FFA manual and web based tool to support the valuation of ecosystem services in Flanders, Belgium

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1 Introduction

Our society benefits from a multitude of resources and processes that are supplied by natural ecosystems. Collectively, these benefits are known as ecosystem services (ES) and include products like, food, timber, clean drinking water, and processes such as the decomposition of wastes. Ecosystem services are distinct from ecosystem functions, because there is human demand for these natural assets. Ecosystem services can be subdivided into four categories: provisioning, such as the production of food and water; regulating such as the control of climate and disease; supporting, such as nutrient cycles and crop pollination; and cultural, such as spiritual and recreational benefits (Millennium Assessment, 2005).

A lot of ecosystems and the ES they are providing are at risks. One of the reasons is that indicators measuring the impact of land use changes, infrastructure projects or nature policy are not taking these ES into account. Ecosystem services are not fully captured in commercial markets or adequately quantified in terms comparable with economic services, therefore they are often given too little weight in policy decisions. By ensuring that projects and policy appraisals fully take into account the costs and benefits of the natural environment and by highlighting much more clearly the implications for human well-being, ecosystem valuation can provide policy with new insights (Defra, 2007).

The Flemish government (Environment Administration LNE) commissioned a study in 2009 to quantify and value the ecosystem services of (semi)-natural land use, including forests. Natural landscapes are in this case defined as landscapes that exist for a major part of natural elements such as trees, wild life and water. The objective was to describe how the loss of ecosystem services needed to be included in cost benefit analyses related to infrastructure works. In practice, results are however also used to assess the value of nature development projects. The findings of this study are summarized in a manual and easy to use webtool called "natuurwaardeverkenner" (nature value explorer). This paper focuses on the different valuation methods that were applied for the different services. A range of possible methods to value goods and services that ecosystems can deliver exist, and the appropriate methods depend on the characteristics of the goods or services. All of these methods have their advantages and disadvantages. It is clear that a combination of valuation techniques is required to comprehensively value ecosystem goods and services.

An important methodological focus was benefit transfer. As the manual needed to serve for a multitude of case and a multitude of nature types, straightforward unit benefit transfer methods per hectare were considered insufficient. Instead, value function transfer methods were developed. Value or demand function transfer methods use functions estimated through valuation applications for a study site together with information on parameter values for the policy site to transfer values. Parameter values of the policy site are plugged into the value function to calculate a transferred value that better reflects the characteristics of the policy site.

2 Valuation methods

As stated, many overviews that link valuation methods to specific ecosystem services exist. The overview we present here is based on Bateman et al., 2010. For provisioning services as the production of fuel, fibre, food, medicinal plants, etc. (so called direct use values), estimating economic values looks relatively straightforward, as these services are largely traded on markets. This is somewhat deceptive as there are a number of limitations to it. First of all the task of the economist is to estimate the value of services in terms of the welfare they generate rather than simply their market price. It is only under a set of assumptions that we can take the market price as a direct estimate value.

Methods to value regulating and cultural services that are not sold on a market often require a number of assumptions to hold as well as copious amounts of data and intensive statistical analysis. Regulating services are mostly valued through avoided (damage) costs e.g. avoided damage costs of floods, avoided investment costs to assess the value of nutrient removal. Cultural services such as amenity values, recreation values etc. are mostly valued through revealed preferences or stated preferences techniques.

The study looked into cultural services and regulating services. The study provides no exhaustive overview of all possible ecosystem services. It is restricted to those ecosystem services that have an important contribution in the Flemish context and for which sufficient scientific research has been performed to give a sound base to the selected functions and numbers.

2.1 Valuation of cultural services

We developed a valuation function by applying a choice-experiment. This experiment was described in detail in Liekens et al., 2010 (bioecon conference paper 2010). The idea behind the development was that the value of a natural landscape is not captured by one characteristic but depends on a number of characteristics of the area studied and on the characteristics of the beneficiaries, i.e. the people that attach a value to this area.

<u>Method: choice experiment</u>

In a choice experiment, individuals are given a hypothetical setting (a policy scenario) and asked to choose their preferred alternative among several alternatives from a choice set. The scenario in this study relates to a change from an agricultural land-use - without specific natural or landscape values - to a natural landscape, which is financed through a fund for which the respondent in the study should contribute by paying a specific tax. In making a choice, the respondent makes a trade-off between the value the natural area has, compared to the additional tax, and thus reveals his preferences and willingness to pay for natural landscapes. As we vary the characteristics of the natural areas between the alternatives, the respondent reveals his preferences for these characteristics during a sequence of choices. These characteristics relate to the nature type[1], number of species, size, adjecent area, availability of walking trails and the distance to the respondents' residence.

The data were obtained from an internet survey conducted through a marketing bureau panel from which respondents were randomly chosen in three different provinces of

[1] The six nature types that have been used are: pioneer vegetation, mudflat and marsh, natural grassland, forest, open water reed and swamp, heath land and inland dunes.

Flanders. 3000 residents filled out the survey. After removing incompletes (no choice section) and protest bidders (19%), approx. 2000 respondents (approx. 10000 observations) where included in the analysis. The sample is representative for the Flemish population, after correcting for the differences in income (lower incomes slightly underrepresented) and the overrepresentation of members of environmental organizations.

Results

We estimated a valuation function for natural landscapes and found that the willingness to pay depends on the characteristics of the natural landscape – as described above - and characteristics of the respondents such as income, membership, age and gender.

The valuation function expressed in yearly WTP (willingness to pay) per household can be written as:

WTP= 122 * pioneer vegetation + 93 * mudflat and marsh + 92 * natural grass land + 157 * forest + 133 * open water, reed and swamp + 133 * heath land and inland dunes + 0,05 * size in ha + 28 * species + 34 * availability of walking trails – 0,63 * distance in km + 8 * natural surroundings + 8 * residential surroundings – 15 * industrial surroundings – 0,36 * high number of species * age + 0,01 * monthly net income - 37 * % women+ 108 *% membership.

As the analysis shows that all the choice variable parameters are significant and have the expected signs, it illustrates that the respondents actually made a trade-off between the good provided and the price (tax) to pay.

The results show that people are willing to pay for extra natural landscape and that the amount depends on the above mentioned characteristics. The respondents are willing to pay more for easily accessible nature but it is not dominant. The nature type is important. Forests are valued higher, pioneer vegetation, marshes and grass lands lower than open water, swamps and heath land. The function calculates the WTP for a household at a specific distance from the natural landscape and thus provides a distance-decay function to determine the area which people have a positive WTP for that natural landscape.

Distance is included as part of the choice experiment as an attribute. Theoretically, and also based on previous empirical findings, we expect a larger distance to have a negative correlation with WTP, but there is not enough research yet to determine the magnitude of the effect. The results of our study are in the order of magnitude as previous research (Georgiou, 2000; Bateman e.a. 2007). They show that distance decay is an important effect that must be taken into account when aggregating the results over the relevant population (also see Bateman e.a. 2007).

The results show that there is sensitivity to scope (e.g. Georgiou 2000), i.e. respondents are willing to pay more for a larger area compared to a smaller one. As the size of the area is just one of the parameters, a 200 ha area is not valued twice as high as an area of 100 ha. This stresses the importance of using this valuation function instead of the mean value/ha. The value function illustrates that size is not a dominant factor, and the WTP for a larger area is relatively small (€0.05 per extra ha) compared to the total WTP. This element has to be accounted for when the function is used to estimate the WTP for larger areas (more than 200 ha).

It has been tested and shown that this function can be transferred between the three regions where the survey was performed. This suggests that the valuation function is applicable for benefit transfer.

From economic theory we expect substitution possibilities to affect the willingness to pay. We failed to find a statistically significant relationship between willingness to pay and the availability of substitutes, but it has to be remarked that it requires further work to develop and test relevant indicators for the availability of nature.

It is not straightforward to compare our results with literature. It is the first time that a choice experiment was performed for the economic valuation of Flemish natural land use that covers these different aspects. To our knowledge, choice experiments that include such a large variety of parameters (attributes) are rare, especially both size and distance. Only Luisetti et al. (2008) accounts for both parameters in a choice experiment valuating mudflats and marshes. They found significant effects for both attributes which are similar to our results.

2.2 Quantification and valuation of regulating services

Quantification regulating services

Valuing the change in quantities of different regulating services is a complex, but crucial element in the valuation of impacts on ecosystems (or the creation of new ecosystems). We often lack tools and models to assess the changes in physical, biochemical and ecological processes on the delivery of ecosystem services. We derived quantification functions on the basis of literature and/or expert judgement. The objective was also more to set up easy to use methods or lookup tables that could be integrated in a webbased instrument and less to use extensive process based models that require specific expert groups to operate.

Following regulating services were quantified:

- Denitrification (contribution to good status of water bodies)
- N, P and C sequestration in soils (contribution to good status of water bodies, climate regulation)
- N, P and C sequestration in forest biomass (contribution to good status of water bodies, climate regulation)
- improvement of air quality
- noise mitigation/buffer function

The quantification of denitrification processes in wetland ecosystems is based on (Seitzinger et al., 2006). Removal efficiency depends mainly on the residence time of the water in the ecosystems. For terrestrial ecosystems we used (PINAY et al., 2007) to deduct potential denitrification. Removal efficiency depends on soil moisture and soil texture.

Carbon sequestration in soils is based on (Meersman et al., 2008). We determined a potential maximal carbon content for a given soil drainage, vegetation type and soil texture. Changes in soil drainage and/or vegetation will change the potential maximal carbon content. The annual carbon sequestration potential is a factor of the difference in potential carbon content, which can be represented by an asymptotic function. This approach is process based and incorporates changes in potential storage and the associated temporal dynamics. Literature estimates of net ecosystem exchange range very broad, as they capture a moment and do not incorporate long-term dynamics and driving variables such as soil properties, climate, and soil hydrology. The N and P content of soils is indirectly derived from the carbon content. Based on analyses performed in Flanders, the C/N ratio varies between 10 and 30 depending on the nature type. Based on (Koerselman & Meuleman, 1996), we set the average N/P ratio at 15.

Carbon sequestration in forest biomass is based on a meta analysis (Berger, Hildenbrandt, & Grimm, 2007; Cairns, S. Brown, Helmer, & Baumgardner, 1997; Hees, 1997; Kemmers & Mekkink, 2002; Milne & T. Brown, 1997; Nabuurs, 2003). Depending on the tree type, age of the forest and type of forest management (intensive, limited or no management) the level of sequestration differs. N- and P-content are set to 4 kgN and 0.4 kgP/ton biomass based on a meta analysis (André & Quentin Ponette, 2003; Hytönen & Saarsalmi, 2009; Maclean DA, 1977; Q Ponette, Ranger, Ottorine, & Ulrich, 2001; Uri V, 2003)

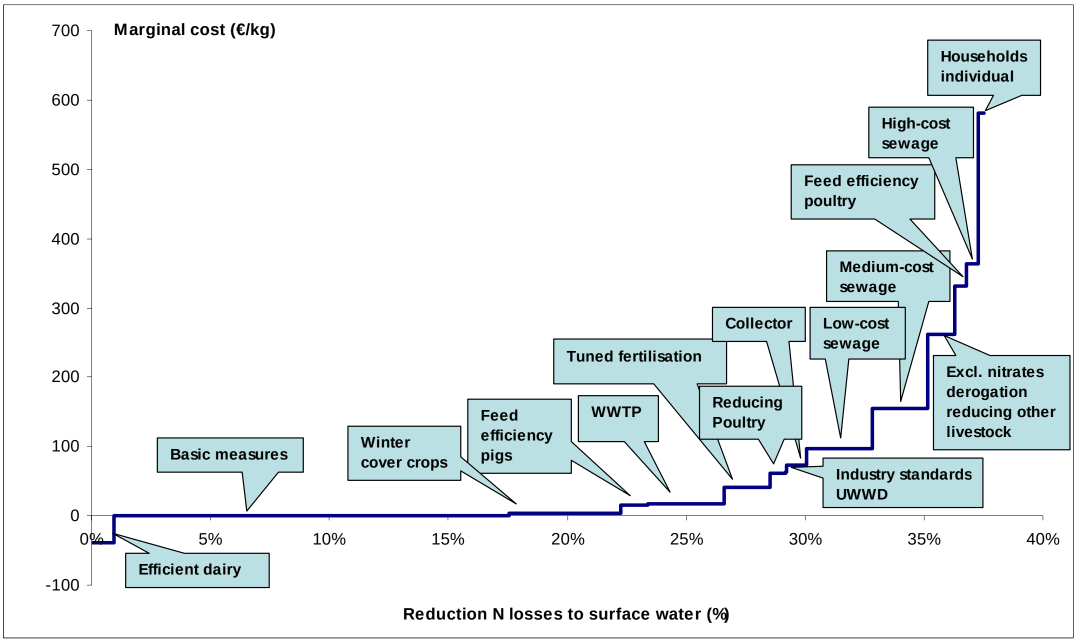
Impacts of vegetation on air quality through capture of pollutants from ambient air is assessed on a more simplified way using indicator data from literature. Vegetation specific figures for fine particles, NOx and NH_3 were selected based on (Oosterbaan & Vries, 2006) who define vegetation specific figures for fine particles, NOx and NH_3. Noise mitigation for forests is derived from (Huisman, 1990; Milieubeheer, 2002).

Valuation for retention of nutrients to surface water (N,P retention)

Bad quality of surface waters (freshwater and coastal waters) is often related to excess levels of nitrogen (N) and phosphor (P) in the water. The removal of these excess levels is therefore valuable. The avoided abatement cost method is used to value nutrient removal, because due to the natural denitrification that an ecosystem delivers, costly abatement measures to obtain environmental goals can be avoided.

The value of an additional kg nitrogen removed by an ecosystem can be derived from the marginal cost curve of nitrogen removal. This cost curve was calculated in preparation of the Flemish river basin management plan to reach a good water status according to the European Water Framework Directive (S Broekx, E Meynaerts, H Wustenberghs, D'Heygere, & De Nocker, 2011; Cools et al., 2011). Figure 1 shows the cost curve for nitrogen removal. The graph gives an overview of all abatement measures, ranked from the cheapest measure per kg N removal to the most expensive. The measure representing the highest marginal cost still included in the programme of measures to reach water quality objectives costs 74€/kg N. This marginal cost of the last necessary measure to reach the reduction goal is used as a proxy for the value of denitrification in Flanders.

Figure 1: Marginal abatement cost curves for reducing N losses in Flanders on regional scale



The same methodology was used for P removal, which results in 800€/kg P. Though measures have impact on both N and P, it is impossible to individually link costs to separate pollutants. Most measures have impact both on N and P. Therefore, to avoid double counting, we estimate the value of nutrient retention for both pollutants and only apply the maximum value.

The valuation of nutrients applied here is significantly higher than figures in literature, which vary between 2 and 20 €/kg for N. (Gren, 1995; Jenkins, Murray, Kramer, & Faulkner, 2010) and 70 €/kg for P (Borjesson, 1999). This reflects on the one hand that nutrients are a large problem in Flanders and on the other hand that already a lot of relatively cheap measures (advanced treatment in WWTPs) are taken and less cost effective measures are necessary to reach environmental objectives.

Valuation for climate regulation (carbon)

The benefits of carbon sequestration are not directly related to the place of sequestration, but rather experienced at a global level, through the impact on climate change. To assess the value of carbon sequestration by ecosystems, theoretically two approaches can be followed: (1) marginal damage costs (2) avoided abatement costs. As impacts are global, the selected data are based on studies at the global level.

Estimates of the marginal damage of GHG emissions

For the first approach, information is needed on the marginal (in the sense of additional) damage costs of emitting 1 extra tonne of CO_2 or GHG. There is a wide range of impacts (public health, agricultural output, adaptation costs to sea level rise, …) which may be both positive or negative, have differentiated impacts in different parts of the world and occur over long time horizons. Scientific literature provides information on these costs, also referred to as the damage, external or social costs of CO_2 or GHG (Stern, 2006; R. Tol, 2005). These data are the result of model runs with climate change impacts models (like DIKE, PAGE or FUND) that assess these impacts building on temperature-effect relationships for impacts in the different sectors like agriculture, public health, energy use. These impacts like loss of agricultural outputs or health impacts are valued using market prices or data from economic literature for non-market impacts (e.g. welfare losses from health impacts due to costs of sickness, loss of labour productivity and willingness to pay to avoid suffering). Compared to the importance of the issue of climate change, there are only a limited number of those models and studies, especially in the peer reviewed literature, as indicated by the reviews and meta analysis of (Tol, 2008).

The range of results of these studies is very broad, ranging from an external costs close to zero to 160 $\$_{1995}$ /tonne CO2 (Tol, 2008). It is difficult to pick a meaningful average for these studies as it varies a lot in function of statistical models, inclusion of grey literature and older studies,…

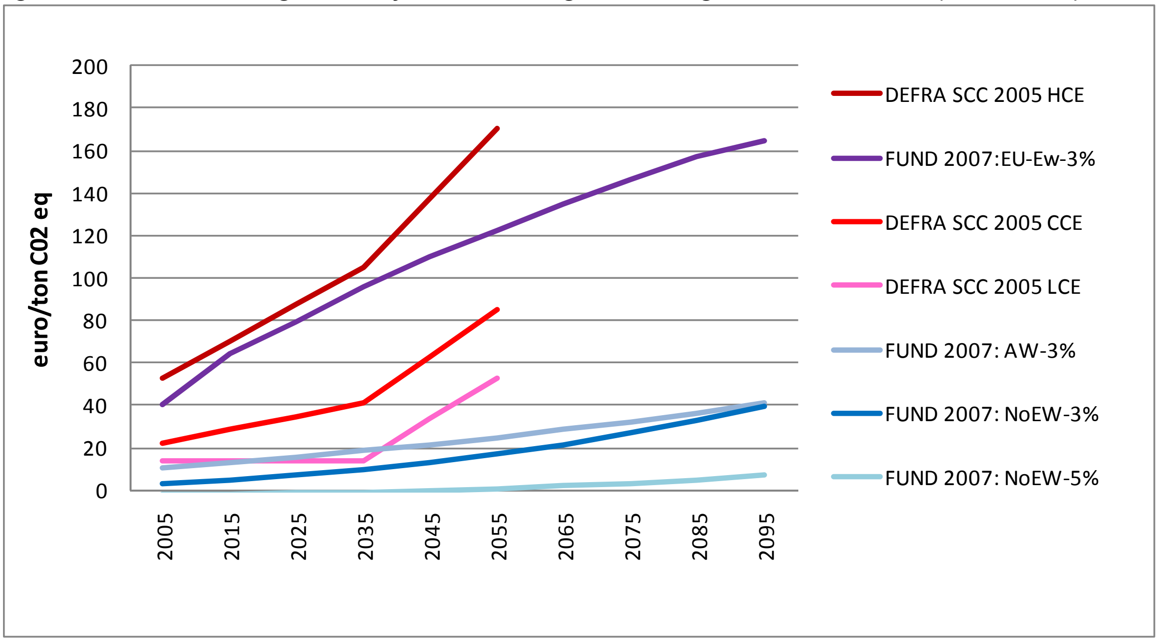
A large part of the variation is explained by the treatment of equity in valuation, both for impacts between generations (reflected in the discount rate) and within generations (reflected in equity weighting, or how impacts for countries with different incomes are valued and aggregated). The importance of these factors is illustrated in figure 2, based on results from the FUND model (Anthoff, Hepburn, & R. Tol, 2009). For the most conservative estimate (i.e. discount rate of 5% and no equity weighting) external costs are lightly negative up to 2035, because the short term benefits in the richer regions in the world dominate. With a discount rate of 3% damage costs increase to 20 euro/ton CO_2-eq. by 2050 and double to 40 euro tonne CO_2-eq. by the end of the century. The impact of including impacts at average world prices (for equity considerations) has a relatively limited effect on the total damage cost (damage in poorer countries become higher, but are compensated with lower damage costs in richer countries). Combining a discount rate of 3% with weighing impacts at West European prices, results in remarkably higher costs from 40 euro/ton CO_2eq. in 2005 to 160 euro/ton CO_2 eq for emissions at the end of this century. Whereas some studies , e.g. Stern report, take a clear position on these valuation issues, other studies report the range of results.

These economic studies have been critised not to account for all potential impacts of climate change, and especially the more unlikely but severe impacts associated with higher temperature increases. Some studies have attempted to take these more into account, including Watkiss et al, 2005, Stern, 2006 and Ackerman et al, 2009. The later study claims that previous studies, including the Stern review, underestimated the non-economic and catastrophic damages from global warming. Weitzman, 2009, has argued that the real issue in economic assessment is "about how much insurance to buy to offset the small chance of a ruinous catastrophe".

In the UK, several studies and guidance documents have been produced to account for the social costs of carbon in policy and decision making. In the 2005 study for Defra, an illustrative range of values has been selected for use in economic analysis (Watkiss, 2005). The central estimate increases from 22 euro/ton C02 for emissions in 2000 to 85 euro/ton C02 for emissions in 2050. The study also produced indicative upper and lower central estimates (figure 2). These values have been used or recommended by a number of authors and organizations, e.g. Krewitt et al (2006) and Maibach et al, 2008. The authors however recommend that these values would be further complemented with additional analysis looking at winners and losers, impacts of potential irreversible effects.

In this light a damage cost of 20 euro per ton CO_2-equivalent, used in previous cost benefit analyses (S Broekx, Smets, & Liekens, 2010) seems to be a (too) low estimate. It is also clear that the external damage costs of GHG emissions will be higher for future emissions.

Figure 2: External damage costs of climate change according to several models (2005-2095)



Source: based on Anthoff (2007) and Watkiss (2005).

Legend:
Defra SCC = study relating social cost of carbon for UK, DEFRA, illustrative ranges (low, central and upper central range (H central high and central estimate (Watkiss et al., 2005).
FUND: results based on FUND model, (Anthoff, 2007) ...
EU-EW-3% = equity weighting with basic prices for West Europe, 3 % discount rate.
AW-3 % = average weighting on basic prices, average for the world, 3 % discount rate; NoEW-5 % = No equity weighting, 5 % discount rate (3 % for pure time preference); NoEW-3%: idem but 3 % discount rate, (1 % pure time preference);

We conclude that there remains considerable uncertainty concerning the marginal damage costs of GHG-emissions and that available studies fail to give guidance on the size of the insurance premium to avoid an temperature increase above 2°C.

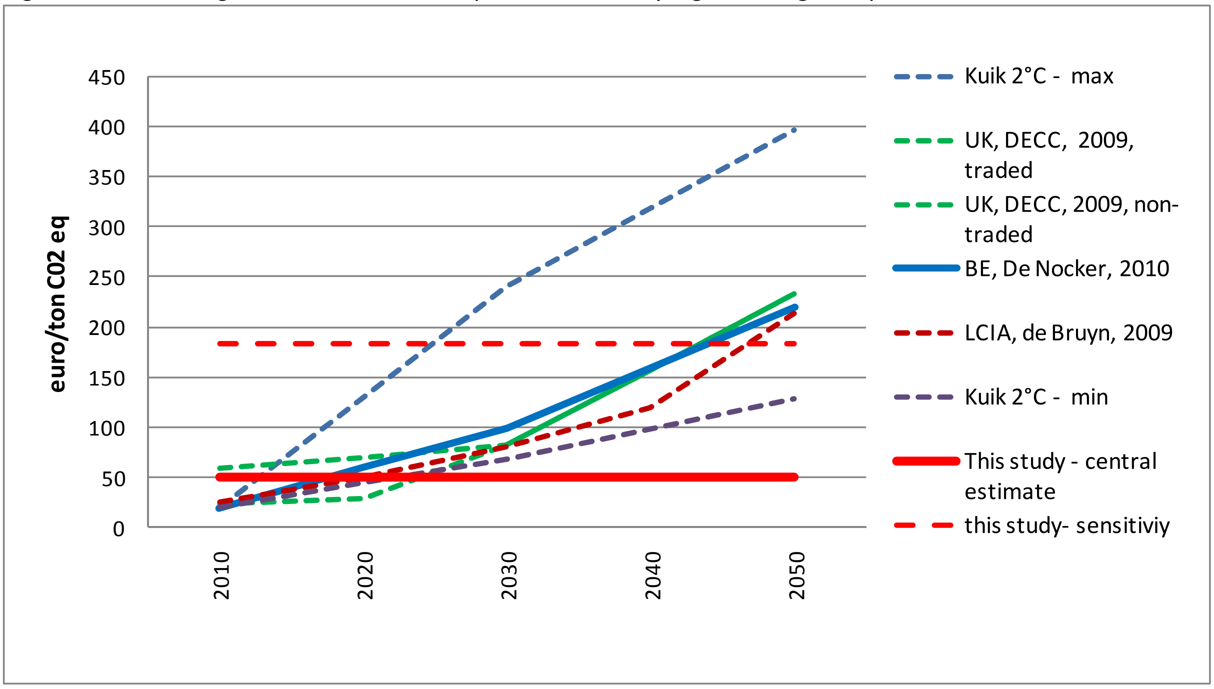
Estimates of the marginal abatement costs of GHG emissions

The second approach to estimate the value of reduced CO_2 emissions or sequestration of carbon is based on the marginal abatement costs of meeting policy targets related to climate change. In that context, the most relevant studies are those that estimate what additional steps have to be taken in terms of improving energy efficiency and carbon efficiency to limit emissions of GHG in order to meet the long term climate objective of limiting global warming to a maximum of 2 °C. Modeling exercises have shown that this will require that concentrations of GHG should not exceed 450 ppm CO_2-eq., which in turn allows to specify a maximum amount of global GHG emissions for the period up to 2050. Consequently, scenario's have been developed that specify emission paths for different groups of countries. The marginal abatement costs, refer to the costs of measures required to reduce emissions from a business as usual scenario to an emission path that limits global warming to around 2°C. It is assumed that countries otimally first apply the less costly options for reaching their targets. But when less costly options are implemented and the target is not yet reached, one has to recur to more costly options. The marginal abatement costs for a certain year and country/region, are the costs (in euro) to abate the last tonne of CO2 in order to stay on the target set for that year for the specified country/region. In figure3, the marginal abatement costs are presented for the period 2009-2050 for different studies. The study by (Kuik, Brander, & R. S. J. Tol, 2009) is based on a meta-analysis, and gives the lower and upper limits for this approach. It also indicates that the costs of meeting this target increases over time. The values from UK, DECC reflect how a study based on this approach recommended values for the UK; with a difference for sectors within the EU-PETS trading scheme and outside this scheme, the latter showing higher costs in the short run. The study by de Bruyn et al produced indicator values to be used wiht LCIA (life cycle impact assessment) and builds on similar literature. The study by De Nocker et al, 2010, recommends an increasing external cost that starts at 20 euro/tonne CO2-eq for emissions in 2010 and that increases yearly with 4 euro/year for the period 2010-2030 and 6 euro/year for period 2030-2050.

Both the original data and studies with recommended values show marginal abatement costs increasing over time as the costs to meet the 2°C target increase because the distance between the required emission path and emissions in the reference case increase and more costly options are required.

Against this background, we have chosen a central value of 50 €/tonne C02-eq., which is higher than recommended values for emissions in 2010 and close to recommended values for 2020. This value corresponds to 183 €/tone of C. As this central estimate does however not reflect the value of CO2 sequestration in the long run, it is recommended to use a higher value of 200 €/ton C02-eq (737 €/tonne C) for sensitivity analysis, especially for projects where C-sequestration in the longer run may be an important part of total benefits.

Figure 3: The marginal abatement cost paths when staying "on target" up to 2050



Source: Vito, based on DECC, 2009, de Bruyn, 2010, Kuik 2009.

<u>Valuation for noise mitigation</u>

To value noise mitigation we used a noise sensitivity depreciation index based on the results of two large studies using hedonic pricing (Theebe, 2004; Udo, Janssen, & Kruitwagen, 2006). Market value of properties decrease with 0.4% per dB(A) at lower noise levels (40 dbA) and 1.9% at higher noise levels (60 dBA).

<u>Valuation for improvement of air quality</u>

The improvement of air quality is monetised based on marginal damage cost figures from literature for impacts of emissions in Belgium. It builds on information and data that are also used in cost benefit analyses for valuation of external costs of airborne emissions, e.g. from transport. Marginal damage costs refer to the additional damage caused by one extra unit of pollution. We treat capture of air pollutants from ambient air by vegetation as negative emissions. We use the indicator values for external costs of airborne emissions developed by European and Flemish research. In this context, external costs to public health for particulate matter is important. Epidemiological studies have estimated the correlation between concentration of these pollutants in ambient air and health indicators (e.g. hospital admissions and chronic mortality). These health indicators are valued by combined information on costs of illness, loss of labour productivity and the willingness to pay to prevent diseases and related suffering.

We use the values that were calculated for the Flemish environmental agency as indicator values for external costs of these pollutants, using the European ExternE methodology (Torfs et al, 2005). For primary particles, we use data related to emissions from low stacks (industry, tertiary and households) as this best represents the negative emissions from capture of PM by vegetation. In addition, we attribute these external costs for emissions caused by human activity only to that fraction of ambient PM which is from human activities (84 %)(Mira, 2009).

The data for external costs for NOx and NH3 are much more uncertain as the impact of changes in precursors for ozone and secondary particulate matter depend on very specific and local circumstances. For NOx, the data are based on specific model runs for Belgium whereas for NH3, marginal damages are estimated based on the aerosol formation factor. This amounts to 30, 6.5 and 4.8 €/kg for PM, NOx and NH3 resp., which is in line with other studies related to air pollution.

5 Manual for practical application and webtool

The use of all the numbers and functions in this report are explained and illustrated in a separate manual. The manual bundles the methods and functions to quantify and value the ecosystem services. To help users better understand calculation procedures, each function is illustrated by examples. This manual is not static. The list of ecosystem services that is described in this manual is not complete as it was not possible to derive quantification functions for all ecosystem services. The quantification and valuation functions that are presented are built on the current state of knowledge and data-availability, but can be improved in the future when new scientific insights emerge and /or better data is available. A new edition of the manual is foreseen at the end of 2011. The manual can be consulted on:
http://www.lne.be/themas/beleid/milieueconomie/waardering-van-baten-en-schaden/literatuur-over-economische-waardering.

As a value function transfer approach proved to be more difficult to implement than a unit approach and first experiences from end users led to misinterpretation of methods, a webtool "natuurwaardeverkenner or "nature value explorer" was designed. The webtool contains all quantification and valuation methods included in the manual. Based on straightforward input boxes (nature type, location, specific characteristics necessary to quantify services), end users can quantify and value selected ecosystem services.

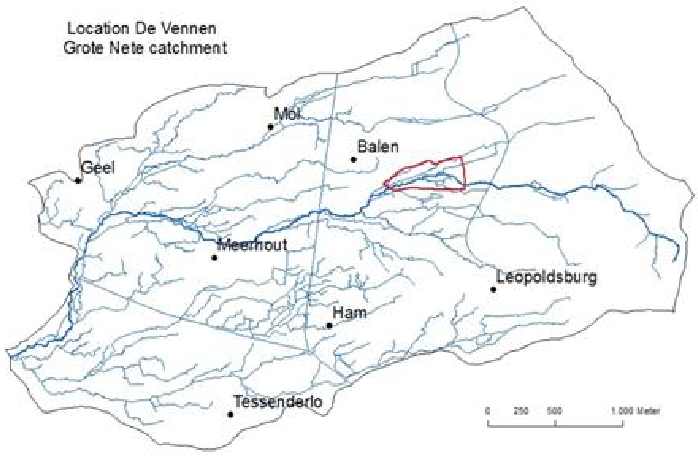
The tool can be consulted on http://rma.vito.be/natuurwaardeverkenner/. (only available in Dutch)

6 Case studies

6.1. De Vennen

De Vennen is located in the upstream part of the Grote Nete catchment in the province of Antwerp. De Vennen is a 380 ha area of which 50 ha is recognised as nature reserve. It is part of the European Life+ project. Due to human impact the landscape changed over the centuries from forest to to a compartmented landscape of forest, heath, arable land and swampy pastures ('meersen'). After the second World War the landscape changed drastically again. Most of the semi-natural cultural landscape of the middle ages was lost due to agricultural intensification and mechanization. People started to build holiday homes in the valleys and on the dryer forested grounds. To protect and improve the remaining natural value, nature organizations bought some of the land. "De Vennen" was one of these remaining habitats.

Figure 4: Location De Vennen



A vision on how the landscape should be restored was based on two themes:

1) Upstream water retention by restoring the natural characteristics of streams within the study area.
2) Spontaneous nature development in combination with pattern management in specific biodiversity hotspots. An autonomous evolution of nature will lead to the development of leaf- and brook forests. In order not to lose valuable cultural landscapes nature development in some species rich parcels will be controlled by means of mowing, grazing and pollarding of historic hedgerow trees once every 8 years. In the meantime borders between the parcels are left to fade out by overgrowth and afforestation. Extensive grazing by cattle and horses is adopted in the management plan in order to restore the historic half-open landscape. Extensive grazing will create vegetation gradients, eventually leading to a greater variation in fauna and flora and preventing the development of one vast leaf forest.

In addition, the accessibility for pedestrians in the reserve will be improved with bridges and wooden pathways. The reserve will also be accessible to cyclists by means of a bicycle track along the edges. By restoring the natural characteristics of the streams and the landscape a range of ecosystem services will be delivered additionally:

<u>Carbon storage</u>

Soils in natural and semi-natural ecosystems (forest, permanent grassland, ...) are capable of storing more C than regularly disturbed soils such as agricultural fields or temporary grasslands. Changes in the land use and the wetness of the area, also brings along improvements in the carbon storage in the soil. Making use of the findings of (Meersman et al., 2008) we calculated that implementing the foreseen measures in the area would increase C-sequestration with 980 ton/year, resulting in a yearly benefit of 180 k€.

Nutriënt retention

For the same reasons, nutrient retention is improved. Through denitrification and N-P-retention in the soil, 57 ton of N was prevented entering surface waters, resulting in a yearly benefit of 4,200 k€. (maximum value of N- and P-sequestration)

Water retention

The artificial embankments of the streams prevent the surroundings from buffering floods during peak discharges so that downstream areas receive too much water. By lowering the embankments (provincial action plan 2010-2015), more storage capacity is created to retain water in the upstream part of the valley. This will also increase infiltration and groundwater recharge. This ecosystem service is however not included in our methodology.

Amenity value and non-use value

In some parts of the area, the land use will change to more natural land use (e.g. acre to forest, fen..), in other parts to less natural land use (e.g. forest to heath). The biodiversity in the area and the accessibility for walking and biking will increase, which has a positive impact on the willingness to pay of the respondents. Based on the estimated valuation study, the amenity and non-use values range between 1,500 – 4,000 k€ per year.

Total value

The total value of the selected ecosystem services is estimated at +/- 6 million €/year. Most important values are related to nutrient retention and amenity values.

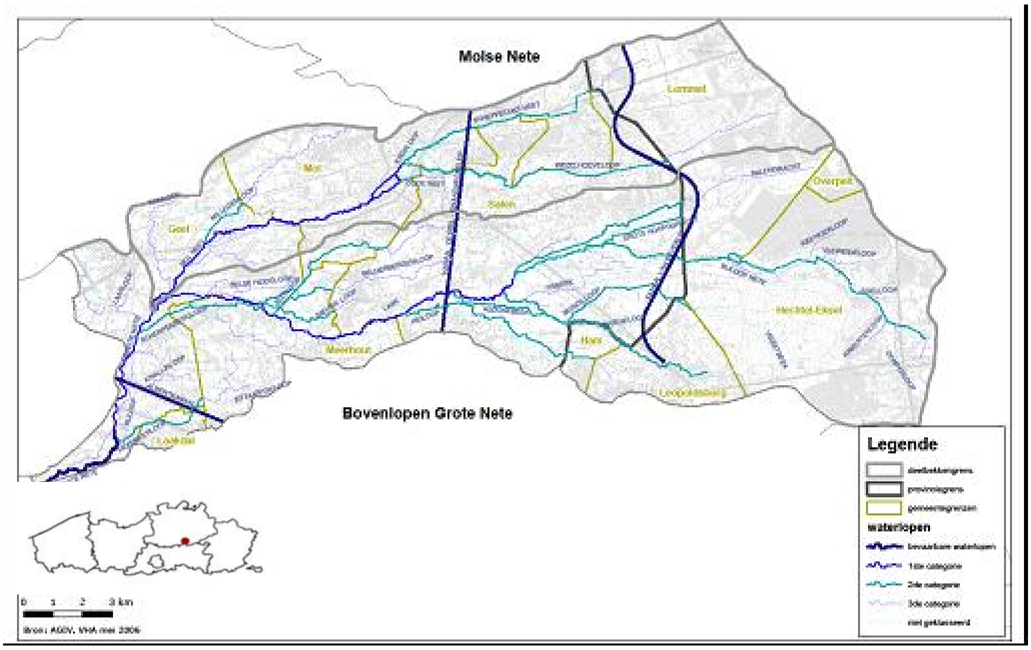
Table 1: Quantity and value of ecosystem services for "De Vennen"

Service	Quantity	Monetary value
regulating services	**kg/year**	**k€/year**
Nutrient retention		
N-sequestration soil	45,719.57	3,383
P-sequestration soil	3,047.97	2,438
Denitrification	11,005.99	814
Climate regulation		
C-sequestration in soil	985.360	180
Improvement air quality		
PM	35.44	1
NOx	2,659.55	17
Amenity and non-use value		
range: 1,503- 4,157 k€		1,502
TOTAL		**5,899**

6.2. Grote Nete

The Grote Nete is an area of 1333 ha along the central part of the Grote Nete catchment in the province of Antwerp, Belgium. The area is designated as an inundation area to protect downstream areas from flooding. Due to human impact the landscape changed over the centuries from a natural inundation area to a mixture of intensively used acres, grasslands and forests. The foreseen project is to reconnect meanders in order to restore the natural stream and river related habitats. The existing agricultural land use will partly be replaced by natural land use.

Figure 5: Location Grote Nete



Protection against flooding
Natural inundation areas will be restored. This will lead to a lower risk of flooding downstream and avoided damage costs. These were calculated in the cost benefit analysis of the Sigmaplan and estimated at 2,400 k€/year (S Broekx et al., 2010).

C-sequestration
In the forest rich valley a lot of carbon is stocked into the soil and into the biomass of the trees. Because of the transition of meadows towards more natural wet habitats, the C sequestration would increase with approximately 2,200 ton/year based on Meersman et al. (2008). This results in a yearly benefit of 410 k€/year.

Nutrient retention
For the same reasons, nutrient retention is improved. Through denitrification an N-P-retention in the soil, 165 ton of N and 7 ton P will be prevented entering surface waters, resulting in a yearly benefit of 12,000 k€.

Improvement of air quality
The transformation from agricultural to specific natural land use increases the precipitation of fine particles out of the atmosphere (Oosterbaan en Vries, 2006). We estimated this increase at 1 ton/year, resulting in a yearly benefit of 36 k€.

Amenity value and non-use value

In some parts of the area, the amenity value due to land use changes will increase (e.g. farmland to swamps, wet grasslands) in other parts decrease (e.g. forest to wet nature areas). The biodiversity in the area is expected to increase and recreation will be still possible, which has a positive impact on the willingness to pay of the respondents.
If we use the estimated valuation study, the additional amenity and non-use values range between 4,200 and 6,500 k€ per year.

Table 2: Quantity and value of ecosystem services for "Grote Nete"

Service	Quantity	Monetary value
regulating services	**kg/year**	**k€/year**
Nutrient retention		
N-sequestration soil	110,360	8,167
P-sequestration soil	7,357	5,886
Denitrification	53,196	3,937
Climate regulation		
C-sequestration in soil	2,239,660	410
Improvement air quality		
PM	1,210	36
NOx	/	/
Flood protection		2,400
Amenity and non-use value		
Range: 4,217-6,500k€		4,217
TOTAL		**19,166**

7 Conclusion

In cost-benefit analyses impacts on ecosystems are seldomly quantified. This is because economists are not familiar with tools and methods to quantify ecosystem services and also because simple, generic indicator data (e.g. in €/ha) are not specific enough to be accepted by ecologists and economists. Even if bigger projects require environmental impact assessments, these do not provide directly the required data to assess the impact on ecosystem services. Contrary to impacts on ecosytems, air pollution impacts are very often valued in CBA as a large amount of indicator data and guidance documents is available (e.g. Maibach, 2008).

This paper describes a methodology to assess the most relevant ecosystem services in the region of Flanders, Belgium by means of a simplified set of functions to quantify the selected services and to value these services. The methodology is implemented in a manual and web-based application. The services vary for issues from local to global importance, issues that address different environmental media (water, air, biodiversity) and issues that vary from impacts that are straightforward to understand by non-specialists or the public (recreation and amity values) to more complex issues (retention of N or capture of PM by vegetation).

The valuation of the different services is necessarily based on different techniques, including stated preferences, hedonic pricing and avoided abatement costs. Values are based both on local studies (amenity and non-use values, N-P retention) and global studies (C-sequestration).

The case studies – although limited in number – confirm the importance of the impacts for which detailed quantification functions and valuation is given. The magnitude of the impacts illustrate the ir importance and justify the efforts and costs to account for them in CBA. This is a first step, and the methods and data are open for further elaboration, refinement and updates. This requires a transparent and open framework.

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