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Ecosystem Services and REDD: Estimating the Benefits of Non-Carbon Services in Worldwide Forests

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Summary. — Forest ecosystems are playing an increasingly important role in climate change mitigation through programs on Reducing Emissions from Deforestation and Forest Degradation (REDD), which targets carbon sequestration. However, decades of environmental valuation studies evidence the economic benefits of other forest ecosystem services different than carbon, and there is no evidence on how these economic benefits differ in countries where REDD is to be implemented. To respond to this question, we conduct a global meta-analysis of forest primary studies published over the past 30 years in which we estimate the economic benefits related to different forest ecosystem services in targeted REDD countries, and discuss the implications of considering these economic figures in REDD decision making. A systematic review of the scientific literature leads to the selection of 52 original studies to conduct a meta-analysis on 205 observations. We obtain that the economic benefits of forest ecosystem services in REDD countries are always greater than in other countries, and provide economic ranges of services to serve as a reference to REDD decision making in relation to co-benefits and opportunity costs. The results have implications for future avoided deforestation programs, which should take co-benefits into account in order to better articulate payments for ecosystems and create proper incentives for forest conservation and sustain local livelihoods.

Key words — avoided deforestation, co-benefits, ecosystem services, forests meta-analysis, REDD

1. INTRODUCTION

Forests are recognized worldwide for providing ecosystem services that sustain human wellbeing, and for their increasing role in climate change policy. While forests remove carbon from the atmosphere, deforestation and forest degradation remain one of the main causes of increasing Green House Gas (GHG) emissions, contributing 10–17% of the total emissions causing climate change (Metz, Davidson, Bosch, Dave, & Meyer, 2007; Harris *et al.*, 2012). Reducing emissions from deforestation and forest degradation in developing countries is therefore an important component of a global climate policy framework, and has captured international attention as a potentially effective and low-cost climate change mitigation option (Metz *et al.*, 2007; Stern *et al.*, 2006). In fact, recent research suggests that reducing deforestation may be a relatively less expensive climate change mitigation option compared to other mitigation options in other sectors (e.g. Anger & Sathaye, 2008; Bosetti, Lubowski, Golub, & Markandya, 2009), leading to increasing efforts in pilot carbon credit programs financed by multi-lateral organizations such as the World Bank or the United Nations (UN) (Phelps, Guerrero, Dalabajan, Young, & Webb, 2010).

The UN is carrying out a collaborative initiative on *Reducing Emissions from Deforestation and Forest Degradation* (REDD) in developing countries. The UN-REDD program is a multi-donor trust fund that allows donors to pool resources and provide funding with the aim of significantly reducing global emissions from deforestation and forest degradation. The UN-REDD Program supports nationally led REDD processes in 50 countries across Africa, Asia–Pacific and Latin America and the Caribbean, and promotes the involvement of all stakeholders, including indigenous peoples and other forest-dependent communities, in national and international implementation. By March 2014, total UN-REDD funding for national and project-based support to countries totaled US$217.7 million (UN-REDD, 2014).

In addition to UN-REDD, an increasing number of bilateral and multilateral agreements between countries and institutions are taking place, with $7 billion already committed since 2008 (Creed & Nakhooda, 2011; Simula, 2010). These other multi-donor initiatives include the *Amazon Fund*, the *Forest Carbon Partnership Facility* (FCPF) or the *Forest Investment Program* (FIP), from the World Bank. Table 1 shows examples of various REDD initiatives in different countries where payments have been identified. Countries are making substantial financial efforts to promote these REDD initiatives, although financial disbursements are taking a long time (Simula, 2010).

The REDD initiatives are actively looking for more donors in order to meet the increasing demand from countries seeking support from the Program. Against this backdrop, the inclusion of forest carbon in a global climate agreement by industrialized nations offers an alternative option to achieve part of their reduction targets through investments in developing countries. Some of these nations have welcomed this initiative as a potential source of financing to support sustainable forest management. However, consensus seems to be emerging that REDD cannot be seen solely as a tool for mitigating excessive carbon emissions, where the so-called win–win solutions for biodiversity and ecosystem services can be misleading, as in

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Table 1. *Examples of payments for carbon sequestration under REDD programs*

Project	Country	Payment
Bolsa Floresta	Brazil	US$50/month to families US$2500 per annum to the community
Região da Rodovia	Brazil	US$82.7 ha/yr
Pimampiro	Ecuador	US$6–12 ha/yr
Programa Sociobosque	Ecuador	US$30 ha/yr
PSA-H	Mexico	US$27 ha/yr
National program	Vietnam	US$3–6.5 ha/yr

Sources: Bond *et al*. (2009) and Cenamo *et al*. (2010).

many cases these interactions will involve trade-offs (Phelps, Friess, & Webb, 2012a; Phelps, Webb, & Adams, 2012b; Sunderlin *et al*., 2005; Thomas *et al*., 2012; Venter, Hovani, Bode, & Possingham, 2013). For biodiversity conservation, several studies have shown that policymakers face important trade-offs with carbon sequestration (Phelps *et al*., 2012a,b; Murray, Grenyer, & Raes, 2015). For example, Murray *et al*. (2015) found that spatial patterns of carbon benefits were not coincident with spatial patterns of biodiversity in Indonesia. These results raise the question of biodiversity and carbon uptake happening inside and outside REDD target areas, and although we are not addressing biodiversity per se, we expect that trade-offs may also occur for ecosystem services (carbon co-benefits).

Benefits from carbon sequestration can be higher at global level than at national level, and these primarily involve offsetting developed countries' emissions instead of assuring the adaptation of vulnerable countries to climate change effects. In this setting, valuation techniques play the role of providing a rational basis for estimating the level of adequate international transfer payments to compensate countries that are conserving forests beyond their own needs for the sake of global gain. This means that REDD should also generate co-benefits, including the conservation of forest ecosystems and biodiversity (Phelps *et al*., 2010; Venter, Laurance, Iwamura, Wilson, Fuller, & Possingham, 2009), recognizing its value, and provide sustainable income for some of the world's poorest people.[1] Additionally, carbon sequestration and biodiversity are not easily interlinked, and it has recently been suggested that a decoupled approach to biodiversity conservation under REDD would be more appropriate (Potts, Kelley, & Doll, 2013). There are implications from solely targeting carbon in REDD. Targeting carbon can lead to the financing of forests with low associated co-benefits (including water and air regulation, food and fiber, etc.), with a leakage effect which means that forests poor in carbon uptake but rich in other ecosystem services can be deforested (Phelps *et al*., 2010). Understanding and quantifying the economic values of these carbon co-benefits is necessary to guide climate policy decisions, but this proves difficult given the set of market and non-market techniques applied to services valuation, and the scarce information that exists at global level (Jacoby, 2004).

In addition to environmental co-benefits, payments to be received by forest farmers to preserve and manage forests according to REDD initiatives should be incentive compatible; that is, initiatives that would make farmers better off when acting according to their true preferences. In fact, reduced deforestation could be an effective and economically efficient way of reducing carbon and other GHG emissions if forest services could be valued and forest land-owners—public, private and community entities—could be adequately compensated for their provision (Boccucci, 2008). In other words, these payments should not only compensate for carbon sequestration benefits, but also for many other economic benefits associated with the preservation of forests. Phelps *et al*. (2010), for example, suggest fund-based subsidies or performance-based payments that enforce the delivery of co-benefits in REDD, as well as allowing for premiums in the form of a bundle of services (co-benefits) that can be delivered via payment for ecosystem services (PES).

Solutions discussed for the consideration of REDD co-benefits need to consider the magnitude and value of these ecosystem services, as well as their trade-offs with carbon sequestration. Estimates of carbon co-benefits are scarce in the literature when dealing with global assessments, with only a few exceptions (Kapos *et al*., 2008), and there is significant interest about estimates of forest ecosystem services values in policy making for the design of climate market instruments for mitigation.

In this paper we focus our analysis on UN-REDD, which implements REDD programs in several countries; for the sake of simplicity, we in this article we will refer to REDD and non-REDD countries. In this setting, and in order to understand the economic valuations and preferences in relation to forest ecosystem benefits, also including non-market benefits, we conduct a worldwide meta-analysis on forest ecosystem services, based on studies conducted over the last 30 years. We explore the data in order to address the general question of whether the threat of global warming and the capacity of forests to act as carbon sinks justify carbon storage becoming the single most important value driving tropical forest management in the new international climate policy arena. Our main objective is to assess the economic value of ecosystem services that forests provide in countries where REDD activities (under UN-REDD) are implemented. The main hypothesis is that the value of carbon co-benefits in REDD targeted countries can be quite significant. We are interested in: (1) understanding how forests deliver co-benefits from ecosystem services other than carbon sequestration; (2) Quantifying these economic values for the different sets of ecosystem services and; (3) Informing climate policy decisions concerning payments for carbon sequestration and ecosystem services. Rather than looking at all REDD initiatives in general, in this paper we focus solely on the UN-REDD program for various reasons: (i) we are interested in tropical and non-tropical forests and UN-REDD covers this range; (ii) the UN-REDD program is by large the initiative with the highest disbursement on field projects (UN-REDD, 2014), allowing us to compare estimated services values in countries where the implementation of carbon credits is more advanced; and (iii) it targets high-value carbon countries (Phelps *et al*., 2010), therefore setting a scenario where co-benefits are estimated for these higher carbon value countries with respect to the rest. Our results provide insights into how valuations for different forest services differ, so that a broader definition of forest payments can be made in order to include additional co-benefits of avoided deforestation. These results are compared with REDD payments and carbon sequestration benefits in the literature and conclusions are drawn about their incentive compatibility in terms of foregone opportunity benefits for landowners and managers.

The structure of this paper is as follows: Section 2 presents the background for the valuation of forest ecosystem services and the use of meta-analyses. Section 3 introduces the data collection and classification; Section 4 presents the data specification and analysis; results from the meta-analysis are shown in Section 5, while the predicted benefits from ecosystems services are contained in Section 6. Our final remarks and conclusions are presented in Section 7.

2. BACKGROUND

A meta-analysis approach refers to the statistical analysis of a large collection of results from individual studies with the purpose of combining the main findings (Glass, McGaw, & Smith, 1981; Hofmann, Hinkel, & Wrobel, 2011; Rudel, 2008). The underlying motivation of meta-analyses is to carry out a literature review with the same methodological rigor as required in primary research (Hofmann *et al.,* 2011). Recent meta-analyses have been conducted in the field of the economic valuation of environmental resources, impacts, and services (Brander, van Beukering, & Herman, 2007). A large number of studies have focused on the valuation of wetlands (Brouwer, Langford, Bateman, Crowards, & Turner, 1997; Brouwer, Langford, Bateman, & Turner, 1999; Woodward & Wui, 2001; Ghermandi, van der Bergh, Brander, de Groot, & Nunes, 2008); woodland recreation (Bateman & Jones, 2003; Zandersen & Tol, 2009); endangered species (Loomis and White, 1996) or general outdoor recreation (Smith and Kaoru, 1990; Rosenberger & Loomis, 2000; Shrestha & Loomis, 2001; Walsh, Johnson, & McKean, 1992).

There are also some notable examples in the literature that deal with forest valuation. Some studies have focused on the valuation of forest recreation in the UK (Bateman & Jones, 2003; Bateman, Lovett, & Brainard, 1999), and other European forests (Zandersen & Tol, 2009). These studies usually compute consumer surplus estimates for activity days obtained from the travel cost method and the contingent valuation method. Most of the previous forest meta-analyses have used studies from a single country in order to assess non-market benefits derived from forests (Bateman & Jones, 2003; Bateman *et al.*, 1999) or a group of countries in the same area (Zandersen & Tol, 2009; Lindhjem, 2007). Lindhjem (2007) studied the non-timber benefits from forests, specifically from Norwegian, Swedish, and Finnish forests. He analyzes the factors behind preferences for the protection or multiple uses of forest, including biodiversity protection. Similarly, Barrio and Loureiro (2010) fit the results of multiple international valuation studies of forest management programs via regression analysis, assessing how society values the application of different management programs involving the provision of forest goods and services at an international level. Ojea, Nunes, and Loureiro (2010) also value forest ecosystem services, with the aim of deriving the impact of biodiversity loss on these services. We build on these previous meta-analyses in order to analyze and create a comprehensive database of forest valuation studies distributed worldwide.

Market and non-market valuations and the aggregation of these economic values play an important role in informing climate policy (Jacoby, 2004). Forest ecosystem services have been valued worldwide using different methodologies. In tropical forests, for example, Chomitz, Alger, Thomas, Orlando, and Vila (2005) value biodiversity ‘hotspots’ in Brazil, examining data from a survey of property values, relating land price to land characteristics. As a result, they conclude that forest land had a market value, which was 70 per cent lower than comparable cleared land. Portela, Wendland, and Ledwith (2008) also derive non-timber economic valuation from revealed preferences, based on actual choices of forest owners for different management schemes. These forest goods were almost twice as large as timber revenues for private non-industrial forests. Godoy *et al.* (2002) conduct an economic valuation of tropical forest services, finding a low economic value for the rain forest on behalf of the local community, which explains their choice to clear forests for other land uses. Although outsiders value the rain forest for its high-use and non-use values, local communities only receive a small share of the total value. Rolfe, Bennett, and Louviere (2000) show that depending on the circumstances of the conservation proposal, foreigners can hold substantial non-use values for rainforest preservation in other countries relative to preservation options in their own country. Their results provide a tool for decision makers in terms of prioritizing rainforest preservation options.

The time span of the present analysis covers the last 30 years, including multiple valuation techniques from primary research in forest ecosystems. This compendium of studies allows us to compute the marginal values[2] of forest ecosystem services under different conditions, particularly in forests that are susceptible to establishing REDD initiatives. The main contribution of using these primary valuation studies is to provide economic estimates for services that generally lack a market price.

REDD involves the creation of a multi-level PES scheme (Duchelle *et al*., 2014; Olsen & Bishop, 2009). At international level, buyers purchase an ecosystem service (in compliance or voluntary markets) from providers (countries or sub-national bodies or projects); in this case reduced emissions from deforestation and forest degradation. To date, REDD projects are still mainly at an early design and planning phase, and so there are few examples of the actual payments received by local communities. Table 1 was constructed with the available information of REDD payments. Two programs in Latin America—Pimampiro (Ecuador) and the payments for hydrological ecosystem services (PSA-H[3]) (Mexico)—pay between US$6–12 and US$27–6 per hectare per annum respectively. In Vietnam, the government pays between US$3 and US$6.5 per hectare/year, although this is considered to be low compared with alternative land uses, and payments have recently been doubled. In Brazil’s Bolsa Floresta, payments are made both to families (US$50/month) and to the community (US $2,500 per annum) (Bond, Grieg-Gran, Wertz-Kanounnikoff, Hazlewood, Wunder, &, Angelsen, 2009). Cenamo, Pavan, Barros, and Carvalho (2010) report some case studies implementing REDD in Brazil and Ecuador, paying compensation of between $82.7 and $30 per hectare/year.

Despite this increasing amount of literature, one of the recurring concerns with PES, particularly in the context of the much larger scale payment schemes that would be required for REDD, is that indigenous and forest-dependent communities will not benefit from them, or could even be negatively affected by them (Bond *et al*., 2009; Grieg-Gran, Porras, & Wunder, 2005; Joyotee and Scherr, 2003). This is a critical issue given that there are an estimated 60 million indigenous people and a further 400–500 million who live in or close to forests and depend on them for their survival (Sunderlin, Hatcher, & Liddle, 2008). Recent literature carefully analyzes existing pilot case studies to address equity concerns, and discuss the social implications of REDD projects in local communities. Context and governance factors are key for REDD success, and issues such as the protection level (Pfaff, Robalino, Lima, Sandoval, & Herrera, 2014), land tenure

(Resosudarmo, Atmadja, Ekaputri, Intarini, Indriatmoko, & Astri, 2014), or empowerment of the poorest groups (Mustalahti & Rakotonarivo, 2014) are non trivial with carbon-oriented REDD implementations and may be carefully addressed. In this context, the inclusion of carbon co-benefits can easily change REDD incentives and effectiveness, and at the same time, provide us with better information on how forest compensation payments should be designed. The present analysis contributes toward shedding light on the marginal economic valuations of forest co-benefits, comparing those from REDD targeted forests with non REDD forests to understand the magnitude of the benefits not entering the existing carbon markets.

3. DATA COLLECTION AND CLASSIFICATION

An intensive search was carried out reviewing studies contained in different databases such as ECONLIT, EVRI, SCIENCEDIRECT, and AGECONSEARCH, among others. Specific keywords were employed in the collection of studies, including *forest, ecosystem service(s), economic value, benefits, recreation, tropical,* etc. The data come from a review of the literature valuing forest ecosystems since the 1980s. A large database has been analyzed with respect to the socioeconomic values derived from the services provided by these worldwide forest ecosystems (a list of the studies is presented in the Annex, Table 5).[4] The studies included match three main criteria: (1) that the forest ecosystem services can be clearly identified; (2) that the methodology used is carefully described and results clearly presented; and (3) that forest economic values can be converted to a common value per hectare per year unit. In the case of studies reporting households' willingness to pay, the estimate was converted to a per capita estimate, dividing it by household size. When a study presented more than one estimate, the best estimate as presented by the authors was selected and included in the database. Otherwise, if different estimates from a single study referred to different characteristics (such as methodology, forest area, respondents subsample, etc.), these estimates were included in the database and the variables coded accordingly. A systematic procedure was developed in defining the variables to be used in this analysis, specifically exploring the MA classification for ecosystem services (detailed below) as well as assigning a specific service to each economic value. Some studies reported incomplete information and were eliminated from our final data set due to a large number of missing values. As a result, the final dataset used for this meta-analysis comes from 51 studies from different parts of the world. The studies are distributed as follows: Europe (33.17%), North and South America (36.09 %), Asia (19.51 %), and remaining continents (11.23%). From these studies, we were able to include 205 observations, with a mean of 3.9 observations per study. The largest number of observations from one single study is 19 and comes from Scarpa, Chilton, Hutchinson, and Buongiorno (2000b), while the minimum is one single observation.[5]

The collected studies report results in different currencies ($US, SEK, €, etc.) and for different time periods (from 1984 to 2009). In order to homogenize all this information, values were transformed to a standard currency, current $US dollars per hectare/year. When necessary, information on the forest hectares as well as on the number of visitors was gathered in order to calculate the standardized values. The values are expressed in 2008 US$, updating them through purchasing power parity (PPP) rates. We choose the PPP rate instead of exchange rate because the latter measure may not accurately represent differences in terms of income and consumption between countries.

(a) *Classification of ecosystem services*

Primary studies are generally focused on one forest good or service, or a bundle of services that are frequently described using different terminology and classifications. Therefore, a thorough re-classification of the services from original studies was needed in order to be able to compare the specific services valued. Since we are performing a secondary analysis, a well-defined classification of ecosystem services needs to be established, as primary studies need to be aggregated into groups in order to proceed with the regression analysis. The Millennium Ecosystem Assessment (MA) classification has been used widely since its publication, also in the field of economics. However, recent studies have found that this classification can lead to problems such as double counting, and that special care needs to be taken when adapting MA to economic valuation (Bateman, Mace, Fezzi, Atkinson, & Turner, 2011; Fisher & Turner, 2008; Fu, Su, Wei, Willett, Lü, & Liu, 2011; Ojea, Martin-Ortega, & Chiabai, 2012). The main reason is that the MA does not help in the identification of links between ecosystem functions, processes and services that provide benefits, leading to the valuation of services and processes that result in the same good (e.g. valuing water flow and hydropower production at the same time).

The new emerging literature proposes output-based classifications in order to avoid double-counting (Fisher, Turner, & Morling, 2009; Fu *et al.*, 2011; Ojea *et al.*, 2012), and recent assessments of ecosystem services such as the TEEB initiative or the UK National Ecosystem Assessment (UK NEA, 2014) have followed these new lines of research, as well as embracing output-based classifications which look at the final services that contribute to wellbeing. In this study we follow this evolving research, and have opted to classify our primary studies according to the output-based classification. We classify the studies in our dataset into the following ecosystem services (see Table 6 in the Annex for more details):

Air quality and water regulation: refers to a forest's capacity to regulate air and water. These services are *regulating* services under MA.

Water supply: refers to the direct use of water quantity, including water for agricultural or human consumption, or for hydroelectric production. Note that some of these services fall under different MA categories, as the MA does not necessarily identify at which point of a process a given ES occurs.

Damage mitigation: refers to a forest's regulation of extreme events such as floods, wildfires or erosion. These services fall into the MA's *regulating* category.

Climate regulation: refers to the forest's role in terms of climate mitigation, sequestering carbon in soil and trees. These are also regulating services under MA.

Food and fiber: refers to the services that derive into food and fiber which can be consumed by humans, as we are focusing on final ecosystem services, including services such as bee pollination or habitat support that are intermediate processes deriving into food or fiber, which is consumed as the final service. Note that this is the main difference with the MA, where these services would be respectively classified as *regulating* and *supporting* services.

Recreation and tourism: refers to services related with leisure and the enjoyment of forests, including tourism, recreation, or scenic beauty. These services are classified as *cultural* services under MA.

Wild species diversity: the MA recognizes biodiversity as a fundamental basis for the provision of services through ecosystem functioning. Under wild species diversity we group these economic approaches according to the value of species and ecosystem diversity. Note that this is not the value of biodiversity per se.

Various services: many primary studies value more than one service. In order to account for this multifunctionality, this category contains all the observations referring to at least more than one service of the output-based categories employed. This is the case of studies looking at the total economic value, or studies looking at conservation values, or passive use values. These are benefits underlying the final services that benefit people and therefore are included under this category.

Due to the lack of observations in some of these ecosystem services, we pooled together the categories of "Damage mitigation", "Air and Water regulation" and "Water supply" into the *Air and Water* category. "Climate Regulation" is dropped from the analysis due to very few observations. The rest of the services are represented by dummy variables in our regression analysis (Table 2).

(b) *Data coding*

Explanatory variables are summarized in Table 2. These include the dependent variable, which is the value of the service per hectare per year in $2008 (l*nvalue*), and the independent variables that are grouped as study characteristics, forest ecosystem services characteristics and site and socioeconomic characteristics. Under study characteristics we consider the scale of the forest valued, distinguishing between local (*local scale*) and non-local *(*which includes regional and national scales); the year of the study publication (*publication year*); the economic valuation method, explicitly differentiating between stated preferences valuation methods (*Stated*), revealed preferences methods (*Revealed*), market-based estimates (*Market*) and other type of methods (*Other method*). Furthermore, and in order to correct for the potential difference in the quality of the studies, we introduce the impact factor of the scientific journal where these studies were published (*Impact factor*). In order to retain observations in our empirical analysis, we established a zero impact factor for studies that have not yet been published. Variables collecting the good characteristics include the type of ecosystem service provided (*Various services, Air and water regulation*, *Food and fiber*, *Wild species diversity* and *Recreation and tourism*), following the output-based classification[6]; and the area of the forest where the service valuation takes place (*forest area*).[7] Socioeconomic variables are also considered, including the income (*GDP*) and the population density (*population density*). Additional site variables were also included, relating to whether the country in which the study was conducted is a REDD operating country (*Redd*) based on where United Nations is implementing projects (UN-REDD, 2014). Estimates of carbon uptake (*carbon uptake*) were also considered to be of crucial importance and were controlled for, given that this is the most important ecosystem service included under REDD. Finally, an indicator of pollution (CO_2) was also included in order to see the relationship between high-emission countries and the value of their forest ecosystem services.

4. MODEL SPECIFICATION AND ANALYSIS

The dependent variable (in its logarithm form) in our meta-regression equation is a vector of individual forest values expressed in 2008 US dollars per hectare and year (and corrected by purchasing power parities), labeled as $\ln y$. Following previous meta-analyses, we conducted a Box–Cox test in order to choose the functional form. The Box–Cox test has a value of 0.715, where the estimated value exceeds the critical value (from a Chi-square table at 1% level with 16 degree of freedom) of 121.350. Therefore, we reject the null hypothesis that the performance of the alternative model is the same, with the best model being the semi-log model. Previous meta-analyses, such as those carried out by Brander Brander, Florax, and Vermaat (2006) or Barrio and Loureiro (2010) have also employed the same functional form.

Following Brander *et al.* (2006), the independent variables are grouped into three different categories that include the study's characteristics in X_{st}, the site's characteristics in X_{si}, and the ecosystem services in X_{es}. The estimated model corresponds with the following equation:

$$\ln y_{\mathrm{i}} = \alpha + X_{st\mathrm{i}}\beta + X_{si\mathrm{i}}\beta + X_{es\mathrm{i}}\beta + \varepsilon_{\mathrm{i}}, \quad (1)$$

where α is the usual constant term, the β vectors contain the coefficients associated with the respective explanatory variables to be estimated, and ε_i is a vector of independently and identically distributed (*i.i.d.*) residuals. Subscript i stands for study *i*. There are several approaches to estimating this regression depending on the assumptions regarding the error variance–covariance matrix (Lindhjem, 2007). Due to the fact our dataset contains several observations for different countries and with different valuation formats, we estimate both, a linear OLS regression and a second random effects (RE) model, using the data in the form of a panel data structure. The Hausman specification test was performed and the RE specification was chosen over fixed effects (FE) due to non-systematic differences in coefficients between models. With these tests and models we follow Nelson and Kennedy's (2009) main recommendations on meta-analysis practice in the environmental economics field.

5. RESULTS

The regression estimates are displayed in Table 3 for both OLS and the RE models, which provide very similar results in terms of the significance and magnitude of the coefficients. In the group of study characteristics, we observe the negative effect of the *publication year* variable. This may suggest that more recent studies are associated with lower estimates per hectare, and therefore that newer studies provide more conservative values. Decreasing values over time may be a consequence of methodological refinements, as found by Ojea and Loureiro (2011), among other potential causes. The *local scale* indicator is positive and statistically significant at 5% level in both models. If we consider the valuation methods employed, we find that the indicator of *other method* is significant in both models, containing combined method-

Table 2. *Description of explanatory variables*

Variable	Description	Mean (Std. Dev)	Source
Lnvalue	Logarithm of value per ha given by study ($ 2008)	3.908 (3.213)	Individual studies
Study characteristics			
Local scale	1, if the scale of the forest is local; 0 otherwise	0.346 (0.477)	Individual studies
Publication year	Year of publication of the study	2000.268 (5.394)	Individual studies
Impact factor	The impact factor of the journal where the study has been published (in the year of the publication or the last year available)	0.870 (1.212)	Isi Web of Knowledge & ResearchGate
Stated	1, if stated preferences techniques were employed; 0 otherwise	0.497 (0.501)	Individual studies
Revealed	1, if revealed preferences techniques were employed; 0 otherwise	0.102 (0.303)	Individual studies
Other method	1, if other method was employed (licenses, donations, benefit transfer); 0 otherwise (omitted variable)	0.127 (0.333)	Individual studies
Market	1, if market prices were employed; 0 otherwise	0.273 (0.446)	Individual studies
Forest valuation characteristics			
REDD	1, if the country is under UN-REDD program; 0 otherwise	0.239 (0.427)	UN-REDD Program
Recreation and tourism	1, if the ecosystem services were recreation and tourism; 0 otherwise (omitted variable)	0.390 (0.489)	Individual studies
Various services	1, if the ecosystem services were various services; 0 otherwise	0.136 (0.344)	Individual studies
Air quality and water regulation	1, if the ecosystem services were air quality and water regulation; 0 otherwise	0.092 (0.290)	Individual studies
Food and fiber	1, if the ecosystem services were food and fiber; 0 otherwise	0.136 (0.344)	Individual studies
Wild species diversity	1, if the ecosystem services were wild species diversity; 0 otherwise	0.244 (0.430)	Individual studies
Forest area	Natural logarithm of forest size (ha)	11.627 (3.488)	Individual studies
Site and socio-economics characteristics			
GDP	Natural logarithm GDP per capita of the country of study on PPP(10^{-4})	1.748 (1.383)	IMF: World Economic Outlook
CO_2	CO_2 emitted per country in tons (10^{-9})	1.266 (2.125)	RIMFROST. NOAA/ NASA/ECA&D
Population density	Natural logarithm of the density of population in the country	17.462 (1.854)	World Bank
Carbon uptake	Carbon uptake percentage (carbon stock country/carbon stock global)	0.022 (0.043)	United Nations Environment Program

ologies as well as benefit transfer estimates. The omitted variable is the one using market prices. With respect to the site's characteristics, the *Redd* variable carries a positive sign and is statistically significant at the 5% significance level. Therefore, we find that forests in countries under the REDD programs have a higher value per hectare, *ceteris paribus*, than in other non REDD countries.[8] This is an important result that reveals the high values associated with ecosystem services other than carbon sequestration for countries targeted by REDD programs.

With respect to the classification of ecosystem services, we observe that all categories have a positive sign with respect to the omitted variable, *Recreation and tourism*, and all are significant in both models. Finally, forest area results in a significant negative coefficient, as expected for marginal decreasing utility with respect to size (Woodward & Wui, 2001; Johnston & Duke, 2007).

In addition, and in order to understand the role played by other environmental variables, we have included the country's carbon emissions (CO_2) which is negative and significant, and another variable representing the carbon uptake in forest biomass (*Carbon uptake*) providing positive and significant estimates in both models. We interpret these results as indicating that CO_2 emissions and carbon co-benefits are inversely related, revealing that countries with low emissions have high carbon co-benefits that should be considered under international climate policies. The income level represented by the GDP variable is positive and significant, as expected, while the density of population is not significant for either model.

Table 3. *Meta regression results of forest valuation studies*

lnvalue	Linear OLS Coefficient (Std. Err.)	$P > \|t\|$	random effects Coefficient (Std. Err.)	$P > \|t\|$
Local scale	1.340** (0.527)	0.012	1.300** (0.543)	0.017
Publication year	−0.178*** (0.041)	0.000	−0.181*** (0.042)	0.000
Impact factor	−0.608*** (0.155)	0.000	−0.600*** (0.156)	0.000
Stated	0.709 (0.519)	0.174	0.788 (0.533)	0.139
Revealed	0.029 (0.726)	0.968	0.164 (0.736)	0.824
Other method	−1.677** (0.676)	0.014	−1.555** (0.688)	0.024
REDD	1.312** (0.569)	0.022	1.277** (0.612)	0.037
Various services	1.255** (0.556)	0.025	1.330** (0.563)	0.018
Air quality and water regulation	1.601** (0.740)	0.032	1.733** (0.740)	0.019
Food and fiber	1.609*** (0.614)	0.009	1.615*** (0.618)	0.009
Wild species diversity	1.662*** (0.487)	0.001	1.692*** (0.493)	0.001
Forest area	−0.421*** (0.065)	0.000	−0.420*** (0.067)	0.000
GDP	1.195*** (0.228)	0.000	1.184*** (0.239)	0.000
CO_2	−0.618*** (0.152)	0.000	−0.645*** (0.171)	0.000
Population density	0.207 (0.144)	0.151	0.208 (0.159)	0.192
Carbon uptake	8.178* (4.330)	0.060	7.937* (4.660)	0.089
Constant	358.189*** (81.659)	0.000	364.462*** (83.315)	0.000
N	205		205	
F(16, 188)	14.23			
Prob > *F*	0.000			
R-squared	0.548			
Adj R-squared	0.509			
Root MSE	2.251			
Wald chi2(16)			202.100	
Prob > chi2			0.000	

* Statistical significance at a = 0.1.
** Statistical significance at a = 0.01.
*** Statistical significance at a = 0.001.

6. BENEFITS FROM CARBON CO-BENEFITS

In this study, it is especially relevant to estimate the average non-carbon benefits from ecosystem services in targeted REDD forests, in order to identify the magnitude of these services and provide economic estimates that can better inform climate policies. Forests are now on the international policy agenda, and many REDD programs are being planned and implemented worldwide. From the meta-regression estimated in this study, we predict carbon co-benefits under specified values of the regressors (Brander *et al.*, 2012; Cameron & Trivedi, 2009), using the benefit transfer method. We specifically assess the values of ecosystem services for the characteristics of REDD countries, non REDD countries and for the full dataset. We do this with a function transfer employing the estimated coefficients from the RE model, introduced at the mean values of the continuous explanatory variables, while holding the respective ecosystem services means at 1 (valued) or 0 (not valued), respectively. In this way, predictions are obtained following Cameron and Trivedi (2009). Table 4 presents the estimated values for REDD and non REDD countries, and for the set of ecosystem service categories employed in our analysis. Mean valuations are predicted, with the corresponding standard errors and the 95% confidence intervals.

Table 4. *Estimated values for carbon co-benefits in REDD and non REDD countries (US$/ha. year) from the linear RE model*

Co-benefits Variable	Mean valuations (Std. Err.)	95% Confidence [95% Confidence Interval]	
Full sample			
Air quality and water regulation	1541.347 (182.028)	1182.449	1900.245
Food and fiber	1268.019 (150.368)	971.542	1564.495
Wild species diversity	1279.493 (151.936)	979.926	1579.060
Various services	922.131 (109.944)	705.358	1138.905
Recreation	218.629 (25.830)	167.701	269.558
REDD			
Air quality and water regulation	5790.742 (766.298)	4279.861	7301.622
Food and fiber	4673.427 (616.345)	3458.203	5888.652
Wild species diversity	4337.895 (568.429)	3217.145	5458.644
Various services	3166.201 (420.447)	2337.220	3995.181
Recreation	747.9432 (97.902)	554.913	940.973
NON REDD			
Air quality and water regulation	1266.806 (164.123)	943.211	1590.401
Food and fiber	1033.528 (133.500)	770.310	1296.746
Wild species diversity	1052.914 (135.147)	786.449	1319.378
Various services	768.288 (99.892)	571.334	965.241
Recreation	180.550 (23.138)	134.929	226.170

Ecosystem services provide an average economic estimate for the full sample of 1541$/ha.yr for the category *air quality and water regulation* and 1268$/ha.yr for *food and fiber*. Focusing on *wild species diversity*, the results show an average value of 1279$/ha.yr. *Recreation* is valued around 218$/ha.yr and *various services* rises to 922$/ha.yr. In addition, as a result from the benefit transfer exercise, we observe how REDD countries carry higher values for ecosystem services. This is in line with the results obtained in our general model, where *Redd* was positively related to higher values. Therefore, the results show that targeted REDD forests do indeed provide highly valued co-benefits that need to be considered for this market mechanism to help conservation, climate change mitigation and adaptation.

The predicted values for carbon co-benefits are comparable to the range of values that exist in the literature. For example, estimates for tropical forests for a range of ecosystem services have been summarized by *The Economics of Ecosystems and Biodiversity* (TEEB) initiative (TEEB, 2010). Although the categories do not exactly match those used in this analysis and are not comparable on an individual basis, we find that our estimates are close to the range of existing values for tropical forests. For example, the average benefits from air quality and water regulation in our sample ($1541/ha.yr) is within the interval values provided by the TEEB regulating bundle services estimation ($57–7135/ha.yr; TEEB, 2010). Food and fiber provision in our sample carries an average estimate ($1268/ha.yr) that is also within the range of TEEB values for provisioning of raw materials from forests ($2–3723/ha.yr; TEEB, 2010). The wild species diversity service in our sample, which includes conservation ($1279/ha.yr), is as well within the range of TEEB habitat conservation services ($6–5277/ha.yr; TEEB, 2010). This is a general comparison of average results, and of course the ranges are extensive. However, our contribution consists of having carried out the analysis for REDD and non REDD countries, understanding the variables that influence the value of ecosystem services. In fact, according to the results shown in Table 4, there is wide spatial heterogeneity in terms of values provided by forests in REDD and non REDD countries

The estimated economic values for each forest ecosystem service in REDD countries are much higher than the level of payments perceived from REDD activities, as shown in Table 1, revealing a large gap between the economic benefits of ecosystem services other than carbon and the magnitude of payments from REDD. Programs aimed at preventing deforestation may take these factors into account, as forest services other than carbon are highly valued, and the forest communities that preserve them could be under-compensated. Also, these benefits from ecosystem services are higher than the benefits from carbon storage in tropical forests. According to the TEEB database, carbon regulation has an average value of $1965/ha.yr, and a maximum of $3218/ha.yr (TEEB, 2009). In roughly comparing these values to our results, we can conclude that there is evidence that co-benefits have high values that directly compare to carbon uptake in REDD forests, and that these could create important economic trade-offs.

The present meta-analysis has also some associated caveats that need to be considered. It was not possible, at this point, to obtain spatially explicit primary data on forest values, so that our analysis was performed on a country basis. More accurate data on the specific forest area that provides the ecosystem services benefits, together with mapping of REDD projects can produce more accurate results that will illustrate the trade-offs between ecosystem services and carbon uptake at the forest level. Additionally, many studies have valued forest services as a bundle of services and in the present analysis it is not possible to disentangle those benefits. Additionally, several studies were excluded from the database as it was not possible to identify the specific service that was valued. Nevertheless we believe the present results highlight an important gap in policy and research and illustrate a potential mismatch in the economic values of REDD co-benefits and REDD project implementation that should be looked with care in the future.

7. FINAL REMARKS

The present study provides a comprehensive review of 30 years of forest valuation studies, and through a meta-regression we have contributed toward identifying the main determining factors that influence the valuation of forest ecosystem services. The main objective was to understand the benefits of forest ecosystem services other than carbon sequestration in REDD targeted countries.

In order to achieve this objective, we gathered information from 52 studies on forest valuation of ecosystem services around the world (see Table 5 in Annex). Following an output-based classification for ecosystem services, we have identified four main types of services: air quality and water regulation, food and fiber, wild species diversity, and recreation and tourism. By means of a meta-analysis, we estimate the benefits of these ecosystem services in REDD target countries and the rest.

The results reveal a number of important conclusions. Overall, and in terms of REDD implementation, we conclude that REDD countries are providing high co-benefits from forest ecosystem services. When considering the values of ecosystem services that are out of the markets, these services provide important benefits to society. REDD has targeted countries with high carbon co-benefits in their forests, and efforts should be made to allow local people to maintain these benefits in the face of a new international instrument such as REDD. However, REDD payments have not been articulated around the total economic value of forest (including carbon and other services). Their total economic value should be of relevance when the objective is to preserve forest lands from being degraded. The results of our analysis confirm that multiple forest services are of economic importance, and that there may be trade-offs between carbon sequestration and the enhancement of other ecosystem services, as well as equity issues related to high-emission countries and sinks. Also, the identified ecosystem services carry different forest values, where various services and food and fiber have the greatest values per hectare.

We estimate the values of ecosystem services for REDD and non REDD forests. The main conclusions indicate that, in line with the current literature, non-carbon ecosystem services from REDD countries are expected to lead to higher values. These results can be useful from the perspective of establishing REDD payments, showing that there are important benefits to people from multiple forest services, and not only carbon uptake. In fact, we recommend that future avoided deforestation programs take these factors into account in order to better articulate payments for ecosystem services and create proper incentives for forest conservation.

NOTES

1. While REDD covers reducing emissions from deforestation and forest degradation, REDD+ has recently been used to denote other additional activities, including conservation, sustainable forest management, and the enhancement of forest carbon stocks (Dickson, EDunning, Killen, Miles, & Pettorelli, 2009) To date, the main focus has been on deforestation and degradation, but there is a considerable movement to include factors other than the "two Ds" (Murray, Lubowski, & Sohngen, 2009). In this paper, we refer to REDD projects for simplicity, but they include REDD+.

2. We refer to *marginal values* of forest ecosystem services, as usually valuation techniques estimate the value of an ecosystem service for a change in the provision of a single unit, and our values are per hectare and per year.

3. PSAH stands for the Program of Payments for Hydrological Ecosystem Services (*Programa de Pagos de Servicios Ambientales Hidrológicos*).

4. Subsamples of this metadata were employed by Ojea *et al.* (2010), Ojea and Loureiro (2011) and Barrio and Loureiro (2010).

5. This is a common range in meta-analysis for Environmental economics as illustrated by Nelson and Kennedy (2009).

6. A Grubbs (1969) test was conducted in order to drop the potential outliers among groups of ecosystem services. A total of 4 observations were eliminated.

7. The type of forest was coded into tropical and non-tropical forests, but this variable was finally excluded from the regression due to strong correlation with economic variables such as country income.

8. We have checked for the possibility that tropical forests as a whole (and not necessarily REDD countries) are driving these results. Unfortunately, due to the large correlation between the variables *tropical forest and REDD*, we were not able to directly control for both effects in the same regression. However, when running both models and replacing *REDD* with *tropical forest* in the estimated regression, the coefficient on *tropical forest* is not statistically significant. Overall, we have tested the presence of correlation among the variables included in the analysis, and can conclude that there are no serious problems with a VIF of 2.26.

REFERENCES

Aakerlund, N. F. (2000). *Contingent ranking study of Danish preferences of forest characteristics*. The Royal Veterinary and Agricultural University (KVL).

Adams, C., Seroa, R., Ortiz, R. A., Reid, J., Aznar, C. E., & de Almeida, P. A. (2008). The use of contingent valuation for evaluating protected areas in the developing world: Economic valuation of Morro do Diablo State Park, Atlantic Rainforest, São Paulo State (Brazil). *Ecological Economics, 66*, 359–370.

Adamson, M. (2001). ¿Cuánto vale un parque nacional? Economía experimental y método de valoración contingente?. *Ciencias Economicas, 21*(1–2), 5–37.

Adger, W. N., Brown, K., Cervigni, R., & Moran, D. (1995). Total economic value of forests in Mexico. *Ambio, 24*(5), 286–296.

Anger, N., & Sathaye, J. (2008). *Reducing deforestation and trading emissions: economic implications for the post-Kyoto carbon market*. Climate Protection Division. Office of Air and Radiation. US Environmental Protection Agency through the US Department of Energy.

Ba, C. O., Bishop, J., Deme, M., Diadhiou, H. D., Dieng, A. B., Diop, O., & Wade, I. A. (2006). *The economic value of wild resources in Senegal: A preliminary evaluation of non-timber forest products*. Game and freshwater fisheries. Gland: IUCN

Barrio, M., & Loureiro, M. L. (2010). A meta-analysis of contingent valuation forest studies. *Ecological Economics, 69*(5), 1023–1030.

Bateman, I. J., & Jones, A. P. (2003). Contrasting conventional with multi-level modeling approaches to meta-analysis: Expectation consistency in U.K. Woodland Recreation Values. *Land Economics, 79*(2), 235–258.

Bateman, I. J., Lovett, A., & Brainard, J. S. (1999). Developing a methodology for benefit transfers using geographical information systems: Modeling demand for woodland Recreation. *Regional Studies, 33*(3), 191–205.

Bateman, I. J., Mace, G. M., Fezzi, C., Atkinson, G., & Turner, K. (2011). Economic analysis for ecosystem services assessment. *Environmental and Resource Economics, 48*, 177–218.

Bellu, L. G., & Cistulli, V. (1997). Economic valuation of forest recreation facilities in the Liguria region, Italy. *CSERGE Working Paper* GEC, 97–08.

Bernard, F., de Groot, R., & Campos, J. J. (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 Economics, 11*, 174–183.

Bienabe, E., & Hearne, R. R. (2006). Public preferences for biodiversity conservation and scenic beauty within a framework of environmental services payments. *Forest Policy and Economics, 9*(4), 335–348.

Boccucci, M. (2008). REDD and investment. In J. Holopainen, & M. Wit (Eds.), *Financing Sustainable Forest Management*. Wageningen, The Netherlands: Tropenbos International.

Bond, I., Grieg-Gran, M., Wertz-Kanounnikoff, S., Hazlewood, P., Wunder, S., & Angelsen, A. (2009). *Incentives to sustain forest ecosystem services. A review and lessons for REDD*. United Kingdom: Institute for Environment and Development.

Bosetti, V., Lubowski, R., Golub, A., & Markandya, A. (2009). Linking reduced deforestation and global carbon market: Impacts on costs, Financial flows and Technological innovation. *BC3 Working paper series.*

Bostedt, G., & Mattsson, L. (2006). A note on benefits and costs of adjusting forestry to meet recreational demands. *Journal of Forest Economics, 12*, 75–81.

Brander, L. M., Bräuer, I., Gerdes, H., Ghermandi, A., Kuik, O., Markandya, A., *et al.* (2012). Using meta-analysis and GIS for value transfer and scaling up: Valuing climate change induced losses of European wetlands. *Environmental and Resource Economics, 52*(3), 395–413.

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

Brander, L. M., van Beukering, P., & Herman, S. J. C. (2007). The recreational value of coral reefs: A meta-analysis. *Ecological Economics, 68*, 209–218.

Brouwer, R., Langford, I.H., Bateman, I.J., Crowards, C., Turner, R.K. 1997. A meta-analysis of wetland contingent valuation studies. Global Environmental Change Working Paper No. 97-20. Centre for Social and Economic Research on the Global Environment (CSERGE). University of East Anglia, Norwich and University College London.

Brouwer, R., Langford, I. H., Bateman, I. A., & Turner, R. K. (1999). A meta-analysis of wetland contingent valuation studies. *Regional Environmental Change, 1*(1), 47–57.

Cameron, C. A., & Trivedi, P. A. (2009). *Microeconometrics Using Stata* (Revised Edition). Stata Press.

Carranza, C. F., Aylward, B., Echeverría, J., Tosi, J., & Mejias, R. (1996). *Valoración de los servicios ambientales de los bosques de Costa Rica*. San José, Costa Rica: ODA-MINAE CCT.

Cenamo, M. C., Pavan, M. N., Barros, A. C., & Carvalho, F. (2010). *Guía sobre Projetos de REDD+ na América Latina*. Manaus. Brazil.

Chase, L. C., Lee, D. R., Schulze, W. D., & Anderson, D. J. (1997). Ecotourism demand and differential pricing of national park entrance fees in Costa Rica. Working paper 97-10. Department of Agricultural, Resource and Management Economics. Cornell University, Ithaca, New York.

Chomitz, K. M., Alger, K., Thomas, T. S., Orlando, H., & Vila, P. (2005). Opportunity costs of conservation in a biodiversity hotspot: The case of southern Bahia. *Environmental and Development Economics, 10*, 293–312.

Creed, A., & Nakhooda, S. 2011. REDD+ Finance Delivery: Lessons from Early Experience. Climate Finance Policy Brief. November 2011.

Dickson, B., EDunning, E., Killen, S., Miles, L., & Pettorelli, N. (2009). *Carbon markets and forest conservation: A review of the environmental benefits of REDD mechanisms*. Cambridge, United Kingdom: UNEP World Conservation Monitoring Centre.

Dubgaard, A. (1998). Economic valuation of recreational benefits from Danish forests. In S. Dalbert, A. Dubgaard, L. Slangen, & M. Whitby (Eds.), *The Economics of Landscape and Wildlife Conservation*. London: CAB International.

Duchelle, A. E., Cromberg, M., Gebara, M. F., Guerra, R., Melo, T., Larson, A., *et al.* (2014). Linking forest tenure reform, environmental compliance, and incentives: Lessons from REDD+ initiatives in the Brazilian Amazon. *World Development, 55*, 53–67.

Echeverria, J., Hanrahan, M., & Solorzano, R. (1995). Valuation of non-priced amenities provided by the biological resources within the Monteverdi cloud forest preserve Costa Rica. *Ecological Economics, 13*, 43–52.

Emerton, L., (1999). Mount Kenya: the economics of community conservation. In: IIED evaluating Eden series. Discussion Paper 4.

Environmental Resources Management, (1996). *Valuing management for biodiversity in British forests*. Report to UK Forestry Commission.

Fisher, B., & Turner, K. R. (2008). Ecosystem services: classification for valuation. *Biology Conservation, 141*, 1167–1169.

Fisher, B., Turner, K. R., & Morling, P. (2009). Defining and classifying ecosystem services for decision making. *Ecological Economics, 68*(3), 643–653.

Fu, B., Su, C., Wei, Y., Willett, I. R., Lü, Y., & Liu, G. (2011). Double counting in ecosystem services valuation: causes and countermeasures. *Ecological Research, 26*(1), 1–14.

Garber-Yonts, B., Kerkvliet, J., & Johnson, R. (2004). Public values for biodiversity conservation in the Oregon Coast Range. *Science, 50*(5), 589–602.

Garrod, G. D., & Willis, K. G. (1997). The non-use benefits of enhancing forest biodiversity: A contingent ranking study. *Ecological Economics, 21*(1), 45–61.

Ghermandi, A., van der Bergh, J., Brander, L., de Groot, R., & Nunes, P. A. L. D. (2008). The economic value of wetland conservation and

creation: A meta-analysis. Nota di Lavoro No 79.2008. Fondazione Eni Enrico Mattei.
Glass, G., McGaw, B., & Smith, M. L. (1981). *Meta-analysis in social research*. Beverley Hills, CA: Sage Publications.
Godoy, R., Overman, H., Demmer, J., Apaza, L., Byron, E., Huanca, T., *et al.* (2002). Local financial benefits of rain forests: comparative evidence from Ameridian societies in Bolivia and Honduras. *Ecological Economics, 40*(3), 397–409.
Grieg-Gran, M., Porras, I., & Wunder, S. (2005). How can market mechanisms for forest environmental services help the poor? preliminary lessons from Latin America. *World Development, 33*(9), 1511–1527.
Grubbs, F. (1969). Procedures for detecting outlying observations in samples. *Technometrics, 11*(1), 1–21.
Gurluk, S. (2006). The estimation of ecosystem services´ value in the region of Misi Rural Development Project: Results from a contingent valuation survey. *Forest Policy and Economics, 9*(3), 209–218.
Hanley, N., Willis, K., Powe, N., & Anderson, M. (2002). Valuing the benefits of biodiversity in forests. Report to UK Forestry Commission.
Hanley, N., Wright, R. E., & Adamowicz, W. L. (1998). Using choice experiments to value the environment. *Environmental and Resource Economics, 11*(3–4), 413–428.
Harris, N. L., Brown, S., Hagen, S. C., Saatchi, S. S., Petrova, S., Salas, W., *et al.* (2012). Baseline map of carbon emissions from deforestation in tropical regions. *Science, 336*, 1573–1576.
Hearne, R. R., & Salinas, Z. M. (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.
Hofmann, M. E., Hinkel, J., & Wrobel, M. (2011). Classifying knowledge on climate change impacts, adaptation, and vulnerability in Europe for informing adaptation research and decision-making: A conceptual meta-analysis. *Global Environmental Change, 21*(3), 1106–1116.
Holmes, T., Alger, K., Zinkhan, C., & Mercer, E. D. (1998). The effect of response time on conjoint analysis estimates of rainforest protection values. *Journal of Forest Economics, 4*, 7–28.
Horne, P., Boxall, P. C., & Adamowicz, W. L. (2005). Multiple-use management of forest recreation sites: A spatially explicit choice experiment. *Ecological Management, 207*, 189–199.
Horton, B., Colarullo, G., Bateman, I. J., & Peres, C. A. (2003). Evaluating non-user willingness to pay for a large-scale conservation program in Amazonia: a UK/Italian contingent valuation study. *Environmental Conservation, 30*, 139–146.
Howard, P. C. (1995). *The economics of protected areas in Uganda: Costs, benefits and policy issues* Dissertation. University of Edinburgh.
Jacoby, H. D. (2004). Informing climate policy given incommensurable benefits estimates. *Global Environmental Change, 14*(3), 287–297.
Johnston, R. J., & Duke, J. M. (2007). Willingness to pay for agricultural land preservation and policy process attributes: Does the method matter?. *American Journal of Agricultural Economics, 89*(4), 1098–1115.
Joyotee, S., & Scherr, S. J. (2003). Capturing the value of forest carbon for local livelihoods. *World Development, 31*(12), 2143–2160.
Kaiser, B., & Roumasset, J. (2002). Valuing indirect ecosystem services: the case of tropical watersheds. *Environmental and Development Economics, 7*(4), 701–714.
Kapos V., Ravilious, C., Campbell, A., Dickson, B., Gibbs, H. K., Hansen, M. C., & Trumper, K. C. (2008). Carbon and biodiversity demonstration atlas. UNEP-WCMC. URL: <http://www.unep.org/pdf/carbon_biodiversity.pdf>.
Kniivilä, M. (2004). Contingent valuation and cost-benefit analysis of nature conservation: a case study in North Karelia, Finland. Research Notes 157. Faculty of Forestry, University of Joensuu.
Kniivilä, M., Ovaskainen, V., & Saastamoinen, O. (2002). Costs and benefits of forest conservation: regional and local comparisons in eastern Finland. *Journal of Forest Economics, 8*, 131–150.
Kramer, R. A., Sharma, N., & Munashinghe, M. (1995). Valuing Tropical Forests. Methodology and Cade Study of Madagascar. World Bank Papers 13. – The World Bank Environment Paper.
Kramer, R. A., Holmes, T. P., & Haefele, M. (2003). Using contingent valuation to estimate the value of forest ecosystem protection. In E. O. Ills, & K. L. Abt (Eds.), *Forests in a Market Economy*. Dordrecht: Kluwer.
Lindhjem, H. (2007). 20 years of stated preference valuation of non-timber benefits from Fennoscandian forests: A meta-analysis. *Journal of Forest Economics, 12*, 251–277.
Loomis, J. B., & White, D. S. (1996). Economic benefits of rare and endangered species: Summary and meta-analysis. *Ecological Economics, 18*, 197–206.
Mallawaarachchi, T., Blamey, R. K., Morrison, M. D., Johnson, A. K. L., & Bennett, J. W. (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.
Menkaus, S., & Lober, D. J. (1996). International ecotourism and the valuation of tropical rainforests in Costa Rica. *Journal of Environmental Management, 47*, 1–10.
Metz, B., Davidson, O. R., Bosch, P. R., Dave, R., & Meyer, L. A. (2007). *Contribution of working group III to the fourth assessment report of the intergovernmental panel on climate change*. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
Mogas, J., Riera, P., & Bennett, J. (2006). Comparison of contingent valuation and choice modelling with second order interactions. *Journal of Forest Economics, 12*(1), 5–30.
Murray, B., Lubowski, R., & Sohngen, B. (2009). Including International Forest Carbon Incentives in a United States Climate Policy: Understanding the Economics. Working Paper. Nicholas Institute for the Environmental Policy Solutions, Duke University.
Murray, J. P., Grenyer, R., Wunder, S., Raes, N., & Jones, J. P. (2015). Spatial patterns of carbon, biodiversity, deforestation threat, and REDD+ projects in Indonesia. *Conservation Biology, 29*(5), 1434–1445.
Murthy, I. K., Bhat, P. R., Ravindranath, N. H., & Sukumar, R. (2005). Financial valuation of non-timber forest product flows in Uttara Kannada district, Western Ghats, Karnataka. *Current Science India Science Publication, 88*(10), 1573–1579.
Mustalahti, I. O., & SRakotonarivo, S. (2014). REDD+ and empowered deliberative democracy: Learning from Tanzania. *World Development, 59*, 199–211.
Nelson, J. P., & Kennedy, P. E. (2009). The use (and abuse) of meta-analysis in environmental and natural resource economics: an assessment. *Environmental and Resource Economics, 42*(3), 345–377.
Nowak, D. J., Hoehn, R. E., Crane, D. E., Stevens, J. C., & Walton, J. T. (2007). Assessing urban forest effects and values. New York City's urban forest. Resources Bulletin NRS-9. U.S. Department of Agriculture. Forest Service, Northern Research Station, Newtown Square, PA.
Ojea, E., & Loureiro, M. L. (2011). Identifying the scope effect on a meta-analysis of biodiversity valuation studies. *Resources and Energy Economics, 33*, 706–724.
Ojea, E., Martin-Ortega, J., & Chiabai, A. (2012). Defining and classifying ecosystem services for economic valuation: The case of forest water services. *Environmental Science & Policy, 19–20*, 1–15.
Ojea, E., Nunes, P. A. L. D., & Loureiro, M. L. (2010). Mapping biodiversity indicators and assessing biodiversity values in global forests. *Environmental and Resource Economics, 47*, 329–347.
Olsen, N., & Bishop, J. (2009). *Financial Costs of REDD: Evidence from Brazil and Indonesia*. Gland, Switzerland: IUCN.
Pfaff, A., Robalino, J., Lima, E., Sandoval, C., & Herrera, L. D. (2014). Governance, location and avoided deforestation from protected areas: greater restrictions can have lower impact, due to differences in location. *World Development, 55*, 7–20.
Phelps, J., Friess, D. A., & Webb, E. L. (2012a). Win-win REDD+ approaches belie carbon-biodiversity trade-offs. *Biological Conservation, 154*, 53–60.
Phelps, J., Guerrero, M. C., Dalabajan, D. A., Young, B., & Webb, E. L. (2010). What makes a 'REDD' country?. *Global Environmental Change, 20*(2), 322–332.
Phelps, J., Webb, E. L., & Adams, W. M. (2012b). Biodiversity co-benefits of policies to reduce forest-carbon emissions. *Nature Climate Change, 2*, 497–503.
Phillips, S., Silverman, R., & Gore, A. (2008). *Greater than zero: Toward the total economic value of Alaska's National Forest Wildlands*. Washington, D.C: The Wilderness Society.
Portela, R., Wendland, K. J., & Ledwith, L. (2008). The idea of market-based mechanisms for forest conservation and climate change. In C. Streck, R. O'Sullivan, R. Tarasofsky, & T. Janson-Smith (Eds.),

Climate change and forests: Emerging policy and market opportunities. Washington, DC: Brookings Institution Press.
Potts, M. D., Kelley, L. C., & Doll, H. M. (2013). Maximizing biodiversity co-benefits under REDD+: A decoupled approach. *Environmental Resource Letters, 8*, 5.
Resosudarmo, I. A. P., Atmadja, S., Ekaputri, A. D., Intarini, D. Y., Indriatmoko, Y., & Astri, P. (2014). Does tenure security lead to REDD+ project effectiveness? Reflections from five emerging sites in Indonesia. *World Development, 55*, 68–83.
Ricketts, T. H., Daily, G. C., Ehrlich, P. R., & Michener, C. D. (2004). Economic value of tropical forest to coffee production. *PNAS, 101*(34), 12579–12582.
Rolfe, J., Bennett, J., & Louviere, J. (2000). Choice modeling and its potential application to tropical rainforest preservation. *Ecological Economics, 35*(2), 289–302.
Rosales, R.M.P., Kallesoe, M.F., Gerrard, P., Muangchanh, P., Phomtavong, S., & Khamsomphou, S. (2005). Balancing the returns to catchment management: the economic value of conserving natural forests in Sekong, Lao PDR. IUCN Water. Nature and Economics Technical Paper 5. The World Conservation Union. Ecosystems and Livelihoods Group Asia.
Rosenberger, R., & Loomis, J. B. (2000). Using meta-analysis for benefit transfer: In sample convergent validity tests of an outdoor recreation database. *Water Resources Research, 36*, 1097–1107.
Rudel, T. K. (2008). Meta-analyses of case studies: A method for studying regional and global environmental change. *Global Environmental Change, 18*(1), 18–25.
Scarpa, R., Buongiorno, J., Hseu, J., & Lee, K. (2000a). Assessing the non-timber value of forests: a revealed-preference, hedonic model. *Journal of Forest Economics, 6*(2), 83–107.
Scarpa, R., Chilton, S. M., Hutchinson, G. W., & Buongiorno, J. (2000b). Valuing the recreational benefits from the creation of nature reserves in Irish forests. *Ecological Economics, 33*, 237–250.
Shahwahid, M., Noor, A. A. G., Rahim, A. N., Zulkifli, Y., & Razani, U. (2003). *Economic benefits of watershed protection and trade-off with timber production: A case study in Malaysia*. Ottawa, Canada: Report International Development Research Centre.
Shrestha, R. K., & Loomis, J. B. (2001). Testing a meta-analysis model for benefit transfer in international outdoor recreation. *Ecological Economics, 39*, 67–83.
Shultz, S., Pinazzo, J., & Cifuentes, M. (1998). Opportunities and limitations of contingent valuation surveys to determine national park entrance fees: evidence from Costa Rica. *Environment for Development Economics, 3*, 131–149.
Siikamaki, J., & Layton, D. F. (2007). Discrete choice survey experiments: a comparison using flexible methods. *Journal of Environmental Economics and Management, 53*(1), 122–139.
Simpson, R., Roger, D., Sedjo, A., & Reid, J. W. (1996). Valuing biodiversity for use in pharmaceutical research. *Journal of Political Economy, 104*(1), 163–185.
Simula, M. 2010. *Analysis of REDD+ financing gaps and overlaps*. REDD + Partnership (http://reddpluspartnership.org).
Smith, K., & Kaoru, Y. (1990). Signals or noise? Explaining the variation in recreation benefit estimates. *American Journal of Agricultural Economics, 72*(2), 419–433.
Stern, N., Peters, S., Bakhshi, V., Bowen, A., Cameron, C., Catovsky, S., *et al.* (2006). *Stern review: The economics of climate change*. London Sunderlin: HM Treasury.
Sunderlin, W. D., Angelsen, A., Belcher, B., Burgers, P., Nasi, R., Santoso, L., *et al.* (2005). Livelihoods, forests, and conservation in developing countries: An overview. *World Development, 33*(9), 1383–1402.
Sunderlin, W., Hatcher, J., & Liddle, M. (2008). From Exclusion to Ownership? Challenges and Opportunities in Advancing Forest Tenure Reform. The Rights and Resources Initiative. Washington DC.
TEEB, The Economics of Ecosystem Services and Biodiversity. (2009). TEEB Climate Issues Update. September 2009.
TEEB, The Economics of Ecosystem Services and Biodiversity. (2010). The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. Edited by Pushpam Kumar. Earthscan, London and Washington.
Thomas, C. D., Anderson, B. J., Moilanen, A., Eigenbrod, F., Heinemeyer, A., Quaife, T., *et al.* (2012). Reconciling biodiversity and carbon conservation. *Ecology Letters, 16*, 39–47.
Tobias, D., & Mendelsohn, R. (1991). Valuing ecotourism in a tropical rain-forest reserve. *Ambio, 20*(2), 91–93.
UK NEA, United Kingdom National Ecosystem Assessment, (2014). Available at http://uknea.unep-wcmc.org/.
UN-REDD. United Nations REDD. *Multi-Partner Trust Fund Office GATEWAY*. (2014) In http://mptf.undp.org/factsheet/fund/CCF00?-fund_status_month_to=3&fund_status_year_to=2014. Last accessed 20 March 2014.
van Beukering, P. J. H. (2002). The economic value of tropical forest and its consequences for setting up payment schemes for environmental services: a comparison between the Leuser National Park (Indonesia) and the Iwokrama Forest (Guyana). In: Seminar proceedings on issues in International Nature Conservation. Utrecht University.
van Beukering, P. J. H., Herman, S. J. C., & Janssen, M. A. (2003). Economic valuation of the Leuser National Park in Sumatra. *Indonesia. Ecological Economics, 44*(1), 43–62.
Van der Heide, C.M., van den Bergh, J.C.J.M., van Ierland, E.C., & Nunes, P. A. L. D. (2005). Measuring the economic value of two habitat defragmentation policy scenarios for Veluwe, The Netherlands. Nota Di Lavoro 42. Fondanzione Enrico Mattei.
Venter, O., Hovani, L., Bode, M., & Possingham, H. (2013). Acting optimally for biodiversity in a world obsessed with REDD+. *Conservation Letters, 6*, 410–417.
Venter, O., Laurance, W. F., Iwamura, T., Wilson, K. A., Fuller, R. A., & Possingham, H. P. (2009). Harnessing carbon payments to protect biodiversity. *Nature, 326*, 1368.
Verma, M. (2000). *Economic valuation of forests of Himachal Pradesh. Report to IIED Himachal Pradesh. Forestry Review*. Bhopal, India: Indian Institute of Forest Management.
Walsh, R. G., Johnson, D. M., & McKean, J. R. (1992). Benefit transfer of outdoor recreation demand studies, 1968–1988. *Water Resources, 28*, 707–713.
Walsh, R. G., Loomis, J. B., & Gillman, R. A. (1984). Valuing option, existence, and bequest demands for wilderness. *Land Economics, 60*(1), 14–29.
Wang, X., Bennett, J., Xie, C., Zhang, Z., & Liang, D. (2007). Estimating non-market environmental benefits of the conversion to cropland to forest and grassland program: a choice modeling approach. *Ecological Economics, 63*(1), 114–125.
Woodward, R. T., & Wui, Y. (2001). The economic value of wetland services: A meta-analysis. *Ecological Economics, 37*(2), 257–270.
Zandersen, M., & Tol, R. S. J. (2009). A meta-analysis of forest recreation values in Europe. *Journal of Forest Economics, 15*(1–2), 109–130.

APPENDIX

Table 5. *Description of studies employed in estimation: author, publication year, country forest, ecosystem services, and number of observations*

Author (Publication year)	Country forest	Ecosystem services				
		Air and Water	Food and Fiber	Recreation and Tourism	Wild Species Diversity	Various Services
Aakerlund (2000)	Denmark	–	–	2	–	–
Adams *et al.* (2008)	Brazil	–	–	–	1	–
Adamson (2001)	Costa Rica	–	–	–	2	–
Adger, Brown, Cervigni, and Moran (1995)	Mexico	–	–	1	1	–
Ba *et al.* (2006)	Senegal	–	2	–	–	–
Bellu and Cistulli (1997)	Italy	–	–	14	–	–
Bernard, de Groot, and Campos (2009)	Costa Rica	2		2	1	–
Bienabe & Hearne, 2006	Costa Rica	–	–	2	2	–
Bostedt and Mattsson (2006)	Sweden	–	–	4	–	–
Carranza, Aylward, Echeverría, Tosi, and Mejias (1996)	Costa Rica	–	–	–	2	–
Chase, Lee, Schulze, and Anderson (1997)	Costa Rica	–	–	3	–	–
Dubgaard (1998)	Denmark	–	–	1	–	–
Echeverria, Hanrahan, and Solorzano (1995)	Costa Rica	–	–	2	–	–
Emerton (1999)	Kenya	1	–	1	–	4
Environmental Resources Management, (1996)	UK	–	–	–	1	–
Garber-Yonts, Kerkvliet, & Johnson (2004)	United States	–	1	–	2	1
Garrod and Willis (1997)	UK	–	–	–	3	–
Gurluk (2006)	Turkey	–	–	1	–	–
Hanley, Willis, Powe, and Anderson (2002)	UK	–	–	–	6	-
Hanley, Wright, and Adamowicz (1998)	UK	–	2	–	1	–
Hearne and Salinas (2002)	Costa Rica	–	–	2	–	–
Holmes, Alger, Zinkhan, and Mercer (1998)	Brazil	–	–	1	–	–
Horne, Boxall, and Adamowicz (2005)	Finland	–	–	–	1	–
Horton, Colarullo, Bateman, and Peres (2003)	Brazil	–	–	–	2	–
Howard (1995)	Uganda	1	2	–	1	1
Kaiser and Roumasset (2002)	United States	1	–	–	–	–
Kniivilä (2004)	Finland	–	–	–	–	1
Kniivilä, Ovaskainen, and Saastamoinen (2002)	Finland	–	–	2	–	1
Kramer, Sharma, and Munashinghe (1995)	Madagascar	–	–	1	–	1
Kramer, Holmes, and Haefele (2003)	United States	–	–	2	–	2

Mallawaarachchi, Blamey, Morrison, Johnson, and Bennett (2001)	Australia	–	1	–	–	1
Menkaus and Lober (1996)	Costa Rica	–	–	1	–	–
Mogas, Riera, and Bennett (2006)	Spain	–	–	–	2	–
Murthy, Bhat, Ravindranath, and Sukumar (2005)	India	–	4	–	–	–
Nowak, Hoehn, Crane, Stevens, and Walton (2007)	United States	4	–	–	-	-
Phillips, Silverman, and Gore (2008)	United States	-	2	2	-	2
Ricketts, Daily, Ehrlich, and Michener (2004)	Costa Rica	–	1	–	–	–
Rosales *et al.* (2005)	Lao PDR	3	4	–	2	–
Scarpa, Buongiorno, Hseu, and Lee (2000a)	United States	–	5	–	–	3
Scarpa *et al.* (2000b)	UK, Ireland	–	–	11 in UK and 8 in Ireland	–	–
Shahwahid, Noor, Rahim, Zulkifli, and Razani (2003)	Malaysia	3	3	–	–	–
Shultz, Pinazzo, and Cifuentes (1998)	Costa Rica	–	–	4	–	—
Siikamaki and Layton (2007)	Finland	–	–	–	3	–
Simpson, Roger, Sedjo, and Reid (1996)	Sri Lanka, Madagascar, India, Philippines, Brazil, Tanzania, South Africa, Malaysia, Australia, Indonesia, Colombia, Chile, and United States				1 in each country except in Brazil with 2 observations in total 14 observations	
Tobias and Mendelsohn (1991)	Costa Rica	–	–	2	–	–
van Beukering (2002)	Guyana	–	–	–	–	2
van Beukering, Herman, and Janssen (2003)	Indonesia	–	–	2	–	3
Van der Heide, van den Bergh, van Ierland, and Nunes (2005)	Netherlands	–	–	4	–	–
Verma (2000)	India	1	1	1	1	2
Walsh, Loomis, and Gillman (1984)	United States	–	–	4	–	4
Wang, Bennett, Xie, Zhang, and Liang (2007)	China	3	–	–	2	–

Table 6. *Classification of ecosystem services in the dataset*

Output-based classif.	Forest good (primary studies)	MA classif
Air quality and water regulation (4)	Air quality and water regulation	Regulating
Climate regulation (1)	Watershed microclimate and carbon sequestration	Regulating
Damage mitigation (4)	Flood control	Regulating
	Increase forest cover and reduce soil erosion	Regulating
Food and fiber (28)	NTFP	Provisioning
	Protection of salmon habitat	Supporting
	Move from large- to small-scale felling	Provisioning
	Move from straight to organic edges	Provisioning
	Wild coffee genetic material	Other services
	Tea tree woodlands	Provisioning
	Salmon harvest	Provisioning
	Timber	Provisioning
	Protection for fisheries and aquatic resources	Supporting
	Protection of agricultural production	Regulating
	National forests. timber value	Provisioning
	Other public forests. timber value	Provisioning
	Industrial forests. TEV	Other services
	Industrial forests. timber value	Provisioning
	Other private forests. timber value	Provisioning
	Direct consumptive (timber. fuel. fuel wood. fodder. salvage)	Provisioning
	Bee pollination for coffee production	Regulating
Recreation and tourism (81)	Scenic beauty	Cultural
	Recreation	Cultural
	Increase quality and quantity for recreation	Cultural
	Income from nature based tourism	Cultural
	Wages from nature based tourism	Cultural
	Recreational benefits (TC)	Cultural
	Forest near roads and trails estimates (with CV-PC)	Cultural
	Tourism revenues	Cultural
	Recreation and non-use values	Cultural
	Ecotourism	Cultural
	esthetic value	Cultural
	Tourism business	Cultural
	Ecotourism	Cultural
Water supply (4)	Protection of micro-hydropower facilities	Regulating
	Protection of potential hydropower supply	Regulating
	Drink water supply	Provisioning
	Water for hydroelectrical generation	Regulating
Wild species diversity (40)	Biodiversity protection	Other services
	Management to increase diversity	Other services
	Increase endangered species habitat	Other services
	Increase biodiversity reserves	Other services
	Conversion to old-growth (native) forest	Other services
	Biodiversity in upland conifer	Other services
	Biodiversity in lowland conifer	Other services
	Biodiversity in lowland ancient semi-natural broadleaved	Other services
	Biodiversity in lowland new broadleaved	Other services
	Biodiversity in upland native broadleaved	Other services
	Biodiversity in upland new native broadleaved	Other services
	Move from evergreen to evergreen + larch + broadleaves	Other services
	Bioprospecting	Provisioning
	Biodiversity	Other services
	Biodiversity conservation for business interests	Provisioning
	Conservation biodiversity	Other services

(*continued on next page*)

Table 6 (*continued*)

Output-based classif.	Forest good (primary studies)	MA classif
Various services (47)	Total economic benefits	Other services
	Watershed protection	Other services
	Increase in old growth forests use and nonuse	Other services
	Marketed benefits (tourism. timber)	Other services
	Watershed protection	Other services
	Existence value	Cultural
	Whole forest estimates (with CV-PC)	Other services
	Whole forest estimates (with CV-DC	Other services
	Wetlands (WTP)	Other services
	Increase forest area by 10% (CV)	Other services
	Increase forest area by 10% (Choice modeling)	Other services
	TEV	Other services
	National forests. TEV	Other services
	Other public forests. TEV	Other services
	Other private forests. TEV	Other services
	Increase conservation area	Other services
	TEV with sustainable management	Other services
	TEV with unsustainable management	Other services
	TEV with deforestation	Other services
	TEV with conservation	Other services
	TEV under selective use	Other services
	Passive uses	Cultural
	Watershed	Other services
	Existence. option and bequest	Cultural
	Conservation	Other services
	Conservation & BD protection	Other services

NTFP: non-timber forest products. WTP: willingness to pay. TEV: total economic value. CV: contingent valuation. The number of observations is in parentheses.