Policy design and the optimal selection of forests in Flanders

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Abstract

This paper analyses the current Flemish afforestation policy and shows that it is not optimal. An important step in improving the afforestation policy in Flanders is the selection of the optimal location of a cluster of new forests as a whole. For this reason, the regulator will select the location that maximises the net social benefits of the afforestation projects. The analysis of the optimal location can provide the regulator with objective criteria, which can be used to develop optimal regulations. It is also worthwhile to consider alternative policies, such as auctions for afforestations projects. To this effect, we investigate several policy options and test these in a real-life example for the creation of new forests in East Flanders.

Keywords: Afforestation / policy instruments / optimal location

1. Introduction

This paper analyses current and alternative afforestation policy instruments in view of the 10.000 ha afforestation goal of the Flemish government. We first select forest sites that maximize net social benefits given a constraint on the total area of new forests and then select policy instruments that yield this optimal combination of sites. Net social benefits include timber yield, hunting, ecosystem, recreation and non-use values deducted by planting and management costs and opportunity costs of foregone agricultural production.

The current policy is based on three pillars: the acquisition of land by the Flemish government, the acquisition of land by local authorities (e.g. city councils), and subsidies for private landowners (mainly farmers). However, this policy is not likely to yield the optimal location of the new forests and thus the highest social value for several reasons. Firstly, the government only buys less productive (farm)land that becomes available on the market, e.g. because of the retirement of its owner. Secondly, subsidies are available for all landowners who meet the requirements and, for this reason, the regulator cannot predict who will use them. Locational aspects obviously are of minor importance. It implies that one already fairly wooded region could potentially increase its forest cover to a much higher extent than scarcely wooded areas, such as highly urbanized areas with a high need for recreation opportunities. It could also imply the creation of multiple small forests of each only a few hectares and thus less interesting from both ecological and recreational point of view. Thirdly, the policy is likely to be expensive for the government. Finally, it is important to analyse the interactions between agricultural and afforestation policies since they are conflicting when pursuing a sustainable environmental policy.

Since the optimality of the current policy is questionable, we suggest alternative policies and test these in a real life example. In our opinion, a first essential step in improving the Flemish afforestation policy is the selection of the optimal location of a set of new forests.

The emphasis lies on the optimal spatial allocation of these new forest from a recreation perspective given the area constraint that cannot be met by creating one single new forest. Similar to Termansen (2004), we find that the location of sites relative to exisiting and other new sites as well as to major population centers is crucial.

Once the optimal location of new forests is found, we examine how the Flemish government can implement it. We investigate several different policy scenarios and check whether they can yield the optimal location of forests. We also calculate the associated costs for landowners and government as well as net social benefits.

Our results allow us to formulate policy recommendations and show that it is worthwhile to consider alternative policy instruments not previously used in Belgian legislation. For example, auctions for afforestation projects can be used to decrease the costs for the government associated with a subsidy system.

In section two we describe the current afforestation policy in Flanders. In section three we look at the decision behaviour of landowners (farmers) and the government. Section four describes methodological issues regarding the selection of forest sites and the selection of an efficient policy instrument. In section five we give an overview of the data that were used and in section six we present and discuss the results for the different policy options and compare them to the optimal and the current situation with a realistic example.

2. Current afforestation policy

The Flemish region is characterized by a low forest cover (< 10% of the land area) and a high population density index (approx. 400 inhabitants per km²). In Flanders, the Long-Term Regional Forest Plan[1] (LTRFP) assumes a forest cover of 12% by the year 2010

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[1] The Long-Term Regional Forestry Plan is a sectorial plan, in which the basic framework of the regional afforestation policy is identified for the future.

(ABG, 2003). These policy targets are very ambitious and therefore unlikely to be met in time. The Land-use Structure Plan of Flanders[2] (LSP) has identified the policy options for the realization of new forests or forest extensions of 10.000 ha by 2007. The Flemish Government is assumed to take a leading role in the realization of this afforestation goal but local administrations and the private sector (agriculture and other) have responsibilities as well. In this paper, we only discuss subsidy schemes for private landowners, in particular farmers, and the purchasing policy of the Flemish government. Since the 10.000 ha goal was set, approx. 206 ha of new forests have been created per year while 126 ha of existing forest has been deforested each year (NARA, 2005). This implies that at the current rate it will take the government 127 years to reach the policy target.

The LSP does not give any guidelines as to the exact location of the new forests. On the qualitative level, the LSP indicates that ecological forest extension should primarily be realized close to existing forests, as a buffer (e.g. between a residential area and an industry zone), or in view of nature development or proximity of urban areas serving as many potential recreationists as possible[3].

2.1 Subsidy schemes for farmers

In order to implement European directives, the Flemish government worked out a subsidy scheme for the afforestation of farmland[4]. Within the framework of the EU Council Regulation No 1257/99 on the support for rural development, support may be granted to

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[2] The Land-use Structure Plan of Flanders (1997) is a new instrument of the Flemish Government for sustainable land-use planning for the next decade. Its main goals are to improve the general quality of life in urbanized areas and to strengthen the open space structures.

[3] It is assumed that – in view of the recreational function of a forest – 1 ha of woodland is needed per 100 inhabitants.

[4] See ABG (2003) for a detailed discussion of the subsidy schemes.

private persons or administrations. More details on the European forest policy can be found in, among others, Bendz (2004) and Pülzl (2005).

The conditions that need to be fulfilled for a Flemish farmer to apply for a subsidy are:

- the parcel of land should be exploited as farmland in the 5 years prior to the subsidy application

- at least 0.5 ha of farmland should be forested

- no deforestation of multifunctional forests for at least 25 years; afterwards the land can only be deforested within the terms of the Forest Decree (Bosdecreet of 13 June 1990)

- plantings of poplar should remain for at least 15 years; afterwards the land can be re-used for farming without any further conditions.

A summary of afforestation subsidies for farmers is given in Table 1. We make a distinction between poplar, deciduous and coniferous trees.

INSERT TABLE 1 ABOUT HERE

2.2 Purchasing policy of the Flemish Government

Forest purchases within the next 40 years will take place within the framework of the LTRFP. The goals of this plan in terms of forest extension and the creation of new forests are set for each of the five Flemish provinces separately taking into account the current forest cover and several criteria such as multifunctionality, fragmentation, urban forests, biodiversity etc.

The purchase policy aims at extending the forest area in Flanders by an average of 625 ha per year[5]. Forests are only purchased by the Flemish Government when a substantial surplus value is created. In other cases a stimulating policy (via subsidies) rather than

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[5] In 2000 the Flemish administration (AMINAL) declared to aim at purchasing 25000 ha of forest by 2040.

purchasing is preferred. Purchasing of land currently used by (economically) sound farms is avoided.

3. Modelling decision behaviour

First, we start by formally describing the decision process of landowners and government. Landowners cultivate their land so that their private income is maximised. The government, on the other hand, looks at the broader picture and wants to maximise the total net benefit of the land under consideration.

3.1 Decision behaviour landowners (farmers)

We assume that each plot of land is owned by one farmer and that land use decisions concern the complete plot as a whole. Landowners are assumed to be risk neutral.

In order to clearly understand the landowners' reaction to specific policies, we explicitly model their decision process (Latacz-Lohmann and Van der Hamsvoort, 1997; Kaplan et al., 2004; Castagnini, 2004). We assume that decisions j on land use $\left(j=0 \text{ for agriculture}; j=1 \text{ for a multifunctional forest}; j=2 \text{ for a poplar forest} \right)$ maximise farmers' private income Y_{ij} obtained from the land parcel i under consideration. This income can differ for each plot depending on its characteristics and its landowner, and it consists of the sum of expected income from agriculture $\left(Y_{ij}^a \right)$, agricultural $\left(s_{ij}^{agr} \right)$ and afforestation subsidies $\left(s_{ij}^{for} \right)$, income from hunting $\left(Y_{ij}^h \right)$ and timber $\left(Y_{ij}^t \right)$, reduced by the manure disposal costs $\left(C_{ij}^m \right)$, planting and management costs $\left(C_{ij}^p \right)$ and taxes $\left(t_{ij} \right)$. Formally the objective function of the owner of plot i is:

$$\max_{j} Y_{ij} = Y_{ij}^a + s_{ij}^{agr} + s_{ij}^{for} + Y_{ij}^h + Y_{ij}^t - C_{ij}^m - C_{ij}^p - t_{ij} \tag{1}$$

Landowners look at income after subsidies (EU agricultural subsidies and others) since this is what interests them. Their income includes these subsidies. Flanders is a small open economy and as such does not influence world prices of agricultural produce and it also does not influence the level of the EU subsidies. Both the government and the farmers can thus take the EU agricultural policy as given. A recent overview of the European agri-environmental policy can be found in Latacz-Lohmann and Hodge (2003). In section 5.1 we discuss the Flemish manure policy and the way we model fertilization decisions made by landowners.

3.2 Decision behaviour government

The government wants to maximise the net social benefit accruing from land-use in the region. Using a utilitarian approach (Sandmo, 2000), net social benefit consists of three terms: the income to landowners, the value of the land to society and the cost of financing the chosen policy. The regulator chooses the optimal land use for each plot, i.e. x_{ij} $(=1 \text{ if land use } j \text{ on plot } i; \text{else} = 0)$ is selected, in order to maximise

$$\sum_i Y_{ij} x_{ij} + \sum_i x_{ij} \left[V_{ij}^R + V_{ij}^E + V_{ij}^{NU} \right] + MCPF \left[\sum_i x_{ij} \left[t_{ij} - s_{ij}^{agr} - s_{ij}^{for} \right] \right]$$

$$s.t. \quad 150 \leq \sum_i \left[x_{i1} + x_{i2} \right] A_i \leq 200$$
$$\sum_j x_{ij} = 1$$

(2)

with V_{ij}^R the recreation value of plot i under land use j, V_{ij}^E the ecosystem value of plot i under land use j, V_{ij}^{NU} the non-use value of plot i under land use j, MCPF the marginal cost

of public funds[6] and A_i the surface area of plot i. The government faces an area restriction: only combinations, which yield a wooded area of at least 150 and at most 200 hectares, are considered. The second restriction to the optimisation problem (2) specifies that each parcel of land can only have one type of use. The land use combination that maximizes total net social benefit given these restrictions is called the optimal location of forest in the remainder of the text.

4. Methods

We evaluate the Flemish afforestation policy and determine how it can be changed in order to improve welfare. First, we have to select those forest sites that maximize net social benefits taking into account the decision behaviour of the landowners as described in section 3 and equations (1) and (2). These net social benefits are the result of subtracting all relevant costs from all relevant benefits for all affected parties in Flanders (OECD, 2006). This is in our opinion a crucial step that is missing in the current Flemish afforestation policy. It implicitly assumes that any forest is a desirable forest. It is, however, clear that not all forests have the same value. Depending on its size and type as well as the distance to other forests and city centres, the increase in welfare brought about by the new forest can differ greatly.

Next we select possible instruments that can yield this set of sites that maximize net social benefits.

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[6] The marginal cost of public funds *(MCPF)* measures the distortions caused by the collection of tax revenue. Each euro of collected taxes leads to a direct cost for the taxpayers (that one euro) as well as an indirect cost due to the less efficient functioning of the economy. After all, the transfer of resources from taxpayers to government alters the consumption and labour decisions of these taxpayers and influences market behaviour.

4.1 Selection of forest sites

First we apply a model to select those forest sites that all together maximize net social benefits (equation (2)) given a constraint on the total area of new forests. The methodology is described in detail in Moons et al. (2005). Net social benefits include all benefits net of all costs for all parties involved: landowners, government and society. We rely on GIS (geographical information systems) for data collection and input.

Landowners (equation (1)) carry the costs of planting and management of either the agricultural use of the land or the afforestation of the land, manure disposal costs (in case of agricultural use of the land) and taxes. They are entitled to the timber yield and selling of hunting permits in case of afforestation and to agricultural or afforestation subsidies. The government (equation (2)) bears the costs of either agricultural or afforestation subsidies as well as the marginal cost of public funds caused by collecting taxes and increases its budget by levying taxes. Society as a whole benefits from afforestation due to recreation, carbon sequestration, other ecological and non-use values created by new forests over and above these values that accrue can be attributed to agriculture.

In the application, we assume that all marginal costs except for manure disposal costs are constant and all costs are additive. Moreover, we assume that all benefits except recreation values of multifunctional forests have constant marginal values and are additive. For non-constant marginal costs and benefits (per hectare and year) there is a geographical interaction between sites. For example, two forests that are located closely together are substitutes since potential visitors will choose between the two.

Recreation benefits of multiple purpose forests are highly dependent on the location of the forest, on the location of its substitute forest sites, which can be both existing and other new forests, and on the regional population density. To estimate recreation benefits of

non-existing multifunctional forest sites, we transfer a zonal recreation demand function that is first estimated for one (or more) base site(s). Here, heverleebos-Meerdaalwoud, a forest in the province of Vlaams-Brabant, serves as the base site. It is up until now the only forest for which a recreation valuation study has been conducted in Flanders (Moons et al., 2000). A zonal recreation demand function, or travel cost model, predicts visit rates in view of the cost of a visit (primarily travel costs), socio-demographic data of potential visitors and surroundings of the site (age, education, professional activity, population density) and the availability and characteristics of other forest sites a person might visit (the so-called subsitutes). Next, we transfer the estimated recreation demand function for Heverleebos-Meerdaalwoud to each of the ten new forest sites in our study region. The transfer of this demand equation gives us an estimate of the number of yearly visits to the new forest site. Further, we calculate the consumer surplus per visit and total recreational value of each forest site. A site may have a different recreation value in the different sets it belongs to due to the varying number of substitutes (see also Moons et al., 2005).

We would like to add that the results might change with different surface constraints due to decreasing returns to scale (especially for recreation values) and increasing opportunity costs of agriculture (when a minimum level of self-support is not met).

4.2 Choice of policy instruments

Having established the optimal location of new forests, the regulator needs to implement a policy and select the most cost effective instrument that will yield this optimal combination of forests. The simplest solution, which is the command-and-control or CAC solution, consists of telling the landowners of the optimal sites to plant forests or face severe penalties. However, this is not a realistic option in a democracy and, for this reason,

we examine several other policy options[7]. We consecutively discuss six possible policies for afforestation in Flanders.

Option 1: Purchasing policy through expropriation

The government could decide to acquire the parcels in the optimal combination through expropriation. This would allow the government to achieve the desired policy goal at reasonable costs and within a short time span. Expropriation in Flanders is, however, only possible if it has a social benefit and if the owner is reasonably compensated. This implies that new legislation is needed that states that 'creating new forests has a social benefit'. This scenario is very unlikely due to the high political costs and will, therefore, be excluded from our case study.

Option 2: purchasing policy at market prices

More realistically, we can assume that whenever pieces of land specified in the optimal location are put up for sale, the government buys them. This can be realised by a system including rights of first purchase. A *right of first purchase* implies that the Flemish government can buy parcels, which are put up for sale, instead of the highest bidder. This only happens on condition that there are no other rights of first purchase. The rights of a tenant or a land consolidation committee always have priority. Notary's offices are obliged to give the Flemish government the opportunity to employ its right of first

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[7] In France forest owners benefit from several tax exemptions and tax allowances (Stenger and Montagné, 2004). For example, young forested areas are temporarily exempted of land tax and the owner's taxable profit is reduced. We, however, do not consider tax incentives and exemptions. After all, according to McCarthy et al. (2003) tax incentives do not significantly influence the private forestation decision in Northern Ireland. A possible explanation is that private forestry in Northern Ireland is dominated by small-scale planters who are unlikely to have significant tax liabilities. Since the same description of private forestry can be applied to Flanders, we do not consider this policy option.

purchase. The government buys the land instead of the highest bidder at the price and conditions specified by this potential buyer.

To obtain the optimal location of forest, the government should only buy land that is part of the optimal combination. This implies that the government needs to wait until these parcels are put up for sale. In our application, we assume that each period parcel i is put on the market with an exogenous probability p_i. This probability is determined, among other things, by the farmer's need of cash, by retirements or inheritances. The government only buys parcels that belong to the optimal combination of forests. This implies that, in the first period, the government has a probability of $\prod_{i \in OPT} p_i$ of acquiring the optimal location for the forest expansion; with *OPT* the set of all parcels belonging to the optimal combination. Obviously, it can take a very long time to optimally create forests using this instrument. It is also a rather expensive way of acquiring the desired forests since the government needs to pay the market price. Moreover, the government becomes owner of the lands and needs to manage and maintain them.

Option 3: Subsidies for specific locations

Can the government decide to only subsidise forests planted at the optimal locations? Subsidies are only legally binding when written down in a law, which determines the necessary requirements that need to be fulfilled in order to apply for the subsidy. These conditions need to be objective criteria[8] and citizens who meet them cannot be excluded arbitrarily (discrimination principle). It is, nonetheless, possible to specify a total budget and work on a 'first come, first serve' basis. It is, therefore, not legally possible to only subsidise the owner of parcel X on an individual basis and not the owner of parcel Y.

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[8] The criteria used to allocate the subsidies need to be effective, i.e. they need to promote the goal of the subsidy policy. They also need to be general, i.e. not specifically tailored for one case.

Given the optimal location of forests, the optimal subsidy policy would be:

$$s^{for} = \max_{i \in OPT} \left\{ Y_i^{agr} - Y_i^{for} \right\} \qquad for \, i \in OPT$$
$$= 0 \qquad for \, i \notin OPT$$

(3)

This optimal subsidy policy cannot be specified as such since 'belonging to the optimal combination' is not a general and objective criterion. The government can, however, specify the criteria for afforestation subsidies with the view of matching the optimal location as closely as possible. For this reason, it is interesting to look closely at the optimal allocation and find which factors (population density, soil conditions, type of farm…) drive the results.

McCarthy et al. (2003) note that upfront payments paid in the early years of planting may be both a persuasive and cost efficient method of increasing the level of private forestry planting. This is because the planter receives the payments immediately and they do not suffer from any risk of changes in government policy or from devaluation due to inflation.

Option 4: Subsidy scheme combined with purchases

Mimicking the current policy in Flanders, the government could also decide to combine the subsidy scheme for specific locations with a purchasing policy. This provides the option to buy certain parcels of land and convert them to forests, if the current landowners are unwilling to use the subsidies provided.

Option 5: Subsidy and tax scheme

The Flemish government can also combine subsidies with taxes. They can provide a subsidy to the farmer who decides to plant a forest. If, on the other hand, the land is used for agriculture, then the farmer has to pay a tax proportional to the number of acres that were not forested. Instead of a tax, the government could also decide to reduce the agricultural subsidies. The conditions for the subsidy can depend on various factors such

as the distance to existing forests or the soil type. Using this policy would reduce the costs to the government substantially because it also receives tax revenues (or a decrease in agricultural subsidies).

Formally we have, on the one hand, if the farmer decides not to plant a forest, a tax t_{i0} must be paid. On the other hand, if a forest is planted, a subsidy s_{i1}^{for} is granted. We also assume that $t_{i1} = s_{i0}^{for} = 0$. The following conditions must hold to obtain the optimal location of forests:

$$
\begin{aligned}
Y_i^{agr} - t_{i0} &\leq Y_i^{for} + s_{i1}^{for} \quad if\ i \in OPT \\
Y_i^{agr} - t_{i0} &> Y_i^{for} + s_{i1}^{for} \quad if\ i \notin OPT
\end{aligned}
\tag{4}
$$

with Y_i^{agr} net income if the land is used for agriculture $\left(Y_i^{agr} = Y_{i0}^a + s_{i0}^{agr} + Y_{i0}^h - C_{i0}^m\right)$ and Y_i^{for} net income if a forest is planted $\left(Y_i^{for} = Y_{i1}^h + Y_{i1}^t - C_{i1}^m - C_{i1}^p\right)$. A possible solution for the tax and subsidy rate is:

$$
\begin{aligned}
s_{i1}^{for} &\geq Y_i^{agr} - Y_i^{for} & if\ i \in OPT \\
&= 0 & if\ i \notin OPT \\
and & & \\
t_{i0} &< Y_i^{agr} - Y_i^{for} & if\ i \notin OPT \\
&= 0 & if\ i \in OPT
\end{aligned}
\tag{5}
$$

It is only possible to obtain these tax and subsidy rates if the optimal parcels are distinguishable from non-optimal parcels using objective criteria (see also Option 3: Subsidy scheme).

Option 6: Auctions

Auctions are a method frequently used in procuring commodities for which there are no well-established markets. Auctions are of particular interest for conservation contracting for at least two reasons (Latacz-Lohmann and Van der Hamsvoort, 1997). First, the traded item, the provision of environmental benefits, is a public-type non-market good which has

no standard value. Second, there is an information asymmetry present in that the farmers know better than the program administrator how participation would affect their production plans and profits. Auctions therefore enable the participants to deal with uncertainty about the object being sold. A recent overview of how auctions can be used in conservation programs can be found in Rousseau and Moons (2006).

In a discriminatory first-price sealed-bid auction farmers can ask the amount of subsidies (=bid) they would like to receive for converting their farmland into forest. This implies that the n lowest bidders are rewarded and receive the payment stated in their bids. The regulator will need to set a reserve price (i.e. a maximal acceptable bid) to induce farmers to reveal their bids truthfully (Myerson, 1981). After all bids are made, the regulator will calculate the optimal cluster of new forests and accept the bids of all landowners that belong to that optimal combination. The farmers do not know in advance the outcome of this optimisation exercise and assume that the probability distribution of winning the auction is equal for all participants. Calculating the optimal location of new forests implies that the government knows the costs and benefits of forestry and agriculture for the different farmers. Landowners, who ask more subsidies than necessary to cover the costs of conversion, will have a zero probability of having their bid accepted. Since it is irrational to bid less than the land conversion costs, farmers will in equilibrium bid precisely enough to cover their costs (Latacz-Lohmann and Van der Hamsvoort, 1997, Cattaneo et al., 2006):

$$b_i = Y_i^{agr} - Y_i^{for} \tag{6}$$

These bids allow the government to reach the optimal combination of forests at a lower cost than with a subsidy scheme.

5. Data

We mostly use GIS-based data. This is the case for the selection of the new forest sites, for the distances between the sites, for the manure disposal and socio-economic characteristics. Other data are derived (or transferred) from relevant Flemish studies or databases where possible.

Each selected site is either planted with poplar (with a rotation cycle of 25 years) or is laid out as a sustainable managed multifunction forest (with a rotation cycle of 150 years).

All costs and benefits for all parties – landowners, society and government - and for all three types of land use are calculated as annuities over a period of 150 years, since this is the rotation cycle for multifunctional forests (Garcia Quijano et al., 2005). All figures are in EURO 2000 and we use a discount rate of 2.5%.

5.1 Setting

The study area in this paper is Wetteren-Aalst, a suburban region in East Flanders with a low forest index. Ten agricultural sites are marked as potential locations for new forests. For reasons of convenience we assume that the ten sites are each owned by one single farmer[9] and that decisions on land use change apply to the site in its entirety. The farmer might have farmland on other locations or might have cowsheds, sties or folds that are not affected by the afforestation of the farmland in our dataset. Two soil types are present in our dataset: loam and sand-loam. For more site information see Appendices 1 and 2.

In line with policy objectives, 150-200 ha of new forestland is allocated to this region. All subsets of ten sites within the region that meet this area constraint are compared with respect to their net social benefits. Over 24000 subsets of at least 2 and at most 7 sites (out of 10 sites) each meet the 150-200 ha area constraint.

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[9] This is reasonable since the average farm size in the province of East Flanders is approx. 30-40 ha.

As all new forests will be planted on agricultural land, net social benefits of forests need to be compared with the value of the current agricultural use of the land. Three branches of agriculture are present in our dataset: crop farms, crop combined with pig farms, and crop combined with grazer (excl. dairy cows) farms. For ease of exposition we use the terms pig farms and grazer farms for the last two categories in the remainder of the text. Net income differs substantially according to the branch of agriculture a site currently belongs to[10]. Crop farms create the highest yearly net income (647 Euro/ha), followed by pigs (549 Euro/ha) and grazers (473 Euro/ha). The net private income includes agricultural subsidies and excludes taxes. Other costs per hectare of land include implicit wages for the farmer, wages paid to third parties, machinery depreciation, maintenance, purchased and self-produced feed, seeds, pesticides, fertilizers, capital costs (CVL, 2000)

Excessive manure production is a serious environmental problem in a densely populated area such as Flanders. Use of the soil for agricultural production allows limited spread of manure on the agricultural land[11]. Manure standards have become more stringent over the last decades. Emission limits for nitrogen and phosphate differ per parcel of land in function of soil type, as well as protection laws for area and ground water and type of crop. The measures included in current Flemish manure policy can be divided into three categories: measures aiming at the source of the problem, instruments to improve fertilizer use and finally manure processing and export (Vervaet et al., 2004).

Therefore, we model in a detailed way the manner in which the farmers dispose of the manure produced. We assume that grazer farms are able to spread their manure completely on their own land. Their manure deposition costs are therefore assumed to be zero. Crop farms do not produce any manure. Pig farms, in contrast, cannot spread all produced

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[10] See Centrum voor Landbouweconomie (2001).

[11] On average 27 tonnes can be spread on one hectare of agricultural land in East Flanders.

manure on their own land. We assume that they have an agreement with crop farms and that they can spread their excess manure on cropland. The cost associated with spreading fertilizer on cropland equals the transportation cost and we assume that the cost of one trip by tractor of 10 tonne manure equals 12 Euro[12].

We assume that, when the farmland is afforested, farmers loose all their agricultural income from that piece of land. As other parcels of farmland or stables owned by the farmer are unaffected, part of the farmers' income will be preserved. Manure produced by the grazers and pigs is spread on remaining agricultural land or disposed of in an alternative way, both of which are costly. If farmers are no longer able to spread their manure on land (at a cost of 1.2 Euro/tonne) due to afforestation, the cost of industrial processing equals 12 Euro/tonne. Including the processing of manure into the model, implies that the farmers' afforestation decisions cannot be examined independently of each other. If crop farmers decide to plant trees on their land, there will be less land available for spreading the pig manure and pig farmers will have to dispose of their manure in another, more costly, way. Since crop farmers do not consider this externality when deciding on land use, their decisions are not always socially optimal.

If the site is afforested, a farmer's income will depend highly on which other sites are afforested due to the change in available land for spreading manure. It might even become negative once more expensive industrial processing of manure is necessary. The lowest (highest) net private farmer's income is -4738 (544) Euro per hectare and year for a pig farm, -1259 (473) for a grazer farm and -364 (647) for a crop farm. The net income per hectare of land of a crop farmer is fixed as he does not have any manure to dispose of and is thus independent of the afforestation decisions of other sites.

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[12] We assume that the fuel use of a tractor is 0.5 liter per km (Rathwell et al., 2000), that the price of diesel is 0.3 Euro/l, that the other costs equal 1.05 Euro/l (Rathwell et al., 2000) and that the average trip is 10 km.

Besides agricultural products, agrarian land produces benefits such as recreation, hunting, carbon sequestration, non-use and ecological values. Hunting values for agrarian land are assumed to be half of the value for multifunctional forests and amount to 8 Euro per ha and year (Moons et al., 2000). Carbon uptake was simulated for agricultural land by Garcia Quijano et al. (2005). As agriculture serves as the benchmark land use, we assume a zero value for carbon sequestration. For data on recreation, non-use and ecological values of agrarian land, very few sources are available. We use data from a Swedish contingent valuation study from 1992 (Drake, 1992). He studies open and varied agrarian landscapes and finds an annual value of 193 Euro per hectare and year for recreation, non-use and ecological values combined[13].

Depending on the afforestation policy scheme, the farmer either receives a subsidy for afforesting the land himself or he sells it to the government. We assume that the price for a hectare of farmland in East Flanders is 25000 Euro[14]. In the latter case, the government is responsible for all costs and entitled to all future yields, in the former case both costs and yields accrue to the farmer who is still the landowner.

5.2 Alternative land uses

We discuss two types of land use: planting poplar forests and creating a sustainable multifunctional forest.

5.2.1 Poplar forests

A site is planted with the best available poplar clones and managed according to the best available management scheme (see also Garcia Quijano et al., 2005). We assume a 25-

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[13] Annuity, Euro 2000.

[14] This is the average of ten parcels of farmland put up for sale on the largest Belgian real estate website www.immoweb.be. We use the annuity of this value over 25 years at 2.5 %, i.e. 1357 Euro/ha.

year rotation cycle. After 25 years, stumps are removed and the plantation is re-established. For reasons of comparability, we assume six consecutive rotations with a total duration of 150 years.

Timber yields depend on the type of soil. On average timber yields amount to approx. 202 Euro per ha and year (Garcia Quijano et al., 2005). Other types of (non-tangible) benefits produced by poplar forests include hunting (8 Euro per ha and year) (Moons et al., 2000), recreation, non-use and ecological values (320 Euro per ha and year) (Drake et al., 1992). The value per tonne of carbon sequestered is estimated at 10 Euro (CIEMAT, 1999). For a total of approximately 29 tonne of carbon sequestered per hectare (Garcia Quijano et al., 2005) compared to 0 tonne of carbon uptake in the benchmark (agricultural land use), this amounts to 292 Euro per ha and year. Planting and management costs accrue to 99 Euro per ha and year (Garcia Quijano et al., 2005).

5.2.2 Sustainable multifunctional forest

A sustainable managed multifunctional forest is a forest where wood production is combined with high ecological and recreational values, characterized by long rotations (i.e. 150 years), managed with a thinning frequency of 10 years and regenerated with a group selection system (Garcia Quijano *et al.*, 2005). We assume a former agricultural site is planted with a mixed oak-beech forest, both native tree types. Thinnings in oak/beech begin at age 40 with a frequency of 10 years. Final harvesting takes place in the year 150. Timber yields as well as the sale of (small game) hunting permits are benefits accruing to the landowner. Other non-tangible benefits include carbon sequestration, other ecological values, non-use values and recreation.

Timber yield accrues to 5 Euro per ha and year on average (Garcia Quijano et al., 2005). These values are much lower than for poplar plantings as harvesting takes place at a later point in time. Hunting values for multifunctional forests are twice the value for poplar

plantings (15 Euro per ha and year; Moons et al., 2000). Carbon sequestration values amounts to 69 Euro per ha and year (or 6.88 tonnes of carbon valued at 10 Euro per tonne; Garcia Quijano et al., 2005 and CIEMAT, 1999), other ecological values amount to 52 Euro per ha and year (Garrod and Willis, 1997) and non-use values are estimated at 3860 Euro per ha and year (Moons et al., 2005). The average[15] recreation value for each of our ten study sites varies from 314 to 2268 Euro per ha and year. These are average figures as the exact recreation value per forest depends on the set of forests it belongs to.

Planting and Management costs are assumed to be 24 Euro per ha and year (Garcia Quijano et al., 2005). This number is quite high compared to timber yield which can be explained by the difference in timing these costs and benefits appear. Costs are high at the beginning of a rotation, benefits are high at the end of a rotation.

Kniivilä et al. (2002) find a present value of 217 million Euro for non-market benefits of forest conservation in Finland. Non-market benefits here include non-use values such as existence and bequest values of habitats and species as well as use values related to actual and potential recreational use

6. Results and discussion

In reality the implementation of the Flemish forest policy happens at a very slow rate and the policy targets are not being met in time (NARA, 2005). One possible explanation can be found in Latacz-Lohmann and Van der Hamsvoort (1997). These authors state that farmers in the EU have proved to be reluctant to participate in conservation programs, such as afforestation programs, because they fear that the government will not allow them to alter the management changes after the contracts have expired.

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[15] Average over all combinations a particular site belongs to.

6.1 Selection of new forests

Applying the methodology explained in section 4.1 combined with the data from section 5, we find that the optimal combination of new forests consists of sites 1, 2, 9 and 10. Sites 1, 9 and 10 are currently used for crop farming whereas site 2 is used for grazing. Site 2 is the largest in terms of surface area (64 ha), while site 9 measures only 22 ha. Population density around sites 1 and 2 is higher than the average for Flanders, sites 9 and 10 are situated in far less densely populated areas. For more information on these sites see Appendix 2. Their geographic location is marked on the provincial map in appendix 1.

6.2 Comparison of policy options

In this section we first look at the differences in social welfare between the current subsidy policy and the optimal command-and-control (CAC) policy. This command-and-control policy implies that the government orders the farmers belonging to the optimal combination to plant multifunctional forests on their plots and the farmers fully comply. The farmers are still the owners of the land and are responsible for all planting and management costs without any compensation from the government. Secondly, we consider several policy options to implement the optimal combination of forests. Finally, we investigate what happens if transfers between agents are no longer costless.

6.2.1 Current subsidy policy versus optimal CAC policy

First we apply the current Flemish subsidy scheme to our benchmark and observe which farmers will participate. For the specified subsidy amounts farmers 1, 9 and 10 decide to plant forests. If the current subsidy scheme is imposed, then social welfare (see equation (2) with $s_{i1}^{for} = 765 \, € / ha$ and $s_{i0}^{for} = t_{i0} = t_{i1} = 0$) increases with 881 968 Euro compared to not having a Flemish afforestation policy. The optimal policy

$\left(with\, s_{i1}^{for} = s_{i0}^{for} = t_{i0} = t_{i1} = 0 \right)$, which ensures that the new cluster of forests is planted at its optimal location, increases social welfare by 220 102 Euro, i.e. 25 percent. This implies that the current afforestation policy in Flanders is not optimal and that there is room for improvement.

In order to identify the possibilities for policy reform, we investigate the differences between current subsidy and optimal CAC policy in table 2. The current subsidy amount, if we model the landowner's behaviour as in equation (1), induces only three (out of ten) farmers to plant forests while the optimal policy involves four landowners. Surprisingly the optimal location of forests has a slightly lower recreational value to Flemish consumers than the present policy. However, the increase in non-use, ecological and carbon sequestration benefits compensates for the loss in recreational value under the optimal policy. Note that it is never socially optimal to plant poplar since these forests have only a limited advantage over agriculture and have higher associated costs. The advantages of poplar plantings, however, may increase once their potential for substituting fossil fuel as a source for electricity production is fully acknowledged.

6.2.2 Implementing the optimal CAC policy

As we mentioned in section 4.2 it is not politically feasible in Flanders to dictate the landowners of the optimal parcels to plant forests. In order to obtain the optimal cluster of forests, we need regulation that respects the Belgian constitution and international agreements. To this end, we look at the different policy options that were previously discussed in section 3. We do not include option 1 since expropriation is a highly unlikely scenario.

INSERT TABLE 2 ABOUT HERE

First we discuss the second option, which is the optimal purchasing policy. In the empirical exercise we chose the probabilities p_i ad hoc and the probability that the optimal combination of plots is acquired by the Flemish government is zero for our example since we assume that parcel 10 is never put up for sale (appendix 2).

The third policy option looks at subsidies for specific locations. In our illustration, the subsidy for optimal parcels is: 911 Euro/ha of multifunctional forest for crop farms and for farms with grazers. This subsidy scheme induces all crop farmers (farmers 1, 9 and 10) to plant a forest, while only one farmer with grazers (farmer 2) does so $\left(Y_2^{agr} \leq Y_2^{for} \right)$. The other two farmers with grazers (farmers 4 and 8) do not use the subsidy since they have more manure to dispose of $\left(Y_{4/8}^{agr} > Y_{4/8}^{for} \right)$. The optimal subsidy is almost 20 percent more than the current annualised subsidy of 765 Euro/ha (see table 1).

In the fourth policy option, we assume that the optimal subsidies from option 3 are complemented with a right of first purchase. We include this option in order to mimic the current afforestation policy, which includes both subsidies and purchases. Given our assumptions, purchasing the land is more expensive for the government than subsidizing afforestation projects. For this reason, the government will only buy the necessary land if the farmer does not take participate in the subsidy program.

The fifth option was the revenue-neutral subsidy-tax scheme. If we combine the optimal subsidy from option 3 with a revenue-neutral tax (or a reduction in subsidies) for farmers who favour agriculture, six landowners (1, 2, 4, 8, 9 and 10) would plant forests. This policy specification would, however, not satisfy our area constraint. The resulting forests would cover 243 ha (>200 ha). Therefore, we opt to offer a subsidy of 910.8 Euro/ha to crop farmers and a revenue-neutral tax of 324 Euro/ha for agricultural land users. This leads to the creation of three forests on land parcels 1, 9 and 10. We are unable to find an objective criterion to induce farmer 2 to cease farming while at the same time convincing

farmers 4 and 8 to continue with agriculture. It appears to be impossible to optimally locate the new forests using this policy option and this will lower net social benefits (see figure 1).

INSERT FIGURE 1 ABOUT HERE

Finally, the auction scheme induced farmers to exactly the amount of subsidies that would allow them to cover their conversion costs of switching from agriculture to forestry. The government can thus reach the optimal combination at a lower cost than through a subsidy scheme.

6.3 Costly transfers

We were able to obtain the same level of social welfare with the policy options 3, 4 and 6 as the optimal CAC policy (see figure 1). The underlying reason is that subsidies and taxes are treated as costless transfers between different agents[16]. We assume that the government can collect funds at zero cost, i.e. the marginal cost of public funds equals one. Obviously, when we relax this assumption and assume a marginal cost of public funds of 1.5, it becomes important how much a policy costs for the government. Policies that are costless or even raise revenues are preferable to more costly options (see figure 2). This implies that option 5, the subsidy-tax scheme, becomes more advantageous since it is designed as a revenue-neutral policy. However, if the government does not want to tax farmers and since the CAC policy is politically infeasible, the auction policy is the best

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[16] We do not consider the difference in rule making, implementation, monitoring and enforcement costs between the different policy instruments. By including these costs for the Flemish textile industry, Rousseau and Proost (2005) show that emission standards can obtain a higher social welfare than emission taxes under certain circumstances. Since we have no reliable estimates of these costs for the current policy exercise, we were not able to include them.

option. If the auction can be optimally designed, it can substantially decrease government expenditures and increase welfare compared to subsidy or purchasing schemes.

INSERT FIGURE 2 ABOUT HERE

7. Conclusion and policy recommendations

Before deciding which afforestation policy will be developed, it is welfare improving to calculate the optimal location of new forests. The analysis of the optimal location can provide the regulator with objective criteria, which can be used to implement an optimal policy. Currently, the Flemish government supposedly only buys land for forest expansion when a substantial surplus value is expected. However, an objective and clear definition of this substantial surplus value has not been incorporated in existing legislation. Our empirical illustration shows that the welfare gain is considerable if the afforestation subsidy is conditioned on an objective criterion rather than a case-by-case approach.
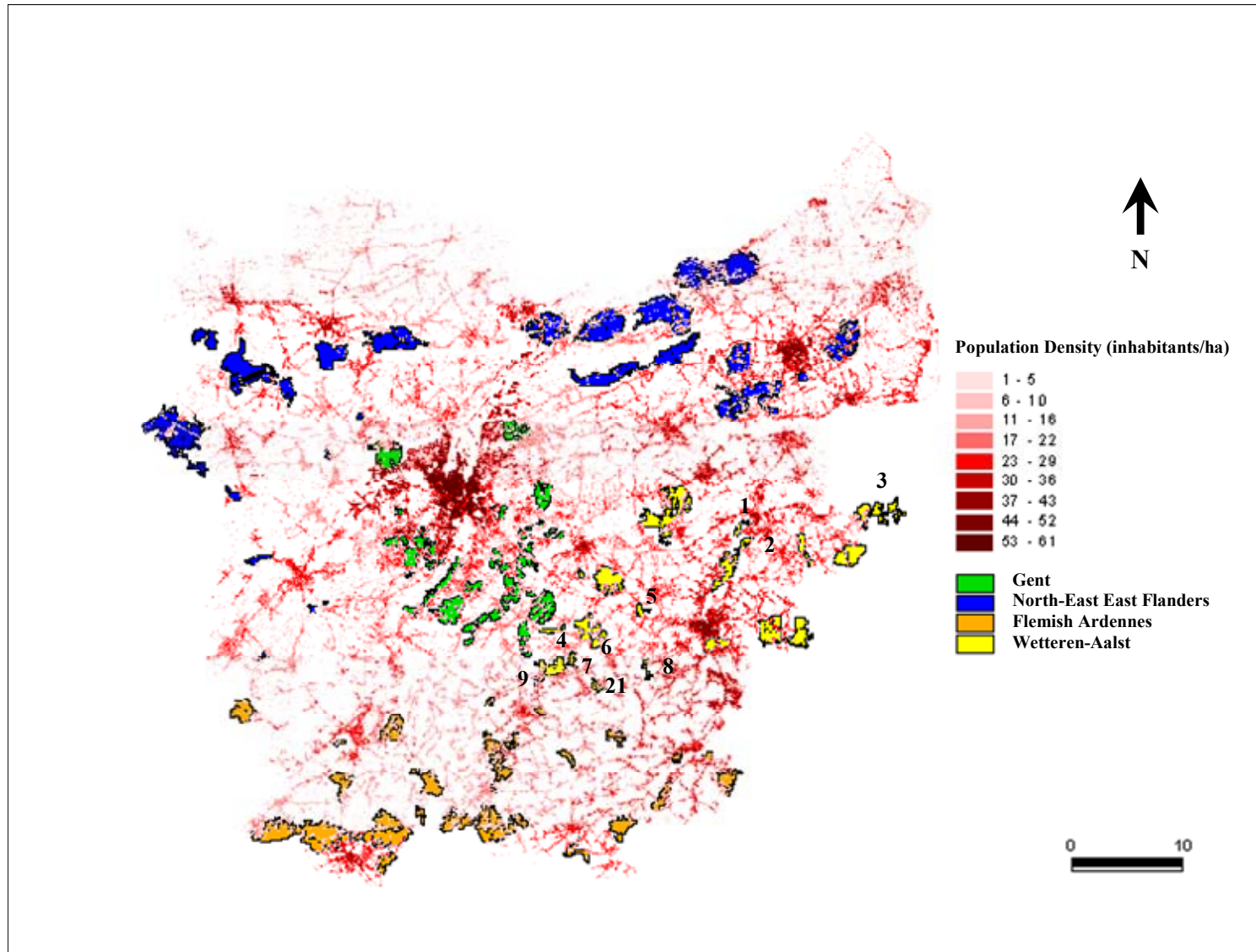
The calculation of the optimal location of a cluster of forests rather than locating individual forests separately is essential when externalities and interdependencies are present. Recreation benefits, for example, differ according to the number of substitutes available and depend on the location of all newly planted forests. The problem of manure deposition can also lead to negative externalities when farmland is used to spread manure of other farmers. The interactions between existing forests, new forests and agriculture need to be considered in order to correctly calculate the net social benefit of the afforestation policy.

The current subsidy scheme stipulates a minimal area constraint of 0.5 ha. Since recreation seems to be a driving force in the Flemish afforestation policy and given its crucial role in selecting multiple forest combinations, forests should have a minimal area surface of several hectares. The recreation value of forests increases dramatically once a threshold of

several hectares is crossed. Keeping this in mind, planting uniform poplar forests is by far less interesting than more complex forest structures. When designing a subsidy policy, the regulator should take the asymmetric timing of costs and benefits into account. The largest part of the cost burden falls at the beginning of the forest rotation whereas benefits only start to accrue after several years. The problem of the cost burden can be mitigated by upfront payments of subsidies. To fully capture the benefits, the current planning horizon of 25 years (for a deciduous forest) is rather short. The political planning horizon is likely to be even shorter since the time to the next elections is of critical importance to most politicians. Ideally, the government should consider the whole rotation cycle (of 150 years for a deciduous forest).

It also seems worthwhile to consider auctions for afforestation contracts. This instrument has not been previously used in Flanders but it has proven its worth in the US Conservation Reserve Program (Latacz-Lohmann and Van der Hamsvoort, 1997). In order to reap the possible benefits, the auction needs to be adequately designed.

Appendix 1: map of East Flanders and the study area Wetteren-Aalst

Population Density (inhabitants/ha)
1 - 5
6 - 10
11 - 16
17 - 22
23 - 29
30 - 36
37 - 43
44 - 52
53 - 61

Gent
North-East East Flanders
Flemish Ardennes
Wetteren-Aalst

Appendix 2: overview and main characteristics of the potential forest sites

Site Number	(Surface) Area	Soil Type	Prob. of sale	Population Density (15 km zone around land parcel)	Number of substitute forests within _km distance (surface area between brackets)				Current Land Use: Agricultural Branch
					2	2-5	5-10	10-15	
1	47	Sand	0.1	476.47	1 (70)	0	3 (648)	5 (799)	Crop farm
2	64	Sand	0.2	504.82	1 (60)	0	5 (949)	3 (498)	Grazer farm (excl. milch cows)
3	101	Sand	0.01	511.32	0	1 (179)	0	3 (312)	Pig farm
4	35	Sand-Loam	0.05	226.21	0	3 (143)	3 (188)	2 (535)	Grazer farm (excl. milch cows)
5	27	Sand-Loam	0.03	416.43	0	2 (107)	6 (724)	4 (130)	Pig farm
6	48	Sand-Loam	0.15	314.00	0	5 (325)	2 (145)	2 (469)	Pig farm
7	44	Sand-Loam	0.02	246.52	0	4 (212)	2 (120)	1 (119)	Pig farm
8	26	Sand-Loam	0.1	340.70	0	3 (179)	4 (282)	5 (781)	Grazer farm (excl. milch cows)
9	22	Sand-Loam	0.5	154.97	0	2 (137)	3 (175)	1 (62)	Crop farm
10	49	Sand-Loam	0	263.66	0	3 (175)	3 (157)	1 (119)	Crop farm

Acknowledgments

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Tables

Table 1: Subsidies for afforestation of farmland (Euro per ha and per year unless mentioned otherwise)

	Poplar	Deciduous trees	Coniferous trees
Planting: basic subsidy	850	1500[17]-3700[18]	1000
Planting: undergrowth	500	500	500
Planting: border (bushes or deciduous trees)	100 per100m	100 per 100m	100 per 100 m
Maintenance	1100	1750	875
Supplement 1: land in forest or forest extension area (according to LSP)	250	250	250
Supplement 2: recommended origin (native species)	250	250	250
Income compensation	375 for 5 years	500 for 20 years for native tree species, 375 for 5 years otherwise	375 for 5 years

[17] Wallnut, false Acacia, American Oak, sweet Chestnut.

[18] Summer Oak, Winter Oak; for other native deciduous tree species one receives 2000, 2500 or 3000 €/ha.

For a complete list see Afdeling Bos en Groen (2003).

Table 2: Comparison between current subsidy and optimal CAC policy

|	Current subsidy policy	Optimal CAC policy
Forested area (in ha)	118	182
Number of forests	3 (1, 9 and 10)	4 (1,2,9 and 10)
Type of forests	Multifunctional	Multifunctional
Net farmers' income (euro)	-13 716	-162 209
Government revenue (euro)	-47 267	67 118
Net recreational value (euro)	473 221	472 663
Net non-use value + net ecological value + net carbon sequestration (euro)	469 729	724 498

Figure 1: Comparison of the different policy options
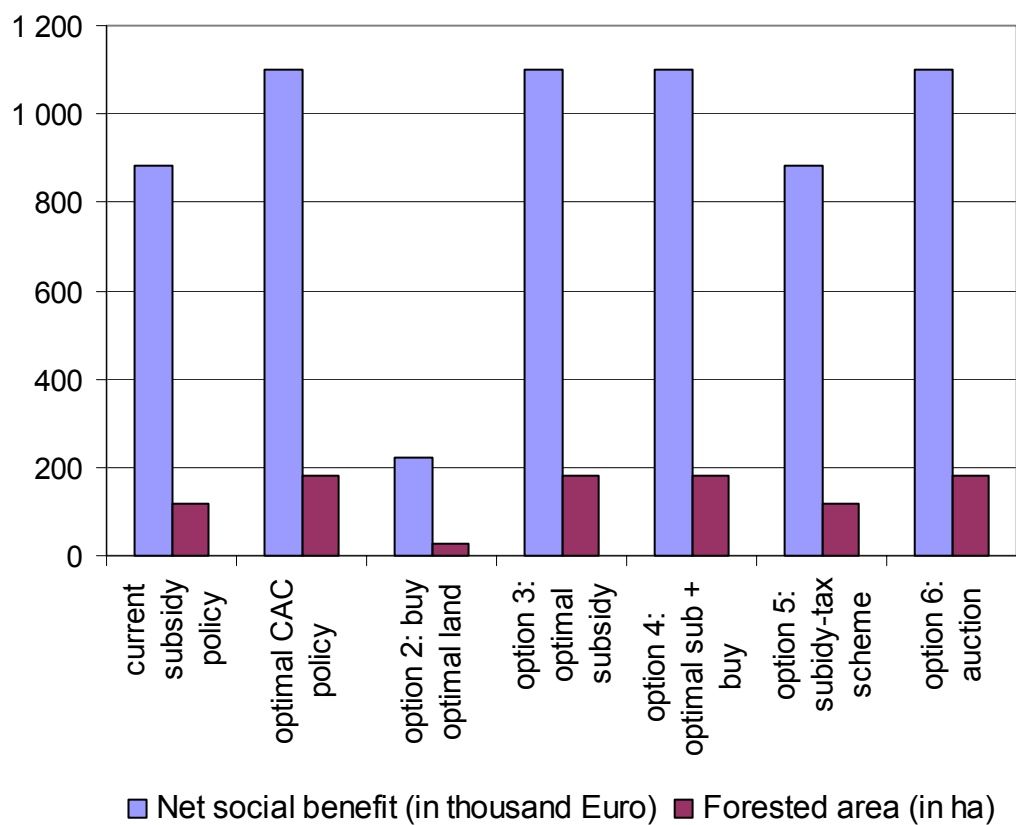
Figure 2: Difference in net social benefit when the marginal cost of public funds is 1.5 (compared to optimal CAC policy with MCPF = 1)