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Which instruments to preserve forest biodiversity?

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Introduction

In general, neither the social norms nor market dynamics stimulate spontaneously activities and practices conducive to biodiversity. The nature of public good of biodiversity leads to its rapid erosion. Even if it can respond positively to social expectations and improve welfare in the long term[1], taking into account biodiversity often leads to changes in the way we produce or how to exercise its property right. The consideration of biodiversity may determine production losses and income decreases. The forest owners receive their income solely from the wood production, which limits their interest *vis-à-vis* biodiversity, but more importantly, biodiversity being a public good, they are strongly encouraged to leave up to other owners to maintain biodiversity on their property, to obtain some benefits without bearing the costs (including opportunity cost, linked to lower productivity of certain types of forestry). In addition, the length of the production cycle and the difficult integration into the quantitative approaches of the concepts of risk and resilience make it difficult, but not impossible, the development of cost-benefits analysis that would allow a forester (but also the public authority) to estimate the value of maintaining some forms of biodiversity, and their opportunity cost.

[1] Biodiversity has a dual function: first, it plays a functional role in the ecosystem (contribution to ecological services and so, participation in the production of goods that have social and economic interests) and, secondly, it contributes to adaptive capacity of ecosystems to environmental changes (role of stabilization and resilience).

Thus, the development of a strategy to stem biodiversity loss requires incentives to change behaviour of different actors (e.g., foresters, landowners, users of nature, managers and experts). To this end, public policies use various kinds of incentives[2]. The instruments the most frequently used are taxes and levies (e.g., taxes for wildlife preservation, entrance rights, and levy taxes for the use of natural resources), subsidies (for reforestation, agro-environmental measures ...) or tradable permits (mainly fishing and hunting licenses). In most cases, these instruments are applied to the preservation of habitats and ecosystems, only one third of the examples involve direct conservation of species (with a clear tendency for the protection of fauna rather than flora). The use of financial mechanisms (reduction of taxes in green investment funds, venture capital green) or the principle of compensation for preserving biodiversity are still poorly developed (as shown in the table 1 below).

Table 1

Field of application		Taxes / Charges	Subsidies /support	Tradable permits	Eco-labelling	Financial mechan.	Liability & Comp.	*Total*
		A	B	C	D	E	F	
Flora	1	7	1	2	0	0	0	*10*
Fauna	2	35	4	19	1	0	0	*59*
Habitat / Ecosystems	3	57	56	12	5	4	1	*136*
Total		*99*	*61*	*33*	*6*	*4*	*1*	*205*

Distribution of market-based instruments in the database of Bräuer *et al.* (2006)

Through an analysis of the international literature, this paper reviews the incentive schemes designed to influence actors' behaviour, especially managers and owners of private forests, in order to support biodiversity. The aim is to establish a typology of incentives measures to improve the provision of ecological services and to identify novel solutions used abroad that could be used in the French private forest sector.

Regulations

In recent decades, the predominant instrument in the European community to achieve the objectives of sustainable use of natural resources has been the use of regulations from environmental laws, based on the principle of *Command And Control*. They are generally used to protect endangered species or natural areas rich in species, by prohibiting their use or by setting restrictions on access (see the IUCN classification): for example, through the creation of national parks, natural reserves, or the establishment of red list of threatened species with specific conservation actions.

Although the creation of protected areas is the form of regulatory intervention most commonly used to preserve forest biodiversity, other regulations aim a sustainable management of private forests through biodiversity offsets, which are defined as

[2] See for example Boyd and Simpson (1999); Doremus (2003); Patterson and Coelho (2009); Ranganathan *et al.* (2008); Brahic (2010a).

"conservation actions intended to compensate for the residual, unavoidable harm to biodiversity caused by development projects, so as to ensure no net loss of biodiversity. Before developers contemplate offsets, they should have first sought to avoid and minimise harm to biodiversity" (ten Kate *et al.*, 2004). They provide flexibility for agents to realize their development project, while respecting biodiversity conservation objectives. This may relate to species, habitats or ecosystems. In some countries, regulations require explicitly the use of biodiversity offsets, including the following:

- The Wetland Banking (United States) was established under the Clean Water Act (1972) and the US Army Corps of Engineers regulations to protect wetlands;

- The Conservation Banking (United States), established under the Endangered Species Act (1973) and the Guidance on Establishment, Use and Operations of Conservation Banks, aims to protect species and their habitat;

- The protection of local vegetation (Australia), established by the Native Vegetation Act (1991, 2003), aims to encourage and promote the management of local vegetation and to prevent the clearing;

- In France, the CDC Biodiversity of the *Caisse des Dépôts et Consignations* (CDC) aims to facilitate compensation actions. It works with businesses, communities, builders and government in their actions (voluntary or regulatory) in favour of biodiversity: from restoration, management and promotion to compensation.

Note that this biodiversity offsets principle is closely linked to the notion of strong sustainability (Daly, 1998)[3]: in the context of a development project, the aim is to ensure that there is no net loss of biodiversity, so the natural capital stock must remain constant (or increase wherever possible).

In the absence of regulatory requirements, various reasons can motivate a company to voluntarily offset the damage it causes to biodiversity: it can enhance the company reputation; induce a certain kindness of the regulator and better relations with local communities, environmental groups and other stakeholders, which may contribute to its functioning (e.g. a more easy access to capital); and giving some freedom in how to comply with regulations *vis-à-vis* biodiversity, biodiversity offsets can help to find the least expensive means.

The advantage of regulations is that they are the most direct way to achieve an environmental objective. The major drawback is that they are economically inefficient and costly: the government is not able to differentiate the conditions of regulation enforcement by agents so it does not allow those who could contribute the most effectively to make the effort.

Due to budgetary constraints, the choice of measures and strategies is not only based on their environmental effectiveness, but also on their monetary efficiency. Thus, given that most regulatory mechanisms are costly to the public and private sectors[4], market-based instruments[5] are becoming increasingly important because they offer new, less expensive[6],

[3] The strong sustainability approach requires that the stocks of natural capital (ecological assets) should not decrease over-time (Pearce *et al.*, 1994). This is mainly because natural capital is associated with ecological assets, which are non-substitutable, and very essential for the welfare and survival of human beings. These assets are often referred to as "critical natural capital".

[4] Regulatory mechanisms are costly indirectly for the public sector and directly for the private one.

[5] Market-based instruments "*seek to address the market failure of 'environmental externalities' either by incorporating the external cost of production or consumption activities through taxes or charges on processes or products, or by creating property rights and facilitating the establishment of a proxy market for the use of environmental services"* (*European Environment Agency*).

perspectives to achieve the biodiversity objectives and can be used to supplement traditional regulatory measures. Moreover, particular attention is paid to the payment for environmental services.

Payment for Environmental Services

The existing literature on markets for forest environmental services has often adopted a broad definition of market (e.g., Landell-Mills and Porras, 2002) to indicate any transaction where financial compensation, or sometimes in kind, is offered to suppliers of an environmental service. Therefore we generally speak of "Payments for Environmental Services" (PES).

Why paying for environmental services?

The various land uses and their characteristics generate a variety of environmental services (e.g., high levels of vegetative cover help regulate water flows, thereby reducing flooding risk and soil erosion). However, the landowners receive no compensation for such services and in fact, ignore them when making decisions about the use of their land. This failure to take into account these environmental services (ES) can lead to suboptimal decisions from a social perspective. Indeed, the owner's benefits resulting from a forest conservation decision are generally lower than those from, for example, forest conversion into crop. However, the deforestation required for this conversion may impose costs on other agents, including the downstream people who no longer receive the benefits of services provided by forests (water filtration...). To ensure that conservation is more attractive and that land use is socially optimal, the idea is that the beneficiaries of ES pay compensation to landowners in return for adopting practices that protect the ecosystem and associated services.

Wunder (2005) defines PES as: voluntary transactions related to well-defined environmental services (or possible land-uses to secure these services) that are bought by at least one buyer and provided by at least one supplier; if, and only if, the provider secures environmental service provision (conditionality).

The PES are efficient because they allow agents whose ES supply cost is below the level of compensation to contract, and agents whose opportunity cost is higher not to do so, unlike a regulatory measure that is not flexible because it requires the same level of ES provision from all. Thus, the more ES provision costs will be heterogeneous, the more PES will be effective when compared to a regulatory approach. This being said, PES are not always environmentally effective: since they are established on a voluntary basis, it is more difficult to identify land that has the highest value in terms of biodiversity, in contrast to protected areas.

The success of a PES and ultimately the achievement of the biodiversity targets, depend on the project characteristics and the context in which it is established: the link between land uses and the provision of ES must be scientifically proved, the ES must be clearly defined, one should check whether the land use is consistent with the provision of ES, transaction costs should not exceed the potential benefits, payments must be flexible (to adapt to possible changes), continuous and accessible to all potentially interested agents.

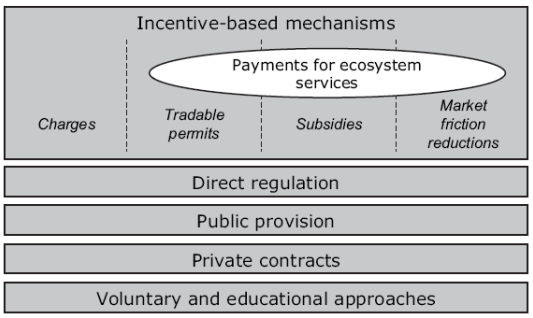
[6] Market-based instruments are more economically efficient than regulatory measures because they use the market forces that allow the least costly activities to be completed first.

The services of biodiversity protection, carbon sequestration, protection of watersheds and scenic beauty are the environmental services considered as having the highest commercial potential. Over 300 markets have been identified in these areas (Landell-Mills and Poras, 2002; Pagiola and Platais, 2002a), most are recent or in their experimental phase. The state has an active role in such markets, as buyer, seller or intermediary[7]. Providers and beneficiaries are private individuals (owners, forest managers, farmers and domestic users) and companies (forestry, hydro-power, tourism, fishing, hunting, companies emitting carbon).

In this paper, we will focus on PES in place to protect biodiversity.

The biodiversity protection consists in protecting valuable ecosystems, natural habitats, species or genetic resources. These services are often difficult to value because of the complexity of biodiversity and scientific uncertainties related to its provision. Furthermore, it is not always easy to identify and therefore to quantify the beneficiaries, which involves high transaction costs (Grieg-Gran and Bann, 2003). Moreover, ES cannot be traded on a market such as directly consumable forest products (e.g. timber products) because of their characteristics of public good. Therefore, they depend heavily on governmental policies and rarely start with spontaneous actions of the private sector, which explains why traditionally the market is dominated by the public sector.

The concept of PES covers a wide range of instruments (Jack *et al.*, 2008) but in this paper, we focus on different forms of subsidies and more widely on conservation contracts.



Source: Jack et al. (2008)

1. Subsidies / Funds

Subsidies are one of the most commonly used instruments[8] (OECD, 2008), especially in agriculture and forestry[9], and more widely for the preservation of habitats and ecosystems (see Table 1). There are grants for maintenance and forest management, forestry, afforestation, reforestation, forest resources..., in Austria, Belgium, Canada, Netherlands, Czech Republic, United Kingdom, Finland, Norway, Sweden and Switzerland. The European Union also funds various programs such as payments for Natura 2000 areas, support for forest certification, LIFE +...

[7] According to the study conducted by Landell-Mills and Porras (2002), the state accounts for 16% of buyers, 23% of sellers and 17% of intermediaries.

[8] This widespread use results in part from their relative political acceptability compared to other instruments and their simplicity of application (Bräuer *et al.*, 2006).

[9] Other application fields: Inland water, Marine and coast, Mountain, Dry and sub-humid land, Species management and others (ecotourism, mining, etc).

Regarding funds for the environment, they are mainly used to protect a particular species and to compensate landowners who are no longer allowed to pursue certain activities on their land. For example:

- The *Monarch butterfly conservation fund* was established in Mexico by the WWF to preserve the Monarch butterfly habitat (Missrie and Nelson, 2005). It consists in paying communities located within the biosphere reserve of the Monarch butterfly to preserve forest by giving up logging permits and conducting conservation actions. Agreements are signed between the communities (who agree to transfer their logging permits and to undertake conservation actions on their lands), WWF (who pays for permits and conservation actions) and government (which is committed to facilitate administrative procedures to make these payments). However, this fund is subject to large institutional complexity, requires long-term financial commitments and the control is expensive.

- In New Zealand, the *Forest Heritage Fund* (created in 1990) supports the voluntary establishment of sustainable forestry practices and compensates the woodland private owners who have no right to cut trees on some plots (Hutching, 1999).

- In Australia, the *Revolving Fund for Nature* (administered by the Victorian Trust for Nature, VTN) funds the purchase of lands with high ecological value. After acquisition, the VTN writes a legally binding agreement that establishes restrictions and protection activities on the lands, and sells them to private owners who are then bound by the Convention (Carter, 1999).

This kind of instruments has the advantage of establishing a direct link between economic incentives and environmental outcome. They also perform well when there are specific goals (specific area…) and when it is necessary to involve the private sector (foresters...) in the provision of public goods. However, procedures for allocating the grants can be quite complex, the costs can be substantial, and incentives are only temporary because when the payment stops, the agents revert again to their former practices.

Overall, the biodiversity conservation opportunities are superior to the funding opportunity. The competition that characterized the supply, namely between projects to be funded, and relatively weak demand, tends to lower the payments allocated to conservation at a level only slightly above the opportunity cost. It should therefore focus more on measures that will strengthen demand in order to stimulate competition and willingness to pay for management and conservation of biodiversity.

2. Conservation contracts / Voluntary agreements

In many industrialized countries, forests are mainly in the private domain (in France, they represent three quarters of forests). Forest preservation and biodiversity protection are problematic in terms of property rights respect (in some cases it can be difficult to compel private owners to undertake actions on their land). Thus, land markets are increasingly used to acquire easements or concessions for conservation[10] and development rights[11] relating to lands

[10] Conservation easements are contractual agreements by which landowners transfer in perpetuity their land use rights on a parcel of land to land trusts, public organization or a Non-governmental organization (NGO) for conservation objectives. These easements may prohibit certain land uses (e.g., new buildings or facilities) or only allow the intended uses, through financial compensation paid to owners.

[11] Development rights have been established by governments to increase the flexibility of land development restrictions in a conservation area. The idea is to make available a certain amount of these tradable rights: owners

that provide natural habitats. This awareness that we may acquire certain use rights rather than global rights has largely contributed to biodiversity conservation. For example:

- In Costa Rica[12], since 1997 the government has established a program[13] under which payments[14] are made to landowners who restrict their activities to certain land uses (new plantations, sustainable forest, conservation of natural lands ...). Funding is provided by the government through FONAFIFO (*Fondo Nacional de Financiamento Forestal*)[15], the World Bank (USD 32.6 million of loan) and Global Environment Facility (USD 8 billion of grant). In return for these payments, landowners give up their right to FONAFIFO on environmental services for 5 years, and manage or protect their forest for 20 years (15 years for reforestation). This program is a success: between 1999 and 2005, the lands under contract have increased, the loss of 72 000 ha of forests in biodiversity priority areas has been prevented (Tattenbach *et al.*, 2006).

- In China[16], the *Natural Forest Conservation Program* is to protect and restore natural forests through logging bans and afforestation incentives. It is largely funded by government (mainly to cover economic losses caused by changes in timber harvesting and management of forest companies) and payments are contingent on actions undertaken. Between 1998 and 2003, areas suffering from soil erosion have declined by 6%, the amount of wood harvested from primary forests has decreased by 41%, which has reduced carbon emissions, and habitat of fauna and flora was improved.

Many governments rely on voluntary programs to acquire land use rights while leaving the land in private ownership. This *voluntary biodiversity-protection* is based on temporary periods of protection and on voluntary participation. Forest owners define the land to protect and the amount of compensation they want to receive. The amount of compensation reflects the forester' objectives, its attitude towards biodiversity (…). If its objectives include environmental concerns (such as biodiversity protection), one can expect that the level of requested compensation is lower than when goals are only productive (Boyd and Simpson, 1999). In addition, a small compensation may create a "win-win" situation for both the owner (who receives income from the forest protection and a utility of forest biodiversity) and society (*via* an increasing protection of biodiversity).

This protection induces a contracting: the owner signs a contract (with the State or a conservation agency) that commits him to protect all or part of its forest in accordance with the wishes he expressed. The contracting facilitates the identification of specific management constraints, for a given period: the concept of contract refers to the idea of mutual consent, which involves that the definition of outcomes is negotiated and individualized. The aim is to make "sustainable" activities as profitable as others, by paying the additional costs and the lost profits incurred by those who choose these activities.

Various arguments advocate for voluntary approaches (Juutinen *et al.*, 2008): because they are voluntary, they are widely accepted by society, which can reduce conflict (expensive)

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who wish to develop their land more than their initial rights allow them can buy additional rights from those who do not wish to develop their land. These rights are mainly used in the United States for the conservation of historic buildings, archaeological sites and wetlands, and are increasingly used to promote forest conservation.

[12] Costa Rica was a pioneer in the use of PES in developing countries.

[13] This program was created under the Forest Act of 1996. See Pagiola (2008), Rojas and Aylward (2003), Chomitz *et al.* (1999), Castro *et al.* (2000), Wunder and Wertz-Kanounnikoff (2009).

[14] The amount of payment varies depending on land use.

[15] 3.5% income tax on sales of fossil fuels is used for the PES, which represents about USD 10 million per year.

[16] Liu *et al.* (2008)

among stakeholders and promote positive attitudes toward environmental protection; they motivate owners to provide biodiversity services (Smith and Shogren, 2002), which reduces transaction costs compared with regulatory approaches. Furthermore, budget constraints encourage the move towards voluntary approaches, particularly to land leases which are less expensive than land purchase.

Some examples of voluntary biodiversity-protection are presented here[17], all of these programs having a biodiversity conservation objective through an increase or maintenance of the overall proportion of forest or specific forest communities:

- In Finland, voluntary protection of non-industrial private forest owners was recently introduced and tested in various pilot areas:

The *Natural Values Trading*[18] is an agreement concludes between a landowner and the State in which the owner agrees to produce biodiversity services on his land. This agreement may define specific areas in which the owner must maintain rare species or essential elements for biodiversity (e.g., dead trees). The owner's proposal is assessed through the proposed conservation objectives. It includes the economic values of ecological characteristics (e.g. dead wood, endangered species, distance to natural areas of protection, area size, landscape values...) and the costs of delayed harvest. This valuation allows comparing different proposals. The State leases the land temporarily to the owner (the agreement has a limited duration of 10 years) and the annual compensation is between 20 €/ha and 300 €/ha.

The *Central Karelia Herb-rich Forests Network*[19] aims to preserve biodiversity values of invaluable herb-rich forests through a network of protected forests that improve connectivity between protected areas. A "Forest Star" model is used to value the ecological quality of the proposal. In this model, experts attribute weights to three criteria (the main type of forest and endangered species, spatial characteristics, and complementary characteristics) according to their priority (Pykälaäinen *et al.*, 2005). Forests are then classified according to their value in terms of biodiversity and the cost of protection (i.e. the compensation requested by the owner) to achieve the best cost-benefit ratio. During the three-year pilot project (2004-2006), 87 owners have shown their interest in this project, 72 owners have met the environmental criteria and finally, 11 permanent contracts and 25 temporary contracts were concluded. The average compensation is 142 €/ha/year.

- In Austria, since 1995, the *Natural Forest Reserves Programme*[20] aims to develop a forest reserves network to maintain biodiversity and the particular characteristics of different ecological communities. It is interested only in protected reserves, forests that depend on specific forestry treatments are excluded from this program. The goal is to include at least one representation of each forest type within each of the 22 biogeographical areas in Austria. Since the beginning of the program, 850 sites have been proposed, 450 sites have been examined in detail, and 180 sites (8272 ha) have been approved and committed to a contract.

[17] See Brahic (2010b)
[18] Mayer and Tikka (2006); Juutinen *et al.* (2008); Kurttila *et al.* (2008).
[19] Kurttila *et al.* (2008).
[20] See Frank and Müller (2003); Mayer and Tikka (2006).

- In Sweden, the *Nature Conservation Agreements* are contracts between a private landowner and the forestry agency in order to maintain or restore forest habitats. Professional foresters propose candidates for protection (propositions are based on the identification of habitats of high ecological quality), and the owners decide to contract or not. The amount of compensation is specific to each case but does not cover the actual costs of lost economic value after the contract. The contracts are established for a maximum period of 50 years. The first agreements were signed in 1994. In 2004, 2 240 sites were involved (i.e., 24 570 ha).

- In Vermont (United States), the *Use Value Appraisal Program* is intended for: slow or prevent the conversion of forest areas in private residential or commercial areas, maintain canopy cover, improve private forest management practices, encourage landowners to harvest crops with high economic value and support the economic sector of forestry. To be part of the program, forests must have a forest management plan approved by the State. Owners who commit pay taxes on the use value (around USD 450/ha) and not on the market value that could reach USD 40,000/ha on lands with high probability of development (for residential or commercial).

Within the *Natura 2000* European network[21], France has opted for a voluntary and contractual sites management, offering users the possibility to get involved in the management through *Natura 2000* management contracts and the Charter of Natura 2000.

- The *Natura 2000* management contracts include a set of commitments to conservation and, when appropriate, restoration of natural habitats and species that justified the Natura 2000 creation. They define the type and modalities of public subsidies and services provided in exchange by the beneficiary. Eligible operations in forest environments are classical operations of marking and cutting wood or clearing made for the purpose of protecting the natural environment and without production issues.

In a town located in the Natura 2000 site of "Lison Valley"[22], the establishment of a Natura 2000 contract allowed to reconcile forestry and natural habitats preservation. Indeed, the additional operating costs related to the "yarder cable" extraction technique[23], which is a more expensive technique than conventional methods (that use tractors and hauling) while respecting the sensitive aquatic environments in place, was fully funded by the State and the European Union through a Natura 2000 contract (total amount is 6 518.70 €).

- The *Natura 2000* Charter involves commitments of sustainable management and returns to sports or leisure practices respectful of natural habitats and species. It does not involve payment of financial compensation but it entitles to exemption from property tax on undeveloped land (*taxe foncière sur les propriétés non bâties*) and provides access to some public funding (especially in forestry where being a Natura 2000 membership is a guarantee of sustainable management of woods and forests). The participant agrees for a period of 5 or 10 years.

[21] The major objective of Natura 2000 is to maintain species and habitats of Community interest in a good state of preservation.

[22] Nans-sous-Sainte-Anne is a small rural district (Department of the Doubs, region of Franche-Comté) whose main income comes from forestry activities and to a lesser extent, tourism benefits associated with its natural and scenic landscape (150,000 visitors per year).

[23] This method allows to extract woods by an aerial mode and thus, not to drag woods on the ground.

- In France, *la loi d'orientation sur la forêt* (2001) affirmed the importance of developing contractual approaches in providing *des Chartes forestières de territoire*[24] (CFT). Established for a fixed duration, the CFT cover a territory identified as relevant vis-à-vis one (or more) problem(s) following the logic: a problem, actors, a territory. Agreements are concluded between forest owners (or their representative organizations) and economic operators, public institutions, associations of forest' users or environmental protection, local authorities or the State. Public aid may be done in return for economic, environmental and social services rendered by the forest when they induce specific constraints or additional costs of investment and management. Regarding biodiversity, the most frequent actions relate to the knowledge of habitats, the preservation of sensitive areas (wetlands, sites of Natura 2000), the promotion of silvicultural practices promoting ordinary biodiversity (such as irregular forest[25] or practices respectful of soil and water resources), the borders' management, the support or the creation of ecological corridors. For example, the charter of the Morvan Forest (2004-2006) has allowed the design and the installation of 10 reference plots and the natural regeneration of Douglas fir.

Finally, the contractual approach has several advantages. It allows: to adapt easily to differentiated territorial approaches depending on the issues and the structure of land ownership; to involve the owners and managers in place, respecting their prerogatives and most of their choices and limiting financial support to the marginal cost induced by the targeted action, without transferring to government (or any set of actors with a project on a territory) all operating expenses; to integrate the multifunctional aspect of the forest (i.e. its ecological, social and economic functions).

In areas of high importance in terms of biodiversity, it is essential to identify the concerned areas and how their management can meet the needs previously specified. The solution of contracting on the basis of clearly stated objectives, identifying performance indicators (and compensation for the forest owner) seems to be favour for an environmentally effective and economically efficient conservation. The contracting will solve complex and territorialised problems that traditional tools of forest policy do not know treat well. However, the objective is not to replace those tools but to supplement them. Indeed, the State is entitled to impose constraints for the public interest but in order to maximize the effectiveness of its intervention these constraints must raise a minimum support among the concerned forest owners. A social contract between government and the owners would allow the latter to feel valued and recognized in their dimension of heritage manager, feelings involved in the acceptability of the mechanism.

3. Procurement auction for conservation contracts

The problem of contractual relationships is that they are subject to informational asymmetries that can limit the efficiency of PES. Indeed, the sellers (i.e. private landowners who provide ES) have private information (including opportunity costs) they can use as market power to obtain informational rent. Due to budgetary constraints, the buyers' objective (public

[24] *Art. L 12. Loi N° 2001-602 du 9 juillet 2001 d'orientation sur la forêt*. Through action programs, the aim of these charters is: to guarantee the satisfaction of specific environmental or social demands on the management of forests and natural areas that are connected; or to encourage the technical and economic grouping of forest owners; or to enhance the competitiveness of the production sector, the promotion of forest products.

[25] Continuous cover forestry with species mixtures and different class-aged.

authorities, conservation agencies) is to limit this informational rent to maximize the ES obtained from a limited budget. The procurement auction use the auction rules to limit the sellers' incentives to inflate their price contract: because of competition for a contract, sellers are less inclined to propose a strategic bid, i.e. a bid higher than their opportunity cost, because it would reduce the probability of selection of their bid.

> *"An auction is a market institution with an explicit set of rules determining resource allocation and prices on the basis of bids from market participants"* (McAfee and McMillan, 1987).
>
> A procurement auction for conservation contracts[26] is defined as *"a process through which a buyer of environmental services invites bids (tenders) from suppliers of environmental services for a specified contract and then buys the contracts with the lowest bids"* (Ferraro, 2008).

The use of an auction mechanism requires a rigorous study of the economic environment in which it is applied. Every economic environment is unique in that it depends on the market structure, the nature of the good or service and the uncertainty about its value. In addition, the choice of an auction format rather than another must be closely linked to the objectives set by its designer. Moreover, conservation contracts have special characteristics (they concern goods and services derived from biodiversity, i.e. a public good) and they do not meet all the standard assumptions of the auction theory. So, to make recommendations and to analyse the performance of different characteristics for the auction, one must turn to existing experiences, experiments and modelling rather than theory (Ferraro, 2008).

In what follows, we present some experiences of auction for conservation contracts[27]. Most of these experiences being recent, results are not yet established.

- The *Conservation Reserve Program* (CRP) – US

The CRP is the greater public-private partnership for conservation and habitat protection in the United States (FSA-USDA, 1999; USDA, 2009). It is a voluntary land retirement program that offers monetary incentives to farmers and landowners to withdraw highly erodible land and sensitive crop-lands to the production channels. Bids (made by landowners) are assigned an *Environmental Benefits Index* (EBI) that allows them to be evaluated in terms of environmental indicators[28] and their cost (i.e. the price required by the owner). This program allowed various environmental benefits such as reduction of nitrogen, soil erosion and phosphorous, and sequestration of carbon dioxide (Ferris and Siikamäki, 2009). Otherwise, habitat improvement has allowed the number of Colchis pheasant (*Phasianus colchicus*) to increase in nine states (Nielson *et al.*, 2006). Currently, the CRP is the federal program that contributes the most to the carbon sequestration benefits (FSA, 2007).

- The *BushTender* and *EcoTender* programs – Australia

The *BushTender*[29] program is a pilot program (launched in 2001) which seeks the participation of private landowners to control salinity, nutrients and biodiversity conservation. Tenders are assessed *via* a *Biodiversity Benefits Index* (BBI) that incorporates three factors:

[26] We call "conservation contract" *a contract that, for certain activities or management, preserve or enhance biodiversity or ecological services.*
[27] See Latacz-Lohmann and Schilizzi (2005), Brahic (2010b).
[28] These indicators include objectives in terms of wildlife, water quality, erosion, air quality…
[29] Stoneham *et al.* (2003); DSE (2008).

the importance of the site in terms of biodiversity (*via* a *Biodiversity Significance Score*), the habitat improvement associated with the owner's actions (*via* a *Habitat Services Score*) and the supply cost (i.e. the amount requested by the owner to protect and improve the vegetation on his land). Bids are ranked from the highest BBI to the lowest one, and contracts are allocated until the funds run out. This program allowed many actions to be undertaken such as retention of large trees or fallen timber, control of rabbits and weeds, supplementary planting and revegetation (Stoneham *et al.*, 2003; Latacz-Lohmann and Schilizzi, 2005).

Encouraged by the success of the *BushTender* program, the Australian government has funded other pilot projects (*RiverTender*, *HabitatTender* and *EcoTender*). Launched in 2005, *EcoTender*[30] project covers multiple environmental objectives[31]: it encourages private landowners to manage their land and water resources in order to improve control salinity, biodiversity and water quality of watersheds, and to sequester carbon. This project includes a complex measure of environmental performance (due to multiple environmental objectives, the metric uses the *Catchment Modelling Framework*[32]). The bids selection for multiple environmental outcomes is the first of its kind; it is therefore a learning exercise.

- The *Auction for Landscape Recovery* (ALR) – Australia

The ALR program concerns highly biodiverse landscapes in area threatened by salinity and clearing effects for agriculture. The objective is to achieve environmental outcomes for native biodiversity, water and soil management. Bids are evaluated with two methods: *via* the EBI (used in *BushTender* and CRP programs) and *via* the *Systematic Conservation Planning* approach (SCP)[33] which uses a complementarity biodiversity metric (Faith and Walker, 1996)[34]. The difference between these two methods is that the bid evaluation through EBI is independent of the other bids, while the evaluation *via* SCP depends on all other selected bids[35]. The management actions implemented include: fence of remnant and vegetation, wild animal control (rabbit, fox), corridors construction, weeds control, revegetation and implementation of commitments to nature conservation and voluntary management agreements (see Gole *et al.*, 2005).

- The *Catchment Care* program – Australia

This auction has been set up in 2004 to encourage management actions for restoring natural resources of the riparian areas and protecting the watershed of Onkaparinga (South Australia). The sites (proposed by the owners) are assigned an environmental value derived from geomorphological and hydrological characteristics and remnant vegetation. This program is based on a risk analysis: the proposed actions are evaluated in terms of risk reduction they can afford. So, the environmental benefit is considered in terms of risk of the site, the total threat reduction achieved by the owners' actions, and the area affected by these actions[36]. To ensure

[30] Eigenraam *et al.* (2006).
[31] EcoTender is also named *Multiple-Outcome Auction of Land-Use Change*.
[32] See Eigenraam *et al*. (2006).
[33] See Margules and Pressey (2000); Sarkar *et al.* (2002).
[34] This approach takes into account synergistic aspects due to the number, the size and the distance from several areas. See Vane-Wright *et al*. (1991); Pressey *et al*. (1993); Sarkar (2004).
[35] Results are comparable from one method to another (cumulated value of selected bids, cost). However, as part of a wider application, it is expected that the SCP approach outperforms the EBI approach due to the integration of the complementarity concept, which can take into account priorities changes when areas contributing to the conservation management are added. So, most comprehensive analysis of these data would be needed.
[36] Details in Bryan *et al.* (2005a, 2005b).

an efficient allocation, bids with the most important environmental benefits per dollar are selected and funded. This program has funded various activities, including weeds eradication, reforestation, control of exotic trees and erosion.

- The *Northeim-project* – Germany

The objective of this project is to reward, through a bidding process, the owners for the provision of environmental services such as withdrawal of intensive cultivation and substitution with meadows of high ecological quality and floristic biodiversity. The program particularity is that the payment is contingent on results (and not on the actions, like the others programs) which are measured through the grassland quality obtained. This quality is classified into three classes[37] defined by the number of different species per control plot. The results are assessed *via* controls at the end of the contract period. In 2006, 89 sites of class I (130.05 ha), 52 sites of class II (76.80 ha) and 23 sites of class III[38] (31.61 ha) were involved in this program (Groth, 2008, 2009).

The success of these experiences shows that, in practice, auctions are an interesting allocation mechanism for biodiversity conservation contracts.

Discussion and conclusion

This analysis of the international literature has shown that different instruments lead through regulation enforcement or through voluntarism to sustainably use or preserve biodiversity and associated services. It also allowed us to see in what context the various instruments are currently applied (the results are summarized in the Table 2 that identifies for each good or service derived from biodiversity a set of tools used to preserve them).

The choice of a particular measure will depend on the element of biodiversity one need to preserve (genes, species, ecosystems, or environmental services provided by biodiversity) or the sectors of activities that exercise pressure on biological resources. The feasibility of the measures depends on the ecosystem, the economic sector or the social group which is targeted. However, it is often necessary to use a set of coupled measures (market-based instruments and regulations).

Regulatory measures are generally used to protect endangered species or natural areas rich in species, by prohibiting their use or by setting restrictions on access. They have the advantage of being the most direct way to achieve a short-term environmental objective, but they are expensive and sometimes economically inefficient. So, market-based instruments offer new perspectives to achieve the biodiversity objectives at a lower cost. Particularly, the contractual approach presents some advantages and seems to be favour for biodiversity preservation. Moreover, procurement auctions for conservation contracts are more economically efficient than direct agreements between the conservation agency and a landowner potentially provider of an environmental service: through competition between owners, auction allows limiting informational rents and thereby increases the efficiency of the PES scheme. So, in the context of budgetary constraints, research should focus on procurement auctions. But *what auction*

[37] Class I: species number ≥ 8 per control plot; Class II: species number ≥ 8 per control plot plus 2 target species; Class III: species number ≥ 8 per control plot plus 4 target species.
[38] Class III is the best one.

design should be used? Given the specific characteristics of goods and services concerned (public goods), the theory is not sufficient and it is necessary to rely on existing experiences. So, the analysis of different auction experiences allowed us to establish a general structure of auction that could encourage the French private forest owners to preserve biodiversity and the ES associated (Table 3).

Table 2: Mechanisms used to preserve biodiversity

	Goods and services derived from biodiversity[39]	**Mechanisms used to preserve biodiversity**
Genetic resources	Patented processes from genetic resources, Access to genetic material	Bio-prospecting rights Research permits
Species and ecosystem	Existence of species and ecosystem	Regulation (protected areas) Subsidies (habitat / ecosystem) Tax benefits (habitat / fauna / flora) Payment for Environmental Services: conservation easement, concession, development rights, land acquisition, management contract, biodiversity offsets
Services provided by forests	Flood control, Erosion control	Protection of ecosystem (*via* regulation, subsidies, tax benefits, payment for environmental services)
	Water quality	Taxes Watershed management contracts Protected areas Water rights Credits (water quality, salinity) Management contract
	Carbon sequestration	Carbon offsets / credits Certified Emission Reductions Emission Reduction Units
	Hunting and fishing licensing International fisheries	Individual Transferable Quotas
	Eco-tourism	Entrance rights Access permits Package tourism services Ecotourism concessions Land lease / land acquisition Natural resource management agreements
Market products	Sustainable local agriculture Organic agriculture Sustainable extraction	Eco-labelling

[39] This list of goods and services comes from OECD (2003).

Table 3: Auction for conservation contracts in French private forests - Recommendations

	Recommendations
Auction features	Sealed-bid Discriminative pricing To capture synergies : joined bids, agglomeration bonus
Budgetary constraint	Yes (generally, it is the case)
Reserve price	Not necessary if budgetary constraint
Payments	Conditional on activities and/or outcomes, depending on the objectives and the possibilities to measure results: - On activities that promote expected environmental results - On outcomes if they are observable - Progressive payments Sites control (realised by experts) and annual reports (made by landowners on actions taken and results achieved) allow sanctions in case of non-compliance (e.g. by stopping payments).
Bid selection method	Bids valuation is based on their quality and their price, the selected bids are the most cost-effective - Valuation of activities through the calculation of an index ➢ *EBI approach*: index that includes the environmental value of the site, the benefits of proposed actions (in terms of environmental objectives), the weighting system related to the conservation agency priorities and the price of the bid. ➢ *Complementarity approach*: use software that calculates and identifies the optimal network of conservation areas. - Valuation of outcomes through the determination of quality classes of results (species number, reforested areas…)
Others - **Revealed information** - **Contract duration**	The environmental objectives, but not their respective weights in the conservation agency priorities. Defined on a case by case, depending on the objectives and the time required to achieve them (5, 10, 30 years...).

Some details about the auctions' characteristics

➢ It is preferable to use a sealed-bids auction to preserve competition and so, to limit the possibility of collusion between the owners, which favours strategic behaviours[40] and informational rents.[41]

➢ The use of discriminatory price and not uniform price is advocated by works that have studied the impact of these two formats:

- Stoneham *et al.* (2003) assessed the efficiency gain of the *BushTender* program compared to a uniform price. Their results showed that: i) a uniform price would need to spend seven times more to achieve the same environmental benefits as those currently obtained with *BushTender*; ii) for the same amount of funding, a uniform price system would generate 25% less benefits in terms of biodiversity.
- Regarding *Auction for Landscape Recovery*, the efficiency gain varies between 207% and 315% for the first session and between 165% and 186% for the second one depending on whether the uniform price payments are based on inputs and outputs respectively (White and Burton, 2005).
- The *Catchment Care* program has been compared to an existing uniform price system, the *Watercourse Management Assistance Program* (WMAP). The results show that the auction is between 24% and 33% more efficient than the WMAP (Bryan *et al.*, 2005).
- Finally, Groth (2008) evaluates the efficiency gains of the *Northeim-project* from a uniform price between 21% and 36%.

However, in an auction that allows owners to revise their bid, Cummings *et al.* (2004) found that initially, prices are lower in average in the discriminatory price auction, but the difference disappears gradually as the suppliers revise their proposal (due to a learning process). So, results are sensitive to the tender' rules, the characteristics of contracts and bidders.

➢ The presence of synergies in the adjacent conservation areas is a possibility that should be addressed because it can increase the effectiveness of conservation efforts. For capture them, it is necessary to allow joined bids and to provide agglomeration bonus (Parkhurst *et al.*, 2002), i.e. consortia of owners and higher payments when multiple owners are coordinated. Current policies do not take into account the synergies; they focus on contracts between the public agency and the owners individually. So, in the future, it will be useful to consider whether such synergies are possible and if so, to evaluate the bids through the complementarity principle.

➢ Except some specific cases, the relationship between a set of biodiversity conservation activities and the results obtained at a given time is subject to various uncontrolled factors such as climate changes, droughts, floods, epidemics, invasive species, or the impacts of activities in upstream areas. Furthermore, it is not always easy (as it is often the case) to measure environmental outcomes[42]. For these reasons, payments are generally contingent on activities undertaken by the owners and not contingent on the environmental results. Nevertheless, the conservation agency retains some control over the outcome through the

[40] The suppliers may agree to bid higher.

[41] The open-bid auctions, repeated, with uniform price, are generally more likely to generate collusion than sealed-bid auctions (Klemperer, 2002).

[42] For example, if the environmental objective is to increase the population of an endangered species, one cannot necessarily estimate accurately the individual's number of this species.

specification of specific management activities that are supposed to provide in a large extent the environmental outcomes. Thus, some programs rely on progressive payments[43]; and sites controls (realised by experts) and annual reports (made by the owners) are required to verify that the terms of the contract are being met and to sanction owner in case of non-compliance with these terms by stopping payments.

➢ The owners differ in their opportunity cost but also in the quality of the ES they offer. So, bids should be ranked and selected on the basis of their price and their quality (we talk about "Score auction"). Theoretically, these auctions are more efficient than those that ignore the heterogeneity in terms of quality (Che, 1993; Latacz-Lohmann and Van der Hamsvoort, 1997). Two possibilities exist:

- To assign an environmental benefits value for each proposed contract, but given the difficulties to give a monetary value on the ES, one prefer to use a scoring rule, with the construction of an index such as the Environmental Benefits Index (EBI) used in most of the programs listed above.
- To use the complementarity biodiversity metric (*SCP* approach) where a bid valuation depends on all the other selected bids. This method should outperform the EBI method.

➢ The conservation agency must decide what information it will reveal to the owners, including that relating to the valuation rules. This choice is not straightforward and depends on the objectives: firstly, the announcement of these rules may encourage owners to reveal information relating to the quality of proposed activities that would be difficult or expensive to obtain for the conservation agency; but on the other hand, quality differentiation can be another source of rent for the owners (e.g., if a landowner knows that he is alone to host an endangered species, he is encouraged to propose a bid higher than his opportunity cost), which increases conservation spending and reduces the auction effectiveness (Cason *et al.*, 2003). A reasonable compromise is to reveal only a part of the information: revealing the quality criteria (relevant to the conservation agency) can attract the 'good' owners and guide them in formulating their bids, which correspond to the agency' preferences; and do not revealing their relative weights (accorded by the conservation agency) will prevent owners to make strategic bids (i.e. bids above their opportunity cost). This partial revelation of information compels owners to offer a price very close to the opportunity cost of the proposed measures. By creating this informational asymmetry (in favour of the conservation agency) and requiring owners to submit their bids individually, the government can maintain the total cost to a level lower than that would get with other systems.

➢ Finally, wherever possible, a multiple-outcome approach[44] is advocated because it reduces transaction costs: establishing a single large program that includes several environmental objectives rather than several programs which target one objective saves time and money (it is more profitable to visit each site once for multiple goods rather than to visit them each time for one good).

[43] Generally 3 payments: one at the beginning of the contract, one at the mid-term and one at the end of the contract.
[44] Via the *Catchment Modelling Framework*.

Which perspectives for the French private forests?

Since conservation contracts and auction participation are based on voluntarism, social acceptability is of great importance. Horne (2006, 2009) examines factors affecting the acceptance of biodiversity conservation contracts to forest owners in Finland and the amount of compensation required[45]. This study uses the *Choice Experiment* method (Adamowicz *et al.*, 1998; Louviere *et al.*, 2000) to analyse data collected from 3000 landowners[46]. It is the first application of this method to evaluate the terms of a contract for environmental policy. This study improves contracts structure in order to maximize participation.

So, our objective is to apply this method to the French private forestry sector. This socio-economic study should allow:

- To identify characteristics of conservation contracts and of auction system that are potentially acceptable by the owners;
- To identify the owners' characteristics supporting the acceptability of conservation contracts and auctions, to target potential participants (a broad participation being a guarantee of an efficient environmental outcome);
- To identify environmental issues (preservation of habitat, fauna, flora, provision of environmental services ...) which are best suited to a contractual approach according to the surveyed landowners (in prospect to a broad participation).

This socioeconomic study is an essential step before the development and implementation of a pilot program based on an auction for conservation contracts. Lessons learned from this first program will allow correcting and improving the system in view of future applications.

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[45] The average annual demand for compensation is around 224 €.
[46] Data were collected by a postal survey (summer 2003).

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