4.3 Non-market valuation of the ecosystem services of the Catalan coast

4.3.1 Introduction to the value transfer approach

Coastal ecosystem services are becoming more scarce. On the supply side, ecosystems are experiencing serious degradation to their capacity of providing services. Similarly, the demand for ecosystem services is increasing rapidly as populations and standards of living increase (UNEP 2006). Ecosystem Services Value (ESV) is the process of assessing the contribution of ecosystem services to meeting a particular goal. Traditionally, this goal is efficient allocation, but other goals are possible, *e.g.* assessment of the sustainability of the scale or magnitude of human activities, and fare distribution of resources and property rights (Daly 1992). ESV provides a tool that enhances the ability of decision-makers to evaluate to evaluate trade-offs between alternative ecosystem management regimes to meet a set of goals (Costanza and Folke 1997).

In this study a value transfer assessment is used to generate baseline estimates of ESV in the Catalan coast. The transfer method constitutes the application of values and other data from the original study site (empirically obtained) to the present policy site (Loomis 1992, Desvouges *et al.* 1998). Following Desvouges *et al.* (1998) the term value transfer is used instead of benefit transfer, since transfer method is not restricted to economic benefits, but can also be extended to include the analysis of potential economic costs, as well as value functions themselves. Therefore, value transfer involves the adaptation of existing valuation information or data to new policy contexts.

Due to the increasing sophistication and number of empirical economic valuation studies in the scientific literature, value transfer has become a useful method to assess ESV when primary data collection is not feasible due to budget and time constraints (Kreuter *et al.* 2001, Moran 1999). Therefore the value transfer method is highly relevant for managers and policy makers since it can be used to estimate the monetary values of the ecosystem services related to human well-being. This method has been used extensible to inform management decisions by public agencies (Downing and Ozuna 1996, Eade and Moran 1996, Kirchoff *et al.* 1997), and thus provides a credible basis for policy decisions involving sites other than the study site for which the values were originally estimated. This is particularly relevant when resources are negligible (zero value) because they have simply been ignored in the existing markets.

The key underlying assumption of international value transfer methods is that the economic value of ecosystem goods or services at the study site can be inferred with sufficient accuracy from the analysis of existing valuation studies at other sites (Ready and Navrud 2006). Despite the known limitations such as the context sensitivity of value estimates (biophysical and socio-economic), accuracy improves clearly when the extent and detail of information increases (Troy and Wilson 2006, Wilson and Hoehn 2006). One of the biggest constrains arise when values are transferred among different reality sites. Therefore, the more one is able to find more accurate data with the target site the better the estimates will be.

Spash and Vatn (2006) refer to value transfer as within the context of information transfer in the natural and social sciences. This raises the question as to how value transfer can establish valid results within the unobservable nature of most ecosystem services values. Thereafter, the discussion on validity of values highlights the role of a wide range of biophysical and socio-economic variables in analyzing ESV. In all valuation applications the defensibility of the amounts will be the final test. At the end, the quality of primary studies determines the quality and applicability of the value transfer study. In practice highly similar scenarios (sites) are uncommon in real world and thus transfer exercises may lead to different results (Barton 2002). Commonly different aspects of transfer validity seem to have little attention, although specific conditions of similarity can be compiled from the literature. Spash and Vatn (2006) found that low errors are expected when the following match at the two sites:

- The environmental service quantity, quality and their change,
- population, their characteristics and their use of services,
- market characteristics,
- institutional settings,
- time between primary value estimation and transfer, and
- geographical location.

However, these constitute desirable characteristics for value transfer data and it will be highly difficult to meet all of them in coastal valuation studies, as this one, due to the lack of adequate data and data gaps in ecosystem services valuated (although for the U.S.A. see a discussion on this issue in Pendleton *et al.* 2007).

There are two main approaches to value transfer: unit and function transfers. Under unit transfer there are three basic avenues. Point estimates define a unit value of benefit, such as an average consumer surplus per ecotourism tour. Hedonic pricing, travel cost and contingent valuations can all provide willingness-to-pay amounts. Finally, the transfer of values can also occur via officially sanctioned numbers, and maybe this is the most common unit value over time (*i.e.* discounting rates) (Spash and Vatn 2006). Function transfer aims to explain economic benefits (mainly willingness-to-pay) in terms of a set of explanatory variables. Meta-analysis can be used to combine functions from several studies and assumes that there is an underlying meta-function linking the valued service. Functions should be statistically tested and adapted to the policy site. Therefore, function transfers depend on reliable data availability.

Traditionally much of the attention has being paid on the economic theory behind value transfer, and much less to the inherently spatial nature of ESV (Troy and Wilson, 2006). Therefore, at present the number of publications using a spatial value transfer methodology is very limited. As an example, Kreuter *et al.* (2001) found that there was a 65 % decrease in rangeland and 29 % increase in urbanize land between 1976 and 1991 with a resulting 4 % decline of annual ecosystem services value in Bexar County, Texas, U.S.A. Economist realize the importance of considering the spatial and ecological context of sites in conducting value transfer, however classifications of ecosystems and landscapes need to be developed for this specific purpose (Bateman *et al.* 2002). The challenge is therefore to effectively link economic valuation and ecosystem functioning using meaningful typologies.

Transferred ESV estimates of a given ecosystem from prior studies have been object of several critics. Some of the relevant ones are, first, every ecosystem is unique, and per-hectares values derived from elsewhere in the world may not be relevant to the ecosystems being studied. Second, the flow value depends on the size of the ecosystem; however in most cases, as the size decreases, per hectare value would be expected to increase and vice versa due to resource scarcity. Thus, the marginal cost per hectare is generally expected to increase as the quantity supplied decreases, and a single average value is not the same thing as a range of marginal values. Third, there is no practical way to obtain all of the data one would need to address these problems, and therefore there is no way of knowing the "real" value of *e.g.* beach ESV. Hence no way of knowing whether the estimated value is accurate or not and, if not, whether it is higher or lower than estimated. In technical terms, there are far too few data points to construct a realistic demand curve or estimate a demand function to value non-market ecosystem services at present. Finally, estimates ESV in a large geographic area is questionable in terms of the standard definition of exchange value because one cannot conceive of a transaction in which ecosystems would be bought and sold. This emphasizes the point that the value estimates for large areas (as opposed to the per hectare value) are comparable to national accounts aggregates and not exchange values (Howarth and Farber 2002). These aggregates (*i.e.* GDP and income) routinely impute values to public goods for which no conceivable market transaction is possible and it is just these kinds of aggregates that the value of ecosystem services of large geographic areas is comparable to.

Although the above objections to value transfer analysis have been responded in detail by other authors (*e.g.* Costanza *et al.* 1989, Howarth and Farber 2002), those relevant to the Catalan coast valuation will be addressed here. While every ecosystem is unique, ecosystems of a given type also by definition have many things in common. The use of average monetary values in ecosystem valuation is only justified in a macroeconomic context (*i.e.* developing economic statistics such as GDP). Proposed estimate of the total flow value of the Catalan coast's ecosystem services is a valid and useful (also imperfect, as well as economic aggregates) basis for assessing and comparing these services with conventional marketed economic goods and services. Studies used in the value transfer include a variety of time periods, geographic areas, investigators, and analytic methods, and many of them provide a range of estimated values rather than single point estimates. The present study preserves this variance; no studies were removed from the database because their estimated values were thought to be too high or too low and limited sensitivity analyses were performed (only confirmed outliers were excluded). At the end, the approach is similar to defining a willingness-to-pay price for a piece of land based on the prices for comparable parcels. Where even though the property being sold is unique, realtors and lenders feel justified in following this procedure, even to the extent of publicizing a single asking price rather than a price range.

The objection of an even imaginary exchange transaction was made in response to the study by Costanza *et al.* (1997) of the value of all of the world's ecosystem services. However, it is possible to consider of an exchange transaction in which all or a large portion of a certain land cover was sold for development, so that the basic technical requirement that economic value reflect exchange value could in principle be satisfied. But even this is not necessary if one recognizes the different purpose of valuation at this scale, a purpose more analogous to national accounting than to estimating exchange values (Howarth and Farber 2002). Finally, to treat the economic value of ecosystem services as zero can be referred as the business as usual alternative (although no really an alternative). Commonly this approach has lead to much more error than value transfer itself.

Although there are conceptual and empirical problems inherent in producing an estimate of ecosystem services value, the analysis was essential to (1) identify an ecosystem services' value provided by coastal ecosystems, (2) estimate the flow value of the coastal zone as a whole and of its administrative units, (3) develop a framework for further analysis, and (4) identify areas that need additional research. Thereafter, the objective of this study is to present a comprehensive unit value transfer assessment of the non-market economic benefits provided by the Catalan coast natural environment. The goal of present valuation constitutes to use the best available conceptual frameworks, data sources, and analytical techniques to generate value estimates that can be use to allocate scarce ecosystem services among competing coastal uses such as development and nature conservation. By estimating the economic value of ecosystem services not traded in the marketplace, social costs or benefits that otherwise would remain hidden or unappreciated are revealed, so that when tradeoffs between alternative land uses in Catalonia are evaluated, information is available to help decision-makers avoid systematic biases and inefficiencies.

4.3.2 Applied methodology

The methodological approach in this study follows that proposed by Troy and Wilson (2006) for estimating and mapping the ESV. The approach is based on a unit value transfer methodology and its implementation consists of six core steps, being: (1) definition of ecosystem services to be valuated, (2) spatial designation of the study extent, (3) establishment of a land cover typology whose classes predict significant differences in the value and flow of the ecosystem services identified, (4) meta-analysis of peer-reviewed valuation literature to link available cover types, (5) mapping land cover and associated ecosystem services value, and (6) calculation of total ESV flow and breakdown by cover class. Additionally, summaries by *comarcas* were performed, which constitute relevant management geographies in the assessment of ESV in the Catalan coast.

Before proceeding to a more detailed description of the methodological steps referred before a couple of points need to be made. First, the term land cover incorporates aspects of both, land cover types and uses, since the typology used primarily refers to cover rather than use and terrestrial rather than aquatic/marine. Second, for comparability purposes with most similar works this section of the study limits its discussion to the calculation of ecosystem services monetary value flow in 2004 U.S. dollars per hectare and year. Economic data in the study has been standardized to represent total present values and not discounted. This allows the results to be incorporated into scenarios that may weight the future costs and benefits differently over the time (Heal 2004). However, ecosystem services stocks may also be calculated by estimating the Net Present Value (NPV) of the future flow of services.

Identification of ecosystem services to be valuated

This first step consists on the definition of the ecosystem services whose value will be assessed. The identification of the ecosystem services to be evaluated is part of the study design stage. The outcome of this process depends of the goal and objectives of the assessment and data availability in the peer-reviewed literature (thus, in close relationship to step 4). Ecosystem services typologies respond to a functional hierarchy, *i.e.* 1. regulating services – 1.1 gas & climate, 1.2 disturbance, 1.3 biological, 1.4 water, 1.5 soil, 1.6 waste, and 1.7 nutrient (following the schema proposed in Farber *et al.* 2006 and see Table 3.5.4 in Chapter 3).

Study area definition

The study area definition is an essential step since even small boundaries adjustments can have large impacts on ESV estimates (*i.e.* highly valued coastal wetlands). While the goal may correspond to an administrative unit or political boundaries, those may not match to relevant biophysical areas. This is normally the case of the coastal zone environmental assessment and valuation, due to poor global definition of coastal and marine waters and coastal influence of land in the ocean and *vice versa*. Therefore, this definition process will have significant impact on the final results of the estimation of the ESV of the coastal zone. For the purpose of this study the ESV will be estimated for the operational definition of the Catalan coast that was defined in Chapter 2.

Land cover typology definition

The development of a land cover typology for ESV assessment start with the identification of existing layers, as land use cover, land cover (*i.e.* natural communities), and habitat mapping. This step also depends on available cartography and GIS layers of the study area, since in most cases it would be unviable to develop its own land cover layer at regional or large geographic scale. Therefore a challenge for this study was to link the ecosystem services of interest to the available land use GIS layer. In this study a vector layer model was used due to the precision needed to estimate the ESV in the Catalan narrow coastal zone. In synthesis, the land cover layer will be used to estimate the flow value per type hectare. Here, the spatial aggregation was conducted at the habitat level increasing the possibility to visualize the exact location of ecologically important elements with in the coastal features.

Literature search and analysis

In this step peer-reviewed empirical studies, preferably from similar biophysical and socio-economic contexts, are analyzed in order to extract ESV data associated with each land cover class it is included in the assessment (Ready and Navrud 2006). The information should be assessed based on ecosystem services type, land cover type, valuation method (see Table 4.1.1 for a list of most appropriated method of valuation by ecosystem service), year of the study, geographic location and per hectare value estimates, among other study-specific relevant attributes. If no applicable studies are available, additional non peer-reviewed and meta-analysis should be located and its data summarized. Ideally, if no available or appropriate data exists, new empirical studies need to be commissioned. By increasing the number of publications used in a value transfer analysis several good conditions arise: value data gaps are filled for some ecosystem services, complementing data for an ecosystem service increases the range of estimates that allows the analysis to determine if any given estimates appears unreasonable. Commonly, steps 1, 3 and 4 are determined in an iterative way because the selection of specific ecosystem services to study will impact the availability of valuation studies, and therefore value data, that will necessary impact the development of the land cover typology.

There are three general categories of valuation studies that can be used in ecosystem services value transfer assessments: (1) peer-reviewed journal articles, book chapters, proceedings and technical reports that use conventional economic valuation techniques (this are the more desirable sources of data), (2) non peer-reviewed publications which could include master and doctoral thesis, technical reports and proceedings, as well as public raw data, and (3) secondary data sources from meta-analysis of peer-reviewed and non peer-reviewed studies that use conventional or non-conventional economic valuation methods.

The development of online databases has provided a new tool for value transfer studies (see McComb *et al.* 2006 for a complete discussion on online databases). Over the past decade, different databases have made available data contained in thousands of primary environmental valuation studies conducted since 1980s (*i.e.* Environmental Valuation Reference Inventory^{TM} by Environment Canada). These databases integrate tools to perform the literature research and some of have paid special attention on the development of benefit transfer applications.

Mapping land cover and value

Maps needed in value transfer analysis are commonly developed in a GIS environment using available data. This step follows the recommendations from Bateman *et al.* (2002) on the application of GIS to environmental economics. Most common geoprocessing techniques involved are data layer overlay, merging (combining or union), clipping (sub-setting) and dissolving (spatial or tabular aggregation). These methods will vary from every project. Other characteristics of data layers need to be evaluated at by project basis in order to determine its quality, such as minimum mapping unit, source and final cartographic scales, year of creation, spatial accuracy and data model. Ideally, a good compromise between data quantity, extent and quality should exist in the value transfer database developed. Although from a technical perspective this type of database shouldn't constitute a highly complex system, it should certainly comprise an accurate spatial and attributed accounting system, due to its valuation nature where every hectare will represent monetary estimates.

Calculation of total ESV

In this step spatial explicit ESV are calculated by ecosystem service and land cover type. The total flow value for a given cover unit is calculated by adding the individual ecosystem service value associated to the land cover and multiplying by the units' area. In this process the total flow values is calculated by ecosystem service and flow maps can be derived. Equation below illustrates how $V(ES_i)$ (flow value expressed in currency amount per year units) can be obtained in the GIS environment:

$$V(ES_i) = \sum_{k=1}^{n} A(LU_i) \cdot V(ES_{ki})$$

where $A(LU_i)$ = area of land cover type (*i*), and $V(ES_{ki})$ = annual value per unit area of ecosystem service type (*k*) (expressed in currency amount per area unit and per year) generated by each land cover type (*i*) (Troy and Wilson 2006).

Summary of ESV by relevant management units

If relevant to the study, land cover types and total flow value can be spatially summarized by any user defined management or political aggregation units (*i.e. comarcas*). Due to the characteristic of ESV to be mapped at their original minimum mapping unit (*i.e.* precise vector or grid cell position and boundary), hierarchical aggregations can be performed to summarize data at other spatial scales. The relevance of such results may depend on the original minimum mapping unit.

The aggregation or disaggregation of data will allow us to visualize the pattern and distribution of ecologically important landscape features (Eade and Moran 1996, Bateman *et al.* 1999). However, spatial aggregated measures of geographic data tend to hide patterns of heterogeneity (see a discussion on the modifiable aerial unit problem and the ecological fallacy in Section 4.2 in this Chapter) (Openshaw 1984, Fotheringham *et al.* 2000). Analogously, aggregated measures of non-market values, while useful, can also obscure the heterogeneous nature of the underlying ecosystem services provisioning processes.

4.3.3 Results and discussion

The results of this study will be presented in two sections. First, results related to steps one to six on the value transfer analysis of the Catalan coastal zone; and second, those related to *comarcas*, thus the Homogeneous Environmental Management Units developed in Section 4.2 in this Chapter.

ESV and flow of the Catalan coast

The Catalan coast natural environment is composed of a diverse mixture of forests, grasslands, wetlands, rivers, beaches and seagrass beds that provide many different valuable goods and services to human beings. Although there are several proposal of ecosystem services typologies (*i.e.* Costanza *et al.* 1997, de Groot *et al.* 2002, Farber *et al.* 2006) this study followed the typology developed by Costanza *et al.* (1997) for standardization and comparability purposes (since publication of the study several valuations follow this classification and/or have adapted to their needs). Therefore, the study used a set of 14 non-consumptive services provided by natural and semi-natural coastal ecosystems: (1) atmospheric gas and climate regulation, (2) disturbance regulation, (3) freshwater regulation, (4) freshwater supply, (5) erosion control, (6) soil formation, (7) nutrient regulation/cycling, (8) waste treatment, (9) pollination, (10) biological control, (11) habitat/refugium, (12) genetic resources, (13) aesthetic and recreation, and (14) cultural and spiritual. A detailed description of each ecosystem service can be consulted in Annex III.

The Catalan coast has been previously described in Chapter 2 in terms of its socio-economic, natural and political characteristics. The operational coastal zone definition defined there constitutes the study area of this value transfer analysis. It comprises a 22.8 % of the total terrestrial surface in Catalonia and 21.5 % of its continental shelf. The study area comprises a total of 922,892 ha, where 731,408 ha correspond to the terrestrial domain and 191,484 ha to the marine domain.

The Catalan coast land cover typology was developed for the purpose of calculating the ESV and flow provided by the defined ecosystem services. This typology is a variant of the Catalonia habitats (DMAH 2006c), the Catalan Sea bathymetry (DARP 2000) and the seagrass beds GIS layers (DARP 2002). The habitats spatial layer has been compiled in with data from ortophotos at 1:25,000 scale from 1998 and 2003 at a final cartographic scale of 1: 50,000. It included more than 600 natural, semi-natural and artificial habitat types for the entire Catalonia Autonomous Community, which was based on the CORINE Biotopes Manual of the European Union. The bathymetry layer was used to develop a ≤ 50 m depth strip of the continental shelf and the seagrass bed layer to map the seagrass communities within that strip (mainly composed of *Posidonia oceanica* meadows).

Land cover typologies were divided into two major domains for synthetically (environmental accounting) and management purposes. The coastal and marine domain includes the true marine continental shelf and seagrass beds, and the oceanic influenced beaches, dunes and saltwater wetlands, which constitutes a 22.2 % of the area valuated. The terrestrial domain constitutes a 77.8 % and includes the vegetated communities, freshwater flows and bodies, and the more artificial and urban related land covers. The aggregated classification fulfilled the coastal zone definition and the ecosystem services of interest in this study.

Table 4.3.1 shows the developed typology with 15 classes, which condenses a unique number of four classes of the coastal-marine domain and seven classes of the terrestrial domain that were valued. Although the classes of urban, barren, burned forest and mining grounds were included in the table below for area-accounting purposes, they where not valuated since either it is not expected to provide services or its value has not been found in the reviewed literature.

Table 4.3.1. Catalan coast land cover typology and surface.

Domain	Land cover	Area (ha)
Coastal-marine	Shelf (≤ 50 m)	191,484
	Seagrass bed	8,568
	Beach or dune	4,098
	Saltwater wetland	2,494
	Total	206,644
Terrestrial	Temperate forest	350,472
	Grassland	37,010
	Cropland	246,416
	Freshwater wetland	73
	Open freshwater	5,611
	Riparian buffer	2,558
	Urban greenspace	1,848
	Urban *	71,589
	Barren	3,781
	Burned forest	2,778
	Mining ground	2,681
	Total	724,816
Total		931,460

*Note: * Urban land cover includes urban areas and other impervious zones.*

The total surface of the land covers included differs from the general area of the study area. The difference corresponds to the addition of the seagrass beds area (8,568 ha). Since the seagrass ecological community provides additional ecosystem services to those accounted for in coastal shelf here, *i.e.* waste processing, storm protection and erosion control (see Gacia and Duarte 2001, Moberg and Ronnback 2003, UNEP 2006), its area was added to the total number of hectares included in the valuation, as shown in Table 4.3.1. Figure 4.3.1 shows the individual area contribution of land covers in the study area. The largest land covers in the Catalan coast are temperate forests, continental shelf (≤ 50 m depth), agricultural land, urban land, barren land, burned forest and mining grounds, and grasslands. A common characteristic among these five land covers is medium to high human influence and resource use that are subject to. Although subject to a lower human influence and are represented in less amount, the rest of the land covers account for high ecological value (*i.e.* beaches, dunes, wetlands, running water and bodies, and seagrasses).

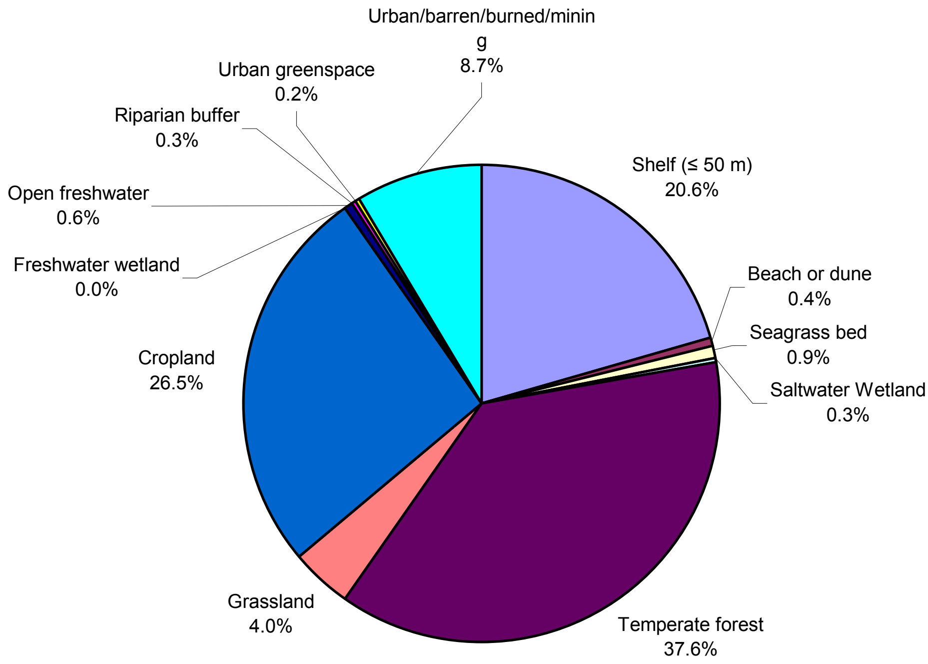


Figure 4.3.1. Area distribution by land cover type of the Catalan coast.

Most categories in the typology represent aggregations of habitats. Annex IV presents a complete description of land covers and sub-categories. As an example, “beach or dune” category in the new typology includes both the beach and the vegetated coastal dunes categories of the habitat layer (DMAH 2006c). However, some categories were developed using ancillary data sources in combination with the habitat layer, *i.e.* rivers, lakes and priority wetlands layers were used to develop the freshwater layers of open freshwater, freshwater wetlands and riparian buffers. Figure 4.3.2 shows the land cover map of the Catalan coast.

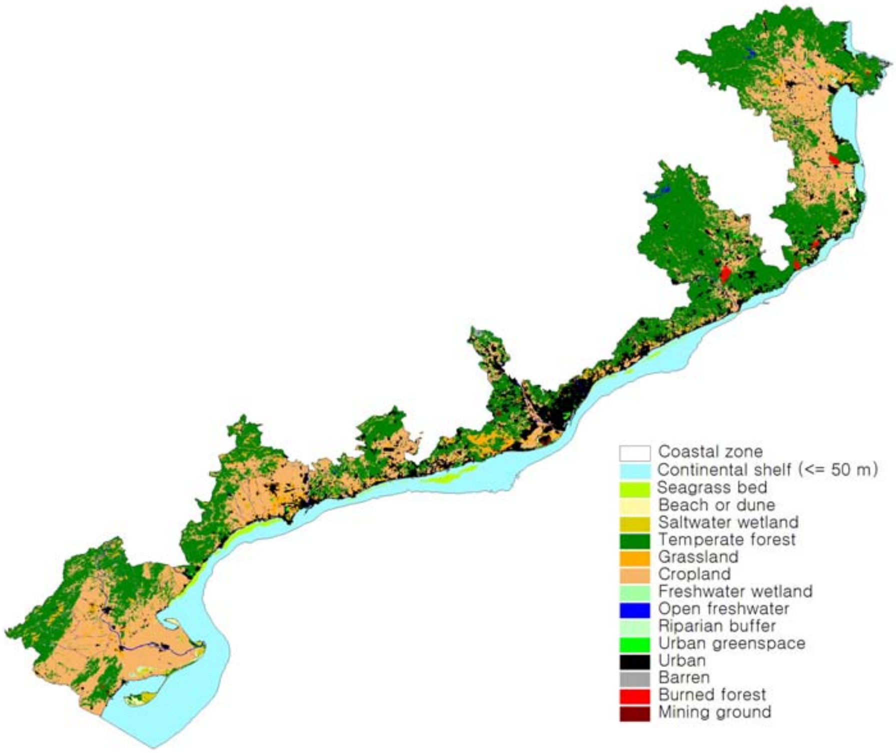


Figure 4.3.2. Land cover map of the Catalan coastal zone.

The raw data for the value transfer analysis was obtained from previously conducted contingent valuation-based empirical studies, which measured the economic (monetary) value of ecosystem services. A set of decision rules were developed for selecting empirical studies from the literature that allowed estimating the economic value. Online scientific literature search engines and databases were used to create the Catalan coast value database, such as ISI Web of Science (Thomson 2005b) and the Environmental Valuation Reference Inventory^{TM} (EVRI 2006).

Decision rules for selecting economic studies for the Catalan coast:

- Published in peer-reviewed journals or books, or in meta-analysis of other documents (see Table 4.3.2 below).
- Limited to results that can readily be translated into spatial equivalencies—(*i.e.* U.S. dollars per hectare).
- Focused on similar socio-economic and biophysical regions as Catalonia in North America and Europe.
- Focused primarily on non-consumptive resource use and ecosystem services (*i.e.* non-market).

According to Brouwer (2000) the quality of the original studies will determine the overall quality of the ESV estimate. Therefore during the literature review two general categories were identified as useful and desirable for the valuation assessment. Table 4.3.2 shows the two types of literature that were used in this analysis, together with its strengths and weakness.

Table 4.3.2. Value transfer data source typology used.

Type I	Type II
Peer-reviewed journal, book chapter	Meta-analysis of peer-reviewed and non-peer-reviewed studies
Uses conventional economic valuation methods	Uses conventional & non-conventional valuation methods
Restricted to conventional, preference-based value	Uses conventional preference-based, non-conventional preference-based & non-preference-based values

Type I studies are peer-reviewed empirical analyses that use conventional environmental economic techniques (*i.e.* travel cost, hedonic pricing and contingent valuation) to determine individual preferences on environmental services. Type II studies represent secondary, summary studies such as statistical meta-analyses of primary valuation literature that include both conventional environmental economic techniques as well as non-conventional techniques (energy analyses, marginal product estimation) to generate meta-estimates of ESV. Non peer-reviewed analyses or grey literature such as technical reports, doctoral theses and government documents were not included in the creation of the value database, due to time constrains in this study. The ESV results presented below integrate Type I & II literature categories to estimate the ESV associated with the Catalan coastal zone. Specific information on all the studies included in the database appears in Annex V and the value database in Annex VI.

Queries of the best available ESV data were performed to the database to generate baseline ecosystem service values estimates for the entire coastal zone. A set of 94 peer-reviewed empirical Type I & II studies was selected, were 188 individual estimates were obtained for 53 pairs of ecosystem service and land cover. The time coverage of literature used ranged from 1971 to 2004, with a median of 1994 and being 1996 the year with most articles. All ESV were standardized to average 2004 U.S. dollar equivalents per hectare and per year to provide a consistent basis for comparison. Value from different dates found in the literature where standardized using annual Consumer Price Index variation for Catalonia (INE 2006b); and when ever needed, the Euro to U.S. dollar were converted using the fix exchange rate ($ 1 = 133.94 Pesetas & 166.38 Pesetas = 1 Euro) set in 1994 by the Bank of Spain (Banco de España 2006). The developed baseline of ecosystem services value and land cover types represented within the study area are presented in Table 4.3.3. Each value presents the standardized average value data for ecosystem services associated with a unique land cover type.

Following convention in the literature all results presented represent the statistical mean for each ESV (*i.e.* Costanza *et al.* 1997, Eade and Moran 1999, Wilson *et al.* 2004). Each mean value can be based on one or several estimates, therefore the number of estimates used to derive each mean ESV is reported in technical Annex VI. Statistical means do tend to be more sensitive to upper bound and lower bound outliers in the literature than median, although some differences do exist between the mean and median ESV estimates. For example, the statistical mean for beach or dune ESV is approximately $ 104,146 USD/ha·yr, while the statistical median is $ 93,905 USD/ha·yr, a difference of approximately $ 10,241 U.S. dollars per year. Given that this difference represents the largest mean-median gap, the analysis assumes that results would not dramatically change if statistical means were replaced with statistical median. While it may also be tempting to narrow statistical ranges by discarding high and low outliers from the literature, the data used in this section were all directly derived from empirical studies rather than theoretical models and there is no defensible reason for favoring one set of estimates over another. Data trimming therefore was not used.

In Table 4.3.3, the summary column at the far right of the table shows a considerable variability in ecosystem service values delivered by different land cover types in the Catalan coastal zone. As expected, each land cover represents a unique mix of services documented in the peer-reviewed literature. On per hectare basis, beaches provide the highest ESV ($ 104,146) by providing disturbance control ($ 67,400) and aesthetic & recreation values ($ 36,687), providing these also the largest individual values in the assessment. Second, it appears that both freshwater wetlands ($ 28,585) and seagrass beds ($ 24,228) contribute significantly to the ESV. On the lower end of the value spectrum, grassland ($ 230) and cropland ($ 2,140) provide the lowest ESV on an annualized basis. This finding is consistent with the focus of the current analysis on non-market values which by definition exclude provisioning services provided by agricultural landscapes (*i.e.* food and raw materials). Empty spaces in Table represent data gaps in the literature and its implications will be discussed later in this document.

The column totals at the bottom of Table 4.3.3 also reveal considerable variability between averages ESV delivered by different ecosystem services. Disturbance regulation constitutes the largest valuable ecosystem service ($ 77,420), followed by aesthetic & recreation services ($ 50,098); while soil formation and genetic resources services account both for the lowest values of the spectrum ($ 20).

Most estimates were based on current willingness-to-pay or other stated-preferences approaches, which are limited by human preferences and knowledge base. Improving people's knowledge base about the contributions of ecosystem services to their welfare would almost certainly increase the values based on willingness-to-pay, as people would realize that ecosystems provided more services than they had previously been aware of.

Table 4.3.3. Value of ecosystem services per land cover and service.

Ecosystem services (2004 USD/ha·yr)

Domain	Land Cover	Gas/ Climate regulation	Disturbance regulation	Water regulation	Water supply	Erosion control	Soil formation	Nutrient cycling	Waste treatment	Pollination	Biological control	Habitat/ refugia	Genetic resources	Aesthetic & recreation	Cultural & spiritual	Total per ha (USD/ha·yr)
Coastal & marine	Shelf (≤ 50 m)				1,287			1,787			49				86	3,210
	Seagrass bed							24,228								24,228
	Beach or dune		67,400											36,687	59	104,146
	Saltwater wetland		766						13,376			497		64	445	15,147
Terrestrial	Temperate forest	133			403	122	12		109	400	5	2,281	20	301	2	3,789
	Grassland	7		5		37	7		109	32	30			2		230
	Cropland									20	30	2,053		37		2,140
	Freshwater wetland	331	9,037	7,378	3,815				2,071			279		3,474	2,199	28,585
	Open freshwater				1,011									880		1,890
	Riparian buffer		217		4,747									3,385	10	8,359
	Urban greenspace	830		15										5,266		6,111
	Urban/barren/burned/mining															0
	Totals	1,302	77,420	7,398	11,263	159	20	26,015	15,664	452	114	5,110	20	50,098	2,802	197,836

Notes: Rows and columns are in USD/ha·yr. Open cells indicate lack of available value data.

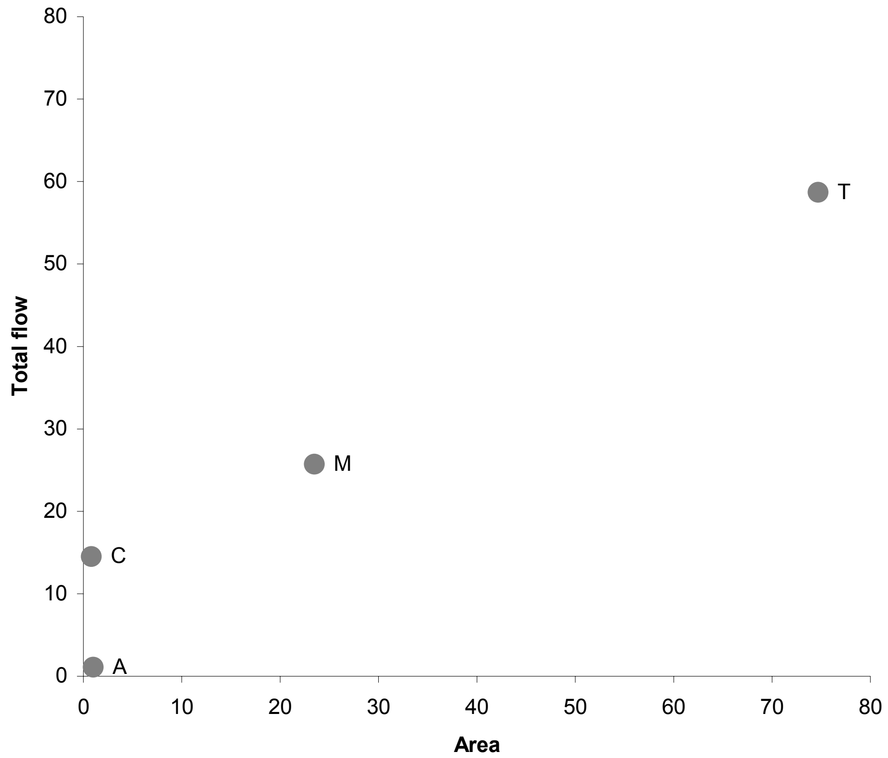
Ecosystem services annual flow value for land cover types in the Catalan coast were determined by multiplying areas of each cover type in hectares, by the estimated annualized ESV in U.S. dollar per hectare for each cover type. ESV presented above in Table 4.3.3 were used to estimate the flow values associated with each ecosystem service. Resulting values were estimated for each land cover type unit (polygon) in the coastal zone using the spatially explicit value transfer described in methods. Total flow ESV estimates for each land cover category were estimated by taking the product of total average per hectare service value and the area of each land cover type in the operational coastal zone definition. These results are summarized below in Table 4.3.4.

The data show that substantial economic values are being delivered to Catalan coast citizens every year by functional ecological systems on the landscape. It was estimated that ecosystem services of the Catalan coastal zone (931,460 ha) provides ***$ 3.2 billion USD per year*** in natural capital. Opposite with the value transfer data results reported above, it appears that ecosystem services associated with temperate forest are the largest flow value providers on annual basis (41.6 %). Although forest does not account for a large ESV ($ 3,789 compared to $ 104,146 of the shelf), results are influenced by having the largest surface (37.6 %) in the coastal zone area. Shelf (19.2 %), cropland (16.5 %) and beach or dune (13.4 %) follow, respectively, in the provisioning of cumulative economic value on annual basis.

Table 4.3.4. Annual flow of ecosystem services per land used cover.

Domain	Land use cover	Total flow (2004 USD/yr)	%
Coastal-marine	Shelf (≤ 50 m)	614,637,663	19.2
	Seagrass bed	207,585,504	6.5
	Beach or dune	426,791,880	13.4
	Saltwater wetland	37,777,608	1.2
	Total	1,286,792,655	40.3
Terrestrial	Temperate forest	1,328,021,174	41.6
	Grassland	8,502,682	0.3
	Cropland	527,307,954	16.5
	Freshwater wetland	2,086,694	0.1
	Open freshwater	10,606,674	0.3
	Riparian buffer	21,383,563	0.7
	Urban greenspace	11,292,851	0.4
	Urban/barren/burned/mining	0	0.0
	Total	1,909,201,592	59.7
	Total	3,195,994,247	100

A closer look to the results shows that coastal and marine land covers provide 40.3 % of the total flow value, although it only accounts for 22.2 % of the total valuated surface in the study. In the other hand, more than 97 % of the contribution to value by the terrestrial domain is provided by only two, forest and cropland, out of the seven valued land covers. Moreover, if land covers are aggregated into classical environmental categories (see Figure 4.3.3 below), results show that coastal (18.1) classes have the best ESV-area relationship (compared to marine and aquatic = 1.1, terrestrial = 0.8). This implies that, based on present knowledge of ESV, beach, dunes and saltwater wetlands provide more value by hectare than any other land cover in the Catalan coastal zone.



Note: (M)arine = shelf and seagrass; (C)oastal = beach, dunes and saltwater wetland; (T)errestrial = forest, grassland, cropland and urban greenspace; (A)quatic = freshwater wetland, open freshwater and riparian buffer.

Figure 4.3.3. Contribution to flow value by area of major land use types. Urban, barren, burned and mining land cover types not included in calculations.

This result probably underestimate shifts in the demand curves as the sources of ecosystem services become scarcer. If the Catalan coast's ecosystem services are scarcer than assumed here, their value has been underestimated in this study. Such reductions in supply appear likely as land conversion and development takes place, *i.e.* during the period 1987-2000 Catalonia experienced an artificial land increment of 12.8 % compared to the average 30 % in Spain during the same period (OSE 2006); climate change may also adversely affect coastal ecosystems. The precise impacts are harder to predict and thus this complementary analysis wasn't under the scope of present study.

The flow estimates were then mapped by land cover across the Catalan coastal zone. This was done by combining the land cover typology spatial layer (individual habitat polygon constituted minimum mapping unit) and the ESV in per hectare basis in Table 4.3.3. Maps in Figure 4.3.4 show per hectare ESV estimates for all Catalan coast land covers and the annual flow they provide. The spatial representation of ESV (A) shows each land cover per hectare value, while ESV flow (B) represents the economic values are being delivered to Catalan coast citizens every year. Maps were produced in GIS environment at a 1:50,000 cartographic scale, since it was based on the original habitats of Catalonia layer (DARP 2006).

As the Catalan coast flow ESV map shows, there is considerable heterogeneity in the actual delivery of ESV's across the coastal zone with particularly notable differences between interior and coastal areas; and North and South, and centre areas. This pattern of spatial heterogeneity suggests that differences are due to underlying landscape patterns on the ground and analogous to the findings above for the coastal-marine domain. For example, same pattern was observed on close examination to beaches, dunes and saltwater wetlands, which although having low surface their contribution to total flow is highly relevant. Similarly, value appears to be concentrated to the extremes of the study area (North and South) due to their large less influenced natural and semi-natural areas (see chapter 2 and Section 4.2 of this Chapter for an explanation of natural areas along the Catalan coast).

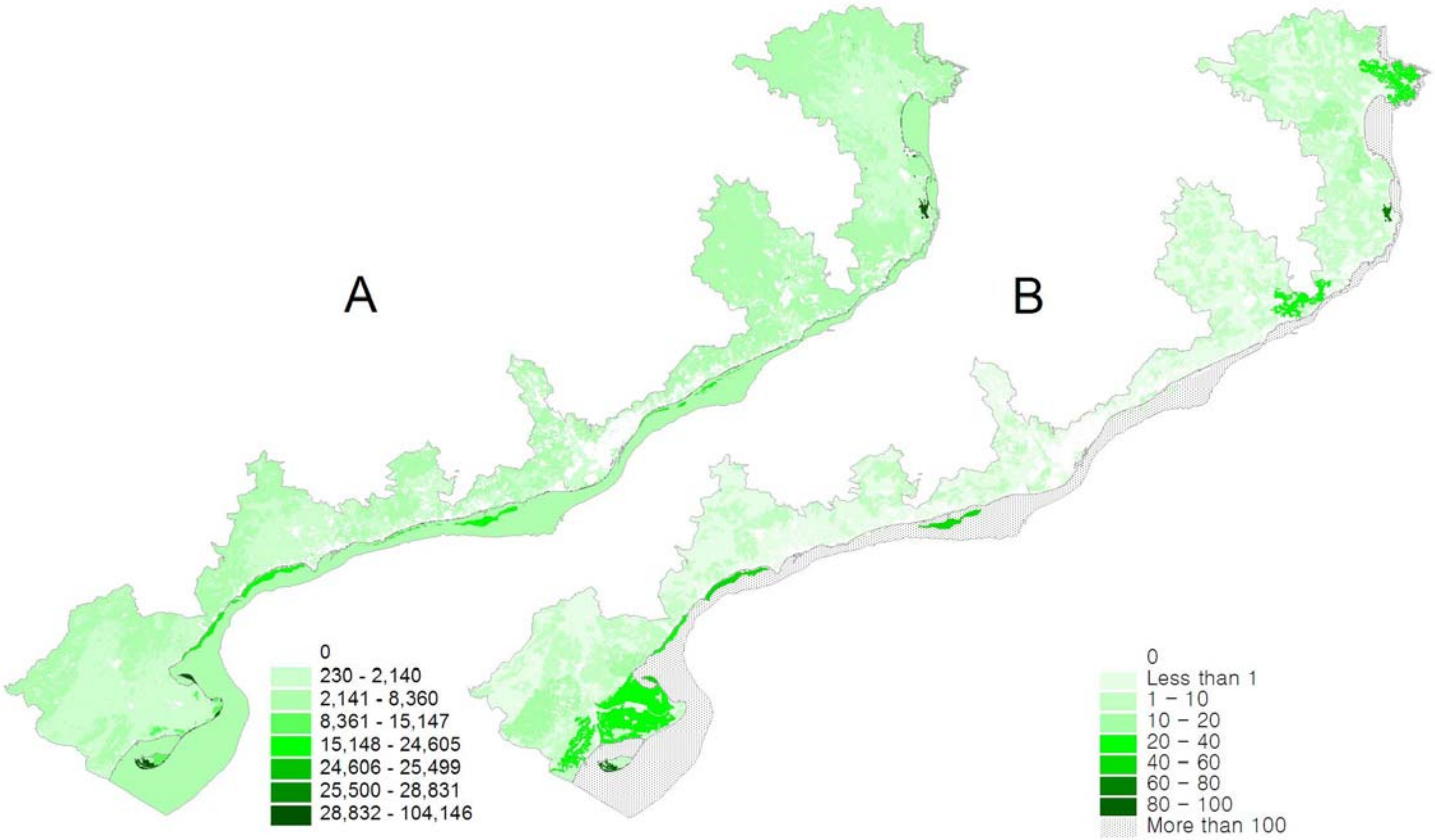


Figure 4.3.4. Ecosystem services value (A) and flow (B) maps of the Catalan coastal zone. A in 2004 USD/ha·yr and B in 2004 millions of USD/yr.

The contribution by ecosystem service to total flow ESV was also analyzed. Figure 4.3.5 shows the considerable variability that resulted between different ecosystem services. Habitat (40.9 %) is the largest value provider to the total flow of ESV. It is followed by nutrient cycling (17.2 %), water supply (12.7 %), aesthetics and recreation (9.0 %), disturbance regulation (8.7 %) and pollination (4.6 %). The addition of the area dimension to the analysis allows land covers with large areas to have a bigger contribution in value (*i.e.* forest and cropland). However, this is not necessary true for all ecosystem services, since most of the contribution of disturbance regulation and aesthetics and recreational services are provided by beaches, dunes and seagrasses which are not very abundant compared to the other terrestrial land covers. There were several ecosystem services which seemed obviously undervalued due to the available literature. Although this issue will be discussed later in this chapter in terms of available data, a number of ESV does not reflect the more classical functional view of the nature of the coastal zone, *i.e.* waste treatment by wetlands, water regulation by river deltas, gas and climate regulation by the shelf, and the cultural and spiritual classical function of the coats.

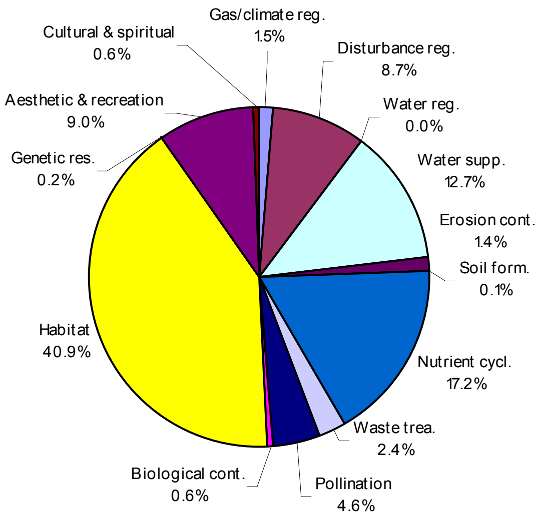


Figure 4.3.5. Contribution to flow value by ecosystem services' type.

Literature on the value transfer approach reveals different conclusions as to the effect of including socio-economic variables suggested by Spash and Vatn (2006). Most studies that are based on function transfer include variables that cover income, gender, age, and education. However, some studies conclude that standard variables used are often insignificant or capture only a small part of the total value variation and do not improve results compared to unit transfer analysis (Brouwer 2000, Barton 2002, Shrestha and Loomis 2003, Jiang *et al.* 2005).

The analysis performed here constitutes a unit transfer approach, which it is based on the review of literature to obtain value estimates that are relevant to the Catalan coast. However, estimates were compared to actual market economic indicators. Table 4.3.5 show the contribution of land cover's flow ESV, to the GDP and income of the Catalan coastal zone (based on the 12 *comarcas* of the coastal zone, see Annex IX). Results show that total flow ESV constitutes 2.8 % of the annual GDP ($ 114,805,986,219 in 2004; Caixa Catalunya 2005) and 4.3 % annual available family income ($ 74,375,954,818 in 2004; IDESCAT 2006) in the coastal zone. Income was found to be more significant since it is this economic measurement which can be compared to natural wealth provided by ecosystem services. While most contribution to GDP and income is provided terrestrial land covers, especially forest, coastal and marine covers account for relevant contributions (*i.e.* shelf, beaches and dunes). The USD/GDP column indicates the contribution of flow ESV available by each 1000 units of GDP. For example, temperate forest services provided an equivalent natural capital of $ 11.57 per 1000 dollars of GDP in 2004, while freshwater wetlands provided only $ 0.02 for the same period.

Table 4.3.5. Comparison of total flow of ecosystem services value with GDP and income by land used type in 2004 (USD/GDP = flow per 1000 GDP units).

Domain	Land use cover	Flow %	GDP %	Income %	USD/GDP
Coastal-marine	Shelf (≤ 50 m)	19.23	0.54	0.83	5.35
	Seagrass bed	6.50	0.18	0.28	1.81
	Beach or dune	13.35	0.37	0.57	3.72
	Saltwater wetland	1.18	0.03	0.05	0.33
	Total	40.26	1.12	1.73	
Terrestrial	Temperate forest	41.55	1.16	1.79	11.57
	Grassland	0.27	0.01	0.01	0.07
	Cropland	16.50	0.46	0.71	4.59
	Freshwater wetland	0.07	0.00	0.00	0.02
	Open freshwater	0.33	0.01	0.01	0.09
	Riparian buffer	0.67	0.02	0.03	0.19
	Urban greenspace	0.35	0.01	0.02	0.10
	Total	59.74	1.66	2.57	
	Total	100	2.78	4.30	

In 1997, Costanza *et al.* estimated the ESV and flow of the global natural capital in an average 33 trillion U.S. dollars per year. Since then many studies have developed ecosystem services valuations (Heal *et al.* 2005; McComb *et al.* 2006, Wilson and Hoehn 2006). Table 4.3.6 below shows a comparison of major ecosystem services value at different geographical scales, including Costanza *et al.* (1997) global estimations. A direct comparison among most of the categories provided is not possible due to differences in goods and services (*i.e.* market *versus* non-market), land cover typologies and resolutions used (including spatial and temporal). Although results show the above mentioned differences among studies, *i.e.* several orders of magnitude in surface, population and GDP; it was evident that the Catalan coast achieves the largest value per hectare ($ 3,463). Differences in coastal zone definition are also relevant when comparing. Although the marine evaluated surface here represents only 20.1 %, it represents more than half the total valuated surface in Scotland (Williams *et al.* 2003). Thereafter, it was more evident that a significant amount of estimated ESV flow in Scotland has been achieved due to the larger marine area included. Furthermore, differences are probably enhanced due to the larger cartographic scale of source data (land cover spatial layer) on what this study relied on. Thereafter, several highly valued land covers were able to be included (*i.e.* saltwater wetlands, seagrass beds, freshwater rivers, bodies and wetlands) and attached to a value in the analysis, which therefore improved the total ESV of the coastal zone.

Table 4.3.6. Comparison of different ecosystem services valuation studies. Data standardized for 2004.

	Area (ha x 10^6)	GDP (USD x 10^6)	Pop (hab x 10^6)	ES flow (USD x 10^6)	GDP %	USD/ha·yr	Flow per capita
World	51,625.0	44,384,871	6,464.0	42,410,000	95.6	822	6,560
Catalan coast	***0.9***	***114,805***	***4.3***	***3,195***	***2.8***	***3,463***	***730***
Scotland	16.0	141,888	5.0	32,622	23.0	1,936	6,424

Notes: Flow value in USD/yr. Each study included its own definition of marine extent. World data from Costanza et al. 1997 and other sources. Scotland data from Williams et al. 2003 and other sources.

It is also interpreted from results that comparisons are only possible among equivalent land covers, where coastal zones include the same ecosystems and the only dependent variable in the analysis is the services' value (normally stated by human preferences). Hence, a common and objective definition of the coastal zone's land covers need to be implemented in the future, if comparisons among sites are relevant. Moreover, this study proposes the use of HEMU in the analysis of flow ESV of the coastal zone, since this approach allows integrating territorial specific characteristics in its management as described in Section 4.2.

ESV and flow of the management units of the Catalan coast

In this sub-section, results of the spatial summaries at the *comarca* administrative level are presented. Previously in this study, *comarcas* were chosen to represent the terrestrial definition of the coastal zone in this study (a larger discussion on the relevance of this administrative unit to the Catalan coast management can be found in Section 4.2 in this Chapter).

The summary of ESV by relevant management units has been reported previously as useful in the understanding of the heterogeneous nature of the underlying ecosystem services provisioning processes (Bateman *et al.* 1999, Troy and Wilson 2006). Thereafter, the objective of this analysis was to identify the relationship between ESV and some relevant characteristics of the coastal zone for its management. Detailed area and value transfer results by land cover and *comarca* are presented in Annexes VII and VIII, respectively.

Results in Figure 4.3.6 show the relationship between the area and flow ESV by *comarca*. Both were found consistent with distribution found in the HEMU analysis, since larger natural values are found in larger *comarcas* and to the North and South extremes of the study area. In the middle, Garraf also follows the patterns and accounts for a considerable ESV. Results show that Montsià (16.5 %) has the larger absolute flow ESV followed by Alt Empordà and Baix Ebre. Barcelonès having (1.2 %) the lowest contribution to the flow ESV, among *comarcas*. From these results and as expected, it can be determined that area has a large effect in the flow ESV estimates. However, this is not only true from the flow calculations (ESV is multiplied by the area to obtain the flow, thus larger areas will provide larger values), but since large *comarcas* also account for a less populated and more natural environment (see Figure 4.2.2). Consequently, Baix Empordà, Garaf, Baix Camp, Baix Ebre and Montsià were found to have flow-area ratios greater than one, and thus represent the larger relative contributions to total flow in the Catalan coast.

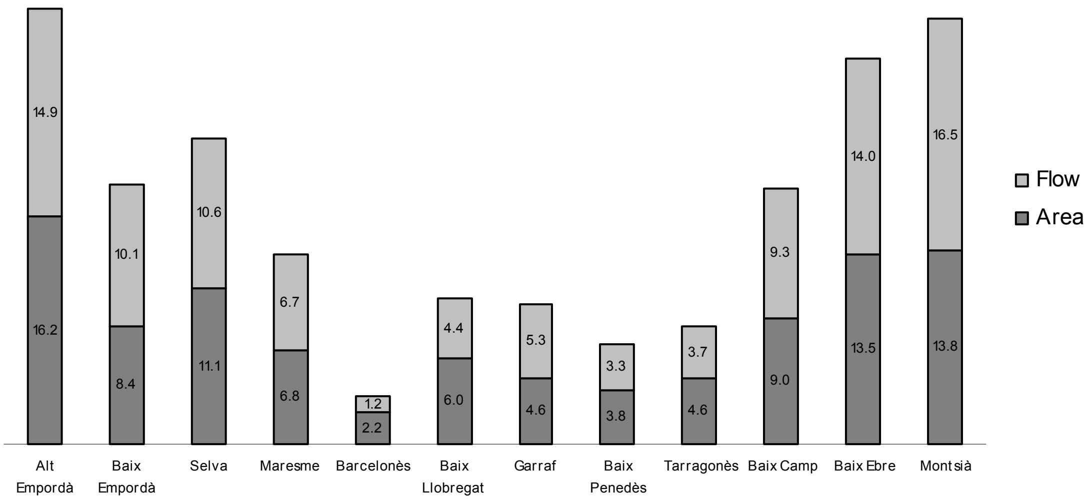


Figure 4.3.6. Contribution of flow value and area by *comarca*. Numbers indicate percentages.

Another relevant characteristic of present ESV estimates is that they also integrate a marine area and its corresponding ecosystem services. This constitutes a major difference between this results and the previous HEMU analysis. Although it has been reported that the coastal-marine ecosystem services contribute to 40.3 % of the total ESV, only the Montsià and Baix Ebre area together account for 17 % of the total ESV in the coastal zone. Therefore it is relevant to understand the "mariness" of *comarcas* in order to determine the nature of its ESV (see Figure 4.3.7). An example of this issue is represented by Maresme, which constitutes an economic dominated HEMU, but has a considerable larger marine portion that certainly provides more ESV that what was expected from its natural resources and HEMU class (see Figures 4.2.2 and 4.2.3).

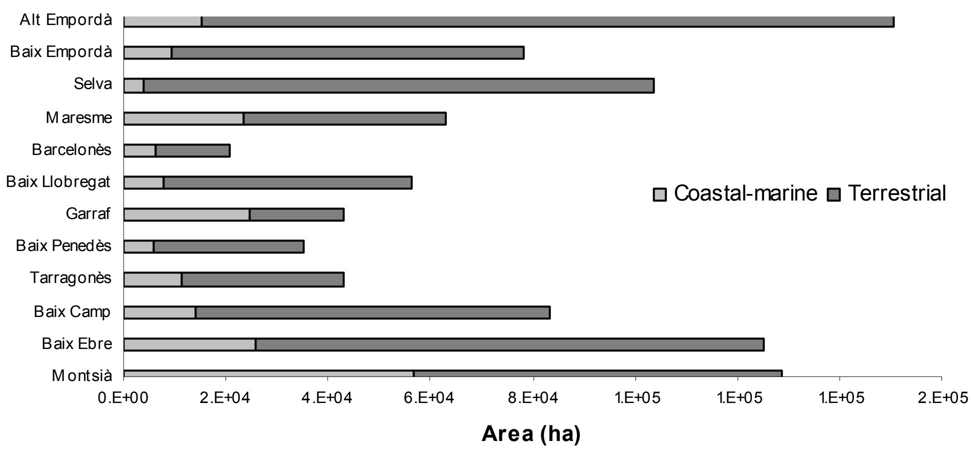


Figure 4.3.7. Coastal-marine and terrestrial area by *comarca*.

When compared ESV flow with demographic and economic variables a general inverse pattern was found (see complete results in Annex IX). As expected, Figure 4.3.8 shows that there is an inverse relationship between flow ESV and other market economic indicators, such as GDP and income. This pattern is also coherent with results found at HEMU level, since less populated and more natural *comarcas* account for the higher ESV and the lowest economic development. The Baix Penedès case is also singular, since as reported before it accounts for the lowest natural value (see Table 4.2.2), and together with Barcelonès the lowest ESV flow (see Figure 4.3.6). Baix Penedès has developed in the last decade large touristic areas, *e.g.* Vendrell and Comarruga which constitute more affordable second residency and recreational area for people from Barcelona than Garraf (Pers. Com. with Alvar Garola). Garraf and Maresme also show a pressure-export effect of Barcelona Metropolitan area. This is captured in the Maresme Strategic Development Plan, which reports that a desirable natural land use model has been losing territory against the developed dormitory cities along its coast (Maresme2015 2007). Similarly, results on contributions of *comarca's* ESV flow to each of its economic variables shows Montsià (52.3 % of its income) having the larger contribution to its economic wealth, with more than double that all other *comarcas*, but Baix Ebre (36.9 % of its income). While Tarragonès and Barcelonès have the smaller contributions (Annex X shows the contribution of ESV flow by *comarca* to its GDP and income).

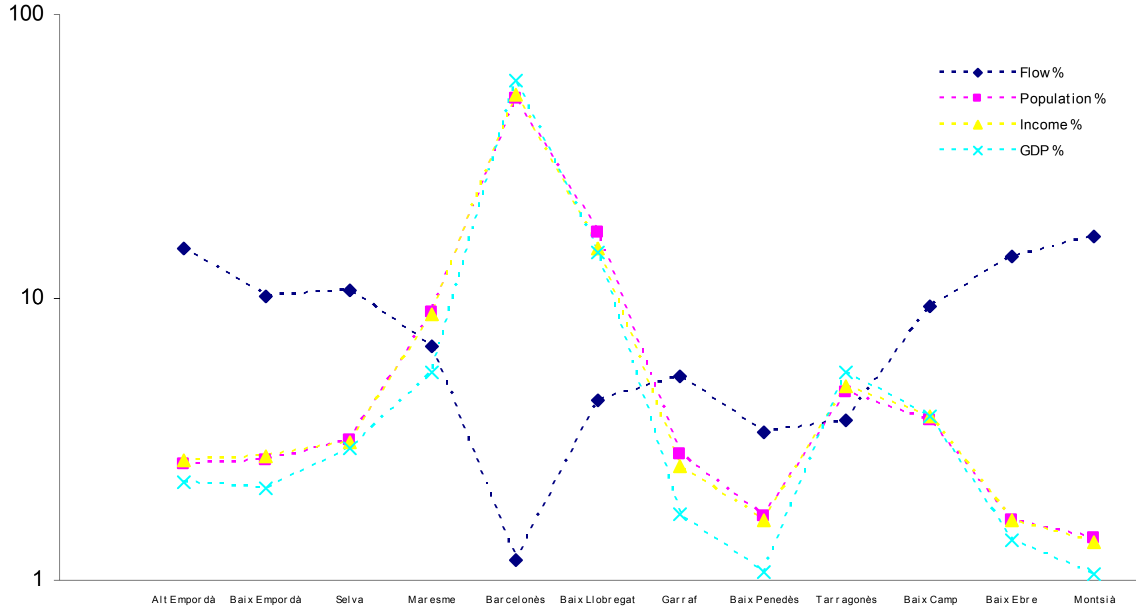


Figure 4.3.8. Comparison of total flow of ecosystem services with population, GDP and income by *comarca*. Y-axis in logarithmic scale. For clarity purposes discrete spatial units have been represented as linear plots.

The map in Figure 4.3.9 shows the average annual ESV per hectare by HEMU. Since these estimates also integrate the marine ESV, the specific pattern differs from those of the HEMU. However, the general distribution of the ESV remains along the coastal zone. Major differences are found in Garraf which has the greater per hectare value ($ 4,123); and Alt Empordà having a considerable lower value ($ 3,166), considering that it accounts for the second largest ESV (14.9 %), among the *comarcas*. For consistency purposes, map was created using the same method and number of classes that the HEMU map. Once defined a desired number of classes (four in this case), the method identifies break points between classes by minimising the sum of the variance within each of the classes (Jenks 1967). Thereafter, the map can vary depending on the specified number of classes and the per hectare values at land cover level constitute the relevant information for management and decision-making processes. Thus, complementarily Annex X also shows the contribution of ESV flow by HEMU to its GDP and income.

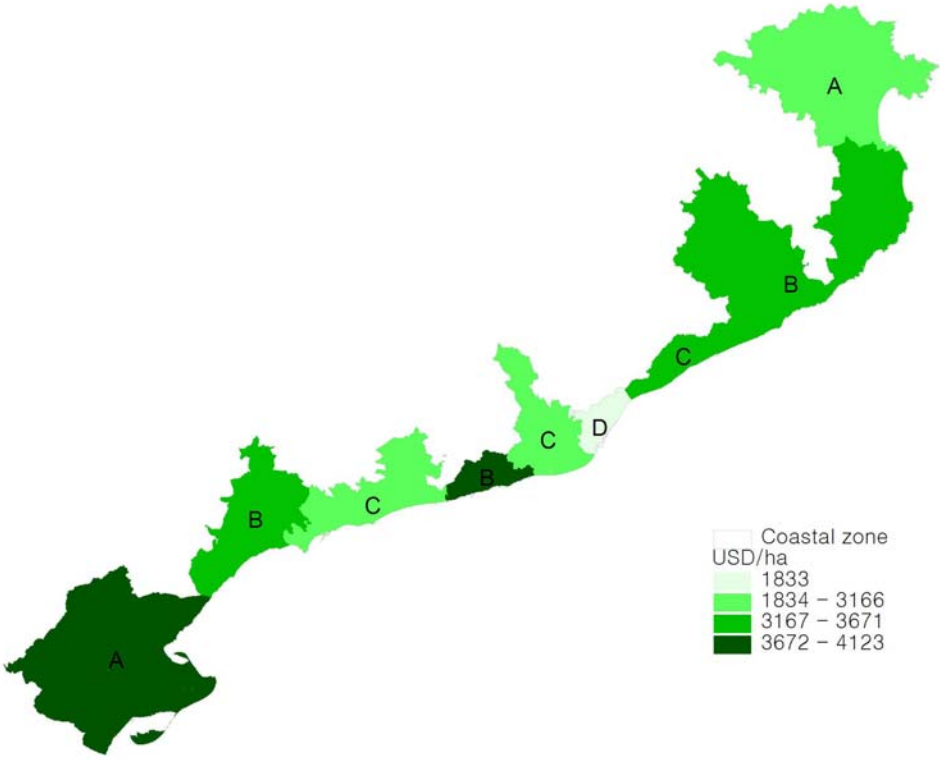


Figure 4.3.9. Average ecosystem service value per hectare and year by HEMU for the Catalan coast. Letters indicate HEMU class membership.

Cobb-Douglas production-type indicators represent the relationship of an output to input (Cobb and Douglas 1928). In ecological economics production-type indicators are used to measure the relationship between ESV flow to biophysical and socio-economic characteristics that are relevant to service provision (GIEE 2006). Area, population and GDP were included as inputs since previous analyses have been conducted with these variables in the study. The three variables were included at equal parts in the Production Indicator (PI), as follows:

$$PI = \frac{ESVflow}{\sqrt[3]{(ha \cdot hab \cdot GDP)}}$$

PI was calculated for each *comarca* and results were standardized in a zero to one continuous scores in order to show largest and smallest contributions along the coast.

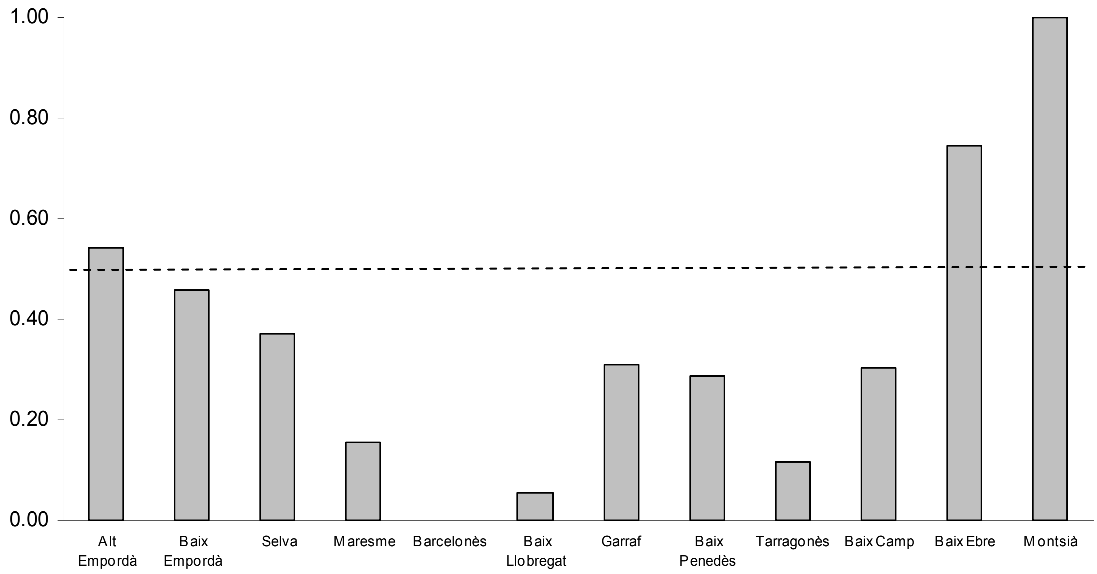


Figure 4.3.10. Production-type indicator showing contributions of area, population and GDP to flow of ecosystem services value by *comarca*.

Results in Figure 4.3.10 show that the larger the ESV flow estimate and the lower the three independent variables, the better the PI performs (equals one). This could be interpreted as that larger ESV values and area, and lower human influence (inhabitants and development) have better contributions in services flow. But the reacting obvious question is, For what? hasn't been raised, and therefore an answer formulated yet (although it is very likely that a good answer is for biodiversity conservation and ultimately humans, but in this section a more direct relationship to human well-being is under exploration). In this scenario for the Catalan coast, Southern *comarcas* accounted for the best compromise among independent variables (see Figures 4.3.6 and 4.3.8), therefore greatest provision performance. However, these results provide a similar picture that in previous *comarca* analyses and of the HEMU section.

A second interpretation can be derived from this analysis if ESV flow and area are though fixed while population and GDP as variables over time. Thereafter, if demography and economy continue to grow as they do now, the question of What areas are more viable to support such increments and thus its influence? becomes relevant. The analysis shows that if an arbitrary 50 % threshold is set to this compromise, only four out of the 12 *comarcas* are likely to provide viable levels of ecosystem services to citizens. If desirable, threshold can vary for different scenarios and *comarcas* with different handicaps and buffer levels will be found.

A third idea on ecosystem services provisioning can be explored. Although physical barriers do exist in nature, there is most likely that natural areas at Garraf or even further provide an amount of services to citizens in Barcelona (*e.g.* climate regulation, water supply, pollination, among others). Thus, this is consistent with the need of a natural reserve network in Catalonia that conserve not only individual species or populations but a range of ecological functions that provide services that flow along the entire coast. Although the idea would need further and more detailed development, an analysis of services' provisioning capacity that is captured in the PEIN will be provided in next section.

Although this indicator constitutes a static simplification of the complex reality and provides only exploratory results, it is proposed as a relevant tool to integrate ecosystem services provisioning capacity into the integrated coastal zone planning. Finally, even if threshold is largely modified, final conclusions will be just slightly altered: starting with Barcelonès (zero), highly populated and developed *comarcas* appear to lack of the basic natural infrastructure to sustain even larger socio-economic growth.

Limitations of the value transfer approach

Previous sub-sections put forward that not all cover types described for the study area were effectively matched to the different ecosystem services. This is the result of the criteria used which focused on Type I literature on ecosystem valuation. Therefore, many landscapes which are of interest from an environmental management perspective simple having not yet been scientifically covered for their non-market values (*i.e.* most shelf, seagrass, beach and open freshwater services).

The data reported in dark gray in Table 4.3.7 show, the 53 ESV obtained from 188 individual estimates found in 94 peer-reviewed empirical valuation literature for the land cover types included in this study. As the table reveals, by expanding the selection criteria to include synthesis studies as Costanza *et al.* (1997) several gaps were able to be filled. Areas not shaded (in white) represent those situations where it is not expected that a particular ecosystem service is provided (*i.e.*, soil formation by the coastal shelf). Light shading indicates those cells where ES are expected to be provided by a land cover type, but for which (i) there is currently no empirical value estimates, (ii) no value has been found, or (iii) the specified criteria was not satisfied. Those Ecosystem service that based on the available literature are considered relevant to the Catalan coastal zone valuation with no actual value estimates are marked with an asterisk. A global list of ecosystem service provided by the coastal zone land use types can be consulted in Martínez *et al.* (2007) and UNEP (2006).

Table 4.3.7.Gap analysis of valuation literature by ecosystem service (Type I & II).

Domain	Land use cover	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Coastal & marine	Shelf (≤ 50 m)	*			3			1	*		1	*		*	1
	Seagrass bed	*	*			*		1				*		*	*
	Beach or dune		2			*						*		4	1
	Saltwater wetland	*	3	*	*	*	*	*	4		*	5		3	1
Terrestrial	Temperate forest	38	*	*	2	1	1	*	1	1	1	8	1	15	1
	Grassland	3	*	1		1	2		1	1	1			2	
	Cropland									2	1	2		2	
	Freshwater wetland	1	1	2	7	*	*	*	1		*	2		8	1
	Open freshwater			*	5			*	*			*		14	*
	Riparian buffer		2	*	9	*	*			*		*		8	1
	Urban greenspace	3		1	*				*	*	*	*		3	
	Urban/barren/burned/mining														

Ecosystem services:
1 Gas/Climate Regulation
2 Disturbance Regulation
3 Water Regulation
4 Water Supply
5 Erosion control

6 Soil Formation
7 Nutrient Cycling
8 Waste Treatment
9 Pollination
10 Biological Control
11 Habitat/Refugia
12 Genetic resources
13 Aesthetic & Recreation
14 Cultural & Spiritual

Based on the available ESV data in Table 4.3.7, the results presented should be treated as conservative estimates of the total non-market ESV of the Catalan coast. Thereafter, estimated ESV is expected to underestimate the actual ecosystem services valued by the society in the coastal zone. Possibly, the integration of grey literature in the analysis (*i.e.* technical reports, doctoral theses, government documents, among others) would lead to a larger total ESV flow if data gaps are filled. This data gap is not unique to this study *et al.* have reported the difficulties of integrating value data from such sources, including commonly difficulties in data standardization, accessibility if data (not always available online), and quality validation (*e.g.* McComb *et al.* 2006, Pendleton *et al.* 2007). Ideally in the future, less data gaps will remain as more studies are integrated into online searchable databases and previous mentioned issues are solved for gray literature to be accessible.

Natural capital of the Catalan coast

Ecosystem services can be seen as a stream of annual income for citizens and thus as part of the Catalan coast's total natural capital. To quantify the value of that capital, the stream of benefits from the future flows of ecosystem services need to be converted into a net present value. This process involves discounting of capital (Costanza and Daly 1992). Discounting is the process of finding the present value of an amount of cash at some future date, and most often the discount rate is expressed as an annual rate. However, discounting of the flow ESV from natural assets is controversial (Azar and Sterner 1996). The simplest discounting case assumes a constant flow of services into the future and a constant discount rate, and thus the NPV of the asset is the value of the annual flow divided by the discount rate.

The discount rate is a matter of debate since there is no clear reason for choosing a discount rate. Debate has centered over whether a zero discount rate should be used or a constant discount rate over time should be assumed. Costanza *et al.* (1989) have explored using a range of discount rates and shown that a major source of uncertainty in the valuation is the choice of discount rate. A constant rate assumes exponential discounting, but decreasing, logistic, intergenerational, among other forms of discounting have also been proposed (Azar and Sterner 1996, Sumaila and Walters 2005, Weitzman 1998, Newell and Pizer 2003, 2004). The general NPV form is calculated using:

$$NPV = \sum_{t=0}^{\infty} V_t W_t$$

where V_t = the value of the service at time t; W_t = the weight used to discount the service at time t.

For standard exponential discounting, W_t is exponentially decreasing into the future at the discount rate, r.

$$W_t = \left(\frac{1}{1+r}\right)^t$$

Table 4.3.8 shows the results for zero and several discount rates using a standard exponential method for a limited time frame of 100 years. The NPV equation was applied to 3.2±0.5 billion USD, due to the possibilities of overestimation and underestimation of the flow ESV. It is important to note that if not limited the time frame for a zero discount rate on the above equation, the NPV would be infinite. Results show that an annual flow of 3.2 billion USD for 100 years at a zero discount rate yields a NPV of 320 billion USD while using a discount rate of 1 % annual yields a NPV of 6.4 billion USD for the same period. Therefore, major differences arise between using a zero and other discount rate since as the discount rate increases the NPV decreases.

Table 4.3.8. Net present value of annual flow of ecosystem services value of the Catalan coast using a standard exponential method, various discount rates and a period of 100 years. Amounts in billions of USD.

		Discount rate (%)				
Flow ($USDx10^9/yr$)		**0**	**1**	**3**	**5**	**10**
2.7	→	270	5.40	3.60	3.24	2.97
3.2	→	***320***	***6.40***	***4.27***	***3.84***	***3.52***
3.7	→	370	7.40	4.93	4.44	4.07

As previously said, there is no clear and unambiguous reason for choosing one a method over the others, or for choosing a particular discount rate. Newell and Pizer (2003) argue for a 4% discount rate, declining to approximately 0 % in 300 years, based on historical data. One could argue that for ecosystem services, the starting rate should be lower. Results presented here intent to demonstrate the economic difference between present estimates of flow of ESV and its translation into natural capital for a future time frame. Since other proposed discount rates have demonstrated to increase the level of uncertainty in the valuation no other NPV methods were performed in this study. NPV calculations are commonly useful in the evaluation of projects, especially in ICZM where cost-benefit analysis is an essential tool (*e.g.* Bingham *et al.* 1995).

4.3.4 Conclusions

Rather than a single methodology approach this study uses a series of decision rules that has served to estimate the ESV using a value transfer approach in a spatially explicit manner. The results presented in this section indicate that a substantial ESV of ***3.2 billion USD is delivered annually to citizens***. The study therefore, makes clear that non-market ecosystem services provide an important contribution to human welfare in the coastal zone.

ESV flow is the functional result from a diverse matrix of land cover types that are present in the coastal zone. The variability found in the Catalan coast is consistent with previous findings in the ecosystem services literature. It was observed from the literature search that ecosystem services when provided by different land cover types vary substantially in its economic value. However, variability emerges from data in the literature used itself and is not an artefact of the study. Thereafter, people seems to value ecosystem services differently in different biophysical contexts, and the ESV estimates presented in this study reflect that inherent variability.

The increasing number of studies measuring ESV (Heal *et al.* 2005) and online databases (McComb *et al.* 2006) in the past decade has resulted in improved levels of specificity and reliability of present study. This can be corroborated by comparing the 822 USD/ha·yr obtained from Costanza *et al.* in 1997 to the 3,463 USD/ha·yr for the Catalan coast. The digital spatial land cover data has also increased recently (with the development of the habitat layer and the future connectivity layer for Catalonia). The increment in spatial and conceptual resolution of these data motivated this study, together with the increase in quality and availability of social, economic and policy data that promised a viable value transfer assessment in the Catalan coast. Although there is presently a lack of contextual diversity in valuation studies (Pendleton *et al.* 2007), more valuation studies are being developed (Wilson and Hoehn 2006) and across a range of socio-economic and biophysical conditions that could be useful for future studies of the Catalan coast.

On per hectare basis, beaches and dunes provided the largest ESV ($ 104,146), accordingly disturbance regulation constituted most valued ecosystem service ($ 77,420). Coastal and marine land covers provide 40.3 % of the total flow value, although they only account for 22 % of the total valuated surface in the study. Single largest contribution in annual basis was provided by forest (41 %) and larger coastal-marine contribution was provided by the continental shelf (19 %).

The study suggests that an extra 4.3 % should be added to the available family income, and that the new amount constitutes the total economic and natural annual wealth of the coastal zone in Catalonia. However, the “real” ESV is almost certainly much larger. If one were to try to replace the current ecosystem services, at least an annual increment in GDP of 2.7 % should take place in the study area (since the evaluated services are not captured in GDP). This task would lead to economic wealth deterioration since we would only be replacing existing services, this without having into account that many ecosystem services are irreplaceable.

Spatially, value appeared to be concentrated to the North and South *comarcas* of the study area due to their large and less influenced natural areas. Thereafter, in general results were found consistent with the HEMU geography developed in Section 4.2. Results showed that Montsià had the larger absolute flow ESV (16.5 %), followed by Alt Empordà and Baix Ebre. Opposite, Barcelonès had the lowest contribution to the flow ESV (1.2 %) among *comarcas*. In average, the Catalan coast accounted for 3,463 USD/ha. However, the per hectare distribution of value in this study included the marine portion of *comarcas* which provided additional variability if directly compared to HEMU. Therefore marine-terrestrial area distribution determined the nature of *comarca's* ESV flow. Due to this, Maresme accounted for a significant 6.7 % of total coastal flow.

If we hypothetically had to pay for ecosystem services presently, the price would be much different from what it is today (since markets are driven by complex supply-demand dynamics). The price would be almost certainly greater (Costanza *et al.* 1997). ESV estimates obtained here can be used to modify the national accounting systems (*e.g.* EC Land and Ecosystem Accounting System, EEA 2002b) to better reflect the value of natural capital flow. Another use of these results is for project appraisal, since ecosystem services are often ignored or undervalued leading to errors in projects where social costs far outweigh the benefits (Bingham *et al.* 1995). In a 100 years time frame, NPV was estimated to be 320 billion U.S. dollars (using a zero discount rate). Therefore, this represents the value of natural capital not included in actual markets in the Catalan coast.

Nevertheless, even this initial estimate of 3.2 billions USD should be considered a useful starting point. It suggests the need for future research. Some envisioned challenges for the future are:

- Improve the quality and availability of ESV data in empirical peer-reviewed literature.

- Develop a global land cover typology for the coastal zone to test the biophysical similarity of the policy site and the study site.

- Increase the consistency in the use of ecosystem service terminology to communicate better the value of ecosystem services.

- Develop a payment for ecosystem services strategies capable of integrating ESV into markets.

- Develop socio-economic functions for value transfer assessments, based on alternative indicators as the Genuine Progress Indicator (see Cobb 1995).

- Integrate the ecosystem services ecological and economic scarcity concepts view into new valuation methods.

4.4 Integrated ecological and economic value of ecosystem services in the Catalan coast

4.4.1 Introduction

The ecosystem services concept has proven useful for landscape management and decision-making. There are two reasons for this: (1) synthesize essential ecological and economic concepts, allowing researchers and managers to link human and ecological systems in a viable and policy relevant manner, and (2) scientists and policy makers can use the concept to evaluate economic and political tradeoffs between landscape development and conservation alternatives.

Most valuations of ecosystem goods and services relay on human preferences which are stated through Contingent Valuation (CV) processes. Intrinsic to those preferences are moral compelling arguments that may be in direct conflict with the moral argument to conserve ecosystems. Thereafter, the value of an object or action is tightly coupled with individual's value system, but people's perceptions are limited (Costanza 2000). An object or activity may therefore contribute to meeting and individual's goals without being fully aware of the connection. The value of objects and actions therefore needs to be assessed from the individual's subjective points of view and from the objective point of view that we know from other sources about the connections (as referred above in the first point, *e.g.* ecological and institutional dimensions).

In 1989 the oil spill accident of the Exxon Valdez ship drew not only attention but also controversy to the CV approach when it became known that a major component of the legal claims for damages. In January 1993 a panel committed by the National Oceanic and Atmospheric Administration of the U.S.A issued a report which concluded that "CV studies can produce estimates reliable enough to be the starting point for judicial or administrative determination of natural resource damages, including lost passive-use value [*i.e.* non-use value]" (Arrow *et al.* 1993). At the same time, the controversy about CV also stimulated a substantial body of transdisciplinary ESV research. Applications include conjoint analysis (Mackenzie 1992), meta-analysis (Walsh *et al.* 1989), group valuation (Jacobs 1997), and multiple criterion decision analysis (Hwang and Yoon 1981).

The emergence of these new transdisciplinary methods can be attributed in part to two workshops in 1990s that brought together ESV researchers from different disciplines (U.S. Environmental Protection Agency 1991 and National Center for Ecological Analysis and Synthesis-UCSB 1999, summarized in special issues of Ecological Economics in 1995 and 1998 respectively). The organizers of the first workshop expressed that "the challenge of improving ecosystem valuation methods presents an opportunity for partnership between ecologists, economists, other social disciplines and local communities. Interdisciplinary dialogue is essential to the task of developing improved methods for valuing ecosystem attributes" (Bingham *et al.* 1995). Participants from the second workshop concluded that "there is clearly not one 'correct' set of concepts or techniques. Rather there is a need for conceptual pluralism and thinking 'outside the box'" (Farber *et al.* 2002).

Ecosystems are complex adaptive systems that perform ecological functions based on its biotic and abiotic elements and the organizing structure that they develop. Thereafter, here are several characteristics of ecosystems that may influence its value. In human-dominated ecosystems, as the coast is, can be considerable changes in the capacity of ecosystems to maintain their structure, resilience and productivity and