emissions of the project.

The final project does not provide any carbon benefits by the 25^{th} year. The increase of the carbon stored in wood products, added to the substitution effects, offsets only 38% of the reduction of the carbon stored in the forest. It should be mentioned, however, that this situation is reversed after 50 years.

Figure 26 translates these numbers into VCS carbon credits (VCUs). It shows that projects 1, 3 and 5 generate most credits per hectare over a 25-year horizon. As indicated above, projects 2 and 7 do not generate any VCUs. On a per-hectare basis, because of its large scale, the number of credits produced by Project 6 becomes almost negligible. However, it reaches 2.6 M VCU at the end of 25 years.

Figure 26 - Number of credits generated by each project after 25 years

(Taking into account the discounted buffer credits)



Source: CDC Climat Research.

III. CERTIFICATION PROSPECTS

A. Forestry projects and the "carbon" certification criteria

After assessing the carbon benefits achieved by each hypothetical project, the next question relates to the carbon certification. To determine and identify the most appropriate standard for each project, the projects are examined in the light of the three major certification criteria explained in Section II: additionality, permanence and double-counting.

Afforestation and Reforestation projects (A/R)

Afforestation project for hardwood sawlog production

Taking the afforestation project to produce sawlog in the Provence-Alpes-Côte d'Azur region as an example, the only compartment of interest in terms of voluntary carbon certification is the forest stock because the increase in wood product stocks occurs relatively late in the course of the project. Since the project takes place on a very small area, it is very unlikely that the project would be profitable, even with carbon revenues (see the economic analysis in Section IV.C). For a more important size, 100 ha for example, this project is not profitable simply from the sale of wood, but it becomes profitable when carbon revenues are added.

In any case, this lack of profitability makes the project eligible to all standards from the point of view of additionality. The sawlog afforestation project has a positive sequestration balance over its entire life. With regard to permanence, this type of management is conservative, because the objective is to leave the trees standing as long as possible. To attempt to reduce vulnerability to the risks associated with fires or storms, the choice of location is fundamental and an insurance system is required by the certifying authorities (the majority of the standards require that a portion of the credits generated be placed in an insurance pool).

Nevertheless, since the project is small and geographically concentrated in a region vulnerable to fires, the risk of non-permanence is quite high. Consequently the VCS, which adjusts the number of credits placed in reserve as a function of the risk profile of the project, may require an important percentage of credits to be placed in the buffer, which could be lowered by France's political stability, clearness in land tenure issues, and preparation to combat forest fires.

The criterion that seems most troublesome for this project is double counting. The effect of this type of project is theoretically counted in the national forestry inventory and therefore may lead to the generation of carbon credits in the national account under Article 3.3. The consequence in terms of the certification prospects depends on the standards, which do not treat double counting in the same manner.

Box No. 1. Conditions set by the VCS for the certification of projects in Annex I countries

Project proponents of projects that reduce GHG emissions from activities that are included in an emissions trading program; or take place in a jurisdiction or sector in which binding limits are established on GHG emissions; shall provide evidence that the reductions or removals generated by the project have or will not be used in the emissions trading program or for the purpose of demonstrating compliance with the binding limits that are in place in that jurisdiction or sector.
Such evidence could include:

- a letter from the program operator or designated national authority that emissions allowances (or other GHG credits used in the program) equivalent to the reductions or removals generated by the project have been cancelled from the program; or national cap as applicable or;
- purchase and cancellation of GHG allowances equivalent to the GHG emissions reductions or removals generated by the project related to the program or national cap.

Extract from Section 5.2.2 of VCS 2007.1

The VCS requires the submission of an official document from the French authorities confirming the retirement of a number of Absorption Units (AU) from the national accounts corresponding to the units that are candidates to voluntary certification (see Box 1). The CCBS requires a convincing demonstration for each project that the problem of double counting has been avoided, but not necessarily an official document. The Carbon Fix standard resolves the problem of double counting by contacting the respective designated national authority of the host country, in order to avoid negotiations from different project developers on the same topic.

Afforestation project for energy production

For an industrial project of this type, an assessment must be conducted to determine whether carbon credits for the carbon inventory in the forest has a genuine financial incidence on the economic model of the project, or whether they represent only a "bonus" and are not a determining factor in the investment choice, which would make the demonstration of the economic additionality of the project problematic. Even though the risk of non-permanence is low, given the short rotation period, the certification of this project would encounter the same problems of the previous project with respect to double counting.

The energy substitution effect of this project can, for its part, be valued in the framework of the EU ETS or a domestic offset project.

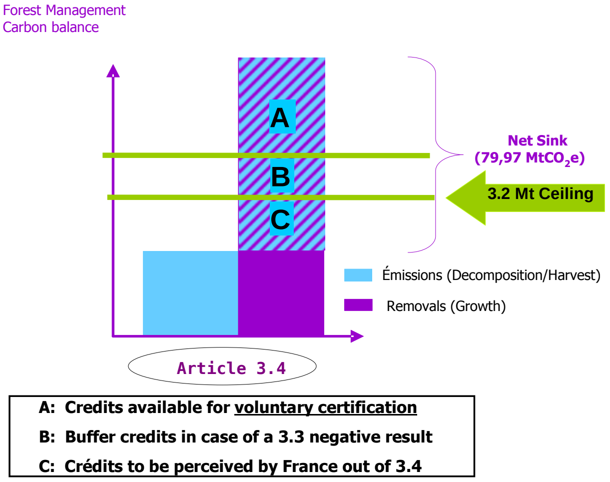
On account of the double counting criterion, the perspectives for the certification of the afforestation projects are low. However, a draft ministerial regulation is being prepared in France (in accordance with Article 8 of the ministerial regulation of March 2, 2007) to integrate afforestation into the "CO_2 domestic offset projects" framework, the national transposition of Joint Implementation (JI). It involves the transfer by the State to the project developer of a number of Kyoto credits equivalent to the projects' reduced emissions or sequestered units.

Improved forest management projects (IFM)

The double counting barrier seems easier to overcome for forest management projects than for afforestation projects. As described in Box 1 for voluntary standards such as VCS, the only requirement is to demonstrate that the project does not have any impact on the 3.2 million tons of RMU credited yearly to the French State according to Article 3.4.

As depicted in Figure 27, the surplus of 70 million uncredited metric tons (A), after deduction of the 3.2 million tons of issued RMUs (C) and the 9 million tons that can be used in the case of a deficit in Article 3.3 (B), represent the amount of credits than can be awarded to "voluntary" IFM projects without double-counting risk. This structure is conceivable under the current accounting rules of the Kyoto Protocol, although it remains to be developed and validated as a VCS methodology.

Figure 27 – Accounting structure for credits pursuant to Article 3.4



Source: CDC Climat Research.

In the long term, the opportunities for improved forest management projects in the voluntary markets depend on the outcome of the post-2012 negotiations. During Copenhagen negotiations at the end of last year, LULUCF in Annex I countries and Articles 3.3 and 3.4 of the Kyoto Protocol were discussed. Neither issue was resolved in the draft decision published by the Ad Hoc Working Groups on Further Commitments for Annex I Countries under the Kyoto Protocol (AWG-KP) supposed to advise the COP on modifications in the accounting of carbon sinks.

If the cap established by Article 3.4 is eliminated, the certification of forest management projects in the voluntary markets would become problematic because of double counting. However, the path would undoubtedly be open for the carbon from such projects to be valued via domestic offset projects. The certification of the carbon sequestration in wood products of these projects should not encounter major obstacles, since they are not accounted in nations' Kyoto accounts, although the quantities of carbon involved are a lot smaller.

None of the selected standards has yet certified improved forest management projects. The certification of a project for the conversion of a coppice forest into an uneven-aged high stand or a change of species would therefore require the development and validation of a methodology by the standard. Several improved forest management methodologies have already been submitted to the VCS for validation. The additionality of the energy densification project could also be difficult to prove because of the economic additionality issue. However, the project seems to be already feasible with revenues expected from the sale of energy wood.

The "wood products" projects

The VCS and CCX certification programs make it possible to earn credits for long lived wood products. The methodology used by CCX counts one carbon credit for each metric ton of CO_2 that remains in wood products and fills 100 years after harvesting. The proportion of remaining carbon is calculated on the basis of factors provided by the US Department of Energy which vary according to the type of wood and the type of usage. This methodology is similar to the one in use under the California Action Registry, a California certification scheme recognized by the VCS.

As indicated in section I.C, the CCX excludes projects developed in Annex I countries such as France. We have nevertheless used their methodology to calculate the hypothetical VCS credits generated by such projects. These coefficients should be readjusted to be officially applicable to the French case given the differences in the life span of wood products. Although no methodology currently validated by the VCS accounts for the carbon stock of wood products, the VCS guidelines allow such methodologies to be submitted.

A methodology of this type does not have to demonstrate the absence of double counting because the carbon sequestered wood products does not appear in the national Kyoto accounts. This element could also change after 2012. Nevertheless, the project developer must include a demonstration of additionality. A project developer may not claim credits on the basis of the carbon sequestered in its wood products, but must present proof that its project generates sequestration in addition to a business as usual scenario.

B. Which standard for which project?

Table 14 provides a summary and preliminary evaluation of the suitability of the voluntary standards for the types of projects envisioning carbon certification:

Table 14 – Preliminary assessment of the potential certifications for each project

Legend: «-» Certification is not possible; «+» Certification seems possible, methodology to be submitted and validated; «++» No major obstacle to certification; «+++» Certification possible, similar projects have already been approved.

Source: CDC Climat Research .

	VCS	CFS	CCBS
A/R Afforestation for sawlog	-	+	+
A/R Afforestation for energy	-	+	-
IFM Conversion of coppice forest into high forest	+	-	++
IFM Densification for energy	+	-	-
IFM Change of species	++	-	-
Reallocation of wood usages	+	-	-
Regional harvest increase	-	-	-

Afforestation/reforestation projects

The hardwood sawlog afforestation project could be certified by both CFS and CCBS, because it would have the ecological and community benefits required by CCBS. However, the risk of double counting remains a major obstacle in both cases. The specific criteria of the VCS are very unlikely to be satisfied on this point, and the demonstration required by the CFS and the CCBS may also be difficult to achieve.

In addition to the risk of double counting, the second energy afforestation project could be certified by CFS if the project developer commits to a period of more than 30 years. CCBS certification is unattainable because of the absence of the biodiversity aspect in the project.

Improved forest management projects

Provided they accept the demonstration of the absence of double counting or get the necessary proof from the national authorities, VCS and CCBS could certify all three projects. Nevertheless, the VCS has not yet approved any project in an Annex I country except for Canada. However, certification via CFS is not possible because this standard certifies only afforestation projects.

For the energy densification project in particular, it will not be easy to prove the benefits in terms of biodiversity necessary for the CCBS certification. The species change project could be based on methodologies relating to the increase of the productivity of the forests which are currently in the process of validation by the VCS.

"Wood products" projects

The CCBS and CFS standards cannot be applied to these projects given that they are not pure forestry projects. For the time being, VCS has not yet validated any methodology for the sequestration of carbon in wood products, although it already includes the carbon accounting of the wood products pool for projects that reduce wood harvest volumes. In this type of projects, the balance of the wood products pool is then negative and partly reduces the balance of the forest pool.

C. Example of a cost benefit analysis of a project to be certified by a voluntary standard

This example illustrates the economic impact of carbon certification, in this case the afforestation for hardwood sawlog production project[27] (see section I.C). In spite of the impossibility of having this particular project certified by the VCS, the VCS accounting rules have been used in the calculations for the sake of illustrating the theoretical carbon benefits generated by the project.

All of the assumptions used for the costs and benefits related to forest practices as well as those related to carbon costs and accounting rules for VCU credits are presented in Annex 4 . For credit accounting, the price of VCUs is assumed to begin at 4.44 €/tCO_2e (average price estimated by Hamilton et al. (2010) for the first semester of 2009 for afforestation projects) and increases by 5% a year[28]. Credits are assumed to be ex-post[29] (i.e. sold after every verification which in our estimations takes place every 5 years).

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[27] The technical details of the project are based on information existing of a walnut tree plantation (Juglans regia) available in Reverchon (2006). The costs associated with forest management and the carbon certification are extracted from recent specialized literature. This technical management mode cannot be directly extrapolated to other planting projects in France and the all the cost data include a margin of uncertainty. Therefore: the conclusions concerning the feasibility of this type of "carbon" project must therefore be regarded with caution.

[28] The prices of the credits originating from afforestation projects have increased by 7.6% between 2008 and the first six months of 2009.

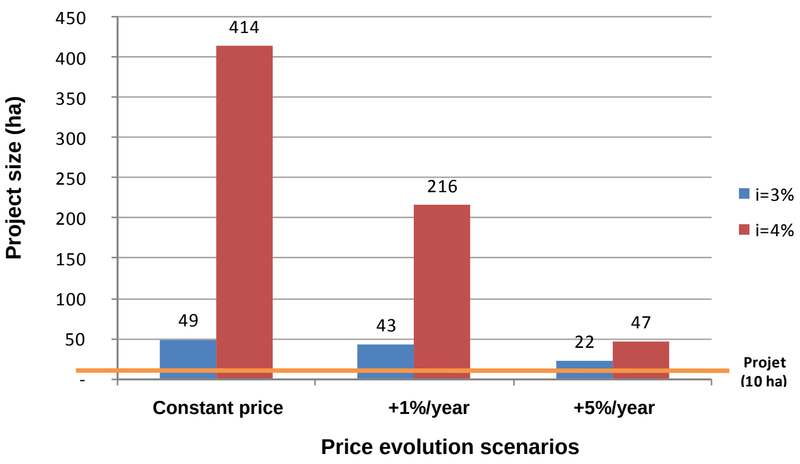
[29] A scenario where credits are sold ex-ante would have an impact on the cash flows and financial indicators of the project. Unfortunately this analysis has not been included in this report.

Based on the discounted net profit, the net present value (NPV) and the internal rate of return (IRR) of the project are calculated with a discount rate[30] (i) of 4%, which is typical for forestry projects. These two financial indicators are insufficient primarily because of the small size of the project:

- The NPV is negative and equals -31,000 € at the end of 40 years, which is considered as the carbon certification period of the project.
- The internal rate of return is 2% and is less than the cost of capital, which is set hypothetically at 5%.

Because project revenues are far away from covering its costs, the "break even size" which would make it possible for the project to achieve an NPV of zero is calculated, i.e. the minimum project size from which it becomes profitable, all other things being equal.

Figure 28 – Break even size



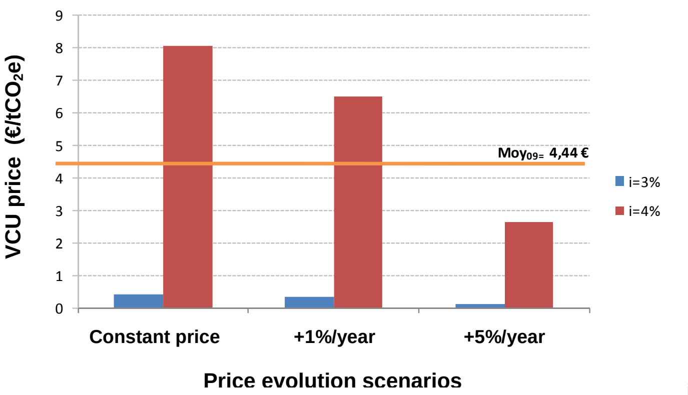
i = discount rate

Source: CDC Climat Research.

The analysis depicted in Figure 28 emphasizes the need to cluster several planting projects to achieve at least the break even point. Under a constant price scenario, the project must be larger than 414 hectares. And even for an optimistic scenario expecting VCU prices to grow at a rate of 5% a year, a plantation must cover at least 50 hectares to begin being profitable.

For a larger scale project covering 100 hectares, we also perform the break even analysis for credit prices (see Figure 29). Under an assumption of prices rising by 1% a year, the minimum price necessary for the project to begin generating income is set at 6.5 €/tCO_2e.

Figure 29 - Break even price, Project size = 100 ha



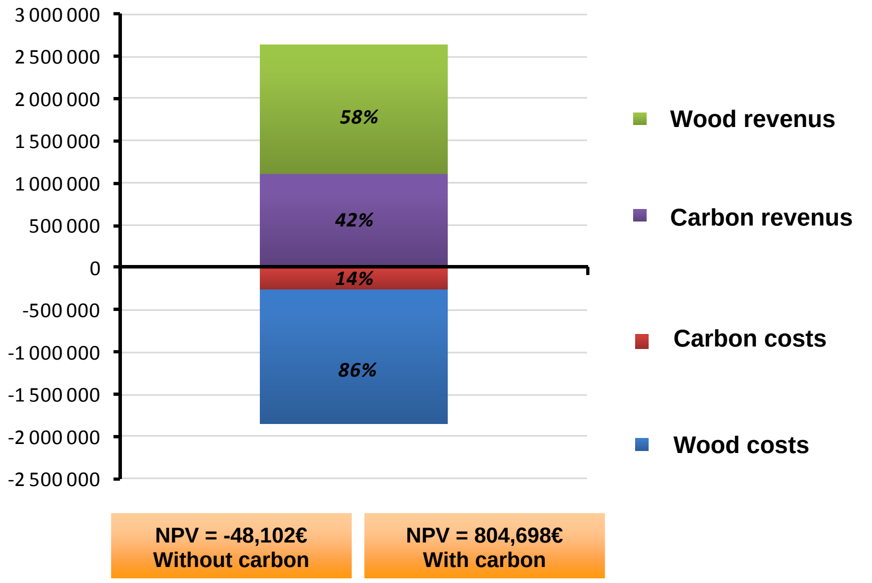
i = discount rate

Source: CDC Climat Research.

[30] The discount rate is used to depreciate future cash flows and determine their current value, i.e. what they would be worth today.

Figure 30 distributes the costs and benefits between forestry and carbon certification. It illustrates, among other things, the economic additionality of an afforestation project of 1,000 hectares. The carbon certification entails certification costs that represent only 14% of the total costs of the project, while the share of carbon profits is 42%. It should be noted that to this point - 40 years - the final harvest has not been performed which would decrease the importance of carbon benefits in the revenue distribution. In the absence of carbon income, the project is not profitable with a negative NPV of -48,102 €. The introduction of the carbon revenues makes it possible to have an NPV of 804,698 € and an IRR of 5%, which offsets the cost of the capital.

Figure 30 – Distribution of discounted costs and profits at 40 years in euros (project size = 1000 ha, Initial price = 4.44€/VCU increasing by 5% a year (i=4%))



Source: CDC Climat Research.

IV. Conclusions

This climate report provides an overview of the carbon valuation of the French forest and wood sector. The synthesis of the sector's characteristics and of the regulatory framework emerging from the Kyoto Protocol for an Annex 1 country, such as France, shows how only the wood-energy and wood-material substitution are valued by compliance markets, albeit indirectly, and why these markets have not so far offered opportunities for projects sequestering carbon in the forest or in the wood products. On this second point, the alternative of getting carbon value out of voluntary markets is developed through the analysis of seven hypothetical projects.

The analysis of the carbon "value" of these projects shows that not all of them are attractive for certification by voluntary market standards. Nevertheless, the certification of afforestation projects or improved forest management could be profitable and these projects have the potential to sequester several millions of tons of CO_2 on a national scale. According to our estimates, an afforestation policy of the order of 30,000 ha/year could allow the sequestration of approximately 35 $MtCO_2$ over a period of 25 years. The massive conversion of coppice systems into high forest stands offers "carbon" benefits as representative as those of afforestation.

Finally, by comparing the certification alternatives for the different projects and through the economic analysis of one of the projects, the obstacles that must be overcome to achieve this potential are illustrated. Among them, the creation of a convincing methodology to deal with the risk of double counting between compliance and voluntary markets is essential. Another fundamental aspect is the need to put together a reasonable number of hectares for the projects to be profitable. In the case of a hardwood afforestation project, this critical size probably exceeds one hundred hectares. Proving the additionality of these projects is also paramount.

In the medium term, the final outcome of post-2012 negotiations on forestry accounting in Annex I countries will have an impact on the opportunities in the voluntary markets identified in this report. In this sense, pursuing voluntary carbon certification for French forestry projects can be perceived as a pre-compliance initiative. Should future rules allow the certification forestry projects on compliance markets, the methodologies and know-how developed on pilot voluntary projects will undoubtedly speed up their practical implementation.

V. ABBREVIATIONS

AAU	Assigned Amount Units
AFOLU	Agriculture Forestry and Other Land Use
CCBS	Climate, Community and Biodiversity Standard
CCX	Climate Carbon Exchange
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CFI	Carbon Financial Instrument
CFS	Carbon Fix Standard
CO_2	Carbon dioxide
ENSTIB	Ecole nationale supérieure des technologies et industries du bois
EU ETS	European Union Emissions Trading Scheme
GHG	Greenhouse gas
IFN	French National Forest Inventory (Inventaire Forestier National)
JI	Joint Implementation
LULUCF	Land-Use, Land-Use Change and Forestry
MAP	French Ministry of Agriculture and Fisheries (Ministère de l'Agriculture et de la Pêche)
RMU	Removal Units
tCO_2e	Metric tons of CO_2 equivalent
TGW	Tons of green wood
VCS	Voluntary Carbon Standard
VCU	Voluntary Carbon Unit
VER	Verified Emission Reduction

ANNEX 1 - CALCULATIONS PERFORMED FOR EACH PROJECT

This Annex describes the procedure followed to calculate the carbon sequestration of each project. The assumptions, extrapolations and approximations employed determine that these results must be considered with prudence. Therefore, they should be considered mainly as rough estimates rather than as precise results.

The conversion coefficients used in our calculations are:

- 1 Dry metric Ton (DMT) = 0.5 metric tons of carbon

- 1 Dry metric Ton (DMT) = 0.5 metric tons of carbon

- 1 metric ton of carbon = 3.667 metric tons of CO_2

Unless indicated otherwise, all the calculations and hypotheses have been performed and defined by CDC Climat Research.

The reader can find the computations of the carbon effects of the remaining projects on the corresponding methodological annex (downloadable at www.cdc.climat.com).

A. General project information

Species: Hybrid walnut *(sp. juglans nigra)*[31]

Location: Region of Provence-Alpes-Cote-d'Azur (PACA)

Project Size: 10 ha

Initial stocking density: 200 trees/ha – *low density*

Forest management: Thinned in years 25, 40 and 55. Clear cut in year 80.

B. Methodology used for the calculation of the carbon sequestration of the afforestation project

Forest stocks

The carbon sequestration data of the project during the certification period are taken from the accounting prepared by Reverchon (2006) for this project. These data are based on growth models (Becquey 1997) and on methodologies validated by the UNFCCC for afforestation projects. The parameters used by Reverchon include, among other things, the infradensity of the wood (D= 0.55[32]) and the rate of carbon in the dry ligneous matter (Tc = 0,5[33]).

The carbon sequestration of the project in its forestry compartment is illustrated in Figure 31.

Intended use of the harvest: on the basis of the data provided by Reverchon on the levels of harvesting during each forestry management operation, we have defined several hypotheses concerning the use of the harvested material. The conversion from m^3/ha to DMT/ha is done by using the density[34] of the species at 15% moisture content = 0.670 DMT/m^3. These estimates allow us to see the other effects of extending carbon sequestration in wood products and the reduction of emissions from other sources than use wood in energy generation or construction.

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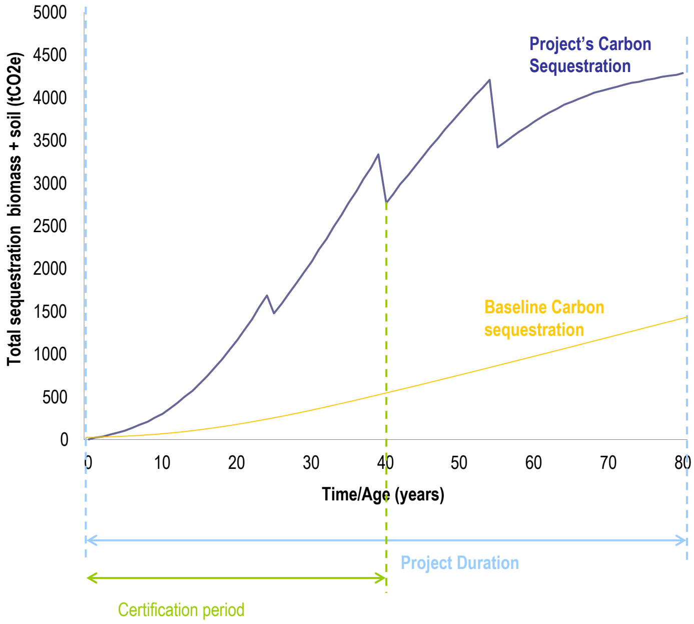
[31] Other eligible species: wild cherry, walnut, alder, sycamore, service tree, field maple, mulberry, linden, pear. These species have been selected on account of their adaptability to the terrain and the climate in the region.

[32] Dupouey et al. (1999).

[33] GIEC.

Figure 31 – Carbon sequestration by the even-age high forest planting (Example: 10 ha of walnut trees – *Juglans sp.*)



Source: CDC Climat Research from Reverchon (2006).

Table 15 – The harvest and its uses

Forestry operation	Age (years)	Harvest (m3/ha)	Conversion DMT/ha (15% hum)	Uses (%)			Aspects valued
				EW	SW	PW	
Thinning 1	25	27.7	18.5	100%	0%	0%	*ES*
Thinning 2	40	57.4	38.5	90%	10%	0%	*HWP, ES, MS*
Thinning 3	55	71.5	47.9	80%	20%	0%	*HWP, ES, MS*
Clear cutting	80	272.9	182.8	50%	50%	0%	*HWP, ES, MS*

EW: Energy Wood, SW: Sawlogs, PW: Pulpwood; ES: Energy Substitution, HWP: Inventory of Wood Products, MS: Material Substitution.

Harvested wood products (HWP)

We use the CCX methodology for the calculation of the extended storage of carbon in wood products. This methodology grants one carbon credit for each metric ton of CO_2 contained in the wood products (in use or buried in a landfill) and not re-emitted into the atmosphere 100 years after the harvest. It is based on data released by the US Department of Energy, each type of wood has its carbon conversion factor, depending on the product category it is destined to (sawlogs, pulpwood). The CCX coefficients are available for the US at the regional level, as an approximation, we calculate the average value of the extended storage of carbon in the wood products, depending on the two usage categories: sawlog and pulpwood.

	Sawlog	Pulpwood
Hardwood	0.276	0.241
Softwood	0.350	0.203

Source: CCX Offset Project Protocol - Forestry Carbon Sequestration [35]

[35] http://www.worldagroforestry.org/sea/Products/AFDbases/WD/asps/DisplayDetail.asp?SpecID=1877 (p.54).

The assumptions of intended use of the harvest were presented in Table 15 and they lead to the results in Table 16 for the stocks in the wood products.

Table 16 – Extended Sequestration in wood products

Forestry operation	Age (years)	Harvest (DMT/ha)	Harvest intended for wood products (DMT)	Stocks in harvested wood products (tC) *(after 100 years)*		Stocks in harvested wood products (tCO_2e) (after 100 years)
				SW	PW	
Thinning 1	25	18.5	0.0	0.00	0.00	0
Thinning 2	40	38.5	38.5	5.30	0.00	19
Thinning 3	55	47.9	95.8	13.20	0.00	48
Clear cutting	80	182.8	914.0	125.90	0.00	462

EW: Energy Wood, SW: Sawlogs, PW: Pulpwood

Energy substitution (ES)

The calculations use the average value by default of the following energy content: one metric ton of dry material (DMT) in the wood produces 2.93 kWh or 10.56 GJ (Sources: CITEPA, 2007. OMINEA). The average of the CO_2 emission factors per GJ of energy generated from coal, home heating oil and natural gas used by CITEPA (in accordance with GIEC recommendations), i.e. 0.8 tCO_2 prevented per DMT of wood used.

Table 17 – Energy substitution

Forestry operation	Age (years)	Harvest (DMT/ha)	Harvest intended for energy(DMT)	Energy substitution	
				Energy produced (KWh)	Avoided emissions (tCO_2)
Thinning 1	25	18.5	185.0	542.1	148
Thinning 2	40	38.5	346.5	1015.2	277
Thinning 3	55	47.9	383.2	1122.8	307
Clear cutting	80	182.8	914.0	2678.0	731

Materials substitution (MS)

This calculation is based on the hypothesis that the entire volume of wood harvested in the project is transformed into beams, and that these wooden beams replace aluminum beams. The substitution coefficient used is that of the ENSTIB for a beam with a span of 7.5 m, a permanent load of 75 kg/m and an operating load of 300 kg/m, and volume per beam of 0.35 m^3, i.e. 321 metric tons of CO_2 emissions avoided per beam. On the basis of the number of beams of this size produced per metric ton of dry wood material, we get the material substitution effect:

Tableau 19 – Material substitution

Forestry operation	Age	SW (m3)	Material substitution	
			Beams	Avoided Emissions (tCO_2) *hyp. aluminum*
Thinning 1	25	0.00	0.00	0
Thinning 2	40	38.46	109.90	35
Thinning 3	55	95.78	273.67	88
Clear cutting	80	914.08	2611.66	838

SW: Sawlogs

C. Carbon sequestration balance - 10 ha hardwood sawlog afforestation project

	ForestStocks	Stocks in Harvested Wood products	Total Stocks	Substitution	Total
Baseline (after 25 years)	0.05 $ktCO_2$	0	0.05 $ktCO_2$	0	0.05 $ktCO_2$
Baseline (after 80 years)	0.3 $ktCO_2$	0	0.3 $ktCO_2$	0	0.3 $ktCO_2$
Project (after 25 years)	1.18 $ktCO_2$	0	1.18 $ktCO_2$	0.14 $ktCO_2$ (ES)	1.33 $ktCO_2$
Project (after 79 years)	3.77 $ktCO_2e$	0.07 $ktCO_2$	3.84 $ktCO_2$	0.73 $ktCO_2$ (ES) + 0.12 $ktCO_2$ (MS)	4.70 $ktCO_2$
Project (after 80 years – harvest)	0 $ktCO_2$	0.53 $ktCO_2$	0.53 $ktCO_2$	1.47 $ktCO_2$ (ES) + 0.96 $ktCO_2$ (MS)	2.95 $ktCO_2$

ANNEX 2 – ESTIMATION OF THE NUMBER OF CARBON CREDITS GENERATED

The number of credits generated for each project is calculated on the basis of the Guidelines of the Voluntary Carbon Standard (VCS). The only effects considered in this calculation are: carbon sequestration in the forest and in the wood products. The substitution effects cannot hope to be valued in the context of the VCS for the reasons relating to the double counting problem explained in Part I. As for the majority of the existing forest carbon projects, root biomass and soil carbon are not taken into consideration.

A. VCS guidelines for the calculation of carbon credits

Carbon credits are calculated with respect to the net carbon sequestration of the project [project-baseline] in Year t (C_t):

$$VCU_t = \left(C_t - \sum_{i=1}^{\frac{t}{v}-1} C_{i*v}\right) * Buffer_t$$

$$Buffer_t = Risk * (1 - Release)^{\frac{t}{v}-1}$$

where:

$Buffer_t$ = Project buffer at year t [tCO_2e]

v = Verification frequency [years]

C_t = Net carbon sequestered by the project in year t [tCO_2e]

Risk =% of the credits to be used according to the 1st risk assessment

Release =% of the credits released as a result of subsequent risk assessments

VCU_t = VCU project account for year t [tCO_2e]

To control the risk of non-permanence, VCS introduced a "buffer", i.e. a fraction of generated credits to be set aside in an insurance account common to all of the forestry projects. The size of this fraction is determined by a risk assessment of the project.

We use a buffer fraction of 30% ***(risk)*** for all the projects. To avoid the application of a penalty, the VCS projects must be verified and their risk re-assessed at least once every 5 years. We therefore assume a verification frequency of 5 years ***(v)***. We also assume that the risk profile of the project does not change, which entitles the project to a reduction (***release***) of 15% of the total amount of the buffer for each verification.

Finally, the maximum number of credits generated by the project may not exceed the temporal average of the project's net sequestration during the rotation period.

By way of example, we have illustrated this calculation for the first afforestation project below:

B. Assumptions

Project size (ha)	10
Buffer (%)	30%
Release (%)	15%
Verification periodicity (Years)	5
Average net sequestration in for the rotation cycle (tCO_2e)	2438,6
Creditable Sequestration rate (tCO_2e)/ha/yr (tCO_2e)[1]	5,8

[1] *Computed under a 35 year basis, considering that in year 35 the maximum number of credits is reached.*

C. Estimated credits

Verif. event	Year (t)	Released Buffer (%)	Sn Net Sequestration (tCO_2) Forest + HWP (see Projet)	Sc Creditable Sequestration (tCO_2) (Forêt+Pbois) Min (Sn.Average)	Generated Credits	Crédits with buffer (VCUs)	Crédits without buffer - cumulative	Credits with buffer (VCUs) - cumulative
A	B	C	D	E	F	G	H	I
0	0	0.0%	0	0	0.00	0.00	0.00	0.00
1	5	30.0%	100.20	100.20	100.20	70.14	100.20	70.14
2	10	25.5%	290.82	290.82	190.63	142.02	290.82	212.16
3	15	21.7%	628.32	628.32	337.49	264.34	628.32	476.50
4	20	18.4%	1126.61	1126.61	498.29	406.49	1126.61	882.98
5	25	15.7%	1425.99	1425.99	299.39	252.50	1425.99	1135.48
6	30	13.3%	2022.58	2022.58	596.59	517.17	2022.58	1652.66
7	35	11.3%	2684.63	2438.64	416.06	368.99	2438.64	2021.65
8	40	9.6%	2683.59	2438.64	0.00	182.46	2438.64	2204.11
9	45	8.2%	3212.57	2438.64	0.00	35.18	2438.64	2239.29
10	50	6.9%	3712.42	2438.64	0.00	29.91	2438.64	2269.19
11	55	5.9%	3320.75	2438.64	0.00	25.42	2438.64	2294.61
12	60	5.0%	3602.46	2438.64	0.00	21.6	2438.64	2316.21
13	65	4.3%	3811.77	2438.64	0.00	18.36	2438.64	2334.58
14	70	3.6%	3938.78	2438.64	0.00	15.61	2438.64	2350.18
15	75	3.1%	4005.85	2438.64	0.00	13.27	2438.64	2363.46
16	80	2.6%	529.97	529.97	0.00	11.26	2438.64	2374.73

Source: CDC Climat Research.

where:

- % Released buffer (C) = 15% released from buffer for each verificationReleased buffer (C) = 15% released from buffer for each verification
- Creditable sequestration, forest (E) = Min (Net sequestration, average)
- Generated Credits (F) = Creditable sequestration (E) – Cumulative credits (H)
- Credits with buffer (G) = Credits generated (K) * (1-Released buffer (C))

ANNEX 3 – CALCULATIONS OF THE NATIONAL AFFORESTATION POTENTIAL

To estimate the national carbon sequestration potential according to the two scenarios and the four afforestation policies previously defined in the report, we have broken down afforestation regionally in proportion to the regional distribution of the potential. The softwood/hardwood ratio[36] of the afforestations follows the current regional ratio. Carbon sequestration capacity per hectare in the above-ground biomass is taken from Zaehle (2006) as shown in Table 18.

[36] Ratio calculated thanks to IFN data

Table 18 – Average CO_2 sequestration capacity per type of species for temperate European forests

Age (years)	Softwoods (tCO_2e/ha)	Hardwoods (tCO_2e/ha)
0–20	32.6	14.7
20–40	206.4	145.2
40–60	345.0	246.8
60–80	404.4	328.2
80–100	435.6	385.7
100–120	447.3	381.0
120–140	425.7	403.7

Source: Zaehle (2006) from EEFR data.

Table 19 – Cumulative sequestration of CO_2 of the four afforestation policies ($MtCO_2e$)

		10 years	20 years	50 years
Conservative scenario	Pol_1 10 000 ha/year	1.8	4.9	62.1
	Pol_3 30 000 ha/year	5.5	14.6	151.8
	Pol_5 50 000 ha/year	9.2	19.6	175.1
	Pol_8 80 000 ha/year	12.9	23.7	198.3
Optimistic scenario	Pol_1 10 000 ha/year	2.1	5.3	65.1
	Pol_3 30 000 ha/year	6.2	16.0	195.3
	Pol_5 50 000 ha/year	10.3	26.7	314.2
	Pol_8 80 000 ha/year	16.5	42.6	406.6

Source: CDC Climat Research.

ANNEX 4 - ASSUMPTIONS MADE FOR THE ECONOMIC ASSESMENT

A. Species, production cycles and certification cycles

The project consists on a plantation of a hardwood species, the rotation cycle is of 80 years. We assumed that the certification standard selected is the VCS, with a chosen accreditation period of 40 years.

	Forest management aspect of the project	Carbon aspect of the project
Year 0:	Implementation: Site preparation and planting	Documentation and certification
Years 1 to 4:	Track maintenance	
Year 5:	Track maintenance	Verification and credit issuance
Years 10, 15, 20:		Verification and credit issuance
Year 25:	Thinning	Verification and credit issuance
Year 30:		Verification and credit issuance
Year 35:		Verification and credit issuance
Year 40:	Thinning	Verification and credit issuance
Year 55:	Thinning	
Year 80:	Harvest	

B. Project carbon sequestration

The project's carbon sequestration data during the certification period are extracted from the carbon accounting prepared by Reverchon (2006) for this project. These data are based on growth models (Becquey, 1997) and methodologies approved by the UNFCCC for afforestation projects.

C. Investment and operating costs[37]

To simplify our calculations, we use the average of the carbon operation costs (applied), which is 40,000 € for any size project.

[37] Exchange rate: 1.429 US$/€ and 6.65 FRF/€

Stages	Project [100 ha]		Project [1000 ha]		Source
Project implementation (wood and carbon)					
Track preparation	259.15			€/ha	Guyon (1998)
Planting cost	609.76			€/ha	Guyon (1998)
Inventory	6,047.99	€ (100 ha)	17,279.98	€ (1000 ha)	Galik et al. (2009)
Preparation of Management Plan	5,183.99	€ (100 ha)	25,919.97	€ (1000 ha)	Galik et al. (2009)
Project operating costs (carbon only)					
Carbon project development (PDD, planning)	3,456.00	€ (100 ha)	8,639.99	€ (1000 ha)	Galik et al. (2009)
Pre-project calculations (risk, leakage, social impacts etc.	864.00	€ (100 ha)	4,319.99	€ (1000 ha)	Galik et al. (2009)
Conversion from inventory to baseline	1,123.20	€ (100 ha)	3,456.00	€ (1000 ha)	Galik et al. (2009)
Modeling of sequestration for early years	302.40	€ (100 ha)	518.40	€ (1000 ha)	Galik et al. (2009)
Wood products accounting	518.40	€ (100 ha)	864.00	€ [1000 ha]	Galik et al. (2009)
Project operating costs (wood and carbon)					
Maintenance costs (5 years)	152.44			€/ha	Guyon (1998)
Forestry operation costs (thinned and clear cut)	207.29			€/ha	Galik et al. (2009)
Project operating costs (monitoring and carbon measurement only)					
Sampling/Monitoring	46.38			€/ha - per event	Galik et al. (2009)
Annual verification report	13.82			€/ha - per event	Galik et al. (2009)
Registry and issuance					
Registry costs (e.g. CDC Register)	0.05			€/VCU	CDC (2009)
Issuance cost (VCSA)	0.04			€/VCU	VCS (2009)

D. Production

The production of wood from this plantation is taken from calculations performed by Reverchon (2006) on the basis of growth models. We get a different value for each thinning and clear cut. This value is presented in the following table, using the density and the moisture content of oak (respectively 0.95 metric tons of green wood (TGW) per cubic meter and 061 metric tons of dry matter (DMT) per TGW.

Forestry operation (diameter)	Age	Harvest (m^3/ha)	Conversion DMT/ha (15% moisture)	Intended use
Thinning 1 (28 cm)	25	27.68	18.5	100% energy wood
Thinning 2 (40 cm)	40	57.41	38.5	80% energy wood 20% sawlog (50% energy)
Thinning 3 (48 cm)	55	71.48	47.9	60% energy wood 40% sawlogs (50% energy)
Clear cut (50 cm)	80	272.86	182.9	100% sawlogs (50% energy)

E. Revenue derived from the harvest

The prices of walnut depend principally on three factors: the diameter, the use and the quality of the trees harvested (good length, absence of knots, attractive veining etc.). In this case, we use a fixed price for wood energy and a price proportional to the diameter for the sawlogs.

P_{energy} = 20 €/DMT *Source: Lecocq (2008)*

$P_{sawlogs\ (harvest\ D\ =\ 50\ cm)}$ = 1300 €/m^3 *Source: Forum Jardinage*[38]

$P_{sawlogs\ (thinned\ D\ =\ 49\ cm)}$ = 1248 /m^3

$P_{sawlogs\ (thinned\ D\ =\ 40\ cm)}$ = 1040 /m^3

F. Revenue from the sale of credits

The revenue expected from the sale of the credits is a function of the volume of credits generated and the discounted value of these credits. This value depends on three factors: the net carbon sequestration potential (absorptions - emissions) of the project, the accounting period and the price of credits on the voluntary market.

The price of the voluntary credits is extremely variable, even if the credits in question are generated by a unique standard such as VCUs (Guigon et al. 2009). Here we use the average price of the voluntary credits originating from afforestation projects on delivery, as estimated by Hamilton et al. (2010) for the year in the first half of 2010: 6.34$/t$CO_2$e (4.44€/t$CO_2$e).The fractions of credits buffered and released are indicated in Annex 2.

[38] http://forums.futura-sciences.com/jardinage/301232-prix-du-noyer.html

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