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Francois Bonnieux, Philippe Le Goffe

### ► **To cite this version:**

Francois Bonnieux, Philippe Le Goffe. Cost-benefit analysis of landscape restoration : a case study in Western France. EU Workshop : Landscape and nature conservation, Sep 1996, Stuttgart, Germany. 16 p. ⟨hal-01595074⟩

**HAL Id: hal-01595074**

**<https://hal.science/hal-01595074v1>**

Submitted on 7 Jun 2020

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INSTITUT NATIONAL DE LA RECHERCHE AGRICOLE  
Station d'Économie et Sociologie Rurales  
**DOCUMENTATION**  
65, Rue de St Brieuc  
35042 RENNES CEDEX  
Tél. : 99.28.54.08 et 09

# Cost-Benefit Analysis of Landscape Restoration: a Case Study in Western France

Presented to the EU workshop on "Landscape and Nature Conservation"

Stuttgart, Germany  
September 26-29, 1996

Authors:

François Bonnieux  
Philippe Le Goffe  
I.N.R.A.  
Unité d'Économie - Rennes  
France

June 1996

DOCUMENTATION ÉCONOMIE RURALE RENNES



\* 0 1 4 3 4 8 \*

INRA-ESR  
REN-FB  
n° 708

## **Abstract**

This contribution is based on a case study related to the possible restoration of hedgerows. The area of interest is located in Lower-Normandy (Western France). This comprises a number of small plots, planted hedges and ditches, the scenery being characterised by a patchwork of meadows. This natural "bocage" is considered to be beautiful and attractive but there was an important decrease in planted hedges. Public decision is now concerned with the opportunity to implementing a programme which would extend over a wide area a pilot scheme which has been carried out.

Such a project is expected to provide a variety of benefits which are considered in the paper. On-site benefits to the farmer (green tourism, wind protection, shelter for animals, soil compaction and wood production) are readily assessed in money units. The public benefits cover a range of non-market priced items, including amenities, recreation, biodiversity, and externalities involved by regulation functions. The most direct benefits of the potential enhancement of hedgerows are derived by visitors and those households living in or near the area.

The contingent valuation method was used to derive the benefits which the general public would receive from the project. As the cost of restoration should be supported by residents through local taxes more emphasis has been devoted to this population. People were asked to value the regional landscape. The corresponding good was constructed from the generalization of the pilot scheme and the referendum question format was used to elicit willingness-to-pay. On the whole residents accepted the contingent market and were willing to pay an important amount (FF 200) on average per household per year.

Over a 100-year time horizon this programme would be profitable since the internal rate of return of the project would be around 5 per-cent. Nevertheless private benefits are not enough to carry out restoration. It is required to take into account the landscape component to justify public expenditures.

**Key words:** Landscape Restoration, Contingent Valuation, Cost-Benefit Analysis.

## 1. Introduction

The modernisation of agriculture brings about significant changes in the landscape of Western France. Larger machinery requires larger fields, demanding the removal of hedgerows. Landscape becomes less attractive for recreation and tourism, and a number of habitats are endangered. Many people deplore this dramatic evolution and ask for policy initiatives directed towards the conservation and restoration of traditional landscapes.

This paper considers the issue of landscape restoration in Lower-Normandy. A project is considered, which would be carried out under the supervision of a Natural Regional Park (NRP) which is in charge of managing an Environmentally Sensitive Area (ESA). This ESA has been primarily designated to protect wetlands, in some of which bird habitats of international interest can be found. It extends over 125,000 hectares of low lying land formed by the flood plains of five rivers and 100,000 hectares of dry land. This comprises a number of small plots, planted hedges and ditches, the scenery being characterized by a patchwork of meadows. This natural "bocage" has been moulded by farmers' activities over the years and is considered to be beautiful and attractive. Elm trees were symbolic of the area and accounted for more than 60 per-cent of the total number of high trees.

The predominant farming activity is dairying whilst beef cattle are also raised. The trend towards more intensive dairy farms has led to the increase of silage and maize crops at the expense of hay and permanent pasture. At the same time the development of plot consolidation changes the character of grassland and leads to a reduction in the area suitable for breeding birds. All such changes, occurring both in dry and wet lands radically alter landscape and wildlife value. The dramatic decrease in planted hedges has been boosted since the late seventies by the Dutch elm disease which led to the death of elm trees.

A pilot scheme to restore planted hedges was initiated in 1992. Its general objective is to achieve a network of four-hectare plots i.e. 150m/ha of hedgerows. This scheme has been implemented through standard agreements, covering a five-year period, between individual farmers and the NRP. The NRP offered technical assistance and a grant aid (FF 4,000/ha) for the planting, regeneration and management of new and existing hedgerows. This scheme has been restricted to a limited area and only thirty farmers have been enrolled up to now. The first purpose is to demonstrate the feasibility of replacing elm trees by other high trees such as

ash trees, maple trees, false acacias and wild cherry trees. The second purpose is to assess the actual cost of replanting and maintaining hedgerows.

## 2. The costs and benefits of the restoration project

The NRP is now faced with the possible generalisation of the pilot scheme, over the whole area affected by the disease. The restoration project would extend over 16,000 hectares and would consist in restoring 2,400 kilometres of hedgerows over a ten-year period. As unitary costs are derived from the pilot scheme, the overall cost of the project is readily assessed. Cost transfer is used and two categories of costs are considered (i) planting and regenerating costs, and (ii) maintaining costs (Table 1). The former are borne during the first ten years whereas the latter are spread over the whole life of the project i.e 100 years.

The issue of benefits is more intricate because they include private benefits as well as public benefits. First of all, hedges are multiple-use assets which provide merchantable timber and firewood. Otherwise they furnish shade, serve as wind breaks and secure soil against rapid water runoff and erosion. They provide habitats for birds and other animals. In there many uses planted hedges yield benefits both when cut and while standing, so benefits flow from exploitation and conservation.

*Table 1. Methodologies to value the costs and the benefits of the project*

	Valuation technique
Costs	
Planting and regenerating	Value transfer
Maintaining hedges	Value transfer
Benefits	
Firewood harvest	Market pricing
Timber harvest	Market pricing
Agricultural productivity	Value transfer
Amenities and recreation	Contingent valuation

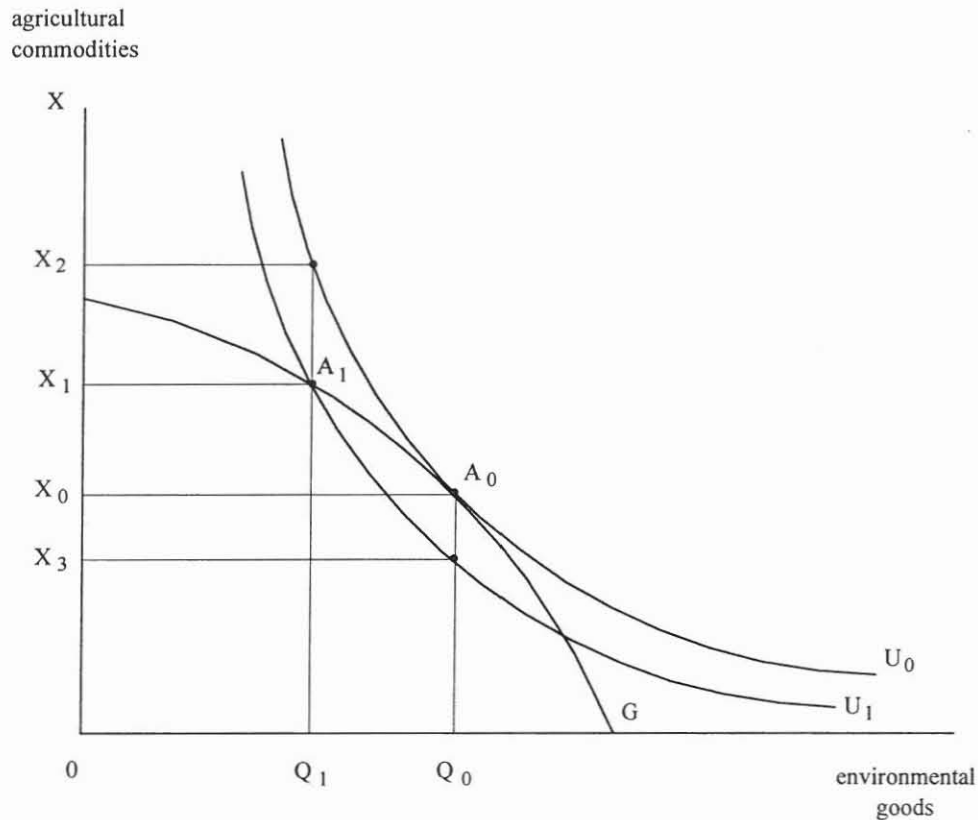
As a commercial crop, trees are viewed in an agricultural setting with relatively long commercial maturation periods (Neher, 1990). In a steady state each cohort experiences the same life cycle over a rotation period. The annual harvest of each cohort is a repetition of the previous harvest of trees planted one year earlier. The number of trees is selected so that a cohort is cut each year and the yield of the planted hedges is sustained. As regards firewood, the rotation period is 15 years and a yearly harvest of 25 cubic-metre per kilometre is expected from the 15th year until the end of the project. As regards timber wood, the rotation period is 60 years and a yearly output equal to 60 cubic-metre per kilometre is expected over 10 years (i.e. from the 60th year until the 69th year). Market prices are used to value both firewood and timber-wood (Table 1).

Farmers enjoy a number of direct benefits which are well documented in the literature. Two of them, which are particularly significant are taken into account. First of all there is a decrease in the rate of occurrence of the mammitis disease which affects one dairy cow out of four; this decrease equals 10per-cent . Second, there is an increase in the yield of permanent pasture resulting in an increase in forage output and therefore a drop in the feeding costs of dairy cows. The increase in forage output is around 100 kilograms of dry matter per hectare. As there is a combination of two opposite effects (a negative one around plots and a positive one elsewhere) no significant effect has been found for maize crops. Finally the overall effect on agricultural productivity is determined by transferring values obtained in other studies.

There are several approaches to value the public benefits the hedges provide. These benefits cover a variety of environmental goods, some of which public goods such as preservation of habitat diversity, others quasi-public goods such as landscape use in hunting, viewing, or exercising. Importantly, the outputs are often multiple and jointly produced with private goods which are priced in the market. The competition between environmental goods and private goods can be illustrated with the production possibility frontier  $G$  (figure 1). It bonds the set of all technologically feasible combinations  $(X,Q)$  where  $X$  is a vector of private agricultural commodities and  $Q$  is a vector of environmental goods. The trade-off between  $X$  and  $Q$  is easily explained in terms of Marginal Rate of Transformation (MRT): because of declining marginal productivity of resources used for either output,  $G$  is concave to the origin and MRT is increasing. With increasing  $Q$  farmers must give up more and more  $X$  to produce

one additional unit of Q. So the marginal cost of producing Q increases with Q (X being the numeraire).

Figure 1. Valuation of an increase in environmental goods



Define social welfare  $\bar{u}(X, Q)$ . The Pareto efficient allocation is given by a feasible combination  $(X, Q)$  which maximizes social welfare. Graphically, there is a single solution illustrated by  $A_0$  which lies at the tangency of the isosocial curve  $U_0$  and the production possibility frontier  $G$ . At the tangency the exchange rate defined in terms of social welfare i.e. the Marginal Rate of Substitution (MRS) between  $X$  and  $Q$  is set equal to the exchange rate between the goods defined by technology (MRT).

Let us consider point  $A_1$  which lies on  $G$ . Here society can only achieve a level of utility indicated by the social indifference curve noted  $A_1$  such as:

$$u_1 = u(X_1, Q_1) < u(X_0, Q_0) = u_0$$

In comparison with the optimal situation, there is an over-production of agricultural commodities ( $X_1 > X_0$ ) and an under-production of environmental goods ( $Q_1 < Q_0$ ). There are several strategies to establish the value of an increase in Q from  $Q_1$  to  $Q_0$  (Bonnieux and Weaver, 1996).

A first strategy is based on the supply side. At point  $A_1$ , farmers must give up X to produce more Q at a rate defined by the slope (MRT) of the production possibility frontier G. Consider a change from  $Q_1$  to  $Q_0$ , then  $\Delta Y = X_1 - X_0$  indicates how much X would have to be paid to farmers to produce  $Q_0$ .  $\Delta Y$  gives the profit foregone and therefore the minimum compensation to be given to farmers. This approach has been considered in the NRP context (Bonnieux et al, 1995).

A second strategy relies on the demand side. It uses the various approaches of the consumer surplus. Basically there are two possibilities in pricing an increase in Q. The first is to consider the compensating surplus CS such as:

$$u(X_1, Q_1) = u(X_3, Q_0) = u(X_1 - CS, Q_0)$$

$$\text{and } CS = X_1 - X_3$$

The second measure is based on the equivalent surplus ES defined by :

$$u(X_0, Q_0) = u(X_2, Q_1) = u(X_0 + ES, Q_1)$$

$$\text{and } ES = X_2 - X_0$$

The choice between CS and ES depends on the entitlement of property rights. Compensating surplus implies property right in the status quo, so the welfare reference level is given by  $U_1$ . Equivalent surplus implies property right in the change and so  $U_0$  gives the welfare reference level. Under standard curvature properties shown in figure 1:

$$MRT \leq MRS \text{ for } Q \leq Q_0$$

$$\Delta Y < CS \leq ES$$

the equality holds if there is no income effect.

The compensating surplus is a measure of willingness to pay (WTP) to obtain an increase in Q. Other wise the equivalent surplus is a measure of willingness to accept a compensation (WAC) to forego an increase in Q. Therefore, as  $Q \leq Q_0$  :

$$\Delta Y < WTP \leq WAC$$

an increase in  $Q$  is valued more highly by consumers than by farmers who produce it. In this paper we rely on WTP measures. But as no income effect is expected to occur, WTP and WAC are assumed to be equal. A third strategy could be based on a surrogate market. Graphically changes in  $Q$  are valued along the tangency of the isosocial welfare curve  $U_0$  and the production possibility frontier  $G$  at point  $A_0$ . This underlies the hedonic approach which has been explored in the same context (Le Goffe, 1996).

The most direct benefits of the project are derived by visitors and those households living in or near the NRP. However, non-use benefits could concern non-visitors who for altruistic motives are willing to pay to restore the "bocage". The landscape of the NRP has many close substitutes in several locations of Western France therefore it is assumed that non value represents a small portion of amenities and recreational benefits. Besides there is a very limited number of visitors so the valuation has been restricted to the resident population. The WTP for the project is derived from a contingent valuation survey of the residents (Table 1).

### **3. The Contingent Valuation Survey**

In comparison with CV studies in the field of recreation, application of CVM to rural landscapes is more subject to misspecification of the product. In particular, geographical part - whole bias and policy-package part- whole bias are likely to result from inadequate specification of the amenity. Geographical part -whole bias occurs when a respondent values a landscape whose spatial attributes are larger or smaller than the spatial attributes of the researcher's intended landscape. This issue has received special attention in our research. People were asked to value the whole area affected by Dutch elm disease, thus the valuation question refers to a regional landscape. In addition questions were related to smaller areas in order to assess differences in WTP. There was empirical evidence that people are able to discriminate a local landscape from a regional landscape. Respondents were able to isolate regional landscape from a smaller area covering the specific village in which they were living.

Policy -package part- whole bias occurs where a respondent values a broader or a narrower policy package than the one intended by the researcher. This issue is of particular interest within the context of our research. Given that agricultural activities and the restoration programme can produce a wide variety of public effects, the public good to be valued had to

be precisely specified. In the context of the Common Agricultural Policy reform, people might have treated at the restoration scheme as symbolic of a larger policy package (e.g. preservation of traditional farming) and assigned to the scheme some of the values they gave to for this more general goal.

The cost of restoration should be supported by residents through local taxes. The population concerned includes both people living in the area to be restored and people living in and near this area. The survey was focused on a 400 square - kilometre area in which there are 10, 118 households. As most French households have the telephone, the phone directory was used to sample the population and no sampling frame bias is assumed to have occurred. People were then asked by phone to meet an interviewer at home to participate in the survey. They were informed about the topics dealt with in the questionnaire and were told that the face -to- face interview would need no more than thirty minutes. 40 per-cent of the contacted individuals refused to be interviewed but some of them accepted to answer some simple questions. There is some evidence that refusals were more frequent among older people. The questionnaire was tested with a sample of 60 households in February 1995. The final sample includes 400 households. People were interviewed by a technical staff, with a basic training in CV, during April and May 1995.

One contingent market was proposed to the interviewees. The corresponding good was constructed from the generalisation, over the whole area affected by the disease, of the pilot scheme. The good was shown using a combination of pictures and photographs. Besides there was a detailed description of the system of standard agreements between farmers and the NRP with an emphasis on the costs and on the way in which they are financed. One - third of the people were aware of this mechanism and 88 per-cent did support this environmental policy. Therefore there is some evidence that the scenario is plausible. However a significant proportion of the interviewees (30 per-cent) underlined inconsistencies of public policies. For example they stated that the modern development of agriculture conflicted with countryside stewardship. So they were wondering about the possible integration of environmental goals into agricultural policy. Their comments show that people are well informed about environmental problems in the area of interest.

After a reading of the scenario, people were asked to reveal their WTP additional local taxes in order to carry out the restoration programme. The referendum question format was used. Here the crucial issue is the choice of the bids offered to the interviewees since it affects the estimation of mean WTP (Cooper 1993, Cooper and Loomis 1993, Duffield and Patterson 1991). This choice has been based on the outcome of the pre-test survey in which an open question format has been considered. People were assigned randomly to six subsamples, with each subsample being asked to respond to a different franc amount. People are equally distributed according to the yes and no-responses (the common percentage is 48) and 4 per-cent of the sample refused to participate in the valuation exercise. The follow-up question allows categorisation of the no-respondents. 70 per-cent judge that local taxes are too high and would prefer spending money on other goods. 30 per-cent consider that farmers are liable for the degradation of the countryside so they are not willing to pay for them. However this second category is heterogeneous because some people could accept to pay for a local good i.e. a scheme restricted to their own village.

In order to convert yes or no responses to a referendum question into a monetary measure, we employ the model of choice of Hanemann (1984). Several models have been estimated. Among those variables explaining the probability of accepting the offer, the most significant and the most robust in passing from one model to another are the bid level, income, education, angling practise outside the local community and concernment. The signs of coefficients are consistent with theoretical expectations since bid level, income and education positively influence the probability. Males and people having a recreational experience locally are more inclined to accept the offer. People who feel concerned about the protection of the whole area are willing to pay more, as the sign of the concernment variable shows. This a good indication that geographical part-whole bias is not a serious problem in our research. Angling experience outside the village negatively influences the probability for accepting the offer. Because this variable is a proxy for recreational substitute sites, this is consistent with demand theory.

*Table 2. Welfare measures (FF per household per year)*

WTP measure	Model 1	Model 2
Median	201	198
Mean (0-400 FF truncation)	201	199
Mean (0-1000 FF truncation)	234	227

Table 2 provides yearly WTP per household. Median and mean estimates are derived from two versions of the model (for the mean two truncations are considered). Results derived from both versions are very close.

*Table 3. Influence of individual characteristics on median WTP (FF per household per year)*

Variable	Model 1	Model 2
Sex	58	66
Monthly income	35	-
Education	-	24
Concernment	122	111
Nature watching locally	92	70
Angling locally	102	110
Angling outside	-161	-191

On average, FF 200 is a good estimate of yearly-WTP per household. This varies according to the values taken by the explanatory variables (Table 4). The income elasticity of the demand for restoration is 0.9 implying a difference in WTP equal to FF 300 between the extreme income intervals. People who feel concerned by protection of the whole area are willing to pay FF 110 - FF 120 more than people who do not. Besides, recreational experience variables significantly affect WTP. For anglers there is a large difference in WTP between those who fish locally and those who fish outside.

#### 4. The Results of the Costs and Benefits Analysis

Planting and regenerating costs equal FF 13,000 per kilometre and 240 kilometres are planned to be yearly planted over the first ten years. Thus overall planting and regenerating costs are:

$$C_1 = 7.92 \sum_{t=0}^9 (1+r)^{-t} \quad FF10^6$$

where  $r$  is the discount rate. Maintaining costs are linearly increasing from the first year until the tenth year, when they reach a plateau. As they equal FF 1,000 per kilometre, overall maintaining costs are:

$$C_2 = 0.24 \sum_{t=1}^9 t(1+r)^{-t} + 2.40 \sum_{t=10}^{99} (1+r)^{-t} \quad FF10^6$$

Based on market prices, the value of fire wood is given by:

$$B_1 = 5 \sum_{t=15}^{99} (1+r)^{-t} \quad FF10^6$$

and the value of timber wood is:

$$B_1 = 2.92 \sum_{t=60}^{69} (1+r)^{-t} \quad FF10^6$$

As benefits to farmers are proportional to the length of hedges, the positive effect on agricultural productivity is:

$$B_3 = 0.072 \sum_{t=1}^9 t(1+r)^{-t} + 0.72 \sum_{t=10}^{99} (1+r)^{-t} \quad FF10^6$$

where the benefits stemming from one kilometre equal FF 300.

Public benefits (amenities and recreational benefits) are assumed to increase with the development of the project and to reach a plateau. The overall public benefits are equal to:

$$B_4 = 0.10 N \text{ WTP} \sum_{t=0}^9 t(1+r)^{-t} + N \text{ WTP} \sum_{t=10}^{99} t(1+r)^{-t} \quad FF10^6$$

where WTP is FF 200 per household and  $N$  is the number of households who benefit from the project. The calculation has been limited to the resident population, so  $N$  equals 10,118 households.

Therefore the Net Present Value (NPV) of the project is:

$$NPV = B_1 + B_2 + B_3 + B_4 - C_1 - C_2 .$$

NPV is reported in Table 4 for different discount rates.

*Table 4. NPV of the project for various discount rates (FF million)*

Discount rate (per-cent)	3	4	4.8	5	6
<b>Costs</b>					
Planting regenerating	69.59	66.81	64.72	64.21	61.79
Maintaining	66.00	49.38	40.38	38.54	31.07
<b>Benefits</b>					
Fire wood	101.26	69.61	53.03	49.71	36.59
Timber wood	4.35	2.34	1.43	1.27	0.69
Agricultural productivity	19.80	14.81	12.11	11.56	9.32
Amenities, recreation	61.18	46.18	38.11	36.37	29.60
Net Present Value	51.00	16.75	- 0.42	- 3.84	- 16.60

100 - year time horizon.

With a 4.8 per-cent discount rate, benefits balance costs (Table 4). It is arguable that the Internal Rate of Return (IRR) is significantly greater, because some benefits are not taken into account. In addition to the benefits considered in Table 4, two other categories deserve some attention. First of all, people crossing the area enjoy amenities from viewing the scenic landscape. As the average daily traffic equals 11,000 cars, there is some evidence that the corresponding benefits are significant. The second category stems from tourism industry. In a broader context, a positive relationship between rural amenities and the rent for secondary houses has been found (Le Goffe, 1996). This result is based on a hedonic equation and can be

transferred to the situation prevailing in the NRP. Taking into account these two categories, a 5 per-cent IRR could be defended. However, based on use values only, the social profitability of the project is limited.

The major part of the costs are borne during the ten first years whereas the benefits are spread over the whole life of the project (Table 5). Therefore in order to enforce the beneficiary-pays principle such a project should be financed by a public loan. Otherwise a significant money transfer would benefit the next generation.

*Table 5. Costs and benefits over the life of the project (FF million)*

Years	0 → 9	10 → 14	15 → 59	60 → 69	70 → 99	0 → 99
<b>Costs</b>						
Planting regenerating	64.72					64.72
Maintaining	8.07	6.85	22.79	1.18	1.49	40.38
<b>Benefits</b>						
Fire wood			47.48	2.45	3.10	53.03
Timber wood				1.43		1.43
Agricultural productivity	2.42	2.06	6.84	0.35	0.44	12.11
Amenities, recreation	9.03	6.17	20.51	1.06	1.34	38.11
<b>Net Present Value</b>	- 61.34	1.38	52.04	4.11	3.39	- 0.42

4.8 per-cent discount rate.

### **Concluding comments**

In the NRP context the economic appraisal of landscape restoration results in a 5per-cent IRR. In comparison with other private projects as well as public projects this is a quite low rate. As public benefit are important a study restricted to private benefits (firewood, timber and impacts on farm productivity) would have been of very limited interest. These private benefits are not high enough to justify such a restoration. So the main contribution of this paper is to extend the scope of project appraisal by incorporating amenities and recreational values.

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As regards the valuation of public benefits two points must be made. First of all the long run decline in hedgerows (for example from 70 metres per hectare in 1975 to 27 metres per hectare in 1987) is expected to continue in the next future resulting in a significant decrease in the supply of amenities and recreational opportunities. Otherwise there is clear evidence that the demand for amenity and recreation is income elastic (Fisher and Krutilla, 1985). A WTP-income elasticity equal to 0.9 has been found in the study. This should lead to higher values for WTP in response to higher incomes in the future. The combination of a downwards shift in supply with an upwards shift in demand involves a greater profitability of the project.

The process of aggregation used to derive the net present value of the project relies on strict assumption regarding social welfare orderings (Boadway and Bruce, 1984). The marginal utility of income is assumed to be constant across the population of interest; this implicitly means that the income distribution is optimal. As the resident population of the NRP is poorer than the average population of France it is arguable, based on equity considerations, that the net present value should be calculated with higher weights for low income people. This alternative process of aggregation would lead to a greater value of the IRR.

As non-use value is not significant, the CV approach is relevant to value non-marketed goods (Diamond and Hausman, 1994). The degradation which occurs in the area considered is not irreversible and the concerned population is clearly identified and limited in scope. Thus altruistic motives are expected to be marginal and the resident population to behave hedonistically. This also supports the use of the CVM (Enneking and Rauschmayer, 1996). The issue of part-whole bias remains a crucial one and has received attention in this paper. Moreover an external test of validity could be based on other studies. Here it may be emphasized that the CV results are consistent with the outcome of a hedonic study (Le Goffe, 1996).