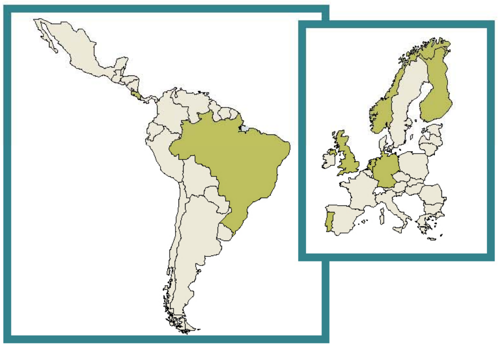

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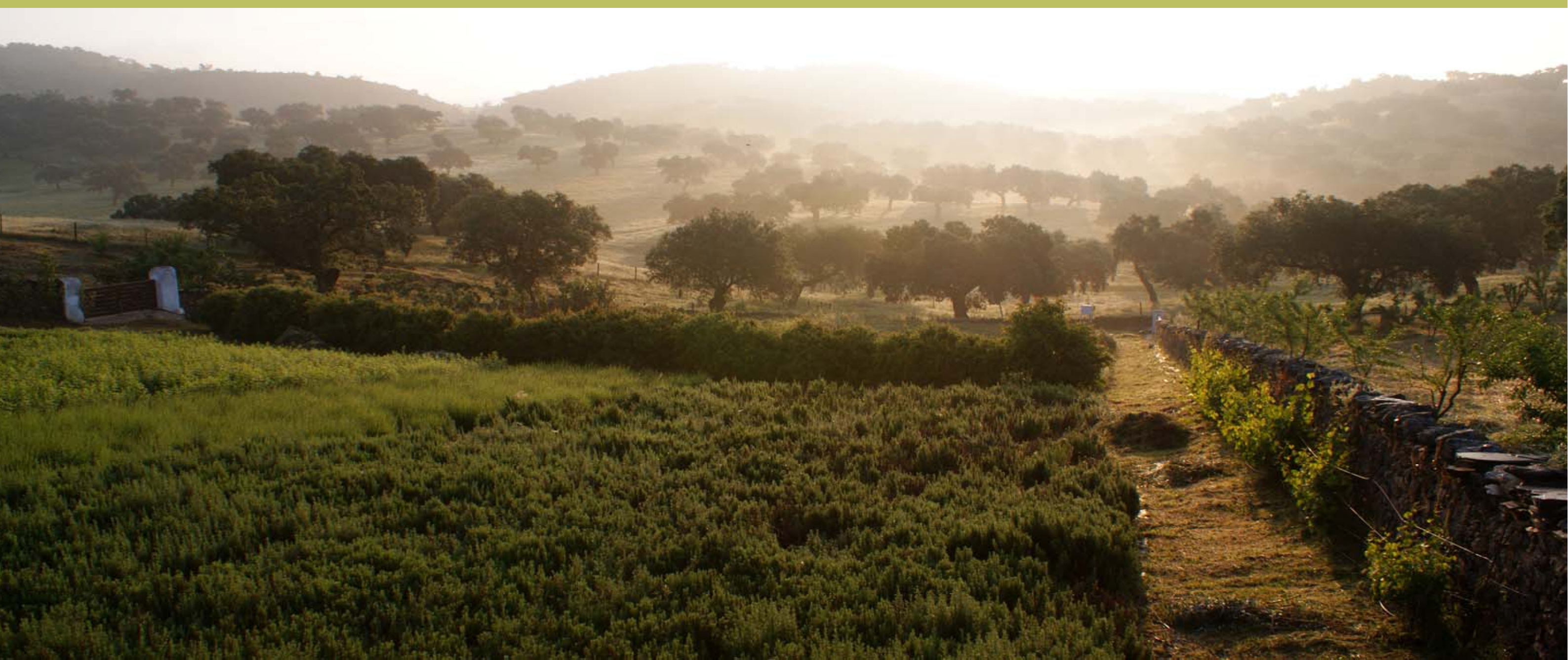

Review of the Biodiversity Valuation Literature and Meta-Analysis

POLICYMIX deliverable D4.1

Roy Brouwer and Tashina Simon

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Abstract

The value of forests is significant in terms of biological resources as well as ecological processes and functions they perform. Economic valuation of ecosystem services is an increasingly used tool to attach an economic value to non-marketed environmental benefits and to promote conservation polices by use of effective economic instruments. The valuation of ecosystem services for marketed goods is a straightforward approach that applies market prices to derive monetary values for the benefits humans receive from ecosystems. Non-marketed environmental goods and services, however, require non-market valuation methodologies to carry out primary valuation studies that follow accepted methods and provide reliable results. The most commonly used methodology is the Contingent Valuation Method (CVM), a stated preference survey method that is used to measure an individual's willingness to pay (WTP) or willingness to accept (WTA) for an environmental good. The use of CVM to facilitate cost-benefit analysis (CBA) is used to evaluate policy decisions and make clear the trade offs and opportunity costs that exist when non-marketed values are not taken into account. The main objective of this paper is to review the existing valuation literature on forest biodiversity and ecosystem services, and conduct a meta-analysis based on existing non-market valuation studies, focusing specifically on the impact of the use of economic instruments to elicit stated preferences and willingness to pay. Existing meta-analyses are also reviewed. The highest values in the meta-analysis conducted in this study were for tropical rainforests followed by boreal, temperate and lastly subtropical forests. Ecosystem services and forest type were highly correlated. However, no significant effect could be detected for the ecosystem service carbon sequestration compared to biodiversity. Furthermore, contrary to existing meta-analysis, no significant effect could be detected either for recreation, although a significant positive effect was found for aesthetic ecosystem services. A significant difference exists between welfare measures where WTP for an avoided loss was higher than average WTP for securing an environmental gain. Voluntary payments gave the highest WTP values followed by resource use tax, municipal tax, user fee, income tax and lastly payments to a trust fund. The results of this study are relevant in that few meta-analyses of forest ecosystem services investigate the influence of payment vehicle on WTP while selection of an appropriate payment vehicle is imperative to create a realistic and acceptable method of securing payment as in Payments for Ecosystem Services (PES) schemes.

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1 Introduction

Forest ecosystems play a critical role in the provision of environmental goods and ser-vices and have been the subject of international concern as alarming rates of deforesta-tion are witnessed worldwide (FAO, 2003). Historically, economic incentives and rapid population growth have favoured forest conversion often in search of new agricultural lands rather than conservation; however in light of severe losses throughout the 1990s the international community has begun to recognize deforestation as a serious concern (FAO, 2003; Horton et al, 2003). The loss of forests involves risks to human health, ac-celerated climate change, and increased watershed disruption, eutrophication, decline of water quality as well as biodiversity (Pearce, 2001). Between 1960 and 2000, the world population doubled and the global economy has increased more than six times (MEA, 2005). The Millennium Ecosystem Assessment (MEA) (2005) declared nearly two thirds of global ecosystem services to be in decline while demand for ecosystem services continues to grow significantly. Forest ecosystems provide unique habitat and support a variety of populations and communities that represent biodiversity (Nunes and van den Bergh, 2000). Biodiversity is being lost at ever increasing rates as a result of land use conversion and other anthropogenic effects such as GHG emissions, water, soil and air pollution. Current biodiversity estimates suggest that roughly 1.5 million species have been identified while there are an estimated 5-30 million still unknown species present (Nunes and Van den Bergh, 2001). The current rate of biodiversity loss is estimated to be up to 100 times the natural rate of extinction further increasing the need for forest conservation and valuation of ecosystem services (UN, 2010).

One of the primary causes of loss in tropical forest areas is attributed to the increasing need for agricultural areas as well as commercial logging. As a result, forest fragmenta-tion occurs due to access and logging roads, effects of climate change and possible ex-otic pest invasions (Horton et al, 2003). There are approximately 4 billion hectares of forests in the world amounting to roughly 0.6 ha per capita and divided among five main forest biomes; tropical, subtropical, temperate, boreal and polar forests (FAO, 2011). An estimated 17.4 percent of global GHG emissions come from the forest sector and in large part from deforestation in developing countries (FAO, 2011). These emissions include those from deforestation, decomposition of biomass that remains after logging and deforestation, CO_2 from peat fires and decay of drained peat soils (FAO, 2011). The Intergovernmental Panel on Climate Change (IPCC) indicated that global forest vegetation contains 283 Gt of carbon in biomass, 38 Gt in dead wood and 317 Gt in soils and forest leaf litter (IPCC, 2007). The total carbon content of forests ecosystems has been estimated at 638 Gt, which exceeds the amount of carbon currently in the atmosphere (FAO, 2011). Therefore there is a critical need to conserve forests in order to mitigate potentially extreme effects of climate change as a result of continued forest loss. The rate of deforestation has declined in recent years from 16 million hectares a year in the 1990s to a rate of approximately 13 million hectares in the past decade (FAO, 2011). Nevertheless, the rate of deforestation and loss of primary forests remains alarming as biodiversity continues to decline and critical habitat for endangered species is lost.

The natural growth of forests as well as afforestation programs have reduced the overall loss of forests on the global scale, however most forest gains remain in boreal and temperate regions while losses are largely concentrated in tropical regions predominantly found in developing countries (FAO, 2011). This often occurs where forests are managed as open access resources and use of forest resources is non-rival and non-excludable. Many rural communities in developing countries rely on forest goods and services for survival; few resources or time are available to promote sustainable forest management practices. Consequently, a general disregard for long term use results due to a lack of clearly defined property or user rights, free riding and excessive resource extraction. As there continues to be a loss of primary forests, the valuation of benefits that humans derive from forest ecosystems becomes increasingly important in light of growing pressure on natural resources, and decline in services as climate change advances.

The rate of conversion from forest to agricultural and other land uses affects the quality and provision of ecosystem services and ecological functions. In a study that compares net primary production in terms of biodiversity richness, Costanza et al. (2007) find that one percent loss in biodiversity in warm eco-regions results in roughly a half percent change in the value of the ecosystem services provided in these regions. In particular tropical rainforests support high levels of biodiversity and endemism that form a complex ecosystem structure and function based on a variety of symbiotic relationships, making the degradation and loss of these areas profound. As deforestation and degradation occur, species can be lost that perform vital roles in ecosystem functioning and overall service provision. Literature suggests a strong relationship between levels of biodiversity present, ecosystem resilience and adaptive capacity (Huitric et al, 2009). The provision of ecosystem services is also dependent upon other factors, such as the forest biome, level of degradation, size and land use practices.

While the quality and provisioning of ecosystem services come under increased threat due to climate change and other anthropogenic effects, the literature identifies four pri-mary reasons to value ecosystem services (e.g. Kramer and Mercer, 1997; Slootweg and van Beukering, 2008). One is to extract revenues by introducing user fees, taxes or voluntary payment mechanisms. Second, is the ability to provide damages assessments following a large scale catastrophe such as Exxon Valdez or the more recent BP oil spill. Furthermore, damage assessment can be conducted prior to actual damage occurring so if or when an incident occurs stakeholders are prepared to seek compensation for damages. Third, the use of ecosystem service valuation to assist decision making for policy decisions is useful for governments to make clear what the tradeoffs associated with various political decisions are. If clear valuation and tradeoffs can be presented to decision makers prior to making important decisions, transparency and equitable decisions that keep the greater public good in mind are more likely to occur. Lastly, valuation of ecosystem services is an important tool to raise awareness regarding the benefits that humans derive from ecosystems and to advocate on the behalf of nature preservation.

The value of forests is significant in terms of biological resources as well as ecological processes and functions they perform. Economic valuation of ecosystem services is an increasingly used tool to attach an economic value to non-marketed environmental benefits and to promote conservation polices by use of effective economic instruments. The valuation of ecosystem services for marketed goods is a straightforward approach that applies market prices to derive monetary values for the benefits humans receive from ecosystems. Non-marketed environmental goods and services however, require non-market valuation methodologies to carry out primary valuation studies that follow accepted methods and provide reliable results. The most commonly used methodology is the Contingent Valuation Method (CVM), a stated preference survey method that is used to measure an individual's willingness to pay (WTP) or willingness to accept (WTA) for an environmental good. The use of CVM to facilitate cost-benefit analysis (CBA) is used to evaluate policy decisions and make clear the trade offs and opportunity costs that exist when non-marketed values are not taken into account. The main objective of this paper is to critically review especially the existing non-market valuation literature and conduct a meta-analysis based on existing CV studies.

2 Ecosystem services and biodiversity valuation

The valuation of ecosystem services is a subject of growing enthusiasm and academic debate as the number of valuations studies and meta-analyses continues to grow. In 1997 Costanza et al attempted to value ecosystem services using various case studies to derive average values per hectare for 17 ecosystem services from 16 different biomes. These values were then extrapolated by multiplying these values by hectares of each biome to obtain global values. Costanza et al estimated the aggregate value of global ecosystem services to range from 18-61 trillion, averaging 38 trillion (updated to 2000 USD) and noted that a large part of this value was due to non-marketed ecosystem services. In this paper forest values were estimated at (4,706 x 10^9) roughly 4.7 trillion USD as the aggregate flow value, this figure was further broken down to values for both tropical and temperate forest types. Among the disaggregated values there were high climate regulation values for tropical compared to temperate forests, high values attributed to nutrient cycling in tropical forests, along with a large part of the value attributed to raw materials and recreational benefits. Temperate forests were estimated to have a slightly higher value for food production but produce a much lower aggregate value of 894 billion USD (894 x 10^9) compared with 3.8 trillion USD (3, 813 x 10^9) for tropical forest value. The overall value for global ecosystem services derived by Costanza et al. is similar in size to global Gross National Product and has been criticized by some in the economic community including Costanza himself who freely admitted faults in the study to include 1) assumed homogeneity in natural capital and economic contexts, 2) the study being partial and static rather than dynamic and 3) values taken from various studies varied greatly in methodology, practical and theoretical assumptions (Costanza et al, 1998). Despite the shortcomings of such a study, the relevance of the findings cannot be ignored. These shortcomings identified by Costanza are generally applicable to meta-analysis and bring attention to potential problems associated with meta-analysis, especially when practiced on a global scale. Despite these apparent shortcomings, valuation of marketed and non-marketed ecosystem services is vital to effectively evaluate policy decisions and incorporate all potential benefits enjoyed by humans into CBA analysis.

Forests provide a number of environmental services with public and quasi public good characteristics such as water regulation, maintenance of biodiversity, potential and uncertain future use, and recreational and aesthetic services. There are also measurable direct economic benefits from tourism related revenues to nearby communities as well as increased recreational opportunities and aesthetic value. Forests play an essential role in regulating the composition of gases in the atmosphere. They absorb and store carbon dioxide and release oxygen through photosynthesis. They provide climate regulation services both locally and globally, for example precipitation patterns and cooler temperatures in adjacent areas. Hydrological flows are regulated as rain is intercepted by the forest tree canopy, slowing down the rainfall and allowing time for the soil to absorb the water thus avoiding erosion and excessive runoff. This prevents large surface flows into rivers that cause flash floods and greatly increase water turbidity. Erosion control is further achieved by protecting soils in upland areas, avoiding siltation of dams, lakes and wetlands. Forests provide wildlife habitat, and refuge in addition to supporting biodiversity, which is necessary to support future human needs for food, medicine and to protect genetic diversity (Mohd-Shahwahid, 2001). While the alternate uses of forests usually include forest removal and conversion to agricultural or pasture uses, the importance of biological resources harboured in forests should not be underestimated (Echeverria et al, 1995). The use of forests for agricultural or timber extraction purposes take away public enjoyment of these amenities as well as potential economic benefits derived from ecotourism and other activities that benefit local communities.

The concept of biodiversity is a complex and at times abstract or unfamiliar concept that can be poorly understood by the general public. Valuation of biodiversity is often achieved through stated preference techniques such as CVM. The widespread use of CVM in the field of environmental economics has been a subject of intense debate and concern regarding its use as a valuation tool. Nevertheless, the CV method has been accepted as an appropriate method to value non-marketed environmental resources when studies adhere to guidelines recommended by the NOAA panel (1993) or Mitchell and Carson (1989), for example. The United Nations Convention on Biological Diversity 1992 defines biodiversity as "the variability among living organisms from all sources, including terrestrial, marine and the ecological complexes of which they are part". As CVM and other stated preference methods require a thorough understanding of environmental concepts such as biodiversity, explanation of these concepts is a necessary part of survey design to maintain validity and accuracy in estimating WTP for environmental goods and services. Biodiversity provides a variety of ecosystem services that contribute greatly to human welfare particularly in developing countries where many people rely on natural resources for survival.

According to Nunes and Van den Bergh (2001) valuation of biodiversity can be divided into genetic, species, ecosystem and functional diversity. Genetic diversity refers to the level of variation among genes present in a certain species while species diversity is defined by the number of species present. Ecosystem diversity refers to the number of communities present in the habitat, and landscape level as well as physical conditions present. Functional diversity can be defined as an ecosystem's ability to withstand change and shock without experiencing a tipping point or regime shift that results in a qualitatively different state of the ecosystem; generally referred to as ecosystem resilience and adaptive capacity (Huitric, 2009). Nunes and Van den Bergh (2001) disaggregate the total economic value of biodiversity (see Table 1) into components that represent elements of biodiversity and can be valued using a range of methods including contingent valuation (CV), hedonic pricing (HP), averting behavior (AB), travel cost method (TC) and production function (PF) methods.

Table 1 *Total Economic Value of Biodiversity (Adapted from Nunes and Van den Bergh 2001)*

Total Economic Value Biodiversity	***Biodiversity benefits***	***Appropriate Valuation Methods***
Genetic and Species Diversity	Pharmaceutical and Agricultural developments	CV, HP, AB, PF
Natural Areas and Landscape Diversity	Natural Habitat-recreational and wilderness areas	CV, TC, PF, AB
Ecosystem functions and services	Nutrient cycling, Hydrologic regulation, waste removal	HP, AB, PF
Nonuse values	Existence, Option and Bequest Values	CV

The primary focus of biodiversity valuation is to aggregate human benefits derived from biodiversity and to place a monetary value on the goods and services provided. Thus, the economic valuation of biodiversity provides a monetary indicator that is used to represent welfare changes related to biodiversity loss or gains. This is often achieved though creating policy options or scenarios to represent small or marginal changes in levels of biodiversity. The total economic value is an aggregation of the use and nonuse values that reflect human preference and motivations for use of ecosystem services provided by biodiversity. This is an anthropocentric view that ecosystem services are only the services that directly benefit human welfare. The importance of ecosystem functions or supporting services should not be forgotten when determining an ecosystem's capacity to provide ES; however inclusion of these services in the economic valuation can lead to issues associated with double counting leading in turn to possible overestimation of TEV.

The use of biological indicators relies on an entirely different set of non-monetary indices that frequently correspond to species richness or abundance (Nunes and van den Bergh, 2001). For example there are worldwide biodiversity indices that can be obtained from the IUCN data for both the absolute number of listed species (biodiversity abundance) and the number of endangered red list species (threatened biodiversity) (Ojea et al, 2010). Biological indicators rely on scientific data that often describe ecosystem health and functioning that can be a proxy for describing biodiversity as a whole. These indicators can describe certain biological resources in an area that may contribute to overall biodiversity in the ecosystem but do not fully encompass the diversity of species or biodiversity present.

The biodiversity indicators most commonly used are the Shannon and Simpson indices. The Simpson index is the probability that two individuals pulled sequentially from a sample will be the same species (Rapidel et al, 2011). The Shannon index on the other hand, is similar but measures the average degree of uncertainty in predicting the species of an individual within a collection of *s* species and *n* individuals. The level of uncertainty increases with species richness and equal distribution of individuals per species (Rapidel et al, 2011). Ideally all economic valuation techniques and thus monetary indices are based on biological indicators; however direct comparison of biological indicators and monetary indices is not always possible and should be regarded as complimentary rather than interchangeable. A variable to represent biodiversity was not used in this meta-analysis as the primary focus of this study is the influence of payment vehicle on WTP and not directly linked to the impact of biodiversity. In addition, not all studies elicit a value for biodiversity preservation, and use of a biodiversity indicator that is representative on a national scale does not necessarily capture population beneficiary effects or characteristics of the goods and services being valued.

3 Forest ecosystem service classification

There are several definitions and methods of classification offered for ecosystem services in the available literature. How an author defines and classifies ecosystem services will dictate the manner in which services are considered in a study and thus can greatly affect the results of economic valuation and meta-analysis. According to Costanza et al, (1997) ecosystem services are defined as "ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions." Ecosystem services are defined by the Millennium Ecosystem Assessment as "the benefits people obtain from ecosystems" (MEA, 2005). While Costanza et al. (2007) state that ecosystem functions refer variously to the habitat, biological or system properties, or processes of ecosystems. According to Daily (1997) forest ecosystem services can be defined as the process and condition through which the forest and the species that live there support and satisfy human life. Daily goes on to say that forests maintain biodiversity and the production of ecosystem services, such as food, raw materials, forage timber, biomass fuels, natural fiber, and many pharmaceutical products, (Daily, 1997). Forest goods and services also include recreational opportunities, scenic landscapes (direct use values); waste protection, watershed services and carbon storage (indirect use values); and wildlife habitat and biodiversity conservation (non-use values) (Costanza et al, 2007).

In the meta-analysis presented in this paper, ecosystem services will be structured according to the Millennium Ecosystem Assessment (MEA) framework (2005) into provisioning services, consisting of products obtained from ecosystems including food, fiber, freshwater or genetic resources; supporting services, which are necessary for the production of other ecosystem services, such as soil formation, photosynthesis, primary production, nutrient cycling and provisioning of habitat; regulating services, including benefits obtained from the regulation of ecosystem processes, such as air quality regulation, climate regulation, water regulation, erosion regulation, pollination or natural hazard regulation; and cultural services or the non-material benefits that people obtain from the ecosystem, including the aesthetic experience, recreation or spiritual enrichment (see Table 2). The MEA is built on a conceptual framework that links biodiversity with the services ecosystems provide society that improve human welfare. Under the conceptual framework of the MEA human welfare is the central focus for ecosystem services assessment. As biodiversity plays a crucial role in determining an ecosystem's ability to provide goods and services, changes in biodiversity will likely affect ecosystem service provisioning and thus are reflected as welfare changes (Ojea et al, 2010). Although the MEA framework has been questioned recently by some literature (Boyd and Banzhav, 2007; Fisher et al, 2009) who seek to find a more effective and accurate accounting framework the MEA remains a commonly used and helpful tool in which to work with ecosystem services.

***Table** 2 Forest Ecosystem Services according to MEA framework*

Service Type	***Ecosystem Service***
Provisioning	Timber, non-timber forest products, medicinal plants, food, fiber
Regulating	Gas regulation, Climate regulation, Hydrological or Flood regulation
Cultural	Recreation, Aesthetic, Spiritual
Supporting	Nutrient Cycling, Erosion Control, Soil formation, pollination

While the value of certain ecosystem services, such as provisioning, can be obtained from existing markets prices, other values related to indirect use or cultural services can only be obtained through non-market valuation techniques. Many of the ecosystem services provided by forests are non-market, public or quasi public environmental goods without financial values. Consequently many ecosystem services that bear non-market values are not regularly considered in management and decision-making processes. Because many of these services and benefits do not have market values, sustainable financing can be difficult to secure. Consequently valuation of these non-market values provided by forests is necessary for forest preservation benefits to be clearly understood and be equally considered for funding in policy decisions as financial resources are limited.

The valuation of ecosystem services is subject to various assumptions and methodologies; there also lies a risk of double counting services leading to a possible overestimation of TEV. Double counting arises when ecosystem services are valued separately but form one final service that is utilized. Boyd and Banzhaf (2007) suggest only considering the end products or services used by humans to avoid potential errors due to double counting. They offer a definition of ecosystem services "Final ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being." Boyd and Banzhaf argue for standardized accounting units in order to quantify and classify ecosystem services and a more stringent definition so only the final services, directly utilized by humans are considered. They feel standardized environmental units are necessary to value environmental goods and services so their contribution to welfare can be determined and aggregated with other economic goods as part of GDP or green GDP.

While the logic of standardized accounting units may hold for ecosystem service valuation it fails to properly highlight many ecosystem processes and functions that take place to provide services that can be directly utilized by humans. These services generally fall into the supporting services category defined by the MEA, and although these services may not be directly enjoyed by humans, they are essential to other ecosystem service provision. It is possible in efforts to avoid double counting of ecosystem services, more recent definitions have become more anthropocentrically based, focusing on the final services that are directly consumed and less focused on ecological functions or supporting services. While there are good reasons for green accounting that attempts to value non market environmental goods it should not be forgotten that as ecosystems degrade the quality of services provided as well as ecosystem resilience and adaptability may be compromised. In many ways the services provided are unique and irreplaceable so any attempts to value then are likely to undervalue rather than over estimate the true total economic value.

4 Total economic value and valuation approaches

4.1 Total economic value

Economic valuation of (limited available) resources, be it human made or natural resources, has as a primary objective to inform policy makers about relative resource scarcity and guide economically efficient decision-making. Valuation is also considered to play an important role in creating markets for the conservation of biodiversity and ecosystem services. Such market creation requires three main stages: demonstration of values, appropriation of values, and sharing of benefits from conservation (Kontoleon and Pascual, 2007).

Economic values reflect what people are willing to trade-off to either employ or conserve these resources. Given the absence of a functioning market mechanism for many natural resources and ecosystem services, and in line with increasing conservation conflicts and a need for more efficient resource allocation, it is necessary to have knowledge and information of the marginal value or benefits of the resource in its alternative uses. An economic value is defined in terms of economic behaviour in the context of supply and demand. Put simply, it is the maximum amount of goods or services - or money income - that an individual is willing to forego (willingness to pay or WTP) in order to obtain some outcome that increases his or her welfare. The economic concept of value differs in this sense from the concept of value in other social sciences. It does not suffice to state that something is considered important, beautiful, worth protecting etc. Value is measured through people's (or society's) financial commitment to preserve something ('put your money where your mouth is'). Ideally, this commitment is measured through observed behaviour in markets where people actually pay for a good or service. This actual behaviour is considered to reveal people's preferences best and actual payments are considered the most reliable indicator of value.

If the outcome reduces welfare then this welfare loss is measured by the minimum amount of money that the individual would require in compensation (willingness to accept or WTA) in order to suffer the changes (see Box 1). These sums of money are demonstrated or implied by the choices people make, and thus reflect individuals' preferences for a particular change (e.g. employment or conservation of resources). It should be noted that the WTP measure of the impact on social welfare does not consider inequalities in the distribution of gains and losses among individuals. However, WTP is theoretically constrained by individuals' ability to pay. Aggregated across those who benefit from a good or service and hence will be affected by any change in their provision level, the aggregate WTP or WTA amount provides an indicator of their Total Economic Value (TEV). Environmental economists have introduced a taxonomy of this TEV, which captures the variety of values emanating from the different uses of resources (Figure 1). The main distinction is made between use and non-use values.

Box 1: Economic welfare measures

A distinction can be made between two types of welfare measures based on two different points of reference: the ‘compensating surplus’ (CS) and the ‘equivalent surplus’ (ES). The former equals the money income adjustment necessary to keep an individual at his initial welfare level before the change in the provision level of a good, while the latter equals the money income adjustment necessary to maintain an individual at his new welfare level after the change in the provision level of a good. Four relevant welfare measures associated with welfare gains and losses can thus be distinguished:

- WTP to secure a welfare gain (CS_{WTP})
- WTA to forego a welfare gain (ES_{WTA})
- WTP to prevent a welfare loss (ES_{WTP})
- WTA to tolerate a welfare loss (CS_{WTA})

The WTP measures have become the most frequently applied in valuation studies and have been given peer review endorsement, especially because they are constrained by income whereas WTA is not.

Use values

- Direct use values arise from direct interaction with natural resources. They may be consumptive, such as the extraction of timber from a wood, or they may be non-consumptive such as recreational activities or the aesthetic value of enjoying a view.
- Indirect use values are associated with services that are provided by natural resources but that do not entail direct interaction. They are derived, for example, from the prevention of soil erosion or pollination.
- There is a further type of value that is related to future direct and indirect uses. This is option value:
- Option value is the satisfaction that an individual derives from ensuring that a natural resource and its services are available for the future given that the future availability of the resource is uncertain. It can be regarded as an insurance for possible future demand for the resource.

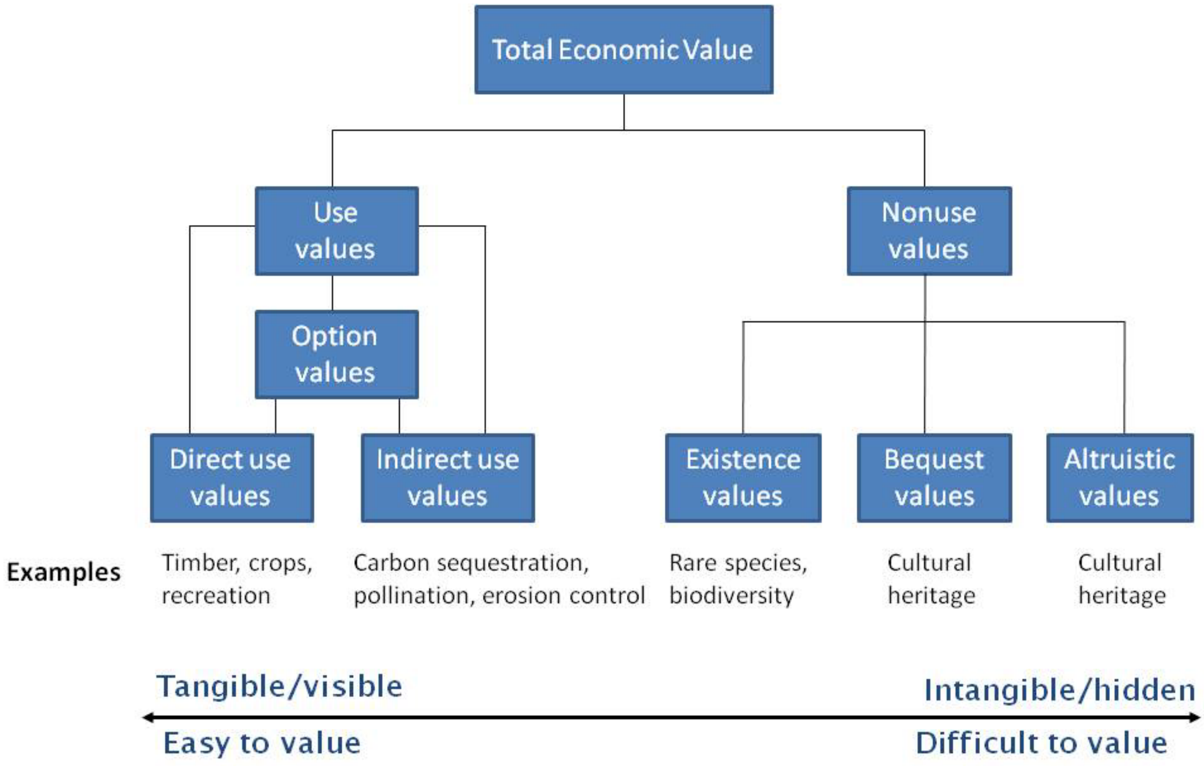

Figure 1: *Components of Total Economic Value*

Non-Use Values

Non-use value reflects value in addition to that which arises from usage and is derived from the knowledge that a natural resource is maintained. By definition, nonuse values are not associated with tangible benefits that can be derived from it (though resource users may derive non-use values). Thus individuals may have little or no use for a given natural asset, but would nevertheless feel a 'loss' if it would disappear. Non-use values are linked to ethical concerns and altruistic preferences. However the boundaries of the non-use category are not clear cut and some human motivations which may underlie the position that the asset should be conserved 'in its own right', and labeled existence value, are arguably outside the scope of conventional economic thought. In practice, what is at issue here is whether it is meaningful to say that individuals can assign a quantified value to the environmental asset, reflecting what they consider to be intrinsic value.

Non-use values can be divided into three types of value (which can be overlapping): existence value, bequest value and altruistic value.

- Existence value is the satisfaction derived from a resource continuing to exist, regardless of whether or not it might be of benefit to others. Motivations here could vary and might include having a feeling of concern for the asset itself (e.g. a threatened species) or a "stewardship" motive whereby the "valuer" feels some responsibility for the asset.
- Bequest value is the satisfaction derived from ensuring that a resource will be passed on to future generations so that they will have the opportunity to enjoy it in the future.

- Altruistic value is the satisfaction derived from ensuring that a resource is available to contemporaries in the current generation.

It is important to note that what is being valued is not the ecosystem per se, but rather independent elements of goods and services provided by biodiversity and forest ecosystems. The aggregation of all function based values provided by a given ecosystem yields the TEV of that ecosystem. TEV does furthermore not provide an exhaustive assessment of the value of natural resources and ecosystem services to society. It measures the extent to which goods and services provided by ecosystems touch on the welfare of society, as direct determinants of individuals' wellbeing or via production processes. It represents two fundamental sets of values: individual values and production values. Individual values include recreational and amenity values, as well as non-use values (existence, bequest and philanthropic values) of goods and services provided by ecosystems. Production or output values occur through the employment of natural resources and ecosystem services as 'natural capital' in the production of other goods and services.

Forest woodlands are natural assets that create flows of goods and services over time. The key to their valuation is to establish the functions that they provide and link this to states or outcomes that are valued by society. If that link can be established, then the concept of derived demand can be applied. The value of a change in the functions provided can be derived from the change in the value of the stream of benefits. Given the multi-faceted nature of benefits associated with forest ecosystems there is a need for a useable typology of the associated values. The focus here is on economic values, which depend on human preferences, i.e. what people perceive as the impact on their welfare. Economic values are relative in the sense that they are expressed in terms of something else that is given up (the opportunity cost).

4.2 Economic valuation approaches

An important distinction to make is between market-based valuation techniques and non-market based valuation techniques. Market valuation means that existing market behaviour and market transactions are used as the basis of the valuation exercise. Economic values are derived from existing market prices for inputs (production values) or outputs (consumption values), through more or less complex econometric modeling of dose-response and/or damage functions. Examples include the economic value of timber, which is sold on a market (market analysis), the costs of soil fertilization to compensate for soil erosion (restoration costs) or water treatment due to soil runoff and sedimentation (damage cost), or the costs of a water filter on tap water (avertive behaviour/defensive expenditures).

The economic value of ecosystem services provided by forests and woodlands can be measured di-rectly through existing market prices for intermediate or final products (e.g. timber price). Here, the market price is multiplied by the quantity of timber sold or consumed to yield the total market value. The market price may have to be adjusted to provide the real economic shadow price, but otherwise it is likely to provide a relatively simple means of assessing economic value. In some cases, human resource use may also include recreational activities. Examples are walking, cycling, camping, or undergoing a wildlife experience. In some cases recreational values can be derived from existing entrance fees.

Many forest ecosystem services are not traded in markets and therefore remain un-priced. It is then necessary to assess the economic value of any environmental damage (avoided with the help of existing pollution abatement and mitigation measures) with the help of direct and indirect non-market valuation methods. Non-market valuation means deriving economic values in cases where such markets are non-existent or distorted. Direct methods (also called stated preference methods) refer to contingent valuation (CV), discrete choice experiments (CE), and contingent ranking (CR) techniques, where individuals are asked directly, in a social survey format, for their WTP for a pre-specified environmental change. WTP can also be measured indirectly by assuming that this value is reflected in the costs incurred to travel to specific sites, such as with recreational visits (travel cost studies), or prices paid to live in specific neighbourhoods (hedonic pricing studies) (also called revealed preference methods). The latter two approaches are based on preferences being 'revealed' through observable behaviour, and are restricted in their application to where a functioning market exists. CV, CE and CR, being based on surveys that elicit 'stated preferences', have the potential to value benefits in all situations, including non-use or passive use benefits that are not associated with any observable behaviour. The legitimacy of these methods and results is still contested, especially in the context of non-use values, and conducting surveys can sometimes be a lengthy and resource-intensive exercise. Of these methods, CV is probably the most widely applied method in contemporary valuation research, but since about 10 years the use of choice experiments has increased exponentially too. Table 3 provides an overview of the ecosystem services provided by forests and woodlands, the associated (direct and indirect) use, option and nonuse values and appropriate valuation approaches.

Table 3 Forest ecosystem services, value type and appropriate biophysical and economic (e)valuation methods

Ecosystem service	*Direct use value*	*Indirect use value*	*Option value*	*Nonuse value*	*Biophysical evaluation method(s)*	*Economic valuation method(s)*
Provisioning services						
Food production	+	-	+	-	Yield (ton/ha/year) Crop yield model	Net present value of crop yield Market-price valuation
Timber production	+	-	+	-	Timber yield (cubic meters/ha/year) Forest yield model	Net present value of timber yield Market-price valuation
Water supply	+	+	+	-	Water extraction (cubic meters/year) Hydrological (water balance) model	Market value Market price valuation
Bioenergy production	+	+	+	-	Yield (ton/ha/year) Crop yield model	Market value Market price valuation
Regulating services						
Carbon sequestration	-	+	+	-	Carbon sequestration (tons carbon/ha/year) Carbon accounting model	Multiple approaches including damage cost avoided or EUTS values
Water quality regulation	-	+	+	-	Water quality model, biochemical water quality indicators (eg mg N, BOD or Chlorofyl/liter)	Avoided opportunity costs
Erosion control	-	+	+	-	Land use model? (tons of soil eroded per year)	Damage cost avoided, avoided opportunity costs
Pollination	-	+	+	-	Production function where bee density is an input factor in crop production	Production function method
Flood regulation	-	+	+	-	Probability of flood happening in location GIS-based hydraulic-hydrological model	Damage cost avoided
Cultural services						
Recreation	+	-	+	+	Landscape properties with known positive or negative recreation potential	Travel cost, hedonic pricing, contingent valuation, choice experiment
Tourism	+	-	+	+	Visitors/year, overnight stays	Tourist expenditures Market price valuation
Landscape aesthetics	+	-	+	+	Landscape properties with known positive or negative perceptual values	Travel cost, hedonic pricing, contingent valuation, choice experiment
Cultural heritage	+	-	+	+	Number and area of significant sites	Travel cost, hedonic pricing, contingent valuation, choice experiment
Supporting services						
Soil formation	-	+	+	-	Soil-yield production model (tons of soil/year)	Avoided opportunity costs
Nutrient cycling	-	+	+	-	Nutrient balance model (kg N/year)	Avoided opportunity costs

5 Existing summaries of forest ecosystem valuation studies

Over the past 8 years, 5 meta-analyses have been conducted, summarizing and explaining the results from existing forest valuation studies. These studies are summarized in Table 4. Two only use stated preference studies such as CV and CE, one focuses on travel cost studies only, one on both CV and travel costs and one contains a mix of stated, revealed, market prices, cost estimates and even benefits transfer values. Bateman and Jones (2003) are the only study that distinguishes between different value types estimates in the different studies examined in their meta-analysis. Use and option values yield a significant higher forest recreation value than nonuse values. An overview of the different variables tested in each meta-analysis is presented in Table 5. The plus and minus signs in Table 5 refer to the direction of the marginal effect of each variable tested in the meta-analysis and the asterixes to the statistical significance level of the effect. A blank cell implies that the relevant variable was not tested in the particular meta-analysis study.

Table 4. *Existing meta-analyses of forest valuation studies*

	Bateman and Jones (2003)	***Lindhjem (2007)***	***Zanderson and Tol (2009)***	***Barrio and Loureiro (2010)***	***Ojea et al. (2010)***
Focus	Woodland recreation	Non-timber benefits	Forest recreation	Forest values	Forest values
Scale	UK	Scandinavia	9 EU countries	World	World
Number of studies	30	28	26	35	65
Valuation method(s)	CV, TC	CV, CE	TC	CV	Mix
No. of value estimates	44	72	166	101	172
Explanatory power (R2)	0.643	0.815	0.851	0.896	0.617

All meta-analyses have a high explanatory power varying between 60 and 90 percent. Bateman and Jones (2003) and Zanderson and Tol (2009) both focus on forest (open access) recreation values. The three other meta-analyses focus on forest values more generally (Lindhjem (2007) on non-timber benefits). Barrio and Loureiro (2010) and Ojea et al. (2010) explicitly distinguish between different ecosystem services in their analysis. The former control for wooduse and recreation, while the latter distinguish between the Millenium Ecosystem Assessment (2005) ecosystem services: cultural services, provisioning services, regulating services and a mix of the three. Only recreation is statistically significant in Barrio and Loureiro and has a positive effect on stated WTP. Commercial wooduse does not have a significant effect. However, it is not clear what exactly the baseline category is in their study. In Ojea et al. regulating services are the baseline category and only those studies that focus on a mix of services appear to have a significant positive effect on forest values. No significant differences are detected between single category ecosystem services.

Table 5. *Overview effects of variables tested in existing meta-analyses of forest valuation studies*

Study characteristic	***Variable***	***Bateman and Jones (2003)***		***Lindhjem (2007)***		***Zanderson and Tol (2009)***		***Barrio and Loureiro (2010)***		***Ojea et al. (2010)***	
	Constant	+	***	+	**	+	***				
Location	Sweden			+	**						
	Finland			+	*						
	Scandinavia							ns			
	Europe							-	***		
	USA							ns			
	Other countries							ns			
	Latitude					ns					
	Urban			ns				ns			
	Open land					+	***				
Year	Study year			+	**	ns					
	Publication year									ns	
	<1995							ns			
	1996-2002							+	*		
Forest characteristics	Old growth							ns			
	Rainforest							+	***		
	Other forest types							+	***		
	Boreal									ns	
	Temperate coniferous									+	*
	Temperate mix not coniferous									ns	
	Tropical wet									ns	
	Tropical dry									ns	
	Forest size			ns		-	***	ns		-	***
	Size squared					-	*				
	Area size not mentioned			+	**						

ns not significant; * significant at 10%; ** significant at 5%; *** significant at 1%

Study characteristic	*Variable*	***Bateman and Jones (2003)***		***Lindhjem (2007)***		***Zanderson and Tol (2009)***		***Barrio and Loureiro (2010)***		***Ojea et al. (2010)***	
Forest characteristics continued											
	Forest size in country							-	***		
	Share national productive land			ns							
	Share national land			ns							
	Local good			ns							
	Regional good			+	*						
	Hotspot (protected area)									ns	
Ecosystem services	Wood use							ns			
	Recreation							+	***		
	Cultural									ns	
	Provisioning									ns	
	Mix cultural-provis.-regulating									+	***
Biodiversity	Flora							ns		ns	
	Fauna							ns		+	*
	Flora and fauna							ns			
	Species diversity					ns					
	Age diversity					+	***				
Management practices	More cautious			ns							
	Mix of practices			ns							
Value types	Use			ns							
	Use and option	+	***								
	Avoid loss			+	*			-	*		
	Gain change							ns			
	No change							ns			
Economic instruments	Payment mode										
	Voluntary donation			+	***						
	Recreational use payment			ns							
Population characteristics	GDP/capita					-	***	+	***		
	GDP									ns	
	Population density					+	***			+	**

ns not significant; * significant at 10%; ** significant at 5%; *** significant at 1%

Study characteristic	Variable	Bateman and Jones (2003)		Lindhjem (2007)		Zanderson and Tol (2009)		Barrio and Loureiro (2010)		Ojea et al. (2010)	
Methodology											
Valuation method	Market prices									ns	
	Revealed preferences									ns	
	Other valuation									ns	
	Choice experiments			ns							
	Actual payment					-	***				
Travel costs	Average distance					+	***				
	Cost/km					+	***				
	Opportunity cost time					+	**				
	Expenditures					ns					
	Holiday					ns					
Survey method	Personal interviews							ns			
	Mail survey			-	***[∫]			+	***		
	Other survey							ns			
	Sample size							ns			
CV elicitation format	Open ended	-	**	ns				+	**		
	Payment card	ns[∫∫]		ns							
	Dichotomous choice							+	***		
	Iterative bidding	ns									
Payment unit	Individual			+	***			-	***		
Payment frequency	One-time			ns[∫∫∫]				ns			
	Annual permanent							+	**		
	Annual temporary							ns			
Publication effects	Published paper			ns							
	Thesis			-	***	-	***				
	Author effects	+	***			+	***				

ns not significant; * significant at 10%; ** significant at 5%; *** significant at 1%

∫ In combination with response rates and season survey.

∫∫ Payment card with high range values appeared to inflate WTP at 10% level.

∫∫∫ Payment mode was mixed up with payment frequency. The latter had no significant effect.

Species composition has been shown to have a positive impact on the recreational choice of forests by increasing the popularity in forests with a higher diversity of species compared to forests with lower diversity (e.g. Scarpa et al. 2000). Zanderson and Tol (2009) show that in recreational studies, visitors more generally prefer open forests with diverse tree age stands and smaller rather than larger sites. However, they are unable to detect a significant effect for the diversity of tree species, measured through the Shannon index[1]. Similar sensitivity to scope effects where marginal WTP decreases as the size of a forest increases are found in Ojea et al. (2010). Lindhjem (2007) includes a dummy in his analysis if forest size is not mentioned in a valuation study. This appears to significantly inflate stated WTP.

Like Zanderson and Tol (2009), also Barrio and Loureiro and Ojea et al. include biodiversity indicators in their analysis. Barrio and Loureiro (2010) include dummy variables in the analysis if the valuation study focused on either flora or fauna and a separate dummy variable labeled 'biodiversity' if the study valued both flora and fauna. Ojea et al. (2010) also include dummy variables for flora and fauna separately, but use different background indicators for flora and fauna, one based on the IUCN Listed Species (absolute biodiversity indices of flora and fauna) and one based on the IUCN Red Species (relative biodiversity indices of flora and fauna). Only the listed species indicator for fauna yields a positive significant effect. The model that included the Red Species indicators only has a significant effect for flora, but this effect is negative. Because the listed species indicator yields a better statistical fit, this indicator is used in an extended model including interaction terms with ecosystem services. This reduced the significance level of the positive fauna indicator from 5% to 10% and produced a significant positive interaction between the flora indicator and provisioning services at the 10% level. None of the other interaction terms are significant. The interpretation of this positive interaction term could be that a higher plant species abundance level is related to higher forest economic values from provisioning services, including timber and non-timber forest products.

Only Barrio and Loureiro and Ojea et al. control for the type of forest in their analysis. Barrio and Loureiro find a significant positive effect of rainforest compared to coniferous forest on WTP values, but not for old growth. Ojea et al. on the other hand find a significant positive effect of temperate coniferous forests on values compared to Mediterranean forest. Tropical forest is only significant at the 10% level in their reduced model excluding interaction terms between the biodiversity indicators and ecosystem services. However, due to the use of different baseline categories, the results between the two meta-analyses are also here not directly comparable. If the forest is located in an urban area, this does not seem to have any effect as demonstrated in Barrio and Loureiro and Lindhjem, neither are protected areas (hotspots) significant in Ojea et al. (2010).

A remarkable and at the same time worrying finding is that despite the use of a wide variety of different valuation methods, measuring different types of use and nonuse values, Ojea et al. do not find a significant effect between valuation methods. Also Lindhjem does not find a significant effect between CV and CE. The application of different types of economic instruments, generally referred to as payment vehicles in the stated preference literature, has only been tested in one study (Lindhjem(2007)). If visitors are asked for a voluntary donation, this has a significant positive effect on stated WTP. This outcome differs from the findings in Brouwer et al. (1997) who show that an increase in annual income tax where everybody pays significantly increases WTP. Although in line with common practices in wildlife conservation, voluntary payments tend to increase protest rates for public environmental goods, partly due to concerns of free riding (Brouwer and Slangen, 1998). Contrary to Barrio and Loureiro (2010),

[1] The Shannon index of diversity takes into account the richness and evenness of species distribution. The higher the index, the more rich and evenly distributed the species classes. Also age diversity can be measured with the Shannon index and this appears to have a significant impact on recreational forest values in Zanderson and Tol (2009).

Lindhjem finds no effect of the payment frequency on stated WTP (annual or one-time-off). The former show that if payments are annual and permanent, this too has a significant positive effect on stated WTP in CV studies.

Finally, there are a number of results in one analysis, which are contradicted or show the opposite sign in another. This includes, for example, the impact of GDP per capita, which is expected to have a positive effect on travel behavior and stated WTP, but is only significant and positive in Barrio and Loureiro, not in Ojea et al. and negative in Zanderson and Tol. On the other hand, Barrio and Loureiro find a positive effect on stated WTP if an open-ended elicitation format was used, which goes against common findings in the CV literature that open-ended WTP values generally produce significantly lower values. If a respondents answers the WTP questions in a stated preference survey as an individual instead of on behalf of his entire household, this has - as expected - a significant negative impact on WTP in Barrio and Loureiro, but a positive effect in Lindhjem.

6 Meta-analysis

6.1 Qualitative description of reviewed studies

There has been considerable literature regarding the valuation of non use and passive use values of forests since a large part of the values people place in forests are linked to existence and bequest values as well as benefits on the global scale such as CO2 sequestration or climate regulation (see Tables 6 and 7 for summaries of selected studies). Horton et al. (2003) seeks to establish WTP values for the non use aspects of forest preservation related to existence values. The study determines WTP of respondents in the United Kingdom and Italy for biodiversity preservation of 5% and 20% of the Amazon tropical rainforest in Brazil by means of a payment card format. The reported household annual WTP was $45 per year for 5% protection and $60 for 20%. A similar attempt to assess non use values for tropical rainforest preservation was done by Baranzini et al. (2010) by surveying a group of individuals in Geneva to determine awareness of tropical deforestation and preference for a payment vehicle. Respondents stated that the primary value of tropical forests was the ability to sequester carbon, followed by biodiversity and use values of local indigenous people. The authors found that the stated WTP is approximately 24% higher for a tax payment vehicle compared to a voluntary payment, that stated WTP values were higher when associated with biodiversity conservation and that education and income have a positive influence on WTP (Baranzini et al, 2010). Kramer and Mercer (1997) also do a similar assessment of non use or passive use values by conducting a survey of US respondents to determine WTP for tropical forest conservation by use of a referendum and payment card survey elicitation format. Results were an average mean of $24 and $31 per household respectively as a one-time payment to a hypothetical United Nations 'Save the Rainforests' Fund. A low percentage of respondents had visited or planned to visit a tropical forest however, two thirds of the sample stated that industrialized countries should help to pay for tropical forest conservation.

Table 6. *Summary of Valuation Methods*

Method of Valuation	***Studies***
Single species	Reaves et al. (1999) Loomis & Eckstrand (1996)
Recreational use	Bostedt/Mattsson (2006), Scarpa et al. (2000), Shultz et al. (1998), Tyrvainen& Vaananen (1997)
Forest conservation (recreational and biodiversity)	Echeverria et al. (1994), Amirnejad et al. (2006), Walsh et al. (1984), Sattout et al. (2006), Knivila et al. (2002), Kramer et al. (1995), Lockwood et al. (1993), Loomis et al. (1996)
Biodiversity enhancement	Christie et al. (2006), Macmillan et al. (1996)
Biodiversity conservation (habitat protection)	Garcia et al. (2009), Boman et al. (2007), Veisten et al. (2004), Turpie (2003)
Non use values	Baranzini et al. (2010), Horton et al. (2003), Kramer & Mercer (1997), Gurluk (2006)

In addition to forest nonuse valuation surveys, there are a growing number of general biodiversity valuation studies such as Garcia et al. 2009, Veisten et al. (2004) and Bo-man et al. (2007). See Table 6 to summarize the methods of valuation used in the se-lected CVM studies. The maintenance of biodiversity in French forests is valued by Garcia et al. (2009) through a DC and OE survey elicitation format and further dividing respondents into forest visitors and non-visitors to estimate WTP. In the survey respon-dents are told that there are a certain number of flora and fauna that are threatened, rare or vulnerable. The survey does not identify endangered species or a particular biodiver-sity enhancement project, but rather refers to biodiversity in relation to protection of national heritage. The authors define biodiversity as 'general loss of flora and fauna of French forests' and conduct the study by means of a telephone survey to a large number of French households. Of the 1,815 observations available, 743 were classified as protest bids and thus removed. While removal of protest bids is a common practice in CVM, removal of a significant proportion of observations can greatly impact results and lead to a potential upward bias. The authors correct for sample selection bias related to forest visitors and non-visitors as well as those willing and unwilling to pay for biodiversity conservation. The WTP results were higher for forest visitors compared to non visitors and also higher for DC compared to OE WTP format.

There remains a significant difference between biodiversity valuation (eg ecological concepts such as rarity or biodiversity enhancement programs) and valuation of biological resources that contribute to overall biodiversity in an ecosystem, however few studies differentiate these two concepts resulting in potential ambiguity or use of the terms interchangeably (Nunes and van den Bergh, 2001). There are a variety of studies that value biological resources by means of one endangered species such as Loomis & Eckstrand (1996) who valued the Mexican spotted owl and Reaves et al. (1998) who valued habitat restoration of the red cockaded woodpecker. There are also biodiversity studies that value preservation of endangered species in an area such as Veisten et al. (2004) or habitat preservation as a means to conserve biodiversity such as Boman et al. (2007) and Garcia et al. (2009). The main aim of the selected CVM studies is to investigate the an individual's or household WTP and thus desire to help finance the preservation of forest habitat whether it occurs as a result of one species, recreational fees or resultant of a desire to conserve forest biodiversity in general. Nevertheless, valuation of a single species and biodiversity as a whole is imperative to raise public awareness as well as initiate funding opportunities for habitat and biodiversity conservation.

The value of potential biodiversity loss in Swedish forests is conducted by Boman et al. (2007) by means of a 'green' indicator to represent forest land protection. In this study, respondents are asked to consider a monthly tax for the following ten years to achieve a range of environmental goals; they are presented with a bid vector and asked to assign a level of uncertainty to each bid amount. A sub sample of respondents is asked if and how much of the monthly tax should be used to protect biodiversity. The authors employ a double bounded DC format to account for respondent uncertainty using definitely yes, probably yes, uncertain, probably no and definitely no to represent respondent uncertainty. Probabilities are assigned with 'definitely yes' and 'definitely no' not always equal to 0 and 1 respectively. These assigned probabilities can have a potentially large impact on WTP results as Boman et al. (2007) illustrate by altering assigned probabilities, resulting in mean WTP results roughly four times the original mean WTP result. Thus methods for managing variables such as uncertainty in CV studies can significantly affect empirical results and should be evaluated to identify possible upward bias in methodologies employed.

A sequencing effect is used to value a general biodiversity package defined as "preservation of all endangered species in Norwegian forests" by Veisten et al (2004). A sequencing effect implies that the value of an item is smaller when offered late in a sequence of items than when it is offered first or alone. The survey stated that "most of the several hundred endangered species are found among insects, fungi, lichen and mosses. About 25 flower-plant species are vulnerable, and among birds about 10 species are considered vulnerable." The aim of the project was to ensure 'certain survival' of endangered species through changes in forest management and additional designation of protected areas. There were four sub samples; one sub-sample valued the biodiversity package directly. Two sub-samples first valued subsets of the composite good protection of endangered crytograms (fungi, lichen, moss), and white woodpecker in addition to crytograms, followed by the entire package. A fourth sub-sample was completed by a dividing-out sequencing initially valuing a more inclusive package of environmental tasks including reduction of water pollution, garbage, noise nuisance, coastal contamination and air pollution, followed by the general biodiversity package. As expected by economic theory, a sequencing effect was observed; the subset goods obtained higher values earlier in a sequence, and the dividing-out approach decreased the stated value for the composite good.

A Choice experiment and CVM study to value biodiversity enhancement as well as avoided development in the United Kingdom was conducted by Christie et al. (2006). The authors identified four main attributes or concepts that were used in explaining biodiversity to the public by way of a PowerPoint presentation. These attributes included familiar wildlife species, rare and endangered species, habitat quality including flagship, keystone and umbrella species, and ecosystem processes. Biodiversity was defined as 'the scientific term used to describe the variety of wildlife in the countryside'. The Choice experiment contained two policy levels and a third 'do nothing' scenario where species continue to decline and no additional action to protect biodiversity is taken. The first policy level protects rare familiar species, slows the decline of rare unfamiliar species and restores ES that directly affect human welfare, while the second protects rare familiar and common species, ensures recovery of endangered species and restores all ES, not simply those enjoyed directly by humans.

The CVM study conducted by Christie et al. (2006) employs the same attributes to represent biodiversity as the Choice experimentand includes an agri-environment, a habitat re-creation and an avoided development of farmland scheme to value biodiversity. The agri-environmental scheme reduces application of pesticides and includes biodiversity benefits such as increased diversity of plants, insects, small mammals and birds, some of which may be rare. The habitat re-creation scheme would enhance biodiversity by creating new wetlands on existing farmland for a wide range of plants, insects, small mammals and birds, including a number of rare species. The third scheme aims to avoid biodiversity loss as a result of housing development on farmland. The types of biodiversity protected under this policy are similar to the agri-environmental scheme described above. The results of this study concluded an average WTP ranging from 75-109 in 2009 USD for the biodiversity enhancement programs. Although the high level of detail present in this study allows for greater understanding of biodiversity as well as proposed enhancements, there lies a risk of confusing respondents by providing too much information at once or engaging in time consuming methods that could leave respondents uninterested or unwilling to participate.

A study valuing biodiversity loss in Scottish forests as a result of acid rain, the cost of abatement and ecological restoration was done by Macmillan et al (1996). The study was done by means of illustrated species boxes that were designed to give respondents a clear picture of species composition and population levels to represent past damage and future recovery. As damage levels increased, species diversity, health and overall numbers decrease allowing respondents to visually interpret and view biodiversity loss during specified time periods. Respondents receive one of fifteen scenarios so they are not able to evaluate additional damage or recovery scenarios. In addition, the use of 'species boxes' to represent biodiversity loss is unable to identify the exact level of damage, thus respondents are left to interpret species loss through visual images rather than numerical values. The results of a CVM study are prone to certain bias and can thus result in a wide range of WTP values. In an OE pilot study, the WTP results were roughly 4 times less than WTP results from the DC survey. This is suggesting a possible yea-saying approach in respondents indicating an upward bias in WTP results derived from the DC format. This finding is confirmed by other studies such as Reaves et al. (1999) and Garcia et al. (2009) and is a subject of continued debate as the survey elicitation format and other survey design features are discussed and improved over time.

***Table 7**. Summary of Selected CVM Studies*

Authors (Year published)	***Payment Vehicle***	***Survey Elicitation Format***	***Forest Type***
Amirnejad et al (2006)	Income tax	DBDC	Subtropical
Baranzini et al (2010)	Voluntary payment, income tax	PC	Tropical
Boman et al (2007)	Income tax	DBDC	Boreal
Bostedt/Mattsson (2006)	User fee	SBDC	Boreal
Christie et al (2006)	Income tax	PC	Temperate
Echeverria et al (1994)	Voluntary payment	SBDC	Tropical
Garcia et al (2009)	No payment vehicle	SBDC, OE	Temperate
Gurluk (2006)	Voluntary payment	OE	Temperate
Horton et al (2003)	Income tax	PC	Tropical
Kramer et al (1995)	User fee	SBDC	Tropical
Kramer & Mercer (1997)	Trust fund	PC, DBDC	Tropical
Knivila et al (2002)	Income tax	DBDC	Boreal
Lockwood et al (1993)	Trust fund	SBDC	Subtropical
Loomis et al (1996)	Income tax	SBDC, OE	Temperate
Loomis & Eckstrand (1998)	Trust fund	SBDC	Temperate
Macmillan et al (1996)	Resource use tax	SBDC	Temperate
Reaves et al (1999)	Trust fund	OE, PC, DBDC	Temperate
Sattout et al (2006)	Municipal tax	OE	Subtropical
Scarpa et al (2000)	User fee	DBDC	Temperate
Shultz et al (1998)	User fee	SBDC	Tropical
Tyrvainen& Vaananen (1997)	User fee, Municipal tax	PC	Boreal
Turpie et al (2003)	Voluntary contribution, resource use tax	OE, DBDC	Subtropical
Veisten et al (2004)	Resource use tax	OE	Boreal
Walsh et al (1984)	Trust fund	OE	Temperate

The value of biodiversity conservation in South Africa's Cape Floristic Region is valued by Turpie (2003) through comparison of 'normal threats' to biodiversity and loss associated with climate change. Turpie (2003) initially values biodiversity as a whole and further asks respondents to react to predicted losses related to climate change. Respondents are initially asked for WTP for biodiversity conservation in South Africa as a whole to protect natural heritage. Following the initial WTP question, respondents are asked if they were in favour of a policy that increases energy costs to mitigate climate change, avoid vegetation loss and desertification. If the response is positive, respondents are presented a series of payment options that increase electricity or petrol prices by a specified amount which corresponds to a certain level of avoided biodiversity loss. The most costly option would hypothetically prevent any loss; the intermediate option was always half the cost of full prevention and no payment corresponded to a loss defined in a country wide study of potential biodiversity loss as a result of climate change. If both presented options were higher than respondent's WTP, an open ended question was asked as follow up. Respondents were also asked a series of questions regarding their interest in nature, familiarity with the fynbos region, ability to recognize species, experience in major protected areas and reaction to predicted vegetation loss. Although biodiversity loss as a result of climate change is a likely scenario this method is subject to starting point bias as well as embedding effect as a result of the WTP question format.

An extensive number of CVM surveys have been conducted in the USA as it was the first government to approve the use as an accurate valuation tool of nonuse or passive use values that could be used to support legal claims (NOAA, 1993). Loomis et al (1996) values the protection of old growth forests in the Pacific Northwest from fires through additional response and fire management strategies while Walsh values the designation of additional wilderness areas in Colorado, USA. Although CVM studies are less prevalent in developing countries, Amirnejad (2006) measures the existence value of Northern Iranian forests adjacent to the Caspian Sea in the face of high deforestation rates in the country, at the same time as Sattout et al. (2006) present a similar problem of minimal funding and loss of Cedar forests in Lebanon. These types of valuation studies are less specific in the hypothetical improvements or avoidance of loss presented in the CVM study and seeks to place an overall value for forest preservation. For this reason it can be difficult to disentangle the type of ecosystem service being valued as forest preservation or impending loss is presented in general rather than specific program details as some CVM studies include.

It is clear that CVM studies value diverse environmental goods that are not always directly comparable. Moreover, there are a variety of factors that can affect stated WTP in studies including the ecosystem good or service being valued, socio-economic characteristics of the population beneficiaries as well as survey design and implementation. Studies that value wildlife and habitat conservation rely upon the specific habitat or species being considered, whether it is unique or known to the public can greatly affect respondents WTP (Jacobsen and Hanley 2008). In addition, endangered, rare or charismatic species as well as the size of hypothetical change in habitat or species preservation can make a difference in respondent’s interest and influence the WTP (Chrisite et al, 2006). There is also variation among survey formats such as dichotomous choice or payment cards as found in Reaves et al. (1999) who value restoration of the red-cockaded woodpecker (an endangered species) habitat following a natural disaster. Finally differences in WTP values can be a result of non-income related factors in population beneficiaries such as urban versus rural location in Sattout et al. (2006) who value Cedar forest of Lebanon and separates village from city dwellers or Turpie (2003) who separates ethnic groups to evaluate WTP for biodiversity conservation in South Africa and vegetation loss due to climate change. The quality of primary valuation studies including the potential pitfalls related to CVM design and implementation greatly affect the quality and accuracy of meta-analysis results and are thus a crucial aspect performing reliable meta-analyses.

6.2 Quantitative description of reviewed studies

6.2.1 Database

To perform meta-analysis a database was compiled of the CVM studies discussed above. The database was created through literature review of the selected CVM studies as well as additional literature to provide missing information not reported in the primary articles. Articles were obtained through Science Direct, the journal Ecological Economics and the Environmental Valuation Reference Inventory (EVRI) database, the Vrije University online library database and Google scholar. A total of 95 observations were obtained from 29 studies, however several were deleted due to a lack of complete information resulting in a total of 84 observations from 24 studies. The mean number of observations per paper was 3.5 with the most (19) coming from Scarpa et al. (2000) and several studies contributing one observation. The majority of studies included in the meta-analysis originate from Europe (25%) followed by the USA (17%), Scandinavia (17%), and other countries (21%) (see Table 8). Most of the required information was available through use of additional secondary sources including journal articles published on the same

CVM study. General information was organized in Microsoft excel regarding bibliographical information, site and study characteristics, survey methods, and ecosystem services were categorized. Particular attention was paid to survey elicitation method, payment vehicle, payment frequency, and ecosystem services.

After initial information was categorized from the selected 24 articles, and forest types included, the database was supplemented with information from various secondary sources including UN FAO, World Bank economic indicators as well as OECD stat extracts. Once the characteristics of the studies were organized in excel, the data was standardized and incorporated into dummy variables to represent ecosystem services, forest type, survey elicitation format, payment vehicle, payment frequency, welfare change, surveys conducted in person, and to differentiate individual and household payments. See Table 8 for a description of the studies used in the meta-analysis, the year of study and ecosystem service or environmental good valued in the study.

All monetary values are converted to 2009 US dollars adjusting for inflation by calculating GDP deflator values for each country based on the year of the study. Once values were inflated to current 2009 figures, they were furthermore converted to USD by using Purchasing Power Parity (PPP) rates (for GDP) to account for purchasing power discrepancies among currencies. Rates for PPP were obtained from OECD Stat Extracts and GDP deflator[2] (% annual change) values were obtained from the World Bank. The PPP[3] exchange rate is used because it is relatively stable over time and equalizes the value of comparable market baskets of goods and services between two countries. The Purchasing Power Parity rate is defined as “the exchange rate at which the currency of one country would have to be converted into that of another country to buy the same amount of goods and services in each country” (IMF, 2007) The PPP conversion method has become the standard method used by the World Bank and others in making cross-country comparisons and is thus used in this study to facilitate comparison of WTP values that originate from a variety of countries worldwide.

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[2] The GDP deflator (implicit price deflator for GDP) is inflation measured by the annual growth rate of the GDP implicit deflator, shows the rate of price change in the economy as a whole. The GDP implicit deflator is the ratio of GDP in current local currency to GDP in constant local currency (World Bank, 2011)

[3] PPP rates are relatively stable over time compared to market exchange rates therefore using PPP exchange rates to convert economic data to a common currency is the preferred way to make international comparisons. International rankings can vary significantly between data converted using actual rather than PPP exchange rates. This is because the variance found among different countries is accounted for. This is why PPP conversions are the preferred method when comparing values internationally (IMF, 2007)

Table 8 *Summary of Valuation Studies included in meta-analysis*

Author	***Year of study***	***Country of Study***	***Valuation Good***	***No of observ ations***
Amirnejad et al	2004	Iran	Forest conservation of Iranian forests	1
Baranzini et al	2007	Switzerland	CO2 sequestration, biodiversity in tropical rainforests	2
Boman et al	2002	Sweden	Forest preservation	1
Bostedt/Mattsson	1992	Sweden	Enhanced recreation	1
Christie et al	2004	England	Enhanced biodiversity of UK farmland	7
Echeverria et al	1991	Costa Rica	Preservation of cloud forest, avoided agricultural land use conversion	2
Garcia et al	2002	France	Biodiversity conservation in French forests	4
Gurluk	2005	Turkey	Preservation of Ecosystem Services in Misi Forest	1
Horton et al	2000	United Kingdom, Italy	Preservation of Brazil, Amazonia	2
Kramer et al	1991	Madagascar	Establishment of new National Park with twice the amount of lemurs and birds	1
Kramer & Mercer	1992	USA	Tropical Rainforest Preservation	2
Knivila et al	2000	Finland	Forest conservation network Illomantsi	1
Lockwood et al	1991	Australia	Reserve unprotected forests in national parks	2
Loomis et al	1996	USA	Protect old growth forest from fires	2
Loomis & Eckstrand	1996	USA	Mexican Spotted Owl and habitat preservation	1
Macmillan et al	1995	Scotland	Acid rain abatement and restoration of biodiversity	2
Reaves et al	1992	USA	Red cockaded woodpecker habitat restoration	3
Sattout et al	2002	Lebanon	Preservation and restoration of Cedar forests	1
Scarpa et al	1992	Ireland	Single use visits to forest area with newly constructed nature reserve	19
Shultz et al	1995	Costa Rica	Recreational use, park services and infrastructure improvement	4
Tyrvainen& Vaananen	1995	Finland	Preservation of Urban forests and recreational use	9
Turpie et al	2000	South Africa	Nature conservation and biodiversity of South Africa	4
Veisten et al	1992	Norway	Preservation of endangered species in Norwegian forests	8
Walsh et al	1980	USA	Wildlife and Forest Preservation Colorado	4

Upon completion of the database, the data was standardized, and dummy variables created to perform multivariate analysis by linear regression. The data for payment vehicle, survey elicitation format, forest type, payment frequency and welfare effect was organized using numeric scales to separate groups and allow for univariate analysis through Kruskal Wallis and Mann-Whitney non-parametric tests. Ecosystem services are included as dummy variables and classified according to the good being valued and theoretically enjoyed by beneficiaries either through use or nonuse. This can often be a difficult part of analysis as many studies value a composite package of environmental goods such as forest preservation and it is difficult to separate a specific ecosystem service that the survey elicits a WTP value for. The most frequently valued ecosystem services included in the meta-analysis are recreational and biodiversity services followed by aesthetic, cultural, CO2 sequestration and restoration or enhancement of supporting services. Forest types were classified to represent tropical, subtropical, temperate and boreal forest biomes.

The payment vehicle was organized into six categories for trust fund, income tax, municipal tax, environmental resource use tax, user fees and voluntary contributions. Environmental resource use tax represent those studies which use higher prices on petrol, electricity and wood products, while municipal taxes include higher municipal, water rates and a local tax initiative to fund land purchases from private developers. There are also a number of studies that select use of an income tax that is paid to fund international efforts or country wide environmental initiatives. Voluntary contributions were paid to various nature and forest conservation agencies or private non-profits while trust funds were both hypothetical UN trust funds as well as existing national trust funds to protect national heritage or a particular endangered species such as the Mexican Spotted Owl.

The payment frequency was separated into annual and one time payments with further distinction between individual and household payments. Household payments were converted to individual payments by dividing the WTP by average household size in the survey. For studies that did not report an average household size, census information was used to supplement the data for Loomis et al. (1998), Veisten et al. (2004), Walsh et al. (1984), Horton et al. (2000) and Loomis et al. (1996). There were two studies that did not specify a payment vehicle, one was left undefined and the other allowed respondents to select the most credible payment vehicle given the study characteristics, political and social circumstances. One of these studies (Garcia et al, 2009) was included in the final meta-analysis. A welfare change was incorporated into the study to represent programs with scenarios for avoided loss or improvements to ecosystem service functions. Literature suggests that people tend to value losses higher than equally sized gains (Lindhjem, 2006). This variable is expected to be a positive parameter for the analysis.

A variable *inperson* was included to represent surveys which employed face to face interviews to collect WTP data and those that used telephone or mailed surveys. It is expected that in person surveys deliver higher WTP values since respondents maybe less likely to refuse environmental protection in person and interviewers are better able to explain difficult environmental concepts and scenarios. Supplementation of the database with additional economic and social data including GDP per capita from which the sample was drawn from the year of the study was done to facilitate statistical analysis and assess reasons for variation in WTP. Additional variables were also included for the amount of forested area per capita in the year 2000 and percent of forest area in the country also in the year 2000. These variables were created with data from FAO (2003) and are used in the meta-analysis to represent scarcity of the forest resource being valued. Variables were also included to represent the region of study to possibly capture income effects of the studies that are not captured by GDP per capita and to represent further characteristics of the population beneficiaries.

6.2.2 Meta-model

To analyze variation in willingness to pay figures an ordinary least square (OLS) regression is used with three groups of variables. The dependent variable in the meta-regression equation is a vector of WTP values, labeled as y. Following Barrio and Loureiro (2010) the explanatory variables are grouped into three categories that include the forest's ecosystem services and program characteristics in Xg, the study's characteristics in Xs, and population beneficiaries’ socio-economic characteristics in Xp. The estimation model corresponds with the following equation:

$$\mathbf{Yi = \alpha + (\beta giXgi) + (\beta siXsi) + (\beta piXpi) + \varepsilon i;}$$

Where α is the usual constant term, the β vectors contain the coefficients associated with the respective explanatory variables to be estimated, and ε is a vector of independently and identically distributed (i.i.d.) residuals. Subscript i is used to denote the variable study. Correlation tests were run to identify variables with a high degree of correlation that were not suitable to include in a linear regression at the same time. As ecosystem services and forest type are highly correlated in this study, the use of two models are employed; one to represent the former and a second to represent the latter. See Table 9 for the groups of variables included in the meta-analysis that are expected to predict WTP values in this study.

WTP= {Goods & Services of forests} + {Study characteristics} + {Population beneficiaries}

***Table 9** Meta-analysis Independent Variables*

Vector	*Variable*	*Classification*
Ecosystem Goods and Services	Ecosystem Service	Biodiversity, Recreation, Restoration of Supporting Services, Aesthetic, CO2 sequestration
	Forest Type	Tropical, subtropical, temperate, boreal
	Welfare effect	Avoid loss, improve ecosystem services
	% forested area 2000	Source:FAO
Study Characteristics	Payment Vehicle	Tax increase, voluntary payment, trust fund, user fee
	Payment frequency	Individual annual or one time payments
	Survey elicitation format	Dichotomous Choice, Open Ended, Payment Card, Double Bounded Dichotomous Choice
	Survey Method	in person, other
	Year of Study	
Population Beneficiaries	GDP per capita (year of study)	Source: World Bank
	Amount forested area per capita 2000	Source: FAO, 2003
	Country of Origin	

6.2.3 Results

A total of 84 observations included in the meta-analysis yielded an average mean individual WTP value of $107 in 2009 US dollars. Mean WTP values were calculated for a number of possible explanatory variables including 1) forest type, 2) payment vehicle, 3) survey elicitation format, 4) payment frequency and 5) welfare change. Statistically significant variables were found in payment vehicle, payment frequency, forest type and welfare change at the 5% significance level (see Tables 10 and 11). The majority of the selected studies use entrance fees as the payment vehicle, followed by income taxes, resource use tax, trust funds, voluntary payments and lastly municipal taxes. Voluntary payments resulted in the highest WTP values followed by resource use tax, municipal tax, user fee, income tax and lastly payments to a trust fund (See Table 10). This result was not expected as respondents at times protest to voluntary payments due to issues regarding free riders resulting in problems where part of the beneficiaries are thus less likely to pay for such programs. Tropical forests yielded the highest WTP values followed by boreal, urban, temperate and lastly subtropical forests. This result is consistent with previous studies such as Barrio and Loureiro (2010) and Costanza et al. (1997) who both find higher values for forests in tropical regions. This result is further supported through finding of the Kramer & Mercer (1997), Horton et al. (2003) and Baranzini et al. (2010) studies where survey respondents stated they were generally aware of the contribution to biodiversity maintenance and CO2 sequestration of tropical rainforests. The survey respondents also expressed that developed countries contribute financially to help finance avoided deforestation in developing countries through international funds and to fulfill commitments of the Kyoto protocol.

The results of forest valuation studies play a critical role in the establishment of PES and REDD+ programs as they generate baseline values to address opportunity costs of development and compensate landowners. Moreover there is an emerging role for meta-analysis and benefit transfer to facilitate economic analysis of projects that cannot conduct primary valuation studies. Below is a histogram (see Figure 2) for WTP values showing the frequency and distribution of values. It shows the wide range of values and that the majority of the WTP amounts are between 0-200 USD.

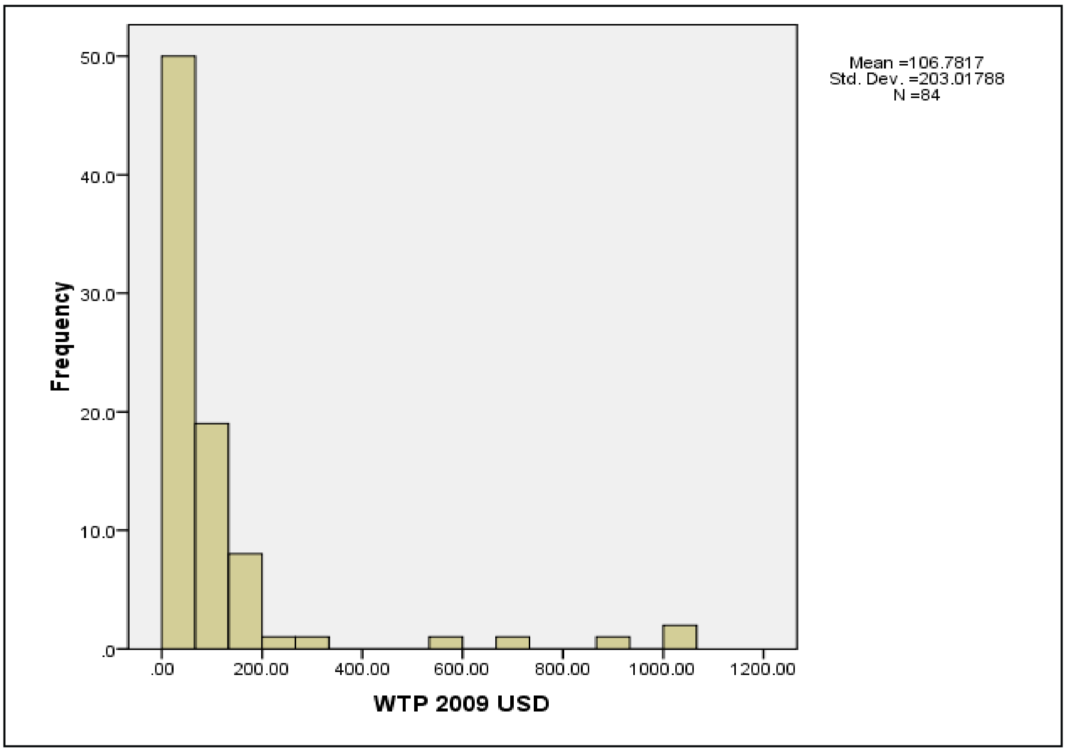

***Figure 2**. Frequency distribution of WTP values*

The mean average WTP by survey elicitation format yielded the highest WTP values for single bounded DC WTP questions followed by PC format, OE and lastly double bounded DC format (see Table 11 for values). The results for double bounded DC formats were lower than expected most likely due to the inclusion of values from Scarpa et al. (2000) that include a number of entrance fees for forested areas with relatively low WTP values. These mean average results by survey elicitation format are consistent with previous meta-analysis that also found DC formats to yield higher WTP amounts than OE (Barrio & Loureiro, 2009; Jacobsen and Hanley, 2008; Lindjhem, 2006). Dichotomous choice survey results were found to be higher than open ended survey formats, by Reaves et al (1998) as they compared question formats when valuing the same composite good and found to be statistically significant in the meta-analysis done by Jacobsen-Hanley (2008).

The samples were divided roughly in half with regards to the specific welfare change (avoid loss or secure gain) as result of the proposed program. This variable was statistically significant in both the Kruskal Wallis and Mann Whitney non-parametric test at the 5% significance level. Values to avoid loss averaged \$135 while programs to secure gain or improve services averaged \$82. This is consistent with previous findings from Jacobsen and Hanley (2008) and Lindjhem (2006), though the variable in the latter study was not statistically significant. On the other hand, these results contradict the findings of Barrio and Loureiro (2010) who find higher WTP values in programs that improve ecosystem services. Findings are also consistent with the hypothesis of loss or risk aversion that people may be more motivated to avoid environmental losses than proposed gains. .

Table 10 *Summary of Welfare Change*

Welfare Change	***Studies***	***n***	***Average WTP in 2009 USD***
Avoid loss	Baranzini et al. (2010), Echeverria et al. (1994), Boman et al. (2007), Garcia et al. (2009), Boman et al. (2007), Veisten et al. (2004), Turpie (2003), Loomis & Eckstrand (1996), Tyrvainen& Vaananen (1997), Amirnejad et al. (2006), Walsh et al. (1984), Shultz et al. (1998)	39	$135
Improve Ecosystem Services	Christie et al. (2006), Macmillan et al. (1996), Bostedt/Mattsson (2006), Gurluk (2006), Horton et al. (2003), Kramer et al. (1995), Kramer & Mercer (1997), Loomis et al. (1996), Lockwood et al. (1993), Sattout et al. (2006), Reaves et al. (1999), Scarpa et al. (2000),	45	$82

Non-parametric tests for the univariate analysis were conducted and are summarized in the following tables. The results from Kruskal Wallis tests are statistically significant at the 0.05 level or below for forest type, survey elicitation format, payment vehicle, payment frequency and the welfare change of the proposed environmental program. A Kruskal Wallis test was not possible to conduct for ecosystem services due to the overlap of many services that are valued as a package, such as forest preservation in general. These variables will be included in the multivariate analysis in the next section as dummy variables are better suited for linear regression analysis. See Table 11 for average mean values by ecosystem service. It can be observed in Table 11 that biodiversity and recreation result in similar WTP values, while CO2 sequestration resulted in a lower average value. This is possibly due to the small sample size for this variable and that several of the studies that value tropical rainforests in this meta-analysis were conducted in the early 1990s when climate change and CO2 levels were less well known as environmental problems.

Table 11 *Mean WTP by Ecosystem Service*

Ecosystem Service	***WTP in 2009 USD***	***n***
Biodiversity	102.22	42
Other	111.34	42
Recreation	104.58	40
Other	109.20	44
CO2 sequestration	44.41	4
Other	109.90	80
Aesthetic	187.42	4
Other	102.75	84
Restoration of Supporting Services	300.91	6
Other	91.85	78

The results of this study yield relatively low WTP for income tax but higher values for resource use tax and voluntary payments. The use of taxation as a payment vehicle is recommended in the NOAA 1993 report (pg. 54), to reduce free rider problems, however the results of this meta-analysis indicate lower overall WTP for income tax which could be a result of protests to additional taxes. The use of user fees as a payment vehicle generates revenue based on actual use and does not contain the same free riding issues which are often observed with a voluntary payment vehicle. The results of this meta-analysis however indicate high values for voluntary payments and rather low values for mandatory income tax. The presence of these findings contradict those found by Barranzini et al (2010) who found that the use of a tax payment vehicle yielded 24% higher WTP values than voluntary payments. The results also show a higher WTP for user fees compared to income tax, though the sample size for income tax is significantly smaller.

***Table 12** Mann-Whitney Non-parametric tests*

	Mean WTP 2009 USD	***n***	***Mann Whitney U (sig)***
Payment Frequency			448.0 (0.000)
Annual	115.9	48	
One time	94.6	36	
Welfare Change			539.0 (0.003)
Avoid loss	135.2	39	
Improve ES	82.2	45	
Survey method			622.0 (0.053)
In person	94.6	52	
other	126.5	32	
Forest type			100.0 (0.013)
Subtropical	44.3	10	
Temperate	61.5	41	
Forest type			70.0 (0.027)
Tropical	241.7	13	
Boreal	143.2	20	

Statistically significant differences at the 5% level were found for forest type between temperate and subtropical, and tropical and boreal. The mean values followed expected trends for higher WTP values for tropical forest conservation; however these results may be partly due to highly inflated values derived from the studies in Madagascar and Costa Rica where values increased up to ten times following GDP inflation. These observations may also explain the high WTP values found for voluntary payments in the meta-analysis These observations affect results considerably and are responsible for causing high standard deviation in the tropical forest and voluntary payment samples. Additionally, one time payments are higher than annual payments when not including entrance fees. However, once entrance fees were included as one time payments, annual payment WTP amounts were greater than one time payments. It is generally observed that one time payments are larger than annual payments due to the discounted future flow of benefits, although the results of this meta-analysis do not indicate such a trend. The results of the Kruskal Wallis test are displayed in Table 13 below.

Table 13 *Kruskal Wallis Non-parametric test*

Variable	*Mean WTP (USD 2009)*	*Standard Error of Mean*	*Min*	*Max*	*n*	*Chi square-Sig*
Combined	106.78	22.2	2.2	1060.3	84	
Forest Type						37.8 (0.00)
Tropical	241.7	103.7	12.1	1060.3	13	
Subtropical	44.3	7.9	11.8	92.9	10	
Temperate	61.5	28.0	2.2	1039.9	41	
Boreal	143.2	13.2	59.6	275.0	20	
Payment Vehicle						26.0 (0.00)
Undefined	17.1	5.0	5.3	29.7	4	
Income Tax	67.0	9.0	11.8	130.3	15	
Municipal Tax	187.4	50.4	53.0	274.9	4	
Resource use tax	207.1	84.8	39.1	1039.9	12	
User fee	72.1	24.1	2.2	686.7	31	
Voluntary Payment	360.7	197.2	19.8	1060.3	6	
Trust Fund	21.9	4.4	11.7	54.1	12	
Survey Elicitation Format						47.1 (0.00)
Single Bounded Dichotomous Choice	305.5	98.9	5.3	1060.3	16	
Double Bounded Dichotomous Choice	14.1	5.1	2.2	104.5	25	
Payment Card	117.8	13.3	12.0	274.9	26	
Open Ended	39.1	7.8	11.7	103.1	17	
Payment Frequency						8.6 (0.03)
Annual payment	115.9	29.1	5.3	1039.9	48	
One-time payment	94.6	34.6	2.2	1060.3	36	
Welfare Change						
Avoid loss	135.2	33.9	5.3	1060.3	39	14.8 (0.00)
Gain change	82.2	29.0	2.2	1039.9	45	

The multivariate analysis was conducted by use of two linear regression models that used forest type (model 1) and ecosystem services (model 2) to identify the key determinants of WTP. Model 1 yielded a slightly lower adjusted R square (0.606) compared to model 2 (0.648), however, results are relatively consistent between both models. The estimated coefficients measure the percentage change in WTP, given a one unit change in the explanatory or predictor variable. Over 50% of the variation in WTP values can be explained by variables included in the linear regression for survey elicitation format, payment vehicle, payment frequency, welfare effect, % of forested area, year of original value, in person, country of study and either forest type (model 1) or ecosystem service (model 2). As mentioned above when introducing the Meta models, ecosystem services and forest type were highly correlated in this study which created a need to use two linear regression models to explain variation in WTP values. This correlation or co-linearity is a probable outcome because ecosystem services are generally linked to the forest type or land use in an area. Refer to Tables 14 and 15 for linear regression results, coefficients and levels of significance for each variable.

***Table 14** Forest Type Linear Regression (Model 1)*

Variable	***B***	***Standard Error***	***Sig***
(Constant)	30933.721	10922.153	.006
DBDC	28.175	53.576	.601
SBDC	167.112	59.367	.006
PC	108.890	53.504	.046
USA_study	-234.029	93.154	.014
Other_study	76.789	91.108	.402
inperson	-292.923	83.564	.001
annualpay	-12.865	99.482	.898
welfare change	-24.698	51.243	.631
forestarea	-19.383	340.384	.955
income_tax	331.687	77.341	.000
municpial_tax	359.613	104.656	.001
resourceuse_tax	482.763	99.446	.000
userpay_vehicle_dummy	174.256	98.054	.080
voluntarypay_vehicle	605.319	87.886	.000
tropicalforest	226.881	106.778	.037
temperateforest	190.546	98.875	.058
borealforest	-46.778	194.268	.810
Year_of_value_original	-15.560	5.471	.006

(baseline variables: EU Studies, subtropical forest, OE, trustfund pay)

The model 1 shows a relatively good fit with an adjusted r square of (0.606), however none of the variables for forest type are statistically significant. The baseline, omitted variables for this linear regression is the OE survey format, EU studies, trust fund payment vehicle and subtropical forest variables. The results of this linear regression yielded statistically significant variables for income tax, resource use tax and voluntary payment vehicles, all with a significant and positive influence on WTP. These results show a significant influence of the payment vehicle on WTP in this study. Furthermore, the results show a strong influence of survey elicitation format on WTP. The variable SBDC is also significant at the .06 level and is a positive influence on WTP compared to the baseline variable OE survey format. Studies conducted in the USA result in lower WTP values than 'Other' country studies and compared to the baseline variable EU studies (see Table 15). The original year of study is statistically significant at the 0.06 level and carries a negative indicator, meaning that lower values are found in more recent studies. This is an expected outcome as survey design and implementation has improved over the years and is able to correct for potential bias and lack of information in CVM studies. In addition, the *inperson* variable for surveys conducted in person is significant at the 0.01 level and has a negative influence on WTP.

***Table 15** WTP by Country*

Country of Study	***Mean***	***N***
EU Studies	$ 72	37
Other	$ 134	47
Other country studies	$ 214	15
Other	$ 84	69
Scandinavia Studies	$ 143	20
Other	$ 95	64
USA Studies	$ 21	12
Other	$ 121	72

Since the variable for GDP per capita from the year of the study was not a good explanatory variable, dummy variables were used to potentially capture income effects in the country of study. While these variables were better overall predictors for WTP than GDP per capita, they were also highly correlated with forest type. Boreal forest and Scandinavian studies were 100% correlated. European studies and temperate forests were also highly correlated and thus not included together in the linear regression model. In addition, studies conducted in the US were highly correlated with the payment vehicle for trust fund payments. Bivariate correlations for ecosystem services and study area did not yield any highly correlated variables. Furthermore, the use of correlation tests to identify variables that explain the variation in willingness to pay is difficult as most variables are dummy coded with values of 0 or 1, making relationships of multi-collinearity more challenging to identify.

In model 2 the baseline, omitted variables are OE, EU studies, trust fund payment vehicle and biodiversity. The adjusted r square for this model was (0.648) and statistically significant variables were found for SBDC, USA study, Scandinavian study, year of value original, income tax, and resource use tax, voluntary payment vehicle, aesthetic and restoration of supporting services at the 0.05 significance level or below. The variable for restoration of ecosystem services is significant at the 0.001 level and has a positive influence of WTP. Aesthetic ecosystem services are also positive and statistically significant at the .000 level. The variable for USA study is significant at the .005 level and negatively impacts WTP. The results of this meta-analysis show statistically significant lower WTP values for studies conducted in the USA. These findings contradict those found by Barrio and Loureiro (2010) who found that European studies resulted in lower WTP than studies conducted in the USA. Consistent with results from model 1, the SBDC variable is a positive indicator and significant at the 0.005 level.

The variable *forest area* is positive which goes against the expected outcome for this variable. The variable was expected to be negative since it was included to represent scarcity of the forest resource being valued. It is expected that a lower percentage of forested area in a country will cause respondents to place a higher value on the resource. This was not the result of this study as an increase in the amount of forested area has a positive influence on WTP estimates for forest management programs. This could be a result of the variable itself not being a useful indicator; however it is significant in model 2 and was less correlated with other variables than 'forest area per capita' variable that was excluded from the final linear regression. Overall, the ecosystem service (model 2) has a higher adjusted r square as well as the presence of more statistically significant variables; therefore this model performs slightly better than model 1.

Table 16 *Ecosystem Service Linear Regression(Model 2)*

Variable	*B*	*Standard Error*	*Sig*
(Constant)	32619.473	9619.148	.001
DBDC	-3.334	51.250	.948
SBDC	164.342	56.192	.005
PC	88.672	51.492	.090
USA_study	-247.305	85.434	.005
Scandinavia_study	-443.456	100.689	.000
Other_study	-139.878	60.870	.025
inperson	-54.749	71.227	.445
annualpay	-236.072	115.759	.046
welfare change	-151.844	63.783	.020
forestarea	533.123	222.426	.019
Year_of_value_original	-16.299	4.834	.001
income_tax	380.079	76.847	.000
resourceuse_tax	485.719	98.387	.000
userpay_vehicle_dummy	-16.698	100.890	.869
voluntarypay_vehicle	493.980	92.866	.000
Recreation	40.042	64.446	.537
CO2	-148.000	95.459	.126
Restoration	293.036	87.689	.001
Aesthetic	410.642	102.143	.000

(baseline variables: OE, trust fund pay, biodiversity, EU study)

7 Conclusions

In conclusion, the results of this meta-analysis show a significant influence on WTP from survey elicitation format, payment vehicle, country of study, ecosystem service and the year the study was conducted. In this paper, willingness to pay for use and non use values of forests related to biodiversity, recreation, aesthetic and cultural services were compared and synthesized in a meta-analysis of forest ecosystem services. The mean individual WTP averaged $107 in 2009 USD. The highest values in the study were for tropical rainforests followed by boreal, temperate and lastly subtropical forests. The use of single bounded dichotomous choice elicitation format yielded the highest WTP followed by payment card, open ended format and lastly double bounded dichotomous choice. Voluntary payments gave the highest WTP values followed by resource use tax, municipal tax, user fee, income tax and lastly payments to a trust fund. There were significantly larger WTP values for voluntary versus income tax payment vehicles. There was also a significant difference in the welfare change variable; average WTP for avoided loss was higher than securing an environmental gain.

The non-parametric, univariate analysis through Kruskal Wallis tests yielded statistically significant results at the 0.005 level of significance for forest type, payment vehicle, payment frequency, survey elicitation format and welfare change. Additional univariate analysis through Mann-Whitney tests found statistically significant variables at the 0.005 level of significance for forest type (temperate/subtropical) and (tropical/boreal), in person surveys, welfare change and payment frequency. The wide range of values found in this meta-analysis can help to possibly explain why all variables in univariate analysis resulted as statistically significant.

The adjusted R square found in multivariate analysis is approximately 0.61-0.65 for both linear regression models meaning that over 50% of variation in WTP values can be explained by the variables included in both models. The regression model 1 for forest type had an adjusted r square of 0.61 and yielded statistically significant results for SBDC, year the study was conducted, income tax, resource use tax, voluntary payment vehicle and in person. The SBDC variable had a positive influence on WTP while the original year of study has a negatively impact on WTP meaning that lower values are found in more recent studies. This result is to be expected as survey design and implementation improves over time and causes WTP to lower. Voluntary payments are also a positive indicator of WTP, shown by the high estimated coefficient and high average WTP values. The adjusted r square for model 2 was 0.65 and produced results at the 0.005 level of significance or below for SBDC, USA study, Scandinavian study, year of study, income tax, resource use tax, voluntary payment vehicle, aesthetic and restoration of supporting services. In both models the payment vehicle variables are statistically significant in determining WTP and show positive influence on WTP, however the variables for voluntary payment and resource use tax have larger coefficients when compared to income tax and thus capture more of the variation in the WTP.
Forest ecosystems are increasingly important in the face of climate change mitigation, biodiversity loss and a variety of other ecosystem services forests provide. Forest valuation studies are relevant in terms of REDD+ as well as PES programs that promote sustainable land practices and provision of ecosystem services. In addition to these uses, meta-analysis and economic valuation of ecosystem services is an essential tool to provide damage assessment, extract revenues, increase awareness and assist in policy decisions. There is increased recognition of non-marketed environmental goods and services and the need to values these resources. The economic valuation of forests, meta-analysis and environmental value transfer are useful tools to be utilized in preparation to establish PES programs and participate in REDD+. The WTP of respondents in CVM studies can be directly linked to forests worth to society as well as potential payments made on the behalf of forest and biodiversity conservation. As primary valuation studies can be expensive and time consuming there is significant interest in meta-analysis to facilitate and improve upon benefit transfer methods for use when project resources or time is limited. The results of

this study are relevant in that few meta-analyses of forest ecosystem services investigate the influence of payment vehicle on WTP while selection of an appropriate payment vehicle is imperative to create a realistic and acceptable method of securing payment. Many of the results of this meta-analysis are consistent with previous meta-analyses that found statistically significant variables for welfare changes, payment frequency, survey elicitation format and forest type.

As there is a wide range of WTP values spread across many countries and reference years, the results of this meta-analysis could be greatly improved with further homogeneity among selected CVM studies. Although the focus of this paper was limited to forest ecosystems that utilized CVM to elicit values, the scope could be further refined to include studies originating from a specific geographic region or valuing a certain ecosystem service. Also such a study would benefit from the inclusion of a biodiversity indicator that is well adapted to the needs or objectives of the research. As the objectives of this paper were not directly linked to the effect of biodiversity on WTP, a variable for species richness or abundance was not included, however the results of including a variable in future studies could provide relevant results or policy implications. This paper has shown there are multiple methods available to value biodiversity as well as communicate the concept to the public that can affect the outcome of WTP results as well as potentially misrepresent hypothetical scenarios presented in a CVM study. As there are many factors to consider when carrying out meta-analysis it is difficult to refine the scope of study and still have a sufficient number studies from which to draw that report all required information.

While the above listed studies perform credible stated preference surveys there remain potential inaccuracies or misinterpretations while designing and implementing stated preference surveys. There are possible sequencing effects, embedding effects, starting point bias, yea-saying and other reasons for variation among biodiversity and ecosystem service valuation studies. In addition, the methods used to conduct such studies, the socio-economic settings of the study areas and ability of respondents to grasp difficult environmental concepts can greatly affect survey results. Further, methods for handling respondent uncertainty, protest and zero bids can affect WTP results and be a source of potential bias in such studies. While the use of monetary indicators to value biodiversity is useful to assist in policy decisions, it may not accurately represent biological processes or ecosystem functions that occur to support ecosystem biodiversity, adaptive capacity or ecosystem resilience. These biological and monetary indices should be regarded as complimentary rather than interchangeable even when monetary valuation is based primarily upon biological indicators. Inclusion of supporting services in economic valuation can lead moreover to possible overestimation of TEV, while failure to highlight these services ignores important ecosystem services even if these services are not those directly enjoyed by humans. For this reason, different definitions and classifications schemes of ecosystem service have been introduced in recent literature in efforts to avoid double counting and only include those ecosystem services directly enjoyed by people. As the above studies show, there are a variety of methodologies to value forest resources and biodiversity, all with potential pitfalls that can lead to bias or inaccuracies in particular, how protest and zero bids are handled. As biodiversity is lost at ever increasing rates, the need for valuation of ecosystem services and resulting welfare changes increase so conservation policy decisions can compete equally for public attention and government funding.

The results of this study serve as a starting point for further studies to investigate the influencing factors of WTP in CVM studies and in particular the influence of the payment vehicle. In general, meta-analysis are also useful in terms of possible value transfer equations, however due to the nature of this data and the wide range of years, values and geographic origin, the transfer error is likely to be large. The policy implications that can be achieved from environmental valuation studies are important in terms of overall conservation and the evaluation of nonuse benefits in CBA analysis as policy decisions are weighed. The inclusion of non-marketed environmental goods into policy decisions is crucial to effectively evaluate the tradeoffs associated with policies and to facilitate long term investments in natural capital. As the total economic value of forests are communicated to policy makers, the practice of short term investments will occur less and less as the long term benefits of forest preservation outweigh the short term revenues associated with commercial logging or agricultural operations. Moreover the introduction of PES schemes provide similar motivation to private landowners to participate in forest preservation rather than development, thus contributing to climate change mitigation and biodiversity conservation. Further research is needed to improve meta-analytic methods and benefit transfer equations. Transfer errors resulting from value transfer create a need for further concentration of studies that share similarities in ecosystem services, geographical and socio-economic factors. Further research is also needed to investigate use of payment vehicle in determining WTP as securing payment is one of the most important aspects of economic valuation study and is thus the focus of many studies.

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