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Cost- benefit analysis of the location of new forest land

Ellen Moons
(K.U.Leuven-CES-ETE)

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secretariat:
Isabelle Benoit
KULeuven-CES
Naamsestraat 69, B-3000 Leuven (Belgium)
tel: +32 (0) 16 32.66.33
fax: +32 (0) 16 32.69.10
e-mail: Isabelle.Benoit@econ.kuleuven.ac.be
http://www.kuleuven.ac.be/ete

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Abstract

In this paper we show how cost-benefit analysis can be used as a decision support mechanism for the location of new (urban) forest land, starting from the multifunctional role of these new forests.

We start with a simple presentation of the cost-benefit analysis (CBA) technique. Key features of this evaluation technique are that (i) all – both positive and negative - impacts for all relevant parties (i.e. not only the project promoter) are taken into account and (ii) evaluation occurs on the basis of monetary values.

Next, we give an overview of all relevant costs and benefits of afforestation projects for the whole society. On the cost side, we distinguish costs directly related to the afforestation project itself, such as tree planting and forest management on the one hand and opportunity costs on the other hand. On the benefit side we make a distinction between use and non-use values. Use values include timber production, hunting, recreation and ecosystem values. Non-use and option values capture forest benefits that are independent from the actual use made of the forest area. As valuation of recreation and non-use/option values is not straightforward, we discuss their valuation methods in more detail. For valuing recreation the travel cost method (TCM) is the most widely used technique. TCM seeks how the visit frequency responds to changes in the price of a visit. Non-use values can only be valued using the contingent valuation method (CVM). CVM uses survey questions to elicit people's preferences for public goods by finding out what they would be willing to pay for specified changes in them.

Finally, we apply the CBA to a real life policy problem. The Flemish government has agreed on a 10.000 ha forest expansion in Flanders, focusing on the multifunction role of forests. In our case study we give an example for the Ghent region (East Flanders). We investigate the net benefits per hectare of combinations of potential forests that meet the surface restriction of 540 ha. We show the importance of including recreation benefits in the evaluation of afforestation projects and more specifically the role of alternative forests (substitutes) in the valuation of one specific forest. We find that this substitution effect is significant in the decision on the location of new forests and leads to a wide variation in the net benefits per hectare of different combinations.

Keywords: Environmental economics; Cost-benefit analysis; Valuation; Land use change; Forestry

Corresponding Address: Center for Economic Studies, K.U.Leuven, Naamsestraat 69, B-3000 Leuven, Belgium, Ellen.Moons@econ.kuleuven.ac.be

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CENTER FOR ECONOMIC STUDIES
Naamsestraat 69 B-3000 LEUVEN
BELGIUM

Cost-benefit analysis of new forest land

1. INTRODUCTION[1]

The Flemish government has set aside a budget for the expansion of existing forests and the creation of new forests. The Land-use Structure Plan of Flanders (Ruimtelijk Structuurplan Vlaanderen) defines 10.000 hectares for ecological forest expansion. According to the Long Term Regional Forest Plan (1993), multifunctionality of forestry is the most important criterion for forest expansion. Forest expansion has to be aimed for in areas where five functions can be fulfilled in one forest, namely the economic, educational, shelter, ecological and social functions.

The decision on the location of these 10.000 hectares should therefore take into account all functions of these forests. How this can be done is not straightforward. Cost-benefit analysis is a technique that was developed to evaluate investments taking into account all positive and negative impacts of the investment on all parties involved. In this paper we first discuss the basic idea of cost-benefit analysis. Next, we explain how this technique can be used to evaluate land use changes such as afforestation on former agricultural land. We give an overview of the different costs and benefits of afforestation projects and discuss their measurement and valuation. To conclude we give an example of the use of cost-benefit analysis in deciding on the location of multiple new urban forests.

2. COST-BENEFIT ANALYSIS: AN INTRODUCTION

Cost-benefit analysis (CBA) is a technique developed to evaluate investments from a social-economic point of view. It helps decision makers (1) to decide on the optimal level of the investment (e.g. the optimal forest expansion area); (2) to find the optimal mix of investments maximizing efficiency (e.g. the optimal mix of urban and regional forests) and (3) to choose among several alternative investments (e.g. the optimal location of new forests) (Loomis and Walsh, 1997). A key factor of CBA is that the evaluation is made on the basis of *monetary* values.

The basic idea is very simple. If we have to decide whether to do investment A or not, the rule is: do A if the benefits exceed those of the next best alternative, and not otherwise. The ‘benefits of the next best alternative’ are referred to as the ‘costs’ of A. The basic rule can now be formulated as follows: do A if the benefits exceed the costs, and not otherwise (Layard and Glaister, 1994).

The first questions that come to mind are how to measure and value these costs and benefits and which costs and benefits should be taken into account. Assuming that only people matter, two (more theoretical) steps can be distinguished: first, find out how the investment affects the individual’s welfare. This impact is measured by the individual’s own valuation. Next, deduce the change in social welfare from these changes in individual

1 We would like to acknowledge the financial support of the ‘Vlaams Impulsprogramma voor Natuurontwikkeling (VLINA)’, projects C9606 and 0017.

welfare. All positive and negative impacts in each year of the project should be taken into account. We will discuss this in more detail in section 3.

Second, what is the relevant society for which the change in welfare should be analysed? Either one takes on an international point of view or one limits the analysis to the population of the country undertaking the investment. In either case, costs and benefits to all members of society are included and not only the monetary expenditures and receipts of the project promoter.

A third question concerns distribution effects. The underlying assumption in most CBA studies is that income is optimally distributed or that – in case of non-optimal distribution – there is some form of redistribution. Consequently, each person's 1 EURO has the same weight. However, in real situations this might not always be true. This implies that one needs to value a poor person's 1 EURO higher than that of a rich person (Layard and Glaister, 1994).

A final issue is the choice of the discount rate. An aggregate present value of the project is obtained by discounting costs and benefits in future years to make them commensurate with present costs and benefits. A high or low discount rate has a large impact on the final result (the net present value) when costs and benefits occur at different points in time.

The advantage of CBA compared to other evaluation techniques is a transparent and objective comparison between projects, since all impacts are expressed in monetary values and can be added up/distracted.

3. COSTS AND BENEFITS OF AFFORESTATION PROJECTS

The most obvious benefits of a forest are timber production. In some forests, hunting permits are issued. On the cost side, plantation and management are the first costs that come to mind. All these costs and benefits are financial expenditures or revenues for the forest owners.

A social CBA however takes into account costs and benefits for the whole society. This implies that impacts related to the afforestation project that do not directly accrue to the project promoters should be taken into account. A full overview of all costs and benefits related to afforestation projects on agricultural land is given in Table 1.

Table 1: Costs and benefits of afforestation projects on agricultural land

COSTS	BENEFITS

Tree planting and forest management
Opportunity cost of afforestation:
  Loss of agricultural production
  Loss of manure deposition possibilities
	Use values:
	  Direct use values: timber, hunting, recreation
	  Indirect use values: ecosystem values (e.g. carbon fixation, biodiversity, ...)
	Non-use values:
	  Existence values
	  Bequest values

3.1. COSTS

Two main categories of costs can be distinguished. On the one hand there are costs directly related to the afforestation project itself. These include costs of tree planting and forest management. The latter includes site preparation, pruning, thinning, felling, etc.

On the other hand one should take into account the net benefits of the land that are lost when the project is executed, i.e. the opportunity cost of the project. In theory, these should be the benefits of the next best alternative land use, in practice, it is obvious one should take the benefits of the current use of the land, i.c. agriculture. In the Flemish case, the opportunity cost includes both the agricultural production lost and the manure deposition lost. Calculating the loss of agricultural production is a complex matter due to the high level of subsidisation of the agricultural sector on both European and national level. These subsidies are merely transfers between different groups in society and should therefore be subtracted from the observed market prices for agricultural goods. One way of dealing with this problem is to use world prices to value agricultural production. In the Flemish case, this leads to a net loss instead of profit for most agricultural crops.

During the past decades, manuring norms became more and more restricted in Flanders due to environmental concerns. For each parcel we now have a maximum amount of manuring. As farmers have a choice between manure deposition on agricultural land (which is free but restricted by law) or manure processing (which is costly), afforestation of agricultural land implies an increase in the cost of manure processing.

Measuring and valuing the costs of afforestation is rather straightforward. Inputs for afforestation, inputs and outputs of agricultural production and manure processing are traded on markets. Consequently, market prices for all these goods are available and reflect the willingness to pay of persons for these goods. However, as mentioned before, one needs to pay attention to government interventions such as subsidies and taxes. In a CBA social values rather than pure market prices matter.

3.2. BENEFITS

On the benefit side we make a (theoretical) distinction between use and non-use values. Like the name suggests the use benefits are the values arising from the actual use made of a forest. The use values are divided into direct use values, such as timber production, hunting or sightseeing, and indirect use values, which refer to the benefits derived from the forest's life functional support (shortly named in economics as externalities) as the example of CO_2 absorption.

On the other hand, we have the non-use values that capture the forest benefits that are independent from the actual use made of such forest area. The non-use values are composed of a bequest value, i.e. the benefit accruing to any individual from the knowledge that others might benefit from the forest in the future, and an existence value, i.e. the benefit accruing to any individual from the knowledge of that forest area.

Valuation of the benefits is more difficult. What is the willingness to pay of persons for these benefits? Only for direct use values such as timber and hunting markets exist for trading these goods. All other values, especially non-use benefits, are more intangible. The value assessment of such functions requires special concepts and tools. Valuation of recreational benefits will be discussed in section 3.2.1., valuation of option and non-use values is considered in section 3.2.2.

3.2.1. VALUATION OF FOREST RECREATION: THE TRAVEL COST METHOD

The travel cost method (TCM) was first mentioned by Hotelling in 1947 but was only formally used in the literature several years later by Wood and Trice (1958) and Clawson and Knetsch (1966). It is based on observed market behaviour of a cross section of users and is therefore the preferred method for outdoor recreation modelling for most economists (Loomis and Walsh, 1997). It is considered to be an empirical application of the household production approach pioneered by Becker (1965).

a) The basic method

The TCM seeks how the visit frequency of users responds to changes in the price of a visit. The costs of travelling to the site, both direct monetary and time costs, and on-site costs, such as entry fees, are used as a proxy for price (Hanley and Spash, 1993). The basic premise of the approach is that the number of visits to the site decreases with increases in the travel costs, to a major extent determined by distance travelled.

We can formally represent travel costs (TC) to a given site 'j' as follows:

$$TC_{ij} = TC\left(DC_{ij}, TTC_{ij}, F_i\right) \qquad i = 1...n; j = 1...m \tag{1}$$

where DC are distance costs for each individual 'i', dependent on the distance travelled and the cost per kilometre[2]. TTC are time costs. These depend on how long it takes individual 'i' to get to the site and on the valuation of that individual's time. F stands for on-site costs including an entrance fee that is charged for some sites[3].

These travel costs are one of the independent variables that are used to explain the dependent variable, some form of quantity of recreation. Usually, one takes the number of visits taken by a person over a year or visits per capita from a specific zone to a recreation site (Loomis and Walsh, 1997)[4].

Other variables that influence visit frequency are socio-economic characteristics such as income, education and age level, family composition, gender, as well as variables giving information on the type of trip. The latter include mainly forest characteristics in the case of forest recreation. The last factor that influences visit frequency is the price and availability of substitutes. Substitutes are, in the case of forest recreation, other forests an individual could visit. The more substitutes a visitor has, or the closer by substitutes are, the lower the number of visits to the studied site.

2 The cost per kilometre consists of variable costs such as fuel costs as well as fixed costs such as insurance, taxes, acquisition costs etc.

3 Entrance fees are unusual for forests with public access.

4 Depending on how the dependent variable is defined, the TCM is described as individual or zonal TCM.

b) Recreation demand function

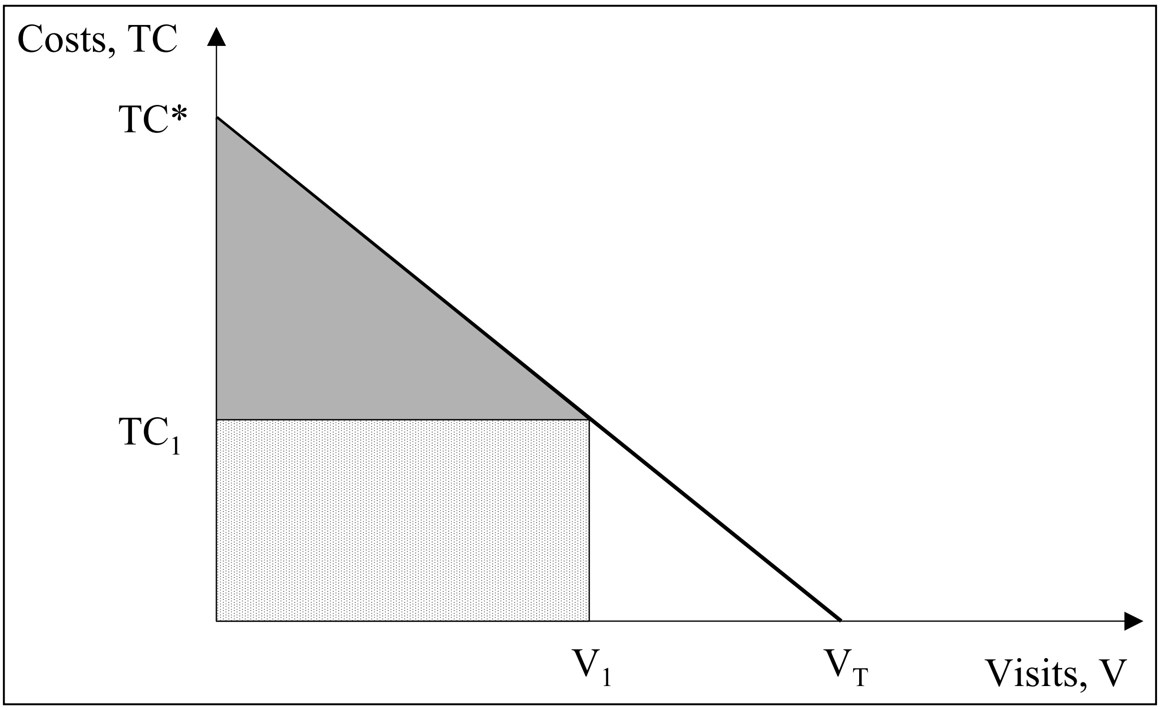
We now have all the ingredients to specify a recreation demand function[5] that explains the quantity of recreation in terms of the price and other explanatory variables. This can formally be stated as follows:

$$V_{ij} = V(TC_{ij}, SC_{ij}, FC_i, S_i) \qquad i = 1...n, j = 1...m \qquad (2)$$

where V are visits of individual 'i' to site 'j', TC are travel costs, SC are socio-economic characteristics, FC are forest characteristics and S is the price of visiting other sites.

This demand function, sometimes also referred to as 'trip generating function' (Hanley and Spash, 1993), is estimated using multiple regression techniques. Using the statistical coefficients from the regression, a demand curve or willingness to pay curve representing the relationship between the number of visits and the cost (price) of a trip can be traced out with increments in costs starting from the current cost of each individual.

Figure 1: Demand curve and consumer surplus



The key assumption behind the demand curve is that as travel costs increase, the number of visits falls. There exists a cost TC* at which no more visits will be made. This is called the 'choke price'. On the other hand, when costs are zero, the number of visits will be highest (V_T). At any price higher than zero, the number of visits will drop, e.g. at a positive price TC_1 visits will trop to V_1.

c) Consumer surplus

The area under the demand curve measures the visitor's net willingness to pay or consumer surplus attributed to the site (Loomis and Walsh, 1997). It is the surplus benefit

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5 From this point forward we will limit the discussion to the individual TCM.

(grey triangle) over and above the cost (dotted rectangle). From Figure 1 we know that at a cost TC_1 an individual would make V_1 visits. However, the individual is willing to pay almost TC* for the first visit and any amount between TC* and TC_1 for the following trips (up to V_1). From that point onwards, the cost of a visit is higher than what the individual is willing to pay for the trip.

d) Problems with the travel cost method

(1) Multipurpose trips vs. single destination trips

If an individual leaves home and drives directly to the recreation site and returns home directly afterwards, costs of making the trip can be exclusively attributed to the site visit. This type of visitors is often referred to as 'purposeful visitors' (Hanley and Spash, 1993). Those visitors for whom a visit to the site is only part of the purpose of their trip are called 'meanderers'. In the latter case, taking into account the full cost of the trip will lead to an overestimation of benefits attributable to the recreation area (Loomis and Walsh, 1997).

There is not a theoretically correct way to allocate the trip costs among multiple destinations. Either these observations are dropped from the analysis or the visitors are asked to subjectively attribute a proportion of trip costs to visiting each destination.

(2) Distance costs

Increases in distance are converted to the monetary amounts visitors would pay if they were required to travel the additional distance. There are basically two options to calculate a price per kilometre: (1) use fuel costs only as an estimate of marginal cost or (2) use full costs including an allowance for depreciation, insurance, etc. as an estimate of average cost. Consumer surplus measures will depend on the choice.

(3) Travel time costs

Travel time costs are calculated by multiplying the duration of the trip (depending on distance and transport mode) by the value of travel time.

The value of travel time is the opportunity cost of that time. The time spent on the trip[6], which is assumed to create no benefits, cannot be spent on other time consuming and benefit creating activities such as working or alternative recreational activities.

Saving time in travelling to the site clearly has a positive value, or, time spent travelling in itself has a negative value. If the individual is giving up working time in order to visit a site, the wage rate is the correct opportunity cost of time travelled. However, most individuals are restricted by fixed working hours and will therefore make the trip in their leisure time. The travel time to a site would alternatively be spent on other leisure activities. No labour income is foregone and the correct opportunity cost here is the value, at the margin, of the other recreation activities foregone.

(4) Statistical problems

Several statistical problems can occur when estimating a (recreation) demand function. First, there are problems related to the independent variables in the regression equation.

6 Here we assume time spent on site has no value, although we are aware of the debate in the literature regarding this aspect of TCM applications.

All relevant variables affecting visit behaviour need to be included. Omission of variables will bias the coefficient estimates and therefore bias the consumer surplus estimates. However, it is not necessary to include variables that do not vary among individuals or according to distance travelled as these variables will not change the slope or the area under the demand curve.

Second, the dependent variable is subject to both truncation and endogenous stratification (Hellerstein, 1992). Truncation occurs when observations are only available greater than (or less than) some lower (or upper) bound. This is the case for most TCM studies when observations originate from on-site surveys and all respondents make at least one visit to the site. The dependent variable (visits) is said to be truncated at one. Endogenous stratification occurs when the probability of being sampled is a function of the value of the dependent variable. When interviewing visitors at specific checkpoints on site, people with higher visit frequencies have a higher chance of being interviewed. Truncation and endogenous stratification require the functional form of the recreation demand function to be chosen with care. A good choice seems to be using count data models that are based on probability distributions that are defined for nonnegative integers only (Hellerstein, 1992).

3.2.2. VALUATION OF NON-USE VALUES: THE CONTINGENT VALUATION METHOD

A procedure to convert changes (qualitative or quantitative) in environmental goods into monetary terms (Willingness To Pay or WTP) is the contingent valuation method (CVM). CVM uses survey questions to elicit people's preferences for public goods by finding out what they would be willing to pay for specified changes in them (Mitchell and Carson, 1989). Constructing a hypothetical yet detailed and realistic market in which consumers have the opportunity to buy the good circumvents the problem of missing markets for many environmental goods. Because valuation is contingent upon the particular hypothetical market, this approach is called the contingent valuation method (Brookshire and Eubanks, 1978; Brookshire and Randall, 1978; Schulze and d'Arge, 1978). The first empirical study can be traced back to 1958 and more studies were done since the 1970s. However, the method only became widely known and used since the Exxon Valdez oil tanker ran aground in Prince William Sound, Alaska (1989). Two groups of eminent economists were asked to undertake an extensive and thorough CV assessment of the non-use damages caused by this disaster (Bateman and Willis, 1999). One study was commissioned by the State of Alaska[7], the other by the Exxon Company because the latter questioned the validity of the CV technique (Hausman, 1993). As a consequence of the disagreement on the validity of the method, the National Oceanic and Atmospheric Administration (NOAA) commissioned an investigation of the CVM. This resulted in a set of explicit guidelines that should be followed in order to perform a valid CVM study (Arrow et al., 1993).

7 The results of this study can be found in Carson et al., 1992.

a) Survey structure

The CVM is solely dependent on survey data. The design of the survey is therefore a key element in determining the quality of the study. The survey has to be pretested in small discussion groups and in a small sample of respondents. This helps to determine whether respondents are likely to correctly interpret the questions, whether response categories are unambiguous and whether visual aids are clear and sufficient (Loomis and Walsh, 1997).

Respondents are best interviewed in person due to the complex nature of a CVM questionnaire.

The survey itself consists of three parts (Mitchell and Carson, 1989):

- The first part gives a precise description of the good that has to be valued and of the hypothetical circumstances under which the public good is made available to the respondent. It also describes the baseline level of provision, the range of available substitutes and the method of payment.
- The second part consists of questions intended to elicit the respondents' WTP for the defined change of availability of the environmental good. An alternative would be asking the respondents' WTA for a qualitative or quantitative change of the good. It is often desirable to ask respondents to specify the reasons for their reported choices, especially when respondents report they are not willing to pay anything. Adding questions about the reason of their zero answer can identify whether their true valuation is zero or whether they protest against the hypothetical market or method of payment.
- The third part of the survey asks for the characteristics of the respondents (e.g. income, age), their preferences relevant to the good being valued and their use of the good. This information is used to explain the WTP of the respondents and to determine the validity and reliability of the CVM as a measuring instrument of WTP for environmental goods.

The answers to the valuation questions provide information on the WTP of respondents. These amounts can then be used to develop an estimate of the benefit of the good.

b) WTP vs. WTA

Asking maximum WTP for an increase in quality of quantity of a good is the preferred approach for determining economic benefits (Loomis and Walsh, 1997). The alternative is to ask for an individual's minimum willingness to accept (WTA) compensation for a decrease in the quality or quantity of a resource. Since WTA is not directly constrained by income, chances are WTA is greater than WTP, which is constrained by income (Loomis and Walsh, 1997; Bishop and Heberlein, 1979) and therefore leads to an overestimation of benefits.

c) Method of payment

How people are asked to pay for a change in the provision of a good determines to a great extent the degree of honesty of their answers. Possibilities include taxes on income or property, voluntary or compulsory donations or contributions, entrance fees for visiting a nature area, hunting permits, ... The NOAA-panel recommends the use of taxes because of their compulsory character.

d) Question format

There are several possibilities to ask for the WTP of a person. Techniques differ in the degree of accuracy, degree of non-response or 'don't know' answers, difficulty of statistical processing, etc.

The most straightforward way of asking is to ask directly what amount a person maximally would be willing to pay for the proposed change. This is called the *open-ended question format*. This is the simplest way to formulate the question and answers can be analysed without further data manipulation. The problem is that it is not straightforward for respondents to answer this question. They are simply not familiar with placing a value on a good that is not traded in a normal market. On the one hand, this leads to a high degree of non-response and protest answers, on the other hand, it creates incentives for strategic behaviour (i.e. stating a higher or lower WTP than the actual WTP) (Desvousges et al., 1983).

The disadvantages of this elicitation format have lead to the development of new techniques taking into account the difficulty for respondents to answer and the possibilities for strategic behaviour without losing valuable information.

The *bidding game* (Davis, 1964) is based on real-life situations in which individuals are asked to state a price for a specific good (cf. auctions). Respondents answer yes or no to an iteration of monetary amounts and this process goes on until the respondent changes his answer. The last (or first) price a respondent accepts is his maximum WTP. The advantage is that this elicitation format directly gives the highest WTP (Cummings et al., 1986). Moreover, due to the iterative character of the approach a respondent has more time to carefully consider his valuation (Hoehn and Randall, 1983). A disadvantage is the possibility of starting point bias implying that the starting bid influences to a great extent the value for the good (Roberts et al., 1985)

Another question format frequently used is the *payment card* (Mitchell and Carson, 1981, 1984). Respondents are shown a card with alternative values and are asked to select their maximum WTP from these values. Sometimes the card provides an indication of what the respondent is already spending on other public goods or services, although the answer can be influenced by these 'benchmarks'. Advantages are: (1) the answer does not depend on the starting bid and (2) respondents only have to answer one question.

The final important question format is the *dichotomous choice question format* (Bishop and Heberlein, 1979, 1980). There are two versions currently in use. The first is the *single bounded dichotomous choice*. The respondent is presented one of a list of previously determined values and is asked whether or not he would be willing to pay this amount for the proposed change. The major advantage of this approach is its simplicity for the respondent. Moreover, it has been shown (Hoehn and Randall, 1987) that this approach minimizes strategic behaviour. The primary drawback is inefficiency. A very large amount of observations is needed for a correct estimate of the WTP. Also, one has to make assumptions about the parametric specification of the valuation function to obtain mean WTP. Finally, the design of the bid amounts requires the greatest care.

A variation of the single bounded is the *double bounded dichotomous choice* (Carson et al., 1986). The respondent is presented with a follow up question with a bid that is dependent on his answer on the first dichotomous choice question. There is a list of several bid values and follow up values. This elicitation method increases the efficiency of the single bounded dichotomous choice and is the preferred format for the NOAA-panel. Studies have shown that the estimated WTP based on this format is lower than based on the single bounded dichotomous choice (Carson et al., 1999).

e) Possible biases of the WTP estimate

Due to the hypothetical nature of the CVM, the method of payment used and other factors, the estimated WTP can be biased. These biases should and can be avoided as much as possible by performing statistical tests during survey design (e.g. after pretesting).

A first possible bias is strategic behaviour of the respondent. This means the respondent 'lies' about his true WTP for the public good because he assumes that, although he states a low WTP, others will not answer strategically and the public good will be provided anyway. Once a forest is created, it is impossible to exclude those respondents that state a lower than their actual WTP. Strategic behaviour can be minimized by stressing the fact that everyone will have to pay, by not giving information on other respondents' WTP and by making the provision of the good dependent on the WTP of the respondents (Mitchell and Carson, 1989).

Other problems are design and information biases. These problems are related to the design of the survey, the way information is presented and the amount and the kind of information that is given previously to the WTP question. Design bias also includes starting point bias (Hanley and Spash, 1993).

Another problem arises from the hypothetical nature of the CVM questionnaire. This implies that incorrect WTP assessments by the respondent will not be punished. The respondent will never actually have to pay his stated WTP.

3.3. OVERVIEW OF BENEFITS AND THEIR VALUATION

Table 2 summarizes the different use and non-use value categories and their valuation methods. The travel cost and contingent valuation method were discussed in detail in this paper, other valuation techniques are not extensively used in this paper and are therefore only briefly mentioned in the table.

Table 2: Benefits and their valuation

BENEFIT CATEGORIES	POSSIBLE VALUATION METHODS
Direct use values: recreation	Travel cost method, Contingent valuation method
Direct use values: hunting, timber	Market approach
Indirect use values: ecosystem	Production cost method, Dose-response method; Damage method
Non-use values	Contingent valuation method

4. CASE STUDY: LOCATION OF NEW (URBAN) FOREST LAND

A methodology was developed to select a combination of potential forest areas (currently agricultural land) in the Ghent region (province of East Flanders, Belgium) that maximizes net social benefits taking into account restrictions on the total surface of new forest land. We assume all newly created forests consist of oak and ash trees and the time period is

200 years (one rotation of oak and two rotations of ash). Our main point of attention was the role of substitutes – both existing and other new forests in determining the recreation value of the potential forest areas. To fulfil the surface restriction, one potential forest area can be included in several combinations of potential forest areas. Therefore, the possible substitutes for its visitors will differ depending on the combination and as a consequence the recreation value of the same forest in different combinations will be different.

In order to limit the number of potential forest areas, we started from the study "Gewenste Bosstructuur voor Vlaanderen" (desired forest structure for Flanders), executed by Mens en Ruimte. Next, we excluded zones on the spatial planning map coloured as valuable ecotopes, legally protected areas (Habitats Directive 92/43/EEC and Birds Directive 79/409/EEC), built-on areas, existing forests, infrastructure, industry and residential areas. Furthermore, ecological arguments like the proximity of existing forests and (non)suitability for agricultural production reduced the total potential forest area even more.

This lead to 14565 ha potential forest area in the whole province of East Flanders which was divided in 113 sites with a minimal surface of 20 ha each. The province was further subdivided into four parts, one of which is the Ghent region in which 32 of the 113 potential forest areas are located (see Appendix A). As it is an objective of the Flemish Community to colour at least 2500 ha new forestland area in East Flanders, proportionally 540 ha (539 – 541 ha) are to be allocated to the Ghent region. This gave us more than 51000 possible combinations of four to eight forest areas out of a total of 32 potential forest areas for which the net social benefits per hectare were calculated for both the combination as a whole and for each forest in the combination.

4.1. COSTS AND BENEFITS OF AFFORESTATION ON AGRICULTURAL LAND

All costs and benefits listed in Table 1 were included in the analysis. Most of the costs and benefits are fixed amounts per hectare of forestland and are independent both of the location of the potential forest area itself and the location of its substitutes. This applies to planting and management costs, timber, hunting, carbon fixation and non-use values. Opportunity costs on the other hand differ according to the characteristics of the soil. This applies to the loss of agricultural production as well as the loss of manure deposition. Consequently, opportunity costs per hectare can differ between forests but are the same regardless of the combination of potential forest areas that particular forest belongs to. Recreation is the only benefit category that is assumed to be both dependent on the location of the forest and the location of its substitutes, which could be either existing or other new forests. The same forest will therefore have a different recreation value depending on the combination that is studied.

An overview of values for the cost and benefit categories is given in Table 3.

Table 3: Costs and benefits ($ha^{-1}year^{-1}$) of afforestation

COSTS		BENEFITS	
Planting and management	€ 38.60	Timber	€ 28.50
Loss of agricultural production	€ -714 - -362	Hunting	€ 15
Loss of manure deposition	€ 457-590	Carbon fixation	€ 25
		Non-use	€ 3680
		Recreation	Av. €1440

The figures show that forest planting and management costs are very modest compared to opportunity costs. On the benefit side we see that non-tangible benefits like non-use and recreation values are far more important than the benefits that are directly perceptible and create direct income for the forest owner (sale of timber and of hunting permits).

As was explained before, recreation values per hectare vary between forests and more importantly they depend on the combination of all potential forest areas a forest area belongs to. A combination of forests that are geographically located close to the same major population centres will each attract fewer visitors than they would when they were located further apart and closer to different population centres. This is the so-called substitution effect.

4.2. RESULTS AND DISCUSSION

We have analysed the maximization problem in two different ways. First, we only take into account the tangible cost and benefit categories (*limited analysis*). This implies we do not take into account carbon fixation, recreation and non-use values. Consequently, for each of the 32 potential forest areas we get one net benefit estimate independent of the combination they belong to. Summing net benefits over the different forest areas in the combination gives the net benefit of the combination or of a fixed surface of forest expansion in the Ghent region. The difference in net social benefits between combinations can be fully ascribed to differences in opportunity costs of the potential afforestation areas, as these are the only cost or benefit categories that have no fixed value per hectare. Opportunity costs per hectare differ between forests, but are not dependent of the combination forest areas belong to.

Next, we include carbon fixation, recreation and non-use values as well (*full analysis*). The difference between the two analyses is that in the latter, combinations do matter. A forest has a different recreation value in combination ‘A’ and combination ‘B’.

The results are presented in Table 4 and Appendix B. Table 4 gives the numbers of the forests areas that are in the ‘best’ and ‘worst’ combination. The map in Appendix B shows the geographical location of all numbered potential forest areas. Looking at the best combination according to the full analysis shows that the potential forest areas are geographically spread throughout the region, but are all located in the southeast to southwest of the city of Ghent where we find the highest population density, i.e. highest number of potential visitors. Just looking at the map of Appendix B, the forest areas in the best combination of the limited analysis are a bit more concentrated either on the southwest or southeast side of Ghent.

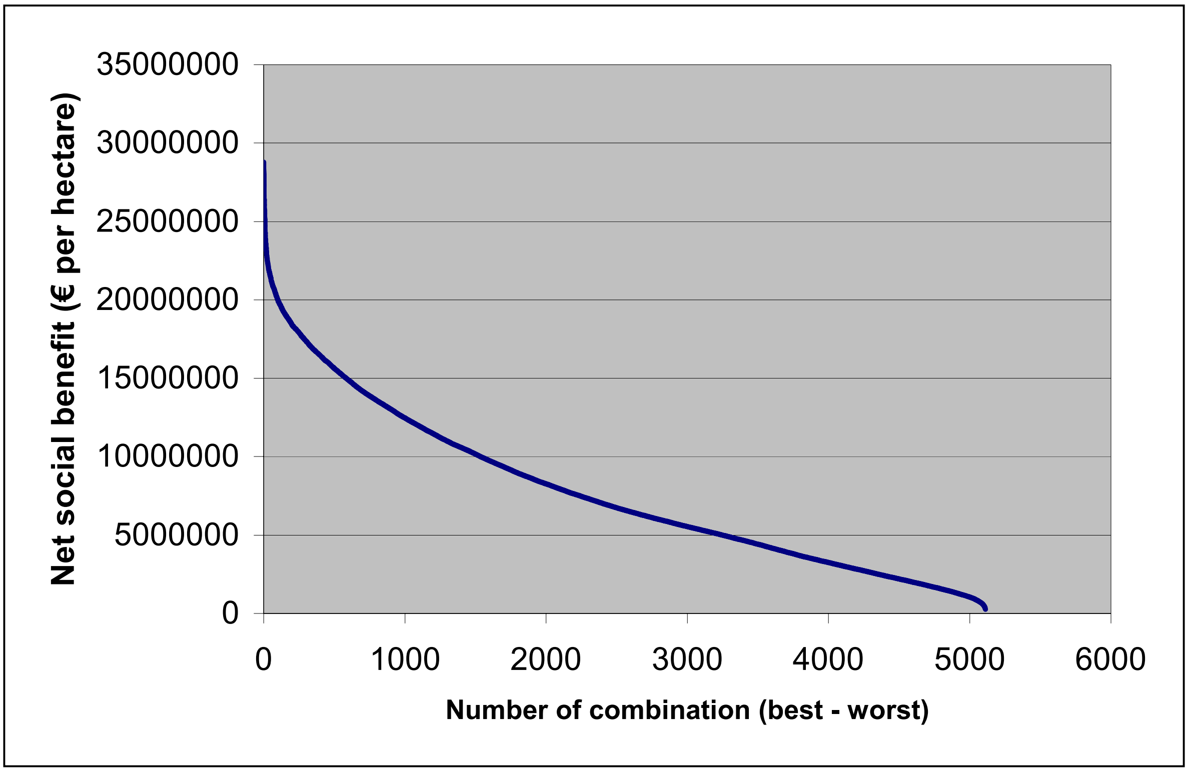
The forest areas in the worst combination of the full analysis are clearly located close to each other at the southwest of Ghent. This implies they are close substitutes in recreation and therefore have low recreation values each, which explains their bad ranking. However, at first sight differences between locations for limited and full analysis seem to be small.

Table 4: Best and worst combinations for the limited and full analysis of the Ghent region

LIMITED ANALYSIS		FULL ANALYSIS	
Best combination	Worst combination	Best combination	Worst combination
1	6	1	4
5	15	6	8
13	16	14	9
24	18	16	29
26		18	
27		24	
30		25	
32		26	

Although results were not clear at first sight, according to the Wilcoxon Signed Ranks test for differences, adding recreation, non-use and carbon fixation values does make a significant difference. Net benefits per hectare for both best and worst combinations are significantly higher for the full analysis. This could also be expected based on the values given in Table 3. Ranking all possible combinations from highest to lowest net benefits (full analysis) shows that the highest net benefit (best combination) is more than 100 times higher than the lowest net benefit (worst combination) per hectare. This is clearly shown on Figure 4, which shows net social benefits per hectare ranked from high to low for every tenth combination (out of the 51000 possible combinations).

Figure 4: Ranking of highest to lowest net social benefit per hectare for combinations of forest expansion projects



Concentrating on the results of the full analysis shows the importance of the substitution effect in estimating the recreational value of a potential forest area. In other words, geographical location of a forest in itself and in relation to other forests matters. The greater the choice of forests a person can visit, the fewer the number of visits to one particular forest, the lower the recreational value of the forest and the lower the net benefit per hectare.

This finding is of great importance for the afforestation policy of the Flemish Community. Afforestation of a certain surface of agricultural land at different locations leads to high variations in the net social benefits per hectare of afforestation. In other words, the same EURO spent on afforestation can create different net benefits.

5. CONCLUSIONS

In this paper we have shown how cost-benefit analysis can be used as a decision support mechanism for the location of new (urban) forest land, starting from the multifunctional role of these new forests.

Cost-benefit analysis is a technique developed to evaluate investments from a social-economic point of view. Key factors of the CBA method are that (i) all impacts for the whole relevant population are taken into account and that (ii) all evaluation occurs on the basis of monetary values. We gave an overview of the costs and benefits of afforestation projects on former agricultural land. Apart from the straightforward costs of tree planting and forest management and the direct revenues from the sale of timber and hunting permits, we have shown the importance of recreation, non-use and option values. We have discussed in detail the most widely used valuation techniques for these non-tangible benefits of forests. Recreation is valued using the travel cost method through the relationship between visit frequency and the price of a visit. Non-use benefits are valued by the contingent valuation method that uses survey questions to elicit people's preferences and willingness to pay for specific changes in public goods.

We have demonstrated how these methods can be used in land use change decisions in a case study for the location of a specific surface of new urban forest land in the Ghent region in the province of East Flanders, Belgium. As the total surface of 540 ha cannot be realized by one forest on one single location, we investigate the net benefits per hectare of combinations of four to eight forests to meet the surface restriction. We have shown the importance of including recreation benefits in the evaluation of afforestation projects. Within the valuation of recreation benefits, we focused on the role of alternative forests in the (recreational) valuation of one specific forest and we have found that this substitution effect is significant in the decision on the location of new forests. Ranking all possible combinations from highest to lowest net social benefit shows that the net benefit of the best combination is more than 100 times higher than the net benefit of the worst combination, or, the same EURO spent on afforestation combinations on different locations can create a wide variation in net social benefits.

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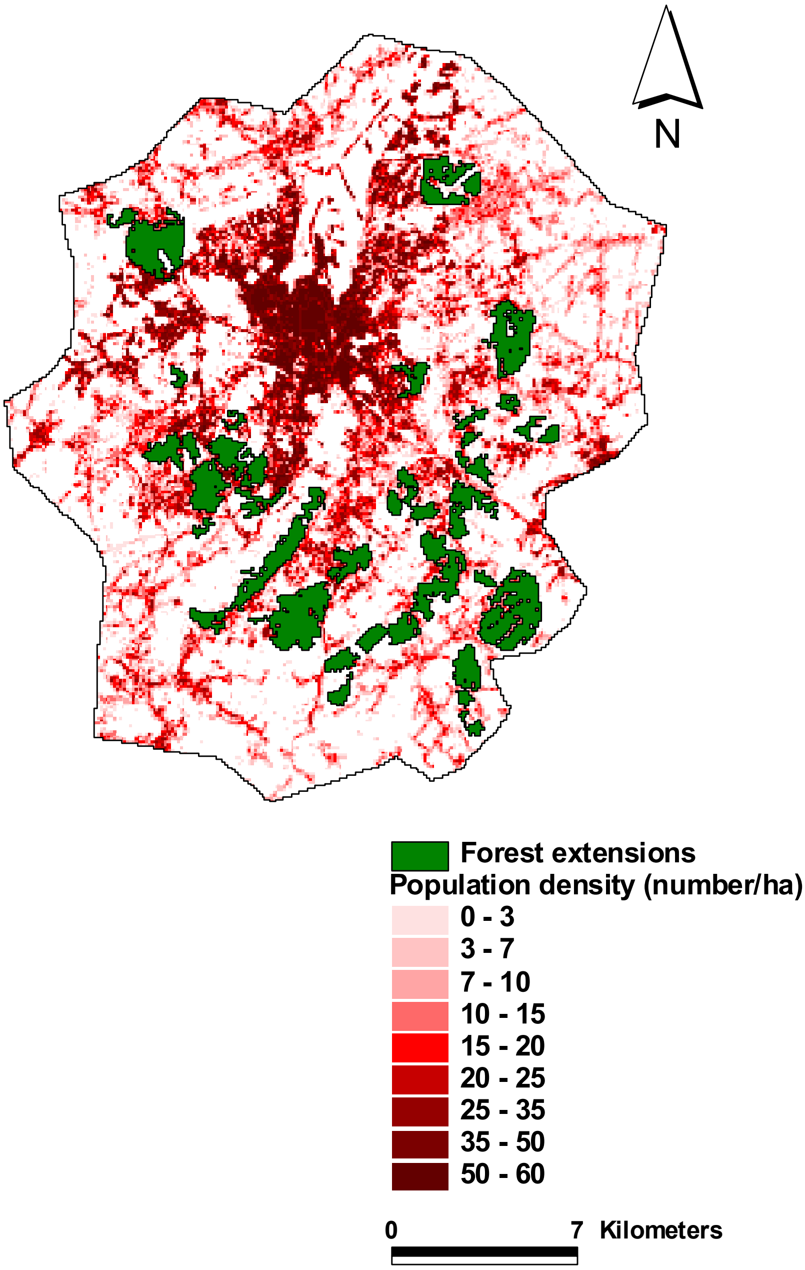
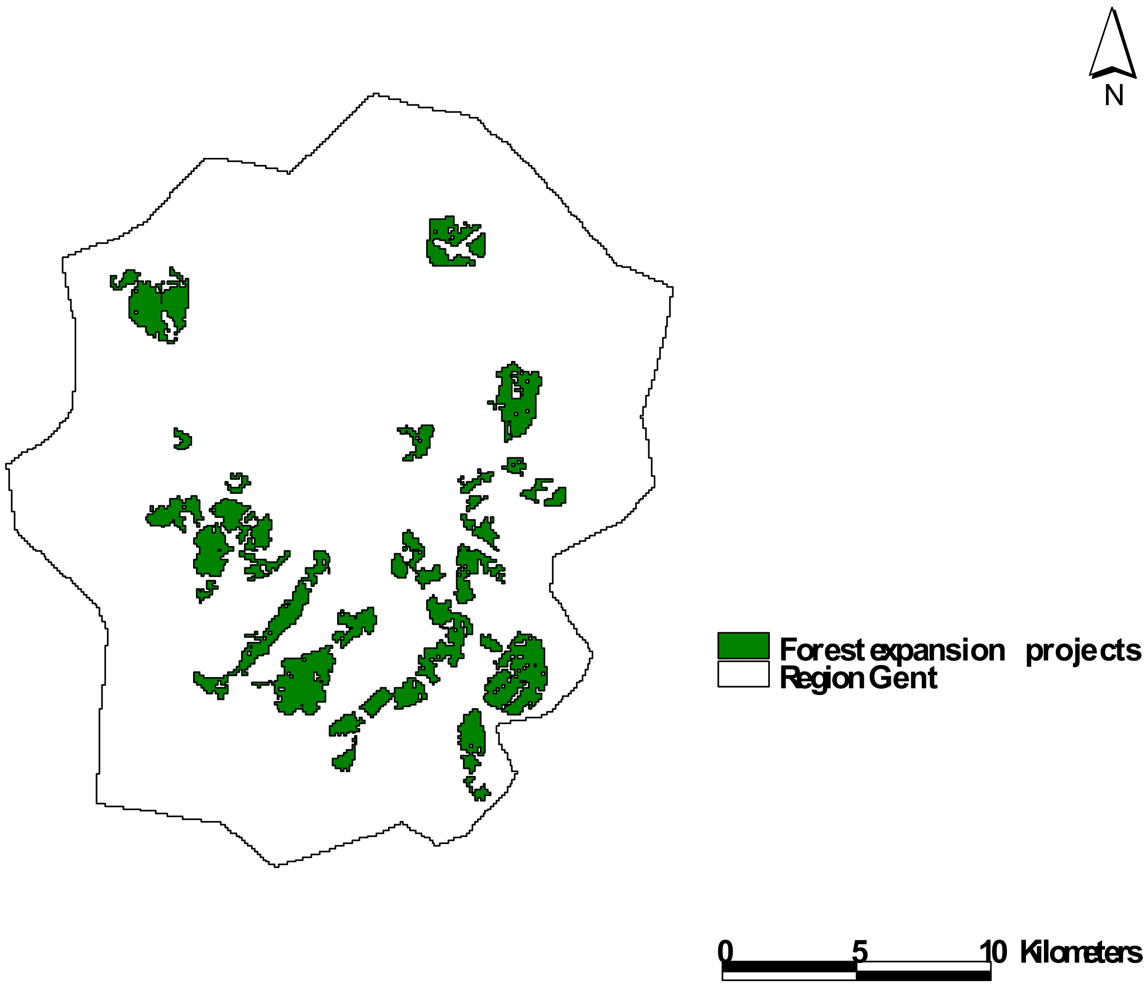
Appendix A : Geographical location of forest expansion projects and population density[8]



[8] Source: Moons et al. (2001).

Appendix B : Numbered forest expansion projects in the Ghent region[9]



[9] Source: Moons et al. (2001).

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