18 Management of the Forest Biodiversity: Feasibility, Efficiency and Limits of a Contractual Regulation

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Forest resources possess a unique multifunctional character. Forests offer a great variety of goods and services on a less artificial level than many other land-uses: for instance, wood, other products (e.g. berries, mushrooms and foliage), soil protection against erosion, regulation of hydraulic regimes and water quality, fixation of carbon dioxide, and making the area favourable for recreational activities. They represent potentially one of the most important terrestrial reservoirs for biological diversity. Even in regions where forests have been transformed by human activity for many decades, they still retain high levels of genetic variation (differentiation within species), in the plant and animal species which make up their ecosystems (systematic organizations of life-forms) and their ecocomplexes (interactions between ecosystems).

However, most of the functions assumed by the forest, apart from wood production and some leisure activities (e.g. hunting) are not commercial transactions. Because of a lack of direction from society and lack of payment for their production, the managers of forest resources do not take these into account in their management practices. As the standardization of numerous production activities and the artificialization of natural areas have caused declines in biodiversity, society is becoming more and more interested in creating facilities for the conservation of biodiversity. This chapter aims to examine – in the case of French forest resources – how such facilities can be implemented.

In the first section we briefly describe the economic, social and political context in which the conservation of the forest biodiversity is to take place. We focus on the objectives and the terms of a new form of regulation of forest resources management which has the goal of maintaining or improving biological diversity: namely, the use of contracts within a European network ('Natura 2000'). We then present the terms and conditions of contracts aiming at defining forest management practices favourable to biodiversity. Next, we analyse their implications for the development both of the methodologies of management and of the extra costs that forest owners and managers may have to bear.

In the second section we analyse in a theoretical way the conditions of the contract implementation. We base our study on the principle of joint production. When examining different initial situations we deduce the main types of contracts that it could be necessary to implement. We then concentrate on the possible application of a

* I deeply regret the sudden death of my colleague and co-author, Dominique Normandin, who contributed significantly to this research.

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Principal–Agent model with adverse selection and moral hazard.[1] We have to note that in France this type of tool has not been implemented yet. Furthermore, as the contract procedure within the 'Natura 2000' network is not yet operational, this chapter can only be a preliminary analysis.

The Need for Contractual Agreements on Biodiversity Protection and Enhancement

Economic, social and political context

Aware of the importance of conserving biological diversity, the European Union has adopted directives with the objectives of protecting faunal and floral diversity.[2] The implementation of these Directives results in the inventory and the designation of several zones offering interesting characteristics concerning the species to be found there and the ecosystems concerned. The creation of a network of sites ('Natura 2000'), within which management practices favourable for biodiversity will be conducted, has to be completed by 2004. This does not exclude human intervention; rather it means a reconciliation between ecological demands and economic and social requirements.

In France, if we consider the 2.6 million ha involved in Natura 2000 (apart from marine zones), about 40% of this is in forested areas whereas forests cover 26% of the country. Among the forested areas concerned, about one-quarter are in state forests, one-quarter in other public forests and one-half in private forests (respectively comprising 10, 15 and 75% of the French forested areas).

In order to regulate the management activities of private forest owners and to assure an increased protection of forest biodiversity, it is essential to know what the objectives of forest owners are. These objectives determine the efficiency of the regulation tools of the implemented forest management. However, there is a great diversity of agents as far as their legal status, available means and constraints are concerned, and obviously their plans for the forest property will vary widely. Globally, one can consider that the objectives underlying forest management belong to five main types of motives: (i) more or less regular or valuable income; (ii) the building up of capital in the form of growing stock; (iii) the opportunity of deriving products or services for personal use from the forest (firewood, hunting); (iv) the concern about leaving one's children a capital asset with interesting tax features (reduced succession rights); and (v) the wish to preserve the environmental functions of the forest. Without generalizing, the protection of the environment seems to be more the concern of public agents who by definition are interested in public welfare. The production of revenue can only be considered in the case of properties of a substantial size, whereas the saving function and personal consumption seem to be most important in small properties. We will concentrate mainly on private forest owners, the extent that these new measures are planned for them and that their aim is not necessarily to maintain the biological diversity; we assume that, despite their possible diversity of situations and objectives, all these agents mainly aim at obtaining the best possible wood production.

One of the main points of interest of the analysis concerning the implementation of the Natura 2000 network in the French forests lies in the fact that the authorities have chosen to use contracts as incentives (National Rural Development Scheme). Until now, only regulatory tools have been used in forest resources management to preserve the biological diversity: the classification in Natural Reserve (law of 1976); state order for Biotope (1960); the classification of protected forest (Forest Code); and the creation of biological reserves (mainly in state forests).[3] In all those cases, the management regulation is a public decision with no countermeasure available to the forest manager.

The recourse to an economic tool, the contractual regulation, as it is considered within the Natura 2000 network, constitutes a real novelty in the context of French forest policy. Furthermore, here we have a resource offering quite a few interesting details (very long-term production, complexity of the managed ecosystems) and economic agents whose objectives are different and for whom the forest activity is rarely their main activity. The role of the forest in their incomes, their activities and their patrimonies is even often residual. Finally, it is useful to indicate that this decision to use contracts for the protection of biodiversity is within the general context of a changing forest policy.

Issues and problems within the Natura 2000 network

The first step of the Natura 2000 network implementation consists in compiling inventories intended to identify ecologically interesting areas. Then, for each chosen site, the protection of natural habitats will be achieved according to some 'objectives documents', giving recommendations in forest management. These 'objectives documents' are not yet available for most of the 1000 sites which at present constitute the state of the French propositions for the Natura 2000 network. However, based on various examples and because of the general philosophy of biodiversity conservation guiding management recommendations, one can consider the main types of measures which will constitute the conditions of the contract to be honoured. These can be classified in three major categories.

The most important recommendations are based on *forest planning* itself (i.e. the basic objectives of forest production): choice of species and silvicultural regimes (even-aged stands, uneven-aged stands, mixed stands). Globally, it is obviously advisable to use only the species that are found naturally on the site and to exclude the use of artificially introduced species (especially conifers). Accordingly, the recourse to natural regeneration is usually advised. It is also often recommended to work on small areas for even-aged stands or to choose uneven-aged stands. Finally, the management of stands with mixed species is often desirable. A second major category of management recommendations comes from the *harvesting and road access system*. The general orientation often consists in limiting the access to the plots to skidders and to recommend the use of less mechanized methods. It is also often advised to avoid certain routes during harvesting operations, which can lead to longer distances for transport. Finally, a last category of recommendations deals with *silvicultural techniques* to limit methods causing disturbance to the environment (like ploughing and fertilization).

The implementation of the Natura 2000 specification rules will result – according to the initial situation of the plots – in distinguishing, both on an ecological and economic level, three main types of objectives:

Restoration objective

This prevails when the state of the stands is very far from the objective set by Natura 2000, i.e. when it deals with naturally regenerated species. In practice it will deal with plots composed of pure and monospecific coniferous stands on sites where the natural state corresponds to various mixed broad-leaved species. In that case, the terms of the contract imply that the forest owner must radically change his silvicultural system of production as far as the objectives are concerned (quantity, value and age of the produced wood). The object of this first type of contract would be to make the Agent change his objectives and management practices.

Conservation with operations objective

This is when the initial state of the stands conforms quite well to the objectives set by Natura 2000 (broad-leaved stands more or less mixed, for instance). However, there are a certain number of practices which do not fit in with the contract applied to the site. The aim is then to modify some special operations to reach an equivalent technical result with the same production objective. We see here a second type of contract with the objective of making the Agent conserve his objectives of production and soften some of his management practices.

Pure conservation objective

This happens when all the production objectives – as far as we can judge them from observation of the stands – on the one hand, and the usual management practices on the other, appear to comply with Natura 2000 conditions of contract. In this case the object of the contract is to have the forest owner maintain the present management and to avoid the use of practices which do not comply with the objectives of biodiversity preservation.

The analysis of both feasibility and efficiency of these three types of contracts requires the knowledge of possible options offered to the forest producer as well as the information that the Authorities can have to orient these practices. This analysis enables to identify two main categories of consequences on the cost savings of wood production and, as such, on extra expenses borne by the forest owner in adopting those management recommendations.

A first category of new expenses consists in an increase in the cost linked to a given technical operation. We will call this type of costs, *direct costs*. They are incurred each time the technical operation mentioned takes place. This includes measures called 'ecological engineering' for which the forest owner is asked to initiate operations (e.g. river bank maintenance) that his usual method of forest production does not lead him to perform. The compensation will be given according to the total expenses corresponding to the operations to be performed. Direct costs also come into account when particular constraints lie on the realization of the operations (silviculture or harvesting) being in the normal technical process of production. Thus the requirement for manual techniques compared with mechanized or chemical operations, or also an increase in the harvesting distances, will generally result in higher cost for the operations performed. In that case, the compensation will be based on the discrepancy between the cost of the cheapest method and the cost of the method authorized by the condition of the contract for the same technical result. This type of cost could appear especially in contracts of the 'conservation with operations' type, where some management techniques are modified slightly so as not to affect the final objective of production.

The second main category of costs is related to the fundamental changes that may be made in systems of production. Here it is the producer's income which is affected. This category recovers the 'opportunity costs'. We assess the forest producer's loss ('loss of earnings') on the basis of simplified systems of production characterized by: an initial investment (D_0) representing the cost of the land and the regeneration (natural or artificial) and maintenance of young stands; the rotation age (n); and a final income in year n (R_n). Comparing the results obtained (in terms of net present value or yearly land rent) for the most efficient system of production with respect to natural conditions and using the system of production specified in the condition of contract, we can estimate the loss undergone by the forest owner. This type of cost is mainly in 'restoration' contracts where the Agent is asked to transform his production process. It can also be the case when the purpose of the contract is to prevent the owner from producing more wood, and thus would be less in line with the objectives of Natura 2000 (the conservation cases). However, the methodology of making contracts is different in the conservation case, where the incentive is 'not to do'.

A Theoretical Implementation of Contracts

For the reasons given above, the implementation of contracts for Natura 2000 is only considered in a theoretical way. Indeed, an exchange of products and services is planned between some forest owners and the State. To characterize – in a theoretical way – potential types of contracts, one relies on the limits of production possible in forestry. We then come back to the idea of multifunctional forests conceptualized by the notion of joint production and delimited by the constraints on the forest owner. We then analyse in a graphical way the possibilities of making contracts for each type of forest owner. This analysis put the actors in the context of informational asymmetry which differs according to the forest owner's initial situation.

Identification of contract incentives on a boundary of production

For each of the three scenarios (restoration, pure or conditional conservation) we characterize the type of the potential forest owner on a production boundary. We presume that the forest offers two types of products: wood and biodiversity (Bowes and Krutilla, 1982). The forest owner can produce one and/or the other of these two products according to his objectives and his technical constraints. Hence, the forest owner is a multi-product producer. This juncture within production can be summed up in a joint production boundary of the possibilities.

We will place ourselves in a context where a decreasing wood production is accompanied by an increasing production of biodiversity. This is the link described for the forest where wood products and non-wood products are more substitutable than complementary, as in agriculture (Gatto and Merlo, 1999; Bonnieux and Rainelli, 2000). The multifunctionality and the analysis of links between market production and non-market production centres on external factors such as landscape, recreational services, erosion, animal welfare,

biodiversity, and so on (OCDE, 1992, 2000; Bennett, 1995; Bonnieux and Dupraz, 2001). The analysis shows that these goods coming from a production process can convey costs or profits according to the link between outputs.

The curve in Fig. 18.1 describes the frontier of the joint production which includes two products, wood and biodiversity. There is vagueness in the relationship described in Fig. 18.1, particularly to the left of R and beyond C_a because relationships between wood and biodiversity could be complementary in a positive or negative way, weakly or strongly. We will not take into account these possibilities but we will remember a relation of substitution which is more frequent in reality and which shows a real ability to modify the production of wood and biodiversity (from R to C_a). On this figure, the Natura 2000 objective is localized at D* which is an extreme point where biodiversity is maximal according to the production possibility of the forest owner (see below for the possible trajectories and their significance).

The use of contracts is both a means of internalizing biodiversity and of recognizing the notion of joint production in a forest. It is a policy which regulates both biodiversity and environmental services in a more general way (Russel, 1993; Romstad, 1999). The efficiency policy is conditioned by the type of functional relation that can exist between the market goods and the non-market goods. A price support on the market goods can be efficient if the relation between the two goods is known to be of a complementary type, for example. To be efficient, a direct help to non-market goods involves the knowledge and the power of observing these non-market goods. The policy of implementation within Natura 2000 consists in financing the production for the public good, i.e. biodiversity. The financing is considered throughout the creation of contract policies by means of incentives. This financing will be applied to producers already involved in the production for public good and encouraged to maintain it as well as those less involved in that activity but advised to do so.

The first objective of the majority of the contracts in Natura 2000 will consist in maintaining biodiversity as it has been defined. However, to be viable, this environmental objective must be accompanied by the economic constraints of the main actors. Monetary incentives must fit budgetary criteria on the one hand, but must convince the owners to find the optimal effort level in favour of biodiversity on the other hand. Globally, two types of contracts are to be considered, the conservation or the restoration of the biodiversity on a given plot. In the case of conservation, biodiversity is analysed like a positive external factor that forest owners must continue to preserve, avoiding the implementation of irreversible actions. The restoration of

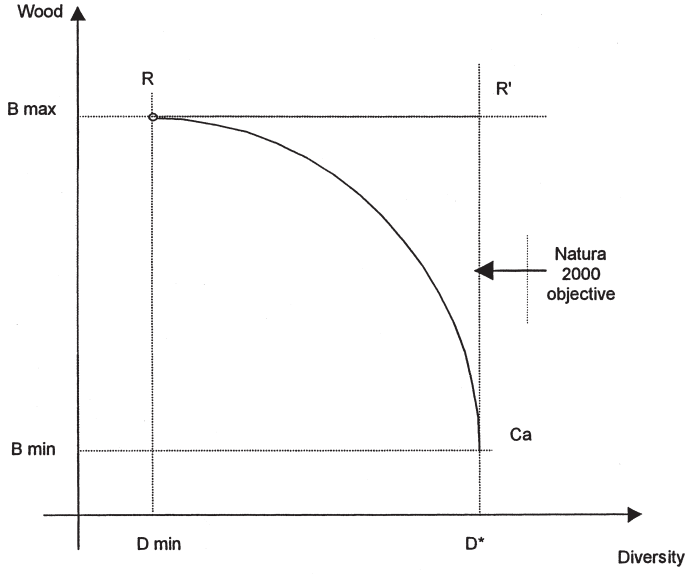

Fig. 18.1. Hypothesis of joint production of wood and biodiversity.

biodiversity is more complex and arises beyond the problem of a reference point. The point is no longer to refer to a group of visible indicators; however, it is possible that the restoration of biodiversity implies the installation of a species poorly or not represented on the plot.

This schematic division of the possible contracts (conservation and restoration) is based on a conflict between wood production and the conservation of biodiversity. Indeed, an owner who would be asked to reduce his wood production so as to favour a faunistic or floristic species would be classified in a production system where market and non-market services of the forest are substitutes. However this situation only represents one case among many and describes the situation where opportunity costs are potentially important. Concretely, it would be convenient to refer to the types of costs imposed on each forest owner within the implementation of a contract and/or his total production possibilities from the different possible links that exist between wood production and biodiversity production. According to the link between the two types of production, the costs borne by the owner will be neither be of the same type (direct costs or opportunity costs) nor on the same scale.

The contract will vary according to the initial situation of the forest owner within the boundary production. The forest owner can find himself in one of three situations (Table 18.1, Fig. 18.2). When positioning the three forest owners on the same boundary of production we make the implicit assumption that the plot allows adjustments without technical or geographical obstacles.

Conservation can be considered in two ways (*a* and *b* in Table 18.1). In the simplest case, the floristic and faunistic richness must be conserved as they are without any extra effort (*a*). However, the conservation of biodiversity can require a particular effort of maintenance and, as such, extra costs as direct costs (*b*). However, in these two cases of conservation, the forest owners also bear opportunity costs bound to their obligation not to divert

Table 18.1. Types of contracts and costs borne by the forest owner.

	Types of contracts		
Types of costs	Conservation *a*	Conservation *b*	Restoration
Direct costs	Loss of option operations	Effective extra costs	Effective extra costs
Opportunity costs	Loss of option on land rent	Loss of option on land rent	Loss of land rent

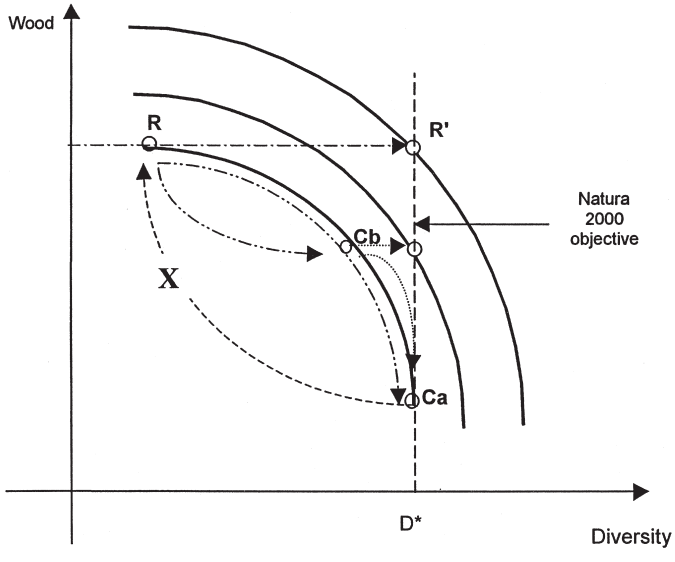

Fig. 18.2. Identification of the three typical forest owners on a boundary of production (R = biodiversity restorator; C_a = conserver of biodiversity; C_b = conserver with operations), Natura 2000 objective = D*.

from this production level even if there are more profitable options available. The presence of opportunity costs is important for the determination of both the effort made by the owner and the amount of compensation given. The presence of opportunity costs certainly contribute to increasing that of moral hazard. In that case, the owner undergoes a loss of options linked to his own commitment of refusal to produce wood. The direct costs incurred in the pure conservation case are recovering extra expenses due to a loss of less expensive options on operations.

The restoration of biodiversity means a hope for an increase or the reintroduction of one or several species thanks to the implementation of a programme of actions elaborated in agreement with the forest owner. The actions considered imply a more or less drastic reorganization of the production system. For instance, the replacing of one species by another implies changes in the production system which are more important than the reinforcement of a species already existing there. To these more or less important opportunity costs according to the imposed change of production system, direct costs are added which will be effective if the contract is accepted.

We suppose that all producers have – before making a contract – different levels of wood production.[4] The introduction of biodiversity will have two possible effects: either the owner stays at his level of initial production or the owner accepts a change in his way of working, recognizing the production of a new output.

First case: *the forest owner is an intensive wood producer* (position R on Fig. 18.2). The forest owner has an objective of maximizing profit based on the only possible valuation of forest, i.e. wood production. In that case he is described as an intensive wood producer since on the same site the presence of other types of owners (C_b and C_a) reveals a less intensive production. However, we can note that, at that maximum level of production, the level of biodiversity is not null but remains insufficient to satisfy Natura 2000.

Thanks to the contracts, the owner will have the choice between at least two solutions to reach D* (Natura 2000 objective): either he decides to reduce his level of production along the possibilities of the boundary till he reaches D*, or he decides to reach D* while maintaining his initial wood production and using higher cost levels on a higher boundary of production. He can also choose an intermediate level of production using a lower production of boundary with the same environmental constraint, so producing in the interval C_a – R. In this case, the owner bears direct costs and a loss of land rent.

Second case: *the forest owner is a biodiversity conserver* (C_a). This situation, which will by definition be that of the majority because Natura 2000 sites have been designed according to their correspondence to natural habitats, reflects the case of an owner who does not produce as much wood as the previous one.

The implementation of contracts must encourage the owner to maintain his initial level of biodiversity. If it is possible to produce wood, he has to forfeit the support of his lost options. Knowing that we deal with a homogeneous area for the three possible cases of owners, the use of contract may be difficult in a context of information asymmetry made complex by a previous behaviour 'out of economic norms'. The incentive must be such that the owner must not be willing to use his initial resources to aid wood production (R). However, he can consider producing more if he wishes to do so, moving along the environmental boundary described by Natura 2000 (vertical) but bearing increasing production costs.

Third case: *the forest owner is a wood and biodiversity producer* (C_b). The owner tends to gain both wood production and biodiversity preservation by adopting a more extensive production mode. The level of biodiversity is nearly that hoped for by the Principal. His profit level is less important than in position R.

The objective of the contract is to encourage him to go on with biodiversity production. The efforts required are less important than those of owner R, nevertheless owner C_b has the same constraints as owner R: incentives must be such that they reach D* either in decreasing his level of wood production or in maintaining it. These incentives must prevent him from reaching position R. He then undergoes direct costs and an option loss.

The implementation of contracts will aim at encouraging all the owners, either to reach the defined level of biodiversity (R and C_b), or to maintain it (C_a). Consequently, contracts are not in the same context of information according to the initial position of the owner, the solutions possible to reach biodiversity level D*, the costs borne by the owner and his objectives – displayed or not.

Theoretical feasibility of contracts: a simple static model

Each of the three listed situations offer possible contracts if we consider the incentive theory. We consider that the Principal (State services) acts in a context of asymmetry of information concerning – according to the situation – the effort, the action and the objective of the Agent (the forest owner). The contract signed between the Principal and the Agent will be made in a context of moral hazard and/or adverse selection. According to the initial situation, the Principal's objective will be to encourage the Agent, either to maintain his level of effort in favour of the conservation of biodiversity, as it will have been referenced, or to help him restore a targeted level of biodiversity.

The analysis of the feasibility of the contract is first based on the knowledge of the origin of the information asymmetry, the nature of incentives begun by the owners (known or not) and the owners' objectives (see Slangen, 1997). The asymmetry of information is always at the expense of the State, forest owners being in all cases better informed. However, according to the type of owner, this asymmetry of information will lie on Agent's actions (moral hazard) or on Agent's objectives (adverse selection). Finally, the proposal of a contract is only done in the case when the owner has different possible forest management options: a potential change of species, the recourse to particular silvicultural or harvesting methods, etc. In the case of moral hazard, we presume that the Agent has a better knowledge than the Principal on how to reach objective Natura 2000. To introduce moral hazard we could distinguish two possible types of contracts. In the first type, the Principal specifies only the objective of biodiversity D* to be fulfilled and the level of subsidies. In the second type, the Principal specifies that it would be advisable to make an extra effort in decreasing wood production, adding that the production of wood should be in parallel with the production of biodiversity. In the case of adverse selection, the Agent knows his objectives better than the Principal does: the conservation case could be an inheritance and the owner could have an objective of intensive production. A greater precision in the contracts reduces the possibility of behaviour in moral hazard.

The restoration contract

In this case the initial and final objectives as well as actions which could be implemented by the Agent are known by the Principal. Only the less expensive solution for society has to be found by the Principal. We are then in a context of moral hazard which is of first order. To simplify the analysis we will suppose that the proposal of a restoration contract will be made at the time of a critical decision, that is to say, during a stand renewal.

We have seen that to reach the environmental objective the owner could employ several routes and could consequently bear the costs of reorientation composed of opportunity and direct costs. We will exclude the extreme cases R' and C_a for which the owner could bear either direct costs for R' or opportunity costs for C_a. The opportunity cost increases when the direct costs decreases. Let us recall that the presence of a direct cost implies the examining of an action whereas the presence of opportunity costs reduces the examining of the Agent's actions except when the levels of joint production are planned.

THE PRINCIPAL'S OBJECTIVES. We know that the Principal knows that the Agent maximizes profit. However, the Principal does not necessarily know precisely the boundary of what the Agent can do and estimates the amount of incentives with a margin of error. *A priori*, the Principal has an objective D* without specifying the level of wood production. The Principal can have reasons to want a decrease in wood: forecasting the level of social utility of wood and biodiversity or budgetary reasons. However, the specifications of the contract dealing with wood production and estimation of the boundary of production condition the presence of moral hazard.

THE AGENT'S OBJECTIVES. The Agent wishes to maintain his initial level of income. To encourage him to produce biodiversity the level of incentives must be similar to the initial one (constraint of participation). According to the modalities of the contract, the Agent is able or not to make a comparison between the different alternatives offered to him as well as respecting the constraints. Indeed, a contract on which he is told to reach D* without constraint on the level of production will be more flexible than a contract in which D* and B* would

be specified. According to his boundary of production and the constraints imposed by the contract, the moral hazard is more or less important.

THE POSSIBLE CASES. It seems important to say that the Principal and the Agent share the same information on the initial situation of the latter and the knowledge of the category to which he belongs: R, C_b or C_a. However, the Principal estimates, *a priori*, the Agent's boundary of production and estimates the amount of subsidies. It is obvious that, according to the boundary of production, he estimates – taking into account budgetary constraints and integrating for the moment only objective D* with two wood production extremes (B_{max} and B_{min})[5] – the Principal acts as a referee between the costs of the different solutions. The restoration cases in Figs 18.3, 18.4, 18.5, 18.6 and 18.7 show that the frontier of production is important both in its curvature aspects (Figs 18.3, 18.4, 18.5) and in its relative position (Figs 18.6, 18.7). In the three figures (18.3, 18.4, 18.5) the Principal can be either indifferent between two extreme solutions or can prefer one solution to another because it costs less[6]. Hence, in Fig. 18.3 the Agent remains indifferent to receive either subsidies that would cover direct costs or subsidies that would only cover opportunity costs[7]. In Figs 18.4 and 18.5 the Principal prefers to give compensation for direct costs (R–R′), (opportunity costs ($B_{max} - B_{min}$)). These three simple cases show that the boundary of production estimated by the Principal determines the most efficient trajectory according to the Principal. In reality, the Principal determines the subsidies which correspond to an intermediate wood production (for instance C_b Fig. 18.1). The Agent is forced to reduce his wood production as

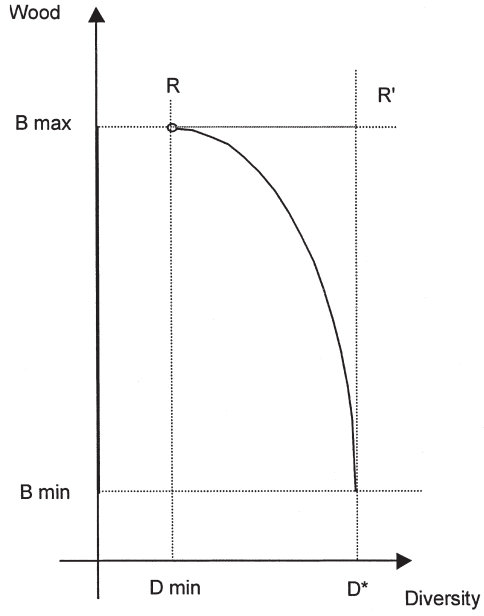

Fig. 18.4. A restoration case: preference (for the Principal) for direct costs subsidies.

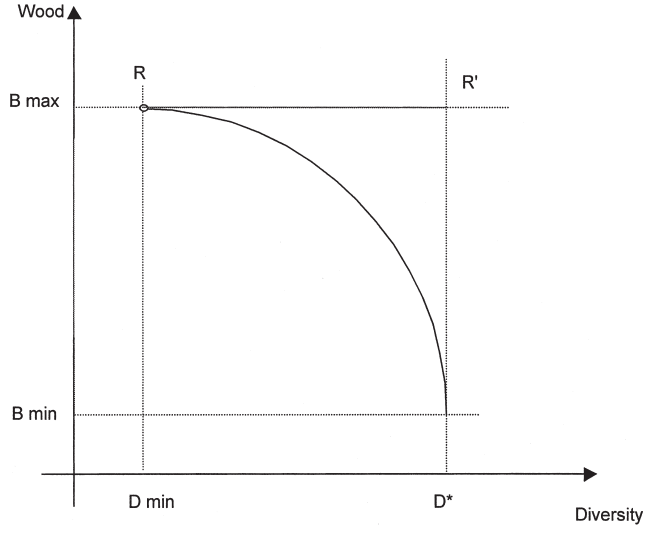

Fig. 18.3. A restoration case: indifference between direct costs and opportunity costs

direct costs $R - R'$ are always superior to the incentives whatever the boundary of production.

If the Principal does not say precisely in the contract that he wishes a decrease in wood production, the moral hazard depends on his estimation of the amount of incentives planned and implicitly on the shape of the boundary of production on which it is based. The moral hazard also depends on the shape of the boundary of production and on the estimation error made by the Principal. Finally, the moral hazard is different according to the meaning of the error made by the Principal, i.e. whether the

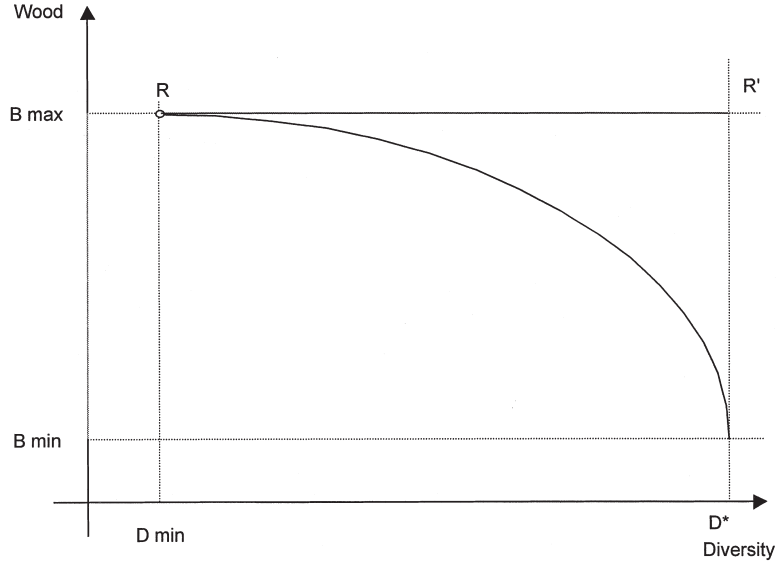

Fig. 18.5. A restoration case: preference (for the Principal) for opportunity costs subsidies.

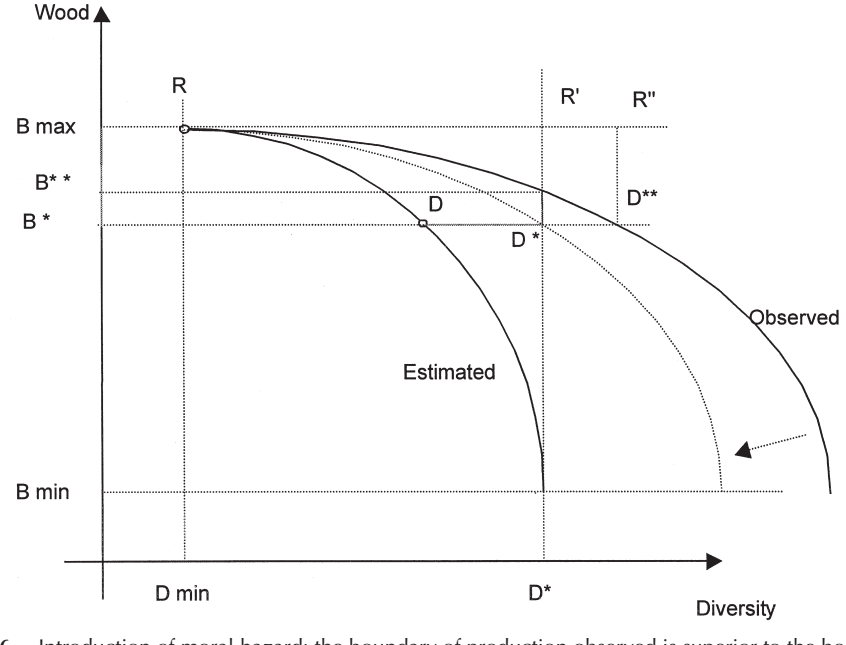

Fig. 18.6. Introduction of moral hazard: the boundary of production observed is superior to the boundary of production estimated.

curve observed by the Agent is, in the end, superior or inferior to the curve estimated by the Principal. To counteract this situation of moral hazard, the Principal must specify the terms of contract. To do so he can indicate that a reduction in wood production would be preferable, or he can impose both the levels of wood production and biodiversity. In the first case, according to the estimation of the boundary of production that he makes, a situation of moral hazard may occur.

If the boundary of production observed is superior to the boundary of production estimated by the Principal (Fig. 18.6), the moral hazard is linked to the Agent's likelihood of respecting contract D* when producing more than the Principal would want. Without constraint on the wood production but with D*, the Agent compares the amount of incentives to the cost he would bear when producing more wood than he is allowed to produce according to the Principal's estimation. He accepts contract D* and the amount $B_{max} - B^* + D - D^*$ but will produce B**. The rational Agent continues to produce wood and undergoes costs which to some extent remain inferior to the amount of incentives. If the contract specifies D* and B*, the moral hazard is reduced but remains. In this case, this Agent accepts the contract but is able either to reduce his possibilities of production until D* or maintain and produce D** superior to D*. Whatever his decisions, the amount of incentives $B_{max} - B^* + D - D^*$ remains superior to the costs observed by the Agent ($R' - D^*$ or $R'' - D^{**}$).

If the production boundary observed is inferior to the boundary of production estimated by the Principal (Fig. 18.7), the Agent refuses the contract because he knows that the costs he bears are superior to subsidies corresponding to (B*, D*). If he wanted to respect contract D* he would undergo losses equivalent either to ED or to DF according to the sacrifice he would be ready to make (in terms of direct costs or loss of earnings).

The conservation contract (C_a)[8]

Conservation Agents have management practices which already fulfil the environmental criteria of Natura 2000 (Fig. 18.8). A contract is proposed to conservation Agents liable to make changes in terms of a more intensive silviculture or in terms of operations less favourable to biodiversity. If, as in the case of an intensive owner, there is a symmetrical information in the Agent's initial position, then an information asymmetry appears here as far as the Agent's objectives (in terms of wood production and/or management) are concerned. This asymmetry can lead to an anti-selection situation. The Principal wishes that the Agent maintain his

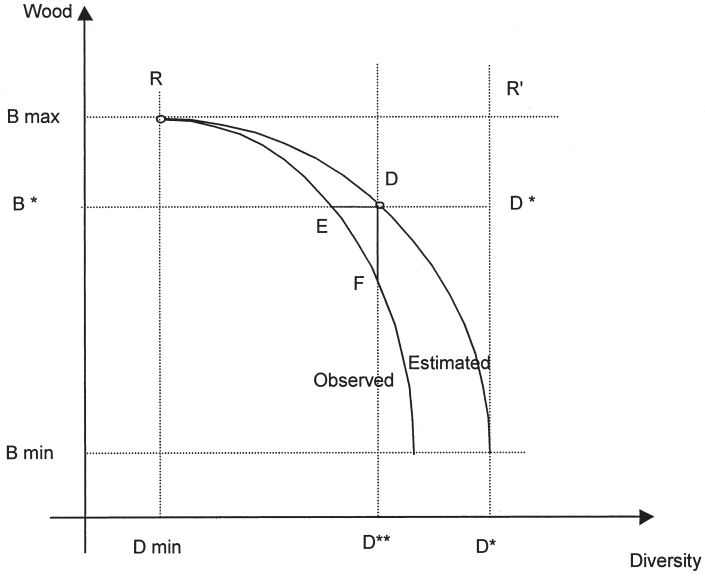

Fig. 18.7. Introduction of moral hazard: the boundary of production observed is inferior to the boundary of production estimated.

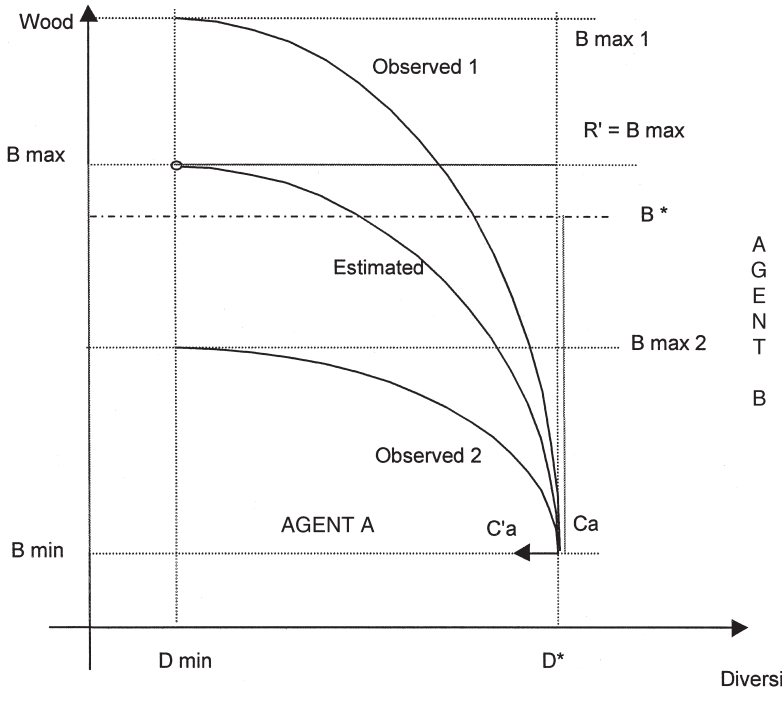

Fig. 18.8. The conservation case: identification of direct costs and opportunity costs according to the Principal's estimation.

level D*. But he does not know either the objectives or the reasons for which the Agent is in C_a though he should be producing B_{max}. However, he must encourage him to stay at D*, distinguishing between the Agents who are there voluntarily, and those who are there involuntarily. The observation of the plot only reveals a few pieces of information: indeed it only gives an indication of how to make a contract with an Agent capable of changing his initial position.

To get rid of adverse selection, a solution would be to confirm the reasons for the Agent's position and the motivations for his future operations. However, this solution may increase the costs of making the contract (information and transaction). Also, another solution calls for the Principal to create categories of conservation based on subjective probabilities. These concern the probabilities of producing wood for some of them on the one hand and /or the possibility of reducing his maintenance operation costs on the other hand. From these subjective probabilities, the Principal is able to make different contracts according to the category of producers (Fig. 18.9). For instance the Principal creates two categories of Agents according to their probability of wood production and gives different subsidies to each of them.

The acceptance of a typical contract by a producer of a category defined by the Principal reveals the Principal's capacity to anticipate potential behaviours: indeed if the producer accepts the contract, it is because he implicitly recognizes the category in which the Principal has placed him. However, on the other hand, the producer who does not accept the contract reveals the Principal's misjudgement. Beside this first information asymmetry there is a second one identical to the previous case and linked to the boundary of possibilities estimated on the one hand by the Principal and known on the other hand by the Agent.

A specific contract is proposed to each conservationist according to his possibilities of wood production and of maintenance determined from the subjective probabilities established by the Principal. Conservationist A, who has *a priori* a higher probability of producing wood (or to use products less favourable to biodiversity) than conservationist B, will have higher subsidies.

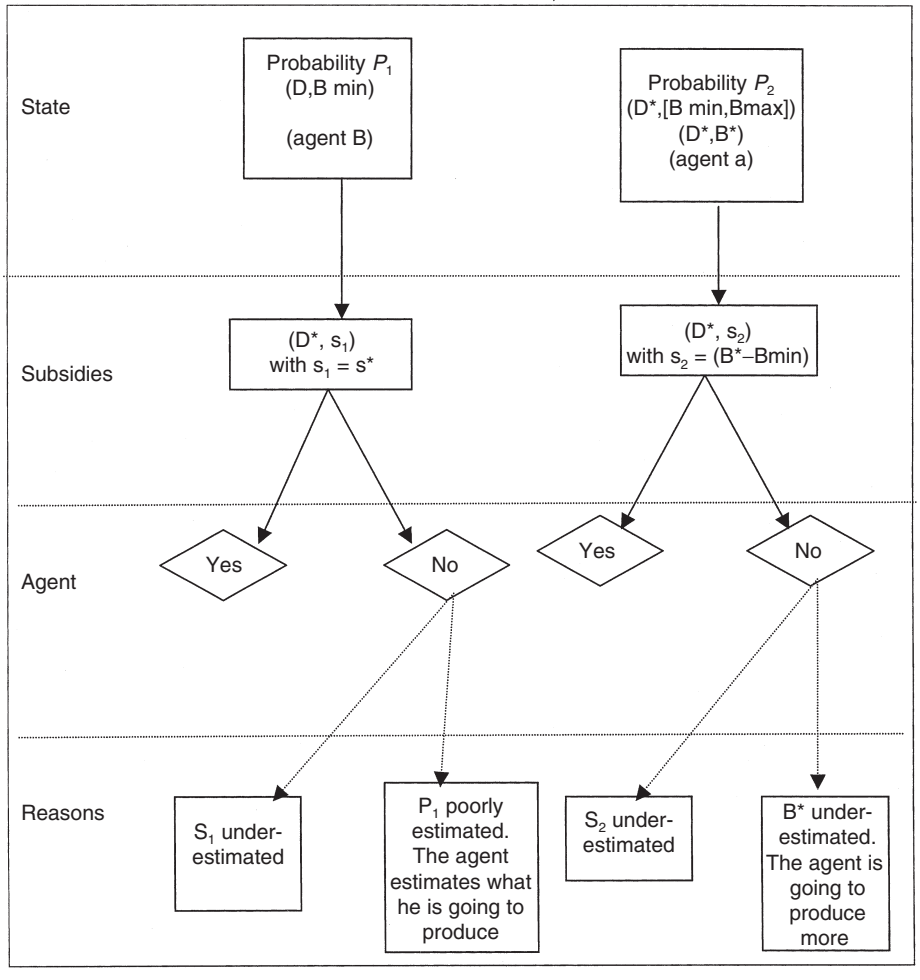

Fig. 18.9. Some strategies for a conservation contract (cf. Fig. 18.8).

Conclusions

These are some preliminary thoughts on the applicability of Natura 2000 in private forests in France. Three types of contracts have been identified on the basis of a joint production that takes into account wood and biodiversity. The implementation of contracts will raise some difficulties for the decider, notably in estimating the frontier of production for each Agent on each site. These difficulties are linked to a context of asymmetrical information concerning the owners' actions and/or objectives. The estimation of the frontier must take into account the link between wood and biodiversity, the curvature, the actions and the objectives of the owners.

This idea has several limitations: first, we have not mentioned the temporal aspect that is, however, fundamental in forestry but the reasons come from the fact that contracts will only be made for the next 10 years. Apart from possible maintenance actions which can appear in contracts relative to the preservation of biodiversity, such a period of time seems both long and short: long when the owner is doing maintenance operations in his forest, short when we take into account the production delays. Some other limits are on the potential risks aspects that could exist in forest management (windstorm, fires, etc.).

The effectiveness of a policy (restoration or conservation) of a non-market good involves knowing of the boundary of production and the

process of the producer's production on the one hand (type of juncture) and the initial position on the boundary on the other hand. Here we have considered that productions of wood and biodiversity were substitutable but this relation does not necessarily prevail in all cases in forests. It would be interesting to analyse a functional relation which would show that wood production and production of biodiversity are strongly complementary. It would be interesting to test this Natura 2000 implementation on a European level to get some idea of the various definitions and difficulties in biodiversity management.

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Endnotes

[1] Adverse selection: in general the uninformed party does not know all the characteristics of the Agent ('hidden information'). Moral hazard: the uninformed party is partially aware of the actions of the Agent ('hidden actions'). The uninformed party observes only the results of the actions.

[2] The 'Birds' Directive (1979), aiming at protecting the habitats necessary to the survival of both rare and endangered species; the 'Habitats' Directive (1992), aiming at protecting species and wild areas.

[3] Around 54,000 ha are concerned, to which we can add some forest areas within National Parks.

[4] If on the same area, with homogeneous natural characteristics, one has the case of an owner restoring and the case of a conservation owner, one can wonder about the rationality of the second who – without contract – should find himself in the situation of the first, i.e. at a level of maximal production. This second owner is not a maximizer of profit. However this situation is linked to the specific circumstances of the forest or to other reasons: formation, information, inertia of forest production, transaction costs, and so on.

[5] One supposes that the demand of the society is either in (B_{max}, D*) or in (B_{min}, D*).

[6] One supposes that the amount of subsidies is proportional to the length of segments.

[7] This case is made only to judge solutions and their costs but we will expect that the Principal considers that a very intensive wood production might be detrimental to the increasing of biodiversity on the one hand and does not favour of production at B_{max} when it is at its smallest level.

[8] The conservation contract b is in between the two that are described here, the restoration case and the pure conservation one.

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