PROFOR.INFO

WORKING PAPER

GLOBAL ASSESSMENT OF NONWOOD FOREST ECOSYSTEM SERVICES

SPATIALLY EXPLICIT META-ANALYSIS AND BENEFIT TRANSFER TO IMPROVE THE WORLD BANK'S FOREST WEALTH DATABASE

DECEMBER 17, 2015

Juha Siikamäki, Francisco J. Santiago-Ávila, and Peter Vail

RESOURCES FOR THE FUTURE

WAVES

PROFOR
PROGRAM ON FORESTS

Acknowledgements

We the authors would like to thank Glenn-Marie Lange and Esther Naikal for their valuable insights throughout this research. We also thank Carter J. Brandon, Carole Megevand, Stefano Pagiola, and Jon Strand for helpful comments and suggestions. Moreover, we thank the seminar participants at the World Bank for their questions and feedback on this assessment. Finally, we thank Jacqueline Ho for excellent research assistance with the literature reviews developed for the meta-analysis.

This research received funding from Program on Forests (PROFOR) and the World Bank WAVES program.

For a full list of publications please contact:

Program on Forests (PROFOR)
1818 H Street, NW
Washington, DC 20433, USA
profor@worldbank.org
www.profor.info/knowledge

PROFOR is a multi-donor partnership supported by the European Commission, Finland, Germany, Italy, Japan, the Netherlands, Switzerland, the United Kingdom and the World Bank.

Learn more at www.profor.info

TABLE OF CONTENTS

Note: In this publication, all dollar amounts are U.S. dollars, unless indicated.

1 INTRODUCTION

The comprehensive wealth program of the World Bank develops global, country-level indicators of sustainability. These indicators include Adjusted Net Saving (ANS) and Adjusted Net National Income (ANI), which have been published annually since 1970, and comprehensive wealth estimates, which have been published for 1995, 2000, and 2005. Data on natural resource rents (from forests, minerals, and energy) are important constituents of these indicators.

Besides helping measure the overall sustainability of an economy, information on natural resource rents is more generally valuable. Findings from recent World Bank assessments suggest that while experts within the World Bank and researchers and policy analysts outside use comprehensive wealth and ANS data, the greatest demand is for the data on natural resource rents. Moreover, even though minerals and energy rent data have gained traction, data for forests are not used as frequently. This situation is despite the importance of forests for the livelihoods of people and their role in economic development.

The current forest assessment by the World Bank estimates the value of forests as the combined economic wealth associated with different wood and nonwood ecosystem services provided by forests. *Wood ecosystem services* denote all wood benefits from forests, including the value of standing stock for commercial wood and wood fuel. *Nonwood ecosystem services*, the focus of this report, refer to the benefits that forests provide in addition to wood production. They include products and services provided or supported by forests that contribute to wealth, such as nonwood forest products (NWFPs), recreation, hunting, fishing, habitat provision, and various regulating services, including hydrological services and carbon sequestration.

A scoping study by Siikamäki and Santiago-Ávila (2014) reviewed the World Bank's current methodology to measure forest wealth, suggesting several key revisions to improve the assessments of both wood and nonwood wealth. The purpose of this study is to address one of the main suggestions from the scoping study: the need for a comprehensive revision of the assessment of nonwood forest wealth, including its methodology, data, and estimates.

The current assessment methodology considers the following three nonwood forest ecosystem service categories: (i) watershed protection; (ii) recreation, hunting, and fishing, and (iii) NWFPs. Each benefit category is valued using a simplified approach. For watershed services, the current assessment uses a constant and globally uniform annual benefit per hectare estimated at $10 per hectare (1995 U.S. dollar) by Lampietti and Dixon (1995). For recreation, hunting, and fishing, the assessment again uses the review by Lampietti and Dixon (1995) to develop a constant value per hectare differentiated between developed and developing countries ($119 per hectare and $17 per hectare, respectively, in 1995 U.S. dollar), applicable to 10 percent of forest area in each country. NWFPs, which include forest plant products harvested for food or raw materials, are assessed using FAO's Global Forest Resource Assessment (FRA) data. See Siikamäki and Santiago-Ávila (2014) and Appendix I of this report for more information on the current methodology and data sources.

The scoping study notes that the current approaches to estimate the value of nonwood forest wealth are empirically outdated and methodologically limited. There are several reasons for this. For example, the valuation of nonwood forest benefits has leaped forward as a field over the last two decades or so. Since the development of the estimates used by the current assessment, an increasingly broad recognition has developed of the importance of ecosystem services as a concept. Moreover, there has been a tidal wave of research aimed at developing robust methods and empirical applications to value ecosystem services. As a consequence, both current valuation methodologies and the availability of existing valuation studies enable assessments of nonwood forest ecosystem services that could considerably improve the current approach.

A specific methodological limitation of the current approach is that it estimates the value of forest ecosystem services by using simple averages of estimates collected from the literature. Accordingly, the value estimates used in the forest wealth assessment are globally uniform or near uniform, thereby, developed under the assumption that each hectare of forest provides ecosystem services of similar value. Yet, forests are characterized by extensive ecological and socioeconomic heterogeneity that likely makes the value of forest ecosystem services similarly heterogeneous. Moreover, even setting aside any spatial heterogeneity, the accuracy of the averaged estimates from the literature in predicting the value of the World's forests, on average, requires that the forests examined by the current valuation literature are representative of the world's forests. Both assumptions above—spatially uniform values and valuation literature representative of global forests—are unrealistic. This calls for the development of a revised methodological approach to synthetizing information from the current literature with the aim of developing estimates applicable throughout the world's forests.

The general methodological approach of this study involves identifying and summarizing findings from the ecosystem service valuation literature, in combination with statistical analyses, to develop a wide-ranging revision of the current nonwood forest wealth assessment. The study first develops a comprehensive database of nonwood ecosystem service valuation estimates from the literature, including 282 value estimates derived from 139 studies addressing a wide range of forest ecosystem services. Thereafter, statistical meta-analyses (meta-regressions) are estimated to develop predictive models of the value of nonwood ecosystem services. The estimations include separate models for the four main types of services represented in the literature: recreation, hunting, and fishing; NWFPs; water services; and habitat and species protection. The meta-regressions combine data from 186 value estimates derived from 123 studies. The study identifies predictive models that are statistically most accurate in forecasting values outside the forest represented in the estimation dataset. In other words, the analysis focuses on finding models best suited to support value predictions throughout the world's forest, rather than in those targeted by the valuation literature. Using the predictive models, in combination with local data on the characteristics of global forests, the study finally constructs localized estimates of the value of nonwood forest ecosystem services globally.

The proposed revision provides several improvements to the current methodology. For example, whereas the current approach uses estimates from a handful of studies, averaged by ecosystem service, the revised approach systematically and comprehensively searched, summarized, and statistically analyzed global literature on the valuation of forest ecosystem services. To the authors' knowledge, they have collected and analyzed data from a far greater number of studies than any previous forest valuation meta-analysis. A key feature of their assessment is that it is spatially explicit and high in resolution. The assessment scrutinizes and models the local drivers of the value of ecosystem services and predicts them locally using a global 10 km by 10 km grid. The predictive models are intended to estimate the value of nonwood ecosystem services for forests in general, not only for forest represented in the current valuation literature. Using data and estimates for each forested grid cell around the world (almost 800,000 in total), the study develops country-level information on the value of nonwood ecosystem service from forests, as required by the World Bank comprehensive wealth assessments.

The proposed revision develops updated value estimates for recreation and water services and considers NWFPs and habitat and species protection as additional services to be valued using information from the ecosystem service valuation literature. Whereas the current approach uses globally uniform or near uniform values, the revised approach is spatially explicit. Finally, it develops a revised approach to determining the accessibility of forests by using spatial measurements of distance of forests to the nearest road or river. This approach to determining accessibility is intended to improve the current approach of simply assuming that 10 percent of forests in each country are accessible for recreation.

The revision reports several alternative estimates to facilitate World Bank's determination of the revised methodology. To highlight different alternatives, the report lists the valuation estimates and several comparisons by each of the four ecosystem services addressed and in total using different combinations of services. Based on the review of the draft report, the authors have added focus in the final report on the combined value of recreation, NWFPs, and water services, as these services are most amenable for the inclusion in the assessments of forest wealth (see the Discussion section). Regardless, they also present estimates for the values associated with habitat and species protection as they may be relevant for other purposes, such as project evaluation or country assessments.

The revised estimates of the total nonwood forest wealth are greater, on average, than those derived using the current approach. On the other hand, the assessment predicts substantial heterogeneity in the values so specific countries may also see the value estimates drop relative to the current approach. When considering the most direct comparison between the current and suggested revised approach (examining only recreation and water services and assuming 10 percent recreation access), the current estimates are about 39 percent of the revised estimates, on average, globally ($26 per hectare per year versus $67 per hectare per year, in 2013 U.S. dollars). Adding NWFPs and considering the revised measure of accessible forest area increases the revised estimate to $84 per hectare per year. Under a comparable approach, the current methodology estimates benefits at $31 per hectare per year (37 percent of the revised estimate). Therefore, when considering the combined value of recreation, NWFPs, and water services for the wealth assessment, similar to the current assessment, the estimated value of nonwood forest ecosystem services is about 2.7 times greater, on average, using the revised estimates.

Adding values for habitat and species protection would further increase the revised estimate to $95 per hectare per year, on average, globally. This is roughly 3.1 times the value of nonwood forest wealth estimated using the current methodology. However, the inclusion of values for habitat and species protection in the wealth accounting framework has conceptual limitations, as discussed in the end of this report. Therefore, for practical purposes of the forest wealth assessment, information on values that address recreation, NWTPS, and water services—but exclude habitat and species protection—are most relevant.

The above estimates are based on global averages, but the value of forest ecosystem services varies greatly by world region and country and within each country. For example, when considering the combined value of recreation, NWTPs, and water services, Sub-Saharan Africa ($13 per hectare per year) and Middle-East and North Africa ($42 per hectare per year) are the regions of lowest values. East Asia and Pacific ($148 per hectare per year) is the region of highest values, along with North America ($128 per hectare per year) and Latin America and Caribbean ($103 per hectare per year).

The rest of the report explains the development of the database of nonwood forest valuation literature and the value database. Then it explains statistical meta-regressions to develop predictive models of four different types of services: recreation, hunting, and fishing; water services; NWFPs; and habitat and species protection. After that, the authors develop a methodology to predicting the value of nonwood forest ecosystem services globally, as predicted by the meta-regression results. Finally, they outline a methodology to future updating of the estimates over time. A discussion concludes the report.

2 DEVELOPMENT OF DATABASE OF NONWOOD FOREST ECOSYSTEM SERVICE VALUATION STUDIES

IDENTIFYING POTENTIALLY RELEVANT STUDIES

The first task in the revision is to summarize currently available literature on nonwood ecosystem service valuation. To identify relevant literature, the authors conducted systematic literature searches to find studies potentially relevant to our assessment. In the first stage of the search, this involved looking for studies that met the following three criteria:

- Focus on nonwood ecosystem service valuation of forests
- Provide primary estimates of nonwood forest values (as opposed to direct benefit transfer values based on generalizations of primary studies)
- Potentially enable estimation of values expressed in per-unit-area estimates (for example, money per hectare).

The above criteria are purposefully general so that the first stage of the literature search unlikely excludes any potentially relevant studies. As a consequence, the search selected many studies which in the end are not applicable for the database. They are identified and excluded using detailed reviews of each study initially identified, as explained below.

The literature search used multiple sources to help find potentially relevant literature. The process began by searching through two general ecosystem valuation literature databases: (i) The Economics of Ecosystems and Biodiversity (TEEB)[1] and (ii) the Environmental Valuation Reference Inventory (EVRI).[2] Both databases are publicly available and comprise searchable collections of academic and nonacademic literature on environmental and ecosystem valuation studies. They include information on all ecosystems, not just forests.

The search continued through previous literature reviews and meta-analyses of ecosystem service valuation literature to help find any forest-related studies not yet included in the database of this study.[3] Thereafter,

1 TEEB database, constructed by The Economics of Ecosystems and Biodiversity initiative, is a searchable collection of valuation study summaries with value estimates for a number of ecosystem services. The user of the database can screen value estimates by service, biome, and world region, as well as several other study and site characteristics. The database consists of 267 publications from 290 study locations, providing 1,310 estimates (Van der Ploeg et al. 2010). The value estimates in the TEEB database are sometimes transformed to per hectare values.

2 The Environmental Valuation Reference Inventory (EVRI) is a searchable database hosted and initially compiled by the Environment Canada. EVRI is now supported and joined by government agencies in several other countries, including environmental and conservation agencies in the United States, United Kingdom, and Australia. EVRI is one of the earliest and largest databases on ecosystem service valuation. EVRI does not modify the value estimates from the original estimates; instead, it simply documents the findings from the current literature. Therefore, the value units available from EVRI range massively, including value estimates per target area (for example, country, specific forest, or park), per hectare, per household, per individual, per year, total net present value, and so forth.

3 These studies include Barrio and Loureiro (2010), Brander et al. (2006), Chiabai et al. (2009, 2010, 2011), Kuik et al. (2009), Lindhjem (2007), Shrestha and Loomis (2001), Zandersen and Tol (2009), and Zandersen et al. (2007).

searching through literature databases, such as Google Scholar, EconLit and Environment Complete, as well as RFF Library Resources and Journal databases, added potentially relevant studies not yet included in the database.

Finally, a "snowballing" technique was used while conducting detailed reviews of studies already identified. It involved checking through the references of each study and added possibly relevant studies into the database if not already included. This method was highly effective in supplementing other searches (as explained below).

The search focused mostly on literature published in English. However, it also identified, reviewed, and included some studies in other languages that were within the language skill limits of the study team, including Danish, French, German, Norwegian, Portuguese, Spanish, and Swedish. Most peer-reviewed literature is published in English, but including other languages helped improve the geographic coverage of the sample.

Academic peer-reviewed literature, the key focus in the literature searches, offers relatively narrow representation of geographic regions and ecosystem services. Therefore, the authors also looked for and included any available grey literature (reports, books, theses, and other nonjournal publications), so long as those studies were deemed relevant and methodologically sound.

Using the literature searches explained above, the authors identified 286 studies for more detailed reviews. However, 32 studies were not available, despite efforts to locate them online, using interlibrary loan or direct purchase, and, in some cases, direct contact with the study authors. These studies are often grey literature or published long time ago. They are listed in the Appendix along with all other studies included in the assessment. By and large, the authors were able to obtain any essential and relatively recent publications, especially those published in peer-reviewed academic journals. The final review of the literature includes information from 254 studies. See the Appendix for the list of included studies.

STUDY REVIEW PROTOCOL

After identifying and obtaining potentially relevant studies, they were systematically reviewed to develop a value database. When reviewing and summarizing each study, the authors conducted multiple rounds of reviews. The first round extracted a range of relevant information to characterize the study and value estimates in it, including the following:

- Source used to identify the study
- Study area ecological characteristics (biome, forest type, inland and coastal, and other landscapes)
- Study location (country, country income group, protection status, study site area, scale of research, region continent, and coordinates)
- Ecosystem service(s) addresses, as well as classification as domestic and foreign value of service and as direct, indirect and nonuse
- Ecosystem service value information (year of value, valuation method, valuation type reported value, units, and value currency)
- Other study variables (type of publication, publication year, and sample size, if applicable)

This study's end goal is to develop estimates of the value of forest ecosystem services on a per hectare basis. Therefore, a key task in the first review was to determine whether the study reports estimates of values on a per unit area basis (per hectare, per acre, per km^2, and so forth) or includes other information from which enables deriving such estimates. If any potentially relevant value estimates were found from the study, they were recorded them in the database.

This study uses a value estimate as the unit of observation. However, not every possible value estimate is recorded from each study, because journal articles often report many estimates addressing the same forest but derived under slightly different assumptions. In those situations, the authors determined a preferred or representative estimate, or averaged the listed estimates, if no preferred estimate could be identified. If the methodologies underpinning the different estimates were completely different (for example, travel cost methods and contingent valuation), multiple estimates were recorded instead choosing a preferred estimate or taking an average.

Studies that report value estimates for different services or target areas also include multiple records in the database. For such studies, the study area characteristics may also vary by value estimate. To address such situations, the authors determined the location (latitude and longitude) of each value estimate.

Many studies lack information necessary to develop value estimates on a per unit area basis. In such situations, the authors turned to external sources to search for supplemental data. Typically, these efforts included retrieving data on variables, such as study area size (when not mentioned in the study), study area location (coordinates), number of households or population addressed by value estimate (in order to calculate aggregate values), and ecological characteristics of study area (type of forest and biome).

The authors used mostly online searches to find external data. However, they also used other approaches when online sources failed to provide the information needed. For example, in one case they contacted state park officials in Washington State (United States) to find out which state park areas permit the collection of NWFPs, such as berries and mushroom. Using a hard copy map mailed to them, the authors estimated the forest area applicable to a value estimate found in a study. In another case, they contacted the authors of a study to estimate the value of NWFPs to households in a small region in East Africa. The study describes the extent and type of forests in the study region and estimates benefits from those forests on a per household basis. However, the study does not list the total number of households receiving the benefit, so deriving a total benefit estimate for the forest is not feasible on the basis of the publication. With help from the study's authors, this publication's authors were able to determine the number of households able to access forests in the study area.

The study reviews include several steps of quality assurance/quality control (QA/QC) to help develop robust and consistent summaries of values included in the database. For example, two reviewers examined separately each study to reveal potential problems in developing data from the study. In addition, the whole study group reviewed and discussed in detail each study and the datasets compiled. Appendix II explains the QA/QC protocol.

DETERMINING APPLICABILITY OF VALUE ESTIMATES FOR THIS ASSESSMENT

In the end, many of the studies originally identified in the literature search are not applicable for this assessment. The primary reason(s) for exclusion for each excluded study are summarized in Table 1. Note that some studies are excluded under several criteria so the classifications in Table 1 are not mutually exclusive.

In total, 115 studies (45 percent) were excluded, out of the 254 studies originally identified. The leading reason for exclusion involves studies that are duplicates of value estimates or studies already included in the database.

TABLE 1. RECORDED REASONS FOR EXCLUDING STUDIES AFTER THE INITIAL REVIEW, BY EXCLUSION CRITERIA

EXCLUSION CRITERIA	FREQUENCY	PERCENTAGE OF ALL RECORDED REASONS
Duplicate study/values	35	23%
Nonapplicable ecological endpoint (excluded services, such as timber or carbon sequestration)	32	21%
Methodological limitations	24	16%
Insufficient information to convert to per unit area values	23	15%
Addressing mostly nonforest areas	20	13%
Lack of value estimates	19	12%
Total	153	100%

Note: The total number of recorded reasons for exclusion does not equal to the number of studies excluded, because one study can have multiple reasons for exclusions. The number of excluded studies is 115.

This criterion also applies to 35 studies, representing 23 percent of all recorded reasons for exclusions. Recorded duplicate studies do not concern only literal replicate studies (for example, the same journal article, or a discussion paper version of a later journal article), but also include studies that use the same data to estimate essentially the same environmental values, with slight methodological differences between different the publications. This is not unusual, especially since studies that focus on distinct methodological contributions are often accompanied by other publications that focus on the general findings or provide estimates to support policy assessments. When identifying such studies, the authors included the version which in their view is most applicable for the purposes of this study and excluded other publications representing the same study or data. Another relatively common occurrence involves graduate dissertations, which may be identified in the initial database both as a thesis and a later academic journal publication. In those cases, the authors generally included estimates from the peer-reviewed journal publications and excluded the thesis.

The second most prevalent reason for exclusion includes valuation studies for a nonapplicable ecological endpoint. This criterion applied to 32 excluded studies (21 percent of all recorded reasons for exclusion). The studies in this group address values outside the scope of this assessment (nonwood benefits), such as timber, wood fuel, or carbon sequestration. Nonapplicable ecological endpoints also include studies that estimate aggregate wood and nonwood benefits without sufficient information to help separate out the nonwood portion of the benefits. Similarly, if the study explicitly addressed carbon and noncarbon value without separating them from one another, the estimate was excluded.

The authors reviewed the methodological approach taken by each study to ensure that values included in the database are derived using conceptually defensible approaches. When they identified methodological approaches inconsistent with the principles of ecosystem service valuation, they excluded the study. This criterion applied to 24 studies (16 percent of all recorded reasons for exclusion). When examining the methodological approach applied in each study, the primary concern was the suitability of the basic conceptual framework for the valuation of forest ecosystem services, not a subjective evaluation of the quality of the assessment. For example, certain methodological approaches, such as the travel cost or stated preference methods, are applicable to the valuation of specific services (such as recreation or habitat and species protection). Therefore, all studies are included that applied such methods using appropriate data and samples to develop findings usable for this study.

As an example of methodological considerations, when the study used survey based approaches, the authors reviewed the survey methodology to evaluate its sample representativeness (for example, households in a region, or recreational users of a forest area) and general suitability to generate a representative estimate of the value estimated. When sample representativeness was clearly not achieved because of convenience sampling, for example (such as surveying park visitors or members of environmental organizations and then directly generalizing the results to the general population), the study was excluded. Another illustrative and a relatively frequent case of methodological limitations includes studies to estimate local economic impacts of forests, such as employment associated with recreation activities or magnitude of expenditures by visitors to a park. These estimates can be informative, but generally do not represent conceptually accurate measures of the economic value of ecosystem services. Therefore, the authors excluded them from the database.

Another class of omitted values involves studies for which developing value estimates on a per hectare basis is impossible, even after sometimes extensive efforts to draw from external data to complement data provided in the study. This reason is valid for 23 excluded studies (15 percent of all recorded reasons for exclusion).

The initial literature database has studies that address mostly a nonforest ecosystem, such as savannah or agricultural landscape mosaics. They were also left out from the assessment as not representative of forests in general. This reasons for exclusion was recorded for 20 excluded studies (13 percent of all recorded reasons for exclusion).

Finally, some studies initially identified neither provided value estimates nor contained information to help the authors develop them. Examples of such studies include mostly theoretical journal articles that do not develop empirical estimates. Those studies are omitted from the database. This criterion applied to 19 excluded studies (12 percent of all recorded exclusions).

Table 2 summarizes the number of studies and value estimates in the database by the source originally used to find the study. In total, the value database includes 282 value estimates developed from 139 studies. Among different sources, previous literature reviews and meta-analyses are most frequent. They account for 44 studies (32 percent of all studies) and 99 value estimates (35 percent of all value estimates). TEEB is the second most frequent source; it identified 38 studies (27 percent of all) and 82 value estimates (29 percent of all). Snowballing—searching the reference lists of studies already reviewed—is the third most frequent method to find relevant studies. Although the authors used snowballing as the final method to supplement an already sizable literature database, snowballing produced 32 new studies (23 percent of all) and 60 new value estimates (21 percent) into the database. EVRI and Science Direct helped identify 14 (10 percent) and 11 (8 percent) studies and 20 (7 percent) and 21 (7 percent) value estimates, respectively.

TABLE 2. NUMBER OF STUDIES AND VALUE ESTIMATES, BY THE ORIGINAL SOURCE USED TO IDENTIFY THE STUDY

SOURCE	NUMBER OF STUDIES	PERCENTAGE OF STUDIES	NUMBER OF VALUES	PERCENTAGE OF VALUES
Previous reviews and meta-analyses	44	32%	99	35%
TEEB	38	27%	82	29%
Snowballing	32	23%	60	21%
EVRI	14	10%	20	7%
Science direct	11	8%	21	7%
Total	**139**	**100%**	**282**	**100%**

VARIABLES TO DESCRIBE VALUE ESTIMATES

The goal of the meta-regressions is to examine location-specific ecological (for example, ecosystem type) and socioeconomic factors (for example, income per capita or population density) as determinants of the value of ecosystem services. Table 3 lists and explains the key variables constructed to characterize each value estimate. These key variables include information on the value estimate and study site, including its biophysical, ecological, and socioeconomic features.

Value estimate

For each value estimate, the authors recorded its magnitude, currency, currency year, method of valuation, type of publication (journal or grey literature), and ecosystem service addressed. Using the currency and currency year, comparable estimates were constructed from multiple study years and countries across the world. Purchasing power parity (PPP) adjusted U. S. dollars for the year 2013, often referred to as "international dollar," serves as the common denomination of value estimates in the estimation dataset.[4] Appendix III explains the currency conversion.[5]

The original value estimates are often not expressed on per hectare basis, annually, so the authors converted them into per hectare per year values. For example, if the original value estimate addressed recreational benefits in a specific area of forest, expressed on value per visit basis, they used information on the number of annual visitors to estimate total annual benefits from the forest. Then, they used the total forest area to estimate recreation benefits per year per hectare.

Some studies list value estimates in net present value (NPV). If the study listed the discount rate and the time horizon used in the NPV calculation, the authors converted it to annual value using the following relationship:

$$\text{Annual value } \frac{NPV}{A_{t,r}}, \text{ where } A_{t,r} = \frac{1-\left(\frac{1}{1+r}\right)^{t}}{r}$$

When the original value was listed in NPV but no information was given on the applicable discount rate and time horizon, the authors used the World Bank wealth assessment assumptions (that is, 4 percent discount rate, 30-year time horizon) to convert the value into annual terms. There were very few cases for which this was necessary.

When recording the type of ecosystem service, the authors initially used a fine-grained classification, including the following: cultural and existence value; erosion control; fishing; flood protection; habitat and species protection; hunting; landscape aesthetics; NWFPs; recreation; and various types of water related services, such as water quality or water quantity. They later aggregated these classifications into fewer but still meaningful aggregate categories, as explained below.

Study site and its biophysical, ecological, and socioeconomic features

The authors recorded information on the study site, including its precise location using latitude and longitude and the country of location. They determined the latitude and longitude by either using information directly from the

4 The authors use GDP and PPP information from the World Bank (World Development Indicators http://databank.worldbank.org).

5 Note that in Chapter 4, the authors use nominal (not PPP adjusted) U. S. dollars to report the final estimates of the value of nonwood forest ecosystem services by country. They do so because the World Bank forest wealth assessment uses nominal U.S. dollars.

TABLE 3. KEY VARIABLES TO CHARACTERIZE VALUE ESTIMATES

VARIABLE	EXPLANATION	SOURCE
Value characteristics		
Value estimate	Value per hectare per year	Directly from study, or calculated using study information and external sources
Currency	Currency of the value estimate	Study information
Year of valuation	Currency year of the value estimate	Study information
Valuation method	Research method to obtain the value estimate	Study information
Publication type	Publication type: journal, thesis, grey literature	Study reference
Service type	Primary ecosystem service addressed	Study information
Study site		
Location	Location coordinates	Study information, manual determination, ArcGIS
Country	Country of study area	Study information
Ecological/biophysical conditions		
Biome/ecosystem	Biome/ecosystem addressed by the value estimate	Study information. When unclear, location coordinates combined with biome data from Hansen et. al, 2010 (using ArcGIS)
Temperature	Annual average temperature in study area (75 km radius)	Location coordinates combined with climate data from WorldClim Global Climate Data (using ArcGIS)
Rainfall	Annual average precipitation in study area (75 km radius)	Location coordinates combined with climate data from WorldClim Global Climate Data (using ArcGIS)
Forest density	% forest cover in study area (75 km radius)	Location coordinates combined with land cover land use data from Globcover 2009 (UCLouvain and European Space Agency, 2011) (using ArcGIS)
Wetland density	% wetlands in study area (75 km radius)	Location coordinates combined with wetland data from the Global Lakes and Wetlands Database (Lehner and Döll, 2004) (using ArcGIS)
Species richness	Total number of species in study area (mammals, birds, amphibians, and reptiles)	Location coordinates combined with data on species ranges by taxonomic group from IUCN 2012, and BirdLife International and NatureServe, 2013 (using ArcGIS)
Distance from the equator	Latitude of the study site	Location coordinates
Socioeconomic conditions		
GDP per capita	GDP per capita in the country of study (PPP adjusted)	Study country information combined with GDP data (World Bank)
Population density	Population density in study area (within a 75 km radius)	Location coordinates combined with spatial data on population density from Gridded Population of the World (V3) (CIESIN et. al 2005) (using ArcGIS)
Distance to city	Distance from the study location to the nearest urban center	Location coordinates combined with data on urban centers from the Global Rural-Urban Mapping Project (V1) (CIESIN et. al 2011)(using ArcGIS)
Rivers	Distance to rivers	Location coordinates combined with river data from NaturalEarthData (using ArcGIS)
Road density	Length of road network in study area (75 km radius) and distance to roads	Location coordinates combined with road data from the Global Roads Open Access Data Set (V1) (CIESIN et. al 2013) (using ArcGIS)

study or, in its absence, manually obtaining the coordinates of the approximate center of the study area. These data are essential for the construction of many other variables the authors use to describe the value estimate. Note that the study location is a point, not a polygon mapping the entire study area. For most studies, consistently determining the study area as a polygon was not feasible using information available from the publication and other possible sources, including mapping software and online sources.

To characterize the biophysical and ecological features of the study area, the authors used ArcGIS and spatial data to construct data on the biome, climate, land use (forests, wetlands), and biodiversity (species richness) of the study area. The biome addressed by the value estimate was also generally easily determined from the study. When this was not the case, the authors used ArcGIS and the study site coordinates in combination with global spatial data on biomes maps to derive the biome. They also used ArcGIS and spatial data to construct data on the annual average temperature and rainfall in the study area.

For land use, the authors measured the percentage forest and wetland cover in the study area. These data help examine whether the magnitude of ecosystem service values is related to the scarcity of ecosystems in the study area.

Because biodiversity may also drive some ecosystem service values, the authors processed data from the International Union for the Conservation of Nature (IUCN) and Birdlife International to measure species richness (total number of species) at study locations (Table 3). The IUCN data comprise overlapping polygons denoting species ranges for mammals, amphibians, and reptiles. The authors obtained similar data for birds from Birdlife International. They used ArcGIS to count the number of extant species in each study location. They also measured the distance of each study location from the equator so that any latitudinal gradient (typical for biodiversity) in the value of ecosystem services can be examined.

Socioeconomic characteristics of the study area are conceptually plausible determinants of ecosystem service values. For example, available income typically affects demand for market goods and services, so a similar relationship may emerge for ecosystem services. Moreover, income may determine preferences for environment. Because of the influence of socioeconomic characteristics, the authors used country-level data on PPP adjusted GDP per capita to measure income at the study location.

The authors also developed data on population density (using a 75 km radius) distance to the nearest urban center, distance to the nearest river, and the density of road network within the study areas (using a 75 km radius). Population density is especially a potentially important determinant of the value of ecosystem services. Although population density may be associated with environmental degradation that could depress local values for ecosystem services, areas of greater population density feature many beneficiaries. High number of beneficiaries, in turn, increases the total value of ecosystem services on a per unit area basis, especially for ecosystem services that are not purely exclusive (rival) in consumption, such as recreation or hydrological services. In the end, the relationship between population density and ecosystem service values is an empirical matter.

The authors considered alternative approaches to measuring local population density, including population density within 25, 50, 75, 100, 200, and 400 kilometers from the study location. Assuming relatively short distances (for example, 25 km and 50 km), would barely, if at all, include populations outside the forest area studied. This is problematic because many of the beneficiaries are situated outside the study area, especially in the context of NWFPs or recreation services. On the other hand, assuming relatively long distances (for example, 200 km or 400 km) includes areas so far away that their populations are at best distantly relevant as potential service recipients. The authors examined multiple approaches and deemed using a 75 km radius well suited for empirical modeling in the context of these data. Moreover, the estimation results in Section 3 regarding the effects of population density on the value of forest ecosystem services are remarkably robust, only minimally varying with the assumed distance from the study site used when calculating local population density.

META-REGRESSION DATASET

This next section discusses the development of the meta-regression estimation dataset on the basis of the value database described above. When conducting initial exploratory analyses of the data, a number of issues emerged regarding the general comparability and applicability of value estimates. For example, a few value estimates in the database address global areas (such as all global tropical forests). Some other values concern large and discontinuous forest areas. When it was not possible to accurately determine the location of the study area, the authors excluded the corresponding value from the statistical analysis because no local spatial data could be developed for such estimates.

Initial summaries of the value database, in combination with insights gathered throughout the detailed study reviews, suggested that several types of ecosystem service valuation studies, such as those addressing recreation, hunting, fishing, NWFPs, or habitat and species protection, are exceedingly comparable in objectives, methods, settings, and value estimates. Moreover, some other ecosystem service valuation studies—especially those addressing such seldom studied endpoints as nutrient recycling or bioprospecting—entail so many idiosyncrasies in objectives, methods, data, and estimates that meaningful comparisons across different studies are difficult. In addition, there are only few value estimates in these categories so statistical analyses are not meaningful. Therefore, the authors set aside from the meta-regression all value estimates addressing nutrient cycling and bioprospecting.

Additionally, some NWFP value estimates comprised partly of fuel wood values. Initially, the authors included those estimates in the database and considered using statistical controls in the meta-regression to help isolate the nonwood portion of the value estimate. However, statistical controls may help only partially disentangle nonwood and wood values. Because wood fuel is out of scope for this assessment, the authors dropped from the meta-analysis all NWFP value estimates with a potential wood component.

After dropping several value estimates as described above, the authors are left with 186 value estimates derived from 123 studies in the meta-regression estimation dataset. Therefore, the authors excluded for various reasons 96 value estimates from the original 282 value estimates developed from the literature reviews.

As the next step, and to help structure the empirical analysis, the authors aggregated ecosystem services into four main categories representative of the literature:

- Recreation, hunting, and fishing (henceforth, recreation)
- Habitat/species protection
- Nonwood forest products
- Water services.

Recreation includes value estimates addressing recreation, hunting, and fishing (Table 4). The estimation dataset includes 86 recreation-related value estimates (Table 5). Habitat and species protection includes values classified as habitat and species protection, cultural and existence values, or landscape aesthetics. There are 55 value estimates in this category in the estimation dataset. Values addressing NWFPs include 30 estimates in the estimation dataset. Values classified as “water services” come from studies that address benefits from forests on

TABLE 4. CLASSIFICATION OF ECOSYSTEM SERVICES

SERVICE CLASSIFICATION	SUBSERVICES INCLUDED
Recreation	Hunting
	Fishing
	Recreation
Habitat/species protection	Landscape aesthetics
	Cultural/existence
	Habitat/species protection
NWFP	NWFP
Water services	Water quality
	Water quantity
	Hydropower
	Erosion control
	Flood protection
Excluded services	Nutrient cycling
	Bioprospecting
	Fuelwood

TABLE 5. NUMBER OF VALUE ESTIMATES IN THE ESTIMATION DATASET, BY ECOSYSTEM SERVICE (IN TOTAL, 186 VALUE ESTIMATES DEVELOPED FROM 123 STUDIES)

ECOSYSTEM SERVICE	NUMBER OF VALUES	PERCENTAGE OF VALUES
Recreation	86	46%
Habitat/species protection	54	29%
NWFPs	30	16%
Water services	16	9%
Total	**186**	**100%**

water quality, water quantity, often in the context of controlling water flow, erosion, or enabling hydropower. There are 16 value estimates for water services in the estimation dataset.

The above four ecosystem service categories organize value estimates so that each category represents relatively similar studies with regards to the study objectives, methodologies, and general settings. For example, studies addressing recreation often estimate values on per trip or per day basis, typically using travel cost methods. Studies valuing habitat and species protection are predominantly based on survey-based stated preference approaches. NWFP valuation studies generally document the volume and market value of products gathered, using methodological approaches that are relatively similar regardless of the location of the study. Water services are frequently valued using replacement and avoided cost methods to examine the value of the service provided by forests.

Note that each category of ecosystem services above includes studies from developed and developing countries, thus, combine data from different settings in terms of the characteristics of activities associated with benefiting from the service. For example, while recreation in developing countries is typically associated with leisure enjoyment, individuals in developing countries may engage in similar activities to support subsistence. The authors addressed this situation in two primary ways. First, they classified activities to collect food and/or income in developing countries as a NWFP service. Second, they used statistical controls in the empirical modeling (below) to account for inherent differences systematically associated with conditions such as income level of the country on the whole.

Differences between the valuation studies in the above four categories are so substantial that their further aggregation is not justified. Moreover, the number of studies in each above four categories enables separate statistical assessments, in particular for recreation and habitat and species protection, which have 86 and 55 value estimates, respectively. The number of value estimates for NWFPs (30) and water services (16) is more limited but regardless, enables further analyses as a separate benefit category.

SUMMARY OF THE META-REGRESSION ESTIMATION DATASET

Distribution by ecosystem service and geographic location

The meta-regression estimation dataset includes values from 42 countries (Table 6). Countries with most value estimates include United States with 26 value estimates (14.0 percent of all value estimates); United Kingdom

TABLE 6. NUMBER OF VALUE ESTIMATES IN THE ESTIMATION DATASET, BY COUNTRY

COUNTRY	NUMBER OF VALUE ESTIMATES	PERCENT OF GLOBAL TOTAL	COUNTRY	NUMBER OF VALUE ESTIMATES	PERCENT OF GLOBAL TOTAL
United States	26	14.0%	Portugal	3	1.6%
United Kingdom	15	8.1%	Thailand	3	1.6%
Finland	12	6.5%	China	2	1.1%
Australia	10	5.4%	Kenya	2	1.1%
Canada	10	5.4%	Mexico	2	1.1%
Malaysia	10	5.4%	Netherlands	2	1.1%
Sweden	10	5.4%	Samoa	2	1.1%
Costa Rica	7	3.8%	Uganda	2	1.1%
Italy	7	3.8%	Belgium	1	0.5%
Brazil	6	3.2%	Chile	1	0.5%
India	6	3.2%	Denmark	1	0.5%
Spain	5	2.7%	Ecuador	1	0.5%
Cameroon	4	2.2%	Guatemala	1	0.5%
Lao PDR	4	2.2%	Iran	1	0.5%
Madagascar	4	2.2%	Malawi	1	0.5%
Peru	4	2.2%	Nepal	1	0.5%
Croatia	3	1.6%	Paraguay	1	0.5%
France	3	1.6%	Poland	1	0.5%
Indonesia	3	1.6%	South Africa	1	0.5%
Ireland	3	1.6%	Sri Lanka	1	0.5%
Norway	3	1.6%	Vanuatu	1	0.5%

with 15 value estimates (8.1 percent of all value estimates); and Finland with 12 value estimates (6.5 percent of all value estimates). Malaysia is the developing country with most value estimates in the data; the country has 10 value estimates (5.4 percent of all value estimates).

Figure 1 maps the geographic locations of value estimates. The map shows concentrations of value estimates originating from North America, Northern Europe, South Asia, and United Kingdom. Regardless, the map indicates relatively wide global distribution in the dataset. For example, all continents with forests are represented. Moreover, all different forest biomes—humid tropics, dry tropics, temperate, and boreal—are represented in the estimation dataset. The map also illustrates a key limitation of the forest ecosystem service valuation literature. There is no coverage of Russian forests in the literature although they cover one fifth of all global forests—an area almost as large as forests in all of South America.

The maps in Figure 2 show the geographic distribution of value estimates by ecosystem service. Recreation value estimates come especially from Europe, North America, and Southeast Asia, but also represent Africa, Central and South America, and Oceania (Figure 2.a). Habitat and species protection value estimates are frequently from Europe and North America but also include data from each other continent—Africa, Asia, and Oceania—as well as South America as a subcontinent in America (Figure 2.b).

Figures 2.c and 2.d map value estimates for NWFPs and water services, respectively. The number of estimates in each category is relatively small, but the geographic distribution of the estimates is quite broad. These maps in part demonstrate the authors' concerted effort to find studies from Africa, Asia, and South America. With North America

FIGURE 1. MAP OF VALUE SITES, ALL ECOSYSTEM SERVICES

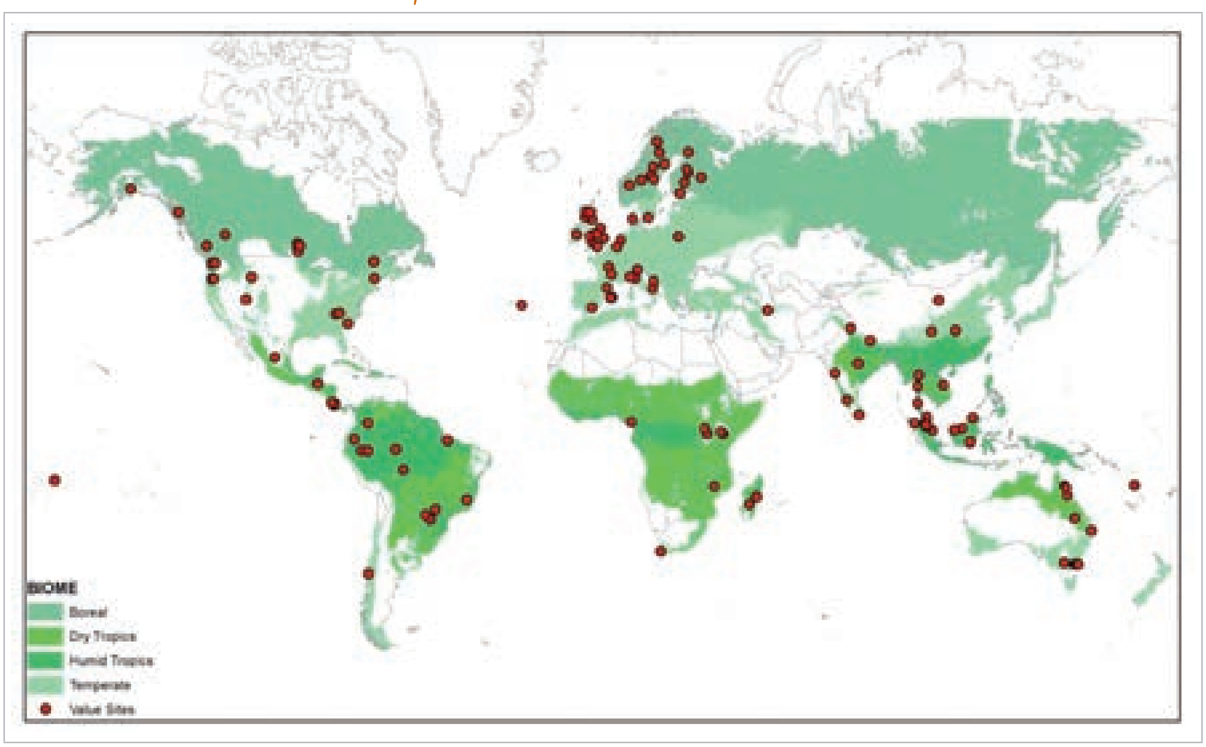
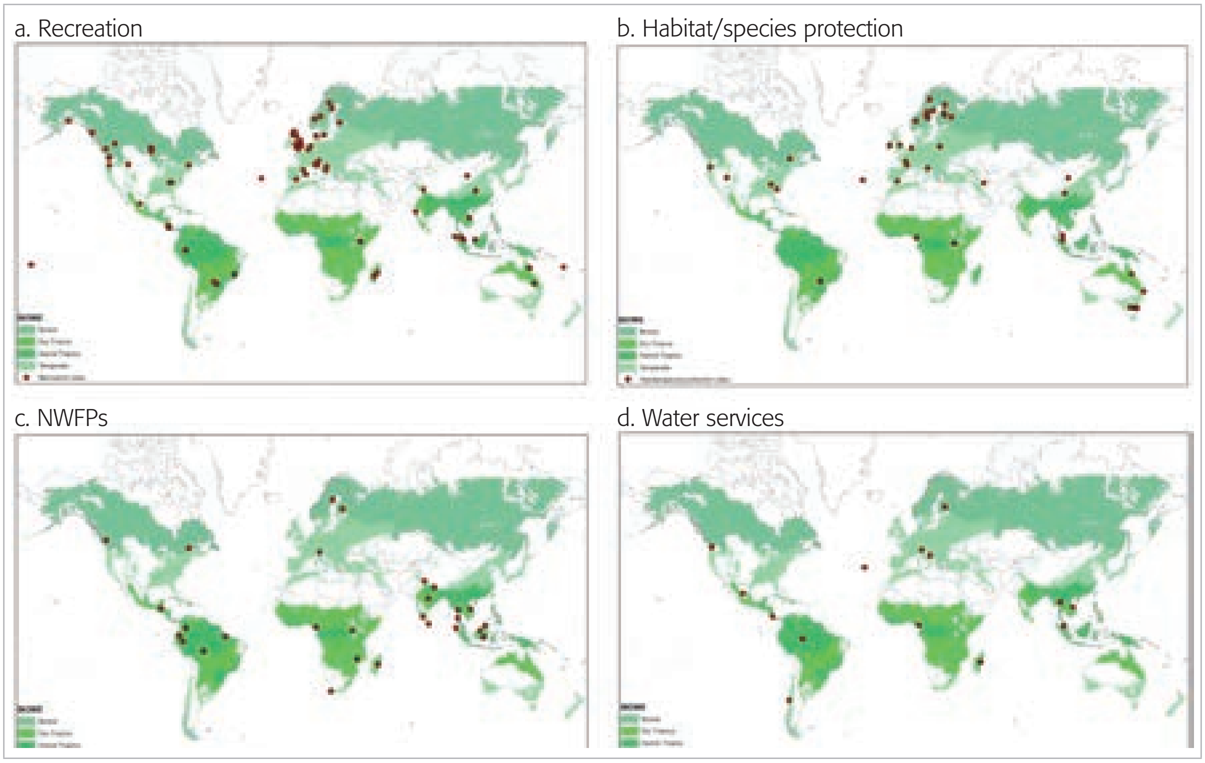


FIGURE 2. MAP OF VALUE SITES, BY ECOSYSTEM SERVICE



and Europe most frequently represented in the valuation literature, the authors stressed efforts in the literature searches to include results from elsewhere around the world.

Table 7 lists the number of value estimates by continent and within each continent. The greatest number of value estimates comes from Europe, which has a total of 69 estimates (37 percent of all value estimates in the dataset). Within Europe, 64 percent (44 estimates) of the estimates come from Northern Europe; 20 percent (14 estimates) come from Southern Europe; 16 percent (11 estimates) come from Western Europe; and one estimate comes from Eastern Europe.

America has the second highest number of estimates in the dataset, including 59 estimates or 32 percent of global total. Within America, 68 percent (40 estimates) of all estimates come from North America; 19 percent (11) come from Central America; and 22 percent (13) come from South America.

Asia is the continent with the third highest number of value estimates. It has a total of 31 estimates (17 percent of global total). Within Asia, 65 percent (20) of the estimates come from Southeast Asia and 26 percent (8) come from South Central Asia. Eastern Asian and Southern Asia both have two value estimates, accounting for 6 percent of all value estimates from Asia.

The continents with the least number of value estimates are Africa (14 estimates) and Oceania (13 estimates). Within Africa, most value estimates (64 percent) address Eastern Africa. Middle Africa has 4 estimates (29 percent of total in Africa); Southern Africa has one value estimate; and Western Africa has none. Within Oceania, most

TABLE 7. NUMBER OF VALUE ESTIMATES IN THE ESTIMATION DATASET, BY CONTINENT AND SUBREGION

CONTINENT/UN SUBREGION	NUMBER OF VALUE ESTIMATES	PERCENT OF SUBREGION	PERCENT OF GLOBAL TOTAL
AFRICA	14		8%
Eastern Africa	9	64%	5%
Middle Africa	4	29%	2%
Southern Africa	1	7%	1%
AMERICA	59		32%
Central America	11	19%	6%
North America	40	68%	22%
South America	13	22%	7%
ASIA	31		17%
Eastern Asia	2	6%	1%
South Asia	2	6%	1%
South-Central Asia	8	26%	4%
Southeast Asia	20	65%	11%
EUROPE	69		37%
Eastern Europe	1	1%	1%
Northern Europe	44	64%	24%
Southern Europe	14	20%	8%
Western Europe	11	16%	6%
OCEANIA	13		7%
Australia and New Zealand	10	77%	5%
Polynesia	3	23%	2%
	186		100%

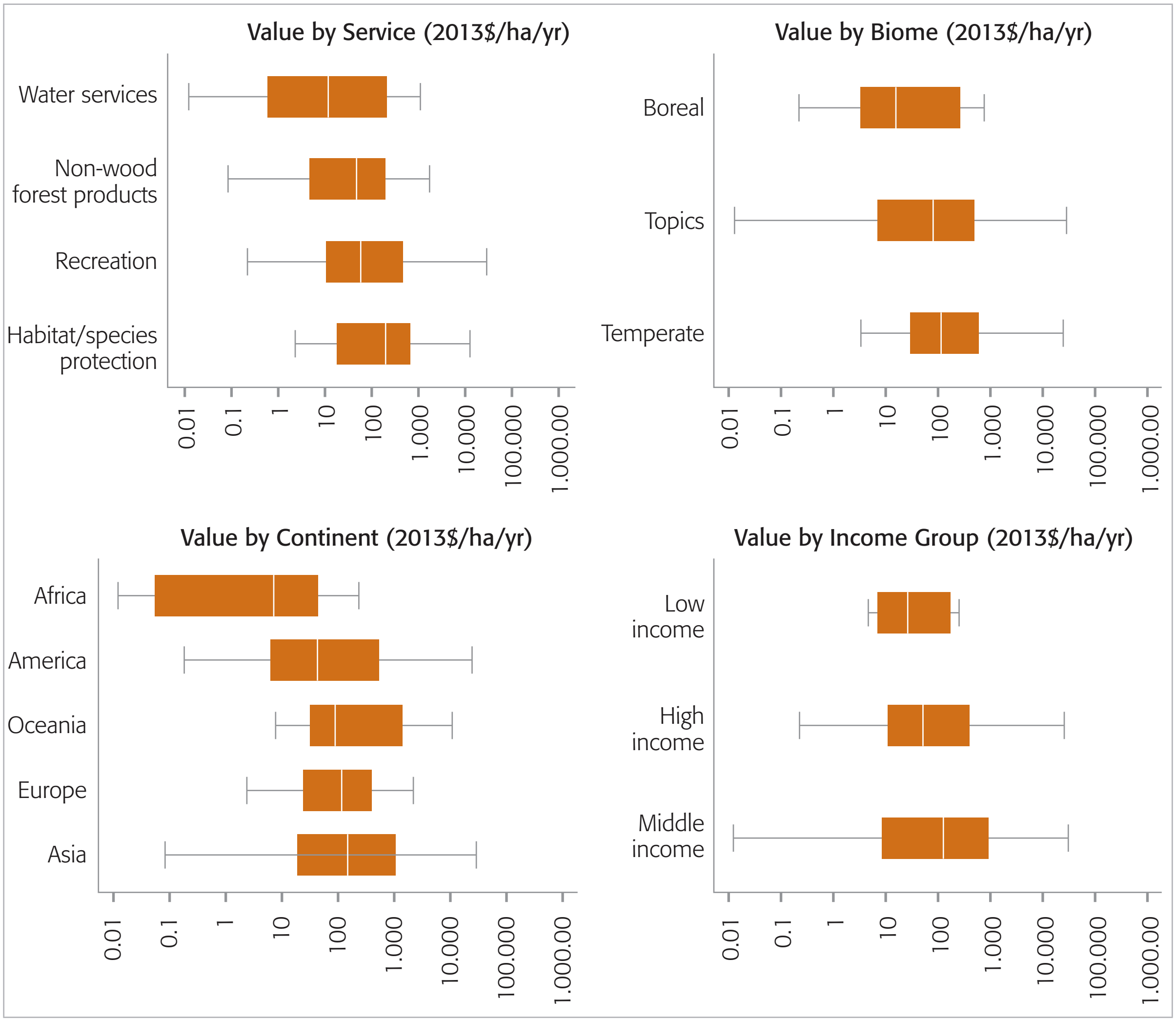
value estimates come from Australia (10 estimates, 77 percent of all estimates in Oceania); the rest are from Polynesia (3 estimates, 23 percent of all estimates from Oceania).

Value estimates

Figure 3 uses box-whisker plots to graphically summarize the value estimates in the estimation dataset by ecosystem service, biome, continent, and country income group. In the figures, the ends of "whiskers" denote the minimum and maximum of estimates; the box in the middle ranges from the 25th to 75th percentile of the estimates, and the line within the box shows the median.

The range of values is considerable both within and between different ecosystem services (Figure 3, top left). Water services have the lowest median (and minimum) value, followed by NWFPs, recreation, and habitat and species protection. Variation by biome (Figure 3, top right) is less distinct, with boreal values lowest in the median, followed by tropics in the middle and temperate forests as the highest. The range of value estimates is especially wide in the tropics.

FIGURE 3. VALUE ESTIMATES BY ECOSYSTEM SERVICE (TOP-LEFT), BIOME (TOP-RIGHT), CONTINENT (BOTTOM LEFT), AND INCOME GROUP (BOTTOM RIGHT)



When summarizing values by continent (Figure 3, bottom left), Africa has relatively low values, but other continents seems relatively similar. When examined by country-income group, Figure 3 (bottom right) shows that low income countries tend to have relatively low values. Moreover, value estimates from low-income countries are relatively more concentrated than those from middle and high income countries.

Valuation methods

Table 8 summarizes the value estimates in the estimation dataset by valuation method and ecosystem service. The distribution of valuation methods by ecosystem services is as expected. For example, studies addressing recreation mostly commonly use the travel cost method (43 percent of value estimates in this category) and contingent valuation (38 percent). Value estimates for habitat/species protection come are derived mostly using contingent valuation (83 percent) or choice experiments (13 percent); NWFPs are assessed primary using market

TABLE 8. PERCENTAGE DISTRIBUTION OF VALUE ESTIMATES BY VALUATION METHOD, BY ECOSYSTEM SERVICE AND IN TOTAL IN THE ESTIMATION DATASET (186 OBSERVATIONS IN TOTAL)

VALUATION METHOD	RECREATION	HABITAT/SPECIES PROTECTION	NWFPS	WATER	TOTAL
Travel cost method	43%	0%	0%	0%	20%
Contingent valuation	38%	83%	3%	0%	42%
Choice experiments	1%	13%	0%	0%	4%
Market pricing	6%	0%	87%	25%	19%
Production function	0%	0%	3%	19%	3%
Value transfer	9%	4%	7%	6%	6%
Avoided cost	2%	0%	0%	50%	5%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

prices (87 percent), and water services come from studies examining avoided costs (50 percent) or market prices (25 percent), or developing production functions (19 percent).

Aggregated across all four services, contingent valuation is the most common method, accounting for 42 percent of all observations. The travel cost method and choice experiments are the second and third most common methods, with a 20 percent and 19 percent share of all observations, respectively.

3 META-REGRESSIONS TO DEVELOP A PREDICTIVE MODEL OF THE VALUE OF FOREST ECOSYSTEM SERVICES

ESTIMATION MODEL

This study uses a statistical meta-regression approach to examine and summarize forest ecosystem service values in the estimation dataset. Meta-regression method is widely used across different disciplines, including natural, health, and social sciences. Applications to environmental economics began in the early 1990s (for example, Smith and Kaoru 1990) and have since then become prevalent (Bergh et al. 1997; Nelson and Kennedy 2009).

The purpose of the meta-regressions is to statistically predict the value of ecosystem service (dependent variable), which is extracted from the literature, as a product of the characteristics of the study and study area (independent variables). The ultimate goal of the meta-regressions is to develop predictive models of the value of forest ecosystem services applicable outside the estimation sample. The authors focus on examining location-specific ecological (for example, ecosystem type) and socioeconomic factors (for example, income per capita and population density) as potential determinants of the value of ecosystem services.

The estimated meta-regression model is the conventional logarithmic transformation of the dependent variable:

$$lny_i = \alpha + \beta X_i + \varepsilon_i,$$

where

- lny_i is the natural logarithm of the value estimate of ecosystem services (dollars per hectare) identified from the literature
- α is a constant
- X_i is a vector of J (indexed by $j=1,2,\ldots, J$) independent variables to characterize the study and study area
- β is a vector of J coefficients estimated on independent variables X
- ε_i is a random error term.

Table 9 lists the variables considered as potential determinants of the value of ecosystem service, which include a range of variables to describe the ecosystem characteristics, such as the biome, temperature, precipitation, forest cover, wetland cover, and species richness of the study area. The authors also examined several socioeconomic variables, such GDP per capita, population density, distance to urban center, road density, and the protection status of the study area. For study variables, the authors have considered such variables as publication type (journal article and grey literature) and the methodological approach employed to estimate the value.

TABLE 9. SUMMARY STATISTICS OF VARIABLES IN THE ESTIMATION DATASET

VARIABLE	MEAN	STD. DEV.	MIN	MAX
Value ($ per hectare per year)	812.0	3097.2	0.01	29,251
Ln(Value)	4.106	2.673	–4.41	10.28
Boreal forest (0/1)	0.220	0.416	0	1
Temperate forest (0/1)	0.409	0.493	0	1
Tropical forest (0/1)	0.371	0.484	0	1
Recreation (0/1)	0.462	0.500	0	1
Habitat/species protection (0/1)	0.290	0.455	0	1
NWFP (0/1)	0.161	0.369	0	1
Water services(0/1)	0.086	0.281	0	1
Africa (0/1)	0.075	0.265	0	1
America (0/1)	0.317	0.467	0	1
Asia (0/1)	0.167	0.374	0	1
Europe (0/1)	0.371	0.484	0	1
Oceania (0/1)	0.070	0.256	0	1
GDP per capita	16406	11948	297	48,377
Ln(GDP per capita)	9.2	1.2	5.7	10.8
Popdensity*	105.7	223.9	0.0	2,444
Ln(Popdensity) *	3.1	2.3	–3.7	7.8
Temperature*	13.1	9.3	–2.4	26.9
Precipitation*	1364	916	0	4,007
Distance to urban center (meters)	38302	45157	0	220,164
Road length*	1820	2607	0	16,600
Forest percentage*	35.1	29.8	0.0	97.5
Wetland percentage*	7.6	14.9	0.0	98.6
Species richness*	178.0	144.3	29.0	548
Latitude	28.5	29.2	–39.7	67.4
High income country (0/1)	0.624	0.486	0	1
Middle income country (0/1)	0.323	0.469	0	1
Protected area (0/1)	0.425	0.496	0	1
Journal publication (0/1)	0.667	0.473	0	1

Notes: (i) Values are expressed in year 2013 international dollars; (ii) 0/1 denotes dummy variables; (iii) Spatially averaged variables are marked by.* They were calculated using ArcGIS within a 75 km radius from the study site (center); (iv) all variables include 186 observations.

The authors developed separate meta-regression models for each of the four service categories considered: recreation, habitat and species protection, NWFPs, and water services. They considered studies within each category similar enough so that they can be meaningfully combined as a group, which is one of the assumptions required for meta-regressions (Nelson and Kennedy 2009). For each service, they developed final model specifications using both conceptual and statistical criteria. For example, conceptual criteria suggest the inclusion of GDP per capita, so the authors generally include it in the model regardless of statistical performance.

For statistical criteria, the authors examined multiple measures to evaluate the models. They measured model performance using information criteria, including Akaike (AIC; Akaike 1974, 1981) and Bayesian Information Criteria (BIC; Schwartz 1978), and out-of-sample predictive power. Out-of-sample predictive power is particularly relevant for this assessment, because the end purpose of the meta-regressions is to facilitate value predictions outside the estimation dataset.

They evaluated out-of-sample prediction using cross-validation (Efron and Tibshirani 1994). It involves first estimating the model by excluding observations from the estimation dataset. The model results are then used to predict the value for the left-out sample. Cycling through the entire estimation dataset, the authors developed an out-of-sample prediction error for each observation (and the entire sample).[6]

The authors used a weighted estimation approach so that studies that contribute more than one value estimate into the estimation dataset are not given greater weight than those contributing only one value estimate. They gave each study an equal estimation weight by determining the weight of each value estimate as 1/n, where ***n*** is the total number of value estimates derived from the study. Therefore, the estimation weight equals 1 for value estimates, which comes from studies that contribute one value estimate to the database. For studies contributing two value estimates, each of them received a weight ½, and so forth. Finally, the authors rescaled the weights so that the weights sum up to the number of observations in the estimation dataset. Because they estimated separate models for four ecosystem services, they determined separate weights for each service.

SUMMARY STATISTICS OF THE ESTIMATION DATASET

Table 9 lists the summary statistics of the estimation dataset. It shows that the value estimates in the dataset range between $0.01 and $29,251 (per hectare per year) and are, on average, $812 per hectare per year. About 22 percent of the value estimates address boreal forests, 41 percent temperate forests, and 37 percent tropical forests. Recreation services constitute 46 percent of the value estimates and about 29 percent of value estimates concern habitat and species protection. NWFPs and water services comprise about 16 percent and 9 percent of the value estimates.

The summary statistics again show the distribution of value estimates by continent as follows: Africa percent; America 32 percent; Asia 17 percent; Europe 37 percent; and Oceania 7 percent. GDP per capita ranges widely in the estimation dataset, with the minimum at less than $3,000 and the maximum at almost $50,000. Population density is similarly varied, ranging between approximately zero to 2,444, which indicates a highly urbanized area. The summary statistics for climatic conditions (temperature and precipitation), distance to urban centers, and road density within the study area also indicate wide variation in the estimation dataset.

Regarding land uses, the study areas are on average about 35 percent forested and include about 8 percent wetlands (within a 75 km radius). Species richness on the study sites ranges from 29 to 548 and is, on average, 178. About 62 percent of the value estimates come from high income countries, 32 percent come from middle income countries, and the rest (6 percent) are from low income countries. Finally, around 43 percent of the value estimates address protected areas and 67 percent of the value estimates come from academic peer-reviewed journal articles.

6 The authors use leave-one-out cross-validation, which involves always leaving out one observation from the estimation dataset, then predicting the value and measuring predictions error for the left-out observation. Each observation is left out once to estimate out-sample prediction error in the sample.

GENERAL ESTIMATION APPROACH AND MODEL SELECTION

Model selection refers to the process of choosing empirical specification for predicting the dependent variable. The authors estimated and compared a broad range of alternative model specifications. They constructed alternative specifications by including and excluding potentially relevant socioeconomic and biophysical variables. For each model, they recorded R^2, information criteria (AIC; BIC), and out-of-sample prediction power (root mean square error [RMSE] and mean average error [MAE]).

As the starting point, the authors used the simplest model specification with only a constant term. Mathematically, this model estimates the constant as the mean of the predicted variable. Because the authors use a log-transformation of the dependent variable, the estimated constant coincides with the predicted median of the untransformed dependent variable. It is obtained as exp (α) where α is the estimated constant. This simplest model is also directly comparable to the value estimates in the current World Bank assessment approach, which uses median values from a select set of studies reviewed and summarized by Lampietti and Dixon (1995).

Estimation results from a wide range of alternative model specifications developed for model specification are listed in Appendix IV. To note, models that empirically yield the lowest out-of-sample prediction errors are also conceptually meaningful in that they include information on variables that drive the value of different ecosystem services, such as GDP, population density, or distinct biophysical data. Qualitatively, the estimated coefficients are also as expected and mostly statistically significant, as discussed below. The authors have also estimated many robustness checks using other alternative specifications for each service, and the estimation results are robust in light of those comparisons.

For each service, the authors selected the specification that yields the lowest out-of-sample prediction error. The same models are also preferred using information criteria. Table 10 lists the estimation results of these preferred model specifications by ecosystem service. The results are discussed by ecosystem service below.

For each service, the model with a constant only is statistically outperformed by many other specifications which incorporate study location data as predictors of the value. Therefore, the authors find considerable empirical evidence that ecosystem service values include heterogeneity, which can be addressed by location specific information on the drivers of the value.

ESTIMATION RESULTS

Recreation services

The estimation results suggest that recreation values are determined both by socioeconomic and ecological factors (Table 10). Socioeconomically, both population density and GDP per capita are positively and statistically significantly associated with recreation values, with the estimated coefficient about 0.56 for population density and 0.57 for GDP. Because both variables are log-transformed, the coefficient estimates directly denote the elasticity of the value of recreation services with respect to population density and GDP per capita. Accordingly, the value of recreation services per hectare of forests increases by roughly 6 percent per every 10 percent increase in population density and GDP per capita, keeping everything else constant.

TABLE 10. META-REGRESSION ESTIMATION RESULTS BY ECOSYSTEM SERVICE

VARIABLE	RECREATION	HABITAT/SPECIES PROTECTION	NWFPS	WATER SERVICES
Ln(population density)	0.562*** (0.0875)	0.643** (0.252)	0.688*** (0.136)	
Ln(GDP per capita)	0.566** (0.274)	1.655** (0.694)	–0.919*** (0.228)	13.32* (6.797)
Temperature	0.0178 (0.0461)	–0.234*** (0.0809)		
Ln(Species richness)	1.133** (0.458)	2.145*** (0.770)		
Boreal				–68.74** (30.59)
Tropics				–65.61* (30.52)
Temperate				–65.64* (30.48)
Africa			5.812** (2.216)	
America			10.87*** (2.046)	
Asia			7.864*** (2.461)	
Europe			10.44*** (2.488)	
Ln(GDP per capita)^2				–0.623 (0.380)
Constant	–8.375** (3.601)	–20.85** (8.799)		
Observations	86	54	30	16
R-squared	0.480	0.296	0.882	0.712
BIC	350.33	256.24	127.78	85.225
AIC	338.06	246.30	119.37	81.362
Out of sample RMSE (cross-validated)	1.777	2.504	1.729	2.861
Out of sample MAE (cross-validated)	1.333	1.920	1.316	2.173

In parentheses, robust standard errors clustered at the level of individual study.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Regarding ecological conditions, recreation values are positively and statistically significantly associated with biodiversity, as measured by species richness. This finding is consistent across models that include controls for continent and distance from the gradient, which proxies for the latitudinal gradient of species richness. This result provides novel evidence of the value of biodiversity in recreation.

Temperature is also positively associated with recreation values but the estimated relationship is not statistically significant. Temperature is included because it is a plausible determinant of recreational values (for example, Ghermandi et al. 2013 finds that coastal recreational values are systematically related to temperature).

Habitat and species protection

Generally, the results show positive and statistically significant relationships between the value of habitat and species protection and population density and GDP per capita. Values for habitat and species protection are highly dependent on income; the estimated coefficient on GDP is large (1.655) and statistically significant. The estimate indicates that the elasticity of habitat and species protection value relative to income is about 1.7. In other words, the value increases by about 17 percent as GDP increases by 10 percent. Intuitively, this is not surprising and suggests that habitat and species protection is a luxury good exceedingly important at high levels of income.

Interestingly, the results also show a statistically significant and positive relationship between species richness and value of habitat and species protection per hectare. The estimated coefficient on species richness—estimated as 2.145 in log-form—suggests that the value of habitat and species protection increases by about 21 percent when species richness increases by 10 percent. In other words, areas of particularly high species richness are also particularly highly valued for habitat and species protection.

Nonwood forest products

The estimation results for NWFPs again highlight the importance of the socioeconomic determinants of ecosystem service values, although with interesting and plausible differences relative to recreation and habitat and species protection. Population density gets a positive and statistically significant coefficient, estimated at 0.688. It indicates that the value of NWFPs increases by about 7 percent for every 10 percent increase in population density. This is plausible as NWFPs require manual collection of the products so areas with low population density simply lack the populations to engage in NWFP collection.

Moreover, the results indicate a negative and statistically significant relationship between GDP per capita and the value of NWFPs. This suggests that at relatively low values of GDP per capita, natural resources such as forests constitute important sources of income and food. But when GDP increases, assuming all other determinants of value remain the same, the importance of forests for NWFPs is reduced. At highest levels of income, NWFPs are mostly of limited importance. The estimated coefficient (–0.919) confirms this logic and suggests that the value of NWFPs declines by about 9 percent per every 10 percent increase in GDP per capita (keeping everything else constant).

In addition, the model estimates continent-specific constants for NWFPs. They suggest systematic differences in the value of NTFS by continent, with America and Europe highest and Africa lowest, on average.

Water services

For water services the regression model is limited by the number of observations, as only 16 applicable value estimates are in the estimation dataset. Because of this, the analysis uses a simple model that predicts the value of water services as a product of biome-specific constants and GDP. The model predicts well, with R^2 at 71.2 percent. The constants for biomes are statistically significant and the coefficient for GDP per capita is positive, large, and statistically significant. Population density is not included in the preferred model; its coefficients are generally not statistically significant and the model without it predicts better out-of-sample than models with population density (see Appendix IV).

4 PREDICTING VALUES FOR NONWOOD FOREST ECOSYSTEM SERVICES GLOBALLY

DEVELOPING GLOBAL PREDICTIONS IN HIGH SPATIAL RESOLUTION

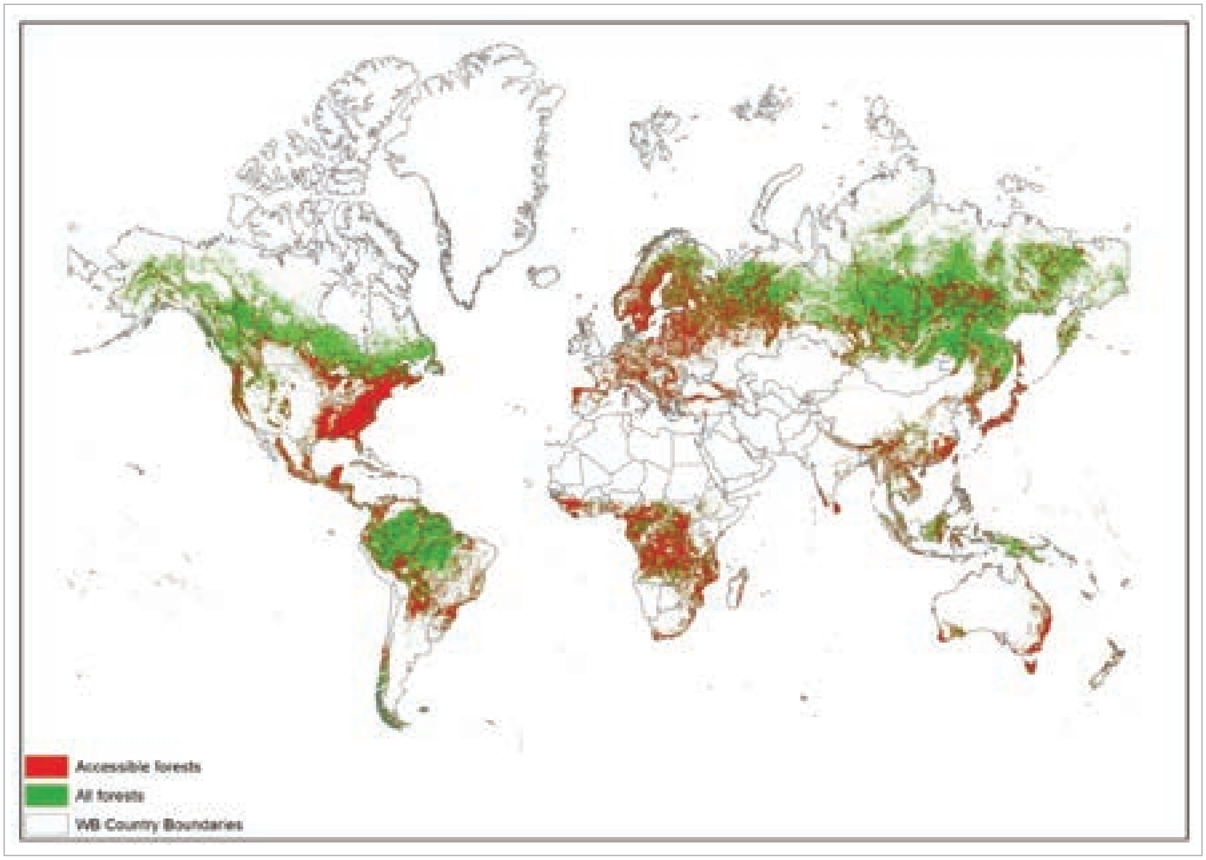
This section explains using the meta-regression estimation results to predict the value of nonwood forest ecosystem services globally. Because the meta-regression models are spatially explicit at local level, global values are predicted using a similar framework. More specifically, the approach involves first dividing global land surface into 10 km by 10 km grid cells (about 3.2 million grid cells). Then, data on land cover (Globcover 2009) is used to determine which grid cells comprise forests. The resulting 782,636 forested grid cells, globally, form the prediction dataset. Next, data are developed for each forested grid cell on the determinants of the value of ecosystem service, so that those data can be used in combination with the meta-regression estimation results (Table 10) to predict the value of forest ecosystem services in each grid cell.

Before finalizing local predictions, it is recognized that not all forests necessarily support all ecosystem services. For services that require physical presence in the forest, including recreation and collection of NWFPs, this study therefore designated service areas as forests that are accessible to potential users. The authors specified accessible forests as forests within 10 km or less from roads or navigable waterways. They used global data on road networks and rivers to determine the accessibility of each grid cell (see Appendix VI). Figure 4 maps all global forests and accessible forest using the grid cell data.

Studies valuing habitat and species protection typically examine forests either already protected or considered for protection. Therefore, their value estimates are conditional on protection to perpetuity, so habitat and species protection are applied only in areas currently protected. This approach excludes values from habitat and species protection associated with unprotected forests, which can be substantial. As such, the value estimates from this study for habitat and species protection should be considered underestimates at the country level. Water service values are the only service applicable to all forests. Table 11 summarizes the service area determination by ecosystem service.

As a further consideration to help better match the estimates developed using the meta-regression dataset with the rest of the world's forests, variation in the prediction dataset (forested grid cells) is set to remain within the variation in the estimation dataset for some of the key variables. For example, GDP per capita in the predictions matches the minimum and maximum in the estimation dataset ($297 to $48,377). Similar truncation of exceedingly high and low values applies for population density (min 0.0 persons per km^2, max 2,444 persons per km^2) and temperature (min –2.4 C, max 26.9 C). The truncations of predictor variables prevent avoid the exceedingly high or low values not represented in the estimation dataset (thus, not represented, within-sample, by the estimated coefficient estimates) from unduly influencing value predictions.

FIGURE 4. MAP OF ALL FORESTS AND ACCESSIBLE FORESTS (RED), GLOBALLY



One additional complication emerged when evaluating predictions derived using the above approach. The value predictions were generally plausible, but some countries saw exceedingly high estimates relative to the estimates from other countries in the same general geographic region, especially for water services in Western Africa and Middle East. Further examination of the data, in combination with inputs from the reviewers of our assessment, revealed that the regional outliers were associated with countries where oil revenue constitutes a substantial share, even the majority of GDP.[7] GDP per capita is a proxy for household income in the meta-regressions. However, the estimation dataset includes few, if any, observation from countries where GDP is primarily oil-based. Moreover, the estimation data come mostly from time periods preceding the recent oil boom. Therefore, the meta-regression results are limited in their applicability to support predictions in countries with GDP drastically inflated by the oil boom.

The authors addressed this issue by measuring GDP adjusted by the percentage of oil rents (oil production revenues minus costs). As such, they attempted to measure "GDP per capita less oil." Then, using the GDP per capita less oil, they predicted local values of ecosystem services. The effect of this GDP adjustment is minimal in most countries (on average, oil revenue constitutes about 3 percent of GDP), but more substantial in countries where oil production

7 For example, according to the World Bank, about 61 percent of GDP per capita in Equatorial Guinea (roughly $33,768 in 2013), the largest oil producer in West Africa, is associated with rents from oil production.

TABLE 11. SERVICE AREAS FOR DIFFERENT ECOSYSTEM SERVICES

SERVICE	SERVICE AREA
Recreation	Accessible forest
Habitat/species protection	All protected forests
NWFPs	Accessible forests and IUCN category V and VI protected forests
Water services	All forests

constitutes a large share of the economy.[8] The ecosystem service value predictions go down by 4 percent, on average, globally. In Africa, however, the oil rent-based adjustment of GDP reduces predicted values by about 25 percent, making the predictions generally more plausible in countries which previously stood out as outliers.

Table 12 lists the summary statistics of the grid cell data. It shows, for example, that 29 percent of forested grid cells are accessible and 16 percent are currently protected. On average, forested grid cells have a population density of 18.4 persons per km^2. High income countries comprise 73 percent of forested grid cells. By continent, their distribution is as follows: Africa 8 percent, Asia 7 percent, Europe 49 percent, America 34 percent, and Oceania

TABLE 12. SUMMARY OF GLOBAL DATA ON FORESTED GRID CELLS

VARIABLE	MEAN	STD. DEV.	MIN	MAX
Accessible forest	0.29	0.45	0	1
Protected area	0.16	0.36	0	1
Population density	18.39	110.01	0	18,762
Temperature	3.82	12.70	–22.0	29.0
Latitude	41.15	28.81	–55.5	70.0
High income country	0.73	0.45	0	1
GDP per capita	27,071	14,175	133	152,933
GDP per capita, less oil rents	25,139	14,164	133	152,933
Species richness	68.4	48.9	2	370
Africa	0.08	0.27	0	1
Asia	0.07	0.25	0	1
Europe	0.49	0.50	0	1
America	0.34	0.48	0	1
Oceania	0.02	0.13	0	1
Boreal	0.61	0.49	0	1
Tropical	0.24	0.43	0	1
Temperate	0.15	0.36	0	1
Recreation active	0.29	0.45	0	1
Habitat active	0.16	0.36	0	1
NWFP active	0.32	0.47	0	1

Note: All variables include 782,636 observations.

8 Note that the percent-share of oil of the overall economy is the key, not the absolute magnitude of oil production.

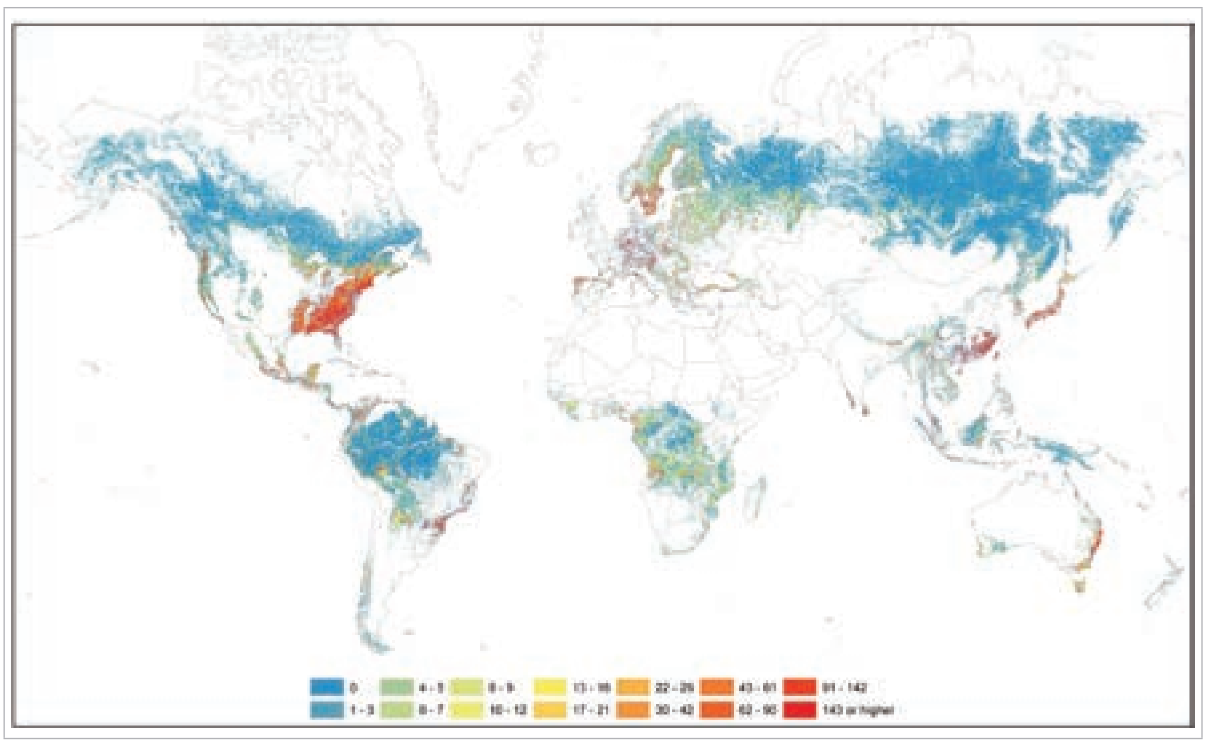
2 percent. Boreal forests comprise 61 percent of forested grid cells, tropical forests account for 24 percent, and temperate forests have 15 percent of the grid cells. Twenty-nine percent of the grid cells are designated for the provision of recreation values; 32 percent provide NWFPs and 16 percent support habitat and species protection.

PREDICTED VALUES OF FOREST ECOSYSTEM SERVICES

Several maps next illustrate value predictions. Note that the rest of results are in nominal dollars (2013 U.S. dollars), as required by the World Bank forest wealth assessment, and not in PPP-adjusted dollars. Note also that the maps are colored according to variation for values within the service illustrated in the map, not according to variation across different services. This works well for geographically contrasting value for each service but is less telling of differences between values for different service, as the same color in one map indicates a different value in another map.[9]

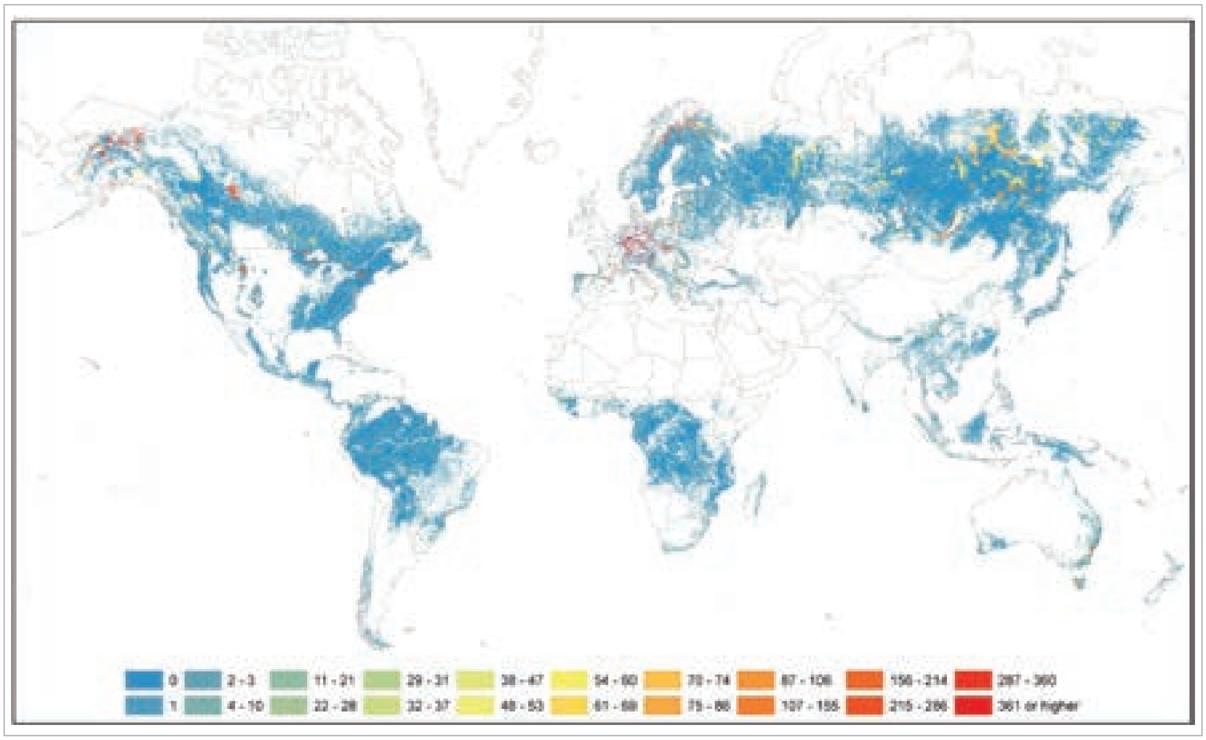
Figure 5 shows the predicted local values for recreation. Recall from the meta-regressions that recreational values are closely associated with population density and GDP per capita. Therefore, forests in areas of high income and populations, such as Eastern United States, Western Europe, Japan, and Eastern China, are valued highly for

FIGURE 5. PREDICTED VALUE OF RECREATION SERVICES FROM FORESTS, PER HECTARE PER YEAR, IN 2013 U.S. DOLLAR. MAPPED GLOBALLY USING DATA ON 782,636 GRID CELLS, EACH 10 KM BY 10 KM IN SIZE (10,000 HECTARES)



9 Using same colors to indicate same dollar values in each map is not practical, because the maps would show little, if any, variation in values for some services, such as NWFPs (their geographic variation is more modest than the overall variation of values across different services).

FIGURE 6. PREDICTED VALUE OF HABITAT AND SPECIES PROTECTION SERVICES FROM FORESTS, PER HECTARE PER YEAR, IN 2013 U.S. DOLLARS. MAPPED GLOBALLY USING DATA ON 782,636 GRID CELLS, EACH 10 KM BY 10 KM IN SIZE (10,000 HECTARES)



recreation. Moreover, recreation values are active only in accessible forests. This results in relatively low values in much of the boreal forests, especially in Russia and Canada, where inaccessible forests are prevalent. Tropical rain forests also get low values because of inaccessibility, especially in the Amazon.

Habitat protection values, shown in Figure 6, are driven by species richness, GDP, and the protection status of forests (this service is provided only in protected forests). High values for habitat and species protection are concentrated in Western Europe and parts of North America.

NWFPs are also available only in accessible forests (Figure 7). Their values tend to be high in areas of high population density, somewhat similar to high values for recreation but also extending to regions of somewhat lower GDP, such as South America. Finally, water services (Figure 8) are available from all global forests and vary largely by continent, as predicted by the meta-regression model.

Figure 9 maps the combined value of forest ecosystem services on average per hectare per year. The value is mapped globally in 10 km by 10 km resolution using predictions for the 782,636 forested grid cells globally. Figure 9 shows several interesting trends. First, there is considerable variation in the values by biome. Boreal forests are relatively low values, temperate forest feature the relatively highest values, and the tropical forests are somewhere between. Industrialized countries, including North America, Europe, Japan, and Australia, feature particularly high value estimates. On the other hand, several developed countries also have relatively high values, including much of South America, parts of Mesoamerica, and several areas in Asia, such as the densely populate areas in Malaysia and China. Africa, in general, has relatively low predicted values, although areas near urban centers in Africa are higher in value.

COUNTRY LEVEL PREDICTIONS

The World Bank comprehensive wealth assessment measures country-level wealth, so the next set of results aggregates grid cell predictions by country. However, simply summing up grid cell predictions does not accurately produce country-level estimates of total forest wealth. This is because not all grid cells are 100 percent forested, so their total land area exceeds the total area of forests by country and globally. This issue was addressed by first using the grid cell predictions to determine the value of each ecosystem service per hectare of forest, on average, in each country. Then, using data on the total forest area by country, the total value of each ecosystem service was projected by country. Forest area by country uses data from he FAO FRA to be consistent with the rest of the World Bank forest wealth assessment and to facilitate annual updating of the country-level wealth estimates.

For the country level estimates, the authors combined the value of recreation, NWFPS, and water services, and excluded values for habitat/species protection, as required for the World Bank nonwood forest wealth assessment. Figure 10 maps the combined value of recreation, NWFPs, and water services. Figure 11 presents the country-level estimates by ecosystem service, which includes a map also for habitat and species protection.

FIGURE 7. PREDICTED VALUE OF NWFPS FROM FORESTS, PER HECTARE PER YEAR, IN 2013 U.S. DOLLARS. MAPPED GLOBALLY USING DATA ON 782,636 GRID CELLS, EACH 10 KM BY 10 KM IN SIZE (10,000 HECTARES)

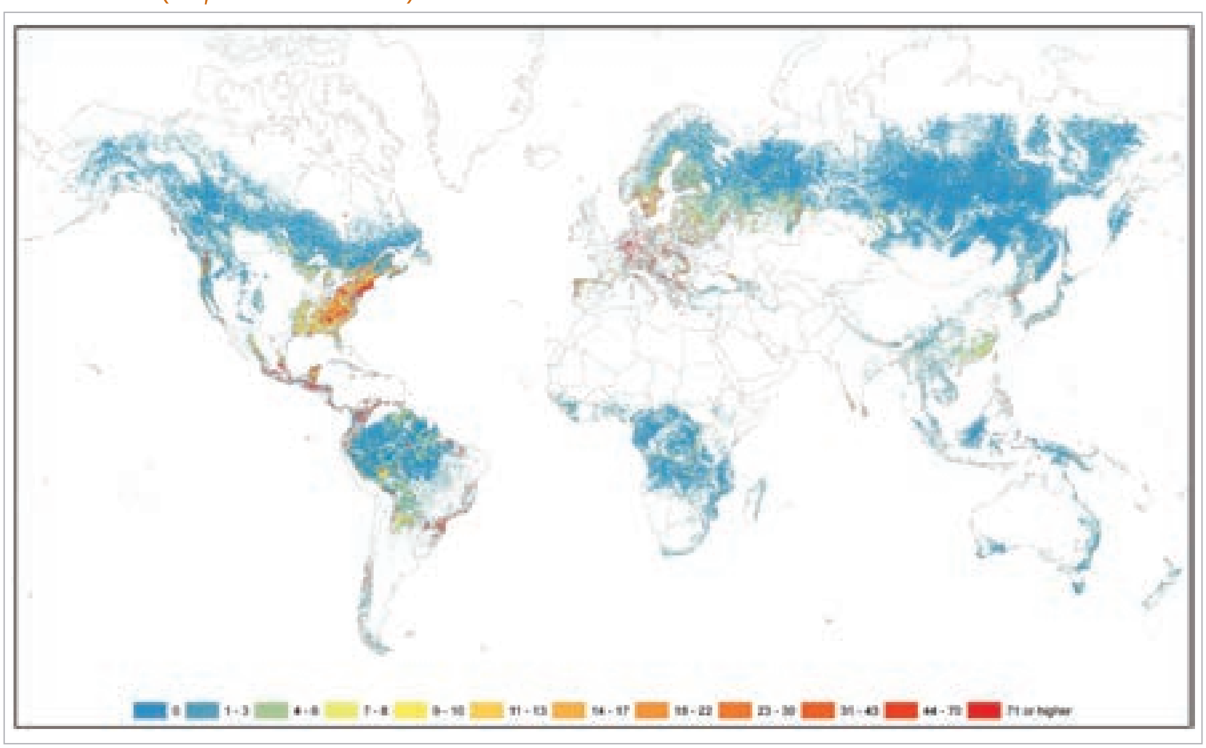


FIGURE 8. PREDICTED VALUE OF WATER SERVICES FROM FORESTS, PER HECTARE PER YEAR, IN 2013 U.S. DOLLARS. MAPPED GLOBALLY USING DATA ON 782,636 GRID CELLS, EACH 10 KM BY 10 KM IN SIZE (10,000 HECTARES)

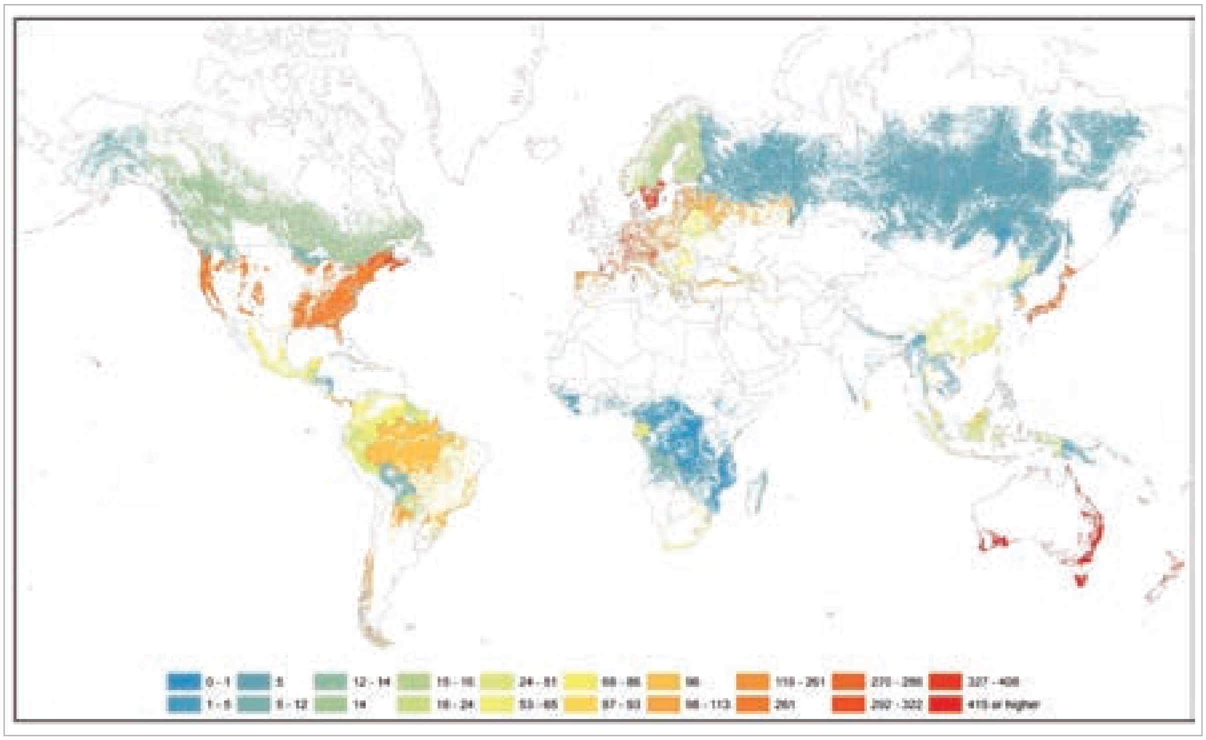


Table 13 lists the country level estimates by country and continent to support the World Bank assessment of forest wealth. The table lists estimates on average per hectare as well as for the total forest ecosystem service values in the country (country-level forest rents in nonwood ecosystem services). Moreover, the table lists values as the combined value of all services (recreation, habitat and species protection, NWFPs, and water services), the combined value of recreation, NWFPs, and water services (excluding habitat and species protection), as well as separate estimates by ecosystem service.

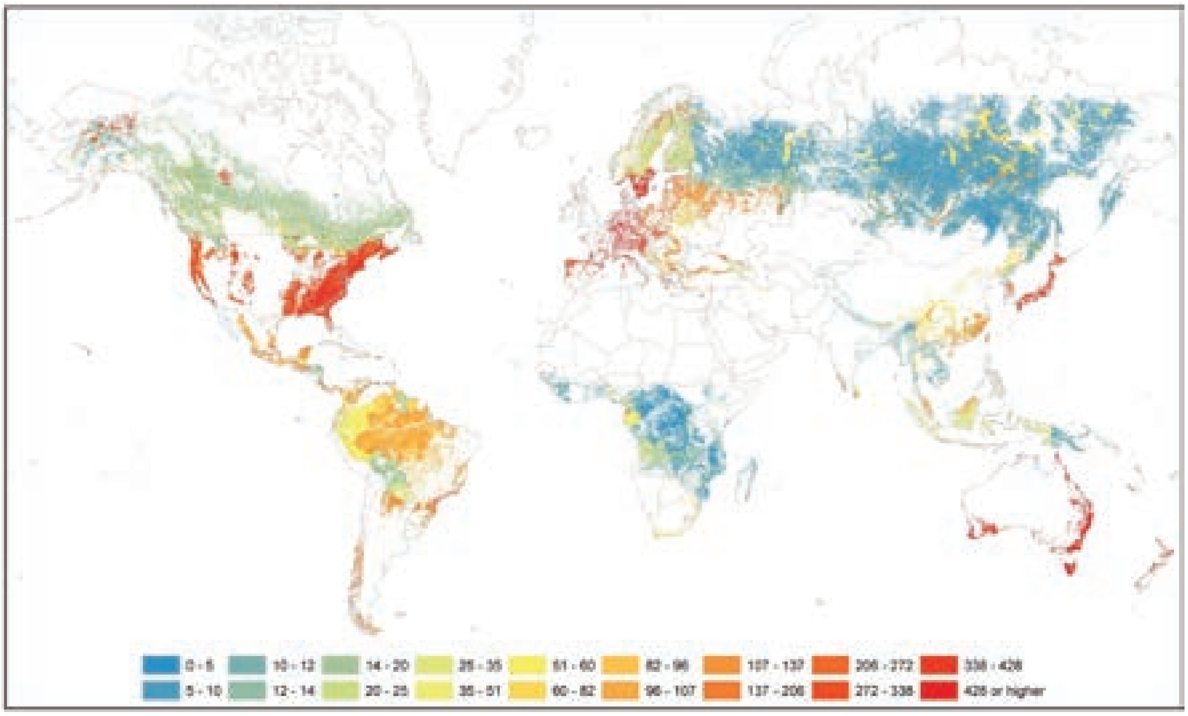
SUMMARY OF PREDICTIONS AND COMPARISON TO THE CURRENT METHODOLOGY

Tables 14 and 15 summarize the value predictions from this assessment and contrast them with estimates obtained using the current World Bank methodology. The tables present several alternative approaches to highlight the differences between the revised estimates and current methodology.

Table 14 shows the predictions by World Bank region using three optional revised predictions:

a. Revised approach considering all four ecosystem services (recreation, habitat and species protection, NWFPs, and water services)

FIGURE 9. PREDICTED VALUE OF ALL FOREST ECOSYSTEM SERVICES, PER HECTARE PER YEAR, IN 2013 U.S. DOLLARS. THE SERVICES CONSIDERED INCLUDE RECREATION, HABITAT AND SPECIES PROTECTION, NWFPS, AND WATER SERVICES. MAPPED USING DATA ON 782,636 GRID CELLS, EACH 10 KM BY 10 KM IN SIZE



b. Revised approach considering recreation, NWFPs, and water services, but excluding habitat and species protection (the current assessment excludes habitat and species protection);

c. Revised approach considering recreation and water services and assuming 10 percent accessibility of forests for recreation (the current assessment also assumes 10 percent).

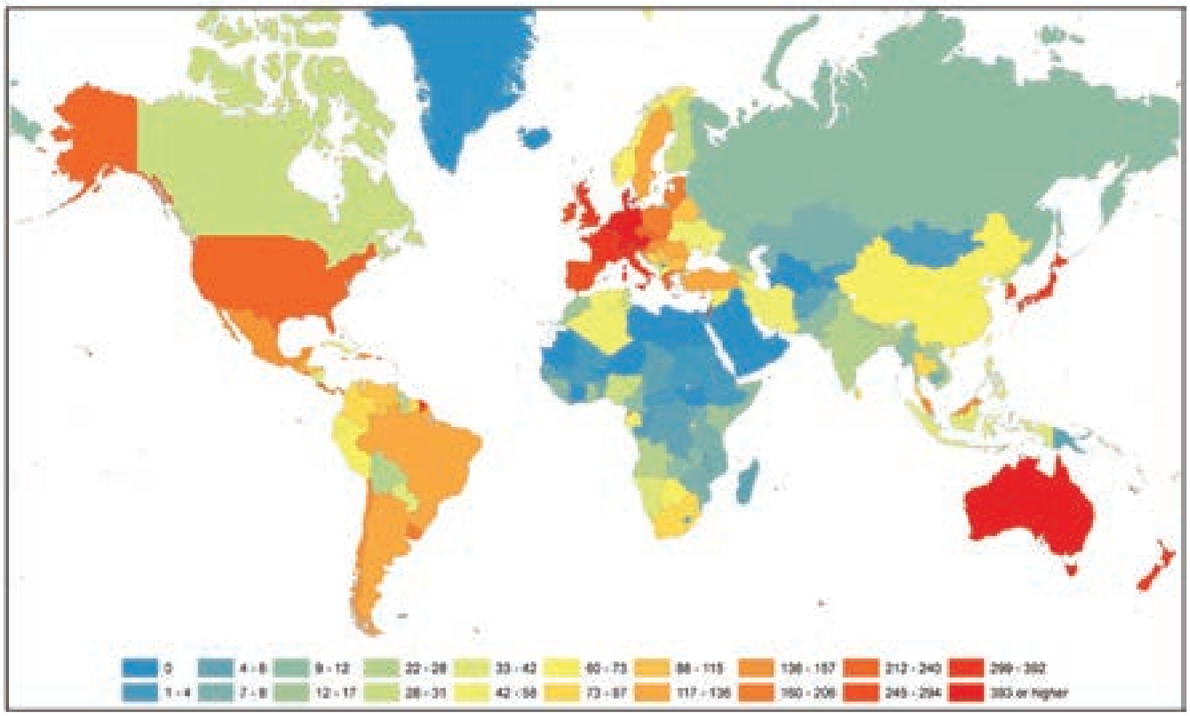
The current assessment uses benefit transfers to value recreation and water services, but values NWFPs using FAO data. Two alternatives denote the estimates using the current methodology:

d. Current methodology, including recreation and water

e. Current methodology, including recreation, water, and NWFPs.

Options C (revised methodology, recreation and water, and 10 percent recreation access) and D (current methodology, recreation, and water) provide perhaps the most direct comparison of the revised and current approaches. Using the revised approach to estimate recreation and water services but assuming a 10 percent access to forest for recreation (option C) generates a global value of recreation and water services of $67 per hectare per year (2013 U. D. dollars). Using the current methodology (option D), the corresponding estimate is $26 per hectare per year, or about 39 percent of the revised estimate. Adding NWFPs and considering the authors'

FIGURE 10. COUNTRY-LEVEL PREDICTIONS OF THE COMBINED VALUE OF RECREATION, NWFPS, AND WATER SERVICES, PER HECTARE PER YEAR, IN USD 2013. OBTAINED BY AGGREGATING THE 782,636 GRID LEVEL ESTIMATES BY COUNTRY AND DIVIDING COUNTRY-TOTALS BY TOTAL FOREST AREA BY COUNTRY (FAO).



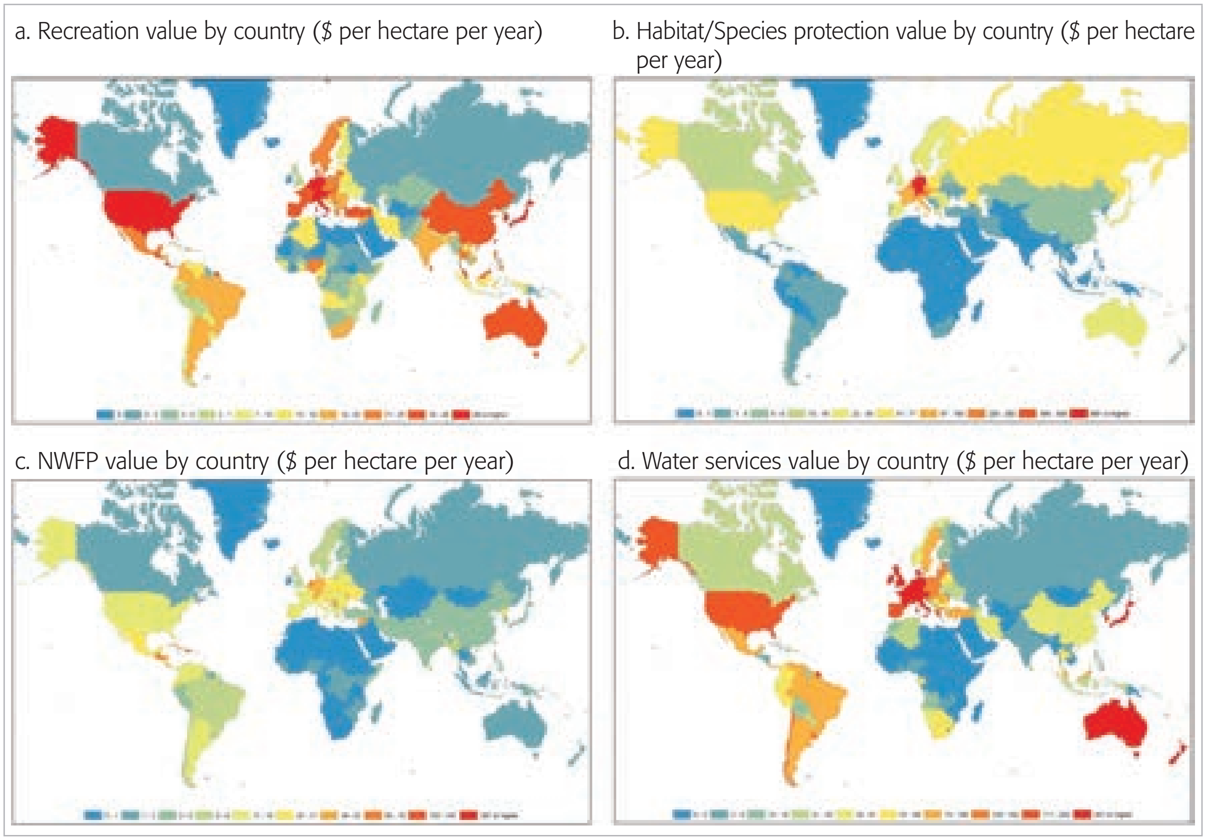
revised measure of accessible area for recreation (option B) increases the revised estimate to $84 per hectare per year, whereas the estimate using the current methodology increases to $31 per hectare per year. The current estimate is now about 37 percent of the revised estimate. Therefore, when considering recreation, NWFPs, and water services, similar to the focus of the World Bank forest wealth assessment, the estimated value of nonwood forest ecosystem services is about 2.7 times greater, on average, under the revised approach.

Finally, adding values for habitat and species protection (option A) greatly increases the revised estimate, resulting in a global average of $95 per hectare per year, which is roughly 3.1 times greater than the value estimated using the current methodology (option E).

Another observation from Table 14 is that the value of forest ecosystem services varies greatly by world region. For example, when adding up values for recreation, NWTPs, and water services, Sub-Saharan Africa ($13 per hectare per year), Middle East, and North Africa ($42 per hectare per year) are the regions of lowest values. East Asia and Pacific ($148 per hectare per year) is the region of highest values, along with North America (128 per hectare per year) and Latin America and Caribbean (103 per hectare per year).

The groupings of the world regions into high and low estimates are driven by factors, such as GDP and population density, as well as species richness for habitat and species protection. For example, the value of forests in Europe

FIGURE 11. PREDICTED VALUE OF ECOSYSTEM SERVICES FROM FORESTS, BY COUNTRY AND ECOSYSTEM SERVICE



and Central Asia drops from $70 to $47 per hectare per year when only recreation, NWFPs, and water services are considered (and habitat and species protection is excluded). On the other hand, many of the other regions remain relatively steady regardless of exclusion or inclusion of habitat values. This result indicates that the values are greatest for recreation and water in those regions.

Table 15 lists the estimated combined present value of nonwood forest ecosystem services of recreation, NWFPS, and water services (thus, excluding habitat and species protection from the total values). The table lists the present value of nonwood forest ecosystem services on a per hectare basis and in total by World Bank region. The calculation of the present value of nonwood forest wealth uses the same assumptions as the current methodology (4 percent discount rate and 25-year time horizon). Moreover, total values are estimated in two ways; one estimate does not consider the annual change of forest area (forest loss and gain), whereas the other estimate incorporates the change in forest area when calculating the present value, similar to the approach in the current assessment (see Appendix I).

Globally, the combined present value of ecosystem services considered is $1,312 per hectare, on average. Variation by World Bank region is considerable, mirroring Table 14 and the annual value of forest ecosystem services. At the lowest, the combined present value of nonwood ecosystem services is $202 per hectare in Sub-Saharan Africa. The highest values take place in East Asia and Pacific ($2,309 per hectare) and North America ($2,001 per hectare).

TABLE 13. ESTIMATED VALUE OF FOREST ECOSYSTEM SERVICES, BY COUNTRY, ON AVERAGE PER HECTARE AND IN TOTAL (2013 U.S. DOLLAR)

	PER HECTARE, ON AVERAGE						COUNTRY TOTAL					
Services included Country	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water
Africa	19.3	19.2	8	0.1	1	10.2	8.2E+09	8.2E+09	3.8E+09	5.1E+07	4.5E+08	3.9E+09
Algeria	42.2	41.9	12.3	0.3	0.3	29.3	8.1E+07	8.0E+07	2.4E+07	5.8E+05	6.0E+05	5.6E+07
Angola	21.8	21.8	10.5	0	0.2	11	1.3E+09	1.3E+09	6.1E+08	1.8E+06	1.4E+07	6.5E+08
Benin	4.3	4.3	3.7	0	0.4	0.2	2.0E+07	2.0E+07	1.7E+07	2.3E+04	1.9E+06	9.4E+05
Botswana	66.1	65.9	3	0.2	0	62.9	7.5E+08	7.5E+08	3.4E+07	2.5E+06	1.9E+05	7.1E+08
Burkina Faso	3.1	3.1	2.7	0	0.3	0.2	1.8E+07	1.8E+07	1.5E+07	3.8E+04	1.8E+06	8.8E+05
Burundi	15.6	15.5	10.2	0	5.4	0	3.9E+06	3.9E+06	2.6E+06	2.1E+03	1.4E+06	9.5E+02
Cabo Verde	15.5	15.5	0	0	0	15.5	1.3E+06	1.3E+06	0.0E+00	0.0E+00	0.0E+00	1.3E+06
Cameroon	11.6	11.5	10.1	0.1	0.5	1	2.3E+08	2.3E+08	2.0E+08	1.1E+06	9.7E+06	1.9E+07
Central African Republic	2.6	2.6	1.9	0	0.6	0	5.8E+07	5.8E+07	4.3E+07	1.1E+04	1.4E+07	1.3E+05
Chad	4	4	3.4	0	0.5	0.1	2.2E+07	2.2E+07	1.9E+07	6.0E+03	2.6E+06	7.6E+05
Comoros	21.7	21.7	14	0	7.6	0.1	8.5E+05	8.5E+05	5.5E+05	0.0E+00	3.0E+05	4.2E+03
Congo	2.7	2.7	1.7	0	0.1	0.9	6.2E+07	6.2E+07	3.9E+07	6.2E+04	2.2E+06	2.1E+07
Congo, Democratic Republic of	5.6	5.6	4	0	1.6	0	8.7E+08	8.7E+08	6.2E+08	5.2E+05	2.4E+08	1.1E+06
Equatorial Guinea	127.9	127	40.2	0.9	0.1	86.7	2.1E+08	2.1E+08	6.5E+07	1.5E+06	2.1E+05	1.4E+08
Ethiopia	1.8	1.8	1.3	0	0.4	0.1	2.2E+07	2.2E+07	1.6E+07	2.3E+05	5.4E+06	7.0E+05
Gabon	53.7	53.6	6.1	0.1	0	47.5	1.2E+09	1.2E+09	1.3E+08	1.2E+06	6.8E+05	1.0E+09
Ghana	15.1	15	11.7	0.1	0.4	2.9	1.4E+08	1.4E+08	1.1E+08	7.2E+05	3.7E+06	2.7E+07
Guinea	9.4	9.4	8	0	1.4	0	6.1E+07	6.1E+07	5.2E+07	1.7E+04	8.9E+06	2.8E+05
Guinea-Bissau	5.2	5.2	4.6	0	0.5	0.1	1.1E+07	1.0E+07	9.4E+06	2.2E+04	9.3E+05	1.4E+05
Kenya	12.5	12.1	10.3	0.4	0.7	1.1	5.3E+07	5.1E+07	4.4E+07	1.7E+06	3.1E+06	4.5E+06
Lesotho	4	3.6	2.5	0.4	0.4	0.7	1.8E+05	1.6E+05	1.1E+05	1.8E+04	1.6E+04	3.2E+04
Liberia	8.2	8.1	6.5	0	1.6	0	3.5E+07	3.5E+07	2.8E+07	1.5E+04	7.1E+06	4.5E+04
Madagascar	5.2	5.2	4.5	0	0.6	0.1	6.5E+07	6.5E+07	5.6E+07	4.5E+05	7.7E+06	7.1E+05

(continued on next page)

TABLE 13. ESTIMATED VALUE OF FOREST ECOSYSTEM SERVICES, BY COUNTRY, ON AVERAGE PER HECTARE AND IN TOTAL (2013 U.S. DOLLAR) *(continued)*

	PER HECTARE, ON AVERAGE						COUNTRY TOTAL					
Services included / Country	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water
Malawi	6.5	6.5	5.1	0	1.4	0	2.1E+07	2.1E+07	1.6E+07	5.6E+04	4.5E+06	1.1E+04
Mali	2.7	2.7	2.3	0	0.3	0.1	1.4E+07	1.4E+07	1.2E+07	9.5E+03	1.6E+06	7.3E+05
Morocco	17.8	16.5	1.7	1.3	0.1	14.7	1.0E+08	9.4E+07	9.8E+06	7.1E+06	3.4E+05	8.4E+07
Mozambique	6.6	6.6	5.5	0	1	0	2.6E+08	2.6E+08	2.2E+08	1.8E+05	4.0E+07	1.2E+06
Namibia	42	41.7	4.1	0.3	0	37.6	3.1E+08	3.0E+08	3.0E+07	2.1E+06	2.1E+05	2.7E+08
Nigeria	30.6	30.6	22.9	0.1	0.8	6.9	2.8E+08	2.8E+08	2.1E+08	7.1E+05	6.8E+06	6.3E+07
Rwanda	35.4	35.1	29.4	0.2	5.6	0.1	1.6E+07	1.6E+07	1.3E+07	1.1E+05	2.5E+06	4.0E+04
Senegal	4.3	4.3	3.6	0	0.2	0.5	3.7E+07	3.6E+07	3.1E+07	1.1E+05	1.6E+06	4.3E+06
Sierra Leone	10	9.9	8.8	0	1.1	0.1	2.7E+07	2.7E+07	2.4E+07	1.3E+04	2.9E+06	2.9E+05
Somalia	8.6	8.6	5.7	0	2.9	0	5.8E+07	5.8E+07	3.9E+07	2.5E+03	2.0E+07	3.8E+04
South Africa	77.8	76.6	19.5	1.2	0.1	57	7.2E+08	7.1E+08	1.8E+08	1.1E+07	1.3E+06	5.3E+08
Sudan	3.2	3.2	1.5	0	0.1	1.6	8.6E+07	8.6E+07	4.0E+07	0.0E+00	2.7E+06	4.4E+07
Swaziland	35.8	35.7	21.7	0.2	0.3	13.6	2.0E+07	2.0E+07	1.2E+07	8.6E+04	1.9E+05	7.7E+06
Tanzania	7.4	7.3	6.3	0.1	0.4	0.6	3.5E+08	3.5E+08	3.0E+08	3.6E+06	2.0E+07	2.7E+07
Togo	8.1	8.1	6.9	0	1.1	0.1	2.3E+06	2.3E+06	2.0E+06	2.3E+03	3.2E+05	2.1E+04
Tunisia	29.4	29.4	0	0	0	29.4	2.9E+07	2.9E+07	0.0E+00	0.0E+00	0.0E+00	2.9E+07
Uganda	6.8	6.7	5.8	0.1	0.8	0.1	1.9E+07	1.9E+07	1.6E+07	2.1E+05	2.1E+06	3.8E+05
Zambia	11.8	11.5	8	0.3	0.2	3.4	5.8E+08	5.7E+08	3.9E+08	1.2E+07	9.6E+06	1.7E+08
Zimbabwe	7.1	7	6.2	0.1	0.6	0.3	1.1E+08	1.1E+08	9.7E+07	8.8E+05	9.3E+06	4.1E+06
Asia	**77.8**	**74.1**	**18.7**	**3.6**	**4.5**	**51**	**4.1E+10**	**3.9E+10**	**1.4E+10**	**2.4E+09**	**1.6E+09**	**2.3E+10**
Afghanistan	6.3	6.3	1.8	0	4.4	0.2	8.6E+06	8.6E+06	2.4E+06	0.0E+00	5.9E+06	2.8E+05
Armenia	30.2	27.9	7.4	2.3	2.2	18.3	1.0E+07	9.2E+06	2.5E+06	7.7E+05	7.1E+05	6.1E+06
Azerbaijan	54.1	49.2	9.5	4.8	1.4	38.3	5.5E+07	5.0E+07	9.6E+06	4.9E+06	1.5E+06	3.9E+07
Bangladesh	21.7	21.7	13	0	7.8	0.9	3.1E+07	3.1E+07	1.9E+07	1.2E+04	1.1E+07	1.3E+06

(*continued on next page*)

TABLE 13. ESTIMATED VALUE OF FOREST ECOSYSTEM SERVICES, BY COUNTRY, ON AVERAGE PER HECTARE AND IN TOTAL (2013 U.S. DOLLAR) *(continued)*

	PER HECTARE, ON AVERAGE						COUNTRY TOTAL					
Services included Country	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water
Bhutan	31.3	28.2	14.5	3.1	2	11.7	8.5E+07	7.6E+07	3.9E+07	8.5E+06	5.4E+06	3.2E+07
Brunei Darussalam	268.9	252.5	107.7	16.5	0.2	144.5	1.0E+08	9.6E+07	4.1E+07	6.3E+06	8.2E+04	5.5E+07
Cambodia	7.3	6.9	4.6	0.4	1.2	1.1	7.3E+07	7.0E+07	4.6E+07	4.0E+06	1.3E+07	1.1E+07
China	77.5	72.2	31.3	5.3	2.7	38.2	1.6E+10	1.5E+10	6.3E+09	1.1E+09	5.4E+08	7.7E+09
Cyprus	217.5	216.9	6.2	0.6	0.6	210.1	3.8E+07	3.8E+07	1.1E+06	1.1E+05	1.0E+05	3.6E+07
Georgia	30.5	29.4	9.7	1.1	2.8	16.9	8.6E+07	8.3E+07	2.7E+07	3.1E+06	8.0E+06	4.8E+07
India	26.6	26.3	17.8	0.3	3.9	4.7	1.9E+09	1.8E+09	1.2E+09	2.1E+07	2.7E+08	3.3E+08
Indonesia	36.5	35.8	12.9	0.7	0.7	22.2	3.5E+09	3.4E+09	1.2E+09	6.4E+07	6.6E+07	2.1E+09
Iran, Islamic Republic of	53.1	51.4	12.3	1.6	2.3	36.8	5.7E+08	5.5E+08	1.3E+08	1.8E+07	2.5E+07	3.9E+08
Israel	278.4	278.4	0	0	0	278.4	4.3E+07	4.3E+07	0.0E+00	0.0E+00	0.0E+00	4.3E+07
Japan	388.7	358.3	78.1	30.3	3.2	277	9.7E+09	9.0E+09	2.0E+09	7.6E+08	7.9E+07	6.9E+09
Kazakhstan	15.2	7.9	3.4	7.3	0.3	4.3	5.0E+07	2.6E+07	1.1E+07	2.4E+07	8.8E+05	1.4E+07
Korea, Democratic People's Republic of	31.2	31.2	2.8	0	28.4	0	1.8E+08	1.8E+08	1.6E+07	0.0E+00	1.6E+08	2.7E+04
Korea, Republic of	289.4	258.7	57.1	30.7	3.1	198.4	1.8E+09	1.6E+09	3.6E+08	1.9E+08	1.9E+07	1.2E+09
Kyrgyz Republic	0.7	0.6	0.2	0.1	0.4	0.1	4.5E+05	4.1E+05	1.3E+05	3.8E+04	2.4E+05	4.4E+04
Lao People's Democratic Republic	13.7	13.5	7.9	0.2	1.2	4.4	2.4E+08	2.4E+08	1.4E+08	2.9E+06	2.2E+07	7.9E+07
Lebanon	88.3	88.3	0	0	0	88.3	1.2E+07	1.2E+07	0.0E+00	0.0E+00	0.0E+00	1.2E+07
Malaysia	138.2	135.9	43.8	2.2	0.4	91.7	3.1E+09	3.0E+09	9.7E+08	5.0E+07	7.9E+06	2.0E+09
Mongolia	4.9	1.2	0.2	3.7	0	1	6.3E+07	1.6E+07	2.0E+06	4.8E+07	4.9E+05	1.3E+07
Myanmar	9.9	9.9	4.5	0	5.4	0	3.2E+08	3.2E+08	1.4E+08	3.6E+05	1.7E+08	1.1E+06
Nepal	13.6	12.9	6.3	0.7	6.3	0.3	5.0E+07	4.7E+07	2.3E+07	2.5E+06	2.3E+07	1.2E+06
Pakistan	10.2	10.2	4.9	0	2.3	3	1.7E+07	1.7E+07	8.3E+06	0.0E+00	3.9E+06	5.1E+06
Philippines	38.2	37.8	22.8	0.4	3.1	11.9	2.6E+08	2.6E+08	1.6E+08	2.6E+06	2.1E+07	8.1E+07

(*continued on next page*)

TABLE 13. ESTIMATED VALUE OF FOREST ECOSYSTEM SERVICES, BY COUNTRY, ON AVERAGE PER HECTARE AND IN TOTAL (2013 U.S. DOLLAR) (*continued*)

	PER HECTARE, ON AVERAGE						COUNTRY TOTAL					
Services included Country	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water
Sri Lanka	74	72.8	44.1	1.1	6.4	22.3	1.6E+08	1.5E+08	9.3E+07	2.4E+06	1.4E+07	4.7E+07
Syrian Arab Republic	65.5	65.5	18.3	0	47.1	0.1	3.2E+07	3.2E+07	9.0E+06	0.0E+00	2.3E+07	6.3E+04
Thailand	78.7	74.7	25.2	4	0.6	49	1.3E+09	1.2E+09	4.1E+08	6.5E+07	9.2E+06	8.0E+08
Timor-Leste	8.6	8.5	0	0.1	2.9	5.6	6.4E+06	6.3E+06	0.0E+00	5.0E+04	2.1E+06	4.2E+06
Turkey	133.3	132	31.2	1.3	2.4	98.4	1.5E+09	1.5E+09	3.5E+08	1.4E+07	2.7E+07	1.1E+09
Vietnam	23.9	23.6	16.2	0.3	2.3	5.1	3.4E+08	3.3E+08	2.3E+08	4.3E+06	3.3E+07	7.2E+07
Europe	**350.1**	**213.8**	**33.3**	**136.3**	**20.7**	**159.8**	**7.0E+10**	**4.7E+10**	**7.0E+09**	**2.3E+10**	**4.2E+09**	**3.6E+10**
Albania	60.2	57.5	8.3	2.7	22	27.2	4.7E+07	4.5E+07	6.5E+06	2.1E+06	1.7E+07	2.1E+07
Andorra	1253.9	224.7	36.5	1029.2	14.2	174	2.0E+07	3.6E+06	5.8E+05	1.7E+07	2.3E+05	2.8E+06
Austria	643.8	392.7	70.1	251.1	24.4	298.1	2.5E+09	1.5E+09	2.7E+08	9.7E+08	9.4E+07	1.2E+09
Belarus	99.3	92.8	12.8	6.5	12.2	67.8	8.5E+08	7.9E+08	1.1E+08	5.6E+07	1.0E+08	5.8E+08
Belgium	658.3	433.4	91.1	224.9	42.6	299.7	4.5E+08	3.0E+08	6.2E+07	1.5E+08	2.9E+07	2.0E+08
Bosnia and Herzegovina	73.4	73.4	11.8	0	31.5	30.1	1.6E+08	1.6E+08	2.6E+07	6.5E+04	6.9E+07	6.6E+07
Bulgaria	134.5	105.2	19.6	29.3	20.3	65.3	5.0E+08	3.9E+08	7.3E+07	1.1E+08	7.6E+07	2.4E+08
Croatia	169	156.4	18.7	12.6	16.3	121.4	3.3E+08	3.0E+08	3.6E+07	2.4E+07	3.1E+07	2.3E+08
Czech Republic	326.1	212.8	29.2	113.2	20.5	163.1	8.7E+08	5.7E+08	7.8E+07	3.0E+08	5.4E+07	4.3E+08
Denmark	532	419.5	35.9	112.5	20.1	363.5	3.1E+08	2.5E+08	2.1E+07	6.6E+07	1.2E+07	2.1E+08
Estonia	205.3	183.2	12.9	22.1	7.7	162.6	4.6E+08	4.1E+08	2.9E+07	4.9E+07	1.7E+07	3.6E+08
Finland	58.8	29.6	9.1	29.2	4.2	16.2	1.3E+09	6.6E+08	2.0E+08	6.5E+08	9.4E+07	3.6E+08
France	461.8	350.2	37.2	111.6	16.2	296.9	7.6E+09	5.8E+09	6.1E+08	1.8E+09	2.7E+08	4.9E+09
Germany	1106.8	420.3	91.1	686.6	48.7	280.5	1.3E+10	4.8E+09	1.0E+09	7.8E+09	5.6E+08	3.2E+09
Greece	250	225.7	24.5	24.3	11.7	189.5	9.8E+08	8.8E+08	9.6E+07	9.5E+07	4.6E+07	7.4E+08
Hungary	210.9	157.2	22.5	53.7	15.6	119.1	4.3E+08	3.2E+08	4.6E+07	1.1E+08	3.2E+07	2.4E+08
Ireland	307.2	293.9	0	13.4	0	293.9	2.2E+08	2.1E+08	0.0E+00	9.7E+06	0.0E+00	2.1E+08

(*continued on next page*)

TABLE 13. ESTIMATED VALUE OF FOREST ECOSYSTEM SERVICES, BY COUNTRY, ON AVERAGE PER HECTARE AND IN TOTAL (2013 U.S. DOLLAR) *(continued)*

	PER HECTARE, ON AVERAGE						COUNTRY TOTAL					
Services included Country	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water
Italy	439	342.3	56.9	96.6	24.7	260.7	4.0E+09	3.1E+09	5.1E+08	8.7E+08	2.2E+08	2.4E+09
Latvia	181.3	159.7	13.4	21.6	9.3	137	6.1E+08	5.4E+08	4.5E+07	7.2E+07	3.1E+07	4.6E+08
Liechtenstein	1011.7	281.2	70.7	730.5	39.5	171	7.0E+06	1.9E+06	4.9E+05	5.0E+06	2.7E+05	1.2E+06
Lithuania	213.3	167.9	20.9	45.4	12.7	134.3	4.6E+08	3.6E+08	4.5E+07	9.9E+07	2.8E+07	2.9E+08
Luxembourg	883.4	375	47	508.3	11.2	316.8	7.7E+07	3.3E+07	4.1E+06	4.4E+07	9.8E+05	2.8E+07
Macedonia, FYR	70.5	67.9	12.9	2.6	18.5	36.5	7.0E+07	6.8E+07	1.3E+07	2.6E+06	1.8E+07	3.6E+07
Moldova	60.8	60.8	7	0	48.3	5.5	2.4E+07	2.4E+07	2.7E+06	0.0E+00	1.9E+07	2.1E+06
Montenegro	92	85.7	10.9	6.3	15.2	59.6	7.6E+07	7.1E+07	9.0E+06	5.2E+06	1.3E+07	4.9E+07
Netherlands, The	741.8	480	127.5	261.7	60.1	292.5	2.8E+08	1.8E+08	4.8E+07	9.8E+07	2.2E+07	1.1E+08
Norway	100.3	72.6	23.9	27.7	7.7	41	1.2E+09	8.8E+08	2.9E+08	3.4E+08	9.3E+07	5.0E+08
Poland	230.5	167.4	26.1	63.2	20.9	120.3	2.2E+09	1.6E+09	2.4E+08	5.9E+08	2.0E+08	1.1E+09
Portugal	254	245.4	41.2	8.6	22.1	182.1	8.2E+08	8.0E+08	1.3E+08	2.8E+07	7.2E+07	5.9E+08
Romania	141.5	117.2	17	24.3	15.9	84.3	9.2E+08	7.6E+08	1.1E+08	1.6E+08	1.0E+08	5.5E+08
Russian Federation	19.2	11.7	1.4	7.5	1.1	9.3	1.6E+10	9.6E+09	1.1E+09	6.1E+09	9.0E+08	7.5E+09
Serbia	123.1	113.7	25.4	9.4	37.9	50.3	3.3E+08	3.1E+08	6.9E+07	2.6E+07	1.0E+08	1.4E+08
Slovak Republic	364.7	211.8	36	152.9	21.7	154.1	7.1E+08	4.1E+08	7.0E+07	3.0E+08	4.2E+07	3.0E+08
Slovenia	403	265.5	49.5	137.5	24.1	191.9	5.0E+08	3.3E+08	6.2E+07	1.7E+08	3.0E+07	2.4E+08
Spain	312	278.9	35.7	33.1	15	228.1	5.7E+09	5.1E+09	6.5E+08	6.0E+08	2.7E+08	4.2E+09
Sweden	153	119.6	21.1	33.4	7.4	91.1	4.3E+09	3.4E+09	5.9E+08	9.4E+08	2.1E+08	2.6E+09
Switzerland	925.9	530.4	108.5	395.5	34	387.9	1.1E+09	6.6E+08	1.3E+08	4.9E+08	4.2E+07	4.8E+08
Ukraine	58.6	56.1	8.2	2.5	23.7	24.2	5.6E+08	5.4E+08	7.8E+07	2.4E+07	2.3E+08	2.3E+08
United Kingdom	323.4	299.4	5.4	23.9	7.5	286.5	9.9E+08	9.2E+08	1.7E+07	7.3E+07	2.3E+07	8.8E+08
North America	**163.7**	**160.4**	**26.9**	**3.4**	**65.7**	**67.8**	**1.1E+11**	**9.7E+10**	**1.9E+10**	**1.3E+10**	**7.5E+09**	**7.1E+10**
Bahamas, The	205.1	205.1	0.3	0	0.6	204.2	1.1E+08	1.1E+08	1.6E+05	0.0E+00	3.2E+05	1.1E+08

(*continued on next page*)

TABLE 13. ESTIMATED VALUE OF FOREST ECOSYSTEM SERVICES, BY COUNTRY, ON AVERAGE PER HECTARE AND IN TOTAL (2013 U.S. DOLLAR) *(continued)*

	PER HECTARE, ON AVERAGE						COUNTRY TOTAL					
Services included Country	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water
Belize	75.2	75	18.8	0.2	30.3	25.9	1.1E+08	1.0E+08	2.6E+07	3.0E+05	4.2E+07	3.6E+07
Canada	36.6	29.1	2.3	7.5	1.6	25.2	1.3E+10	1.0E+10	7.9E+08	2.6E+09	5.4E+08	8.8E+09
Costa Rica	219.9	205.6	63.9	14.3	54.9	86.8	5.7E+08	5.4E+08	1.7E+08	3.7E+07	1.4E+08	2.3E+08
Cuba	58.6	58.4	6.6	0.1	41.4	10.4	1.7E+08	1.7E+08	1.9E+07	3.3E+05	1.2E+08	3.1E+07
Dominica	184.5	184.5	30.3	0	103	51.3	8.2E+06	8.2E+06	1.4E+06	0.0E+00	4.6E+06	2.3E+06
Dominican Republic	140.1	137.2	17.9	2.8	72.2	47.2	2.5E+08	2.5E+08	3.2E+07	5.1E+06	1.3E+08	8.6E+07
El Salvador	218.5	217.5	49.8	1	147.1	20.6	6.3E+07	6.2E+07	1.4E+07	2.8E+05	4.2E+07	5.9E+06
Guatemala	127.6	127.1	31.5	0.5	78.4	17.2	4.8E+08	4.7E+08	1.2E+08	1.8E+06	2.9E+08	6.4E+07
Haiti	118.7	118.7	1.8	0	116.7	0.2	1.2E+07	1.2E+07	1.8E+05	0.0E+00	1.2E+07	1.8E+04
Honduras	95.1	95	16.1	0.1	72.9	6	4.9E+08	4.9E+08	8.3E+07	2.8E+05	3.8E+08	3.1E+07
Jamaica	154.2	154.1	17.1	0.1	104	33	5.2E+07	5.2E+07	5.8E+06	2.1E+04	3.5E+07	1.1E+07
Mexico	143.7	140.7	28.1	3	26.2	86.4	9.6E+09	9.4E+09	1.9E+09	2.0E+08	1.7E+09	5.8E+09
Nicaragua	32.7	32.6	4.9	0.1	23.1	4.5	1.0E+08	1.0E+08	1.5E+07	2.4E+05	7.2E+07	1.4E+07
Panama	143.2	139.5	25.8	3.6	11.3	102.5	6.7E+08	6.6E+08	1.2E+08	1.7E+07	5.3E+07	4.8E+08
Puerto Rico (US)	351	350.5	53.7	0.5	79.3	217.5	1.7E+08	1.7E+08	2.6E+07	2.5E+05	3.8E+07	1.0E+08
Saint Lucia	53	53	0	0	0	53	1.1E+06	1.1E+06	0.0E+00	0.0E+00	0.0E+00	1.1E+06
Saint Vincent and the Grenadines	415.9	415.9	71	0	297.5	47.4	1.1E+07	1.1E+07	1.9E+06	0.0E+00	8.0E+06	1.3E+06
Trinidad and Tobago	229.2	228.5	48.2	0.7	41.8	138.5	5.2E+07	5.2E+07	1.1E+07	1.5E+05	9.5E+06	3.1E+07
United States of America	272.2	239.5	49.8	32.7	12.4	177.4	8.4E+10	7.4E+10	1.5E+10	1.0E+10	3.8E+09	5.5E+10
Oceania	**156.2**	**153**	**10.4**	**3.2**	**3.9**	**138.6**	**6.3E+10**	**6.0E+10**	**4.7E+09**	**2.8E+09**	**2.4E+08**	**5.5E+10**
Australia	477.9	455.6	36.7	22.3	0.9	418	5.9E+10	5.6E+10	4.5E+09	2.8E+09	1.1E+08	5.2E+10
Fiji	34.8	34.8	6.5	0	4.8	23.5	3.5E+07	3.5E+07	6.5E+06	7.5E+03	4.7E+06	2.3E+07
New Caledonia (Fr.)	392.4	392.2	21.9	0.2	0.9	369.4	3.3E+08	3.3E+08	1.8E+07	1.5E+05	7.9E+05	3.1E+08
New Zealand	323.1	316.6	7.2	6.5	0.7	308.7	3.3E+09	3.2E+09	7.3E+07	6.6E+07	7.0E+06	3.1E+09

(*continued on next page*)

TABLE 13. ESTIMATED VALUE OF FOREST ECOSYSTEM SERVICES, BY COUNTRY, ON AVERAGE PER HECTARE AND IN TOTAL (2013 U.S. DOLLAR) *(continued)*

	PER HECTARE, ON AVERAGE						COUNTRY TOTAL					
Services included Country	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water	Total	Total (no habitat)	Rec.	Habitat	NWFPs	Water
Palau	115.4	115.4	5.6	0	2	107.7	4.7E+06	4.7E+06	2.3E+05	0.0E+00	8.2E+04	4.3E+06
Papua New Guinea	5.6	5.6	1.5	0	2.8	1.3	1.9E+08	1.9E+08	5.0E+07	1.3E+05	9.6E+07	4.3E+07
Samoa	29.7	29.7	7	0	7.4	15.3	5.1E+06	5.1E+06	1.2E+06	0.0E+00	1.3E+06	2.6E+06
Solomon Islands	9.7	9.7	2.6	0	6.4	0.7	2.1E+07	2.1E+07	5.7E+06	4.5E+02	1.4E+07	1.6E+06
Vanuatu	17.1	17.1	4.7	0	9.2	3.2	7.5E+06	7.5E+06	2.1E+06	1.6E+03	4.1E+06	1.4E+06
South America	**90.7**	**89.2**	**9.3**	**1.5**	**9.5**	**70.4**	**8.5E+10**	**8.4E+10**	**1.0E+10**	**1.2E+09**	**6.7E+09**	**6.7E+10**
Argentina	137.4	135.7	18.4	1.8	11.9	105.4	3.9E+09	3.9E+09	5.3E+08	5.0E+07	3.4E+08	3.0E+09
Bolivia	22.5	22.4	5.3	0.1	7	10	1.3E+09	1.3E+09	3.0E+08	6.8E+06	4.0E+08	5.6E+08
Brazil	118.3	116.6	14	1.7	6.5	96.1	5.9E+10	5.8E+10	7.0E+09	8.6E+08	3.2E+09	4.8E+10
Chile	160.4	155.1	6.8	5.4	7.8	140.5	2.6E+09	2.5E+09	1.1E+08	8.7E+07	1.3E+08	2.3E+09
Colombia	88.3	87	14.5	1.4	16.6	55.9	5.2E+09	5.1E+09	8.5E+08	8.2E+07	9.7E+08	3.3E+09
Ecuador	70.1	69.4	13.8	0.7	23.4	32.2	9.1E+08	9.0E+08	1.8E+08	9.4E+06	3.0E+08	4.2E+08
Guyana	22.4	22.4	2.5	0	3.8	16.2	3.7E+08	3.7E+08	4.1E+07	1.4E+05	6.2E+07	2.7E+08
Paraguay	37	36.9	6.7	0.1	6.3	24	6.3E+08	6.3E+08	1.1E+08	9.8E+05	1.1E+08	4.1E+08
Peru	60.9	60.3	5.7	0.6	3.7	51	4.6E+09	4.5E+09	4.2E+08	4.2E+07	2.7E+08	3.8E+09
Suriname	83.8	83.7	3	0.1	1.4	79.4	1.3E+09	1.3E+09	4.6E+07	1.5E+06	2.1E+07	1.2E+09
Uruguay	175.6	170.7	8	4.9	8.7	154	3.0E+08	3.0E+08	1.4E+07	8.5E+06	1.5E+07	2.7E+08
Venezuela, Republica Bolivariana de	111.2	110.1	12.6	1.1	17.3	80.2	5.3E+09	5.2E+09	6.0E+08	5.0E+07	8.2E+08	3.8E+09
Grand Total	**147.1**	**111.3**	**19.3**	**35.8**	**15.9**	**76.1**	**3.8E+11**	**3.3E+11**	**5.8E+10**	**4.3E+10**	**2.1E+10**	**2.6E+11**

Services included are listed as follows. “Total” denotes the combined value of recreation, habitat/species protection, NWFPs, and water services. “Total (no habitat)” denotes the combined value of recreation, NWFPs, and water services. “Rec” denotes recreation, hunting, and fishing; “Habitat” denotes habitat/species protection, and “Water” denotes water services.

TABLE 14. ESTIMATED VALUE OF NONWOOD FOREST ECOSYSTEM SERVICES UNDER ALTERNATIVE REVISED APPROACHES AND CURRENT WORLD BANK METHODOLOGY, BY WORLD BANK REGION, ON AVERAGE, PER HECTARE PER YEAR (2013 U.S. DOLLARS)

	REVISED APPROACH			CURRENT METHODOLOGY	
	Option A	Option B	Option C	Option D	Option E
World Bank region	Recreation, habitat/ species protection, NWFPs, and water	Recreation, NWFPs, and water (no habitat/species protection)	Recreation and water (10% access to recreation)	Recreation and water (10% access to recreation)	Recreation, NWFPs, and water (10% access to recreation)
East Asia & Pacific	156	148	125	22	32
Europe & Central Asia	70	47	37	33	41
Latin America & Caribbean	105	103	83	18	19
Middle East & North Africa	43	42	34	20	22
North America	147	128	100	34	37
South Asia	27	26	9	18	20
Sub-Saharan Africa	13	13	7	18	18
Global	95	84	67	26	31

TABLE 15. ESTIMATED VALUE OF NONWOOD FOREST ECOSYSTEM SERVICES USING THE REVISED AND CURRENT WORLD BANK METHODOLOGIES, INCLUDING PRESENT VALUE PER HECTARE (4 PERCENT, 25 YEARS), ON AVERAGE, AND TOTAL FOREST WEALTH (2013 U.S. DOLLARS), BY WORLD BANK REGION, WITH AND WITHOUT CONSIDERING FOREST AREA LOSS AND GAIN IN THE CALCULATION OF TOTAL WEALTH. NOTE THAT THE REVISED APPROACH INCLUDES VALUES FOR RECREATION, NWFPS, AND WATER SERVICES, BUT EXCLUDES VALUES FOR HABITAT AND SPECIES PROTECTION

	REVISED APPROACH			CURRENT METHODOLOGY
World Bank region	Forest wealth ha^{-1} (present value)	Total forest wealth (not considering forest loss/gain)	Total forest wealth (considering forest loss/gain)	Total forest wealth
East Asia & Pacific	2,309	1.47E+12	1.50E+12	3.74E+11
Europe & Central Asia	733	7.58E+11	7.80E+11	7.36E+11
Latin America & Caribbean	1,610	1.51E+12	1.45E+12	2.67E+11
Middle East & North Africa	654	1.31E+10	1.36E+10	4.27E+09
North America	2001	1.31E+12	1.33E+12	3.89E+11
South Asia	410	3.39E+10	3.51E+10	2.88E+10
Sub-Saharan Africa	202	1.24E+11	1.18E+11	1.16E+11
Global	1,312	5.22E+12	5.23E+12	1.92E+12

The effect of considering forest losses and gains is small, globally, although it varies more by World Bank region. Accounting for forest losses and gains increases the estimated forest wealth especially in South Asia and Europe and Central Asia. It has a decreasing effect on forest wealth, particularly in Sub-Saharan Africa and Latin America and Caribbean. Globally, the value of forest wealth varies only by a fraction of a percentage point, depending on whether forest losses and gains are considered.

In comparison to the current methodology, the total value estimate is about 2.7 times greater using the revised approach and considering all ecosystem services, except for habitat and species protection. Including habitat and species protection into the assessment makes the revised estimates about 3.1 times greater, globally. There are several drivers of differences between the estimates derived using the revised and current approaches. First, the revised estimates of the value of recreation, NWFPs, and water services, on average per hectare in areas available for recreation, differfrom the estimates underlying the current approach. Second, this study revises measures of service areas for recreation and NWTPs. For example, the revised approach estimated that about 29 percent of forested grid cells are accessible for recreation, whereas the current approach assumes a uniform 10 percent accessibility of forests for recreation.

In the terms of values estimates for recreation, this study estimated benefits at about $15 per hectare per year, on average globally, by forested grid cell. The current World Bank approach uses a recreational value of $10 per hectare per year, on average globally, by forested grid cell. For water services, the revised s' estimate is $64 per hectare per year, on average globally, by forested grid cell. This is substantially larger than the current estimate of $10 per hectare per year (1995 U.S. dollars). For NWFPs, this study estimates benefits of about $5 per hectare per year, on average globally, by grid cell. It coincides with the current estimate developed using FAO data (also $5 per hectare per year, on average globally, by forested grid cell, according to the authors' calculations). In other words, the higher values for water and recreation services in the revised approach generate higher estimates relative to the current approach. For recreation services, the difference between the revised and current approach is a combination of differences between the measures of accessibility of forests for recreation and estimated value of recreation per hectare. Water services are active in all forests, so the only difference is the predicted value per hectare per year.

5 UPDATING THE ESTIMATES

The World Bank comprehensive wealth assessment is conducted annually. While some aspects of the revision developed in this report can be updated annually, a detailed revision using spatially explicit estimates at the grid cell level requires considerable efforts, including revising spatial data on the determinants of the value of nonwood ecosystem services. The sheer computational time to update the grid cell data amounts to many days if not weeks of data processing in ArcGIS. Moreover, such revision is unlikely to considerably alter the estimates, as much of the external data, such as population density or species data, are not annually updated by their sources regardless. Therefore, the authors recommended a detailed grid-cell level update only periodically, for example, every five years.

However, meaningful annual updates can still be developed. At the simplest, an annual update could involve revising data on forest area by country from FAO but assuming that the value of forest ecosystem services on a per-hectare remains unchanged, on average, within each country. The authors consider this a highly plausible assumption. Using this approach, annual total wealth estimates can be updated routinely by multiplying the per hectare value of forest ecosystem services by the updated estimate of forest areas in each country, along with updating the currency year using a deflator.

The literature on ecosystem service valuation is continually developing. Considerable changes in the body of literature take many years, so revising the meta-regression model to incorporate new value estimates is not meaningful every few years. The authors recommend a revised literature review and meta-analysis only after the literature expands or improves to the extent that it could support improvements by providing additional value estimates or improving their quality. This situation likely will not emerge in the next few years, but should be considered within the next five to ten years or so.

In sum, the authors suggest the following update protocols:

1. Every year:
    a. Revision of forest area by country
    b. Inflation adjustment of the value of nonwood forest ecosystem services per hectare per year
3. Every five years:
    a. Evaluations of the availability of updated external data on the determinants of nonwood ecosystem services, including forest cover, population density, GDP, species richness, road network, and so forth (the relevant variables and their sources are listed in Table 4)
    b. If new data are available, revision of grid cell predictions using updated data (forest cover, population density, GDP, species richness, road network, and so forth; see Table 4)
3. Every 5–10 years:
    a. Incorporation of new data from new literature into the meta-regressions
    b. Incorporation of new spatial data into the meta-regressions and predicted values across the World's forests.

In addition to this report, this study delivered to the World Bank a dataset comprising country-level estimates of the value of nonwood forest ecosystem services, similar to the summary of values of value predictions in Table 13. The data include value estimates separately by ecosystem service, in annual and present value, and per hectare and in total by country. The data also include variables for country forest area and annual deflator to facilitate easy annual updating of the estimates.

6 SUMMARY AND RECOMMENDATIONS

This report summarizes the authors' study to support the revision of the World Bank assessment of nonwood forest wealth. The authors first identified, reviewed, and summarized global literature on forest ecosystem valuation. Then, they used meta-regression estimations to develop predictive models for four distinct ecosystem services: recreation, NWFPs, water services, and habitat and species protection. Thereafter, using the meta-regression estimation results, they developed localized estimates of the value of these forest ecosystem services for nearly 800,000 grid cells, each sized 10 km by 10 km, covering the world's forests. Finally, using these local predictions, they summarized the value of forest ecosystem services by country and ecosystem service, globally. They also compared alternative value predictions with estimates derived using the current World Bank assessment approach.

The proposed revision provides several improvements to the current methodology. For example, whereas the current approach uses estimates from a handful of select studies, the revised approach systematically and comprehensively searched, summarized, and statistically analyzed global literature on the valuation of forest ecosystem services. The revised assessment collects and analyzes data from a far greater number of studies than any previous forest valuation meta-analysis of which the authors are aware. While this study examined in the meta-regression 182 value estimates developed from 123 studies, the highest number of studies included in the previous forest meta-analyses is 65 (Ojea et al. 2010).[10] Moreover, of previous forest valuation meta-analyses, only Ojea et al. (2010 and Barrio and Loureiro (2010) take a global approach; other studies consider smaller geographic regions.

The revised approach addresses four ecosystem services: recreation, NWFPs, water services, and habitat and species protection. In addition, whereas the current approach uses globally uniform or near uniform values, the suggested revised approach is spatially explicit at high resolution. The meta-regression approach is designed to enable and improve value estimation outside areas commonly represented in the studies. The development of systematic measures of accessible forest areas for recreation and NWFPs also improves the current approach. Moreover, spatially explicit meta-analytic estimates of the value of nonwood forest ecosystem services do not yet exist in the literature, so the revised approach also more generally improves the informational basis for evaluations of forest management and conservation options.

This study has reported several alternative estimates to facilitate World Bank's determination of the revised methodology applicable to the comprehensive wealth assessment. One key decision concerns what ecosystem services should be included in the assessment. The inclusion of revised recreation and water services is justified as a direct update of the current methodology. The inclusion of NWFPs also seems justified as a possibly more comprehensive assessment of NWFPs than is feasible using the FAO data. The FAO data on NWFPs are missing for many countries; the quality and comprehensiveness of country-reported data are more generally limited; and the availability of comprehensive data on NWFPs from FAO in

10 Other previous forest meta-analyses include studies as follows: 26 studies by Zanderson and Tol (2009); 28 studies by Lindhjem (2007); 30 studies by Bateman and Jones (2003); and 35 studies by Barrio and Loureiro (2010).

the future is unlikely. With the help of the revised estimates of NWFPs, the assessment could increase the coverage of wealth estimates to countries that current lack data.

The inclusion of habitat and species protection in the wealth assessment is more complicated. On one hand, it is an economically valuable service currently excluded. On the other hand, if the wealth assessment requires consistency with current approaches to environmental accounting, then the inclusion of habitat and species protection values deserves yet additional consideration. The valuation estimates for habitat and species protection address may include values not directly applicable in the context of current environmental accounting practices.

Beyond the needs of the comprehensive wealth assessment, the new estimates of the value of forest ecosystem services are more broadly informative for the World Bank (and other organizations). For example, spatial estimates of the value of forest ecosystem services can support project design and evaluation, land use planning, and conservation assessments developed by the World Bank and other international agencies, as well as any similar assessments by government and nongovernment agencies in different countries and around the world. So far, ecosystem service assessments typically rely on either globally uniform or near uniform value estimates or, alternatively, develop more customized estimates from the current literature. The advantage of the new estimates is that they draw information from all forest valuation literature and develop estimates that are locally relevant, but globally consistent.

On the whole, the scope of improvements provided by the revised assessment is substantial. Regardless, as any meta-analysis, this assessment depends on the current literature, including the quality of studies and the coverage of the literature geographically and by ecosystem service. The objective here was to thoroughly search and assessing current valuation literature. For example, many studies were excluded for various limitations and lack of applicability in the context of this assessment. However, the studies included in the assessment are not without limitations, neither individually nor as a group. Individually, each study represents a certain context and methodological approach, neither one of which typically perfectly coincided with the goals of this assessment. Moreover, as a group, the existing body of the forest ecosystem service valuation literature was not developed with the goal of achieving any geographic representation, neither regionally nor globally.

As a consequence, the availability of information on specific ecosystems and ecosystem services varies greatly. As a general observation, the authors note that the number of valuation studies from the developing countries is limited, and some services, such as water related benefits, are studied relatively infrequently. On the other hand, information on the value of forest recreation, hunting, and fishing in developed countries is relatively rich, and so is information on the value of forests for habitat and species protection. The meta-regression approach is designed to produce estimates that are informative outside the study sites examined by the current literature. Regardless, any wholesale limitations in the geographic coverage of the current literature necessarily also limit the robustness of meta-analytic predictions in areas outside the literature. Gaps in the current literature could help guide future research on the basis of where it could provide most informative inputs to support forest ecosystem service valuation in general.

REFERENCES

Akaike, H. 1974. "A New Look at the Statistical Model Identification" (PDF), *IEEE Transactions on Automatic Control* 19 (6): 716–723.

Akaike, H. 1981. "Likelihood of a Model and Information Criteria." *Journal of Econometrics*, 16(1), 3–14.

Barrio, M., and Loureiro, M.L. 2010. "A Meta-analysis of Contingent Valuation Forest Studies." *Ecological Economics* 69: 1023–1030.

Bergh, J. C. J. M., K. J. Button, P. Nijkamp, and G. C. Pepping. 1997. *Meta-analysis in Environmental Economics* (Vol. 12). Springer Science & Business Media.

BirdLife International and NatureServe. 2013. *Bird Species Distribution Maps of the World.* Cambridge, UK: BirdLife International; Arlington, VA: NatureServe.

Brander, L. M., Florax, R. J., & Vermaat, J. E. 2006. The empirics of wetland valuation: a comprehensive summary and a meta-analysis of the literature. Environmental and Resource Economics, 33(2), 223–250.

(CIESIN) Center for International Earth Science Information Network — Columbia University, (FAO) United Nations Food and Agriculture Programme, and (CIAT) Centro Internacional de Agricultura Tropical. 2005. *Gridded Population of the World*, Version 3 (GPWv3): Population Density Grid. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC).

(CIESIN) Center for International Earth Science Information Network – Columbia University, (IFPRI) International Food Policy Research Institute—The World Bank, and (CIAT) Centro Internacional de Agricultura Tropical. 2011. Global Rural-Urban Mapping Project, Version 1 (GRUMPv1): Urban Extents Grid. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://sedac.ciesin.columbia.edu/data/set/grump-v1-urban-extents.

(CIESIN) Center for International Earth Science Information Network — Columbia University, and (ITOS) Information Technology Outreach Services — University of Georgia. 2013. Global Roads Open Access Data Set, Version 1 (gROADSv1). Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). http://dx.doi.org/10.7927/H4VD6WCT.

Chiabai A., et al. 2010. "Economic Assessment of Ecological Services in Tropical forests: Potential for Conservation Policies in Central America." Document prepared to the 2010 ISEE Conference: Bremen, GE.

Chiabai, A., et al. 2011. *"Economic Assessment of Forest Ecosystem Services Losses: cost of Policy Inaction." Environmental Resource Economics.* DOI: 10.1007/s10640-011-9478-6

Chiabai, A., et al. 2009. *Economic Valuation of Forest Ecosystem Services: Methodology and Monetary Estimates*. Venice, IT: Fondazione Eni Enrico Mattei.

Efron, Bradley, and Robert J. 1994. *Tibshirani. An Introduction to the Bootstrap.* CRC press.

Environmental Valuation Reference Inventory. 2013. Retrieved from: https://www.evri.ca/Global/HomeAnonymous.aspx

Food and Agriculture Organization. *FAOSTAT-Forestry, Joint Forest Sector Questionnaire*. Retrieved from http://faostat.fao.org/Portals/_Faostat/documents/pdf/FAOSTAT-Forestry-def-e.pdf

———. *FAOSTAT-Forestry*. Retrieved from http://faostat3.fao.org/home/index.html

_____. 2000. *Global Forest Resources Assessment (FRA)*. Rome: FAO.

_____. 2005. *Global Forest Resources Assessment (FRA)*. Rome: FAO.

_____. 2010. *Global Forest Resources Assessment (FRA)*. Rome: FAO.

_____. 1997. *State of the World's Forests, 1997*. Rome: FAO.

Hansen M., S. Stehman, and P. Potapov. 2010. Quantification of Global Gross Forest Cover Loss. Proceedings of the National Academy of Sciences of the U.S.A.

Hansen et al. 2013. *High-Resolution Global Maps of 21st-Century Forest Cover Change*. Science 342: 850–853.

IUCN. 2012. IUCN Red List of Threatened Species. Version 2012.1. http://www.iucnredlist.org.

Kindermann, G., et al. 2008. "Global Cost Estimates of Reducing Carbon Emissions through Avoided Deforestation." *Proceedings of the National Academy of Sciences* 105(30):10302–10307.

Kuik, Ghermandi and Brander. 2009. *The Value of Wetland Ecosystem Service in Europe: An Application of GIS and Meta-Analysis for Value Transfer*. Retrieved from: http://www.webmeets.com/files/papers/EAERE/2009/448/Value_transfer_and_GIS_EAERE.pdf

Lampietti, J., and J. Dixon. 1995. *To See the Forest for the Trees: A Guide to Non-Timber Forest Benefits*. Environment Department Papers, No. 13. Washington, DC: World Bank.

Lehner, B., and Döll, P. 2004. "Development and validation of a global database of lakes, reservoirs and wetlands. Journal of Hydrology 296/1–4: 1–22.

Lindhjem, H. 2007. 20 years of stated preference valuation of non-timber benefits from Fennoscandian forests: A meta-analysis. Journal of Forest Economics, 12(4), 251–277.

Loomis, J.B., and D. S. White. 1996. "Economic Benefits of Rare and Endangered Species: Summary and Meta-analysis." *Ecological Economics* 18: 197–206.

Nelson, J. P., and P. E. Kennedy. 2009. "The Use (and Abuse) of Meta-analysis in Environmental and Natural Resource Economics: An Assessment." *Environmental and Resource Economics,* 42(3), 345–377.

Ojea, E., and A. Chiabai. 2010. *Benefits from the Recreation Service of Tropical Central American Forests*. Document prepared to the 2010 ISEE Conference: Bremen, GE.

Ojea, E., J. Martin-Ortega, and A. Chiabai. 2012. "Defining and Classifying Ecosystem Services for Economic Valuation: The Case of Forest Water Services." *Environmental Science and Policy* 19–20: 1–15.

Saatchi, S. S., N. L. Harris, S. Brown, M. Lefsky, E. T. Mitchard, W. Salas, A. Morel, and et al. 2011. "Benchmark Map of Forest Carbon Stocks in Tropical Regions across Three Continents." *Proceedings of the National Academy of Sciences*, *108*(24), 9899–9904.

Schaafsma, M. et al. 2011. *The Importance of Local Forest Benefits: Valuation of non-timber forest products in the Eastern Arc Mountains in Tanzania*. Centre for Social and Economic Research on the Global Environment, Working Paper. University of East Anglia: Norwich, UK.

Schwarz, Gideon E. 1978. "Estimating the Dimension of a Mode." *Annals of Statistics* 6 (2): 461–464

Shrestha, R. K., and J. B. Loomis. 2001. *Testing a meta-analysis model for benefit transfer in international outdoor recreation*. Ecological Economics 39: 67–83.

Simpson, R. D., R. Sedjo, and J. Reid. 1996. "Valuing Biodiversity for Use in Pharmaceutical Research." *Journal of Political Economy* 104(1): 163–85.

Smith V.K, and Y. Kaoru. 1990. "What have we learned since Hotelling's letter? A meta-analysis." *Economics Letters* 32:267–272.

The Economics of Ecosystems & Biodiversity (TEEB). 2013. Retrieved from: http://www.teebweb.org/

UCLouvain and ESA. 2011. Globcover 2009.

UNEP-WCMC. 2012. *Data Standards for the World Database on Protected Areas*. Cambridge, UK: UNEP-WCMC.

Van der Ploeg, S., R.S de Groot and Y. Wang. 2010. *The TEEB Valuation Database: overview of structure, data and results*. Wageningen, the Netherlands: Foundation for Sustainable Development.

Vedeld, P., et al. 2007. "Forest Environmental Incomes and the Rural Poor" *Forest Policy and Economics 9*: 869–879.

WorldClim Global Climate Data. Data for current conditions (~1950–2000). Accessed from: http://www.worldclim.org/current.

World Bank. 2013. *Annex 1: Methodology for Estimating Forest Wealth*.

———. 2013. *Living Standards Measurement Study*. Retrieved from: http://econ.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/0,,contentMDK:21478196~menuPK:3359066~pagePK:64168445~piPK:64168309~theSitePK:3358997,00.html

———. 2013. *Living Standards Measurement Study: Integrated Surveys on Agriculture*. Retrieved from: http://web.worldbank.org/WBSITE/EXTERNAL/EXTDEC/EXTRESEARCH/EXTLSMS/EXTSURAGRI/0,,menuPK:7420268~pagePK:64168427~piPK:64168435~theSitePK:7420261,00.html

———. 2011. *The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium*. Washington, DC: World Bank.

Zandersen, M., M. Termansen, and F. S. Jensen. 2007. "Testing Benefits Transfer of Forest Recreation Values over a Twenty-Year Time Horizon." *Land Economics* 83 (3): 412–440.

Zandersen, M., & Tol, R. S. 2009. A meta-analysis of forest recreation values in Europe. Journal of Forest Economics, 15(1), 109–130.

APPENDIX I: CURRENT NONWOOD FOREST WEALTH ASSESSMENT METHODOLOGY

OVERVIEW

The current World Bank methodology for estimating nonwood forest wealth (NWFW) values the following products and services:

1. Watershed protection
2. Recreation, hunting, and fishing
3. Nonwood forest products.

NWFW is calculated as the sum of the present value of these annual goods and services over 25 years, using a 4 percent discount rate. Benefits are based on per hectare values of the good or service derived from the literature. The per-hectare benefit estimates are multiplied by the relevant forest area to obtain the total value for each service, by country. Data on forest area are obtained from FAO's Global Forest Resource Assessment (FRA).

More specifically, the following formula estimates the value of nonwood benefit *i* for country *c* in year *t*:

$$TNFW_{ct} = \Sigma_{1} \Sigma_{t}^{T} \frac{NWFW_{cti}}{(1+r)^{t}}$$

where *TNFW* = total non-wood forest wealth ($) in country *c* and year *t;*

NWFW is the annual value of non-wood good or service *i* ($);
r is the discount rate (4 percent); and
T is the time horizon of asset valuation (25 years).

Next, the assessment methodologies by each ecosystem service are considered.

WATERSHED SERVICES

The value of watershed protection provided by forests for country ***c*** in year ***t*** is estimated using the following formula:

$$NWFW_{ct,i=watershed} = A_{ct} * V_{ct,i=watershed}$$, where

- *NWFW* is the total benefits ($),
- *A* is total forest area (ha), and
- *V* is the annual benefit per hectare from watershed protection ($10/ha).

The assessment uses a constant annual benefit per hectare (*V*), globally. It is estimated at $10/ha (1995 U.S. dollars) and taken directly from a review by Lampietti and Dixon (1995). Using a GDP deflator, the $10/ha value is adjusted to the year of the assessment. The estimate also takes into account annual deforestation rate (2005–2010) by taking into account changes in the forest area, assuming that the current rate of change remains constant over time.

The $10/ha value adopted by the current assessment is the median value of the four studies—ranging from $1 to $30/ha—which are reviewed in Lampietti and Dixon (1995) and contain sufficient information to calculate the value on a per hectare basis. These studies (and their year of publication and study location) include Magrath and Arens (1989, Java), Cruz et al. (1988, the Philippines), Ruitenbeek (1989, Cameroon), and Johnson and Kolavalli (1984, Thailand). Each of the four studies above examines watershed protection through erosion and sedimentation control.

The scoping study notes that the value estimate ($10 per hectare) is outdated (Siikamäki and Santiago-Ávila 2014). There are numerous, more recent, valuation studies that could be used to improve the estimate. Moreover, the scoping study notes that advances in nonmarket valuation, in particular, meta-analyses could provide a better approximation of the value of such benefits. Additionally, geographic differences in the value of watershed services could arise from many sources, such as differences in geography, hydrology, forests, and local water usage. Using a globally uniform value per hectare ignores all potentially substantial geographic variation in the value.

RECREATION, HUNTING, AND FISHING

Value estimates for benefits from recreation, hunting, and fishing for country ***c*** in year ***t*** are derived using the following formula:

$$NWFW_{ct,i=recfishhunt} = \left(0.10 * A_{ct}\right) * V_{ct,i=recfishhunt}\text{, where}$$

- *NWFW* is total value of services ($)
- *A* is total forest area (ha)
- *V* is the annual benefit per hectare from recreation, hunting, and fishing ($/ha).

As with watershed protection, the assessment uses a constant value per hectare, also based on Lampietti and Dixon (1995). However, values are different for developed and developing countries ($119/ha and $17/ha, respectively, in 1995 U.S. dollars, see below).

Lampietti and Dixon use six studies (one in Venezuela, three in Africa, and two in Malaysia) to estimate the value of hunting in developing countries. Their median value estimate is $5/ha/year. Three studies (in Mexico, Kenya and Costa Rica) were used to estimate the recreational benefits in developing countries, with a median value of $12 per hectare per year. Summing up the median values, estimated benefits from recreation and hunting total $17 per hectare per year for developing countries.

For developed countries, only one study (from the United States) was used for hunting value (Johnson and Linder 1986) since it was the only one that contained information on a per hectare basis. This study calculated the value of hunting at $64 per hectare per year. Recreational benefits value estimates for developed countries were taken from Walsh et al. (1989) (United States) and amounted to $55 per hectare per year, bringing the total benefits from recreation and hunting in developed countries to $119 per hectare per year. Both these values (in 1995 U.S. dollars) are adjusted using a GDP deflator.

Finally, one-tenth of the total forest area is assumed to be available for recreation in each country, so the formula multiplies total forest area by 0.10.

The current valuation approach for recreation, hunting, and fishing suffers from similar problem as the valuation of watershed services. The estimate is based on nine studies in developing countries (six for hunting value and three for recreation value) and only two studies (one for recreation and hunting each, both from the United States) in developed countries. There are numerous more recent valuation studies for these types of services that could be used, together with more advanced econometric methods, to provide more representative value estimates for these services. In addition, the assumption of the amount of forest area available for recreation (10 percent of the forest area) is not supported by any study and could easily vary by country.

NONWOOD FOREST PRODUCTS

Nonwood forest products (NWFPs) "consist of goods of biological origin other than wood, as well as services, derived from forests and allied land uses" (FRA 2010). They include forest plant products harvested for food (which consist mostly of oil seeds, nuts and bamboo shoots) tanning extract and raw lacquer, and raw materials for medicinal and aromatic uses.

In the current assessment, the annual value for NWFPs is taken directly from FAO's Forest Resource Assessment (FRA), which is published every five years. Because these data are country reported, their adequacy is determined in part by the priority given to the NWFP s in each country, as well as the human and financial resources in the national statistics institutions in charge of collecting and analyzing the data (FRA 2010). Because of these limitations, FAO no longer plans to comprehensively consider NWFPs in future FRAs.

SUMMARY OF DATA SOURCES

Table A-1 summarizes the key variables currently required for producing the nonwood wealth estimates. Data on total forest area come from FAO's FRA, which is typically updated every five years. Data on the value of NWFPs similarly come from the FAO. Estimates on the per-hectare value of forests in recreation, hunting, and fishing and in watershed protection come from a literature review by Lampietti and Dixon (1995), as discussed above.

TABLE A-1. SUMMARY OF CURRENT KEY VARIABLES AND DATA SOURCES

VARIABLE	UPDATE FREQUENCY	COVERAGE	SOURCE
Total Forest Area (ha)	Updated every five years	All countries	FAO FRA
Value of nonwood forest products (e.g. oil seeds, nuts, raw materials; presented in monetary value)	Updated every five years	All countries	FAO FRA
Estimated benefits from recreation, hunting, fishing (in dollars per hectare per year)	Based on a literature review; not updated	Developed country average; developing country average	Lampietti and Dixon (1995)
Estimated watershed protection benefits (in dollars per hectare per year)	Based on a literature review; not updated	Globally uniform (median)	Lampietti and Dixon (1995)

APPENDIX II: STUDY REVIEW QUALITY CONTROL/QUALITY ASSURANCE PROTOCOL

The authors implemented several steps of quality assurance/quality control (QA/QC) to help develop robust and consistent summaries of studies included in the database.

One of the primary QA/QC protocols involved a duplicate review of each study by another reviewer. The second reviewer evaluated and confirmed information developed and recorded in the first review. When discrepancies appeared, they were resolved using discussion among the team.

In addition, each reviewer noted any missing details or questions relevant in the context of each study. The reviewers also recorded the method to develop each value estimate, including details on any calculations and external data required.

Moreover, the group of researchers developing the database (three research assistants and the PI) met at least twice a week, each time typically for several hours, to review and examine studies and to discuss any complications or open questions. The purpose of the group meetings was to maximize consistency of different reviews and enable learning within the group. In addition to the meetings, each study review and value estimate was discussed, evaluated, and potentially revised jointly by the reviewer and PI.

Finally, at the conclusion of the literature reviews and database development, the value database and all variables constructed to support the analysis were once more reviewed and finalized in collaboration between the PI and the research assistant primarily responsible for a specific study/value. This helps ensure that all the study characteristics in the database are consistently and comprehensively developed and recorded.

As a result of multiple reviews and revisions, each study and value estimate was subject to a high degree of scrutiny. The overall QA/QC efforts were substantial, but necessary in developing consistent and comprehensive data from a large number of studies that do the following: address many different value end points and study areas; use a wide variety of methodological approaches; report study details and estimates in different ways; include varying degrees of relevant details; and were developed under study goals typically considerably different from the goals of this assessment.

APPENDIX III: CURRENCY CONVERSION

DETERMINING THE YEAR OF VALUE ESTIMATES

Information on the currency and currency year of the value estimate enables the use of deflators to develop comparable estimates from multiple study years and countries across the world. When recording the year of valuation, the authors searched for the currency year of value estimate from the publication. If the year was not listed, they searched for information on the year of data collection and used it for the year of currency.

If neither approach yielded the year, the authors approximated when the publication was prepared. However, they did not necessarily use the year of publication for the year of value. Instead, they looked for, for example, the year of initial submission, which is often listed for journal articles. Using the initial submission date and assuming a typical lag between data collection and manuscript preparation, they listed the year of currency as the year of the submission or the year before the submission. If the initial submission of a journal article was during the first six months of the year (for example, February 2001), and the study listed no information on the year of the currency, then they recorded the year before as the currency year (2000). But for studies submitted in the last six months of the calendar year, they recorded the calendar year of the submission as the currency year. Note that these imputations are necessary only for studies that list no information to more precisely determine the year of the currency (not a common occurrence).

CONVERSION OF VALUES INTO INTERNATIONAL DOLLARS

The authors use the year 2013 purchasing power parity (PPP) adjusted U.S. dollars, often referred to as "international dollar," for the common denomination of value estimates. When the original value estimates were in local currency units (LCU), they used PPP-adjusted exchange rates to convert the values into dollars. PPP-adjusted exchanges rates make estimates from different countries comparable as economic values.[11]

The original value estimates come from many years and in many currencies. When the original value estimate is in LCU, the authors first used a local GDP deflator to express the value in the year 2013 LCU. This value was then converted to international dollars by using a PPP conversion factor.[12]

Several studies address values in LCU but use USD in reporting the results. However, these estimates are typically not PPP-adjusted but use a conversion based on currency exchange rate. To ensure consistent use of PPP adjusted estimates, the authors first converted any original, non-US estimates expressed in dollars back into LCU, using either the exchange rate reported in the publication or, in its absence, the reported exchange rate for the year of value estimates. The currency conservation was then conducted similarly as for value originally listed in LCU.

11 The authors use GDP and PPP information from the World Bank (World Development Indicators, http://databank.worldbank.org).

12 For example, consider an original estimate 13.54 in Peruvian sols in 2008. The GDP deflator value is 225 in 2012 and 171 in 2008, so the authors convert the value into 2012 LCU as 13.54 sols*225/171=17.81 sols. The PPP adjusted exchange rate is 1 international $ = 1.89 sols. The final value estimate is, therefore, 17.81 sols/1.89 = 9.43 international dollars (2012).

Finally, PPP conversion factors are not available for a few countries. For them, the authors first deflated the value into 2013 using a local GDP deflator and then adjusted the 2013 LCU value into international dollars using a regionally averaged PPP conversion factor (using UN subregions as regions).

CONVERSION INTO VALUE PER HECTARE PER YEAR

In general, the authors convert all value estimates into international dollars per hectare per year (2013 U.S. dollars). When the original value estimates were expressed in other units, they converted them into per hectare per year values. For example, if the original value estimate addressed recreational benefits in a specific area of forest, expressed on value per visit basis, they used information on the number of annual visitors to estimate total annual benefits from the forest. Then, they used the total forest area to estimate recreation benefits per year per hectare.

Some studies list value estimates in net present value (NPV). If the study listed the discount rate and the time horizon used in the NPV calculation, the authors converted it to annual value using the following relationship:

$$\text{Annual value } \frac{NPV}{A_{t,r}},\ where\ A_{t,r} = \frac{1-\left(\frac{1}{1+r}\right)^{t}}{r}$$

When the original value was listed in NPV but no information was given on the applicable discount rate and time horizon, the authors used the World Bank wealth assessment assumptions (4 percent discount rate, 30-year time horizon) to convert the value into annual terms. There are very few cases for which this was necessary.

APPENDIX IV. META-REGRESSION ESTIMATION RESULTS BY ECOSYSTEM SERVICE, WITH MODEL SPECIFICATION SELECTED FOR GLOBAL PREDICTIONS HIGHLIGHTED

RECREATION

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	log_value	log_value	log_value	log_value	log_value	log_value	log_value	log_value
Ln(pop. density)		0.611*** (0.0867)		0.562*** (0.0875)	0.564*** (0.0902)	0.655*** (0.143)	0.424*** (0.124)	0.560*** (0.0883)
Ln(GDP)		0.113 (0.216)		0.566** (0.274)	0.552* (0.276)	0.425 (0.354)	0.419 (0.272)	–2.326 (2.419)
Temperature			0.0493 (0.0445)	0.0178 (0.0461)	0.0167 (0.0465)	–0.0451 (0.0568)	0.0854 (0.0808)	0.0194 (0.0468)
Ln(species richness)			0.657 (0.461)	1.133** (0.458)	1.112** (0.474)	1.729*** (0.491)	1.337*** (0.500)	1.175** (0.461)
Africa						–9.787*** (3.590)		
America						–9.631** (4.216)		
Asia						–9.881** (4.215)		
Europe						–9.341** (4.225)		
Oceania						–7.668* (4.356)		
Protected					0.121 (0.457)			
Journal					–0.231 (0.515)			
Boreal							–7.997** (3.409)	
Temperate							–7.725** (3.481)	
Tropics							–9.535** (3.950)	
$Ln(GDP)^2$								0.166 (0.143)
Constant	4.480*** (0.282)	1.385 (2.073)	0.631 (1.797)	–8.375** (3.601)	–8.048** (3.663)			3.694 (9.911)

(*continued on next page*)

RECREATION (*continued*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	log_value	log_value	log_value	log_value	log_value	log_value	log_value	log_value
Observations	86	86	86	86	86	86	86	86
R-squared	0.000	0.357	0.142	0.480	0.483	0.900	0.898	0.489
BIC	388.753	359.641	384.457	350.332	358.700	363.459	356.288	353.283
AIC	386.299	352.278	377.094	338.060	341.520	341.370	339.107	338.557
Out of sample RMSE (cross-validated)	2.290	1.883	2.178	1.777	1.844	1.840	1.795	1.809
Out of sample MAE (cross-validated)	1.860	1.429	1.735	1.333	1.385	1.397	1.387	1.389

Robust standard errors in parentheses.
*** p < 0.01, ** p < 0.05, * p < 0.1.

HABITAT/SPECIES PROTECTION

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	log_value	log_value	log_value	log_value	log_value	log_value	log_value	log_value	log_value
Ln(pop. density)		0.342 (0.215)			0.628** (0.256)	0.590* (0.298)	0.605** (0.283)	0.634** (0.244)	0.643** (0.252)
Ln(GDP)		1.353 (0.828)			1.463 (0.936)	0.180 (0.837)	1.447 (1.009)	16.03* (9.340)	1.655** (0.694)
Temperature			–0.113 (0.0715)	–0.0415 (0.0646)	–0.214** (0.0958)	–0.256*** (0.0904)	–0.188 (0.146)	–0.270*** (0.0964)	–0.234*** (0.0809)
Ln(species richness)			1.019 (0.641)	1.573** (0.638)	2.215*** (0.751)	1.038 (0.837)	2.243*** (0.780)	1.984** (0.820)	2.145*** (0.770)
Ln (abs [latitude])				1.235** (0.542)	0.331 (0.636)	–1.340** (0.553)	0.211 (0.803)	–0.543 (0.783)	
Africa						–5.288 (8.152)			
America						4.188 (10.19)			
Asia						4.624 (10.09)			
Europe						3.899 (10.48)			
Oceania						5.445 (10.30)			
Boreal							–20.06** (9.147)		
Temperate							–20.30** (8.803)		
Tropics							–21.07** (9.283)		

(*continued on next page*)

HABITAT/SPECIES PROTECTION (*continued*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	log_value	log_value	log_value	log_value	log_value	log_value	log_value	log_value	log_value
$Ln(GDP)^2$								–0.799 (0.508)	
Constant	4.659*** (0.416)	–9.555 (8.496)	1.131 (2.525)	–6.451* (3.520)	–20.60** (9.351)			–81.43** (39.74)	–20.85** (8.799)
Observations	54	54	54	54	54	54	54	54	54
R-squared	0.000	0.150	0.046	0.131	0.300	0.885	0.837	0.342	0.296
BIC	259.259	258.475	264.709	263.262	259.945	256.721	267.763	260.616	256.240
AIC	257.270	252.508	258.742	255.671	248.012	236.831	251.851	246.693	246.295
Out of sample RMSE (cross-validated)	2.633	2.702	2.727	2.697	2.619	2.623	2.734	2.863	2.504
Out of sample MAE (cross-validated)	2.065	2.094	2.050	2.078	2.024	2.150	2.151	2.072	1.920

Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

NONWOOD FOREST PRODUCTS

	(1)	(2)	(3)	(4)
VARIABLES	log_value	log_value	log_value	log_value
Ln(pop. density)		0.344** (0.165)	0.688*** (0.136)	0.702*** (0.211)
Ln(GDP)		–0.334 (0.275)	–0.919*** (0.228)	–0.958*** (0.245)
Africa			5.812** (2.216)	–4.327*** (1.411)
America			10.87*** (2.046)	0.759 (1.396)
Asia			7.864*** (2.461)	–2.331** (0.984)
Europe				—
Oceania			—	—
Boreal				10.67*** (2.590)
Temperate				10.36*** (2.680)
Tropics				11.05*** (2.526)
Europe			10.44*** (2.488)	
Constant	3.545*** (0.459)	5.112* (2.692)		

(*continued on next page*)

NONWOOD FOREST PRODUCTS (*continued*)

	(1)	(2)	(3)	(4)
VARIABLES	log_value	log_value	log_value	log_value
Observations	30	30	30	30
R-squared	0.000	0.210	0.882	0.884
BIC	138.337	138.079	127.780	134.239
AIC	136.936	133.875	119.373	123.029
Out of sample RMSE (cross-validated)	2.377	2.226	1.729	2.058
Out of sample MAE (cross-validated)	1.931	1.741	1.316	1.575

Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

WATER SERVICES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	log_value	log_value	log_value	log_value	log_value	log_value	log_value
Log_popd		–0.857 (0.533)	–0.830* (0.428)	–0.753 (0.450)	–1.112 (0.705)		
Log_GDP		2.228*** (0.689)	3.008*** (0.871)	9.767 (6.325)	9.036 (7.974)	2.718** (1.026)	13.32* (6.797)
Africa					–45.90 (35.86)		
America					–46.05 (38.52)		
Asia					–42.27 (37.80)		
Europe					–46.17 (38.81)		
Oceania					—		
Log_GDP^2				–0.399 (0.354)	–0.354 (0.408)		–0.623 (0.380)
Boreal			–25.02** (9.565)	–52.53* (29.12)		–25.90** (10.69)	–68.74** (30.59)
Tropics			–20.46** (7.747)	–49.08 (28.98)		–20.96** (8.682)	–65.61* (30.52)
Temperate			–20.84** (9.017)	–49.04 (29.10)		–21.71* (10.14)	–65.64* (30.48)
Constant	2.485** (0.909)	–14.12** (5.695)					
Observations	16	16	16	16	16	16	16
R-squared	0.000	0.478	0.754	0.763	0.812	0.688	0.712
BIC	87.131	82.270	82.734	84.897	83.953	83.725	85.225

(*continued on next page*)

WATER SERVICES (*continued*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	**log_value**	**log_value**	**log_value**	**log_value**	**log_value**	**log_value**	**log_value**
AIC	86.358	79.952	78.871	80.262	78.545	80.635	81.362
Out of sample RMSE (cross-validated)	3.597	3.085	2.830	2.915	3.242	2.873	2.861
Out of sample MAE (cross-validated)	2.853	2.612	2.432	2.475	2.724	2.254	2.173

Robust standard errors in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

APPENDIX V. LIST OF STUDIES INCLUDED, EXCLUDED, AND NOT ACCESSED

INCLUDED STUDIES

1. Adams, C., et al. 2008. "The Use of Contingent Valuation for Evaluating Protected Areas in the Developing World: Economic Valuation of Morro do Diabo State Park, Atlantic Rainforest, São Paulo State (Brazil). *Ecological Economics* 66(2): 359–370.
2. Adger, W.N., et al. 1995. "Toward Estimating Total Economic Value of Forests in Mexico." Working Paper 94–21, Centre for Social and Economic Research on the Global Environment: University of East Anglia and University College, London.
3. Amirnejad, H. et al. 2006. "Estimating the Existence Value of North Forests of Iran by Using a Contingent Valuation Method." *Ecological Economics* 58(4): 665–675.
4. Ammour, T., et al. 2000. "Economic Valuation of Mangrove Ecosystems and Subtropical Forests in Central America." In *Sustainable Forest management and Global Climate Change," eds. Dore M. and R. Guevara*. UK: Edward Elgar Publishing.
5. Banzhaf, H.S., et al. 2014. "Valuation of Ecosystem Services in the Southern Appalachian Mountains." RFF Discussion Paper. September 2014.
6. Barreiro-Hurle, J., and J. A. Gomez-Limon. 2007. "Reconsidering Heterogeneity And Aggregation Issues In Environmental Valuation: A Multi-attribute Approach." *Environmental and Resource Economics* 40(4): 551–570.
7. Barrick, K.A., and R.I. Beazley. 1990. "Magnitude and Distribution of Option Value for the Washakie Wilderness, Northwest Wyoming, USA." *Environmental Management* 14(3): 367–380.
8. Batagoda, B.M.S., et al. 2000. "Towards Policy Relevant Ecosystem Services and Natural Capital Values: Rainforest Nontimber Products." CSERGE Working Paper CEC 2000–06: University of East Anglia, UK.
9. Bateman, I.J., et al. 1996. "Measurement Issues in the Travel Cost Method: A Geographical Information Systems Approach." *Journal of Agricultural Economics* 47(1–4): 191–205.
10. Beal, D.J. 1995. "A Travel Cost Analysis of the Value of Carnarvon Gorge National Park for Recreational Use." *Review of Marketing and Agricultural Economics* 63(2): 292–303.
11. Bellu L.G. and V. Cistulli. 1997. "Economic valuation of forest recreation facilities in the Liguria Region (Italy)." Working paper GEC 97–08: Centre for Social and Economic Research on the Global Environment, Norwich, UK.
12. Bernard, F., et al. 2009. "Valuation of Tropical Forest Services and Mechanisms to Finance their Conservation and Sustainable Use: A case study of Tapantí National Park, Costa Rica." *Forest Policy and Economics* 11(3): 174–183.
13. Bestard, A.B. and A.R. Font. 2010. "Estimating the Aggregate Value of Forest Recreation in a Regional Context." *Journal of Forest Economics* 16(3): 205–216.
14. Boman, M., et al. 2008. "On the Budget for National Environmental Objectives and Willingness to Pay for Protection of Forest Land." *Canadian Journal of Forest Research* 38(1): 40–51.
15. Bostedt, G. and L. Mattsson. 1995. "The Value of Forests for Tourism in Sweden." *Annals of Tourism Research* 22(3): 671–680.
16. Boxall, P.C., et al. 1999. "Valuing Wilderness Recreation: A Demand Systems Approach in the Canadian Shield." Information Report NOR-X-361: Canadian Forest Service, Northern Forestry Center, Canada.

17. Broberg, T. 2007. "Assessing the Non-Timber Value of Old-Growth Forest in Sweden." *Umeä Economic Studies*, vol. 712: Department of Economics, Umeå University.
18. Bujosa A., and A. Riera. 2010. "Estimating the Aggregate Value of Forest Recreation in a Regional Context." *Journal of Forest Economics* 16(3): 205–216.
19. Chase, L.C. et al. 1998. "Ecotourism Demand and Differential Pricing of National Park Access in Costa Rica." *Land Economics* 74(4): 466–482.
20. Chopra, K. 1993. "The Value of Nontimber Forest Products: An Estimation for Tropical Deciduous Forests in India." *Economic Botany* 47(3): 251–257.
21. Clinch, J.P., 1999. "Economics of Irish Forestry: Evaluating the Returns to Economy and Society." COFORD: Dublin, Ireland.
22. Czajkowski, M. et al. 2009. "Valuing Changes in Forest Biodiversity." *Ecological Economics* 68(12): 2910–2917.
23. de Beer, J.H., and M.J. McDermott. 1989. "Economic Value of Non-timber Forest Products in South-east Asia." The Netherlands: Council for the International Union of the Conservation of Nature.
24. De la Cruz, A. and J. Benedicto. 2009. "Assessing Socio-economic Benefits of Natura 2000: A Case Study on the Ecosystem Service Provided by SPA PICO DA VARA / RIBEIRA DO GUILHERME. Output of the project Financing Natura 2000: Cost Estimate and Benefits of Natura 2000."
25. Delang, C. 2006. "Not just Minor Forest Products: The Economic Rationale for the Consumption of Wild Food Plants by Subsistence Farmers." *Ecological Economics* 59(1): 64–73.
26. Driml, S. 2002. "Travel Cost Analysis of Recreation Value in the Wet Tropics World Heritage Area." *Economic Analysis and Policy* 32(2): 11–26.
27. Dubgaard, A. 1998. "Economic Valuation of Recreational Benefits from Danish Forests." In: "The economics of Landscapes and Wildlife Conservation," eds. Dabbert, S., A. Dubgaard and M. Whitby. CAB International: 53–64.
28. Duthy, S. 2002. "Whian Whian–State Forest or National Park: Community attitudes and economic values." *Economic Analysis and Policy* 32(2): 91–111.
29. Echeverria, J., et al. 1995. "Valuation of Nonpriced Amenities Provided by the Biological resources within the Monteverde Cloud Forest Preserve, Costa Rica." Ecological Economics 13(1): 43–52.
30. Emerton, L., and E. Muramira. 1999. "Uganda Biodiversity — Economic Assessment." Prepared with National Environment Management Authority, Kampala: IUCN, Gland, Switzerland.
31. Englin, J., and R. Mendelsohn. 1991. "A Hedonic Travel Cost Analysis for Valuation of Multiple Components of Site Quality: The Recreation Value of Forest Management." *Journal of Environmental Economics and Management* 21(3): 275–290.
32. Everett, R.D. 1979. "The Monetary Value of the Recreational Benefits of Wildlife." *Journal of Environmental Management* 8: 203–213.
33. Flatley, G., and J. Bennett. 1995. "International Values of Tropical Forest Conservation: A Cross-cultural Contingent Valuation Experiment." Paper presented to the 39th Australian Agricultural Economic Society Annual Conference: Perth, Australia.
34. Fredman, P., and L. Emmelin. 2001. "Wilderness Purism, Willingness to Pay and Management Preferences: A Study of Swedish Mountain Tourists." *Tourism Economics* 7(1): 5–20.
35. Garcia, S., et al. 2009. "Models for Sample Selection Bias in Contingent Valuation: Application to Forest Biodiversity." *Journal of Forest Economics* 15(1): 59–78.
36. Garrod, G.D., and K.G. Willis. 1997. "The Non-use Benefits of Enhancing Forest Biodiversity: A Contingent Ranking Study." *Ecological Economics* 21(1): 45–61.
37. Garrod, G.D., and K.G. Willis. 1997. "The Recreational Value of Tropical Forest in Malaysia." *Journal of World Forest Resource Management* 8(2): 183–201.

38. Goio, I., et al. 2008. "The Development of Forest Accounting in the Province of Trento (Italy)." *Journal of Forest Economics* 14(3): 177–196.
39. Gram, S. 2001. "Economic Valuation of Special Forest Products: An Assessment of Methodological Shortcomings." *Ecological Economics* 36(1): 109–117.
40. Greiner, R., and J. Rolfe. 2004. "Estimating Consumer Surplus and Elasticity of Demand of Tourist Visitation to a Region in North Queensland using Contingent Valuation." *Tourism Economics* 10(3): 317–328.
41. Grimes, A., et al. 1994. "Valuing the Rain forest: The Economic Value of Nontimber Forest Products in Ecuador." *Ambio* 23: 405–410.
42. Guo, Z., et al. 2001. "Ecosystem Functions, Services and their Values – A Case Study in Xingshan County of China." *Ecological Economics* 38(1): 141–154.
43. Hadker, N., et al. 1997. "Willingness-to-pay for Borivli National Park: Evidence from a Contingent Valuation." *Ecological Economics* 21(2): 105–122.
44. Halstead J.M., et al. 1991. "Use of Tobit Model in Contingent Valuation: Experimental Evidence from the Pemigewasset Wilderness Area." *Journal of Environmental Management* 33(1): 79–89.
45. Hanley, N. 1989. "Valuing Rural Recreation Benefits: An Empirical Comparison of two Approaches." *Journal of Agricultural Economics* 40(3): 361–374.
46. Haqen, D.A., et al. 1992. "Benefits of Preserving Old-growth Forests and the Spotted Owl." *Contemporary Economic Policy* 10(2): 13–26.
47. Hoen, H., and G. Winther. 1993. "Multiple Use Forestry and Preservation of Coniferous Forests in Norway." *Scandinavian Journal Forest Resource* 8(1–4): 266–280.
48. Houghton, K., and R. Mendelsohn. 1997. "An Economic Analysis of Multiple-use Forestry in Nepal." *Ambio* 25(3): 156–159.
49. Hutchinson, W., and S. Chilton. 1999. "Combining Preferences Ordering and Contingent Valuation Methods to Assess Nonmarket Benefit of Alternative Afforestation Projects." *Journal of Rural Studies* 15(1): 103–109.
50. Johansson, P.O. 1989. "Valuing public goods in a risky world: an experiment." In *Evaluation Methods and Policy Making in Environmental Economics,* eds. H. Folmer, E.C. van Ierland.: North-Holland, Amsterdam, pp. 39–48.
51. Kamanga, P., et al. 2009. "Forest Incomes and Rural Livelihoods in Chiradzulu District, Malawi." *Ecological Economics* 68(3): 613–624.
52. Kniivila, M., et al. 2002. "Costs and Benefits of Forest Conservation: Regional and Local Comparisons in Eastern Finland." *Journal of Forest Economics* 8(2): 131–150.
53. Kontoleon, A., and T. Swanson. 2003. "The Willingness to Pay for Property Rights for the Giant Panda: Can a Charismatic Species be an Instrument for Nature Conservation." *Land Economics* 79(4): 483–499.
54. Kramer, R.A., et al. 1995. "Valuing Tropical Forests: Methodology and Case Study of Madagascar." World Bank Environment Paper 13. Washington, DC: World Bank.
55. Kramer, R.A., et al. 1997. "Ecological and Economic Analysis of Watershed Protection in Eastern Madagascar." *Journal of Environmental Management* 49(3): 277–295.
56. Kriström, B. 1990. "Valuing Environmental Benefits using the Contingent Valuation Method." Umeå Economic Studies vol 219: Department of Economics, Umeå University.
57. Kumari, K. 1995. "An Environmental and Economic Assessment of Forest Management Options: A Case Study in Malaysia. No. 26." Environment Department. Washington, DC: World Bank.
58. Lehtonen, E. et al. 2003. "Nonmarket Benefits of Forest Conservation in Southern Finland." *Environmental Science and Policy* 6(3): 195–204.
59. Lockwood, M. et al. 1993. "A Contingent Valuation Survey and Benefit–cost Analysis of Forest Preservation in East Gippsland, Australia." *Journal of Environmental Management* 38(3): 233–243.
60. Loomis, J. et al. 1993. "Some Empirical Evidence on Embedding Effects in Contingent Valuation of Forest Protection." *Journal of Environmental Economics and Management* 25(1): 45–55.

61. Loomis, J. et al. 1996. "A Contingent Valuation Study of the Value of Reducing Fire Hazards to Old-Growth Forests in the Pacific Northwest." United States Department of Agriculture Forest Service Pacific Southwest Research Station Research Paper.
62. MacMillan, D.C., and E. I. Duff. 1998. "Estimating the Non-Market Costs and Benefits of Native Woodland Restoration Using the Contingent Valuation Method." *Forestry* 71(3): 247–259.
63. Maille, P., and R. Mendelsohn. 1993. "Valuing Ecotourism in Madagascar." *Journal of Environmental Management* 38(3): 213–218.
64. Mallawaarachchi, T., et al. 2001. "Community Values for Environmental Protection in a Cane Farming Catchment in Northern Australia: A Choice Modelling Study." *Journal of Environmental Management* 62(3): 301–316.
65. Mäntymaa, E. 2002. "Estimating the Demand for Biodiversity-vagueness Band and Open Ended Questions." In *Proceedings: Risk and Uncertainty in Environmental and Resources Economics*, eds. Ierland, Weikard, and Wesseler. Netherlands: Wageningen University.
66. Marikan, D. A., et al. 2006. "The Economics of Recreational Park Conservation: A Case Study of Bako National Park." Staff Paper 4/2006: Faculty of Economics and Management, University Putra Malaysia, Malaysia.
67. Marinelli, A., and D. Romano. 1987. "La Foresta Umbra: Criteri di scelta nell'impiego di una risorsa naturale ad uso multiplo." *Rassegna Economica* 51: 515–530.
68. Marinelli, A. et al. 1990. Valutazione economica dell'impatto aggregato e dei benefici diretti della ricreazione all'aperto di un parco naturale della Toscana. Genio Rurale 9: 51–58.
69. Matero, J., and O. Saastamoinen. 2007. "In Search of Marginal Environmental Valuations — Ecosystem Services in Finnish Forest Accounting." *Ecological Economics* 61(1): 101–114.
70. Mattsson, L., and C.Z. Li. 1993. "The Non-Timber Value of Northern Swedish Forests — An Economic-Analysis." *Scandinavian Journal of Forest Research*, 8(1–4): 426–434.
71. McFarlane, B.L., and P.C. Boxall. 1998. "An Overview and Nonmarket Valuation of Camping in the Foothills Model Forest." Information Report NOR-X-358: Canadian Forest Service, Northern Forestry Center, Canada.
72. Menkhaus, S., and D. J. Lober. 1995. "International Ecotourism and the Valuation of Tropical Rainforests in Costa Rica." *Journal of Environmental Management* 47(1): 1–10.
73. Mercer, E., et al. 1995. "Rain Forest Tourism: Estimating the Benefits of Tourism Development in a New National Park in Madagascar." *Journal of Forest Economics* 1(2): 239–26
74. Mikhailova, I., and F.A.R. Barbosa. 2002. Estimativa Preliminar do Valor dos Recursos Ambientais do Parque Estadual do Rio Doce (MG): uma aplicação dos métodos "disposição a pagar". Simpósio Nacional sobre Recuperação de Áreas Degradadas: Belo Horizonte, CEMAC/UFLA/SOBRADE.uly, 2004).
75. Mogas, J., et al. 2006. "A Comparison of Contingent Valuation and Choice Modelling with Second-order Interactions." *Journal of Forest Economics* 12(1): 5–30.
76. Mohd-Shahwahid, H.O. and R. McNally. 2001. *The Terrestrial and Marin Resources of Samoa.* Malaysia: Universiti Putra Malaysia.
77. Moons, E., et al. 2001. "Travel Cost and Time Measurement in Travel Cost Models." Working Paper Series no 2001–22, 1–19: Faculty of Economics and Applied Economic Sciences, Katolieke Universiteit Leuven.
78. Moran, D. 1994. Contingent valuation and biodiversity: measuring the user surplus of Kenyan protected areas. *Biodiversity and Conservation* 3(8): 663–684.
79. Muniz-Miret N., et al. 1996. "The Economic Value of Managing the Acai Palm (Euterpe Oleracea Mart.) in the Floodplains of the Amazon Estuary, Para, Brazil." *Forest Ecology and Management* 87(1): 163–173.
80. Naidoo, R., and T.H. Ricketts. 2006. "Mapping the Economic Costs and Benefits of Conservation." *PLoS Biology* 4(11): 2153–2164.
81. Naidoo, R., and W.L. Adamowicz. 2005. "Biodiversity and Nature-Based Tourism at Forest Reserves in Uganda." *Environment and Development Economics* 10(2): 158–178.

82. Narendran, K., et al. 2001. "Nontimber Forest Product Extraction, utilization and valuation: a case study from the Nilgiri Biosphere Reserve, Southern India." *Economic Botany* 55(4): 528–538.
83. Niskanen, A. 1998. "Value of External Environmental Impacts of Reforestation in Thailand." *Ecological Economics* 26(3): 287–297.
84. Norton-Griffiths, M. 1994. "Biodiversity Conservation in Kenya." Dissertation submitted to University College London, UK.
85. Notaro, S. and A. Paletto. 2012. The Economic Valuation of Natural Hazards in Mountain Forests: An Approach Based on the Replacement Cost Method. *Journal of Forest Economics* 18(4): 318–328.
86. Nuñez D., et al. 2006. "Forests and Water: The Value of Native Temperate Forests in Supplying Water for Human Consumption." *Ecological Economics* 58(3): 606–616.
87. Olar, M., et al. 2010. Caractérisation de l'Importance Économique de la Flore au Québec et Analyse de Différentes Possibilités de Financement. ÉcoRessources Consultants: Canada.
88. Ortiz, R.A., et al. 2001. Estimando o valor ambiental do Parque Nacional do Iguaçu: uma aplicação do método de custo viagem. IPEA, Rio de Janeiro. January (Texto para Discussão no 777).
89. Othman, J. and S. Asmuni. 2003. Economic values of wetlands conservation from the perspective of urban non-users. Analisis 10(2): 35–48.
90. Ovaskainen, V. et al. 2001. "Estimating Recreation Demand with On-site Data: an Application of Truncated and endogenously stratified count data models." *Journal of Forest Economics* 7(2): 125–142.
91. Pagiola, S. 1996. *Republic of Croatia Coastal Forest Reconstruction and Protection Project. Annex 1 Economic Analysis.* Washington: The World Bank.
92. Pendleton, L., et al. 1998. "Measuring Environmental Quality in the Southern Appalachian Mountains." *Forest Science* 44(4): 603–609.
93. Peters, C.M., et al. 1989. "Valuation of an Amazonian Rainforest." *Nature* 339: 655–656.
94. Peyron, J.L., et al. 2002. "National survey on demand for recreation in French forests." Report for EUROSTAT: Nancy, France.
95. Phillips, S., et al. 2008. *Greater than Zero: Toward the Total Economic Value of Alaska's National Forest Wildlands.* Washington: The Wilderness Society.
96. Pinedo-Vasquez, M., et al. 1992. "Economic Returns from Forest Conversion in the Peruvian Amazon." *Ecological Economics* 6(2): 163–173.
97. Pope, C.A., and J.W. Jones. 1990. "Value of Wilderness Designation in Utah." *Journal of Environmental Management* 30(2): 157–174.
98. Pouta, E., et al. 2000. "Contingent Valuation of the Natura 2000 Nature Conservation Programme in Finland." *Forestry* 73(2): 119–128.
99. Powe, N.A., et al. 1997. "Using a Geographic Information System to Estimate an Hedonic Price Model of the Benefits of Woodland Access." *Forestry* 70(2): 139–149.
100. Reaves, D.W., et al. "Does Question Format Matter? Valuing an Endangered Species." *Environmental and Resource Economics* 14(3): 365–383.
101. Rosales, R.M.P., et al. 2005. "Balancing the Returns to Catchment Management." IUCN Water, Nature and Economics Technical Paper 5: IUCN, Ecosystems and Livelihoods Group Asia, Colombo.
102. Rubin, J., et al. 1991. "A Benefit-cost Analysis of the Northern Spotted Owl." *Journal of Forestry* 89(12): 25–30.
103. Shone, B. and J. Caviglia-Harris. 2006. "Quantifying and Comparing the Value of Non-timber Forest Products in the Amazon." *Ecological Economics* 58(2): 249–267.
104. Siikamäki, J., and D.F. Layton. 2007. "Discrete Choice Survey Experiments: A Comparison using Flexible Methods." *Journal of Environmental Economics and Management* 53(1): 122–139.

105. Swanson, C.S., and J.B. Loomis. 1996. "Role of Non-market Economic Values in Benefit-cost Analysis of Public Forest Management." USDA Forest Service: Pacific Northwest Research Station, General Technical Report 361.
106. Tobias D. and R. Mendelsohn. 1991. "Valuing Ecotourism in a Tropical Rain-forest Reserve." *Ambio* 20: 91–93.
107. Torras, M. 2000. "The Total Economic Value of Amazonian Deforestation, 1978–1993." *Ecological Economics* 33(2): 283–297.
108. Troy, A., and M.A. Wilson. 2006. "Mapping Ecosystem Services: Practical Challenges and Opportunities in Linking GIS and Value Transfer. *Ecological Economics* 60(2): 435–449.
109. Turpie, J.K., et al. 2003. "Economic Value of Terrestrial and Marine Biodiversity in the Cape Floristic Region: Implications for Defining Effective and Socially Optimal Conservation Strategies." *Biological Conservation* 112: 223–251
110. Van Beukering, P.J.H., et al. 2003. "Economic Valuation of the Leuser National Park on Sumatra, Indonesia." *Ecological Economics* 44(1): 43–62.
111. Van der Heide, C.M., et al. 2005. *Measuring the Economic Value of two Habitat Defragmentation Policy Scenarios for the Veluwe.* The Netherlands: Nota di Lavoro, Fondazione Eni Enrico Mattei, No. 42.2005.
112. van Kooten, et al. 1999. "How much Primary Coastal Temperate Rain Forest should Society Retain? Carbon Uptake, Recreation, and other Values." *Canadian Journal of Forest Research* 29(12): 1879–1890.
113. Veisten, K. et al. 2004. "Scope Insensitivity in Contingent Valuation of Complex Environmental Amenities." *Journal of Environmental Management* 73(4): 317–331.
114. Verma, M. 2000. *Economic Valuation of Forests of Himachal Pradesh.* London: International Institute for Environmental Development.
115. Vincent et al. 2014. "Tropical Countries May be Willing to Pay More to Protect their Forests." Proceedings of the National Academy of Sciences 111(28): 10113–10118.
116. Walsh, R., et al. 1990. "Estimating the Public Benefits of Protecting Forest Quality." *Journal of Environmental Management* 30(2): 175–189.
117. Walsh, R.G., et al. 1984. "Valuing Option, Existence, and Bequest Demand for Wilderness." *Land Economics* 60: 14–29.
118. Willis, K.G. and G.D. Garrod. 1991. "An Individual Travel Cost Method of Evaluating Forest Recreation." *Journal of Agricultural Economics* 42(1): 33–42.
119. Wna Sabri, W. M. 1989. "Forest Recreation Use Patterns, User Behaviour and Recreational Value in Malaysia." Dissertation Abstracts International. A, Humanities and Social Sciences 50(6).
120. Yaron, G. 2001. "Forest, Plantation Crops or Small-Scale Agriculture? An Economic Analysis of Alternative Land Use Options in the Mount Cameroun Area." *Journal of Environmental Planning and Management* 44(1): 85–108.

EXCLUDED FROM DATABASE

1. Adamowicz, W., et al. 1990. "A Sequential Choice Model of Recreation Behavior." *Western Journal of Agricultural Economics* 15(1): 91–99.
2. Adamowicz, W., et al. 1998. "Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation." *American Journal of Agricultural Economics* 80(1): 65–75.
3. Anderson, D. 1987. *The Economics of Afforestation: A Case Study in Africa*. Baltimore: Johns Hopkins University Press.
4. Anielski, M., and S.J. Wilson. 2005. *Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystems*. Canada: Canadian Boreal Initiative, Pembina Institute.

5. Appasamy, P.P. 1993. "Role of Non-timber Forest Products in a Subsistence Economy: The Case of a Joint Forestry Project in India." *Economic Botany* 47(3): 258–267.
6. Asquitha, N.M., et al. 2008. "Selling two Environmental Services: In-kind Payments for Bird Habitat and Watershed Protection in Los Negros, Bolivia." *Ecological Economics* 65(4): 675–684.
7. Bahuguna, V. 2000. "Forests in the Economy of the Rural Poor: An Estimation of the Dependency Level." *Ambio* 29: 126–129.
8. Bann, C. 1999. *A Contingent Valuation of the Mangroves of Benut, Johor State, Malaysia.* Report to DANCED, Copenhagen.
9. Baral, H., et al. 2009. "GIS-based Classification, Mapping and Valuation of Ecosystem Services in Production Landscapes: A Case Study of the Green Triangle Region of South-eastern Australia." In *Forestry: A Climate of Change*, eds. Thistlethwaite, R., Lamb, D., and Haines, R. pp. 64 –71. Proc. IFA Conf. Caloundra, Queensland, Australia, 6–10 September 2009.
10. Barnes, J.I. 2001. "Economic Returns and Allocation of Resources in the Wildlife Sector of Botswana." *South Africa Journal of Wildlife Research* 31: 141–153.
11. Barnes, J., et al. 1999. "Tourists' Willingness to Pay for Wildlife Viewing and Wildlife Conservation in Namibia." *South African Journal of Wildlife Research* 29.4: 101–111.
12. Bateman, I.J. and A.A. Lovett. 2000. "Estimating and Valuing the Carbon Sequestered in Softwood and Hardwood Trees, Timber Products and Forest Soils in Wales." *Journal of Environmental Management* 60(4), 301–323.
13. Blackwell, B.D. 2006. "The Economic Value of Australia's Natural Coastal Assets: Some Preliminary Findings." Australian and New Zealand Society for Ecological Economics Conference Proceedings, Ecological Economics in Action, December 11–13, 2005, New Zealand.
14. Boman, M. 2009. "To Pay or Not to Pay for Biodiversity in Forests – What Scale Determines Responses to Willingness to Pay Questions with Uncertain Response Options?" *Journal of Forest Economics* 15(1–2): 79–91.
15. Boxall, P. et al. 1996. "Backcountry Recreationists' Valuation of Forest and Park Management Features in Wilderness Parks of the Western Canadian Shield." *Canadian Journal of Forest Research* 26(6): 982–90.
16. Boxall, P.C., and B. MacNab. 2000. "Exploring the Preferences of Wildlife Recreationists for Features of Boreal Forest Management: A Choice Experiment Approach." *Canadian Journal of Forest Research* 30(12): 1931–1941.
17. Boxall, P.C., et al. 1996. "A Comparison of Stated Preference Methods for Environmental Valuation." *Ecological Economics* 18(3): 243–253.
18. Brown, G., and W. Henry. 1993. "The Viewing Value of Elephants." In *Economics and Ecology: New Frontiers and Sustainable Development,* ed. B. Barbier. London: Chapman & Hall: 146–155.
19. Bush, G., et al. 2010. "Measuring the Costs of Conservation: A Provision Point Mechanism for Willingness to Accept Estimates of the Impacts of Protected Areas in Uganda" Paper presented at the Fourth World Congress of Environmental and Resource Economists. Montreal, Canada.
20. Cavendish, W. 1999. "Empirical Regularities in the Poverty-Environment Relationship of African Rural Households." Working paper 99–21. Centre for the Study of African Economics, Oxford University, Oxford, UK.
21. Chen, N., et al. 2009. "A GIS-based Approach for Mapping Direct use Value of Ecosystem Services at a County Scale: Management Implications." *Ecological Economics* 68(11): 2768–2776.
22. Chomitz, K.M., and K. Kumari. 1995. *The Domestic Benefits of Tropical Forests: A Critical Review Emphasizing Hydrological Functions.* Washington, DC: The World Bank, PRDEI.
23. Christensen, J.B. 1988. "An Economic Approach to Assessing the Value of Recreation with Special Reference to Forest Areas." Ph.D. Thesis, Frederiksberg, Denmark: Royal Veterinary and Agricultural University [Valuation results from (a) Denmark and (b) Wales], pp. 123–178.

24. Costanza, R., et al. 1997. "The Value of the World's Ecosystem Service and Natural Capital." *Nature* 387: 253–260.
25. Costello, C., and M. Ward. 2006. "Search, Bioprospecting and Biodiversity Conservation." *Journal of Environmental Economics and Management* 52(3): 615–626.
26. Cruz, W., et al. 1988. "The On-site and Downstream Costs of Soil Erosion in the Magat and Pantabangan Watersheds." *Journal of Philippine Development* 26: 85–11.
27. Dixon, J.A., and G. Hodgson. 1988. "Economic Evaluation of Coastal Resources: The El Niño Study." *Tropical Coastal Area Management* (August): 5–7.
28. Dixon, J.A., et al. 1995. The Benefits and costs of establishing a national park in Madagascar. In *Economic Analysis of Environmental Impacts*. pp. 165–169. Earthscan Publications Ltd., London, in association with the Asian Development Bank and the World Bank.
29. Eade, J.D.O., Moran, D., 1996. "Spatial Economic Valuation: Benefits Transfer Using Geographical Information Systems." *Journal of Environmental Management* 48(2): 97–110.
30. Edwards, S.F. 1991. The Demand for Galapagos Vacations: Estimation and Application to wilderness preservation. *Coastal Management* 19: 155–199.
31. Egoh, B., et al. 2008. Mapping ecosystem services for planning and management. Agriculture, Ecosystems and Environment 127: 135–140.
32. Ellingson, L. and A. Seidl. 2007. "Comparative Analysis of Non-market Valuation Techniques for the Eduardo Avaroa Reserve, Bolivia." *Ecological Economics* 60(3): 517–524.
33. Elsasser, P. 1996. *Der Erholungswert des Waldes.* Frankfurt am Main: J.D. Sauerländer's Verlag,
34. Emerton, L. 1996. *Participatory Environmental Valuation: Subsistence Forest Use Around the Aberdares, Kenya.* Nairobi, Kenya: African Wildlife Foundation.
35. Emerton, L. 1998. Mont Kenya: the economics of community conservation. Institute for Development Policy and Management, University of Manchester, UK.
36. Farnworth, E.G., et al. 1983. "A Synthesis of Ecological and Economic Theory Toward More Complete Valuation of Tropical Moist Forest." *International Journal of Environmental Studies* 21: 11–28.
37. Fearnside, P. 1997. "Environmental Services as a Strategy for Sustainable Development in Rural Amazonia." *Ecological Economics* 20(1): 53–70.
38. Fisher, B. et al. 2011. Implementation and Opportunity Costs of Reducing Deforestation and Forest Degradation in Tanzania. *Nature Climate Change* 1(3): 161–164.
39. Gadaud, J. 2009. "Contracting Free Recreational Access to Private Forests: The Economic Values of Forest Amenities for Landowners Matter." Paper presented at the 17th Annual Conference of European Association of Environmental and Resource Economists (EAERE). Amsterdam, the Netherlands.
40. Gadaud, J. and M. Rambonilaza. 2010. "Amenity Values and Payment Schemes for Free Recreation Services from Non-Industrial Private Forest Properties: A French Case Study." *Journal of Forest Economics* 16(4): 297–311.
41. Glück, P. and H. Kuen. 1977. *Der Erholungswert des Großen Ahornbodens.* AFZTG, 88: 7–11.
42. Godoy, R., et al. 1993. "A Method for the Economic Valuation of Non-Timber Tropical Forest Products." *Economic Botany* 47(3): 220–233.
43. Godoy, R., et al. 2000. "Valuation of Consumption and Sale of Forest Goods from a Central American rain forest." *Nature* 406: 62–63.
44. Godoy, R., et al. 2002. "Local Financial Benefits of Rain Forests: Comparative Evidence From Amerindian Societies in Bolivia and Honduras." *Ecological Economics* 40(3): 397–409.
45. Guitart, A.B., and L.C. Estraviz Rodriguez. 2010. "Private Valuation of Carbon Sequestration in Forest Plantations." *Ecological Economics* 69(3): 451–458.
46. Gundimeda, H., et al. 2006. "The Value of Biodiversity in India's Forests." Monograph 4 — Green Accounting for Indian States and Union Territories Project. TERI Press, New Delhi, India.

47. Guo, Z.W., et al. 2000. "An Assessment of Ecosystem Services: Water Flow Regulation And Hydroelectric Power Production." *Ecological Applications* 10: 925–936.
48. Hanley, N. and R. Ruffell. 1993. "The Valuation of Forest Characteristics." In *Forestry and the Environment: Economic Perspectives*, eds. W. Adamowicz, W. White, W.E. Phillips. Oxon, UK: CAB International: 171–197.
49. Hanley, N., et al. 2002. Valuing the Benefits of Biodiversity in Forest. Forestry Commission, United Kingdom.
50. Hansen, L., and D. Hellerstein. 2007. "The Value of the Reservoir Services Gained with Soil Conservation." *Land Economics* 83(3): 285–301.
51. Hearne, R.R. and Z.M. Salinas. 2002. "The Use of Choice Experiments in the Analysis of Tourist Preferences for Ecotourism Development in Costa Rica." *Journal of Environmental Management* 65: 153–163.
52. Hein, L., et al. 2006. "Spatial Scales, Stakeholders and the Valuation of Ecosystem Services." *Ecological Economics* 57 (2): 209–228.
53. Hodgson, G., and J. Dixon. 1988. "Measuring Economic Losses due to Sediment Pollution: Logging Versus Tourism and Fisheries." *Tropical Coastal Area Management* 3(1): 5–8.
54. Holmes, T., et al. 1998. "The Effect of Response Time on Conjoint Analysis Estimates of Rainforest Protection Values." *Journal of Forest Economics* 4(1): 7–28.
55. Horne, P. 2006. "Forest Owners' Acceptance of Incentive Based Policy Instruments in Forest Biodiversity Conservation-A Choice Experiment Based Approach." *Silva Fennica* 40(1): 169.
56. Horne, P., et al. 2005. "Multiple-use Management of Forest Recreation Sites: A Spatially Explicit Choice Experiment." *Forest Ecology and Management* 207(1–2): 189–199.
57. Horton, B., et al. 2003. "Evaluating Non-User Willingness to Pay For a Large Scale Conservation Program in Amazonia: A UK/Italian Contingent Valuation Study." *Environmental Conservation* 30(2): 139–146.
58. Hougner, C., et al. 2006. "Economic Valuation of a Seed Dispersal Service in the Stockholm National Urban Park, Sweden." *Ecological Economics* 59: 364–374.
59. Jakus, P.M., and V.K. Smith. 1992. "Measuring Use and Nonuse Values for Landscape Amenities: A Contingent Behavior Analysis of Gypsy Moth Control." Annual Meeting of the Association of Environmental and Resource Economists, New Orleans, LA, January.
60. James, D. 1992. "Xateros, Chicleros, and Pimenteros: Harvesting Renewable Tropical Forest Resources in the Guatemalan Peten." In *Conservation Of Neotropical Forests: Working from Traditional Resource Use*, eds. Kent Hubbard Redford; Christine Padoch. New York: Columbia University Press.
61. Jensen, F.S. 2003. Friluftsliv i 592 Skove og Andre Naturomr?der. [Recreation in 592 Forests and other Nature Areas]. Skovbrugsserien nr. 32-2003. Horsholm: Forskningscentret for Skov & Landskab.
62. Jensen, F.S. and N.E. Koch. 1997. Frilufts liv i Skovene 1976177-1993194. [Recreation in Forests 1976/77–1993/94]. Forskningsserien nr. 20. Horsholm: Forskningscentret for Skov & Landskab.
63. Kaplowitz, M.D. 2000. "Identifying Ecosystem Services Using Multiple Methods: Lessons from the Mangrove Wetlands of Yucatan, Mexico." *Agriculture and Human Values* 17(2): 169–179.
64. Kerr, G.N. 1996. "Recreation Values and Kai Tahu Management: The Greenstone and Caples Valleys." New Zealand Economic Papers 30(1): 19–38.
65. Köhlin, G. 2001. Contingent valuation in project planning and evaluation: the case of social forestry in Orissa, India. Environment and Development Economics 6(2): 237–258.
66. Kramer, R., et al. 1996. Valuing tropical rain forest protection using the contingent valuation method. Adamowicz W. et al: 181–194.
67. Lal, P. 1990. Ecological Economic Analysis of Mangrove Conservation; a case study from Fiji. In Mangrove Ecosystems Occasional Papers No. 6. UNDP/UNESCO. New Delhi, India
68. Lampietti, J.A. and J.A. Dixon. 1995. To see the forest for the trees: a guide to non-timber forest benefits. Environmental Economics Series 013. The World Bank, Washington, D.C., USA.
69. Lee, C.K. et al. 1998. Measuring the economic value of ecotourism resource: the case of South Korea. Journal of Travel Research 36(4): 40–46.

70. Lee, H. C. and H. S. Chun. 1999. "Valuing Environmental Equality Change On Recreational Hunting in Korea: A Contingent Valuation Analysis." *Journal of Environmental Management* 57: 11–20.
71. Li, Chuan-Zhong, and Leif Mattsson. 1995. "Discrete Choice under Preference Uncertainty: An Improved Structural Model for Contingent Valuation." *Journal of Environmental Economics and Management* 28(2): 256–269.
72. Li, T., et al. 2008. "Variations in Ecosystem Service Value in Response to Land Use Changes in Shenzhen." *Ecological Economics* (In Press), Corrected Proof: 9.
73. Loomis, J., and E. Ekstrand. 1998. "Alternative Approaches for Incorporating Respondent Uncertainty When Estimating Willingness-to-pay: The Case of the Mexican Spotted Owl." *Ecological Economics* 27(1): 29–41.
74. Luoga, E.J., et al. 2000. "Economics of Charcoal Production In Miombo Woodlands Of Eastern Tanzania: Some Hidden Costs Associated with Commercialization of the Resources." *Ecological Economics* 35(2): 243–257.
75. Luzadis, V.A. 1997. "The Integrated Valuation Method as a Holistic Approach to Measuring Forest Values for Policy Development." Faculty of Forestry, College of Environmental Science and Forestry, State University of New York
76. Mamo, G., et al. 2007. "Economic Dependence on Forest Resources: A Case from Dendi District, Ethiopia." *Forest Policy Economics* 9(8): 916–927.
77. Markandya, A., et al. 2008. "Review On The Economics of Biodiversity Loss — Economic Analysis and Synthesis," Final report for the European Commission, Venice, Italy. 140 pp.
78. Matero, J. and O. Saastamoinen. 1998. "Monetary Assessment of the Impacts of Forestry on Water-Based Benefits in Finland." *Boreal Environment Research* 3(1): 87–96.
79. Matthews, D.I., et al. 2009. "Testing the Stability of the Benefit Transfer Function For Discrete Choice Contingent Valuation Data." *Journal of Forest Economics* 15 (1–2): 131–146.
80. Miller, J.D. and B.E. Lindsay. 1993. "Willingness to Pay for A State Gypsy Moth Control Program In New Hampshire: A Contingent Valuation Case Study." *Journal of Economic Entomology* 86(3): 828–837.
81. Ministerie van Landbouw, Natuur en Voedselkwaliteit. 2006. Kentallen waardering natuur, water, bodem en landschap. Hulpmiddel bij MKBA's. Eerste editie. Witteveen en Bos, Deventer, the Netherlands.
82. Myers, N. 1988. "Tropical Forests: Much More Than Stocks of Wood." *Journal of Tropical Ecology* 4(2): 209–221.
83. Othman, J. 2000. "Estimating Non-use Values of Environmental Resources using Contingent Valuation: Case of Matang Mangroves." *Environmental Management* 9(6): 214–222.
84. Othman, J., and R. Othman. 1998. "Economic Benefits from Wetland Biodiversity: Case of Fireflies Recreation, Malaysia." *Tropical Biodiversity* 5(1): 65–74.
85. Pagiola, S., et al. 2004. "Paying for Biodiversity Conservation Services in Agricultural Landscapes." Final draft. Forthcoming as Environment Department Paper No.96.
86. Pattanayak, S., and D.E. Mercer. 1998. "Valuing Soil Conservation Benefits of Agroforestry: Contour Hedgerows in the Eastern Visayas, Philippines." *Agricultural Economics* 18: 31–46.
87. Pearce, D.W. 1990. *An Economic Approach to Saving the Tropical Forests.* LEEC Paper 90–06. International Institute for Environment arid Development, London, 30 pp.
88. Pearce, D.W. 2001. "Economic Value of Forest Ecosystems." *Ecosystem Health* 7(4): 284–296.
89. Perrot-Maître, D., and P. Davis. 2001. "Case Studies of Markets and Innovative Financial Mechanisms for Water Services from Forests." Forest Trends, working paper.
90. Phillips, A., ed. 1998. "Economic Values of Protected Areas: Guidelines For Protected Area Managers." Task Force on Economic Benefits of Protected Areas of the World Commission on Protected Areas (WCPA) of IUCN, in collaboration with the Economics Service Unit of IUCN, UK.

91. Rajmis, S., et al. 2009. "User Community Preferences for Climate Change Mitigation and Adaptation Measures around Hainich National Park, Germany." *Climate Research* 40: 61–73.
92. Rausser, G.C., and A. Small. 2000. "Valuing Research Leads: Bioprospecting and the Conservation of Genetic Resources." UC Berkeley: Berkeley Program in Law and Economics. *Journal of Political Economy* 108(1): 173–206.
93. Regmi, B.N. 2003. "Contribution of Agroforestry for Rural Livelihoods: A Case of Dhading District, Nepal." Paper presented at The International Conference on Rural livelihoods, Forests and Biodiversity 19–23 May 2003, Bonn, Germany.
94. Richards, M.T., et al. 1990. "The Lack of an Expected Relationship between Travel Cost and Contingent Value Estimates of Forest Recreation Value." *Leisure Sciences* 12(3): 303–319.
95. Rodriguez, L.C., et al. 2006. "Local Identification and Valuation of Ecosystem Goods and Services From Opuntia Scrublands of Ayacucho, Peru." *Ecological Economics* 57(1): 30–44.
96. Rogers, M.F. and J.A. Sinden. 1994. "Safe Minimum Standard for Environmental Choices: Old-Growth Forest in New South Wales." *Journal of Environmental Management* 41.2: 89–103.
97. Rolfe, J., and J. W. Bennett. 2002. "Assessing Rainforest Conservation Demands." *Economic Analysis and Policy* 32(2): 51–67.
98. Rolfe, J., et al. 2000. "Choice Modelling and its Potential Application to Tropical Rainforest Preservation." *Ecological Economics* 35: 289–302.
99. Rollins, K. 1997. "Wilderness Canoeing in Ontario: Using Cumulative Results to Update Dichotomous Choice Contingent Valuation Offer Amounts." *Canadian Journal of Agricultural Economics* 45: 1–16.
100. Saastamoinen, O., et al. 2013. "Concepts and Considerations for the Synthesis of Ecosystem Goods and Services in Finland." Publications of the University of Eastern Finland. Reports and Studies in Forestry and Natural Sciences 10: 108.
101. Schaafsma, M., et al. 2012. "Towards Transferable Functions for Extraction of Non-Timber Forest Products: A Case Study on Charcoal Production in Tanzania." *Ecological Economics* 80: 48–62.
102. Shaikh, S. L., et al. "Does Inclusion of Landowners' Non-Market Values Lower Costs of Creating Carbon Forest Sinks?" Resource Economics and Policy Analysis (REPA), Research Group at the University of Victoria, Department of Economics, Working paper 2003–03.
103. Sheil, D., and S. Wunder. 2002. "The Value of Tropical Forest to Local Communities: Complications, Caveats, and Cautions." *Conservation Ecology* 6.2: 9.
104. Shultz, S., et al. 1998. "Opportunities and Limitations of Contingent Valuation Surveys to Determine National Park Entrance Fees: Evidence from Costa Rica." *Environment and Development Economics* 3: 131–149.
105. Shyamsundar, P. and R. Kramer. 1997. "Biodiversity Conservation–At What Cost? A Study of Households in the Vicinity of Madagascar's Mantadia National Protected Area." *Ambio* 26(3): 180–184.
106. Simpson, R.D., et al. 1996. "Valuing Biodiversity for Use in Pharmaceutical Research." *Journal of Political Economy* 104(1): 163–183.
107. Smith, J., et al. 1998. "Willingness to Pay for Environmental Services among Slash-and Burn Farmers in the Peruvian Amazon: Implications for Deforestation and Global Environmental Markets." Paper presented at the World Congress of Environmental and Resource Economists, Venice, Italy.
108. Solino, M., et al. 2009. "Social Demand for Electricity from Forest Biomass in Spain: Does Payment Periodicity Affect the Willingness to Pay?" *Energy Policy* 37: 531–540.
109. Svedsäter, H. 2000. "Contingent Valuation of Global Environmental Resources: Test of Perfect and Regular Embedding." *Journal of Economic Psychology* 21: 605–623.
110. The, B.D. and H.B. Ngoc. 2006. "Payments for Environmental Services in Vietnam: Assessing an Economic Approach to Sustainable Forest Management." Economy and Environment Program for Southeast Asia, International Development Research Centre (IDRC), 2006

111. Turpie, J.K. 2003. "The Existence Value of Biodiversity in South Africa: How Interest, Experience, Knowledge, Income and Perceived Level of Threat Influence Local Willingness To Pay." *Ecological Economics* 46(1–2): 199–216.
112. Tyrtyshny, E. 2005. "Economic Value of the Ecosystem in Kazakhstan. Paper presented at Seminar on Environmental Services and Financing for the Protection and Sustainable Use of Ecosystems." Geneva, 10–11 October 2005.
113. Veisten, K. and S. Narvud. 2006. "Contingent Valuation and Actual Payment for Voluntarily Provided Passive-Use Values: Assessing the Effect of Fan Induced Truth-Telling Mechanism and Elicitation Formats." *Applied Economics* 38: 735–756.
114. Willis, K.G. 1991. "The Recreational Value of the Forestry Commission Estate in Great Britain: A Clawson–Knetsch Travel Cost Analysis." *Scottish Journal of Political Economy* 38: 58–75.
115. Yacob, M.R. et al. 2009. "A Contingent Valuation Study of Marine Parks Ecotourism: The Case of Pulau Payar and Pulau Redang in Malaysia." *Journal of Sustainable Development* 2(2): 95.

EXCLUDED FROM ESTIMATION DATASET

1. Balick, M.J. and R. Mendelsohn. 1992. "Assessing the Economic Value of Traditional Medicines from Tropical Rainforests." *Conservation Biology* 6: 128–130.
2. Brey, R., et al. 2007. "Estimation of Forest Values Using Choice Modeling: An Application to Spanish Forests." *Ecological Economics* 64(2): 305–312.
3. Croitoru, L. 2007. "Valuing the Non-timber Forest Products in the Mediterranean Region." *Ecological Economics* 63(4): 768–775.
4. Curtis, I.A. 2004. "Valuing Ecosystem Goods and Services: A New Approach Using a Surrogate Market And The Combination of a Multiple Criteria Analysis and a Delphi Panel to Assign Weights to the Attributes." *Ecological Economics* 50: 163–194.
5. Damnyag, L., et al. 2011. "Economic Cost of Deforestation in Semi-Deciduous Forests – A Case of Two Forest Districts in Ghana." *Ecological Economics* 70: 2503–2510.
6. Kaiser, B. and J. Roumasset. 2002. "Valuing Indirect Ecosystem Services: The Case of Tropical Watersheds." *Environment and Development Economics* 7: 701–714.
7. Kosz, M. 1996. "Valuing Riverside Wetlands: The Case of the "Donau-Auen" National park." *Ecological Economics* 16: 109–127.
8. Kramer, R.A., and D.E. Mercer. 1997. "Valuing a Global Environmental Good: US Residents' Willingness to Pay to Protect Tropical Rain Forests." *Land Economics* 73(2): 196–210.
9. Mendelsohn, R. and M. Balick. 1995. "The Value of Undiscovered Pharmaceuticals in Tropical Forests." *Economic Botany* 49(2): 223–228.
10. Priess, J.A., et al. 2007. "Linking Deforestation Scenarios to Pollination Services and Economic Returns in Coffee Agroforestry Systems." *Ecological Applications* 17(2): 407–417.
11. Qiu, Y., et al. 2010. "Valuation of Flood Reductions in the Yellow River Basin under Land Use Change." *Journal of Water Resource Planning and Management* 136: 106–115.
12. Raunikar, R. and J. Buongiorno. 2006. "Willingness to Pay for Forest Amenities: The Case of Non-industrial Owners in the South Central United States." *Ecological Economics* 56(1): 132–143.
13. Ricketts T.H., et al. 2004. "Economic Value of Tropical Forest to Coffee Production." Proceedings of the National Academy of Sciences 101(34): 12579–12582.
14. Sattout, E., et al. 2007. "Economic Value of Cedar Relics In Lebanon: An Application Of Contingent Valuation Method For Conservation," *Ecological Economics* 61: 315–322

15. Scarpa, R., et al. 2000. "Importance of Forest Attributes in the Willingness to Pay for Recreation: A Contingent Valuation Study of Irish Forests." *Forest Policy and Economics* 1(3): 315–29.
16. Scarpa, R., et al. 2000. "Valuing the Recreational Benefits from the Creation of Nature Reserves in Irish Forests." *Ecological Economics* 33(2): 237–250.
17. Starbuck, M.C., et al. 2004. "Valuing Special Forest Products Harvesting: A Two-Step Travel Cost Recreation Demand Analysis." *Journal of Forest Economics* 10(1): 37–53.
18. van Rensburg, T.M., et al. 2002. "Preferences and Multiple Use Forest Management." *Ecological Economics* 43(2–3): 231–244.
19. Xue, D. and C. Tisdell. 2001. "Valuing Ecological Functions of Biodiversity in Changbaishan Mountain Biosphere Reserve in Northeast China." *Biodiversity and Conservation* 10(3): 467–481.

NOT FOUND

1. Anderson, A.B. and E.M. Ioris. 1992. "The Logic of Extraction: Resource Management and Income Generation by Extractive Producers in the Amazon." *Conservation of Neotropical Forests: Working from Traditional Resource Use*: 179–99.
2. Anderson, A.B., et al. 1991. "The Subsidy from Nature: Palm Forests, Peasantry, and Development on an Amazon Frontier." New York: Columbia University Press.
3. Boatto, V. et al. 1984. La funzione turistico-ricreativa della Foresta di Tarvisio. Istituto di Economia e Politica Agraria, Università degli Studi, Padova.
4. Bojö, J. 1985. Kostnadsnyttoanalys av fjällnära skogar: Fallet Vålådalen (Cost-benefit analysis of mountainous forests: the Vala Valley Case). Research Report, The Economic Research Institute, Stockholm School of Economics.
5. Bojö, J. 1985. Samhällsekonomisk analys av miljövärden i Valadalen. In: Kostnadsnyttoanalyd av fjällnära skogar. Fallet Valadalen, Research Report edn, 6:1–6:25. Ekonomiska Forskningsinstitutet vid Handelshögskolan i Stockholm, Stockholm.
6. ERM (Environmental Resources Management). 1996. "Valuing Management for Biodiversity in British Forests," Report to UK Forestry Commission.
7. Gunatilake, H. M., et al. 1993. "Role of Non-Timber Forest Products in the Economy of Peripheral Communities of Knuckles National Wilderness Area of Sri Lanka: A Farming Systems Approach." *Economic Botany* 47(3): 275–281.
8. Haefele, M., et al. 1992. Estimating the Total Value of Forest Quality in High-Elevation Spruce-Fir Forests. The Economic Value of Wilderness. General Technical Report SE-78, Southern Forest Experiment Station, Research Triangle Park, NC.
9. Hagestuen, W. and K. Skogen. 1995. "Socio-Economic Value of the Natural Resources of the Ullensvang State Commons—Samfunnsøkonomisk verdi av naturressursene i Ullensvang statsalmenning, Hardangervidda." Universitetet for miljø- og biovitenskap (UMB), Study only available in Norwegian
10. Hutchinson, W.G. 1995. "How Public Preferences Affect Non-Market Values For Afforestation in Ireland" Paper Presented to the Agricultural Economics Society of Ireland, Monday, 25 September 1995.
11. International Resources Groups Ltd. 2000. The case of Duru Haitemb community-based forest management project Babat District, Arusha Region, Tanzania. USAID, Tanzania.
12. Jamal, O., and A. Shahariah. 2003. "The Economics of Wetlands Conservation: Case of Paya Indah Wetlands, Malaysia." International Ecotourism Conference, Organized by SEAMEO-SEARCA and UPM, at Bangi, Malaysia.
13. Koch, N.E. 1978. "Skovenes Friluftsfunktion I Danmark. I. Del. Befolkningens Anvendelse af Landets Skove." ["Forest Recreation in Denmark. Part I: The Use of the Country's Forests by the Population"]. Det Forst lige Forsogs v sen i Danmark 35(3): 285–451.

14. Koch, N.E. 1980. "Skovenens Friluftsfunktion i Danmark. II. Del Anvendelsen af Skovene Regionalt Betragtet." ["Forest Recreation in Denmark. Part II: The Use of the Forests Considered Regionally"]. Det Forstlige
15. Koch, N.E., and F.S. Jensen. 1988. "Skovenes Friluftsfunktion i Danmark. IV. del. Befolkningens 0nsker til Skovenes og det ?bne Lands Udformning." ["Forest Recreation in Denmark. Part IV: The Preferences of the Population"]. Det Forstlig Forsogsv sen i Danmark Al (3): 243–516
16. Krutilla, J.V. 1991. *Environmental Resource Services of Malaysian Moist Tropical Forest.* Baltimore: Johns Hopkins University Press, for Resources for the Future.
17. Löwenstein, W. 1991. Die Monetäre bewertung der Fernerholung im Südharz mit der Reisekostenmethode, eds. V. Bergen, H.D. Brabänder, A.W. Bitter, W. Löwenstein, Beiträge zum Symposium-Monetäre Bewertung der landeskulturellen Leistungen der Forstwirtschaft (first ed.), J.D. Sauerländer's Verlag, Göttingen, p. 162
18. Marangon, F., and E. Gottardo. 2001. La valutazione monetaria del danno ai boschi del Friuli-Venezia Giulia. In: La valutazione dei beni ambientali come supporto alle decisioni pubbliche, Università degli Studi di Udine, Udine, Italy, pp. 1–27.
19. Merlo, M. 1986. Valutazione dei servizi ricreativo-ambientali dei boschi. Economia Montana 4: 3–11.
20. Merlo, M. and G. Signorello. 1991. In *Alternative Estimates of Outdoor Recreation Benefits in Italy,* eds. V. Bergen, H.D. Brabänder, Beiträge zum Symposium: Monetäre Bewertung der landeskulturellen Leistungen der Forstwirtschaft Band (first ed), J.D. Sauerländer's Verlag, Göttingen pp. 133–161
21. Ninan, K.N. and M. Inoue. 2013. "Valuing Forest Ecosystem Services: Case Study of a Forest Reserve in Japan." *Ecosystem Services* 5: 78–87.
22. Olsen, S.B. and T. Lundhede. 2005. "Recreational Values in Near-natural Silviculture — An Economic Valuation of Forest Characteristics using Discrete Choice Experiment." The Royal Veterinary and Agricultural University (KVL).
23. Othman, J. 2001. "Estimating Non-Use Values of Environmental Resources Using Contingent Valuation: Case Of Matang Mangroves." Jamaluddin Jahi, et. al: 214–222.
24. Shackleton, C.M., et al. 2002. The role and value of savanna non-timber forest products to rural households in the Kat River Valley, South Africa. Journal of Tropical Forest Products 8(1): 45–65.
25. Simensen, K., and M. Wind. 1990. Holdninger til og betalingsvillighet for ulike skogbehandlinger i fjellskog: En empirisk undersøkelse av hirkjølen statsallmenning (attitudes and wtp for different forestry practices in mountainous forests: a survey of the hirkjolen common). Master Thesis, Norwegian University of Life Sciences.
26. Skagestad, E., 1996. Friluftsliv og Skogbruk – En spørreundersøkelse blant turgjengere i ytre Oslomarka, Romeriksåsen, på vinterstid (Skagestad, E., 1996. Friluftsliv og Skogbruk – En spørreundersøkelse blant turgjengere i ytre Oslomarka, Romeriksåsen, på vinterstid (Recreation and forestry – a survey of hikers in the outer Oslomarka, Romeriksåsen, in the winter time). Master Thesis, Norwegian University of Life Sciences. Romeriksåsen, in the winter time). Master Thesis, Norwegian University of Life Sciences.
27. Skagestad, E.C. "Recreation and Forestry — Friluftsliv og skogbruk" Norwegian University of Life Sciences (UMB), 1996
28. Termansen, M., et al. 2004. "Economic Valuation of Danish Forest Recreation Combining Mixed Logit Models and GIS." EAERE Conference. June 25–28. Budapest, Hungary.
29. Tisdell, C. 2009. "The Economics of Biodiversity Conservation: Valuation in Tropical Forest Ecosystems," in *Earthscan,* ed. K.N. Ninan, *Ecological Economics* 68(5): 1566–1567.
30. Weisten, K., et al. 1993. "Valuing Biodiversity in Norwegian Forests: A Contingent Valuation Study with Multiple Bias Testing, No 07/1993," Memorandum, Oslo University, Department of Economics.
31. Willis, K.G. and J.F. Benson. 1988. "A Comparison of User Benefits and Costs of Nature Conservation at Three Nature Reserves." *Regional Studies*, 22: 417–428.
32. Willis, K.G. and J.F. Benson. 1989. "Recreational Values of Forests." *Forestry* 62: 93–110.

ALL STUDIES

1. Adamowicz, W., et al. 1990. "A Sequential Choice Model of Recreation Behavior." *Western Journal of Agricultural Economics* 15(1): 91–99.
2. Adamowicz, W., et al. 1998. "Stated Preference Approaches For Measuring Passive Use Values: Choice Experiments and Contingent Valuation." *American Journal of Agricultural Economics* 80(1): 65–75.
3. Adams, C., et al. 2008. "The Use of Contingent Valuation for Evaluating Protected Areas in the Developing World: Economic Valuation of Morro do Diabo State Park, Atlantic Rainforest, São Paulo State (Brazil)." *Ecological Economics* 66(2): 359–370.
4. Adger, W.N., et al. 1995. "Toward Estimating Total Economic Value of Forests in Mexico." Working Paper 94–21, Centre for Social and Economic Research on the Global Environment: University of East Anglia and University College, London.
5. Amirnejad, H. et al. 2006. "Estimating the Existence Value of North Forests of Iran by Using a Contingent Valuation Method." *Ecological Economics* 58(4): 665–675.
6. Ammour, T., et al. 2000. "Economic valuation of mangrove ecosystems and sub-tropical forests in Central America." In *Sustainable Forest Management and Global Climate Change,* eds. Dore M. and R. Guevara. UK: Edward Elgar Publishing.
7. Anderson, A.B., and E.M. Ioris. 1992. "The Logic of Extraction: Resource Management and Income Generation by Extractive Producers in the Amazon." *Conservation of Neotropical Forests: Working from Traditional Resource Use*: 179–99.
8. Anderson, A.B., et al. 1991. *The Subsidy from Nature: Palm Forests, Peasantry, and Development on an Amazon Frontier.* New York: Columbia University Press.
9. Anderson, D. 1987. *The Economics of Afforestation: A Case Study in Africa*. Baltimore: Johns Hopkins University Press.
10. Anielski, M. and S.J. Wilson. 2005. *Counting Canada's Natural Capital: Assessing the Real Value of Canada's Boreal Ecosystems.* Canada: Canadian Boreal initiative, Pembina institute.
11. Appasamy, P.P. 1993. "Role of Non-Timber Forest Products in a Subsistence Economy: The Case of a Joint Forestry Project in India." *Economic Botany* 47(3): 258–267.
12. Asquitha, N.M., et al. 2008. "Selling Two Environmental Services: In-Kind Payments for Bird Habitat and Watershed Protection in Los Negros, Bolivia." *Ecological Economics* 65(4): 675–684.
13. Bahuguna, V. 2000. "Forests in the Economy of The Rural Poor: An Estimation of the Dependency Level." *Ambio* 29: 126–129.
14. Balick, M.J. and R. Mendelsohn. 1992. "Assessing the Economic Value of Traditional Medicines from Tropical Rainforests." *Conservation Biology* 6: 128–130.
15. Bann, C. 1999. "A Contingent Valuation of the Mangroves of Benut, Johor State, Malaysia." Report to DANCED, Copenhagen.
16. Banzhaf, H.S., et al. 2014. "Valuation of Ecosystem Services in the Southern Appalachian Mountains." RFF Discussion Paper. September 2014.
17. Baral, H., et al. 2009. "GIS-based Classification, Mapping and Valuation of Ecosystem Services In Production Landscapes: A Case Study of The Green Triangle Region of South-Eastern Australia." In *Forestry: A Climate of Change*, eds. Thistlethwaite, R., D. Lamb, and R. Haines. pp. 64 –71. Proc. IFA Conf. Caloundra, Queensland, Australia, 6–10 September 2009.
18. Barnes J.I. 2001. "Economic Returns and Allocation of Resources in the Wildlife Sector of Botswana." *South Africa Journal of Wildlife Research* 31: 141–153.
19. Barnes, J., et al. 1999. "Tourists' Willingness to Pay for Wildlife Viewing and Wildlife Conservation in Namibia." *South African Journal of Wildlife Research* 29.4: 101–111.

20. Barreiro-Hurle, J., and J. A. Gomez-Limon. 2007. "Reconsidering Heterogeneity And Aggregation Issues In Environmental Valuation: A Multi-attribute Approach." *Environmental and Resource Economics* 40(4): 551–570.
21. Barrick, K.A., and R.I. Beazley. 1990. "Magnitude and Distribution of Option Value for the Washakie Wilderness, Northwest Wyoming, USA." *Environmental Management* 14(3): 367–380.
22. Batagoda, B.M.S., et al. 2000. "Towards Policy Relevant Ecosystem Services and Natural Capital Values: Rainforest Non-Timber Products." CSERGE Working Paper CEC 2000–06: University of East Anglia, UK.
23. Bateman, I.J., and A.A. Lovett. 2000. "Estimating and Valuing the Carbon Sequestered in Softwood and Hardwood Trees, Timber Products and Forest Soils in Wales." *Journal of Environmental Management* 60(4), 301–323.
24. Bateman, I.J., et al. 1996. "Measurement Issues in the Travel Cost Method: A Geographical Information Systems Approach." *Journal of Agricultural Economics* 47(1–4): 191–205.
25. Beal, D.J. 1995. "A Travel Cost Analysis of the Value of Carnarvon Gorge National Park for Recreational Use." *Review of Marketing and Agricultural Economics* 63(2): 292–303.
26. Bellu L.G. and V. Cistulli. 1997. "Economic Valuation of Forest Recreation Facilities in the Liguria Region (Italy)." Working paper GEC 97–08: Centre for Social and Economic Research on the Global Environment, Norwich, UK.
27. Bernard, F., et al. 2009. "Valuation of Tropical Forest Services and Mechanisms to Finance Their Conservation and Sustainable Use: A Case Study of Tapantí National Park, Costa Rica." *Forest Policy and Economics* 11(3): 174–183.
28. Bestard, A.B., and A.R. Font. 2010. "Estimating the Aggregate Value of Forest Recreation in a Regional Context." *Journal of Forest Economics* 16(3): 205–216.
29. Blackwell, B.D. 2006. "The Economic Value of Australia's Natural Coastal Assets: Some Preliminary Findings." Australian and New Zealand Society for Ecological Economics Conference Proceedings, Ecological Economics in Action, December 11–13, 2005, New Zealand.
30. Boatto, V. et al. 1984. La funzione turistico-ricreativa della Foresta di Tarvisio. Istituto di Economia e Politica Agraria, Università degli Studi, Padova.
31. Bojö, J. 1985. Kostnadsnyttoanalys av fjällnära skogar: Fallet Vålådalen (Cost-benefit analysis of mountainous forests: the Vala Valley Case). Research Report, The Economic Research Institute, Stockholm School of Economics.
32. Bojö, J. 1985. Samhällsekonomisk analys av miljövärden i Valadalen. In: Kostnadsnyttoanalyd av fjällnära skogar. Fallet Valadalen, Research Report edn, 6:1–6:25. Ekonomiska Forskningsinstitutet vid Handelshögskolan i Stockholm, Stockholm.
33. Boman, M. 2009. "To Pay or not to Pay for Biodiversity in Forests – What Scale Determines Responses to Willingness to pay Questions with Uncertain Response Options?" *Journal of Forest Economics* 15(1–2): 79–91.
34. Boman, M., et al. 2008. "On the Budget for National Environmental Objectives and Willingness to Pay for Protection of Forest Land." *Canadian Journal of Forest Research* 38(1): 40–51.
35. Bostedt, G. and L. Mattsson. 1995. "The value of forests for tourism in Sweden." *Annals of Tourism Research* 22(3): 671–680.
36. Boxall, P. et al. 1996. "Backcountry Recreationists' Valuation of Forest and Park Management Features in Wilderness Parks of the Western Canadian Shield." *Canadian Journal of Forest Research* 26(6): 982–90.
37. Boxall, P.C., and B. MacNab. 2000. "Exploring the Preferences of Wildlife Recreationists for Features of Boreal Forest Management: A Choice Experiment Approach." *Canadian Journal of Forest Research* 30(12): 1931–1941.
38. Boxall, P.C., et al. 1996. "A Comparison of Stated Preference Methods for Environmental Valuation." *Ecological Economics* 18(3): 243–253.

39. Boxall, P.C., et al. 1999. "Valuing Wilderness Recreation: A Demand Systems Approach in the Canadian Shield." Information Report NOR-X-361: Canadian Forest Service, Northern Forestry Center, Canada.
40. Brey, R., et al. 2007. "Estimation of Forest Values Using Choice Modeling: An Application to Spanish Forests." *Ecological Economics* 64(2): 305–312.
41. Broberg, T. 2007. "Assessing the Non-Timber Value of Old-Growth Forest in Sweden." *Umeä Economic Studies*, vol. 712: Department of Economics, Umeå University.
42. Brown, G. and W. Henry. 1993. "The viewing value of elephants." In *Economics and Ecology: New Frontiers and Sustainable Development*, ed. Barbier, B. London: Chapman & Hall: 146–155.
43. Bujosa A., and A. Riera. 2010. "Estimating the Aggregate Value of Forest Recreation in a Regional Context." *Journal of Forest Economics* 16(3): 205–216.
44. Bush, G., et al. 2010. "Measuring the Costs of Conservation: A Provision Point Mechanism for Willingness to Accept Estimates of the Impacts of Protected Areas in Uganda" Paper presented at the Fourth World Congress of Environmental and Resource Economists. Montreal, Canada.
45. Cavendish, W. 1999. "Empirical Regularities in the Poverty-Environment Relationship of African Rural Households." Working paper 99–21. Centre for the Study of African Economics, Oxford University, Oxford, UK.
46. Chase, L.C. et al. 1998. "Ecotourism Demand and Differential Pricing of National Park Access in Costa Rica." *Land Economics* 74(4): 466–482.
47. Chen, N., et al. 2009. "A GIS-based Approach for Mapping Direct Use Value of Ecosystem Services at a County Scale: Management Implications." *Ecological Economics* 68(11): 2768–2776.
48. Chomitz, K.M. and K. Kumari. 1995. "The Domestic Benefits of Tropical Forests: A Critical Review Emphasizing Hydrological Functions." Washington, DC: The World Bank, PRDEI.
49. Chopra, K. 1993. "The Value of Non-Timber Forest Products: An Estimation for Tropical Deciduous Forests in India." *Economic Botany* 47(3): 251–257.
50. Christensen, J.B. 1988. "An Economic Approach to Assessing the Value of Recreation with Special Reference to Forest Areas." Ph.D. Thesis, Frederiksberg, Denmark: Royal Veterinary and Agricultural University [Valuation results from (a) Denmark and (b) Wales], pp. 123–178.
51. Clinch, J.P., 1999. *Economics of Irish Forestry: Evaluating the Returns to Economy and Society.* Dublin, Ireland: COFORD.
52. Costanza, R., et al. 1997. "The Value of the World's Ecosystem Service and Natural Capital." *Nature* 387: 253–260.
53. Costello, C. and M. Ward. 2006. "Search, Bioprospecting and Biodiversity Conservation." *Journal of Environmental Economics and Management* 52(3): 615–626.
54. Croitoru, L. 2007. "Valuing the Non-Timber Forest Products in the Mediterranean." Region. *Ecological Economics* 63(4): 768–775.
55. Cruz, W., et al. 1988. "The On-Site and Downstream Costs of Soil Erosion in the Magat And Pantabangan Watersheds." *Journal of Philippine Development* 26: 85–11.
56. Curtis, I.A. 2004. "Valuing Ecosystem Goods and Services: A New Approach Using a Surrogate Market and the Combination of a Multiple Criteria Analysis and a Delphi Panel to Assign Weights to the Attributes." *Ecological Economics* 50: 163–194.
57. Czajkowski, M. et al. 2009. "Valuing Changes in Forest Biodiversity." *Ecological Economics* 68(12): 2910–2917.
58. Damnyag, L., et al. 2011. "Economic Cost of Deforestation in Semi-deciduous Forests – A Case of Two Forest Districts in Ghana." *Ecological Economics* 70: 2503–2510.
59. de Beer, J.H. and M.J. McDermott. 1989. "Economic Value of Non-Timber Forest Products in South-East Asia." The Netherlands: Council for the International Union of the Conservation of Nature.
60. De la Cruz, A. and J. Benedicto. 2009. "Assessing Socio-economic Benefits of Natura 2000: A Case Study on the Ecosystem Service Provided by SPA PICO DA VARA / RIBEIRA DO GUILHERME." Output of the project Financing Natura 2000: Cost estimate and benefits of Natura 2000.

61. Delang, C. 2006. "Not just Minor Forest Products: The Economic Rationale for the Consumption of Wild Food Plants by Subsistence Farmers." *Ecological Economics* 59(1): 64–73.
62. Dixon, J.A. and G. Hodgson. 1988. "Economic Evaluation of Coastal Resources: The El Niño Study." *Tropical Coastal Area Management* (August): 5–7.
63. Dixon, J.A., et al. 1995. "The Benefits and Costs of Establishing a National Park in Madagascar." In *Economic Analysis of Environmental Impacts*. pp. 165–169. Earthscan Publications Ltd., London, in association with the Asian Development Bank and the World Bank.
64. Driml, S. 2002. "Travel Cost Analysis of Recreation Value in the Wet Tropics World Heritage Area." *Economic Analysis and Policy* 32(2): 11–26.
65. Dubgaard, A. 1998. "Economic Valuation of Recreational Benefits from Danish Forests." In *The Economics of Landscapes and Wildlife Conservation,* eds. Dabbert, S., A. Dubgaard, and M. Whitby. CAB International: 53–64.
66. Duthy, S. 2002. "Whian Whian–State Forest or National Park: Community Attitudes and Economic Values." *Economic Analysis and Policy* 32(2): 91–111.
67. Eade, J.D.O., Moran, D., 1996. "Spatial Economic Valuation: Benefits Transfer Using Geographical Information Systems." *Journal of Environmental Management* 48(2): 97–110.
68. Echeverria, J., et al. 1995. "Valuation of Non-Priced Amenities Provided by the Biological Resources within the Monteverde Cloud Forest Preserve, Costa Rica." *Ecological Economics* 13(1): 43–52.
69. Edwards, S.F. 1991. "The Demand for Galapagos Vacations: Estimation and Application to Wilderness Preservation." *Coastal Management* 19: 155–199.
70. Egoh, B., et al. 2008. "Mapping Ecosystem Services for Planning and Management." *Agriculture, Ecosystems and Environment* 127: 135–140.
71. Ellingson, L. and A. Seidl. 2007. "Comparative Analysis of Non-market Valuation Techniques for the Eduardo Avaroa Reserve, Bolivia." *Ecological Economics* 60(3): 517–524.
72. Elsasser, P. 1996. "Der Erholungswert des Waldes." J.D. Frankfurt am Main: Sauerländer's Verlag,
73. Emerton, L. 1996. *Participatory Environmental Valuation: Subsistence Forest Use around the Aberdares*, Kenya. Nairobi: African Wildlife Foundation.
74. Emerton, L. 1998. *Mont Kenya: The Economics of Community Conservation*. University of Manchester, UK: Institute for Development Policy and Management.
75. Emerton, L. and E. Muramira. 1999. *Uganda Biodiversity — Economic Assessment.* Prepared with National Environment Management Authority, Kampala: IUCN, Gland, Switzerland.
76. Englin, J. and R. Mendelsohn. 1991. "A Hedonic Travel Cost Analysis for Valuation of Multiple Components of Site Quality: The Recreation Value of Forest Management." *Journal of Environmental Economics and Management* 21(3): 275–290.
77. ERM (Environmental Resources Management). 1996. "Valuing Management for Biodiversity in British Forests," Report to UK Forestry Commission.
78. Everett, R.D. 1979. "The Monetary Value of the Recreational Benefits of Wildlife." *Journal of Environmental Management* 8: 203–213.
79. Farnworth, E.G., et al. 1983. "A Synthesis of Ecological and Economic Theory Toward More Complete Valuation of Tropical Moist Forest." *International Journal of Environmental Studies* 21: 11–28.
80. Fearnside, P. 1997. "Environmental Services as a Strategy for Sustainable Development in Rural Amazonia." *Ecological Economics* 20(1): 53–70.
81. Fisher, B., et al. 2011. "Implementation and Opportunity Costs of Reducing Deforestation and Forest Degradation in Tanzania." *Nature Climate Change* 1(3): 161–164.
82. Flatley, G., and J. Bennett. 1995. "International Values of Tropical Forest Conservation: A Cross-cultural Contingent Valuation Experiment." Paper presented to the 39th Australian Agricultural Economic Society Annual Conference: Perth, Australia.

83. Fredman, P. and L. Emmelin. 2001. "Wilderness Purism, Willingness to Pay and Management Preferences: A Study of Swedish Mountain Tourists." *Tourism Economics* 7(1): 5–20.
84. Gadaud, J. 2009. "Contracting Free Recreational Access to Private Forests: The Economic Values of Forest Amenities for Landowners Matter." Paper presented at the 17th Annual Conference of European Association of Environmental and Resource Economists (EAERE). Amsterdam, the Netherlands.
85. Gadaud, J., and M. Rambonilaza. 2010. "Amenity Values and Payment Schemes for Free Recreation Services from Non-Industrial Private Forest Properties: A French Case Study." *Journal of Forest Economics* 16(4): 297–311.
86. Garcia, S., et al. 2009. "Models for Sample Selection Bias in Contingent Valuation: Application to Forest Biodiversity." *Journal of Forest Economics* 15(1): 59–78.
87. Garrod, G.D. and K.G. Willis. 1997. "The Non-use Benefits of Enhancing Forest Biodiversity: A Contingent Ranking Study." *Ecological Economics* 21(1): 45–61.
88. Garrod, G.D. and K.G. Willis. 1997. "The Recreational Value of Tropical Forest in Malaysia." *Journal of World Forest Resource Management* 8(2): 183–201.
89. Glück, P. and H. Kuen. 1977. *Der Erholungswert des Großen Ahornbodens.* AFZTG, 88: 7–11.
90. Godoy, R., et al. 1993. "A Method for the Economic Valuation of Non-Timber Tropical Forest Products." *Economic Botany* 47(3): 220–233.
91. Godoy, R., et al. 2000. "Valuation of Consumption and Sale of Forest Goods from a Central American Rain Forest." *Nature* 406: 62–63.
92. Godoy, R., et al. 2002. "Local Financial Benefits of Rain Forests: Comparative Evidence from Amerindian Societies in Bolivia and Honduras." *Ecological Economics* 40(3): 397–409.
93. Goio, I., et al. 2008. "The Development of Forest Accounting in the Province Of Trento (Italy)." *Journal of Forest Economics* 14(3): 177–196.
94. Gram, S. 2001. "Economic Valuation of Special Forest Products: An Assessment of Methodological Shortcomings." *Ecological Economics* 36(1): 109–117.
95. Greiner, R., and J. Rolfe. 2004. "Estimating Consumer Surplus and Elasticity of Demand of Tourist Visitation to a Region in North Queensland Using Contingent Valuation." *Tourism Economics* 10(3): 317–328.
96. Grimes, A., et al. 1994. "Valuing the Rain Forest: The Economic Value of Nontimber Forest Products in Ecuador." *Ambio* 23: 405–410.
97. Guitart, A.B. and L.C. Estraviz Rodriguez. 2010. "Private Valuation of Carbon Sequestration in Forest Plantations." *Ecological Economics* 69(3): 451–458.
98. Gunatilake, H. M., et al. 1993. "Role of Non-Timber Forest Products in the Economy of Peripheral Communities of Knuckles National Wilderness Area of Sri Lanka: A Farming Systems Approach." *Economic Botany* 47(3): 275–281.
99. Gundimeda H., et al. 2006. "The Value of Biodiversity in India's Forests." Monograph 4 — Green Accounting for Indian States and Union Territories Project. New Delhi, India: TERI Press.
100. Guo, Z., et al. 2001. "Ecosystem Functions, Services and Their Values – A Case Study in Xingshan County of China." *Ecological Economics* 38(1): 141–154.
101. Guo, Z.W., et al. 2000. "An assessment of ecosystem services: water flow regulation and hydroelectric power production." *Ecological Applications* 10: 925–936.
102. Hadker, N., et al. 1997. "Willingness-to-pay for Borivli National Park: Evidence from a Contingent Valuation." *Ecological Economics* 21(2): 105–122.
103. Haefele, M., et al. 1992. "Estimating the Total Value of Forest Quality in High-Elevation Spruce-Fir Forests. The Economic Value of Wilderness." General Technical Report SE-78, Southern Forest Experiment Station, Research Triangle Park, NC.
104. Hagestuen, W. and K. Skogen. 1995. "Socio-Economic Value of the Natural Resources of the Ullensvang State Commons — Samfunnsøkonomisk verdi av naturressursene i Ullensvang statsalmenning, Hardangervidda." Universitetet for miljø- og biovitenskap (UMB), Study only available in Norwegian

105. Halstead J.M., et al. 1991. "Use of Tobit Model in Contingent Valuation: Experimental Evidence from the Pemigewasset Wilderness Area." *Journal of Environmental Management* 33(1): 79–89.
106. Hanley, N. 1989. "Valuing Rural Recreation Benefits: An Empirical Comparison of Two Approaches." *Journal of Agricultural Economics* 40(3): 361–374.
107. Hanley, N., and R. Ruffell. 1993. "The Valuation of Forest Characteristics." In *Forestry and the Environment: Economic Perspectives*, eds. W. Adamowicz, W. White, and W.E. Phillips. Oxon, UK: CAB International, Oxon: 171–197.
108. Hanley, N., et al. 2002. *Valuing the Benefits of Biodiversity in Forest.* Forestry Commission, United Kingdom.
109. Hansen, L. and D. Hellerstein. 2007. "The Value of the Reservoir Services Gained with Soil Conservation." *Land Economics* 83(3): 285–301.
110. Haqen, D.A., et al. 1992. "Benefits of Preserving Old-Growth Forests and the Spotted Owl." *Contemporary Economic Policy* 10(2): 13–26.
111. Hearne, R.R., and Z.M. Salinas. 2002. "The Use of Choice Experiments in the Analysis of Tourist Preferences for Ecotourism Development in Costa Rica." *Journal of Environmental Management* 65: 153–163.
112. Hein, L., et al. 2006. "Spatial Scales, Stakeholders and the Valuation of Ecosystem Services." *Ecological Economics* 57 (2): 209–228.
113. Hodgson G. and J. Dixon. 1988. "Measuring Economic Losses due to Sediment Pollution: Logging Versus Tourism and Fisheries." *Tropical Coastal Area Management* 3(1): 5–8.
114. Hoen, H. and G. Winther. 1993. "Multiple Use Forestry and Preservation of Coniferous Forests in Norway." *Scandinavian Journal Forest Resource* 8(1–4): 266–280.
115. Holmes, T., et al. 1998. "The Effect of Response Time on Conjoint Analysis Estimates of Rainforest Protection Values." *Journal of Forest Economics* 4(1): 7–28.
116. Horne, P. 2006. "Forest Owners' Acceptance of Incentive Based Policy Instruments in Forest Biodiversity Conservation-A Choice Experiment Based Approach." *Silva Fennica* 40(1): 169.
117. Horne, P., et al. 2005. "Multiple-use Management of Forest Recreation Sites: A Spatially Explicit Choice Experiment." *Forest Ecology and Management* 207(1–2): 189–199.
118. Horton, B., et al. 2003. "Evaluating Non-user Willingness to Pay for a Large Scale Conservation Program in Amazonia: A UK/Italian Contingent Valuation Study." *Environmental Conservation* 30(2): 139–146.
119. Houghton, K. and R. Mendelsohn. 1997. "An Economic Analysis of Multiple-use Forestry in Nepal." *Ambio* 25(3): 156–159.
120. Hougner, C., et al. 2006. "Economic Valuation of a Seed Dispersal Service in the Stockholm National Urban Park, Sweden." *Ecological Economics* 59: 364–374.
121. Hutchinson, W. and S. Chilton. 1999. "Combining Preferences Ordering and Contingent Valuation Methods to Assess Non Market Benefit of Alternative Afforestation Projects." *Journal of Rural Studies* 15(1): 103–109.
122. Hutchinson, W.G. 1995. "How Public Preferences Affect Non-Market Values For Afforestation in Ireland" Paper Presented to the Agricultural Economics Society of Ireland, Monday, 25 September 1995.
123. International Resources Groups Ltd. 2000. "The Case of Duru Haitemb Community-Based Forest Management Project Babat District, Arusha Region, Tanzania." USAID, Tanzania.
124. Jakus, P.M., and V.K. Smith. 1992. "Measuring Use and Nonuse Values for Landscape Amenities: A Contingent Behavior Analysis of Gypsy Moth Control." Annual Meeting of the Association of Environmental and Resource Economists, New Orleans, LA, January.
125. Jamal, O., and A. Shahariah. 2003. "The Economics of Wetlands Conservation: Case of Paya Indah Wetlands, Malaysia." International Ecotourism Conference, Organized by SEAMEO-SEARCA and UPM, at Bangi, Malaysia.
126. James, D. 1992. "Xateros, Chicleros, And Pimenteros: Harvesting Renewable Tropical Forest Resources in the Guatemalan Peten." *Conservation of Neotropical Forests: Working from Traditional Resource Use* (1992): 208.
127. Jensen, F.S. 2003. Friluftsliv i 592 Skove og Andre Naturomr?der. [Recreation in 592 Forests and other Nature Areas]. Skovbrugsserien nr. 32-2003. Horsholm: Forskningscentret for Skov & Landskab.

128. Jensen, F.S., and N.E. Koch. 1997. Frilufts liv i Skovene 1976177-1993194. [Recreation in Forests 1976/77–1993/94]. Forskningsserien nr. 20. Horsholm: Forskningscentret for Skov & Landskab.
129. Johansson, P.O. 1989. "Valuing Public Goods in a Risky World: An Experiment." In *Evaluation Methods and Policy Making in Environmental Economics*, eds. H. Folmer, E.C. van Ierland. North-Holland, Amsterdam, pp. 39–48.
130. Kaiser, B. and J. Roumasset. 2002. "Valuing Indirect Ecosystem Services: The Case of Tropical Watersheds." *Environment and Development Economics* 7: 701–714.
131. Kamanga, P., et al. 2009. "Forest Incomes and Rural Livelihoods in Chiradzulu District, Malawi." *Ecological Economics* 68(3): 613–624.
132. Kaplowitz, M.D. 2000. "Identifying Ecosystem Services Using Multiple Methods: Lessons from the Mangrove Wetlands of Yucatan, Mexico." Agriculture and Human Values 17(2): 169–179.
133. Kerr, G.N. 1996. "Recreation Values and Kai Tahu Management: The Greenstone and Caples Valleys." *New Zealand Economic Papers* 30(1): 19–38.
134. Kniivila, M., et al. 2002. "Costs and Benefits of Forest Conservation: Regional and Local Comparisons in Eastern Finland." *Journal of Forest Economics* 8(2): 131–150.
135. Koch, N.E. 1978. "Skovenes Friluftsfunktion I Danmark. I. Del. Befolkningens Anvendelse af Landets Skove." ["Forest Recreation in Denmark. Part I: The Use of the Country's Forests by the Population"]. Det Forst lige Forsogs v sen i Danmark 35(3): 285–451.
136. Koch, N.E. 1980. "Skovenens Friluftsfunktion i Danmark. II. Del Anvendelsen af Skovene Regionalt Betragtet." ["Forest Recreation in Denmark. Part II: The Use of the Forests Considered Regionally"]. Det Forstlige
137. Koch, N.E., and F.S. Jensen. 1988. "Skovenes Friluftsfunktion i Danmark. IV. del. Befolkningens 0nsker til Skovenes og det ?bne Lands Udformning." ["Forest Recreation in Denmark. Part IV: The Preferences of the Population"]. Det Forstlig Forsogsv sen i Danmark Al (3): 243–516
138. Köhlin, G. 2001. "Contingent Valuation in Project Planning and Evaluation: The Case of Social Forestry in Orissa, India." *Environment and Development Economics* 6(2): 237–258.
139. Kontoleon, A. and T. Swanson. 2003. "The Willingness to Pay for Property Rights for The Giant Panda: Can a Charismatic Species be an Instrument for Nature Conservation." *Land Economics* 79(4): 483–499.
140. Kosz, M. 1996. Valuing Riverside Wetlands: The Case of the "Donau-Auen" National Park. *Ecological Economics* 16: 109–127.
141. Kramer, R., et al. 1996. "Valuing Tropical Rain Forest Protection Using the Contingent Valuation Method." Adamowicz W. et al: 181–194.
142. Kramer, R.A., and D.E. Mercer. 1997. "Valuing a Global Environmental Good: US Residents' Willingness to Pay to Protect Tropical Rain Forests." *Land Economics* 73(2): 196–210.
143. Kramer, R.A., et al. 1995. "Valuing Tropical Forests: Methodology and Case Study of Madagascar." World Bank Environment Paper 13. Washington, DC: World Bank.
144. Kramer, R.A., et al. 1997. "Ecological and Economic Analysis of Watershed Protection in Eastern Madagascar." *Journal of Environmental Management* 49(3): 277–295.
145. Kriström, B. 1990. "Valuing Environmental Benefits Using the Contingent Valuation Method." Umeå Economic Studies vol 219: Department of Economics, Umeå University.
146. Krutilla, J.V. 1991. "Environmental Resource Services of Malaysian Moist Tropical Forest." Baltimore: Johns Hopkins University Press, for Resources for the Future.
147. Kumari, K. 1995. "An Environmental and Economic Assessment of Forest Management Options: A Case Study in Malaysia." No. 26. Environment Department: World Bank.
148. Lal, P. 1990. Ecological Economic Analysis of Mangrove Conservation; a case study from Fiji. In Mangrove Ecosystems Occasional Papers No. 6. UNDP/UNESCO. New Delhi, India
149. Lampietti, J.A. and J.A. Dixon. 1995. "To see the Forest for the Trees: A Guide to Non-Timber Forest Benefits." Environmental Economics Series 013. Washington, DC: The World Bank.

150. Lee, C.K. et al. 1998. "Measuring the Economic Value of Ecotourism Resource: The Case of South Korea." *Journal of Travel Research* 36(4): 40–46.
151. Lee, H. C. and H. S. Chun. 1999. "Valuing Environmental Equality Change on Recreational Hunting in Korea: A Contingent Valuation Analysis." *Journal of Environmental Management* 57: 11–20.
152. Lehtonen, E. et al. 2003. "Non Market Benefits of Forest Conservation In Southern Finland." *Environmental Science and Policy* 6(3): 195–204.
153. Li, Chuan-Zhong, and Leif Mattsson. 1995. "Discrete Choice under Preference Uncertainty: An Improved Structural Model for Contingent Valuation." *Journal of Environmental Economics and Management* 28(2): 256–269.
154. Li, T., et al. 2008. "Variations in Ecosystem Service Value in Response to Land Use Changes in Shenzhen." *Ecological Economics* (In Press), Corrected Proof: 9.
155. Lockwood, M. et al. 1993. "A Contingent Valuation Survey and Benefit–Cost Analysis of Forest Preservation in East Gippsland, Australia." *Journal of Environmental Management* 38(3): 233–243.
156. Loomis, J. and E. Ekstrand. 1998. "Alternative Approaches for Incorporating Respondent Uncertainty When Estimating Willingness-To-Pay: The Case of The Mexican Spotted Owl." *Ecological Economics* 27(1): 29–41.
157. Loomis, J. et al. 1993. "Some Empirical Evidence on Embedding Effects in Contingent Valuation of Forest Protection." *Journal of Environmental Economics and Management* 25(1): 45–55.
158. Loomis, J. et al. 1996. "A Contingent Valuation Study of the Value of Reducing Fire Hazards to Old-Growth Forests in the Pacific Northwest." United States Department of Agriculture Forest Service Pacific Southwest Research Station Research Paper.
159. Löwenstein, W. 1991. "Die Monetäre bewertung der Fernerholung im Südharz mit der Reisekostenmethode." V. Bergen, H.D. Brabänder, A.W. Bitter, W. Löwenstein (Eds.), Beiträge zum Symposium-Monetäre Bewertung der landeskulturellen Leistungen der Forstwirtschaft (first ed.), J.D. Sauerländer's Verlag, Göttingen, p. 162
160. Luoga, E.J., et al. 2000. "Economics of Charcoal Production in Miombo Woodlands of Eastern Tanzania: Some Hidden Costs Associated With Commercialization of the Resources." *Ecological Economics* 35(2): 243–257.
161. Luzadis, V.A. 1997. "The Integrated Valuation Method as a Holistic Approach to Measuring Forest Values for Policy Development." Faculty of Forestry, College of Environmental Science and Forestry, State University of New York
162. MacMillan, D.C. and E. I. Duff. 1998. "Estimating the Non-Market Costs and Benefits of Native Woodland Restoration Using the Contingent Valuation Method." *Forestry* 71(3): 247–259.
163. Maille, P., and R. Mendelsohn. 1993. "Valuing Ecotourism in Madagascar." *Journal of Environmental Management* 38(3): 213–218.
164. Mallawaarachchi, T., et al. 2001. "Community Values for Environmental Protection in a Cane Farming Catchment in Northern Australia: A Choice Modelling Study." *Journal of Environmental Management* 62(3): 301–316.
165. Mamo, G., et al. 2007. Economic Dependence on Forest Resources: A Case from Dendi District, Ethiopia. *Forest Policy Economics* 9(8): 916–927.
166. Mäntymaa, E. 2002. "Estimating the Demand for Biodiversity-Vagueness Band and Open Ended Questions." In *Proceedings: Risk and Uncertainty in Environmental and Resources Economics*, eds. Ierland, Weikard, and Wesseler. The Netherlands: Wageningen University.
167. Marangon, F., and E. Gottardo. 2001. La valutazione monetaria del danno ai boschi del Friuli-Venezia Giulia. In: La valutazione dei beni ambientali come supporto alle decisioni pubbliche, Università degli Studi di Udine, Udine, Italy, pp. 1–27.
168. Marikan, D. A., et al. 2006. "The Economics of Recreational Park Conservation: A Case Study of Bako National Park." Staff Paper 4/2006: Faculty of Economics and Management, University Putra Malaysia, Malaysia.
169. Marinelli, A., and D. Romano. 1987. La Foresta Umbra: Criteri di scelta nell'impiego di una risorsa naturale ad uso multiplo. Rassegna Economica 51: 515–530.

170. Marinelli, A., et al. 1990. Valutazione economica dell'impatto aggregato e dei benefici diretti della ricreazione all'aperto di un parco naturale della Toscana. Genio Rurale 9: 51–58.
171. Markandya, A., et al. 2008. "Review On The Economics of Biodiversity Loss — Economic Analysis and Synthesis," Final report for the European Commission, Venice, Italy. 140 pp.
172. Matero, J., and O. Saastamoinen. 1998. "Monetary Assessment of the Impacts of Forestry on Water-Based Benefits in Finland." *Boreal environment research* 3(1): 87–96.
173. Matero, J., and O. Saastamoinen. 2007. "In Search of Marginal Environmental Valuations — Ecosystem Services in Finnish Forest Accounting." *Ecological Economics* 61(1): 101–114.
174. Matthews, D.I., et al. 2009. "Testing the Stability of the Benefit Transfer Function for Discrete Choice Contingent Valuation Data." *Journal of Forest Economics* 15 (1–2): 131–146.
175. Mattsson, L. and C.Z. Li. 1993. "The Non-Timber Value of Northern Swedish Forests — An Economic-Analysis." *Scandinavian Journal of Forest Research*, 8(1–4): 426–434.
176. McFarlane, B.L., and P.C. Boxall. 1998. "An Overview and Nonmarket Valuation of Camping in the Foothills Model Forest." Information Report NOR-X-358: Canadian Forest Service, Northern Forestry Center, Canada.
177. Mendelsohn, R. and M. Balick. 1995. "The Value of Undiscovered Pharmaceuticals in Tropical Forests." *Economic Botany* 49(2): 223–228.
178. Menkhaus, S., and D.J. Lober. 1995. "International Ecotourism and the Valuation of Tropical Rainforests in Costa Rica." *Journal of Environmental Management* 47(1): 1–10.
179. Mercer, E. et al. 1995. "Rain Forest Tourism: Estimating the Benefits of Tourism Development in a New National Park in Madagascar." *Journal of Forest Economics* 1(2): 239–26
180. Merlo, M. 1986. Valutazione dei servizi ricreativo-ambientali dei boschi. *Economia Montana* 4: 3–11.
181. Merlo, M. and G. Signorello. 1991. "Alternative Estimates of Outdoor Recreation Benefits in Italy." V. Bergen, H.D. Brabänder (Eds.), Beiträge zum Symposium: Monetäre Bewertung der landeskulturellen Leistungen der Forstwirtschaft Band (first ed), J.D. Sauerländer's Verlag, Göttingen pp. 133–161
182. Mikhailova, I., and F.A.R. Barbosa. 2002. Estimativa Preliminar do Valor dos Recursos Ambientais do Parque Estadual do Rio Doce (MG): uma aplicação dos métodos "disposição a pagar". Simpósio Nacional sobre Recuperação de Áreas Degradadas: Belo Horizonte, CEMAC/UFLA/SOBRADE.uly, 2004).
183. Miller, J.D., and B.E. Lindsay. 1993. "Willingness to Pay for a State Gypsy Moth Control Program in New Hampshire: A Contingent Valuation Case Study." *Journal of Economic Entomology* 86(3): 828–837.
184. Ministerie van Landbouw, Natuur en Voedselkwaliteit. 2006. Kentallen waardering natuur, water, bodem en landschap. Hulpmiddel bij MKBA's. Eerste editie. Witteveen en Bos, Deventer, the Netherlands.
185. Mogas, J., et al. 2006. "A Comparison of Contingent Valuation and Choice Modelling with Second-order Interactions." *Journal of Forest Economics* 12(1): 5–30.
186. Mohd-Shahwahid, H.O. and R. McNally. 2001. "The Terrestrial and Marin Resources of Samoa." Universiti Putra Malaysia, Malaysia.
187. Moons, E., et al. 2001. "Travel Cost and Time Measurement in Travel Cost Models." Working Paper Series no 2001–22, 1–19: Faculty of Economics and Applied Economic Sciences, Katolieke Universiteit Leuven.
188. Moran, D. 1994. "Contingent Valuation and Biodiversity: Measuring The User Surplus of Kenyan Protected Areas." *Biodiversity and Conservation* 3(8): 663–684.
189. Muniz-Miret N., et al. 1996. "The Economic Value of Managing the Acai Palm (Euterpe Oleracea Mart.) In the Floodplains of The Amazon Estuary, Para, Brazil." *Forest Ecology and Management* 87(1): 163–173.
190. Myers, N. 1988. "Tropical Forests: Much more than Stocks of Wood." *Journal of Tropical Ecology* 4(2): 209–221.
191. Naidoo, R., and T.H. Ricketts. 2006. "Mapping the Economic Costs and Benefits of Conservation." *PLoS Biology* 4(11): 2153–2164.
192. Naidoo, R., and W.L. Adamowicz. 2005. "Biodiversity and Nature-Based Tourism at Forest Reserves in Uganda." *Environment and Development Economics* 10(2): 158–178.

193. Narendran, K., et al. 2001. "Nontimber forest Product Extraction, Utilization and Valuation: A Case Study from the Nilgiri Biosphere Reserve, Southern India." *Economic Botany* 55(4): 528–538.
194. Ninan, K.N. and M. Inoue. 2013. "Valuing Forest Ecosystem Services: Case Study of a Forest Reserve in Japan." *Ecosystem Services* 5: 78–87.
195. Niskanen, A. 1998. "Value of External Environmental Impacts of Reforestation in Thailand." *Ecological Economics* 26(3): 287–297.
196. Norton-Griffiths, M. 1994. "Biodiversity Conservation in Kenya." Dissertation submitted to University College London, UK.
197. Notaro, S. and A. Paletto. 2012. "The Economic Valuation of Natural Hazards in Mountain Forests: An Approach Based on the Replacement Cost Method." *Journal of Forest Economics* 18(4): 318–328.
198. Nuñez D., et al. 2006. "Forests and Water: The Value of Native Temperate Forests in Supplying Water for Human Consumption." *Ecological Economics* 58(3): 606–616.
199. Olar, M., et al. 2010. "Caractérisation de l'Importance Économique de la Flore au Québec et Analyse de Différentes Possibilités de Financement." ÉcoRessources Consultants: Canada.
200. Olsen, S.B. and T. Lundhede. 2005. "Recreational Values in Near-natural Silviculture — An Economic Valuation of Forest Characteristics using Discrete Choice Experiment." The Royal Veterinary and Agricultural University (KVL).
201. Ortiz, R.A., et al. 2001. "Estimando o valor ambiental do Parque Nacional do Iguaçu: uma aplicação do método de custo viagem." IPEA, Rio de Janeiro. January (Texto para Discussão no 777).
202. Othman, J. 2000. "Estimating Non-Use Values of Environmental Resources Using Contingent Valuation: Case Of Matang Mangroves." *Environmental Management* 9(6): 214–222.
203. Othman, J. 2001. "Estimating Non-Use Values of Environmental Resources Using Contingent Valuation: Case of Matang Mangroves." Jamaluddin Jahi, et al.: 214–222.
204. Othman, J. and R. Othman. 1998. "Economic Benefits from Wetland Biodiversity: Case of Fireflies Recreation, Malaysia." *Tropical Biodiversity* 5(1): 65–74.
205. Othman, J. and S. Asmuni. 2003. "Economic Values of Wetlands Conservation from the Perspective of Urban Non-Users." *Analisis* 10(2): 35–48.
206. Ovaskainen, V. et al. 2001. "Estimating Recreation Demand with On-Site Data: An Application of Truncated and Endogenously Stratified Count Data Models." *Journal of Forest Economics* 7(2): 125–142.
207. Pagiola, S. 1996. "Republic of Croatia Coastal Forest Reconstruction and Protection Project. Annex 1 Economic Analysis." Washington, DC: The World Bank.
208. Pagiola, S., et al. 2004. "Paying for Biodiversity Conservation Services In Agricultural Landscapes." Final draft. Forthcoming as Environment Department Paper No.96. Washington, DC: World Bank.
209. Pattanayak, S. and D.E. Mercer. 1998. "Valuing Soil Conservation Benefits of Agroforestry: Contour Hedgerows in the Eastern Visayas, Philippines." *Agricultural Economics* 18: 31–46.
210. Pearce, D.W. 1990. "An Economic Approach to Saving the Tropical Forests." LEEC Paper 90–06. International Institute for Environment arid Development, London, 30 pp.
211. Pearce, D.W. 2001. "Economic Value of Forest Ecosystems." *Ecosystem Health* 7(4): 284–296.
212. Pendleton, L., et al. 1998. "Measuring Environmental Quality in the Southern Appalachian Mountains." *Forest Science* 44(4): 603–609.
213. Perrot-Maître, D. and P. Davis. 2001. "Case Studies of Markets and Innovative Financial Mechanisms for Water Services from Forests." Forest Trends, working paper.
214. Peters, C.M., et al. 1989. "Valuation of an Amazonian Rainforest." *Nature* 339: 655–656.
215. Peyron, J.L., et al. 2002. "National Survey on Demand for recreation in French Forests." Report for EUROSTAT: Nancy, France.
216. Phillips, A. ed. 1998. "Economic Values of Protected Areas: Guidelines for Protected Area Managers." Task Force on Economic Benefits of Protected Areas of the World Commission on Protected Areas (WCPA) of IUCN, in collaboration with the Economics Service Unit of IUCN, UK.

217. Phillips, S., et al. 2008. “Greater than Zero: Toward the Total Economic Value of Alaska’s National Forest Wildlands.” Washington, DC: The Wilderness Society.
218. Pinedo-Vasquez, M., et al. 1992. “Economic Returns from Forest Conversion in the Peruvian Amazon.” *Ecological Economics* 6(2): 163–173.
219. Pope, C.A., and J.W. Jones. 1990. “Value of Wilderness Designation in Utah”. *Journal of Environmental Management* 30(2): 157–174.
220. Pouta, E., et al. 2000. “Contingent Valuation of the Natura 2000 Nature Conservation Programme in Finland.” *Forestry* 73(2): 119–128.
221. Powe, N.A., et al. 1997. “Using a Geographic Information System to Estimate an Hedonic Price Model of the Benefits of Woodland Access.” *Forestry* 70(2): 139–149.
222. Priess, J.A., et al. 2007. “Linking Deforestation Scenarios to Pollination Services and Economic Returns in Coffee Agroforestry Systems.” *Ecological Applications* 17(2): 407–417.
223. Qiu, Y., et al. 2010. “Valuation of Flood Reductions in the Yellow River Basin under Land Use Change.” *Journal of Water Resource Planning and Management* 136: 106–115.
224. Rajmis, S., et al. 2009. “User Community Preferences for Climate Change Mitigation and Adaptation Measures around Hainich National Park, Germany.” *Climate Research* 40: 61–73.
225. Raunikar, R., and J. Buongiorno. 2006. “Willingness to Pay for Forest Amenities: The Case of Non-industrial Owners in the South Central United States.” *Ecological Economics* 56(1): 132–143.
226. Rausser, G.C. and A. Small. 2000. “Valuing Research Leads: Bioprospecting and the Conservation of Genetic Resources.” UC Berkeley: Berkeley Program in Law and Economics. *Journal of Political Economy* 108(1): 173–206.
227. Reaves, D.W., et al. “Does Question Format Matter? Valuing an Endangered Species.” *Environmental and Resource Economics* 14(3): 365–383.
228. Regmi, B.N. 2003. “Contribution of Agroforestry for Rural Livelihoods: A Case of Dhading District, Nepal.” Paper presented at The International Conference on Rural livelihoods, Forests and Biodiversity 19–23 May 2003, Bonn, Germany.
229. Richards, M.T., et al. 1990. “The Lack of an Expected Relationship Between Travel Cost And Contingent Value Estimates of Forest Recreation Value.” *Leisure Sciences* 12(3): 303–319.
230. Ricketts T.H., et al. 2004. “Economic Value of Tropical Forest to Coffee Production.” Proceedings of the National Academy of Sciences 101(34): 12579–12582.
231. Rodriguez, L.C., et al. 2006. “Local Identification and Valuation of Ecosystem Goods and Services from Opuntia Scrublands of Ayacucho, Peru.” *Ecological Economics* 57(1): 30–44.
232. Rogers, M.F., and J.A. Sinden. 1994. “Safe Minimum Standard for Environmental Choices: Old-Growth Forest in New South Wales.” *Journal of Environmental Management* 41.2: 89–103.
233. Rolfe, J., and J. W. Bennett. 2002. Assessing Rainforest Conservation Demands. *Economic Analysis and Policy* 32(2): 51–67.
234. Rolfe, J., et al. 2000. Choice Modelling and its Potential Application to Tropical Rainforest Preservation. *Ecological Economics* 35: 289–302.
235. Rollins, K. 1997. “Wilderness Canoeing in Ontario: Using Cumulative Results to Update Dichotomous Choice Contingent Valuation Offer Amounts.” *Canadian Journal of Agricultural Economics* 45: 1–16.
236. Rosales, R.M.P., et al. 2005. “Balancing the Returns to Catchment Management.” IUCN Water, Nature and Economics Technical Paper 5: IUCN, ecosystems and livelihoods group Asia, Colombo.
237. Rubin, J. et al. 1991. “A Benefit-Cost Analysis of the Northern Spotted Owl.” *Journal of Forestry 89*(12): 25–30.
238. Saastamoinen, O., et al. 2013. “Concepts and Considerations for the Synthesis of Ecosystem Goods and Services in Finland.” Publications of the University of Eastern Finland. Reports and Studies in Forestry and Natural Sciences 10: 108.

239. Sattout, E., et al. 2007. "Economic Value of Cedar Relics in Lebanon: An Application of Contingent Valuation Method for Conservation." *Ecological Economics* 61: 315–322
240. Scarpa, R., et al. 2000. "Importance of Forest Attributes in the Willingness to Pay for Recreation: A Contingent Valuation Study of Irish Forests." *Forest Policy and Economics* 1(3): 315–29.
241. Scarpa, R., et al. 2000. "Valuing the Recreational Benefits from the Creation of Nature Reserves in Irish Forests." *Ecological Economics* 33(2): 237–250.
242. Schaafsma, M., et al. 2012. "Towards Transferable Functions for Extraction of Non-Timber Forest Products: A Case Study on Charcoal Production in Tanzania." *Ecological Economics* 80: 48–62.
243. Shackleton, C.M., et al. 2002. "The Role and Value of Savanna Non-Timber Forest Products to Rural Households in the Kat River Valley, South Africa." *Journal of Tropical Forest Products* 8(1): 45–65.
244. Shaikh, S. L., et al. "Does Inclusion of Landowners' Non-Market Values Lower Costs of Creating Carbon Forest Sinks?" Resource Economics and Policy Analysis (REPA), Research Group at the University of Victoria, Department of Economics, Working paper 2003–03.
245. Sheil, D. and S. Wunder. 2002. "The Value of Tropical Forest to Local Communities: Complications, Caveats, and Cautions." *Conservation Ecology* 6.2: 9.
246. Shone, B. and J. Caviglia-Harris. 2006. "Quantifying and Comparing the Value of Non-Timber Forest Products in the Amazon." *Ecological Economics* 58(2): 249–267.
247. Shultz, S., et al. 1998. "Opportunities and Limitations of Contingent Valuation Surveys to Determine National Park Entrance Fees: Evidence from Costa Rica." *Environment and Development Economics* 3: 131–149.
248. Shyamsundar, P. and R. Kramer. 1997. "Biodiversity Conservation–At What Cost? A Study of Households in the Vicinity of Madagascar's Mantadia National Protected Area." *Ambio* 26(3): 180–184.
249. Siikamäki, J. and D.F. Layton. 2007. "Discrete Choice Survey Experiments: A Comparison Using Flexible Methods." *Journal of Environmental Economics and Management* 53(1): 122–139.
250. Simensen, K., and M. Wind. 1990. Holdninger til og betalingsvillighet for ulike skogbehandlinger i fjellskog: En empirisk undersøkelse av hirkjølen statsallmenning (attitudes and wtp for different forestry practices in mountainous forests: a survey of the hirkjolen common). Master Thesis, Norwegian University of Life Sciences.
251. Simpson, R.D., et al. 1996. "Valuing Biodiversity for Use in Pharmaceutical Research." *Journal of Political Economy* 104(1): 163–183.
252. Skagestad, E., 1996. Friluftsliv og Skogbruk – En spørreundersøkelse blant turgjengere i ytre Oslomarka, Romeriksåsen, på vinterstid (Skagestad, E., 1996. Friluftsliv og Skogbruk —En spørreundersøkelse blant turgjengere i ytre Oslomarka, Romeriksåsen, på vinterstid (Recreation and forestry— a survey of hikers in the outer Oslomarka, Romeriksåsen, in the winter time). Master Thesis, Norwegian University of Life Sciences. Romeriksåsen, in the winter time). Master Thesis, Norwegian University of Life Sciences.
253. Skagestad, E.C. "Recreation and Forestry —Friluftsliv og skogbruk" Norwegian University of Life Sciences (UMB), 1996
254. Smith, J., et al. 1998. "Willingness to Pay for Environmental Services among Slash-and Burn Farmers in the Peruvian Amazon: Implications for Deforestation and Global Environmental Markets." Paper presented at the World Congress of Environmental and Resource Economists, Venice, Italy.
255. Solino, M., et al. 2009. "Social Demand for Electricity from Forest Biomass in Spain: Does Payment Periodicity Affect the Willingness to Pay?" *Energy Policy* 37: 531–540.
256. Starbuck, M.C., et al. 2004. "Valuing Special Forest Products Harvesting: A Two-Step Travel Cost Recreation Demand Analysis." *Journal of Forest Economics* 10(1): 37–53.
257. Svedsäter, H. 2000. "Contingent Valuation of Global Environmental Resources: Test of Perfect and Regular Embedding." *Journal of Economic Psychology* 21: 605–623.
258. Swanson C.S. and J.B. Loomis. 1996. "Role of Non-Market Economic Values in Benefit-Cost Analysis of Public Forest Management." USDA Forest Service: Pacific Northwest Research Station, General Technical Report 361.

259. Termansen, M., et al. 2004. "Economic Valuation of Danish Forest Recreation Combining Mixed Logit Models and GIS." EAERE Conference. June 25–28. Budapest, Hungary.
260. The, B.D., and H.B. Ngoc. 2006. "Payments for Environmental Services in Vietnam: Assessing an Economic Approach to Sustainable Forest Management." Economy and Environment Program for Southeast Asia, International Development Research Centre (IDRC), 2006
261. Tisdell, C. 2009. "The Economics of Biodiversity Conservation: Valuation in Tropical Forest Ecosystems." In *Earthscan* (2007), ed. K.N. Ninan. *Ecological Economics* 68(5): 1566–1567.
262. Tobias D. and R. Mendelsohn. 1991. "Valuing Ecotourism in a Tropical Rain-Forest Reserve." *Ambio* 20: 91–93.
263. Torras, M. 2000. "The Total Economic Value of Amazonian Deforestation, 1978–1993." *Ecological Economics* 33(2): 283–297.
264. Troy, A. and M.A. Wilson. 2006. "Mapping Ecosystem Services: Practical Challenges and Opportunities in Linking GIS and Value Transfer." *Ecological Economics* 60(2): 435–449.
265. Turpie, J.K. 2003. "The Existence Value of Biodiversity in South Africa: How Interest, Experience, Knowledge, Income and Perceived Level of Threat Influence Local Willingness to Pay." *Ecological Economics* 46(1–2): 199–216.
266. Turpie, J.K., et al. 2003. "Economic Value of Terrestrial and Marine Biodiversity in the Cape Floristic Region: Implications for Defining Effective and Socially Optimal Conservation Strategies." *Biological Conservation* 112: 223–251
267. Tyrtyshny, E. 2005. "Economic Value of the Ecosystem in Kazakhstan." Paper presented at Seminar on Environmental Services and Financing for the protection and sustainable use of ecosystems, Geneva, 10–11 October 2005.
268. Van Beukering, P.J.H., et al. 2003. "Economic Valuation of the Leuser National Park on Sumatra, Indonesia." *Ecological Economics* 44(1): 43–62.
269. Van der Heide, C.M., et al. 2005. Measuring the Economic Value of Two Habitat Defragmentation Policy Scenarios for the Veluwe, the Netherlands." Nota di Lavoro, Fondazione Eni Enrico Mattei, No. 42.2005.
270. van Kooten, et al. 1999. "How Much Primary Coastal Temperate Rain Forest Should Society Retain? Carbon Uptake, Recreation, and Other Values." *Canadian Journal of Forest Research* 29(12): 1879–1890.
271. van Rensburg, T.M., et al. 2002. "Preferences and Multiple Use Forest Management." *Ecological Economics* 43(2–3): 231–244.
272. Veisten, K. and S. Narvud. 2006. "Contingent Valuation and Actual Payment for Voluntarily Provided Passive-Use Values: Assessing the Effect Of Fan Induced Truth-Telling Mechanism and Elicitation Formats." *Applied Economics* 38: 735–756.
273. Veisten, K. et al. 2004. "Scope Insensitivity in Contingent Valuation of Complex Environmental Amenities." *Journal of Environmental Management* 73(4): 317–331.
274. Verma, M. 2000. "Economic Valuation of Forests of Himachal Pradesh." International Institute for Environmental Development, London, UK.
275. Vincent et al. 2014. "Tropical Countries may be Willing to Pay More to Protect their Forests." Proceedings of the National Academy of Sciences 111(28): 10113–10118.
276. Walsh, R. et al. 1990. "Estimating the Public Benefits of Protecting Forest Quality." *Journal of Environmental Management* 30(2): 175–189.
277. Walsh, R.G., et al. 1984. "Valuing Option, Existence, and Bequest Demand for Wilderness." *Land Economics* 60: 14–29.
278. Weisten, K., et al. 1993. "Valuing Biodiversity in Norwegian Forests: A Contingent Valuation Study with Multiple Bias Testing." No 07/1993, Memorandum, Oslo University, Department of Economics.
279. Willis, K.G. 1991. "The Recreational Value of the Forestry Commission Estate in Great Britain: A Clawson–Knetsch Travel Cost Analysis." *Scottish Journal of Political Economy* 38: 58–75.

280. Willis, K.G., and G.D. Garrod. 1991. "An Individual Travel Cost Method of Evaluating Forest Recreation." *Journal of Agricultural Economics* 42(1): 33–42.
281. Willis, K.G., and J.F. Benson. 1988. "A Comparison of User Benefits and Costs of Nature Conservation at Three Nature Reserves." *Regional Studies,* 22: 417–428.
282. Willis, K.G., and J.F. Benson. 1989. "Recreational Values of Forests." *Forestry* 62: 93–110.
283. Wna Sabri, W. M. 1989. "Forest Recreation Use Patterns, User Behaviour and Recreational Value in Malaysia." Dissertation Abstracts International. A, Humanities and Social Sciences 50(6).
284. Xue, D. and C. Tisdell. 2001. "Valuing Ecological Functions of Biodiversity in Changbaishan Mountain Biosphere Reserve in Northeast China." *Biodiversity and Conservation* 10(3): 467–481.
285. Yacob, M.R. et al. 2009. "A Contingent Valuation Study of Marine Parks Ecotourism: The Case of Pulau Payar and Pulau Redang in Malaysia." *Journal of Sustainable Development* 2(2): 95.
286. Yaron, G. 2001. "Forest, Plantation Crops or Small-Scale Agriculture? An Economic Analysis of Alternative Land Use Options in the Mount Cameroun Area." *Journal of Environmental Planning and Management* 44(1): 85–108.

APPENDIX VI. SPATIAL DATA AND METHODS

VALUE SITES DATA

In order to extract the spatial data necessary to conduct the meta-regressions and benefit transfer, the authors imported their value sites into ArcMAP Version 10.0 using the spatial reference information and proceeded to extract the necessary data from various sources and datasets. Below is a description of the data and methods used to extract the necessary variables for each value site included in the authors' estimation dataset. Because of the global nature of the authors' datasets, the projection used for all the data was *WGS 1984 Web Mercator*.

Population density in 2000

Population density data was obtained as a raster with a cell resolution of 2.5 arc-minutes for the year 2000 from Columbia University's Center for International Earth Science Information Network's (CIESIN) Gridded Population of the World (V3) datasets. The data used was that adjusted to UN country totals. In order to retrieve this data for each of their sites, the authors used a 75km buffer around their sites (*Buffer* tool). They then projected (*Project raster* tool) their population density grid using a bilinear interpolation. They extracted the data for each value site buffer using the *Zonal Statistics as Table* tool.

Forest biome

The authors retrieved forest biome data from the Global Forest Monitoring Center's[13] Global Data Biome boundaries shapefile. After retrieving and projecting (*Project* tool) the data, they extracted the information for each value site using the *Spatial Join* tool to get the biome information for each coordinate.

WorldClim Global Climate Data (temperature and precipitation)

The authors downloaded data for temperature and precipitation from the WorldClim Global Climate Data website.[14] They used the data for current conditions (~1950–2000) in the form of 10 arc-minute ESRI grids (for mean temperature and precipitation). They used the *Raster Calculator* tool create raster datasets with the sum (for precipitation) and mean (for temperature) annual measurements. In addition, the temperature raster was also transformed into degrees C using the *Raster Calculator* and dividing by 10. Both datasets were then projected (*Project Raster*). They used *Zonal Statistics as Table* together with their 75km buffer shapefile of value sites to extract total annual precipitation and mean annual temperature by point buffer.

Distance from urban areas

To calculate distance from urban areas they retrieved an urban extent raster from CIESIN's Global Rural-Urban Mapping Project (GRUMP) with a 30-arc-second resolution. After projecting this raster, they converted the raster to a polygon

13 http://glad.geog.umd.edu/projects/gfm/.
14 http://www.worldclim.org/download.

shapefile (*Raster to Polygon*) and extracted only the values indicating urban areas to export to a new shapefile. They then employed the *Near* tool to extract the distance from each point to the closest urban area (in meters).

Road density

Spatial data for global roads were obtained from CIESIN's Global Roads Open Access Dataset (V1). After projecting the shapefile, the authors used the *Intersect* tool together with their 75km buffer shapefile for their value sites to extract only those segments of roads within the value site buffers. They then created a new attribute that would measure (in km) the length of those road segments. They aggregated the length of the segments using the *Summary Statistics* tool and buffered unique identifiers.

Forest area

To get forest area within the75km value site buffers, the authors used land use-land cover spatial data from the European Space Agency (*Globcover 2009*). This raster dataset is a 300-m global land cover map with 22 land cover types. After projecting their raster, the authors used the *Reclassify* to aggregate all areas classified as forests (40, 50, 60, 70, 90, and 100). They then used the resulting dataset, along with their buffer shapefile, to extract the area of each LULC type inside each buffer using the *Tabulate Area* tool. After that, they just proceeded to calculate the percent area in forest for each buffer, taking the area of the circle (buffer) as the total area.

Wetland area

The authors retrieved spatial data on wetlands from the Global Lakes and Wetlands Database.[15] Before processing, they ran the *Int* tool, in order to create an attribute table for the raster dataset with the corresponding wetland categories. After projecting the resulting raster, they used the *Tabulate Area* tool together with their value sites buffers shapefile to get the area of wetland by value site. After that, they used the resulting table to calculate the percent area in wetlands for each buffer, taking the area of the circle (buffer) as the total area.

Species count

Taxonomic group spatial data shapefiles for amphibians, reptiles, and mammals were retrieved from the IUCN Red List,[16] while the bird data was requested and received from BirdLife International and NatureServe.[17] From this data, they extracted counts of native and extant species, as well as threatened species for each taxonomic group, for each value site buffer.

After projecting the data, for the *extant and native* species data, they first selected and exported the records for species with native (1) and reintroduced (2) values from the "Origin" attribute and then did the same with this subset for the records with extant (1), probably extant (2) and possibly extant (3) values from the "Presence" attribute. This way, they end up only with records of native and extant species. They then used the *Dissolve* command in order to have multi-part polygons of the same species, to avoid double counting. After doing this for every taxonomic group file, they used the *Spatial Join* tool (Intersect) together with their value sites buffer shapefile (again, for each taxa) to obtain the count of species within each buffer.

15 http://worldwildlife.org/pages/global-lakes-and-wetlands-database.
16 http://www.iucnredlist.org/technical-documents/spatial-data.
17 http://www.birdlife.org/.

The authors used these same dissolved extant and native species shapefiles to obtain a count of *endangered* species. To do this, they had to make use of each taxa's "Higher Taxonomy" Excel files (provided by IUCN and BirdLife International along with the spatial data), which provided them with the Red List Status of each species. They joined the Red List status with each species in ArcMap using the species unique identifiers and extracted the records for species classified as vulnerable, endangered, critically endangered, extinct in the wild, and extinct species. After the *endangered* species were extracted, they proceeded to use the *Spatial Join* tool to obtain the number of endangered species within each ED.

WORLD 10*10 KM GRID

To provide their results at a finer spatial scale, the authors used a world national boundaries shapefile retrieved from NaturalEarthData[18] to create a 10*10km world grid. They started by projecting the dataset to *WGS 1984 Web Mercator* and proceeded to process it using the *Polygon to Raster* (Value FID, Cell size 10,000), *Raster to Point*, *Point to Raster*, *Raster to Polygon* (Value) tools and, again, *Project* to return their grid shapefile to the same projection. They then proceeded to process the data necessary to accomplish the benefit transfer exercise for each grid cell in the region. They added coordinate information (latitude, longitude) for each cell using the *Calculate Geometry* table tools.

Forests and accessible forests

To precisely attribute forest values to each cell, the first step would be to classify each cell as within a forest and classify this forest as accessible or not. To classify each grid cell as within or outside a forest, we first extracted forests from our reclassified LULC dataset and resampled (*Resample* tool, NEAREST) this raster to a 10*10km grid as well. They then used the *Spatial Join* tool (HAVE_THEIR_CENTER_IN) to classify each grid cell as within or outside a forest.

For calculating accessible forest, the authors made use of the global roads dataset, as well as a global rivers dataset retrieved from NaturalEarthData. After projecting both datasets, they created a 10 km buffer around the features in both datasets. They defined accessible forests as forests falling within 10 km of these types of infrastructure (roads and rivers). They then used these buffered infrastructure shapefiles to extract (*Extract by Mask* tool) the forest pixels that fall within the buffers from their forest raster. After they had only those accessible forests, they resampled this dataset to a 10*10km grid and used the *Spatial Join* (HAVE_THEIR_CENTER_IN) tool to classify each grid cell as within or outside an accessible forest.

Population density

Using their population density rasters, the authors were able to extract this data for each cell in their grid. They resampled their projected population density raster into a 10*10km grid and used the *Int* tool to create an attribute table for the raster, as well as to reduce processing time. They then converted their resampled dataset to polygons (*Raster to Polygon* tool) and used the *Spatial Join* tool to extract population density values for each 10*10km cell.

18 www.naturalearthdata.com.

WorldClim Global Climate Data (temperature)

To extract temperature data by pixel, they used their mean temperature dataset and used a bilinear interpolation to resample it to a 10*10 km grid. They then converted this raster to a polygon shapefile and used the *Spatial Join* tool (HAVE_THEIR_CENTER_IN) to extract the data for all their grid cells.

Forest biome

To extract forest biome information by grid cell, the authors first converted their forest biome shapefile to a raster dataset (*Polygon to Raster*, Cell size 10,000) and then converted it back to a polygon shapefile in order to obtain the same data at a 10*10km resolution. They then used the *Spatial Join* tool (INTERSECT) to extract the forest biome data by grid cell.

Protected Areas and IUCN category

Spatial data for protected areas (PAs) was obtained from the World Database on Protected Areas (August 2013), from UNEP-WCMC. We converted our polygon shapefile to a raster dataset using the designation attribute (MAXIMUM_AREA, Cell size 10,000). We then reclassified all values as binary (1 if inside a PA, 0 otherwise). This dataset was then converted back to a polygon shapefile (MAXIMUM_AREA, Cell size 10,000) and added to our grid using the *Spatial Join* tool (HAVE_THEIR_CENTER_IN). In addition, they also used the *Spatial Join* tool to add IUCN category of each protected area to the grid.

Species count

The authors obtained species count by adding the native and extant species counts extracted from each taxonomic group. They extracted the data using the *Spatial Join* tool (INTERSECT for amphibians and reptiles, HAVE_THEIR_CENTER_IN for mammals and birds), along with their world grid shapefile.

Country Level Data

The authors added country level data to their grid cells by using a World Bank country shapefile to add country information (name and unique identifier) to each grid cell, using the *Spatial Join* tool (HAVE_THEIR_CENTER_IN). They then imported country level data from the World Bank in a .csv file and, using the country unique identifiers, appended the data to each grid cell.