# A human well-being approach for assessing the value of ecosystem services providing areas

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PRELIMINARY VERSION – PLEASE DO NOT CITE OR QUOTE

**Abstract**

The economics of subjective well-being provides an innovative theoretical and empirical approach of individual well-being analysis that has been increasingly applied in the recent past for valuing environmental amenities such as climate. In this paper, this approach is extended for assessing the non-market value of ecosystem services providing areas by investigating people's preferences for particular types of land cover such as agricultural areas, pasture, natural forests, natural grass- and scrubland, natural areas with little or no vegetation and wetlands. In particular, the paper aims at explaining differences in life satisfaction by amongst other things individual and household characteristics, climate conditions and the percentage of different artificial and natural area categories at the NUTS 2 level for the EU 27 member states as well as Norway, Turkey and Macedonia. Marginal values for natural areas are derived from the estimated relationship, which indicate that individuals would be willing to pay a significant amount of money for increasing ecosystem services providing areas.

**Keywords**: Ecosystem services, environmental valuation, Europe, subjective well-being, land cover

**JEL codes**: D1, I31, Q24, Q51, Q57

## 1. Introduction

Resources and services generated on cultivated and natural areas such as food provisioning, nutrient cycling, water and air purification, climate regulation and recreational services are essential for the well-being of mankind in multiple ways (MA 2005). Population growth and increasing economic activity, however, compromise natural systems and thus threaten the provisioning of these goods and services. Climate change is an additional reason for concern. Ensuring a sustainable use of land is hence of high importance to society.

To govern a more sustainable use of land in the future, global economic analyses are required. These have to be detailed enough to allow for the analysis of these complex relationships. However, economic analyses require information on prices of goods and services. Such information is unavailable for most ecosystem services, i.e. for those which are not traded on markets. To obtain this information, economic approaches to valuing non-market environmental goods, such as contingent valuation or contingent choice modeling, can be applied (see Mendelsohn and Olmstead 2009). Existing studies, however, only analyze services for single types of land cover and have a clear national or sub-national focus (see e.g. Mogas et al. 2006). Due to incomparability between the results emerging from differences in research designs and methods applied, the results cannot be used for comprehensive cross-country or global analyses.

One method that suggests itself for obtaining large scale information on the value of ecosystem services for different categories of land cover is benefit transfer. Despite an increasing use of this approach, methodological questions remain (see e.g. Nelson and Kennedy 2009) and no generally accepted large scale assessment of non-market values of ecosystem services across countries has been provided so far.

The objective of this paper is to present an alternative approach, the subjective well-being approach, for valuing ecosystem services providing areas by analyzing people's preferences for particular types of natural land cover across European countries. To our knowledge, this analysis is the first attempt.

Previous studies that have used information on subjective well-being to investigate preferences for environmental amenities have mostly looked at the amenity value of climate. Far fewer studies exist investigating other environmental aspects.[1] All studies have been limited either on a specific country (see e.g. Moro et al. 2007 or Ferreira and Moro 2010) or they were based on country level averages (see e.g. Rehdanz and Maddison 2005 or Welsch 2006).

This paper overcomes some of the limitations of existing research by using data from the second and most recent European Quality of Life Survey (EQLS) of the year 2007, which provides information for 31 European countries up to the NUTS 2 level for 292 regions including 35,634 observations.[2] The first advantage of this dataset is its high level of disaggregation. This is advantageous as it has been found that the relationship between environmental goods and services and subjective well-being is more significant on the local than on the national level (see Welsch 2006). The second advantage is that households reveal

[1] For a recent overview of the literature focusing on environmental aspects see Welsch and Kühling (2009).
[2] NUTS stands for Nomenclature des Units Territoriales Statistiques, which is a classification system for dividing up the EU into regional economic territories. The category 2 provides the average population size of the region, which is between 800,000 and 3 million.

exact figures for net household income. Other datasets, including the European Value Survey and the European Social Survey, provide information on income deciles only.[3]

The remainder of the paper is structured as follows. Section 2 reviews the environmental valuation literature on ecosystem services focusing on benefit transfer and reviews briefly other researchers' attempts to estimate ecosystem services using a subjective well-being approach. Section 3 describes the data used for the analysis and presents the empirical model. Section 4 reports the results of the econometric analysis and presents the marginal willingness to pay estimates for changes in land cover. Section 5 discusses the limitations of the approach and concludes.

## 2. Literature Review

Environmental valuation methods such as contingent valuation or choice modeling have been widely applied to value ecosystem services (see Mendelsohn and Olmstead 2009 for a review). However, few studies exist investigating people's willingness to pay (WTP) for changes in the size of particular land areas (see e.g. Mogas et al. 2006). By far, more studies can be found that evaluate conservation programs of natural habitat (see e.g. Kramer and Mercer 1997, White and Lovett 1999, Lehtonen et al. 2003, Siikamaki and Layton 2007 and Adams et al. 2008). Using the information provided in these studies as WTP estimates for increasing natural area, however, might underestimate the true WTP due to the fact that the area that will be conserved is already covered by the biome in question.

Although stated preference techniques are very flexible in their application in general, surveys are costly and time consuming. In addition to that, it is difficult to explain the full complexity of ecosystem services to respondents. As a consequence, values are typically site specific and include only one or a few specific ecosystem services (see e.g. Birol et al. 2010). Furthermore, differences in research design and methodologies applied complicate comparisons among studies. For this reason, a cross-country assessment of ecosystem services based on primary data would lack on accuracy.

One method that overcomes these problems is the benefit transfer. It consists of an analysis of information of one single study or a group of studies from the existing literature to value similar goods or services in other locations. The transfer includes the application of the values from the original study site to the policy site (see Wilson and Hoehn 2006 for an overview). Benefit transfer comprises point estimate transfer, functional transfer and more recently meta analysis.

An early application in the context of the valuation of ecosystem-services is the study by Constanza et al. (1997). Based on information provided by more than 80 economic studies and some primary data supplements, 17 ecosystem services for 16 biomes were valued. While the transfer was almost universal in this study (see Plummer 2009), more recent developments include the application of benefit or meta analytic transfer functions and the use of Geographical Information Systems (GIS) (see e.g. Johnston and Rosenberger 2010). A more advanced benefit transfer, taking forest specific and context specific information into consideration, is provided by Chiabai et al. (forthcoming). For obtaining non-market values for forest ecosystem services, meta analytic functions for recreation and passive use values are estimated in this study based on 59 and 27 observations respectively from a majority of European and other studies. Despite some approval and belief in further improvements of the

[3] The EVS can be found on the following website: http://www.europeanvaluesstudy.eu/. The ESS is available on the following website: http://ess.nsd.uib.no/.

benefit transfer method (see e.g. Wilson and Hoehn 2006), several methodological problems remain and no generally accepted global assessment of non-market values of ecosystem services has been provided so far (see e.g. Nelson and Kennedy 2009).

A recent development in the field of environmental economics that constitutes an alternative to the benefit transfer is the subjective well-being approach. According to this approach, individuals' subjective life-satisfaction is estimated as a function of factors, such as climate characteristics and income while controlling for other socio-economic, demographic and geographical information. From this estimated relationship, marginal willingness to pay (MWTP) is derived that can capture several aspects of environmental conditions, such as aesthetic values, ecological effects, recreational values but also altruism.

Easterlin (1974) conducted the first empirical economic analysis of subjective well-being, estimating at both, the national and international level, how changes in income impact on life-satisfaction. A large literature now links subjective well-being to economic indicators (see Frey and Stutzer 2002 for an overview). Fewer studies exist estimating the trade-off between life-satisfaction and environmental attributes such as climatic conditions (see e.g. Frijters and van Praag 1998, Rehdanz and Maddison 2005, Brereton et al. 2008 and Moro et al. 2008), natural flood desasters (see e.g. Luechinger and Raschky 2009), the occurance of drought conditions (see Caroll et al. 2009), proximity to infrastructure (see Brereton et al. 2008) and air quality (see e.g. Welsch 2006, Di Tella and MacCulloch 2007, Rehdanz and Maddison 2008, Levinson 2009, Luechinger 2009 and MacKerron and Mourato 2009).[4]

None of the previous studies based on self-reported levels of life-satisfaction focus on people's preferences for land cover. Studies that investigate the amenity value of climate (e.g. Rehdanz and Maddison 2005 or Moro et al. 2008) only implicitly control for differences in natural land cover since vegetation is determined by climate. However, the extent is limited since most of the natural areas, at least in densely populated industrialized countries, are converted to other uses and managed by humans. In addition to the conversion of natural areas into urban areas, land management such as the irrigation of agricultural area or the logging of forests can have large impacts on natural vegetation.

An exception is Brereton et al. (2008) where land coverage is measured based on proximity of infrastructure (such as landfill, harzadous waste facility, airports, etc. ). This does not allow calculating MWTP estimates for changes in land coverage. To overcome these limitations, the empirical part presented in the following section attempts to uncover the impact of land cover changes on subjective well-being.

## 3. Empirical Approach

### 3.1 The Data

For the empirical analysis, data on individual's subjective well-being alongside information on demographic and socio-economic characteristics are obtained from the second and most recent European Quality of Life Survey (EQLS).[5] People from 31 European countries including the EU 27 Member States as well as Norway, Turkey, Croatia and the Former Yugoslav Republic of Macedonia participated. The data refers to the year 2007 when the

[4] For a recent overview on the literature focusing on environmental aspects see Welsch and Kuehling (2009).

[5] The EQLS survey can be found at the Eurofound website: http://www.eurofound.europa.eu/. The principal investigators were: the European Foundation for the Improvement of Living and Working Conditions. Data Collector: TNS Opinion. Sponsor: European Foundation for the Improvement of Living and Working Conditions. Distribution by UK Data Archive, University of Essex, Colchester; October 2009 (SN: 6299).

interviews were carried covering a total of 35,634 observations including persons aged 18 and older.[6]

In this survey, information on subjective well-being is obtained by asking individuals the following question: *"All things considered, how satisfied would you say you are with your life these days?"*. To answer this question individuals can choose on a scale of 1 to 10, where 1 means very dissatisfied and 10 means very satisfied.

Further information on demographic and socio-economic characteristics from the EQLS relevant for our analysis includes income, citizenship, age, number of people living in the household, number of children, gender, head status, marital status, employment status, living area, education level, attendance of religious services and health status.

In contrast to other household surveys on the European level such as the European Social Survey (ESS) or the European Value Study (EVS) that only provide ranges of household income, the EQLS provides net household income reported by individuals.[7] If only ranges are available from the underlying dataset, the midpoint has to be used as an indicator, which is a less accurate measure for household income. The use of the reported amount of income thus can be seen as an improvement to earlier large scale subjective well-being analyses.

The set of geographical variables used in the analysis is obtained from different sources. Population density of the NUTS 2 regions is taken from Eurostat.[8] Information on longitude and latitude at the center of the NUTS 2 regions are calculated and also included in the analysis. Latitude is used for capturing the variation in sunlight over the annual cycle, while the variable elevation controls for the adiabatic lapse rate at different regional altitudes. Finally, a coastline dummy is included in the analysis as a further control variable.

Climate data is derived from New et al. (2000).[9] This dataset contains 10-minute latitude/longitude data of mean monthly surface climate averaged from 1961 to 1990 over global land areas. With this information, monthly averages are calculated for each NUTS 2 region. Our dataset includes information on mean temperature of the hottest month, mean temperature of the coldest month, the mean precipitation of the wettest month, mean precipitation of the driest month. These variables are chosen according to the main findings in the literature (see e.g. Maddison and Bigano 2003, Rehdanz and Maddison 2005, Rehdanz and Maddison 2009 or Moro et al. 2008).

Information on the share of different land cover categories on the total area of NUTS 2 regions is obtained from the CORINE Land Cover database, which provides area coverage of 44 land cover categories in raster format of 100 m resolution for European countries in 2006.[10] By using this information, we assume that shares of land coverage have not changed between 2006 and 2007, the reference year of the other data. As information on Great Britain and Greece is not available for the year 2006, shares of area categories for these countries were calculated from CORINE Land Cover data referring to 2000. The information was aggregated to the NUTS 2 level. Due to the large number of land cover categories we experimented with two different levels of categories. A first set of information includes the following information on shares of land coverage: (1) artificial surfaces, (2) agricultural area and pasture, (3) forest and semi-natural areas and (4) wetlands. Another specification of

[6] The number of observation per countries varies between 1,000 and 2,000.

[7] The ESS can be found at: http://ess.nsd.uib.no/; the EVS is available at: http://www.europeanvaluesstudy.eu/.

[8] The Eurostat website is available at: http://epp.eurostat.ec.europa.eu.

[9] This data is provided by the Climate Research Unit and the Tyndrall Centre: http://www.cru.uea.ac.uk/cru/data/hrg/.

[10] The CORINE Land Cover data is provided by the European Environment Agency: http://dataservice.eea.europa.eu.

shares of land cover is calculated for more disaggregated categories, i.e. (1) urban, industrial and commercial areas, (2) road, rail, port areas and airports, (3) mineral extraction sites, dumping sites and construction sites, (4) green urban areas, sport and leisure facilities, (5) agricultural land, (6) pasture land, (7) agro-forestry areas, (8) natural forests, (9) natural grassland and scrubland, (10) areas with little or no vegetation and (11) wetlands.

When using shares of area variables, it is important to mention that an increase in a particular category of land area always requires a decrease in another category of land area. In this paper, we assume that an increase in a particular area category will always take place at the expense of another non-artificial area category, which has to be omitted from the analysis. Since urban areas can be considered as being more or less sealed, we assume that an increase in a natural land cover category takes place at the expense of water areas. This includes inland waters as well as marine waters. More detailed information on area categories is provided in Appendix A.1.

Before proceeding with the analysis, there are a few issues with the data that are worth mentioning. For Croatia we were unable to allocate the EQLS regions to existing NUTS 2 regions. Therefore, Croatia is excluded from the sample. Other observations are dropped for miscellaneous reasons (typically the failure of respondents to provide answers to specific questions). In total the data consist of slightly in excess of 18,742 observations across 285 NUTS regions in 30 different countries. Table 1 provides summary statistics.

## Table 1: Summary Statistics

| Variable | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| **Life Satisfaction** | | | | |
| Life Satisfaction | 6.85621 | 2.20251 | 1 | 10 |
| **Income** | | | | |
| Income | 1,652.99700 | 2,853.72100 | 25 | 100000 |
| Log of Income (Log of Euros) | 6.85128 | 1.08628 | 3.21888 | 11.51293 |
| **Demographic Characteristics** | | | | |
| Male | 0.44552 | 0.49704 | 0 | 1 |
| Citizen | 0.96841 | 0.17490 | 0 | 1 |
| Age | 50.14214 | 17.34115 | 18 | 97 |
| Age Squared | 2,814.93400 | 1,791.34000 | 324 | 9,409 |
| Head | 0.68456 | 0.46470 | 0 | 1 |
| Number of People Living in Household | 2.56648 | 1.38826 | 1 | 10 |
| Number of Children | 1.72362 | 1.36468 | 0 | 13 |
| **Marital Status** | | | | |
| Married | 0.62635 | 0.48379 | 0 | 1 |
| Divorced | 0.10794 | 0.31031 | 0 | 1 |
| Widowed | 0.12896 | 0.33517 | 0 | 1 |
| Never Married | 0.13675 | 0.34359 | 0 | 1 |
| **Employment Status** | | | | |
| Employed or Self-Employed | 0.46292 | 0.49864 | 0 | 1 |
| Childcare | 0.01739 | 0.13074 | 0 | 1 |
| Family Business | 0.00352 | 0.05924 | 0 | 1 |
| Short-time Unemployment | 0.01867 | 0.13538 | 0 | 1 |
| Long-time Unemployment | 0.03057 | 0.17216 | 0 | 1 |
| Disabled | 0.02775 | 0.16425 | 0 | 1 |
| Retired | 0.31496 | 0.46451 | 0 | 1 |
| Homemaker | 0.08286 | 0.27568 | 0 | 1 |
| Student | 0.03223 | 0.17661 | 0 | 1 |
| Other | 0.00912 | 0.09508 | 0 | 1 |
| **Education Level** | | | | |
| Education Level 0 (lowest) | 0.02732 | 0.16301 | 0 | 1 |
| Education Level 1 | 0.12853 | 0.33469 | 0 | 1 |
| Education Level 2 | 0.18178 | 0.38568 | 0 | 1 |
| Education Level 3 | 0.38576 | 0.48679 | 0 | 1 |
| Education Level 4 | 0.08003 | 0.27135 | 0 | 1 |
| Education Level 5 | 0.18584 | 0.38899 | 0 | 1 |
| Education Level 6 (highest) | 0.01072 | 0.10301 | 0 | 1 |
| **Health Status** | | | | |
| Very Bad | 0.02492 | 0.15588 | 0 | 1 |
| Bad | 0.10447 | 0.30588 | 0 | 1 |
| Fair | 0.29154 | 0.45448 | 0 | 1 |
| Good | 0.39302 | 0.48843 | 0 | 1 |
| Very Good | 0.18605 | 0.38916 | 0 | 1 |
| **Attendance of Religious Services** | | | | |
| Never | 0.33950 | 0.47355 | 0 | 1 |
| Less than Once a Year | 0.09967 | 0.29957 | 0 | 1 |
| Once a Year | 0.07166 | 0.25793 | 0 | 1 |
| A few Times a Year | 0.20579 | 0.40429 | 0 | 1 |
| Once or Twice a Month | 0.09689 | 0.29582 | 0 | 1 |
| Once a Week | 0.13600 | 0.34280 | 0 | 1 |
| More than Once a Week | 0.03356 | 0.18010 | 0 | 1 |
| Every Day | 0.01691 | 0.12895 | 0 | 1 |
| **Living Area** | | | | |
| The Open Country Side | 0.12784 | 0.33392 | 0 | 1 |
| Village | 0.37899 | 0.48515 | 0 | 1 |
| Medium Town | 0.23807 | 0.42592 | 0 | 1 |
| City | 0.25510 | 0.43593 | 0 | 1 |
| **Population Density on NUTS 2 Level** | | | | |
| Population Density (Number of People/Km$^2$) | 287.89240 | 658.10740 | 3 | 9,354 |
| **Geographical Information on NUTS 2 Level** | | | | |
| Longitude (°) | 16.19165 | 10.58225 | -15.66680 | 43.20280 |
| Latitude (°) | 49.04855 | 7.49084 | 28.34400 | 68.86880 |
| Average Elevation (m) | 329.89450 | 316.46610 | -3 | 2,075 |
| Coast Dummy | 0.53628 | 0.49870 | 0 | 1 |

| Variable | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| **Climate Information on NUTS 2 Level** | | | | |
| Maximum Annual Average Temperature (°) | 18.43198 | 3.37490 | 10.22500 | 29.60400 |
| Minimum Annual Average Temperature (°) | -1.94873 | 3.56655 | -14.70100 | 9.87000 |
| Maximum Annual Average Precipitation (mm) | 91.85993 | 26.07701 | 52.61600 | 211.09600 |
| Minimum Annual Average Precipitation (mm) | 36.18527 | 18.32386 | 0.10000 | 99.17100 |
| Mean Annual Average Temperature (°) | 9.08307 | 3.80561 | -1.24467 | 18.49167 |
| Mean Annual Average Temperature$^2$ (°$^2$) | 14.48258 | 23.87970 | 0.00040 | 107.21320 |
| Mean Annual Average Precipitation (mm) | 61.35468 | 19.11678 | 26.08875 | 149.70650 |
| Mean Annual Average Precipitation$^2$ (mm$^2$) | 365.44220 | 979.92810 | 0.00264 | 7,824.15700 |
| **Area Information on NUTS 2 Level (Aggregated)** | | | | |
| Artificial Surfaces (%) | 8.12658 | 10.76021 | 0.20536 | 96.21970 |
| Agricultural Area and Pasture (%) | 47.53995 | 18.98652 | 0.00000 | 93.03016 |
| Agro-Forest, Forest and Semi Natural Areas (%) | 40.28450 | 20.33940 | 1.16617 | 87.92450 |
| Wetlands (%) | 1.31994 | 2.79599 | 0.00000 | 22.52699 |
| **Area Information on NUTS 2 Level (Disaggregated)** | | | | |
| Urban, Industrial and Commercial Area (%) | 6.83197 | 9.07618 | 0.15738 | 82.79794 |
| Road, Rail, Port Areas and Airports (%) | 0.32138 | 0.53014 | 0.00607 | 4.17776 |
| Mineral Extraction, Dumping and Construction Sites (%) | 0.29884 | 0.35407 | 0.00000 | 1.98054 |
| Green Urban Areas and Sport and Leisure Facilities (%) | 0.67439 | 1.38516 | 0.00000 | 13.05959 |
| Agricultural Area (%) | 39.89488 | 17.59565 | 0.00000 | 89.93536 |
| Pasture Land (%) | 7.64507 | 10.25964 | 0.00000 | 71.14883 |
| Agro-Forestry (%) | 0.12134 | 1.16103 | 0.00000 | 25.75230 |
| Natural Forest (%) | 28.21267 | 16.29073 | 0.38381 | 66.28912 |
| Natural Grass- and Scrubland (%) | 9.76164 | 9.99966 | 0.00000 | 46.49992 |
| Open Space with Little or No Vegetation (%) | 2.18887 | 6.31440 | 0.00000 | 46.24280 |
| Wetlands (%) | 1.31994 | 2.79599 | 2.79599 | 22.52699 |
| **Number of Observations** | **18,742** | | | |

Source: Own calculations.

### 3.2 The Econometric Model

To analyze the impact of land cover on subjective well-being while controlling for demographic, socio-economic, geographical and climate characteristics, the following regression is estimated:

$$SWB_{ij} = \alpha + \beta \ln(Y_i) + \textstyle\sum_{k=1}^{o} \gamma_k X_{ki} + \sum_{l=1}^{p} \delta_l G_{lj} + \sum_{m=1}^{q} \varphi_m C_{mj} + \sum_{a=1}^{n} \eta_a AS_{aj} + \varepsilon_{ij}, \quad (1)$$

where $SWB_{ij}$ represents reported life-satisfaction on a scale from 1 to 10 of household $i$ in NUTS 2 region $j$, $Y_i$ is reported income of household $i$, $X_{ki}$ are demographic and socio-economic variables of households $i$, $G_{kj}$ is geographical information including country dummies, $C_{mj}$ are climate variables and $AS_{aj}$ are shares of different categories of areas $a$ in percent.[11] The variables $G_{kj}$, $C_{lj}$ and $AS_{aj}$ are all measured at the NUTS 2 level. The error term is represented by $\varepsilon_{ij}$ and $\beta$, $\gamma_{(1,\ldots,o)}$, $\delta_{(1,\ldots,p)}$, $\varphi_{(1,\ldots,q)}$ and $\eta_{(1,\ldots,n)}$ are parameters to be estimated.

Following Fereira-i-Carbonell and Frijters (2004) we use OLS for estimating the model to allow for an easier interpretation of the results. For a robustness check an ordered logit regression is applied in addition.

Two issues have to be addressed when estimating the specified model. First, it has to be accounted for the fact that the relation of the number of individuals in the sample in comparison to the population size on the NUTS 2 level varies. For this reason, we use weights of the population of the NUTS 2 regions relative to the sample size for each NUTS 2 region throughout the analysis. Second, we include information on different levels of aggregation in the same regression. In particular, data on the individual level is combined with information

[11] Area shares in percent of land cover category $a$ for each NUTS 2 region $j$ are calculated as follows:
$$AS_{aj} = \left(\frac{A_{aj}}{Total\ A_{aj}}\right) \cdot 100.$$

of area shares on the NUTS 2 level. As a result, correlation within groups can cause standard errors to be too small which can lead to an over-rejection of the null hypothesis. For this reason, clustering is applied on the NUTS 2 level, which relaxes the assumption that observations are independent and adjusts standard errors for intra-regional correlation accordingly (see Moulton 1990). With this procedure, heteroscedasticity robust standard errors are obtained.

## 4 Results

### 4.1 Estimation Results

Results of the econometric analysis from five different models are presented in table 2. These models are characterized by different specifications of land cover characteristics. Throughout we report robust t-statistics which assume clustering at the level of the NUTS 2 region. Models 1 to 4 are based on OLS regression while Model 5 uses ordered logit estimation.

In Model 1, socio-economic variables are introduced into the model representing standard control variables in life-satisfaction analyses. The results are in line with the literature on subjective well-being. We find that income, being a citizen and being married has a significant and positive effect on subjective well-being. Furthermore, being a student positively affects subjective well-being while unemployment has a negative effect. Following our expectations, long-time unemployment has a stronger effect than short-time unemployment. Furthermore, lower levels of education lead to a significant decrease in subjective well-being. Living in a village or in a town has a significantly positive effect on well-being compared to those living in a city. The results also indicate a significant u-shaped relationship between age and subjective well-being. As found in earlier studies, good health and being religious positively contributes to subjective well-being. While the positive impact on subjective well-being increases with an increase in health status, the positive impact of an "everyday" attendance of religious services is lower than a "more than once a week" attendance. In the following specifications we keep all variables of this model as control variables and add further information on the NUTS 2 level.

In Model 2, we add geographical and climate information. The results of this model are unchanged compared to the findings in Model 1. In addition we find that longitude and latitude have a negative and significant effect on subjective well-being. Furthermore, an increase in maximum annual average temperature has a negative impact on subjective well-being. This is in line with the findings in the literature (see e.g. Rehdanz and Maddison 2005).

In Model 3, aggregated land cover information is introduced into the model. We find that aggregated variables of land coverage are not significant. The high level of aggregation suggests that individual effects are cancelled. In the following we disaggregate the information.

In Model 4, we find that all area shares have a positive effect on subjective well-being, most are significant at the 5 percent level of significance. The share of area devoted to road, rail, port or airports has a higher positive effect than the share of mineral extraction, dumping and construction sites. Agricultural, pasture area and the share of agro-forestry, natural forests, grass- and scrubland, areas with little or no vegetation and wetlands also positively affect subjective well-being. The effect, however, is smaller. The other results are not affected.

In Model 5, we conduct a robustness check by applying ordered logit estimation on the same model specification as presented in Model 4. When comparing the results it can be seen that qualitative results do not change. For the reason, the following calculation of MWTPs for an increase in natural area shares is based on Model 4.

## Table 2: Estimation Results of General Model Specification

| | Model 1<br>OLS | Model 2<br>OLS | Model 3<br>OLS | Model 4<br>OLS | Model 5<br>Ordered Logit |
|---|---|---|---|---|---|
| Log Income | 0.5132437*** | 0.507092*** | 0.5078529*** | 0.508061*** | 0.485326*** |
| | (6.90) | (7.03) | (6.97) | (7.14) | (6.18) |
| Male | 0.0021257 | -0.007067 | -0.0124405 | -0.0146376 | -0.024814 |
| | (0.04) | (-0.14) | (-0.25) | (-0.29) | (-0.48) |
| Citizen | 0.2830458* | 0.236235 | 0.2309956 | 0.240219 | 0.230925 |
| | (1.78) | (1.57) | (1.52) | (1.62) | (1.53) |
| Age | -0.0457205*** | -0.045232*** | -0.0453513*** | -0.0457799*** | -0.045175*** |
| | (-4.65) | (-4.71) | (-4.72) | (-4.77) | (-4.66) |
| $Age^2$ | 0.0005764*** | 0.00057*** | 0.0005711*** | 0.000572*** | 0.000583*** |
| | (6.36) | (6.43) | (6.43) | (6.43) | (6.28) |
| Head | -0.1145891* | -0.105564* | -0.1022818 | -0.0952458 | -0.081455 |
| | (-1.80) | (-1.68) | (-1.62) | (-1.52) | (-1.28) |
| People | -0.0435396 | -0.043602 | -0.0444643* | -0.0449918* | -0.040875 |
| | (-1.50) | (-1.6) | (-1.66) | (-1.67) | (-1.51) |
| Children | 0.0119422 | 0.007647 | 0.0061978 | 0.0075881 | 0.010500 |
| | (0.52) | (0.33) | (0.27) | (0.33) | (0.44) |
| Married | 0.3929312*** | 0.404224*** | 0.4098598*** | 0.4053958*** | 0.406744*** |
| | (4.33) | (4.6) | (4.61) | (4.61) | (4.66) |
| Divorced | -0.1359901 | -0.125619 | -0.119426 | -0.120423 | -0.151522 |
| | (-1.38) | (-1.3) | (-1.24) | (-1.24) | (-1.6) |
| Widowed | 0.0702914 | 0.087913 | 0.0924861 | 0.0921273 | 0.090111 |
| | (0.63) | (0.81) | (0.85) | (0.85) | (0.84) |
| Employed | 0.15696 | 0.106466 | 0.1121117 | 0.1106636 | 0.114107 |
| | (0.73) | (0.5) | (0.53) | (0.52) | (0.58) |
| Childcare | 0.308251 | 0.298139 | 0.3072804 | 0.2906157 | 0.404996 |
| | (1.11) | (1.09) | (1.14) | (1.08) | (1.63) |
| Family Business | -0.1653712 | -0.184827 | -0.1864546 | -0.172949 | -0.155957 |
| | (-0.43) | (-0.48) | (-0.49) | (-0.45) | (-0.41) |
| Short-time Unemployed | -0.5525864** | -0.606261** | -0.5981372** | -0.5923445** | -0.494123* |
| | (-1.97) | (-2.19) | (-2.19) | (-2.15) | (-1.85) |
| Long-time Unemployed | -0.9000217*** | -0.986847*** | -0.9685421*** | -0.9734588*** | -0.938863*** |
| | (-3.20) | (-3.59) | (-3.50) | (-3.55) | (-3.66) |
| Disabled | 0.014415 | -0.084247 | -0.0747089 | -0.086324 | 0.027312 |
| | (0.05) | (-0.3) | (-0.27) | (-0.31) | (0.11) |
| Retired | 0.3080087 | 0.235068** | 0.2410721 | 0.2414736 | 0.264238 |
| | (1.33) | (1.04) | (1.07) | (1.07) | (1.28) |
| Homemaker | 0.350717 | 0.241005 | 0.2492801 | 0.2376855 | 0.289011 |
| | (1.42) | (0.98) | (1.01) | (0.96) | (1.21) |
| Student | 0.7345024*** | 0.691634*** | 0.6950455*** | 0.6885557*** | 0.731222*** |
| | (3.17) | (3.01) | (3.02) | (2.98) | (3.37) |
| Educ. Level 0 (lowest) | -0.3218844 | -0.347805* | -0.3611548* | -0.3375231* | -0.406281* |
| | (-1.58) | (-1.71) | (-1.78) | (-1.68) | (-1.88) |
| Educ. Level 1 | -0.4702447*** | -0.489216*** | -0.5011269*** | -0.4906541*** | -0.574935*** |
| | (-3.19) | (-3.28) | (-3.34) | (-3.31) | (-3.62) |
| Educ. Level 2 | -0.2957535* | -0.304858* | -0.3179952** | -0.3024551* | -0.357678** |
| | (-1.94) | (-1.96) | (-2.04) | (-1.96) | (-2.14) |
| Educ. Level 3 | -0.2934716** | -0.316466** | -0.3252057** | -0.3076266** | -0.357071** |
| | (-2.15) | (-2.26) | (-2.31) | (-2.22) | (-2.5) |
| Educ. Level 4 | -0.0078334 | -0.009068 | -0.0192533 | -0.0044273 | -0.032224 |
| | (-0.05) | (-0.06) | (-0.12) | (-0.03) | (-0.2) |
| Educ. Level 5 | -0.1280003 | -0.131432 | -0.1388433 | -0.1152827 | -0.133598 |
| | (-0.95) | (-0.96) | (-1.01) | (-0.84) | (-0.96) |
| Bad Health | 0.9621973*** | 0.944641*** | 0.9316986*** | 0.9193661*** | 0.826394*** |
| | (4.48) | (4.51) | (4.54) | (4.56) | (4.26) |
| Fair Health | 1.847234*** | 1.825023*** | 1.815081*** | 1.801845*** | 1.714884*** |
| | (8.48) | (8.51) | (8.61) | (8.62) | (8.23) |
| Good Health | 2.308948*** | 2.276784*** | 2.268362*** | 2.251711*** | 2.174398*** |
| | (10.59) | (10.58) | (10.71) | (10.73) | (10.44) |
| Very Good Health | 2.806268*** | 2.768215*** | 2.756603*** | 2.736858*** | 2.800224*** |
| | (12.21) | (12.26) | (12.49) | (12.57) | (12.74) |
| Rel. Serv.: < Once a year | -0.0089486 | -0.004861 | -0.0090584 | -0.0022627 | -0.024422 |
| | (-0.11) | (-0.06) | (-0.12) | (-0.03) | (-0.32) |
| Rel. Serv.: Once a year | 0.0638857 | 0.067455 | 0.0614099 | 0.0658139 | 0.074358 |
| | (0.58) | (0.63) | (0.58) | (0.62) | (0.75) |
| Rel. Serv.: Few times a year | 0.1377539* | 0.124768 | 0.1208555* | 0.1245619* | 0.099865 |
| | (1.95) | (1.84) | (1.79) | (1.88) | (1.55) |
| Rel. Serv.: Once or twice per month | 0.2663808*** | 0.243841** | 0.2360477** | 0.2376388** | 0.226203** |
| | (2.71) | (2.5) | (2.41) | (2.43) | (2.33) |
| Rel. Serv.: Once a week | 0.402349*** | 0.384745*** | 0.3782827*** | 0.3735487*** | 0.357475*** |
| | (5.02) | (4.95) | (4.92) | (4.87) | (4.62) |
| Rel. Serv.: > Once a week | 0.6054896*** | 0.537081*** | 0.5348838*** | 0.5430261*** | 0.522419*** |
| | (4.54) | (3.68) | (3.69) | (3.77 ) | (3.49) |
| Rel. Serv.: Every day | 0.4245618** | 0.383409* | 0.3806101* | 0.3809369** | 0.368232** |
| | (2.09) | (1.93) | (1.95) | (2.02) | (1.97) |

| | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| | OLS | OLS | OLS | OLS | Ordered Logit |
| Countryside | 0.0316759 | -0.023002 | -0.0399251 | -0.0103003 | 0.042904 |
| | (0.28) | (-0.2) | (-0.35) | (-0.09) | (0.44) |
| Village | 0.178654** | 0.127507 | 0.1147505 | 0.1383174* | 0.153866* |
| | (2.25) | (1.63) | (1.46) | (1.76) | (1.93) |
| Town | 0.1673365** | 0.107681 | 0.0932052 | 0.114497 | 0.118941 |
| | (1.99) | (1.28) | (1.12) | (1.39) | (1.46) |
| Population Density | | -0.000053 | 0.0000333 | -0.0000161 | -0.000019 |
| | | (-1.09) | (0.38) | (-0.20) | (-0.24) |
| Longitude | | -0.033211* | -0.0356595* | -0.0195109 | -0.024033 |
| | | (-1.78) | (-1.93) | (-1.08) | (-1.39) |
| Lattitude | | -0.078902*** | -0.0784661*** | -0.0943712*** | -0.102219*** |
| | | (-2.81) | (-2.69) | (-3.18) | (-2.96) |
| Avg. Elevation | | -0.000124 | 0.0000192 | -0.0000786 | -0.000006 |
| | | (-0.51) | (0.08) | (-0.23) | (-0.02) |
| Coastline | | 0.150882 | 0.1865911 | 0.218433** | 0.236576** |
| | | (1.42) | (1.65) | (2.08) | (2.21) |
| Min. Avg.Temperature | | -0.096899* | -0.0922974 | -0.0876142 | -0.092708 |
| | | (-1.85) | (-1.64) | (-1.56) | (-1.53) |
| Max. Avg. Temperature | | -0.075985* | -0.0723459* | -0.1011293** | -0.090472** |
| | | (-1.91) | (-1.79) | (-2.54) | (-2.33) |
| Min. Avg. Precipitation | | -0.003203 | -0.0026411 | -0.0005987 | 0.000589 |
| | | (-0.58) | (-0.47) | (-0.11) | (0.11) |
| Max. Avg. Precipitation | | -0.00093 | -0.0003292 | 0.000617 | 0.000854 |
| | | (-0.48) | (-0.16) | (0.28) | (0.36) |
| Artificial Surfaces | | | 0.0275096 | | |
| | | | (1.00) | | |
| Agricultural Area and Pasture | | | 0.0334793 | | |
| | | | (1.47) | | |
| Forest and Semi Natural Areas | | | 0.0287916 | | |
| | | | (1.21) | | |
| Wetlands | | | 0.0437344 | | |
| | | | (1.54) | | |
| Urban, Industrial and Commercial Area | | | | 0.0563106** | 0.049434* |
| | | | | (2.03) | (1.74) |
| Road, Rail, Port and Airport | | | | 0.2475118** | 0.235020** |
| | | | | (2.32) | (2.2) |
| Mine, Dump and Construction Sites | | | | 0.2320927** | 0.269815*** |
| | | | | (2.41) | (2.67) |
| Green Urban Area and Sport Facilities | | | | 0.0114983 | 0.021703 |
| | | | | (0.17) | (0.29) |
| Agricultural Area | | | | 0.0597299** | 0.053333** |
| | | | | (2.33) | (2.04) |
| Pasture | | | | 0.056085** | 0.050696* |
| | | | | (2.21) | (1.96) |
| Agro-Forestry | | | | 0.1021593*** | 0.089177*** |
| | | | | (3.22) | (2.81) |
| Natural Forests | | | | 0.0532836** | 0.047507* |
| | | | | (2.03) | (1.78) |
| Natural Grass- and Scrubland | | | | 0.0545778** | 0.045658* |
| | | | | (2.03) | (1.72) |
| Little Vegetation | | | | 0.0611438* | 0.052548* |
| | | | | (1.92) | (1.7) |
| Wetlands | | | | 0.0688638** | 0.061283* |
| | | | | (2.02) | (1.76) |
| Constant | 1.873993*** | 7.462793*** | 4.493083* | 2.651911 | - |
| | (2.92) | (4.22) | (1.65) | (0.92) | - |
| Country Dummies | yes | | yes | yes | yes |
| Observations | 18,742 | | 18,742 | 18,742 | 18,742 |
| R-squared | 0.2549 | | 0.2637 | 0.2665 | - |
| Pseudo R-squared | - | | - | - | 0.0783 |
| **F-Statistic** | | | | | |
| Socio-Economic Variables | 45.83*** | 46.70*** | 47.31*** | 45.28*** | - |
| Geographical Variables | - | 5.23*** | 4.54*** | 4.65*** | - |
| Climate Variables | - | 3.46*** | 2.79** | 3.46*** | - |
| Area Variables | - | - | 1.37 | 1.62* | - |

Source: Own calculations. T-statistics in parenthesis. * indicates significant at the 10% level, ** at the 5% level and *** at the 1% level.

### 4.2 Marginal Willingness to Pay for Changes in Land Cover

In the following we calculate households' MWTP for a 1 % increase in natural area, which can be calculated by totally differentiating the estimated function setting d$SWB$ = 0. The MWTP is then given by the marginal rate of substitution between income $Y$ and area share $AS_a$:

$$\text{MWTP} = -\left.\frac{\delta Y}{\delta AS_a}\right|_{dSWB \equiv 0} = Y_M \frac{\hat{\eta}_a}{\hat{\beta}}, \tag{2}$$

where $Y_M$ is the median household income in the sample.

To allow for a reasonable interpretation, we calculate MWTPs for an increase of 1 km² of each natural area category for the average NUTS 2 region in the sample. This can be obtained by dividing the average MWTPs for a 1 % increase, as derived in equation (2), by the average change of total area of the NUTS 2 regions equal to a 1 percent increase. The results are presented in Table 3.

The annual MWTP of the household in the sample evaluated at the median (mean) income of 12,000 (19,836) Euros for an increase of natural areas by 1 km² lies between 6.72 (11.11) Euros for natural forests and 12.88 (21.29) Euros for agro-forestry.

**Table 3: Marginal Willingness to Pay for a 1km² Increase in Natural Area for the Average NUTS 2 Region**

| Land Cover | Average Total Area of NUTS 2 Regions (in %) | MWTP of 1 km² Increase (in EUR) |
|---|---|---|
| Agricultural Area | 40.80 | 7.53 |
| Pasture | 10.12 | 7.07 |
| Agro-Forestry | 0.26 | 12.88 |
| Natural Forests | 24.04 | 6.72 |
| Natural Grass- and Scrubland | 9.96 | 6.88 |
| Little Vegetation | 2.83 | 7.71 |
| Wetlands | 1.00 | 8.68 |
| **Average of Natural Areas** | **12.72** | **8.21** |

Source: Own calculations. 1 km² is equal to 100 ha.

Our findings reveal that all MWTP values for increases in natural areas are positive; this is as expected and follows from our estimation results. Moreover, MWTP values tend to be higher for those land cover categories with a low share of total area and it is lower for those land cover categories with a higher share. People are willing to pay the highest amount for an increase in the area category agro-forestry, which is sparsely available. The MWTP for natural forests is lowest, which is more plentiful. This conforms to economic theory; the WTP is higher for an increase in environmental goods that are sparsely available than for those that are more plentiful.

The preference structure of natural areas determined by our estimates, however, does not strictly follow the order determined by area availability. This can be explained by the fact that scarcity is not the only factor influencing households' willingness to pay. Other factors such as distance, quality, composition, size of individual parcels of area types, etc. are important as well. For example, households might value natural land area closer to their living area higher compared to those further away. Based on the way urbanization took place in Europe, agricultural areas tend to be closer to living areas (such as cities, towns and villages) than natural forests. This might be one reason why the MWTP value for natural forests is smaller than MWTP for agricultural area, which means that the proximity effect offsets the impact of area availability in this case.

In addition to its scarcity, there are further characteristics of agro-forestry that support the high MWTP value for this area category. They relate to the definition of agro-forestry:  land area on which agriculture and forestry are combined. First, it can be expected that agro-forestry is in closer proximity to living areas than other natural area categories such as natural forest, since they emerge on agricultural area. Second, agro-forestry areas are more diverse than agricultural area since they combine several plant types. Both might have a positive impact on the preferences for this category of natural land cover.

## 5 Discussion and conclusion

While an increasing number of studies focuses on subjective well-being analysis for determining individual's preferences for particular environmental amenities such as climate, its application in the field of ecosystem services is new. This paper makes a first attempt by using highly disaggregated data on the NUTS 2 level that allows for uncovering the relationship between well-being and ecosystem services providing areas.

Our main findings are that land cover types have a positive significant effect on human well-being but to varying degrees. Key control variables, such as the effect of income, age, unemployment, marital status, education, health and the attendance of religious services follow previous subjective well-being research findings.

Our main conclusions are that households in Europe place a positive value on an increase in natural land area. In particular, agro-forestry is highly valued, while the lowest value is attached to natural forest. These results are partly driven by the availability of natural land areas, which means that MWTP values tend to be higher for those land cover categories with the lowest share of total area. It is lowest for those land cover categories with the highest shares. However, further factors such as distance, quality, individual parcel sizes of land areas within a NUTS 2 region, etc. might influence MWTP values but cannot be controlled for in our analysis.

Several issues and limitations are worth being discussed. First, the analysis uses information on subjective well-being as an approximation for individual welfare. We assume that it is a valid approximation as long as individuals with a higher latent utility also have a higher life-satisfaction, which is in line with a large number of discrete choice models in economics (see Levinson 2009). Due to the subjective nature of the welfare measure and the information we used to describe natural land areas, however, individual factors that determine the marginal willingness to pay are difficult to separate. We are unable to divide the MWTP value into components of the total economic value. This includes among others values attached to aesthetic values, ecological effects, recreation but also altriuism. Despite these difficulties in specifying its true nature, the subjective wellbeing approach is an important concept to overcome the lack of market prices for environmental goods and services and can support a more sustainable decision making.

Second, although the availability of exact income information instead of income ranges can improve accuracy of estimates, it has to be emphasized that the use of exact income information does not prevent the analysis to be affected by temporary fluctuations away from the permanent income level as it would be the case when significant amounts are inherited. Furthermore, subjective well-being does not only depend on income, but income can be expected also to depend on subjective well-being. It thus can be considered as an endogenous variable. To avoid possible inaccuracy of MWTP estimates, instrumental variables can be applied. The use of instrumental variables, however, is not without problems and no consensus on the choice of instrumental variables exists. For our study, gathering information on instrumental variables on the European scale is difficult. Information on property prices, which could e.g. be used, is not available throughout Europe. Neither does the EQLS provide any such information for the survey participants. Since our analysis is a first attempt of estimating the impact of natural areas on subjective well-being, this is left to future research.

Third, while it seems plausible to assume a positive effect of an increase in natural area on subjective well-being, we find a highly positive effect for most urban areas. Generally, this is in line with our expectation, since urban areas provide a large variety of non-market benefits to households. A large positive effect of road, rail, ports and airports follows our expectations as well, as a higher share of infrastructure simplifies traveling to work, friends, family, etc and supports economic activity. However, the relatively high positive effect of mineral extraction, dumping and construction sites seems more difficult to explain. A more detailed analysis focusing on urban areas is required that could help to improve our understanding of the underlying effects. A future study could focus on urban areas including information on property prices to analyze the underlying effects in more detail.

Fourth, the small number of observations per country in the sample does not allow for the analysis of sub-samples. The MWTPs evaluated at the median income of the sample and the average NUTS 2 region provided in this paper thus only allow for a first orientation on the approximate level of MWTP estimates that can be expected to prevail for Europe. Since the preference structure might differ significantly between regions, it can be highly recommended to use larger samples that allow for regional differentiation of the preference structure for future research.

Finally, the paper focuses on the analysis of ecosystem services providing areas. The use of land cover shares in this analysis does not capture the complexity of ecosystems and its services. Our analysis is a first attempt and future research should either use different indicators for ecosystem services or introduce additional information to capture differences in the quality of natural areas by considering e.g. biodiversity.

**Acknowledgements**

The authors are grateful to the UK Data Archive for permission to use data from the European Quality of Life Survey 2007 and acknowledge that the original data creators, depositors or copyright holders, the founders of the Data Collections and the UK Data Archive bear no responsibility for their further analysis or interpretation. Financial support by the German Ministry of Research and Technology (01LL0901A) is greatly acknowledged.

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## Appendix

**Table A.1: Information on Area Aggregation**

| Aggregated Areas | Disaggregated Areas |
|---|---|
| Artificial Surfaces | Urban, Industrial and Commercial Area |
| | Road, Rail, Port Areas and Airports |
| | Mineral Extraction, Dumping and Construction Sites |
| | Green Urban Areas and Sport and Leisure Facilities |
| Agricultural Area and Pasture | Agricultural Area |
| | Pasture Land |
| Agro-Forest, Forest and Semi Natural Areas | Agro-Forestry |
| | Natural Forest |
| | Natural Grass- and Scrubland |
| Wetlands | Inland Wetlands |
| | Maritime Wetlands |
| Areas covered with Water | Inland Waters |
| | Marine Waters |

Source: Author's compilation.