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Costs of restoration measures in the EU based on an assessment of LIFE projects

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Abstract
Restoring ecosystems to reverse biodiversity loss and to enhance ecosystem services is an important target of the EU Biodiversity Strategy to 2020. At global and European level the target is to restore 15% of degraded ecosystems. Identifying sites that should be considered for restoration in order to achieve the target requires spatial information on where degraded ecosystem are, on the kind of mitigation measures that are needed to restore ecosystems to a good condition, and on the costs and benefits of restoration in order to prioritise investments. At all these levels, detailed spatial information is lacking. This report contributes to the ecosystem restoration knowledge base by providing cost estimates of specific restoration measures.

Costs of restoration measures in the EU based on an assessment of LIFE projects

Contents

Acronyms

CLC	Corine Land Cover
EC	European Commission
ETC/BD	European Topic Centre on Biological Diversity
EU	European Union
EUNIS	European Nature Information System classification
HICP	Harmonized Indices of Consumer Prices
NGO	Non-Governmental Organisation
NUTS	Nomenclature of Territorial Units for Statistics
PLI	Price Level Index

Executive Summary

Restoring ecosystems to reverse biodiversity loss and to enhance ecosystem services is an important target of the EU Biodiversity Strategy to 2020. At global and European level the target is to restore 15% of degraded ecosystems. Identifying sites that should be considered for restoration in order to achieve the target requires spatial information on where degraded ecosystem are, on the kind of mitigation measures that are needed to restore ecosystems to a good condition, and on the costs and benefits of restoration in order to prioritise investments. At all these levels, detailed spatial information is lacking. This report contributes to the ecosystem restoration knowledge base by providing cost estimates of specific restoration measures.

The cost estimates are based on an analysis of Life Nature projects. Life is the name of the main EU funding instrument for the environment. In this analysis, Life projects classified under the strand 'Nature' were considered since these projects target restoration activities in Natura 2000 sites. Although project reports differ in quality and level of detail, the LIFE database constitutes a valuable source of information on ecosystem restoration across the EU presented in a standardized format.

We adopted and refined a restoration measure classification system developed by Benayas, Newton, Diaz, & Bullock (2009) through an initial screening process of Life project reports. The resulting restoration typology discriminated between 23 different restoration measures. Next 215 Life Nature projects were selected for a more in-depth analysis of different the restoration actions. For every project the total budget was known. Where possible restoration activities were quantified using length, area or mass based units. If quantification was not possible, restoration activities were recorded using presence or absence on a project basis. We then conducted a series of multiple regression analyses to provide cost confidence intervals for 15 restoration measures so that the sum of cost of all restoration measures taken per project equalled the total project budget. In the analysis we considered overhead costs as well as economy of scale effects.

A summary of the best available information with cost estimates per restoration measure is presented in the summary table.

Despite the high variance in cost estimates the presented cost confidence intervals and average unit costs with standard deviation this report provides a usable approximation of actual restoration costs for the assumptions we made. Although the high variance may preclude them from being used for fine-grain analysis such as cost predictions on a project basis, we are confident that cost ranges may prove useful for more coarse-grain analysis such as the prediction of restoration expenditures at national or EU level given certain biodiversity conservation or restoration targets. For such meta-analysis purposes the upper and lower bounds of the cost confidence intervals can be used to provide a range of expected restoration expenditures.

Average, median and range of costs of restoration measures based on an analysis of Life Nature project budgets (prices in 2006 Euro, €)

Restoration measure	Unit	Mean	Standard Deviation	25 percentile	Median	75 percentile
Road Rehabilitation	€ (per project)	19,320	25,263	9,509	13,657	15,852
Constructing nests	€ (per project)	487,780	265,062	199,303	491,773	754,405
Constructing nurseries	€ (per project)	465,170	278,714	278,773	402,940	576,506
Constructing fish passages	€ (per project)	1,168,210	353,705	960,320	1,187,391	1,257,933
Rewetting	€ (per project)	1,940,381	484,289	1,723,454	1,866,185	2,200,796
Modifying the riverbank	€ km^{-1}	535,596	203,340	369,874	548,882	668,194
Fencing	€ km^{-1}	2,055	884	1,500	2,076	2,750
Removing invasive species	€ ha^{-1}	901	435	594	700	1,214
Clearing vegetation	€ ha^{-1}	3,769	1,699	2,216	4,105	5,345
Land acquisition	€ ha^{-1}	796	364	500	700	941
Remodelling topography	€ ha^{-1}	4,194	3,485	837	4,635	6,565
Grassland management	€ ha^{-1}	1,227	722	621	1,372	1,569
Replanting vegetation	€ ha^{-1}	4,857	2,065	3,818	5,258	6,035
Abiotic amendments	€ ha^{-1}	6,557	8,504	3,520	5,438	6,358
Aquatic restoration	€ ha^{-1}	7,965	4,749	3,900	8,836	10,867
Waste removal	€ ton^{-1}	3.87	3.26	1.00	2.98	6.12
Project overhead	% of budget	28	2	26	27	30

1 Introduction

Centuries of land transformation, industrialisation, urbanisation and agricultural intensification have left their scars on Europe's landscape, with devastating effects for its species and habitats (e.g. MEA, 2005). In an attempt to halt and reverse these trends, the European Commission (EC) adopted the Birds Directive and the Habitats Directive, which since their establishment in 1979 and 1992 respectively have formed the backbone of nature conservation policy in the European Union (EU).

The EU has set itself the ambitious target of halting biodiversity loss by 2020 (formerly 2010) and beyond. To monitor the envisioned improvements in biodiversity conservation, a large-scale monitoring scheme has been set in place obligating every member state to periodically conduct biodiversity surveys and report on the conservation status of those habitats and species considered to be of European interest (listed in Annexes 1 and 2 of the Habitats Directive). The results of the first survey conducted between 2001 and 2006 revealed that the majority of habitat (65%) and species (52%) assessments recorded an unfavourable conservation status. A second survey round, reporting for the period between 2006 and 2012 confirms by large these findings and paint a dire picture of the state of Europe's habitats and species. Conservation policies should go beyond the mere preservation of the status-quo and instigating the large-scale restoration of degraded habitats.

The restoration of degraded ecosystems is known to be effective in enhancing ecosystem services and reversing biodiversity loss (Bullock, Aronson, Newton, Pywell, & Rey-Benayas, 2011; Rey Benayas, Newton, Diaz, & Bullock, 2009) and is regarded as a cornerstone of the EU's endeavours to reach its biodiversity conservation targets. The LIFE programme, launched in 1992, provides the necessary financial incentives. Besides projects on innovative environmental policy approaches and information and communication campaigns LIFE has co-financed about 1400 best practice and demonstration projects of species and habitat conservation (LIFE Nature) throughout Europe. LIFE Nature projects have targeted a wide variety of species and habitats, have sought to mitigate a diverse set of anthropogenic pressures and have been carried out all over Europe. Project reports specifying, amongst others, the restoration objectives and results are stored in the LIFE database and publicly available.

Harvesting the wealth of practical restoration experience for policy-making purposes and to advance restoration science is a major challenge often neglected (Menz, Dixon, & Hobbs, 2013; Suding, 2011). Inherent problems of restoration science include the lack of replicates and clear boundaries, especially in terrestrial and marine ecosystems, or the heterogeneity of sites and methods (Weiher, 2007). Limited monitoring, restricted access to monitoring data and a lacking consensus on standard evaluation criteria further exacerbate the generalizability of practical insights into ecosystem restoration activities (Suding, 2011). Although project reports differ in quality and level of detail, the LIFE database constitutes a valuable source of information on ecosystem restoration in the EU presented in a standardized format. Few studies have, however, attempted to translate this piecemeal information into more general, scientific findings.

In this study, we harnessed the wealth of information stored in the LIFE database to draw conclusions about one of the major knowledge gaps of ecosystem restoration in the EU, the costs of restoration activities. Information on the costs of ecosystem restoration activities is sparse and inconsistent (e.g. Bernhardt et al., 2005) and thus difficult to use for policy-making purposes at the EU level. Insights into restoration costs could be used for a variety of purposes such as benchmarking restoration projects or efficient budget allocation. When combined with an economic evaluation of the impact of restoration activities on ecosystem service supply, cost estimates can also be consulted for cost-benefit analyses on the economic viability of restoration projects (De Groot et al., 2013). Acuña et al. (2013), for instance, investigated whether the benefits of restoring rivers by adding dead wood outweighed the costs accrued.

Putting a price tag on restoration activities would, however, not only prove useful for informing decision making at project but also at member state and EU level, especially when faced with the challenge of up-scaling demonstration projects to the ecologically more meaningful landscape level (Menz et al., 2013). At the national and supranational level cost estimates could be used to set restoration priorities or calculate the cost implications of the EU's biodiversity targets, which, amongst others, stipulate that by 2020 at least 34 per cent of the habitat assessments will report a favourable or significantly improved conservation status (The EU biodiversity strategy to 2020).

LIFE restoration projects have targeted a wide variety of species, habitats and anthropogenic pressures. Adding to that the wide gaps in e.g. labour costs and land prices that prevail between member states, we get a good picture of the difficulties encountered when trying to generalize restoration costs over a "study area" as economically and ecologically heterogeneous as Europe. For this, we screened the LIFE database for projects providing a detailed and quantified account on restoration activities, filled data gaps by approximating quantities and calculated average costs for the most frequently applied measures through a regression analysis.

2 Material and Methods

2.1 The LIFE database

The LIFE programme is the European Union's financial instrument for fostering environmental and nature conservation. Since 1992, in 4 consecutive phases, €3.1 billion has been conceded to co-finance about 4000 projects in the categories Nature & Biodiversity (formerly LIFE Nature), Environment Policy & Governance (formerly LIFE Environment) and Information & Communication (since LIFE+, phase 4). The LIFE strand Nature (& Biodiversity) comprises more than 1400 best practice and demonstration projects that contribute to the implementation of the EU's Birds and Habitats Directives and to the establishment of the Natura 2000 network. Project beneficiaries cover the whole spectrum of public and private actors and include, amongst others, national, regional and local public authorities, non-governmental organisations (NGO), research institutions and enterprises. Short reports indicating the background, objectives and results constitute one of the project deliverables and have been made publicly available on the LIFE website. Although information quality and level of detail vary between project reports, the LIFE database exhibits a great source of concise information on ecosystem restoration projects in the European Union.

To give an overview of the content of the LIFE database we conducted a series of simple frequency analyses including 1409 LIFE Nature projects which were registered between 1992 and 2011. We assessed the following information:

- the main **beneficiaries** of the LIFE program,
- the frequency of targeted broad **taxonomic** (amphibians, birds, fish, invertebrates, mammals, plants and reptiles) and **habitat groups** (coastal and halophytic habitats, coastal sand dunes and inland dunes, forests, freshwater habitats, raised bogs and mires and fens, rocky habitats and caves, sclerophyllous scrub, temperate heath and scrub, natural and semi-natural grassland formations) and
- patterns in **LIFE budget allocation** (over taxonomic and habitat groups and over NUTS-1 regions)

The budget of projects targeting more than one habitat, species or region was assumed to be equally distributed over target habitats, species and regions.

For the geographical distribution analysis, budgets were standardized following the procedure explained in section 2.3 accounting for differences in economic development between member states and over time. Only projects between the years 1996 and 2011 were considered as for earlier projects data on economic indicators used for the budget standardization was not available. To account for different entry dates of member states to the EU, budget allocation was mapped for different time horizons (1996-2011, 2004-2011, and 2007-2011). The years 2004 and 2007 were chosen as milestones in the eastward expansion of the EU with ten (Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, and Slovenia) countries joining the EU in 2004 and two more (Bulgaria and Romania) in 2007.

The budget allocation maps were visually compared to maps of population density, number of Article 17 species (all at NUTS-1 level) and the proportion of artificial land cover (NUTS-level 0) to draw conclusions about potential geographic patterns in budget allocation. Data on population density (reference year 2006) and artificial land cover (reference year 2009) was retrieved from the EU's statistical office Eurostat. The diversity of Article 17 species per region was calculated by intersecting species distribution maps (as reported during the Article 17 of the Habitats Directive (92/43/EEC) covering the period 2001 to 2006) with the NUTS regions. A species was considered to be present in a respective NUTs region if at least one raster cell (resolution 10x10km) at least partially overlapped with the respective NUTs polygon.

2.2 Restoration typology

The purpose of this study was to derive cost estimates of the most frequently applied restoration measures from the wealth of information contained in the LIFE database. For this, we adopted and refined a restoration measure classification system developed by Benayas, Newton, Diaz, & Bullock (2009) through an initial screening process of LIFE project reports.

The resulting restoration typology (table 1) discriminates between 23 different measure classes and was subsequently used to retrieve for each of the LIFE Nature project reports examined in this study the measures applied and corresponding quantities (e.g. the total area of habitat restored, fenced or put under extensive grazing). Records lacking quantified information were treated as binary (presence-absence) data, for instance the construction of a fish ladder to restore the connectivity of a stream.

There was no consistency in the project files of the database when reporting on the different restoration actions taken in the project. Some projects just list certain restoration actions whereas other projects provide more detail. Restoration actions are quantified using unit area (ha), unit length (km) in case of actions along rivers, roads or in case of placing fences, or unit mass (ton) in case of removal of sediment or waste (table 1). Some restoration measures are hard to quantify in any of these units and were quantified as present or absent (yes/no, table 1) and treated as a binary variable in subsequent analysis. Semi-quantitative information was converted into presence or absence of a measure. Some projects did not provided estimates of restoration actions which are quantified in units area, length or mass in table 1. In the statistical analysis these records were given either the median value based on all positive records within the same restoration measure, or the maximum value of all restoration actions within the same project, or whichever of these two values is the smallest.

In order to reduce the number of explanatory variables in the dataset, we omitted some less frequently recorded restoration measures and merged similar restoration measures. Table 1 gives an overview of the revision of the classification scheme. For statistical reasons, we harmonized measures containing records with different dimensions (e.g. surface area and length) applying the assumptions listed in table 2.

Table 1. Measure reclassification scheme showing how measure classes were regrouped, merged or dropped after the initial screening of the database.

Original classification	Unit	Final classification
AQUATIC RESTORATION		
River flow modification	km	Aquatic Restoration
Restoration of water bodies (ponds, streams)	ha	
Rewetting/raising of groundwater table	ha	Rewetting
Fish passages	yes/no	Fish Passages
Bank modifications/stabilization	km	Bank Modification
VEGETATION RESTORATION		
Planting of forbs or grasses	ha	Replanting vegetation
Planting of trees and shrubs	ha	
Reinstatement of burning	ha	Burning Vegetation
Removal of vegetation (single event)	ha	Clearing Vegetation
Grazing or mowing	ha	Grassland Management
OVERHEAD		
Cessation of degrading action only (passive)	yes/no	Passive restoration
Tourist infrastructure	yes/no	Tourist Infrastructure
Others	yes/no	Others
Establishment of seed banks	yes/no	-
OTHERS		
Extirpation of damaging/invasive species	ha	Invasive Species
Artificial nests	yes/no	Nesting sites
Nursery and release	yes/no	Nursery
Restrict access to humans and animals	km	Fencing
Road rehabilitation	km	Road Rehabilitation
Removal of infrastructure, rubbish, sediment	tonne	Waste Removal
Land acquisition/compensation/material	ha	Land Acquisition
Remodelling of topography	ha	Remodelling topography
Nutrient removal or enrichment	yes/no	Abiotic amendments

Table 2: Assumptions applied to harmonize restoration measures with different dimensions.

Restoration measure	Value	Unit
Width of riparian vegetation	10	m
Width of road	5	m
Width of river	10	m
Width of dune/dyke	50	m
Width of hedge	5	m
Width ditch	2	m
Density of trees planted	1750	ha^{-1}
Density of cranberries planted	2500	ha^{-1}
Density of shrubs planted	5	m^{-2}
Weight of soil	1.6	$t\ m^{-3}$
Volume of one truck load	10	m^3
Depth of sod cutting	0.1	m
Dredging depth of top soil/silt/sediment removed	0.5	m
Average size of pond	0.5	ha
Average size of pool	50	m^2
Thinning forest/cutting whole forest	10	%
Decaying wood/cutting whole forest	5	%
Fence length per ha	0.4	$km\ ha^{-1}$

2.3 Budget standardization

The prevalent disparities in the economic development of EU member states presuppose a budget standardization procedure that accounts for differences in restoration costs between countries and over time. We used the indicators Harmonized Indices of Consumer Prices (HICP) and Price Level Index (PLI) from Eurostat (cf. appendix A) to let all project budgets reflect 2006 € levels (HICP) at an EU-average level of economic development (PLI). The definition of the two economic indicators is given below.

Definitions of economic indicators	
Price Level Index (PLI)	The price level index, abbreviated as PLI, expresses the price level of a given country relative to another (or relative to a group of countries like the European Union), by dividing the Purchasing power parities (PPPs) by the current nominal exchange rate.
Harmonized Indices of Consumer Prices (HICP)	The HICPs are economic indicators constructed to measure the changes over time in the prices of consumer goods and services acquired by households. The HICPs give comparable measures of inflation in the euro-zone, the EU, the European Economic Area and for other countries including accession and candidate countries. They are calculated according to a harmonised approach and a single set of definitions.

2.4 Multiple linear regression

The goal of this study was to extract cost estimates of restoration measures which were most frequently applied throughout the LIFE program based a sample of 215 restoration projects with detailed accounts of stated project budgets, applied measures and their quantities. For this, we constructed a multiple linear regression analysis to solve the system

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & x_{2p} \\ \vdots & \vdots & & \vdots \\ \vdots & \vdots & & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{np} \end{bmatrix} \begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \vdots \\ \beta_n \end{bmatrix}$$

where the regression coefficients $(\boldsymbol{\beta_0}, \boldsymbol{\beta_1}, \ldots\ldots\ldots, \boldsymbol{\beta_p})$ correspond to the cost estimates of each measure *p* per unit, x_{np} corresponds to the reported quantities of each measure applied in project n and *y* to the predicted project budgets. Recall that reported quantities can either take continuous or binary values. We used the ordinary least squares (OLS) optimization approach to solve this over-constrained (i.e. more constraints/equations than explanatory variables/measures) system and to find sets of regression coefficients that best predict stated project budgets. We followed two different approaches to multiple OLS regression, the R package *non-negative-least-squares* (*NNLS*) and a manual solution involving MS Excel's *SOLVER* function, and compared their suitability for extracting reasonable cost estimates from our dataset.

For both methods, the optimization rule uses the sum of least squares approach which reads as

$$\min_x \sum_{j=1}^{n} (P_j - S_j)^2$$

where n is the number of projects, P_j is the predicted budget and S_j is the stated budget of project j.

2.4.1 Non-negative least squares (NNLS)

The NNLS package (Version 1.4) is an R interface to the Lawson-Hanson implementation of an algorithm for non-negative least squares that allows for constraining regression outputs to non-negative and non-positive values. It solves the least squares problem $min\ ||Ax = b\ ||_2$ with the constraint $x \geq 0$ where x ▯ R^n; b ▯ R^m and A in an $m \times n$ matrix (Lawson and Hanson, 1995). The constraint is necessary to avoid negative values for restoration measures.

NNLS runs were performed in RStudio (Version 0.97.551) for different versions of the original dataset. Versions differed in the number of measures and projects included and were derived by

a) a step-wise elimination of the less frequently recorded measures,
b) regrouping/merging similar measure classes

c) using only projects with a certain minimum number of measures applied.

The restoration measure classes *Others*, *Tourist Infrastructure* and *Passive* (table 1) were excluded from all runs and were, together with labour and administrative costs, accounted for as *Overhead* expenditures. Overhead costs were assumed to consume about twenty per cent of overall budgets in the NNLS approach. An overview over the specifications of the different *NNLS* runs is given in Table 3.

Table 3. Overview if specifications of NNLS regression analysis runs with N(project) indicating the number of projects included in the run, N(measure) the amount of measure classes included and Nmin (measures per project) the minimum number of applied measures for a project to be included in the analysis.

Dataset	N (project)	N (measure)	Dropped measures	N_{min} (measures per project)
OR $_{raw}$		25	-	-
OR $_{ref}$	215	25	-	-
A1	215	17	Tourist Inf, Passive, Others	-
A2	198	17	-	2
A3	177	17	-	3
A4	130	17	-	4
A5	82	17	-	5
A6	202	16	Road	-
A7	185	16	Nurse	-
A8	199	16	Nests	-
A9	202	16	Burn	-
A10	206	16	Abiotic	-
B1	156	13	Nurse, Nests, Burn, Road, Abiotic	-
B2	140	13	-	2
B3	122	13	-	3
B4	84	13	-	4
C1	179	11	{Burn & Clear Veg} and {Shore Mod & Topo}	-
C2	158	11	-	2
C3	127	11	-	3

For each *NNLS* output, we calculated the median, the minimum and maximum values, the first and third quartile and the average of all non-zero values to provide a cost confidence range for each restoration measure. The goodness-of-fit between stated project budgets and budgets predicted using the derived cost estimates per measure was tested using MS Excel’s LINEST function. LINEST offers an OLS-curve-fitting routine that calculates trend line statistics and corresponding uncertainties (slope, standard error of slope, intercept, standard error of intercept, R^2, F statistics, degrees of freedom and regression sum of squares and residual sum of squares). The Intercept $\boldsymbol{\beta_0}$ was set to zero and the goodness-of-fit was assessed on the basis of line slope, slope error and R^2 values. An optimal set of regression coefficient values would produce a regression line with a slope of one, thus, on average, neither under- nor overestimating predicted LIFE budgets, and return a high R^2 value, i.e. a high explained variance.

2.4.2 MS Excel's Solver

Likewise to NNLS, SOLVER can be used to conduct a multiple (OLS) regression analysis. SOLVER allows for constraining regression coefficients not only to non-negative values but to a user-defined range, which reduces the risk of the optimization procedure getting trapped in local optima. It also offers different optimization algorithms that compute an "optimal" solution for a specified objective by changing the values in a range of cells (decision variable cells) that can be subject to constraints (upper and lower bounds). In our study, we combined SOLVER with MS Excel's LINEST function and set the optimization objective to maximizing LINEST's R^2 value by varying the regression coefficients (decision variable cells) within a certain range.

Given the scarcity of information on restoration costs and the heterogeneity in scope of restoration projects choosing reasonable constraints was often based on defining reasonably wide ranges around reference values found in (grey) literature. The installation of fish passages as a mitigation measure for river hydrological works nicely exemplifies this problem. Depending on the size of river and installation fish passage costs can range between a couple of thousand to almost 70 million dollars (Francfort et al., 1994). To test for the potential occurrence of local optima or attractors and evaluate the sensitivity of outcomes to initial values and applied constraints, we subjected the decision variable cells to different sets of constraints and varied starting conditions (start from upper bound, lower bound, mean of upper and lower bound). We also tested our dataset under virtually unconstrained conditions by opting for a very wide constraint range (sets C and D) and excluded some measures with good references from literature or high stability in previous runs from the regression analysis in order to reduce the number of explanatory variables (set E). Table A1 (Appendix) lists the constraints applied in this study and the corresponding reference values found in literature. For SOLVER runs we merged the class *Burning vegetation* with the class *Clearing vegetation*. Contrary to the *NNLS* approach, *Overhead* expenditures were treated as a separate measure class and allowed to vary within certain constraints in the SOLVER approach (cf. Table X).

2.4.3 Economy of scale

In addition we examined to what extent scale-dependencies may have an influence on restoration costs. Similar to other economic activities economies of scale can be assumed to be present in ecological restoration (Cairns and Heckman, 1996). For account for this, we extended the regression model by adding the following economy-of-scale equation to all continuous explanatory variables. Assuming restoration costs per unit area, length or mass to decrease with increasing scale, we let

$$m_p = \left(C_p - a * C_p * \left(\frac{X_{rec}}{X_{max}} \right)^e \right) * X_{rec}$$

where m_p represents the cost contribution of measure p, C_p the cost of measure p per unit that is optimized by Solver, a corresponds to an impact factor ranging between 0 and 1, e the exponent, X_{rec} corresponds to the actually recorded quantity of measure p in project n and X_{max} to the maximum recorded extent of measure p over all projects. The two scale-dependencies examined in our study are illustrated in Fig. 1. We opted for a linear and an exponential correlation between restoration costs per unit and restoration extent. In both cases we assume that restoration costs decrease with increasing extent, however, never below half the initial value (a=0.5). We evaluated whether adding scale-dependencies can increase the predictive power of our regression model by comparing the LINEST slope and R^2 results of the two (linear and exponential) scaling vectors with each other and with the original approach lacking a scaling vector.

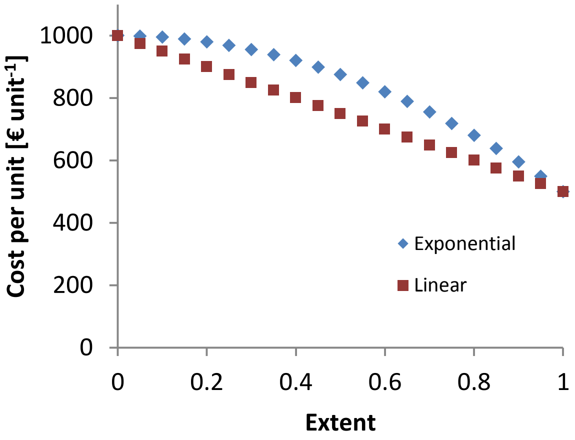

Figure 1. Scale-dependency of restoration costs.

We examined the effect of a linear (a=0.5, e=1) and of an exponential (a=0.5, e=2) correlation between restoration costs and scale. Costs are assumed to decrease with increasing extent. For illustrative purposes the (geographical) extent of the respective measure is assumed to range between 0 and 1 and restoration costs reach a maximum of 1000€ per unit.

2.4.4 Solving methods

SOLVER offers a range of different solving or optimization methods for linear and nonlinear problems. We executed SOLVER with two different solving methods, the GRG nonlinear method (Covergence=0.0001, Population=100, Random Seed=0) suitable for smooth, non-linear problems and the evolutionary solving method (Convergence = 0.0001, mutation rate=0.075, population size=10000, random seed=0, maximum time without improvement=100) used for non-smooth problems.

Concordantly with the NNLS approach described above, we assessed the goodness-of-fit of model predictions using Excel's LINEST function. Since the two goodness-of-fit criteria maximizing R^2 and letting the line slope converge to one do not necessarily coincide and may require a trade-off, we separately executed SOLVER for these two different objectives. For each set of constraints and starting conditions we executed SOLVER once with the solving method GRG nonlinear and three times with the solving method Evolutionary, which contrary to the GRG method did not produce identical results for the same setting.

For the subsequent statistical analysis, we retained only regression outputs with a high explained variance (R^2>0.5) and reasonable line slopes m (0.8<m<1.2). For each of these best-fit outputs we calculated the mean, standard deviation, median, the minimum and maximum values and the first and third quartile to provide a cost confidence range for each measure.

3 Results

3.1 Frequency analyses

To give an overview over the content of the LIFE database (all projects included), we conducted a series of simple frequency analyses. About half (49%) of all LIFE projects were carried out by public authorities but also NGOs (27%), park-reserve authorities (12%) and research institutes (5%) played an important role in the history of the LIFE program. Less than one per cent of projects were conducted by private actors.

Fig. 2 illustrates which taxonomic groups and broad habitat types were targeted most frequently and how much money was conceded to their conservation. About half (51%) of the overall budget was spent on projects at least partially targeting *bird* species with *mammals* being the second most prominent conservation target. *Reptiles* (1% of budget) and *plants* (4%) on the contrary played only a minor role in conservation considerations. Amongst habitat types, *forests* (24%) were the most frequently targeted with expenditures of about €288 million (14%), while the habitat types *sclerophyllous scrub*, *temperate heath and scrub* and *rocky habitats and caves* received considerably less funding.

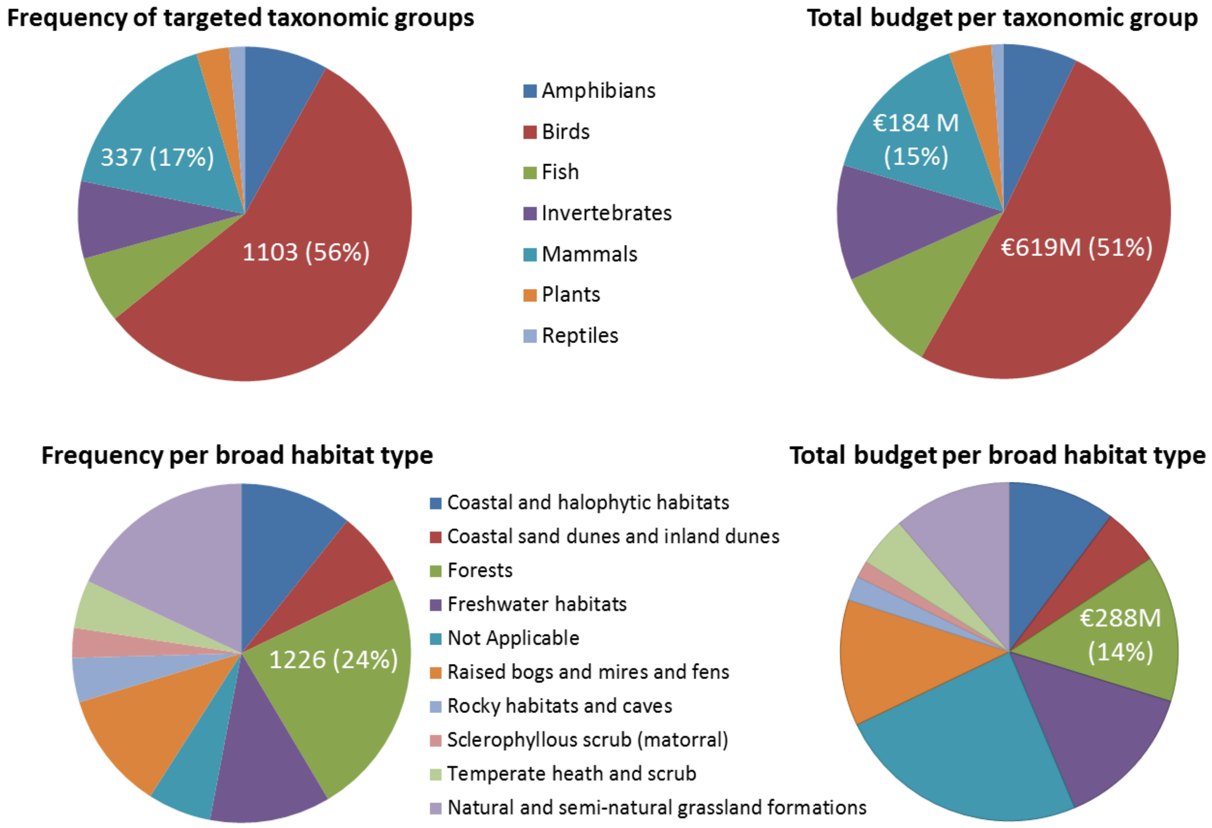

Figure 2. Target frequency and budget allocation of taxonomic groups and habitat types

Differences in budget allocation were not only detected for different taxonomic groups and habitat types but also become apparent when mapped over the EU. Fig. 3 illustrates the geographical differences in budget allocation on the NUTS-1 level. LIFE investments have been particularly high in the South of the United Kingdom (UK), Belgium, the Netherlands, Western Germany and Denmark with regional peaks in the regions of Vienna, Austria, and Budapest, Hungary. Investments have been markedly lower in wide parts of Eastern Europe, Northern Scandinavia, the Baltics and wide parts of Spain and France. Regional expenditures peaked at more than €37,000 per km^2 in the Brussels-Capital region (NUTS-Code: BE1) and was lowest in the Czech Republic with an average of only about €36 per km^2.

Spatial patterns in budget allocation were found to coincide with spatial patterns in other socio-economic and ecological indicators. Fig. 3 illustrates that NUTS regions characterized by a high population density, low number of Article 17 species and a high percentage of artificial land cover (e.g. the Netherlands, Belgium, Southern UK) received in general more LIFE funding than regions with a low population density, high number of Article 17 species and low share of artificial land cover (e.g. Northern Scandinavia, Eastern Europe, Spain).

3.2 Cost estimation

The principal aim of this study was to calculate cost estimates of the ecosystem restoration measures most frequently applied throughout the LIFE program. We conducted a series of multiple (OLS) regression analyses to provide cost confidence intervals for 15 restoration measures. Results for both regression methods, R's NNLS and MS Excel's SOLVER, are summarized in Fig. 4 and Table 4. Fig. 4 provides an estimate of the order of magnitude of cost intervals using a logarithmic scale, whereas Fig. 5 gives a more detailed account of cost intervals and also shows average costs and corresponding standard deviations.

3.2.1 SOLVER

The calculation of cost confidence intervals is based on 23 (out of 48) SOLVER runs meeting the best-fit criteria ($R^2>0.5$, $0.8<m<1.2$). The likelihood of model runs to fulfil these criteria was found to be dependent on decision variable constraints and solving method. While SOLVER did not find solutions meeting these criteria under constraint ranges A, C and D, constraint ranges B, F and G only produced best-fit outputs for the solving method Evolutionary and E only for the GRG method. The solving method Evolutionary proved to be more successful in finding best-fit solutions as 33.3 % of all Evolutionary runs met best-fit criteria compared to only 9.5 % of GRG runs. Starting conditions on the other hand had little impact on the likelihood of producing best-fit outputs with lower bound (8), mean (7) and upper bound (8) contributing almost equally to best-fit outputs. Most best-fit model runs achieved an R^2 value between 0.5 and 0.6 with the highest recorded R^2 value reaching 0.608 (constraint set G, method Evolutionary, start from upper bound). The regression line slopes *m* of the best-fit model runs varied between 0.87 and 1.17.

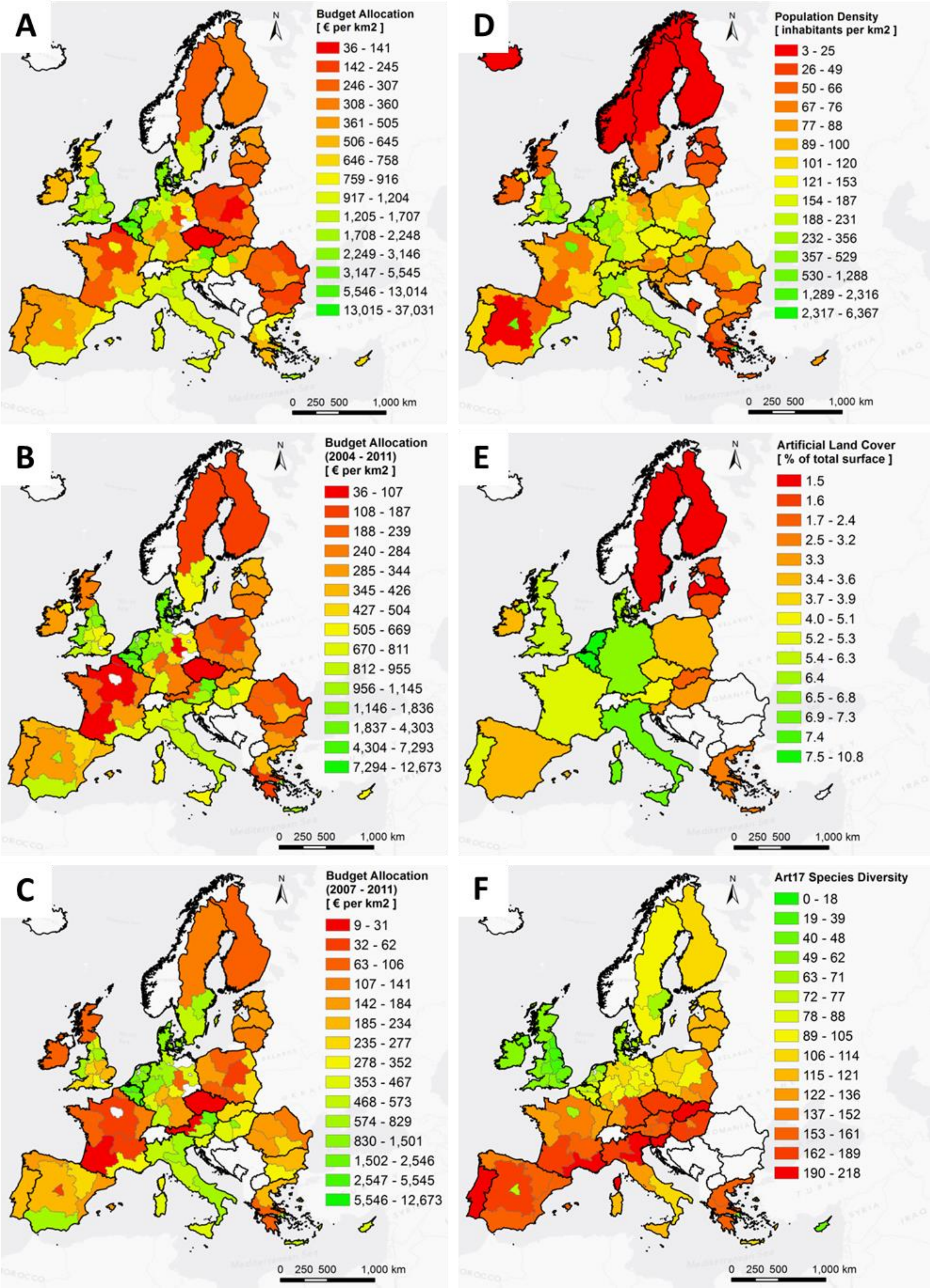

Figure 3. EU maps of LIFE budget allocation (different time horizons, **A–C**), population density (**D**), proportion of artificial land cover (**E**) and Article 17 species diversity (**F**). All information was aggregated to the NUTS-1 level except for artificial land cover for which information was only available at member state level. Natural breaks were used for color-code classification.

3.2.2 NNLS

The NNLS approach showed a high tendency to return zero values for the restoration measure classes *Burning Vegetation* (100% zero values, all 17 runs), *Abiotic Amendment* (78%), *Aquatic Restoration* (71%) and *Fencing* (76%). The measure class *Burning Vegetation* was therefore excluded from the illustration and also for the SOLVER analysis to allow for the comparability of the two methods. The high percentage (>50%) of zero values in these measure classes caused first quartile and median values to be zero.

For illustrative purposes the results for the measure classes *Overhead* and *Waste Removal* are not included in the figures. Despite marked differences between the results of the two approaches the logarithmic illustration shows that cost estimates for both approaches largely agree on the order of magnitude. The class *Road Rehabilitation* constitutes an exception with difference exceeding one order of magnitude.

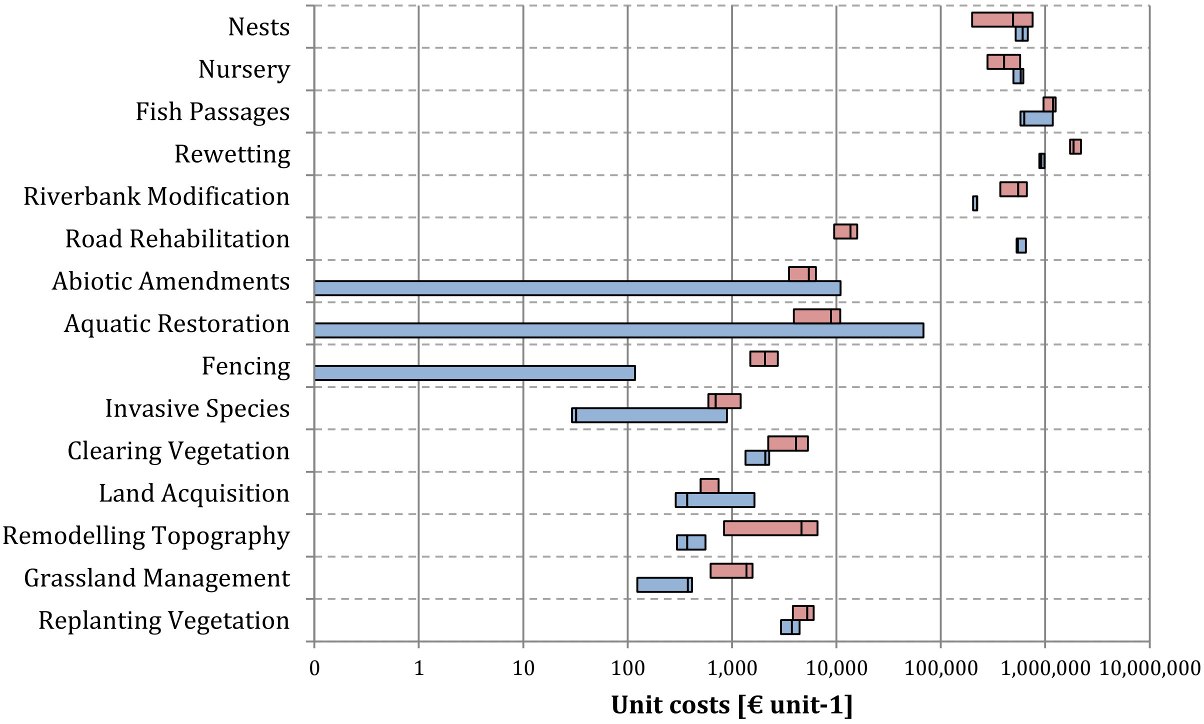

Figure 4. Confidence intervals of cost estimates for of 15 restoration measures classes depicted on logarithmic scale for SOLVER (red) and NNLS (blue) approach. Bars indicate value space spanned by first quartile (lower bound) and third quartile (upper bound) and split by median value.

The emerging differences between the two methods become more evident when looking at Fig. 5, which depicts cost confidence intervals and (non-zero) average costs for both methods on a linear scale. The cost intervals of 6 out of 15 measure classes show no overlaps. Particularly marked differences exist for the measure classes *Road Rehabilitation*, *Rewetting* and *Fencing*. For most measures the (non-zero) average cost estimates falls within the cost confidence interval. The NNLS cost intervals of the classes *Fencing*, *Abiotic Amendment*, *Aquatic Restoration* (high percentage of non-zero outputs), *Remodelling Topography* and *Grassland Management* form an exception to this.

The width of cost confidence intervals and the standard deviations serve as good indicators of the variance in model outputs. For some measure classes like *Fencing*, *Abiotic Amendment*, *Aquatic Restoration* and *Remodelling topography* (NNLS) the observed variance differed widely. The marked differences between the space covered by cost confidence intervals and non-zero cost estimates with corresponding standard deviations can be ascribed to the different treatment of zero values for the calculation of the two ranges. In contrary to the calculation of the cost confidence interval, zero values were excluded for the calculation of average costs and standard deviations. The two ranges should therefore be regarded separately rather than in comparison with each other.

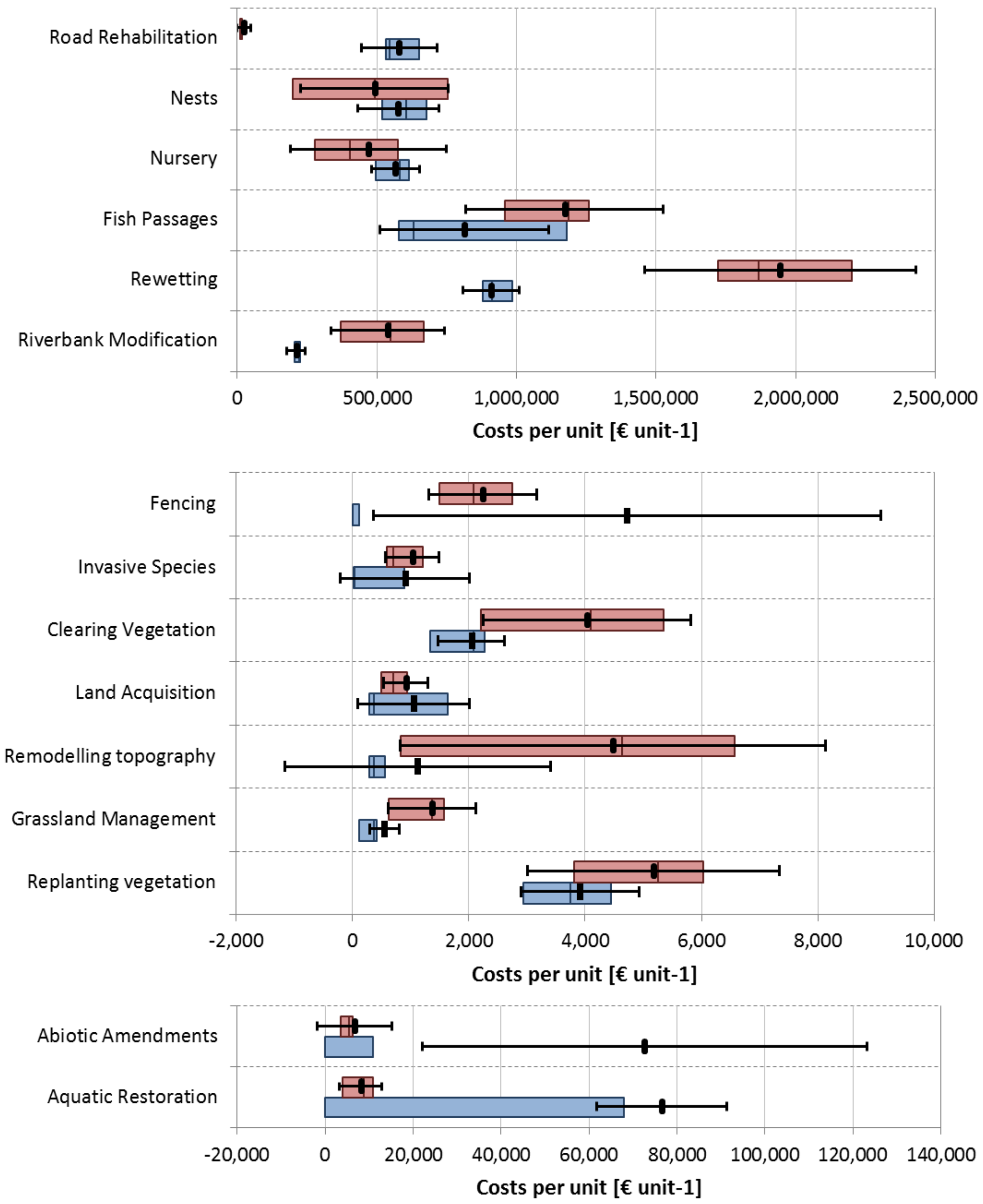

Figure 5. Average costs and cost intervals for 15 measures using the NNLS (blue) and SOLVER (red) methods. Coloured bars indicate value space spanned by first quartile (lower bound) and third quartile (upper bound) and split by median value (zero values included). Black bars indicate average restoration costs (all non-zero model outputs included) and standard deviations from average costs.

Table 4. Summary statistics of regression outputs using SOLVER method with cost confidence intervals spanned by 1st quartile, median and 3rd quartile.

	Unit	Min	1st quartile	Median	3rd quartile	Max	Mean	Standard Deviation	StDev/Mean
Road Rehabilitation	€ (per project)	3,168	9,509	13,657	15,852	100,000	19,320	25,263	1.31
Nests	€ (per project)	51,600	199,303	491,773	754,405	1,000,000	487,780	265,062	0.54
Nursery	€ (per project)	56,512	278,773	402,940	576,506	1,000,000	465,170	278,714	0.60
Fish Passages	€ (per project)	408,110	960,320	1,187,391	1,257,933	2,000,000	1,168,210	353,705	0.30
Rewetting	€ (per project)	965,871	1,723,454	1,866,185	2,200,796	3,000,000	1,940,381	484,289	0.25
Riverbank Modification	[€ km^{-1}]	169,328	369,874	548,882	668,194	958,149	535,596	203,340	0.38
Fencing	[€ km^{-1}]	500	1,500	2,076	2,750	3,960	2,055	884	0.43
Invasive Species	[€ ha^{-1}]	500	594	700	1,214	1,987	901	435	0.48
Clearing Vegetation	[€ ha^{-1}]	500	2,216	4,105	5,345	6,356	3,769	1,699	0.45
Land Acquisition	[€ ha^{-1}]	500	500	700	941	1,648	796	364	0.46
Remodelling topography	[€ ha^{-1}]	500	837	4,635	6,565	12,733	4,194	3,485	0.83
Grassland Management	[€ ha^{-1}]	100	621	1,372	1,569	3,043	1,227	722	0.59
Replanting vegetation	[€ ha^{-1}]	1,006	3,818	5,258	6,035	9,009	4,857	2,065	0.43
Abiotic Amendments	[€ ha^{-1}]	700	3,520	5,438	6,358	45,380	6,557	8,504	1.30
Aquatic Restoration	[€ ha^{-1}]	500	3,900	8,836	10,867	19,764	7,965	4,749	0.60
Waste Removal	[€ ton^{-1}]	1.00	1.00	2.98	6.12	11.76	3.87	3.26	0.84
Overhead	[% of budget]	23	26	27	30	30	28	2	8

4 Discussion

4.1 Cost estimates

Our study presents one of the most extensive economic analyses of ecosystem restoration costs in Europe. We collected restoration data from more than 200 LIFE restoration projects and calculated the cost confidence intervals for the 15 most frequently applied restoration measures. The strong dependence of restoration costs on the environmental and socio-economic context is not only reflected in the scarcity of published data on costs of restoration measures but also in the variance of model outputs observed in our study. Factors that are likely to contribute to variance in unit costs include the degree of degradation, the accessibility and heterogeneity of the restoration site (Weiher, 2007), the resilience or recovery potential of the degraded site (e.g. intact seed banks) (Suding, 2011), the definition of the desired end state and, as illustrated in this study, scale effects. Furthermore, the costs of labour and land can be expected to differ widely not only between but also within countries, which adds bias to the analysis. The fact that most LIFE projects served as demonstration projects with the objective to explore rather than apply best-practice procedures is likely to further aggravate the variance in regression outputs. The results of our study are based on LIFE projects from a variety of different local contexts and with different combinations and quantities of applied measures. Therefore the presented values are only indicative and should be regarded with caution. A different suite of projects, measure categories, applied assumptions or regression methods would likely yield different results.

We argue, however, that despite the high variance in cost estimates the presented cost confidence intervals and average unit costs with standard deviation provide a good approximation of actual restoration costs for the assumptions we made. Although the high variance may preclude them from being used for fine-grain analysis such as cost predictions on a project basis, we are confident that cost ranges may prove useful for more coarse-grain analysis such as the prediction of restoration expenditures at national or EU level given certain biodiversity conservation or restoration targets. For such meta-analysis purposes the upper and lower bounds of the cost confidence intervals can be used to provide a range of expected restoration expenditures.

In this study we explored the information value of the LIFE database to provide cost estimates of restoration measures. The quality of data was found to vary widely between projects and is thus one of the main sources of uncertainty in our analysis. To improve the accuracy of cost estimates we therefore suggest a number of measures for enhancing the comparability of project data derived from the LIFE database. The LIFE database constitutes an invaluable source of practical information on ecosystem restoration projects. However, in order to allow for efficiently harvesting the vast amount of data stored in the database more standardized and detailed reporting guidelines would be desirable. Most project reports are lacking a detailed account of spatial extent or quantities, which, in the absence of a spatial reference of overall project size, renders project reports unsuitable for quantitative analyses.

Another major source of uncertainty is the lack of accurate information on land prices in the EU. An attempt to deduct costs for land acquisition from overall project budgets using data on land prices retrieved from Eurostat resulted in a high share of "negative" budgets, i.e. costs of land acquisition exceeded overall budgets. Restoration sites are likely to be located on marginalized lands with lower than average costs per hectare. This assumption is also supported by our results for the measure class land acquisition with an average of about 800€ per hectare (SOLVER). Considering that land prices can reach as much as 31,000€ per hectare (Netherlands, year 2006, Eurostat), we can assume cost estimates for land acquisition to underestimate actual costs. More accurate accounts of land prices for ecosystem restoration in the EU could substantially improve the cost estimates of the remaining restoration measures as land acquisition consumed major parts of some project budgets.

4.2 Comparison of regression methods NNLS and SOLVER

The observed discrepancies in regression outcomes of the two selected methods (NNLS and SOLVER) illustrate the dependence of regression outcomes on the constraint range. SOLVER allows for subjecting each explanatory variable to a specific user-defined constraint range and thus for more control of regression outcomes. Applying constraints, if reasonably selected, can help minimize the risk of the regression procedure getting trapped at local optima. In this study, we applied different constraint ranges and starting conditions to test for the occurrence of such local or false optima. The great variance in regression outputs can be an indicator for the presence of local optima. The NNLS approach furthermore shows a higher susceptibility to returning zero values. Although both methods produce similar degrees of variance, we argue that the SOLVER approach is superior to the NNLS approach due to its higher adaptability.

4.3 Cost estimates of individual measures

The scarcity of information published on ecosystem restoration costs complicates conclusions over the validity of the cost estimates presented in this study. The results for some measures, however, require a closer inspection. For instance, we assumed overhead costs to consume a certain percentage of the overall budget, which inevitably evokes a bias of regression outputs towards high values in this class. The extreme example of allowing overhead costs to reach values close to 100% nicely illustrates this bias. Overhead costs consuming the whole budget would coerce the regression procedure to assign values close to zero to the remaining measures but cause also a high concordance between predicted and stated budgets and thus a high explained variance (R^2). In our study variable overhead costs in the SOLVER approach consistently scored best-fit values at the higher end of the constraint range (max at 30% of total budget). These results should be regarded with caution. Fixing overhead costs to an empirical value from literature would improve the analysis and also reduce the amount of explanatory variables.

4.4 Budget allocation

We have further shown that high expenditures on ecosystem restoration coincided with high population densities, a high share of artificial land and low number of Article 17 species. These findings indicate a prioritization of degraded restoration sites subject to high anthropogenic pressure in the allocation of LIFE funding. The unbalanced allocation of LIFE budgets over species or taxa and habitats has often been criticized. Our budget mapping exercise can help to shed light on potentially unbalanced LIFE funding. A more in-depth analysis is, however, required to examine which species, taxa and habitats are notoriously underfunded. A more concerted and centrally commissioned approach to managing restoration activities in the EU is indispensable to ensure that the natural heritage of the EU is appropriately managed and brought back into good conservation status.

4.5 Conclusion

This report is among the first to infer costs of specific restoration measures which can be applied across the EU for estimating the costs of restoration projects. This is a first step to assess the costs of a restoration prioritisation framework which is currently developed under Action 6 of the EU Biodiversity Strategy. Member States and the EU are committed (globally under the convention of biological diversity and in Europe under the EU Biodiversity Strategy) to restore 15% of the degraded ecosystems.

In combination with the information of habitat and species conservation status collected under Article 17 of the Habitats Directive, this report can help assessing the costs to achieve the restoration target.

The estimates should clearly be used with care, considering the also the ranges reported in table 4. To be used, we suggest to assess total projects costs using median and mean values but to include a sensitivity analysis using the ranges reported here.

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6 Appendix

Table A1: Constraint ranges applied for SOLVER runs for each individual measure. for constraint range E.

Table A2: Harmonized Indices of Consumer Prices (HICP) taken from Eurostat (last update: May 16 2013)

Table A3: Price Level Index (PLI)

Table A1: Constraint ranges applied for SOLVER runs for each individual measure. Min and Max indicate the lower and upper bound of the potential range. For each constraint range A, B, C, D, E, F and G SOLVER was executed three times with the solving method Evolutionary and once with the solving method GRG-Nonlinear. To test the effect of reducing the amount of explanatory variables the measure classes Replanting Vegetation, Grassland Management, Clearing Vegetation, Waste Removal and Fencing were fixed to a certain value (marked in grey) for constraint range E.

		Replanting vegetation	Grassland Management	Remodelling topography	Land Acquisition	Clearing Vegetation	Bank Modification	Aquatic Restoration	Invasive Species	Abiotic Amendments	Rewetting	Road Rehabilitation	Fish Passages	Nursery	Nests	Waste Removal	Fencing	Overhead
A	**Min**	1,000	1,000	1,000	500	500	10,000	1000	100	1,000	10,000	1,000	10,000	1,000	1,000	1	10	0
	Max	20,000	20,000	200,000	25,000	100,000	1,000,000	100,000	50,000	3,000,000	3,000,000	3,000,000	3,000,000	3,000,000	1,000,000	2,000	4,000	0.3
B	**Min**	500	100	500	500	500	500	500	500	500	1,000	500	5,000	1,000	500	1	500	0
	Max	10,000	5,000	20,000	10,000	10,000	1,000,000	20,000	10,000	10,000	3,000,000	20,000	2,000,000	1,000,000	1,000,000	200	4,000	0.3
C	**Min**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
	Max	100,000	50,000	1,000,000	30,000	100,000	3,000,000	1,000,000	100,000	3,000,000	3,000,000	1,000,000	3,000,000	3,000,000	1,000,000	1,000,000	10,000	0.3
D	**Min**	500	100	500	500	500	500	500	500	500	1,000	500	5,000	1,000	500	1	500	0
	Max	50,000	50,000	20,000	10,000	10,000	1,000,000	200,000	200,000	100,000	3,000,000	100,000	2,000,000	2,000,000	200,000	200	4,000	0.3
E	**Min**	1,500	1,500	700	700	1,500	700	700	700	700	700	700	700	700	700	5	1,500	0
	Max			200,000	25,000		1,000,000	100,000	50,000	500,000	3,000,000	100,000	2,000,000	1,000,000	100,000			0.3
F	**Min**	500	100	500	500	500	500	500	500	500	1000	500	5,000	1,000	500	1	500	0
	Max	10,000	5,000	20,000	10,000	10,000	1,000,000	20,000	10,000	10,000	3,000,000	20,000	2,000,000	1,000,000	1,000,000	200	4,000	0.3
G	**Min**	500	100	500	500	500	500	500	500	500	1000	500	5,000	1,000	500	1	500	0
	Max	10,000	5,000	20,000	10,000	10,000	1,000,000	20,000	10,000	10,000	3,000,000	20,000	2,000,000	1,000,000	1,000,000	200	4,000	0.3

Table A2: Harmonized Indices of Consumer Prices (HICP) taken from Eurostat (last update: May 16 2013)

GEO/TIME	1996	1997	1998	1999	2000	2001	2002	2003	2004	**2005**	2006	2007	2008	2009	2010	2011	2012
Belgium	85.25	86.53	87.32	88.31	90.67	92.88	94.32	95.75	97.53	**100**	102.33	104.19	108.87	108.86	111.40	115.14	118.16
Bulgaria	:	56.90	67.53	69.27	76.41	82.04	86.80	88.84	94.30	**100**	107.42	115.55	129.36	132.56	136.58	141.21	144.58
Czech Republic	72.2	78.0	85.6	87.1	90.6	94.7	96.1	96.0	98.4	**100**	102.1	105.1	111.7	112.4	113.7	116.2	120.3
Denmark	84.3	85.9	87.0	88.8	91.2	93.3	95.6	97.5	98.3	**100**	101.8	103.5	107.3	108.4	110.8	113.8	116.5
Germany	88.6	90.0	90.5	91.1	92.4	94.1	95.4	96.4	98.1	**100**	101.8	104.1	107.0	107.2	108.4	111.1	113.5
Estonia	65.97	72.09	78.42	80.85	84.03	88.76	91.95	93.22	96.05	**100**	104.45	111.49	123.31	123.56	126.95	133.40	139.02
Ireland	75.7	76.7	78.3	80.3	84.5	87.8	92.0	95.7	97.9	**100**	102.7	105.6	108.9	107.1	105.4	106.6	108.7
Greece	72.68	76.63	80.10	81.81	84.18	87.26	90.67	93.79	96.63	**100**	103.31	106.40	110.90	112.40	117.68	121.35	122.61
Spain	77.92	79.39	80.79	82.59	85.47	87.88	91.04	93.86	96.73	**100**	103.56	106.51	110.91	110.64	112.90	116.35	119.18
France	86.64	87.75	88.34	88.84	90.46	92.07	93.86	95.89	98.14	**100**	101.91	103.55	106.82	106.93	108.79	111.28	113.75
Italy	81.8	83.3	85.0	86.4	88.6	90.7	93.1	95.7	97.8	**100**	102.2	104.3	108.0	108.8	110.6	113.8	117.5
Cyprus	78.70	81.31	83.21	84.15	88.25	90.00	92.51	96.18	98.00	**100**	102.25	104.46	109.03	109.22	112.02	115.93	119.52
Latvia	69.31	74.89	78.11	79.77	81.87	83.94	85.58	88.10	93.55	**100**	106.57	117.32	135.21	139.62	137.91	143.73	147.02
Lithuania	80.15	88.39	93.15	94.51	95.53	97.01	97.34	96.29	97.41	**100**	103.79	109.83	122.01	127.09	128.60	133.90	138.14
Luxembourg	81.18	82.30	83.10	83.94	87.12	89.21	91.04	93.36	96.37	**100**	102.96	105.69	110.01	110.02	113.10	117.32	120.72
Hungary	46.04	54.53	62.28	68.49	75.31	82.15	86.46	90.50	96.63	**100**	104.03	112.28	119.05	123.85	129.70	134.79	142.42
Malta	77.97	81.02	84.02	85.94	88.55	90.77	93.14	94.95	97.53	**100**	102.58	103.29	108.13	110.12	112.37	115.19	118.91
Netherlands	80.43	81.92	83.38	85.07	87.06	91.51	95.05	97.18	98.52	**100**	101.65	103.26	105.54	106.57	107.56	110.23	113.34
Austria	87.21	88.22	88.95	89.41	91.16	93.25	94.83	96.06	97.94	**100**	101.69	103.93	107.28	107.71	109.53	113.42	116.34
Poland	57.6	66.3	74.1	79.4	87.4	92.0	93.8	94.5	97.9	**100**	101.3	103.9	108.3	112.6	115.6	120.1	124.5
Portugal	78.12	79.60	81.36	83.13	85.46	89.23	92.51	95.52	97.92	**100**	103.04	105.54	108.34	107.36	108.85	112.72	115.85
Romania	5.01	12.77	20.31	29.62	43.15	58.02	71.09	81.94	91.68	**100**	106.60	111.84	120.69	127.43	135.17	143.04	147.88
Slovenia	56.50	61.21	66.05	70.09	76.36	82.90	89.09	94.16	97.60	**100**	102.54	106.39	112.28	113.25	115.62	118.03	121.35
Slovakia	53.71	56.93	60.74	67.09	75.27	80.66	83.48	90.52	97.28	**100**	104.26	106.23	110.41	111.43	112.21	116.79	121.16
Finland	87.30	88.37	89.56	90.73	93.41	95.90	97.82	99.10	99.24	**100**	101.28	102.88	106.91	108.66	110.49	114.16	117.77
Sweden	87.51	89.09	90.01	90.51	91.67	94.12	95.94	98.18	99.18	**100**	101.50	103.20	106.65	108.72	110.80	112.31	113.36
United Kingdom	88.1	89.7	91.1	92.3	93.1	94.2	95.4	96.7	98.0	**100**	102.3	104.7	108.5	110.8	114.5	119.6	123.0

Table A3: Price Level Index (PLI) data used in the report (based on Eurostat).

GEO/TIME	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Belgium	113.8	110.5	106.2	107.3	106.5	102.5	103.2	101.3	104.0	106.4	107.5	108.4	109.2	111.7	114.0	112.2	112.8
Bulgaria	25.6	21.6	25.9	30.2	30.9	31.8	33.4	33.4	33.9	35.1	36.6	38.1	40.1	42.7	44.7	44.7	45.2
Czech Republic	38.1	41.0	41.4	45.0	44.3	45.9	48.6	54.4	52.2	53.2	57.4	60.8	61.8	73.1	69.8	73.1	73.6
Denmark	137.9	135.4	131.8	130.7	131.7	129.8	132.4	130.8	136.0	134.1	137.7	137.1	136.1	137.4	139.7	136.3	137.3
Germany	125.2	120.0	115.3	114.6	112.7	111.2	111.3	110.3	108.6	106.4	103.5	102.9	102.3	103.8	107.5	105.3	104.6
Estonia	37.9	44.7	46.7	49.8	51.3	52.4	55.6	55.9	56.9	57.7	60.0	63.9	68.3	70.2	69.7	69.1	70.4
Ireland	94.8	96.9	105.2	103.2	107.5	110.7	115.7	117.5	120.1	119.4	120.7	120.9	118.0	121.7	118.5	110.7	108.9
Greece	76.9	79.6	81.2	79.7	82.3	78.9	78.2	77.3	81.5	82.6	85.3	85.9	88.5	89.7	92.7	92.6	92.9
Spain	86.4	87.7	84.4	83.6	84.7	84.5	86.2	85.9	89.1	90.1	91.4	90.3	89.7	92.1	94.2	93.6	93.4
France	119.1	117.9	113.1	112.2	111.0	108.0	107.0	105.9	111.0	111.6	110.3	110.9	110.0	112.8	114.4	112.8	112.7
Italy	85.5	94.4	95.9	94.1	94.6	94.0	94.1	99.0	101.1	103.6	103.5	102.4	100.6	100.9	103.5	103.8	103.6
Cyprus	84.0	83.1	84.1	85.4	85.8	85.9	85.7	86.1	88.5	88.0	88.2	88.6	88.0	87.6	88.8	88.8	89.0
Latvia	33.3	36.6	40.4	41.4	44.5	51.2	51.7	50.3	47.8	48.9	51.8	57.5	66.6	71.9	68.2	65.4	66.9
Lithuania	27.2	32.6	39.9	41.3	42.1	47.2	47.6	48.1	47.0	48.4	51.4	54.1	57.4	62.9	61.9	59.7	61.4
Luxembourg	118.4	114.7	111.6	110.0	108.9	108.1	110.5	109.4	111.5	109.5	113.8	112.3	113.9	115.9	120.5	120.6	120.6
Hungary	44.7	44.6	47.0	45.7	46.2	47.7	50.2	55.4	56.3	59.6	61.9	59.7	64.3	65.8	59.5	60.8	60.7
Malta	57.6	62.4	64.2	64.7	65.5	68.0	71.1	69.7	68.4	67.4	67.7	69.0	69.9	71.7	72.7	72.1	72.8
Netherlands	114.6	110.5	106.1	105.1	104.9	102.7	105.6	105.6	109.7	107.9	107.0	106.6	105.6	107.7	111.8	110.4	109.7
Austria	116.3	112.4	107.6	106.4	106.0	103.6	106.9	104.9	104.7	103.8	105.9	105.2	106.8	109.0	112.1	109.7	110.2
Poland	44.3	46.9	47.8	49.5	47.6	52.8	59.0	55.5	49.5	48.8	55.5	58.1	60.0	67.6	57.2	60.2	59.3
Portugal	79.1	79.8	79.4	80.5	80.6	80.5	82.2	82.9	83.6	85.0	81.7	81.3	81.3	83.0	84.1	82.6	82.4
Romania	26.5	25.3	29.4	36.4	32.2	36.5	36.8	37.1	37.3	38.1	46.9	49.9	55.8	55.5	49.6	50.8	52.0
Slovenia	73.7	71.5	71.5	73.0	72.8	70.9	72.4	73.1	74.6	72.7	73.1	74.7	77.5	81.1	85.6	84.7	83.9
Slovakia	40.1	40.5	42.1	41.9	39.5	42.8	42.3	43.6	47.7	51.2	52.8	55.2	59.9	65.7	67.9	67.9	69.1
Finland	124.2	120.8	118.0	116.4	116.0	114.5	117.9	117.5	119.6	115.8	116.7	116.7	115.8	117.4	120.0	120.1	122.1
Sweden	119.7	128.2	125.8	122.8	122.0	124.4	117.7	119.5	121.1	118.5	120.7	120.5	118.3	116.7	111.5	123.4	128.8
United Kingdom	92.2	93.0	107.3	111.4	114.6	120.0	117.4	116.8	109.6	110.7	111.1	112.9	116.1	104.5	97.8	101.0	101.8

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