The 'Ecosystem Service Concept' and the 'Valuation of Ecosystem Services' as a framework and tool for developing integrated approaches to mangrove management and conservation.

A thesis submitted to the University of Manchester for the degree of Master of Philosophy (Environmental Biology) in the Faculty Science and Engineering

2017

Alexandria Gabb

School of Earth and Environmental Sciences

Table of Contents

Word count: 43,389 (with references)

List of Figures

Chapter 1

Chapter 2

Chapter 3

List of Tables

Chapter 3

Abstract

The 'Ecosystem Service Concept' and the 'Valuation of Ecosystem Services' as a framework and tool for developing integrated approaches to mangrove management and conservation.

Lessons from past conservation efforts have highlighted the necessity for movements away from traditional, top down efforts following the preservationist approach and towards more integrated, approaches characterised by typically characterised by public participation and multi-sector collaboration. The 'Ecosystem Service Concept' (ESC) has become a popular framework upon which to facilitate said collaboration, uniting stakeholders through concepts of societal dependence on ecosystems as a rational for their sustainable management and conservation. Ecosystem service (ES) valuation is an associated tool developed to bridge communication gaps across stakeholder types by providing a common language with which to manage ES values. At present, valuation attempts have primarily focused on the use of monetary units in the monetary valuation of ecosystem services (MVES). This method aids in translating the values of ES into a language more readily adopted in land-use decisions thus facilitating communication between practitioners and decision-makers. The issue here however is that despite facilitating discourse at said level, MVES excludes local stakeholders by foregoing public participation and ultimately neglecting the social values and the non-material benefits of ES. As a result, MVES has received criticisms concerning its relative one-dimensionality, leading to calls for value plurism and greater consideration of social values needed for integrated management schemes. Mangroves have become widely recognized as highly productive ecosystems delivering a variety of services vital in supporting coastal communities, national economies and adjacent ecosystems. The diversity of their services, in addition to the range to which their benefits extend make mangroves an interesting system within which to explore the discourse surrounding ESC and valuation and examine the potential and limitations of the tool in developing integrated approaches to mangrove management. This study reviews use of MVES in mangrove ecosystems, identifying gaps in the literature with regards to the cultural services of mangroves, representation of their ecological values and a research deficit concerning mangroves of Africa, Latin America and the Caribbean. To address some of these gaps this thesis also employed social valuation techniques in coastal communities on the Caribbean Coast of Honduras. The social valuation study demonstrated variation in stakeholder perceptions as to the importance of mangrove services amongst communities and that these were affected by community geographies, ultimately highlighting the importance of social considerations to avoid conflict when implementing management schemes.

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or institute of learning.

Copyright statement

Acknowledgements

First and foremost, I am especially indebted to Professor Richard Preziosi for his support, guidance and much needed reassurance throughout the completion of my research and the writing of this thesis. I would like to offer special thanks to both Steven Canty and Dr. Giles Johnson for their assistance, supervision and encouragement throughout this process. I am grateful to Professor Daniel Rigby for his expertise and assistance in designing the choice-experiments crucial to this paper. Collection of the data used in this study would not have been possible without the aid of Cristhian Perez, to whom I extent sincere thanks for his help and the inspiration he provided me through his dedication to his job. I am also grateful to BICA, PROLANSATE and FUSCA for their facilitation of this study. Finally, I would like to thank my family, friends and boyfriend for their support and patience with me during this time.

Chapter 1

General introduction

1.1 Conservation biology

The 20th century has seen a staggering increase in global population growth. In just 50 years the human population has grown from 3 to 7.5 billion and is estimated to reach 10 billion by 2050 (Van Bavel 2013). Ecosystems and their relative biodiversity are the foundation upon which human society has been built and human well-being is maintained. Nature and its resources are, and always have been, deeply rooted in our economy, societies and cultures. Despite our dependency on nature, we continue, in a somewhat paradoxical manner, to overexploit the ecosystems that have contributed so heavily to our development (M. Christie et al. 2012; Williams 2013; Johnson, Poulin, and Graham 2003). Today, strong demographic pressures, such as intensive farming, pollution and overexploitation are causing the degradation and loss of the ecosystems at a rate meaning that they will not be capable of sustaining us in the future (M. Christie et al. 2012; Williams 2013; Johnson, Poulin, and Graham 2003). Reports indicate that we are on the cusp of entering the preliminary stages of the planets 6th mass extinction event and although sceptics might argue that these events are a natural occurrence, with 5–20% of the species in many groups already extinct, todays species are disappearing at a rate 1000 times faster than pre-human rates (Wake and Vredenburg 2008; Dirzo and Raven 2003; Chapin et al. 2000; Pimm et al. 2014). We continue to make untenable demands of the earths ecosystems and this, in combination with our on-going, exponential growth, means we need to look to more sustainable practises to conserve what we have.

Conservation science, originally defined by Soule (1985), is the crisis discipline synthesised to provide the guidance and tools with which to achieve this goal. Traditional approaches to conservation typically involve the procurement of land to be set aside for protection and management as protected areas (PAs), such as national parks or marine protected areas (Adams, Aveling, and Brockington 2004; Muhumuza and Balkwill 2013; Bonilla-Moheno and García-Frapolli 2012). Many of these protected areas are managed as 'no-take' zones (P. Christie 2004) where direct use of natural resources in the area become prohibited and human activity is excluded, sometimes with the exception of tourism (Hughes and Flintan 2001; Muhumuza and Balkwill 2013). Recent reports by the United Nations Environmental Program (UNEP) and the International Union for Conservation of Nature (IUCN) indicate that The World Database of Protected Areas (WDPA) currently includes more than 209,429 sites, which is summative to a total of 32,868,673 km^2 of natural space (Hlaváčková and Palaghianu 2015). This traditional, preservationist approach has undeniably made significant contributions to safeguarding natural spaces however recent reports biodiversity is in fact still being lost from PAs (P. Christie 2004). This represents a failure by traditional, preservationist approaches to halt and reverse the issue of biodiversity decline (P. Christie 2004; Shorb 2016; Muhumuza and Balkwill 2013). An issue with traditional methods is that they assume a degree of optimism and simplicity with regards to the problem of conservation. Theoretically, prohibition of land and resource use in an area of concern would stop degradation and thus secure the area for the future. In reality, there is a suite of socio-economic and political variables involved that traditional approaches fail to acknowledge. PAs prevent land use and have a high opportunity cost for local people (Norton-Griffiths and Southey 1995). With the highest levels of biodiversity situated in the least developed countries (LDCs) this poses a problem as PAs take resources and options for land use away from those who have the greatest immediate dependency on them (P. Christie 2004; Adams, Aveling, and Brockington 2004; Norton-Griffiths and Southey 1995; Williams 2013). Traditional methods have thus failed to consider and adapt to what we already know are some of most influential drivers of environmental problems (Small, Munday, and Durance 2017; Erik Gómez-Baggethun et al. 2010).

Conservation is a complex, multi-level problem composed of various socio-economic and political dimensions, however in addressing ecological concerns the policy spheres of ecology, sociology and economics remain for the most part segregated (Johnson, Poulin, and Graham 2003; Erik Gómez-Baggethun et al. 2010). It is becoming increasingly acknowledged that the conservation problem is in need of integrated approaches toward solutions (Johnson, Poulin, and Graham 2003; Carter, Schmidt, and Hirons 2015; J. Reed et al. 2016). Integrated approaches are considered those that combine scientific methods and societal values and aspire to combine social development with conservation goals (Carter, Schmidt, and Hirons 2015; Hughes and Flintan 2001). The concept emerged during the 1980s as an alternative to conventional conservation approaches and was highlighted as a necessary step for global conservation and sustainability by world leaders and international institutions in the Millennium Ecosystem Assessment (MEA 2005). The UN MDGs are premised on such integration, with the area of land protected to maintain biological diversity being an indicator of performance against MDG Goal 7 (Likens and Lindenmayer 2012; M. S. Reed, Fraser, and Dougill 2006). With a growing population, it is crucial that conservation efforts work with development rather than against it. However, to do this we need to understand the human-nature relationship (Erik Gómez-Baggethun et al. 2010; Folke 2006).

1.2 The ecosystem services concept

The ecosystem service concept (ESC) provides a framework with which to examine the human-nature relationship for use in creating integrated approaches to conservation (Erik Gómez-Baggethun et al. 2010; Folke 2006). The ESC uses a utilitarian perspective in framing ecosystem functions as ecosystem services (ES) or “the processes and conditions of natural ecosystems that support human activity and sustain human life’” (Chapin et al. 2000; Daily 1997). By looking at ecosystem function from this utilitarian angle, the ESC provides a vehicle for the integration of ecological considerations into common thinking (Chee 2004). ES are integral to human health, well-being as well as to the global economy yet they proceed largely without any recognition (Costanza et al. 1997). The concept thus acts as ideology to help bridge natural and social sciences with the objective of communicating the worth and importance of nature to stimulate increased interest in conservation (Braat and de Groot 2012)(Erik Gómez-Baggethun et al. 2010). Examples of ES can be found commonplace, integrated into our daily routines, providing some of our most basic needs and necessities. A popular, and particularly demonstrative example is that of insect pollination in agriculture (Vanbergen 2013). Pollination by insect’s accounts for 35% or a third of global food production, the majority of this being carried out by the Honeybee (*Apis mellifera L.*) (Allsopp et al.

2008). Of course, the uses of crops are not limited to food production. Out of a total of 300 crops used commercially, 252 are pollinated by insects and used for biofuels, medicines, fodder, aesthetics, construction materials and raw substances (Allsopp et al. 2008). The economic value of crops affected by pollinators is between US$235 billion and US$577 billion per annum (IPBES 2016). Pollination and other ecosystem services are products of ecosystem function that serve to maintain, benefit and enhance the economy and human well-being (Daily 1997; Chapin et al. 2000).

The notion that we as a society reap benefits from our surrounding environments is nothing new, however our understanding of this relationship and the potential, long-term effects of exploitative use are relatively modern (Lele et al. 2013). The early 1900's saw a shift in attitudes toward and understanding of ecological concerns and with it slowly came the development of related policy and management. The ESC first emerged in the 1970s as "environmental services" (Wilson and Matthews 1970), a term designed to help conceptualize the relationship between humans and ecosystems (Abson and Termansen 2010; Braat and de Groot 2012). The concept underwent further development, emphasising a focus on the value of nature to society and eventually becoming the concept coined as "ecosystem services" in 1980s (Ehrlich and Mooney 1983; Lele et al. 2013). From here, the ESC gained considerable momentum and the 1990s the concept began to transcend the academic arena becoming heavily featured in the policy domain (Lele et al. 2013; Cornell 2011; Erik Gómez-Baggethun et al. 2010). In 1992, the ESC was adopted by the Convention on biological Diversity (Lele et al. 2013; Braat and de Groot 2012). The years to follow brought the development of frameworks which typed and identified different ES until its eventual integration into the Millennium Ecosystem assessment (MEA 2005), published in 2005. Becoming a component of the MEAs underlying framework placed the concept firmly within the international environmental policy agenda (Lele et al. 2013; Cornell 2011; Erik Gómez-Baggethun et al. 2010). Concurrently, changes in the field of economics were giving rise to a suite of novel cross-disciplinary methods and techniques that would aid in better investigating the paradigm (Lele et al. 2013; Cornell 2011; Erik Gómez-Baggethun et al. 2010).

Today, many frameworks and definitions exist in relation to the ESC, however the classification framework used in the MEA (2005) has since become one of the most widely used (Fisher et al. 2009). Here the ESC was delineated, giving rise to four main categories of ES described as follows:

Provisioning: Services that directly provide usable material or energy outputs. Examples include medicinal recourses, raw materials, food and freshwater (TEEB 2010; MEA 2005).

Regulating: Services that benefit us as a secondary effect of regulating ecosystem processes. Examples include the regulation of air quality, climate, water treatment, and erosion control (TEEB 2010; MEA 2005).

Supporting: The services needed for the production and maintenance of all other ecosystem services. Examples include soil formation, nutrient cycling and refuge services (TEEB 2010; MEA 2005).

Cultural: The services that provide non-material benefits to people. Examples include spiritual enrichment, cognitive development, and aesthetics experience (TEEB 2010; MEA 2005).

1.3 The Tragedy of the Commons

Despite their contribution to our well-being, societies and economy, the degradation of ecosystems and the loss of biodiversity continue at unprecedented rates. In 2005, it was reported that approximately 60% of our global ecosystem services have been unsustainably used or degraded (MEA, 2005). The ways in which we perceive ecosystems have been influential in this. Ecosystems and their relative services can possess one of many property statuses. Land can be privately owned, publically owned, be common property or subject to international treaties or agreements (Turner &daily 2008). Many ecosystems, their services and natural resources are considered as common pool resources or public goods (Kretsch, Dijk, and Schleyer 2016; de Groot et al. 2012) and are defined by two main characteristics: (1) considered 'non-excludable' as individuals cannot be excluded from their use, and (2) 'non-rival' as consumption by a single individual does not reduce the service received by others (de Groot et al. 2012; Brander et al. 2012). These characteristics in combination with undefined property rights means that ecosystems become open-access resources leaving them vulnerable to a phenomenon called "a tragedy of the commons" first described by Hardin (1968)(Lant, Ruhl, and Kraft 2008). Hardin (1968) uses the metaphor of an English commons where farmers share pastureland (Lant, Ruhl, and Kraft 2008). As no users own the land, they do not incur the costs of its use meaning they are likely to over exploit it (Farley 2012). When the fund is degraded or destroyed (i.e., depreciates), it endangers not only the quantity and quality of future flows but also the viability of the fund itself, over exploited to the point of collapse (Lant, Ruhl, and Kraft 2008). Although his theories have been deemed over simplified, Hardin (1968) original message stands true, labeling ecosystem services as free and infinite is dangerous as we forget their value and take their presence for granted, promoting their exploitation as we fail to recognize their increasing scarcity (Kretsch, Dijk, and Schleyer 2016). In not appreciating ecosystem importance and worth we leave them undervalued, which in turn leaves them vulnerable to trade-offs (Farley 2008) against development concepts promising short term economic gain (Costanza, Farber, and Maxwell 1989; Primavera 1997; J. Reed et al. 2016)

1.4 Mangroves and their ecosystem services

Mangrove forests are a particularly illustrative example of how undervaluing ecosystems can lead to degradation. Mangroves are considered incredibly unique and productive ecosystems, providing multiple services vital to the well-being of local communities (Walters et al. 2008; Hussain and Badola 2010) but also beneficial to societies at a national (Aburto-Oropeza et al. 2008; Anneboina and Kavi Kumar 2017) and even global scale (Costanza et al. 1997; Donato et al. 2011). Despite this, up until the late 1960's, mangroves were largely considered marshy wastelands of little to no value (Lugo and Snedaker 1974; Carter, Schmidt, and Hirons 2015; Zhao and Wu 2013), leaving them vulnerable to conversion to alternate land uses (Rönnbäck 1999). Mangroves are defined as assortments of woody and salt tolerant trees and shrubs found to grow within estuaries and along coastlines in tropical and subtropical regions (Tomlinson 1986; Kathiresan and Bingham 2001; T. Vo, Kuenzer, and Oppelt 2015). The term "mangrove" can be used to describe both the habitat, as well as its constituent trees (Duke 1992a). This plays a part in the common misconception that mangroves are a single species, when in fact mangrove trees are approximately 70 different species to around 20 different families (Hogarth 2015). Conditions in the intertidal zone are harsh featuring high levels of salinity, a humid climate, strong winds, regular tidal flooding and anaerobic soils (Kathiresan and Bingham 2001). Despite being inhospitable to the majority of plant life this severe and varying environment provides the perfect precursors to mangrove formation (Duke 1992a). Their success here is owed to a myriad of highly specialised adaptations (Kathiresan and Bingham 2001; Lugo and Snedaker 1974). Duke (1992), notes some of the most unique, namely, branching aerial roots aiding in structural strength, upward growing roots (puemataphores) that facilitate respiration in anoxic muds, and salt excreting leaves allowing for life in hypersaline conditions (Hogarth 2015). Establishment in the intertidal zone depends on a variety of additional environmental conditions (Duke and Schmitt 2016; Schmitt and Duke 2014). Forest growth requires high air temperatures of above 20° with a seasonal range of 10°C, combined with shallow waters, contributed to by warm ocean currents and muddy substrate in areas that are protected from strong winds and that experience regular tidal influxes (Chapman 1984). These specifics are reflected in their distinctly circumtrophic distribution which rarely extends further than 30°N or 30°S from equator as is demonstrated in Figure 1.1 (Kathiresan and Bingham 2001; Hogarth 2015). Giri *et al.*, (2011) notes a few exceptions to this rule examples being the mangroves in New Zealand (38°59'S) and Japan (31°22'N), although these coincide with warm ocean currents. Ocean currents limit mangrove distribution in such a way that the cooler waters between the Americas and Asia as well as those southward of Africa act as a natural barrier, which has resulted in two distinct biogoegraphical regions of occurrence (Lo, Duke, and Sun 2014); The Indo-west pacific region (IWP), which consists of Asia, Australia, Oceania and the Eastern coast of Africa, and Atlantic- Caribbean-East-Pacific (AECP) region which consists of the Americas and the West coast of Africa (Duke 1992a; Luther and Greenberg 2009). These regions differ in their species diversity with the IWP housing approximately three times as many genera as the AECP meaning that there are approximately 3 to 4 species per site in the AECP compared to 11 to 25 in IWP (Figure 1.1) (Hogarth 2015; Luther and Greenberg 2009; Spalding 2010). Asia has the greatest extent of mangroves and New Guinea, Indonesia has the highest species diversity (Figure 1.1) (Giri et al. 2011).

It has become widely acknowledged that mangroves provide multiple provisioning (e.g. timber, medicines and multiple-use fisheries; (Bandaranayake 1999; Walters et al. 2008; Aburto-Oropeza et al. 2008), regulating (e.g. storm protection, erosion control, climate regulation; (Donato et al. 2011)(Das and Crépin 2013)(E. Barbier et al. 2011) supporting (e.g. nutrient cycling; (Hussain and Badola 2008; Feller et al. 2003) and cultural services (recreational, aesthetic and spiritual; Souza Queiroz, 2017) which support both terrestrial and marine ecosystems as well as human society and a range of levels. For detailed descriptions of the services that mangroves provide please see: (UNEP 2014)

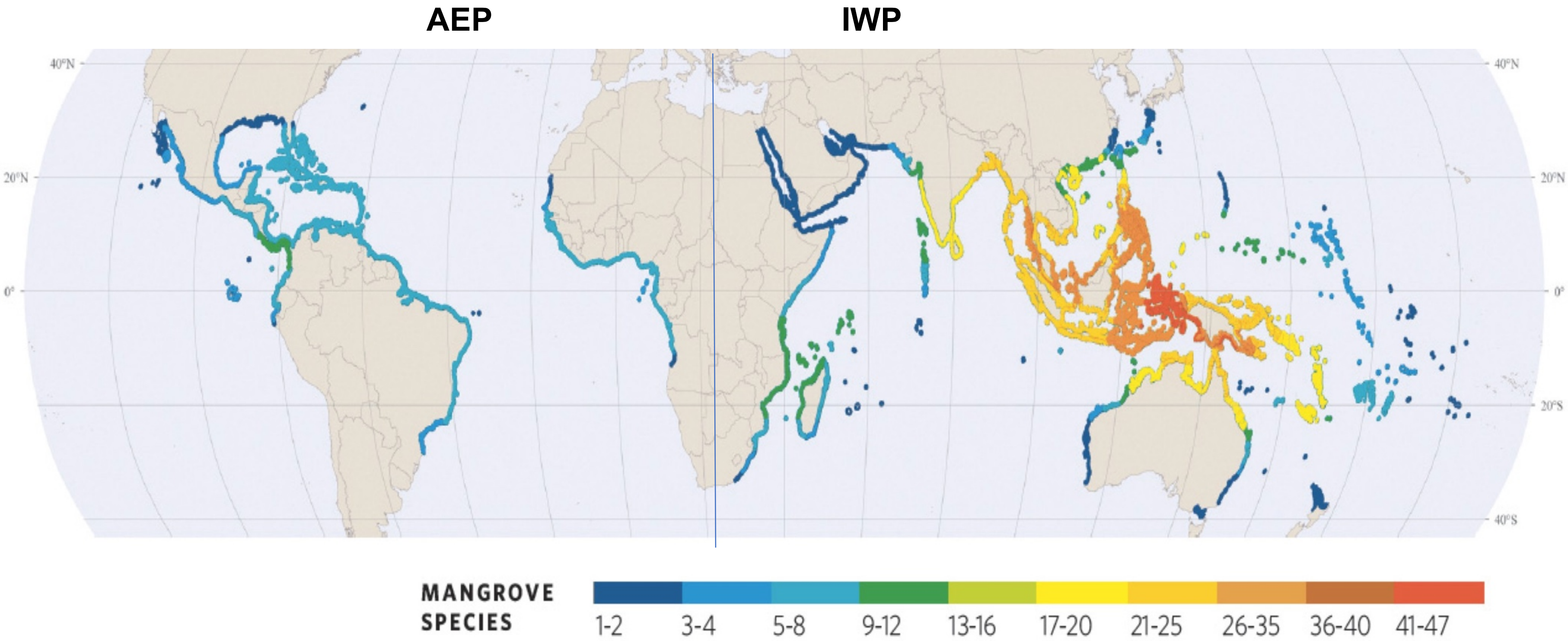

Figure 1.1. The global distribution of mangrove forests is split between two biogeographical regions of occurrence; The Indo-west pacific (IWP) and the Atlantic-Caribbean-East-Pacific (AECP) (Duke 1992a; Spalding 2010**).** Mangroves in the IWP region are distributed amongst Asia, Australia, Oceania and the Eastern coast of Africa where as AECP region constitutes the Americas and the West coast of Africa (Duke 1992b; Spalding 2010; Hogarth 2015). These regions differ primarily in their species diversity (IWP; ~65 species of 23 genera: AEP; ~15 species of 8 genera) (Duke, Ball, and Ellison 1998; Lo, Duke, and Sun 2014). Global mangrove cover is estimated at 137,760km^2 (Giri et al. 2011) and distributed amongst 123 countries, the majority of which are still developing (Carter, Schmidt, and Hirons 2015).

1.5 Global decline

Despite these benefits, mangroves are disappearing at a rate that exceeds the loss of our rainforests and coral reefs (Valiela, Bowen, and York 2001; Duke et al. 2007). Recent estimates place global cover at 137,760 km^2 (Giri et al. 2011), meaning that more than one third of the world's mangrove forests have been lost in the past 50 years (Valiela, Bowen, and York 2001; Alongi 2002). In addition to this, the remaining mangroves are not pristine; their degradation causing reduced functionality (UNEP 2014). Undervaluation of mangroves is believed to be an underlying driver of their decline (Dixon, Miller, and Hamilton 1989; Huxham, Emerton, and Kairo 2015; Rönnbäck 1999; E. B. Barbier et al. 2008). The many ecosystem services provided by mangroves are often ignored or forgotten in pursuit of development (Hussain and Badola 2005; Ruitenbeek 1994). Failure to recognize and account for the true value of their services means they are often vulnerable in land use decisions and cleared for alternative uses such as aquaculture, agriculture and coastal development which promise tangible, economic gain (E. Barbier 2007; Rönnbäck 1999). Additional pressures such as the over-exploitation of their resources, agricultural runoff and fragmentation by infrastructure development compound upon these threats (Thomas et al. 2017; Valiela, Bowen, and York 2001; Alongi 2002; Jiao et al. 2015; Godoy and Lacerda 2015; Blanco-Libreros and Estrada-Urrea 2015). Finally, concerns are growing with regards to potential threats to mangrove forests at the hand of increasing sea-levels resulting from climate change (Ward et al. 2016; Krauss et al. 2014; Godoy and Lacerda 2015) Under normal circumstances, mangroves are capable of adapting to sea-level changes through their ability to build up land (sediment accretion) by facilitating sediment deposition and peat accumulation (Krauss et al. 2014). It is the case however, that modern sea-level rise is occurring at accelerated rates, meaning that mangrove forests may not be able to up (Ward et al. 2016; Krauss et al. 2014; Godoy and Lacerda 2015).

1.6 The monetary valuation of ecosystem services

Undervaluation becomes an issue in policy and decision making as these processes are usually driven by cost-benefit analyses within an economic framework (Farley 2008). In these, the costs and benefits of a development project (such as the implementation of an aquaculture pond) are weighed up against the current land use (for example a section of mangrove forest) (Farley 2008; Ruitenbeek 1994; Gunawardena and Rowan 2005). Without true representation of their values ecosystems usually fall short to such projects, which often promise quick, short-term economic gain and employment prospects (Dixon, Miller, and Hamilton 1989; Huxham, Emerton, and Kairo 2015; Rönnbäck 1999; E. B. Barbier et al. 2008; Costanza et al. 1997; TEEB 2010). Lal, (2003), commented that "only when people incur the true economic costs of using natural resources will they have the incentives to limit their degradation and loss". Mangroves provide a very illustrative example of how undervaluation can lead to ecosystem destruction and loss. Response to this issue prompted economists to develop various techniques with which monetary values could be assigned to ecosystem services in an approach called the monetary valuation of ecosystem services (Chee 2004; Spaninks and Beukering 1997). The "monetary valuation of ecosystem services" (MVES) is a tool that was developed alongside the ESC as a means of trying to communicate the values of nature in the common language of the public domain, policy and economics (de Groot et al. 2012; Gunawardena and Rowan 2005). The desired outcome of this process is that valuing ES in monetary terms could help better inform trade-offs against developments projects, encourage investment, provide raise awareness and create justifications for protection that the public will appreciate (Braat and de Groot 2012; Daily et al. 2009; Erik Gómez-Baggethun et al. 2010; Laurans et al. 2013; Bateman et al. 2013). The fundamental roots of MVES emerged in the 1970s, with Schumacher, (1973) being the first to describe the worlds stocks of natural resources as “natural capital”. Shortly after, the 1980s witnessed the rise of the ESC within the academic arena, fuelling interest in estimating money values of ES (Lele et al. 2013). In 1997, a key paper by Costanza *et al.*, (1997) “The value of the world’s ecosystem services and natural capital” estimated economic value of 17 main ES to average 33 trillion dollars per year. The paper has heavily criticised (Schröter et al. 2014; Chan et al. 2011; Ludwig 2000; McCauley 2006) however it succeeded in paving the way for a wealth of monetary valuation literature yet to come (Chee 2004; Spaninks and Beukering 1997). This, in combination with the adoption of the ESC into the millennium ecosystem assessment (MEA, 2005) have contributed to the rapid proliferation in literature concerning the topic. Adoption by the MEA took ESC into the policy agenda and took monetary valuation with it, resulting in the formulation of various international initiatives focusing on the concept and tools. In 2008, the United Nations Environmental Program (UNEP) released an international initiative called “The Economics of Ecosystems and Biodiversity” (TEEB 2010) initiative which brought the concept to the attention of scientists, policy- makers and practitioners alike (Costanza et al. 2014).

Figure 1.2 demonstrates the different types of value identified by the initiative; these are designed to be aggregated for a total economic value (TEV) (TEEB 2010; Sukhdev 2008). Within this framework, ecosystems are considered to possess “use” and “non-use values”. Use values can directly benefit be of “direct use” value in that ecosystems provide uses that benefit populations directly (e.g. food, raw materials etc.) (TEEB 2010; Sukhdev 2008; Salem and Mercer 2012; Fisher et al. 2008), for example, through the provision of raw materials such as food and tannins. Otherwise direct use values can be used in non-consumptively, for example through recreation (TEEB 2010). Use values can also possess indirect, yielding benefits to society as by-products of normal ecosystem function through regulating services such as pollination or through supporting services like nutrient cycling (TEEB 2010; Gunawardena and Rowan 2005). Ecosystem services also possess a variety of non-use values, in that they provide non-material well-being though ethical, religious, historical or spiritual meaning (Chan et al. 2011; Milcu et al. 2013). They also hold value in our being able to use them and experience them in the future (TEEB 2010). Under the framework presented in TEEB, all of these values can be aggregated to work out an ecosystem Total economic value (TEV) using a variety of techniques designed by ecological economists (Chee 2004; Spaninks and Beukering 1997), a summary of which is provided as follows. A detailed description of the techniques and their use in mangrove forests can be found in (Vo et al. 2012).

1. **Market based approaches**: Direct and indirect use values are evaluated using market-based approaches as these services often exist in markets. For indirect values look at either change in productivity or cost-based values.

   a. **Market-based approach techniques for direct use values**

      i. **Market price method**, this involves assigning prices to environmental goods that are commonly traded based on their revenue in markets (Chee 2004; Q. T.

Vo et al. 2012; Fisher et al. 2008).

ii. **Shadow pricing method**, involves the use of proxy prices assigned to services when the true value is not being properly reflected due to distortions in the market. (Chee 2004; Q. T. Vo et al. 2012; Fisher et al. 2008).

iii. **Surrogate price method**, this is used when the market price is not available. This can be determined through the barter/trade value, a substitute price, the opportunity cost or though indirect substitute prices (Chee 2004; Q. T. Vo et al. 2012; Fisher et al. 2008).

b. Market-based approach techniques for indirect use

i. **Net factor income approach,** this attempts to value an ecosystem as a production line. It prices all inputs and the ecosystem is valued "as the gross income from the final product (Chee 2004; Q. T. Vo et al. 2012; Fisher et al. 2008).

ii. **The production function approach** is used where an ecosystem contributes to the production of other outputs. Changes in productivity of set outputs associated with changes in ecosystem area or quality can then estimate using the technique (Chee 2004; Q. T. Vo et al. 2012; Fisher et al. 2008).

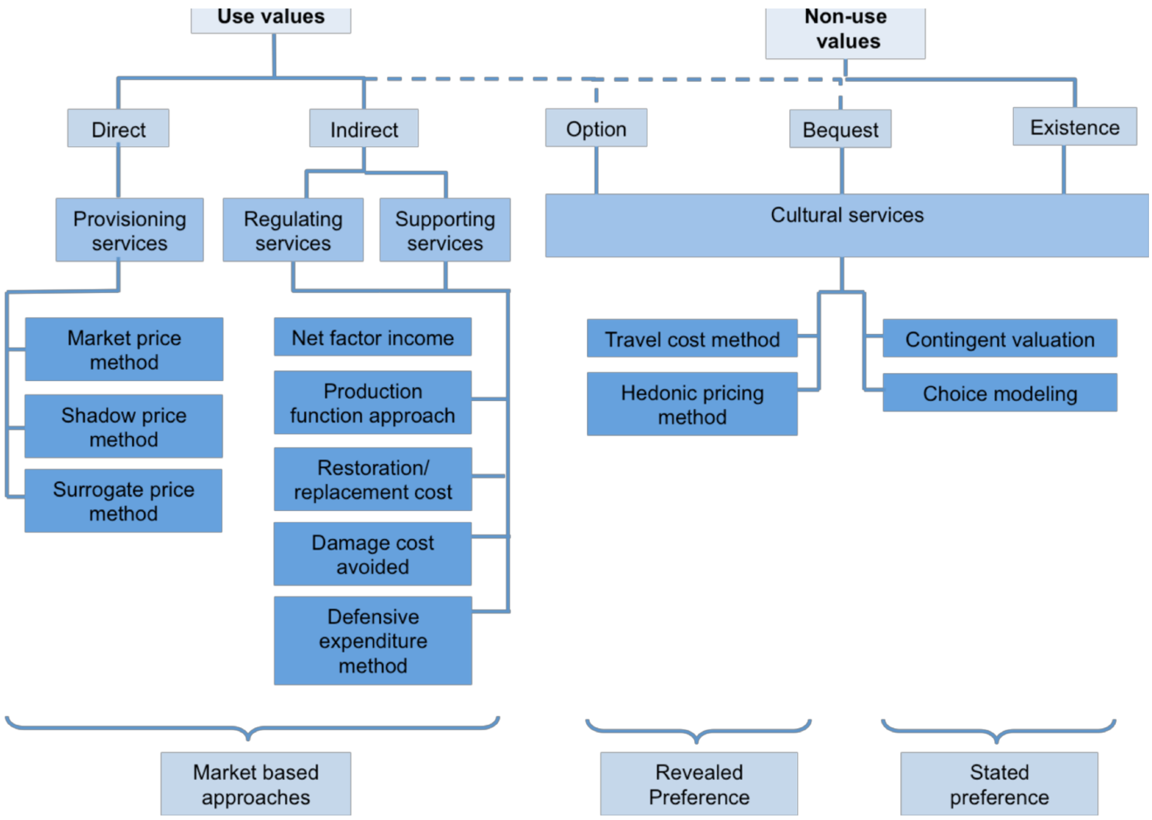

Figure 2.2 demonstrates a summary of the different types of value recognized by a TEV framework, the ecosystem service categories they reflect and the different methods with which to value them (Q. T. Vo et al. 2012; Spaninks and Beukering 1997; TEEB 2010; Chee 2004)

iii. **Restoration/replacement cost** looks at the costs of restoring a natural ecosystem and its goods and services either by restoration or by replacement with man-made substitutes (Chee 2004; Q. T. Vo et al. 2012; Fisher et al. 2008).

iv. D**amage cost avoided** looks at estimated costs of the damages that would happen if the ecosystem were to be lost (Chee 2004; Q. T. Vo et al. 2012; Fisher et al. 2008).

2. Revealed preference approaches are used for certain non-use values. This uses revealed preference techniques, which involve estimations based on observation on individuals' choices related to the ecosystem.

i) **Travel cost** involves looking at the expenditures incurred by households or individuals involving the use of an ecosystem and uses these as an estimate of willingness to pay (WTP) (Chee 2004; Q. T. Vo et al. 2012; Fisher et al. 2008).

ii) **Hedonic pricing** looks at the how services contribute the total market value or property price of an asset (Chee 2004; Q. T. Vo et al. 2012; Fisher et al. 2008).

3. Simulated market approach is used for other non-use values. This involves the use of stated preference techniques, which look at the preferences individuals, give in response to hypothetical changes in the ecosystem and its services (Chee 2004; Q. T. Vo et al. 2012; Fisher et al. 2008)..

i) **Contingent valuation** estimates economic values of services and environments by asking stakeholders to state their "willingness to pay" for its continues existence in a hypothetical scenario (Chee 2004; Q. T. Vo et al. 2012; Fisher et al. 2008).

ii) **Choice modelling** estimates economic values of ecosystem or environmental services by asking people to make trade-offs among them; willingness to pay is inferred from trade-offs that include cost as an attribute (Chee, 2004; Fisher et al., 2008; Vo et al., 2012).

Payments for ecosystem services

"Payments for ecosystem services" (PES) are a type of incentive scheme designed for the incorporation of monetary valuation methods and data. Wunder, (2006) defines PES as "voluntary and conditional transactions over well-defined ecosystem services between at least one supplier and one user". PES schemes aim to provide payments for the management of services that are likely to aid in securing the provision of said services in the future, thus providing an incentive for actions that would have otherwise gone unrewarded (Wunder 2015; MEA 2005; Le Velly and Dutilly 2016; TEEB 2010). The objective of PES schemes is to create a demand for desirable behaviour and use this market force as a driver to change undesirable behaviours and promote more sustainable outcomes (Farley and Costanza 2010; TEEB 2010; Fisher, Turner, and Morling 2009; Bulte et al. 2008). They present a useful management alternative for environments that may not be suitable for PAs may not be appropriate due to resource dependent communities and are thus theoretically well suited to non-

OECD (Fisher, Turner, and Morling 2009). In contrast to the majority of conditional cash transfer schemes, PES is designed to benefit the supplier and the buyer, as well as any other ES beneficiary (Le Velly and Dutilly 2016).This creates opportunities for win-win outcomes where by involving local stakeholders these schemes create the option to try and achieve both social and environmental objectives (Fisher and Christopher 2007).

PES schemes can be applied at varying scales, (international, national, local) and can involve governments, companies and NGOs (Wunder 2015; Farley and Costanza 2010). Often touted as a “perfect” PES example, is the Vittel water shed PES scheme (Perrot-Maître 2006). After discovering that it’s water sources were becoming contaminated with nitrites resulting from nearby agricultural lands, the Vittel mineral water company set up a program in which farmers were paid to make their practices more sustainable (Perrot-Maître 2006; TEEB 2010; Bulte et al. 2008). Costa Rica has been labelled as a poster child for PES after developing the national “Pago por Servicios Ambientales” (PSA) scheme where landowners were rewarded for protecting forests and the services they provide (Locatelli, Imback, and Wunder 2014; Robalino and Pfaff 2013; Farley and Costanza 2010). The program has been praised for helping change perceptions of forests to something to be appreciated and reducing deforestation.

Controversy and critique

The monetary valuation of ES and related PES schemes has gained a lot of momentum over the past two decades (S. S. K. Scholte, van Teeffelen, and Verburg 2015; Lele et al. 2013; Cornell 2011). They have also attracted a lot of criticism and debate (McCauley 2006; Kosoy and Corbera 2010; Gomez-Baggethun and Ruiz-Perez 2011; Schröter et al. 2014). Concerns about the tool and its application are generally focussed around fears related commodification and potential ways in which the process might impact conservation (Friess and Thompson 2016; Kosoy and Corbera 2010; Gomez-Baggethun and Ruiz-Perez 2011). Commodification is the process by which resources (in this case ES) that would not previously be considered tradable are entered into the market domain and become considered as commodities (Kosoy and Corbera 2010; Gomez-Baggethun and Ruiz-Perez 2011). There are 4 stages to commodification, these do not need to happen in this order and do not necessarily happen one by one but provide an angle within which to examine the criticism related to the tool (Kosoy and Corbera 2010; Gomez-Baggethun and Ruiz-Perez 2011; Schröter et al. 2014)

The first stage of commodification involves the economic framing of resources that would not have previously been perceived in such a manner. With regards to the commodification of nature, this stage commences with the application of the ESC framework. Many authors have expressed concerns of multiple ethical issues with the ESC. Many believe the concept is overly anthropocentric, stating that a biocentrism (McCauley 2006; Redford and Adams 2009). Many also condemn the utilitarian framing of the concept stating that it fails to acknowledge ignore the important, intrinsic values of nature that are independent of our wellbeing (Sagoff 2008; McCauley 2006; Gomez-Baggethun and Ruiz-Perez 2011). Critics say that such a view will skew perceptions of the human-nature relationship and resultantly undermine moral reasoning for conservation in a way that may be counterproductive toward conservation efforts in the long run and further distancing people from nature (Kallis, Gómez-Baggethun, and Zografos 2013; Gomez-Baggethun and Ruiz-Perez 2011; McCauley 2006; Schröter et al. 2014).

The second stage involves the monetizing or pricing of said resources, which is achieved through the use of monetary valuation. Again, MVES raises various ethical arguments regarding what should and should not be sold, with some authors stating that the process blurs the line as to where valuation is and is not appropriate. There are fears that what may have been intended as a conservation tool may result in a practical guide on how to cash ES as commodities on markers (Erik Gómez-Baggethun et al. 2010). Kosoy and Corbera, (2010) argue that encouraging such a mind-set may result in the phenomena known as “commodity fetishism” causing ES to be considered ‘mere’ commodities, which could be counterproductive in conservation. Several authors also raise more practical concerns regarding the reliability or accuracy of monetary valuation techniques that some fear could be either over or under pricing (Kosoy and Corbera 2010; Gomez-Baggethun and Ruiz-Perez 2011; Schröter et al. 2014; Small, Munday, and Durance 2017).

The third stage, appropriation involves the assigning of property rights to land that may have previously been open access, public or communal property (Gomez-Baggethun and Ruiz-Perez 2011). Some fear that this could cause equity issues amongst stakeholders as this stage often comes coupled with privatisation (Costanza et al. 2014), which could leave resources accessible only to those with purchasing power and induce competition in societies previously structured upon community and reciprocity values (Gomez-Baggethun and Ruiz-Perez 2011).

The fourth stage involves commercialisation where markets are set up in which to trade these resources. The concerns raised regarding commercialisation of ES mirror those mentioned above. Additional concerns relate to the instability of markets and their vulnerability to exploitation. Some fear that ES markets could work against biodiversity conservation as efforts to maximise production or recreate function of ES may result in “homogeneity” amongst ecosystems (Kosoy and Corbera 2010; Leimona et al. 2015). Chee, (2004) argues that the level of supporting legislation and other prerequisites to successful markers are too much for commercialisation to even be possible (Laurans et al. 2013; Gomez-Baggethun and Ruiz-Perez 2011; Schröter et al. 2014).

1.7 Non-monetary valuation

The rapid rate with which monetary valuation was adopted into the political and academic arenas has largely over shadowed other forms of valuation and become considered the conventional approach (Kenter et al. 2015). The general term valuation is now associated with pricing ES rather than the broad process of applying values (Norgaard 2010; M. Christie et al. 2012). Some authors fear that this has blocked the potential for other social scientific methods (S. Scholte, van Teeffelen, and Verburg 2015). Monetary valuation is very illustrative but there are many services that are not easily translated into economic terms, which means they often get left out of traditional economic frameworks (Small, Munday, and Durance 2017; Chan et al. 2012, 2011). Yet, it is often these less tangible ecosystem services that shape societies, cultures, welfare, and often drive environmental change (Small, Munday, and Durance 2017). The ESC offers an interdisciplinary approach however when coupled solely with MVES the resulting findings and values are rather one-dimensional (Kenter et al. 2015). The CBD however encourages decision makers and researchers alike to the Parties consider *"economic, social, cultural, and ethical valuation in the development of relevant incentive measures*" (CBD 2003; E. Gómez-Baggethun et al. 2014). Non-monetary valuation (NMV) examines "the importance, preferences or demands expressed by people towards nature, and articulates plural values through different quantitative and qualitative measure other than money" (Chan *et kal.*, 2011; Kelemen *et al.*, 2014; Kenter *et al.*, 2015). NMV focuses on the human expressions of preferences, exploring the beliefs, motivations and socio-demographic factors that influence individual and social choices in ES management, which helps identify potential intervention points to present unsustainable practices (Small, Munday, and Durance 2017; Kenter et al. 2015; M. Christie et al. 2012; E. Gómez-Baggethun et al. 2014; Chan et al. 2012, 2011). These participatory approaches to environmental valuation and are becoming increasingly advocated as a way to include the multidimensionality of value within decision-making (Chan *et al.*, 2011, 2012; Christie *et al.*, 2012; Gómez-Baggethun *et al.*, 2014; Kenter *et al.*, 2015; Small, Munday and Durance, 2017).cThe methods by which to carry out NMV (i.e. surveys, interviews) involve, participatory and deliberative tools, such as focus groups, citizens juries, participatory or rapid rural appraisal (PRA/RRA), Delphi panels, etc.), as well as methods expressing preferences in non-monetary but quantifiable terms (i.e. preference assessment, time use studies, Q-methodology) (Kenter et al. 2015; M. Christie et al. 2012). It is important to remember that NMV methods are not meant to serve as an alternative, but rather as a complement to current, monetary forms of ES valuation for movements toward an integrated valuation framework (E. Gómez-Baggethun et al. 2014; S. Scholte, van Teeffelen, and Verburg 2015)

1.8 Project aims

The objective of this thesis was to the Ecosystem Service Concept and the Valuation of Ecosystem Services with regards to their application in mangrove ecosystems and examine the potential and limitations of this tool in implementing integrated approaches to mangrove management.

Chapter 2 Provides a review of all reports of monetary values to mangrove ecosystems or their services to identify potential trends and gaps and ultimately provide an update as to the state of said literature.

Chapter 3 Showcases the utilisation of social valuation in assessing the values of mangrove services to four coastal communities along the Caribbean Coast of Honduras. This study examines the perceptions of importance attributed to mangroves and their services in this region.

Chapter 4 provides a discussion of the results overall and their implications for use of this tool in mangrove management.

1.9 Bibliography

Abson, David J., and Mette Termansen. 2010. “Valuing Ecosystem Services in Terms of Ecological Risks and Returns.” *Conservation Biology* 25 (2): no-no. doi:10.1111/j.1523-1739.2010.01623.x.

Aburto-Oropeza, O., E. Ezcurra, G. Danemann, V. Valdez, J. Murray, and E. Sala. 2008. “Mangroves in the Gulf of California Increase Fishery Yields.” *Proceedings of the National Academy of Sciences of the United States of America* 105 (30): 10456–10459.

Adams, WM, Ros Aveling, and Dan Brockington. 2004. “Biodiversity Conservation and the Eradication of Poverty.” *Science* 306 (5699): 1146–49. doi:10.1126/science.1097920.

Allsopp, Mike H., Willem J. de Lange, Ruan Veldtman, AHM Görgens, and T Willems. 2008. “Valuing Insect Pollination Services with Cost of Replacement.” Edited by Andy Hector. *PLoS ONE* 3 (9). Cambridge University Press: e3128. doi:10.1371/journal.pone.0003128.

Alongi, Daniel M. 2002. “Present State and Future of the World’s Mangrove Forests.” *Environmental Conservation* 29 (3). Cambridge University Press: 331–49.

Anneboina, L., and K. Kavi Kumar. 2017. “Economic Analysis of Mangrove and Marine Fishery Linkages in India.” *Ecosystem Services* 24: 114–23.

Bandaranayake, W M. 1999. “Traditional and Medicinal Uses of Mangroves.” *Mangroves and Salt Marshes* 2 (3). Kluwer Academic Publishers: 133–48.

Barbier, E. 2007. “Valuing Ecosystem Services as Productive Inputs.” *Economic Policy* 22 (49): 177–229.

Barbier, E., S. Hacker, C. Kennedy, E. Kock, A. Stier, and Brian R. 2011. “The Value of Estuarine and Coastal Ecosystem Services.” *Ecological Monographs* 81 (2). Ecological Society of America: 169–93.

Barbier, Edward B., Evamaria W. Koch, Brian R. Silliman, Sally D. Hacker, Eric Wolanski, Jurgenne Primavera, Elise F. Granek, et al. 2008. “Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values - Supporting Material.” *Science (New York, N.Y.)* 319 (5861): 321–23. doi:10.1126/science.1150349.

Bateman, Ian J, Amii R Harwood, Georgina M Mace, Robert T Watson, David J Abson, Barnaby Andrews, Amy Binner, et al. 2013. “Bringing Ecosystem Services into Economic Decision-Making: Land Use in the United Kingdom.” *Science (New York, N.Y.)* 341 (6141): 45–50. doi:10.1126/science.1234379.

Bavel, J Van. 2013. “The World Population Explosion: Causes, Backgrounds and -Projections for the Future.” *Facts, Views & Vision in ObGyn* 5 (4). Vlaamse Vereniging voor Obstetrie en Gynaecologie: 281–91.

Blanco-Libreros, J., and E. Estrada-Urrea. 2015. “Mangroves on the Edge: Anthrome-Dependent Fragmentation Influences Ecological Condition (Turbo, Colombia, Southern Caribbean).” *Diversity* 7 (3). Multidisciplinary Digital Publishing Institute: 206–28.

Bonilla-Moheno, Martha, and Eduardo García-Frapolli. 2012. “Conservation in Context: A Comparison of Conservation Perspectives in a Mexican Protected Area.” *Sustainability* 4 (9): 2317–33. doi:10.3390/su4092317.

Braat, Leon C., and Rudolf de Groot. 2012. “The Ecosystem Services Agenda:bridging the Worlds of Natural Science and Economics, Conservation and Development, and Public and Private

Policy." *Ecosystem Services* 1 (1). Elsevier: 4–15. doi:10.1016/j.ecoser.2012.07.011.

Brander, L., A. Wagtendonk, S. Hussain, A. McVittie, P. Verburg, R. de Groot, and S. van der Ploeg. 2012. "Ecosystem Service Values for Mangroves in Southeast Asia: A Meta-Analysis and Value Transfer Application." *Ecosystem Services* 1 (1). Elsevier: 62–69.

Bulte, E, L Lipper, R Stringer, and D Zilberman. 2008. "Payments for Ecosystem Services and Poverty Reduction: Concepts, Issues, and Empirical Perspectives." *Environment and Development Economics* 13 (3). Cambridge University Press: 245–54.

Carter, H., S. Schmidt, and A. Hirons. 2015. "An International Assessment of Mangrove Management: Incorporation in Integrated Coastal Zone Management." *Diversity* 7 (2): 74–104. CBD. 2003. *Handbook of the Convention on Biological Diversity*. *Biological Conservation*. Vol. 114. Taylor and Francis.

Chan, Kai M. A., Joshua Goldstein, Terre Satterfi, Neil Hannahs, Kekuewa Kikiloi, Robin Naidoo, Nathan Vadeboncoeur, and Ulalia Woodside. 2011. "Cultural Services and Non-Use Values." In *Natural Capital: Theory and Practice of Mapping Ecosystem Services*, 206–28. Oxford University Press. doi:10.1093/acprof:oso/9780199588992.003.0012.

Chan, Kai M. A., Anne D. Guerry, Patricia Balvanera, Sarah Klain, Terre Satterfield, Xavier Basurto, Ann Bostrom, et al. 2012. "Where Are Cultural and Social in Ecosystem Services? A Framework for Constructive Engagement." *BioScience* 62 (8): 744–56. doi:10.1525/bio.2012.62.8.7.

Chapin, F., E. Zavaleta, V. Eviner, R. Naylor, P. Vitousek, H. Reynolds, D. Hooper, et al. 2000. "Consequences of Changing Biodiversity." *Nature* 405 (6783): 234–42.

Chapman, V. J. 1984. "Mangrove Biogeography." In *Hydrobiology of the Mangal*, edited by F. Por and I. Dor, 15–24. Junk Publishers.

Chee, Y E. 2004. "An Ecological Perspective on the Valuation of Ecosystem Services." *Biological Conservation* 120 (4): 549–65. doi:10.1016/j.biocon.2004.03.028.

Christie, Mike, Ioan Fazey, Rob Cooper, Tony Hyde, and Jasper O Kenter. 2012. "An Evaluation of Monetary and Non-Monetary Techniques for Assessing the Importance of Biodiversity and Ecosystem Services to People in Countries with Developing Economies." *Ecological Economics*. doi:10.1016/j.ecolecon.2012.08.012.

Christie, P. 2004. "Marine Protected Areas as Biological Successes and Social Failures in Southeast Asia." *American Fisheries Society* 42: 155–64.

Cornell, Sarah. 2011. "The Rise and Rise of Ecosystem Services: Is 'value' the Best Bridging Concept between Society and the Natural World?" In *Procedia Environmental Sciences*, 6:88–95. Elsevier. doi:10.1016/j.proenv.2011.05.009.

Costanza, R., R. D'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, et al. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* 387 (6630): 253–60.

Costanza, R., S. Farber, and J. Maxwell. 1989. "Valuation and Management of Wetland Ecosystems." *Ecological Economics* 1 (4): 335–61. doi:10.1016/0921-8009(89)90014-1.

Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S. Anderson, I. Kubiszewski, S. Farber, and R. Turner. 2014. "Changes in the Global Value of Ecosystem Services." *Global Environmental Change* 26: 152–58.

Daily, Gretchen C. 1997. *Nature's Services: Societal Dependence on Natural Ecosystems*. Vol. 1. Island Press, Washington, DC.

Daily, Gretchen C, Stephen Polasky, Joshua Goldstein, Peter M Kareiva, Harold A Mooney, Liba Pejchar, Taylor H Ricketts, James Salzman, and Robert Shallenberger. 2009. "Ecosystem Services in Decision Making: Time to Deliver." *Frontiers in Ecology and the Environment* 7 (1). Ecological Society of America: 21–28. doi:10.1890/080025.

Das, S, and AS Crépin. 2013. "Mangroves Can Provide Protection against Wind Damage during Storms." *Estuarine, Coastal and Shelf Science* 134 (1): 98–107.

Dirzo, Rodolfo, and Peter H Raven. 2003. "Global State of Biodiversity and Loss." *Annual Review of Environment and Resources* 28 (1): 137–67. doi:10.1146/annurev.energy.28.050302.105532.

Dixon, John A., Glenys Owen Miller, and Lawrence S. Hamilton. 1989. "Mangrove Forests: An Undervalued Resource of the Land and of the Sea." *Ocean Yearbook Online* 8 (1). Brill: 254–88. doi:10.1163/221160089X00146.

Donato, D., J. Kauffman, D. Murdiyarso, S. Kurnianto, M. Stidham, and M. Kanninen. 2011. "Mangroves among the Most Carbon-Rich Forests in the Tropics." *Nature Geosci* 4 (5). Nature Publishing Group: 293–97.

Duke, N. 1992a. "Mangrove Floristics and Biogeography." *Tropical Mangrove Systems* 41: 63–100.

———. 1992b. *Tropical Mangrove Ecosystems*. Edited by A. I. Robertson and D. M. Alongi. Vol. 41. Coastal and Estuarine Studies. Washington, D. C.: American Geophysical Union. doi:10.1029/CE041.

Duke, N., M. Ball, and J. Ellison. 1998. "Factors Influencing Biodiversity and Distributional Gradients in Mangroves." *Global Ecology and Biogeography Letters* 7 (1). Wiley: 27–47. doi:10.2307/2997695.

Duke, N., J. Meynecke, S. Dittmann, A. Ellison, K. Anger, U. Berger, S. Cannicci, et al. 2007. "A World Without Mangroves ?" *Science* 317: 41–43.

Duke, N., and K. Schmitt. 2016. "Mangroves: Unusual Forests at the Seas' Edge." In *Tropical Forestry Handbook, Second Edition*, 2:1693–1724. Berlin, Heidelberg: Springer Berlin Heidelberg.

Ehrlich, Paul R, and Harold A Mooney. 1983. "Extinction, Substitution, and Ecosystem Services." *Source: BioScience* 33 (4): 248–54.

Farley, Joshua. 2008. "The Role of Prices in Conserving Critical Natural Capital." *Conservation Biology*. doi:10.1111/j.1523-1739.2008.01090.x.

———. 2012. "Ecosystem Services: The Economics Debate." *Ecosystem Services* 1 (1): 40–49. doi:10.1016/j.ecoser.2012.07.002.

Farley, Joshua, and Robert Costanza. 2010. "Payments for Ecosystem Services: From Local to Global." *Ecological Economics* 69 (11): 2060–68.

Feller, Ilka C., Dennis F. Whigham, Karen L. McKee, and Catherine E. Lovelock. 2003. "Nitrogen Limitation of Growth and Nutrient Dynamics in a Disturbed Mangrove Forest, Indian River Lagoon, Florida." *Oecologia* 134 (3): 405–14. doi:10.1007/s00442-002-1117-z.

Fisher, Brendan, and Treg Christopher. 2007. "Poverty and Biodiversity: Measuring the Overlap of Human Poverty and the Biodiversity Hotspots." *Ecological Economics* 62 (1): 93–101. doi:10.1016/j.ecolecon.2006.05.020.

Fisher, Brendan, Kerry Turner, Matthew Zylstra, Roy Brouwer, Rudolf De Groot, Stephen Farber, Paul Ferraro, et al. 2008. "Ecosystem Services and Economic Theory: Integration for Policy-Relevant Research." *Ecological Applications* 18 (8): 2050–67.

Fisher, Brendan, R. Kerry Turner, and Paul Morling. 2009. “Defining and Classifying Ecosystem Services for Decision Making.” *Ecological Economics* 68 (3): 643–53. doi:10.1016/j.ecolecon.2008.09.014.

Folke, C. 2006. “Resilience: The Emergence of a Perspective for Social-Ecological Systems Analyses.” *Global Environmental Change* 16 (3). Pergamon: 253–67.

Friess, Daniel A., and Benjamin S. Thompson. 2016. “Mangrove Payments for Ecosystem Services (PES): A Viable Funding Mechanism for Disaster Risk Reduction?” In , 75–98. Springer International Publishing. doi:10.1007/978-3-319-43633-3_4.

Giri, C., E. Ochieng, L. L. Tieszen, Z. Zhu, A. Singh, T. Loveland, J. Masek, and N. Duke. 2011. “Status and Distribution of Mangrove Forests of the World Using Earth Observation Satellite Data.” *Global Ecology and Biogeography* 20 (1): 154–59.

Godoy, Mario D.P., and Luiz D. de Lacerda. 2015. “Mangroves Response to Climate Change: A Review of Recent Findings on Mangrove Extension and Distribution.” *Anais Da Academia Brasileira de Ciências* 87 (2). Academia Brasileira de Ciências: 651–67.

Gómez-Baggethun, E., B Martín-López, D Barton, L Braat, H Saarikoski, E Kelemen, M García-Llorente, et al. 2014. “State-of-the-Art Report on Integrated Valuation of Ecosystem Services.” *European Commission FP7*.

Gomez-Baggethun, E., and M. Ruiz-Perez. 2011. “Economic Valuation and the Commodification of Ecosystem Services.” *Progress in Physical Geography*, 1–16. doi:10.1177/0309133311421708.

Gómez-Baggethun, Erik, Rudolf de Groot, Pedro L. Lomas, and Carlos Montes. 2010. “The History of Ecosystem Services in Economic Theory and Practice: From Early Notions to Markets and Payment Schemes.” *Ecological Economics* 69 (6). Elsevier B.V.: 1209–18. doi:10.1016/j.ecolecon.2009.11.007.

Groot, Rudolf de, Luke Brander, Sander van der Ploeg, Robert Costanza, Florence Bernard, Leon Braat, Mike Christie, et al. 2012. “Global Estimates of the Value of Ecosystems and Their Services in Monetary Units.” *Ecosystem Services* 1 (1): 50–61.

Gunawardena, M., and J. S. Rowan. 2005. “Economic Valuation of a Mangrove Ecosystem Threatened by Shrimp Aquaculture in Sri Lanka.” *Environmental Management* 36 (4): 535–50.

Hardin, G. 1968. “The Tragedy of the Commons.” *Science* 162 (3859). American Association for the Advancement of Science: 1243–48.

Hlaváčková, P., and C. Palaghianu. 2015. “Differences in the Natural Areas Protection in the Czech Republic and Romania: A Socioeconomic View.” *Public Recreation and Landscape Protection*.

Hogarth, Peter J. 2015. *The Biology of Mangroves and Seagrasses*. Oxford University Press.

Hughes, Ross., and Fiona. Flintan. 2001. *Integrating Conservation and Development Experience : A Review and Bibliography of the ICDP Literature. International Institute for Environment and Development*. Vol. 3. International Institute for Environment and Development.

Hussain, S., and R. Badola. 2005. “Valuing Ecosystem Functions: An Empirical Study on the Storm Protection Function of Bhitarkanika Mangrove Ecosystem, India.” *Environmental Conservation* 32 (1): 85–92. doi:10.1017/S0376892905001967.

———. 2008. “Valuing Mangrove Ecosystem Services: Linking Nutrient Retention Function of Mangrove Forests to Enhanced Agroecosystem Production.” *Wetlands Ecology and Management* 16 (6): 441–50. doi:10.1007/s11273-008-9080-z.

———. 2010. “Valuing Mangrove Benefits: Contribution of Mangrove Forests to Local Livelihoods in Bhitarkanika Conservation Area, East Coast of India.” *Wetlands Ecology and Management*.

Huxham, M, L Emerton, and J Kairo. 2015. “Applying Climate Compatible Development and Economic Valuation to Coastal Management: A Case Study of Kenya’s Mangrove Forests.” *Journal of Environmental …*.

IPBES. 2016. “Pollinators Vital to Our Food Supply Under Threat.”

Jiao, Nian-Zhi, Da-Ke Chen, Yong-Ming Luo, Xiao-Ping Huang, Rui Zhang, Hai-Bo Zhang, Zhi-Jian Jiang, and Fei Zhang. 2015. “Climate Change and Anthropogenic Impacts on Marine Ecosystems and Countermeasures in China.” *Advances in Climate Change Research* 6 (2). Elsevier: 118–25. doi:10.1016/j.accre.2015.09.010.

Johnson, M C, M Poulin, and M Graham. 2003. “Towards an Integrated Approach to the Conservation and Sustainable Use of Biodiversity: Lessons Learned from the Rideau River Biodiversity Project.” *Human Ecology Forum* 10 (1): 40–55.

Kallis, Giorgos, Erik Gómez-Baggethun, and Christos Zografos. 2013. “To Value or Not to Value? That Is Not the Question.” *Ecological Economics* 94: 97–105. doi:10.1016/j.ecolecon.2013.07.002.

Kathiresan, K., and B.L. Bingham. 2001. “Biology of Mangroves and Mangrove Ecosystems.” *Advances in Marine Biology* 40: 81–251. doi:10.1016/S0065-2881(01)40003-4.

Kelemen, Eszter, Marina García-Llorente, György Pataki, Berta Martín-López, and Erik Gómez-Baggethun. 2014. “Non-Monetary Techniques for the Valuation of Ecosystem Services.” In *OpenNESS Reference Book.*, 1–4.

Kenter, Jasper O, Liz O’Brien, Neal Hockley, Neil Ravenscroft, Ioan Fazey, Katherine N Irvine, Mark S Reed, et al. 2015. “What Are Shared and Social Values of Ecosystems?” *Ecological Economics* 111: 86–99. doi:10.1016/j.ecolecon.2015.01.006.

Kosoy, Nicolás, and Esteve Corbera. 2010. “Payments for Ecosystem Services as Commodity Fetishism.” *Ecological Economics* 69 (6). Elsevier: 1228–36.

Krauss, Ken W., Karen L. McKee, Catherine E. Lovelock, Donald R. Cahoon, Neil Saintilan, Ruth Reef, and Luzhen Chen. 2014. “How Mangrove Forests Adjust to Rising Sea Level.” *The New Phytologist* 202 (1): 19–34. doi:10.1111/nph.12605.

Kretsch, Conor, Jiska van Dijk, and Christian Schleyer. 2016. “Public Goods and Ecosystem Services.” *OpenNESS Ecosystem Services Reference Book* 1: 1–7.

Lal, Padma. 2003. “Economic Valuation of Mangroves and Decision-Making in the Pacific.” *Ocean and Coastal Management*.

Lant, Christopher L, J B Ruhl, and Steven E Kraft. 2008. “The Tragedy of Ecosystem Services.” *BioScience* 58 (10): 969–74. doi:10.1641/B581010.

Laurans, Yann, Aleksandar Rankovic, Raphaël Billé, Romain Pirard, and Laurent Mermet. 2013. “Use of Ecosystem Services Economic Valuation for Decision Making: Questioning a Literature Blindspot.” *Journal of Environmental Management* 119: 208–19. doi:10.1016/j.jenvman.2013.01.008.

Leimona, B, M van Noordwijk, R de Groot, and R Leemans. 2015. “Fairly Efficient, Efficiently Fair: Lessons from Designing and Testing Payment Schemes for Ecosystem Services in Asia.” *Ecosystem Services* 12. Elsevier: 16–28.

Lele, S, O Springate-Baginski, R Lakerveld, D Deb, and P Dash. 2013. “Ecosystem Services: Origins, Contributions, Pitfalls, and Alternatives.” *Conservation and Society* 11 (4): 343–58. doi:10.4103/0972-4923.125752.

Likens, Gene E., and David B. Lindenmayer. 2012. “Integrating Approaches Leads to More Effective Conservation of Biodiversity.” *Biodiversity and Conservation* 21 (13). Springer Netherlands: 3323–41. doi:10.1007/s10531-012-0364-5.

Lo, E., N. Duke, and M. Sun. 2014. “Phylogeographic Pattern of Rhizophora (Rhizophoraceae) Reveals the Importance of Both Vicariance and Long-Distance Oceanic Dispersal to Modern Mangrove Distribution.” *BMC Evolutionary Biology* 14 (1). BioMed Central: 83.

Locatelli, B, P Imback, and S Wunder. 2014. “Synergies and Trade-Offs between Ecosystem Services in Costa Rica.” *Environmental Conservation* 41 (1): 27–36.

Ludwig, Donald. 2000. “Limitations of Economic Valuation of Ecosystems.” *Ecosystems*.

Lugo, A., and S. Snedaker. 1974. “The Ecology of Mangroves.” *Annual Review of Ecology and Systematics*.

Luther, David A., and Russell Greenberg. 2009. “Mangroves: A Global Perspective on the Evolution and Conservation of Their Terrestrial Vertebrates.” *BioScience* 59 (7). Oxford University Press: 602–12. doi:10.1525/bio.2009.59.7.11.

McCauley, D. 2006. “Selling out on Nature.” *Nature* 443 (7107): 27–28. doi:10.1038/443027a.

MEA. 2005. “Ecosystems and Human Well-Being.” *Island Press, Washington, DC*. Vol. 5. doi:10.1196/annals.1439.003.

Milcu, Andra Ioana, Jan Hanspach, David Abson, and Joern Fischer. 2013. “Cultural Ecosystem Services: A Literature Review and Prospects for Future Research.” *Ecology and Society* 18 (3). The Resilience Alliance: art44. doi:10.5751/ES-05790-180344.

Muhumuza, Moses, and Kevin Balkwill. 2013. “Factors Affecting the Success of Conserving Biodiversity in National Parks: A Review of Case Studies from Africa.” *International Journal of Biodiversity* 2013. Hindawi Publishing Corporation: 1–20. doi:10.1155/2013/798101.

Norgaard, R. 2010. “Ecosystem Services: From Eye-Opening Metaphor to Complexity Blinder.” *Ecological Economics* 69 (6): 1219–27.

Norton-Griffiths, Michael, and Clive Southey. 1995. “The Opportunity Costs of Biodiversity Conservation in Kenya.” *Ecological Economics Ecological Economics Ecological Economics* 12 (12): 125–39.

Perrot-Maître, Danièle. 2006. “The Vittel Payments for Ecosystem Services: A " Perfect " PES Case? The Vittel Payments for Ecosystem Services: A " Perfect " PES Case? The Vittel Payments for Ecosystem Services: A " Perfect " PES Case?”

Pimm, S L, C N Jenkins, R Abell, T M Brooks, J L Gittleman, L N Joppa, P H Raven, C M Roberts, and J O Sexton. 2014. “The Biodiversity of Species and Their Rates of Extinction, Distribution, and Protection.” *Science (New York, N.Y.)* 344 (6187): 1246752. doi:10.1126/science.1246752.

Primavera, J. 1997. “Socio-Economic Impacts of Shrimp Culture.” *Aquaculture Research* 28 (10): 815–27.

Redford, Kent H., and William M. Adams. 2009. “Payment for Ecosystem Services and the Challenge of Saving Nature: Editorial.” *Conservation Biology*, August 1. doi:10.1111/j.1523-1739.2009.01271.x.

Reed, James, Josh Van Vianen, Elizabeth L. Deakin, Jos Barlow, and Terry Sunderland. 2016.

"Integrated Landscape Approaches to Managing Social and Environmental Issues in the Tropics: Learning from the Past to Guide the Future." *Global Change Biology* 22 (7): 2540–54. doi:10.1111/gcb.13284.

Reed, Mark S, Evan D G Fraser, and Andrew J Dougill. 2006. "An Adaptive Learning Process for Developing and Applying Sustainability Indicators with Local Communities." *Ecological Economics* 59 (4): 406–18. doi:10.1016/j.ecolecon.2005.11.008.

Robalino, J, and A Pfaff. 2013. "Ecopayments and Deforestation in Costa Rica: A Nationwide Analysis of PSA's Initial Years." *Land Economics* 89 (July 2015): 432–48.

Rönnbäck, Patrik. 1999. "The Ecological Basis for Economic Value of Seafood Production Supported by Mangrove Ecosystems." *Ecological Economics* 29 (2): 235–52.

Ruitenbeek, J. 1994. "Modelling Economy-Ecology Linkages in Mangroves: Economic Evidence for Promoting Conservation in Bintuni Bay, Indonesia." *Ecological Economics* 10 (3): 233–47. doi:10.1016/0921-8009(94)90111-2.

Sagoff, M. 2008. "On the Economic Value of Ecosystem Services." *Environmental Values* 17 (2). White Horse Press: 239–57.

Salem, Marwa E., and D. Evan Mercer. 2012. "The Economic Value of Mangroves: A Meta-Analysis." *Sustainability* 4 (3): 359–83. doi:10.3390/su4030359.

Schmitt, K., and N. Duke. 2014. "Tropical Forestry Handbook," 1–29.

Scholte, Samantha S.K., Astrid J.A. van Teeffelen, and Peter H. Verburg. 2015. "Integrating Socio-Cultural Perspectives into Ecosystem Service Valuation: A Review of Concepts and Methods." *Ecological Economics* 114: 67–78. doi:10.1016/j.ecolecon.2015.03.007.

Scholte, S, A. van Teeffelen, and P. Verburg. 2015. "Integrating Socio-Cultural Perspectives into Ecosystem Service Valuation: A Review of Concepts and Methods." *Ecological Economics*.

Schröter, Matthias, Emma H. van der Zanden, Alexander P.E. E van Oudenhoven, Roy P. Remme, Hector M. Serna-Chavez, Rudolf S. de Groot, and Paul Opdam. 2014. "Ecosystem Services as a Contested Concept: A Synthesis of Critique and Counter-Arguments." *Conservation Letters* 7 (6): 514–23.

Schumacher, E F. 1973. "Small Is Beautiful: Economics as If People Mattered." *Technology* 9 (1). Blond and Briggs: 277–88.

Shorb, Cameron Meyer. 2016. "Top-Down, Bottom-Up, or Something in Between? Relative Efficacy of Efforts to Reduce Bushmeat Poaching in the Democratic Republic of the Congo." *Undergraduate Journal of Humanistic Studies @BULLET Spring* 3.

Small, N, M Munday, and I Durance. 2017. "The Challenge of Valuing Ecosystem Services That Have No Material Benefits." *Global Environmental Change* 44: 57–67. doi:10.1016/j.gloenvcha.2017.03.005.

Soulé, M. E. 1985. "What Is Conservation Biology?" *BioScience* 35 (11): 727–34. doi:10.2307/1310054.

Spalding, Mark. 2010. *World Atlas of Mangroves*. Routledge.

Spaninks, Frank, and Pieter Van Beukering. 1997. "Economic Valuation of Mangrove Ecosystems: Potential and Limitations." *CREED Working Paper*, no. 14.

Sukhdev, P. 2008. "The Economics of Ecosystems and Biodiversity: An Interim Report." In *European Communities*, edited by P. Kumar, 64. London and Washington. doi:10.1093/erae/jbr052.

TEEB. 2010. "The Economics of Ecosystems and Biodiversity : Ecological and Economic

Foundations." Earthscan.

Thomas, Nathan, Richard Lucas, Peter Bunting, Andrew Hardy, Ake Rosenqvist, and Marc Simard. 2017. "Distribution and Drivers of Global Mangrove Forest Change, 1996-2010." Edited by Shijo Joseph. *PLoS ONE* 12 (6). Food and Agriculture Organization of the United Nations: e0179302. doi:10.1371/journal.pone.0179302.

Tomlinson, Philip. 1986. *The Botany of Mangroveshe*.

UNEP. 2014. *The Importance of Mangroves to People: A Call to Action*. *United Nations Environment Programme World Conservation Monitoring Centre.*

Valiela, Ivan, Jennifer Bowen, and Joanna. York. 2001. "Mangrove Forests: One of the World's Threatened Major Tropical Environments." *BioScience*.

Vanbergen, Adam J. 2013. "Threats to an Ecosystem Service: Pressures on Pollinators." *Frontiers in Ecology and the Environment* 11 (5). Ecological Society of America: 251–59. doi:10.1890/120126.

Velly, Gwenolé Le, and Céline Dutilly. 2016. "Evaluating Payments for Environmental Services: Methodological Challenges." Edited by Asim Zia. *PLoS ONE*. Public Library of Science.

Vo, Quoc Tuan, C. Kuenzer, Quang Minh Vo, F. Moder, and N. Oppelt. 2012. "Review of Valuation Methods for Mangrove Ecosystem Services." *Ecological Indicators*.

Vo, TQ, C Kuenzer, and N Oppelt. 2015. "How Remote Sensing Supports Mangrove Ecosystem Service Valuation: A Case Study in Ca Mau Province, Vietnam." *Ecosystem Services* 14: 67–75.

Wake, David B, and Vance T Vredenburg. 2008. "Are We in the Midst of the Sixth Mass Extinction? A View from the World of Amphibians." *Proceedings of the National Academy of Sciences of the United States of America* 105 (suppl. 1): 11466–73. doi:10.1073/pnas.0801921105.

Walters, B., P. Rönnbäck, J. Kovacs, B. Crona, S. Hussain, R. Badola, J. Primavera, E. Barbier, and F. Dahdouh-Guebas. 2008. "Ethnobiology, Socio-Economics and Management of Mangrove Forests: A Review." *Aquatic Botany* 89 (2): 220–36.

Ward, Raymond D., Daniel A. Friess, Richard H. Day, and Richard A. MacKenzie. 2016. "Impacts of Climate Change on Mangrove Ecosystems: A Region by Region Overview." *Ecosystem Health and Sustainability* 2 (4): 1–25. doi:10.1002/ehs2.1211.

Williams, John N. 2013. "Humans and Biodiversity: Population and Demographic Trends in the Hotspots Humans and Biodiversity: Population and Demographi Trends in the Hotspots." *Source: Population and Environment Popul Environ* 34 (34). doi:10.1007/sl.

Wilson, C, and Matthews. 1970. *Man's Impact on the Global Environment; Assessment and Recommendations for Action; Report*. *Report of the Study of Critical Environment Problems (SCEP) 1970. Cambridge Massachusetts MIT Press 1970. 319 P*.

Wunder, Sven. 2006. "Payments for Environmental Services: Some Nuts and Bolts."

———. 2015. "Revisiting the Concept of Payments for Environmental Services." *Ecological Economics* 117 (September). Elsevier: 234–43.

Zhao, S., and C. Wu. 2013. "Valuation of Mangrove Ecosystem Services Based on Emergy: A Case Study in China." *International Journal of Environmental Science and Technology* 12 (3): 967–74. doi:10.1007/s13762-013-0458-y.

Chapter 2

The monetary valuation of mangrove services: A review of the literature

Abstract

Mangroves are becoming increasingly recognized as highly productive ecosystems, delivering a variety of services vital in supporting coastal communities, national economies and adjacent ecosystems. The monetary valuation of ecosystem services (MVES) has become a popular means of communicating the importance of ecosystems to society. Over the past decade use of MVES has gained considerable momentum, and several studies have reported its use in mangrove systems. Here we provide an extensive review of publications reporting monetary values mangrove forests and services, examining the prevalence of MVES in the literature, geographical locations of the sites studied, types of services described, the methods used and the ways in MVES has been employed. This review provides aims to update our knowledge of MVES used in mangroves and to supplement information collected in earlier meta-analyses. Here we identify gaps in our knowledge concerning the mangroves of Africa and the Americas and our knowledge of cultural mangrove services. The gaps highlighted in this study are discussed in light of limitations to MVES as a tool as discussed in the wider valuation literature.

2.1 Introduction

Mangrove forests are defined as a collection of woody, salt-tolerant trees and shrubs that occur on tropical and subtropical coastlines, approximately 30N and 30S of the equator (Tomlinson 1994; Mark Spalding 2010; Hogarth 2015). The global extent of mangrove coverage is estimated at 137,760km^2 (Giri et al. 2011) and is distributed amongst 123, primarily developing countries however approximately 75% of this is distributed amongst just 15 (Mark Spalding 2010; Carter, Schmidt, and Hirons 2015). The mangrove forests that inhabit the Asian continent account for approximately 42% of global cover (Giri et al. 2011). The Americas and the Caribbean then possess the second greatest extent of cover (26%) followed by Africa (20%) and Oceania (12%) (Giri et al. 2011). Global distribution is split between two distinct biogeographical regions of occurrence; The Indo-west pacific (IWP) and the Atlantic-Caribbean-East-Pacific (AECP) (Duke 1992) differing primarily in their species diversity (IWP; ~65 species of 23 genera: AEP; ~15 species of 8 genera) (Duke, Ball, and Ellison 1998; Lo, Duke, and Sun 2014). Mangroves in the IWP region are distributed amongst Asia, Australia, Oceania and the Eastern coast of Africa where as AECP region constitutes the Americas and the West coast of Africa (Duke 1992; Mark Spalding 2010; Hogarth 2015). Until relatively recently mangrove forests were widely considered as unimportant wastelands (Lugo and Snedaker 1974; Lugo, Medina, and McGinley 2014; E. Barbier, Strand, and Sathirathai 2002), however they are becoming increasingly recognized (Mark Spalding 2010) as one of the world’s most productive ecosystems, capable of delivering a variety of services, vital in supporting coastal communities (Walters et al. 2008; Hussain and Badola 2010; Abdullah, Said, and Omar 2014), national economies (Costanza et al. 1997) and adjacent ecosystems (Mumby et al. 2004; Nagelkerken et al. 2008; Anneboina and Kavi Kumar 2017).

As is the case for all ecosystems, the existence of mangrove forests depends on their capacity to undergo and maintain the flow of various ecological functions and processes, that provide benefits to and support constituent species and associated ecosystems (Alho 2008). Many of said benefits extend to human populations and have provided the foundation for our societies. What makes mangrove forests unique however is the sheer scale to which said benefits extend, because as a secondary effect of their maintenance, mangroves (independent of its associated ecosystems) are believed to support and benefit upward of 210million people (UNEP 2014). The means by which these benefits are delivered to humans by nature are becoming increasingly referred to as ecosystem services (ES) a term of utilitarian connotations (Small, Munday, and Durance 2017; Fisher, Turner, and Morling 2009; Lele et al. 2013), designed to demonstrate and communicate human dependency on nature and highlight societal support by ecosystems (Daily 1997; Braat and de Groot 2012). Of course acknowledgement of the human-nature relationship is nothing new (Ingram, Redford, and Watson 2012), however the origins of the modern Ecosystem Service Concept (ESC) date back to the 1970s (Wilson and Matthews 1970; P. R. Ehrlich and Mooney 1983). Seminal works by Daily (1997) and Costanza *et al.*, (1997) fostered significant interest in the concept and today the concept has become widely adopted into academic and political arenas as a framework with which to approach issues of resource management and environmental conservation (Lele et al. 2013; Ingram, Redford, and Watson 2012; Polasky, Tallis, and Reyers 2015; Kull, de Sartre, and Castro-Larranaga 2015). The concept was a fundamental component of the Millennium Ecosystem Assessment released in 2005 (MEA 2005; Watson et al. 2005) where it reached a wider audience and gained attentions from being used by scientists, policy makers and practitioners alike (Lele et al. 2013). Under the MEA (2005) framework, ES were categorized into provisioning, supporting, regulating and cultural services (MEA 2005).

Research concerning mangroves has gained considerable momentum in recent years (Lee et al. 2014), and it has become increasingly acknowledged that mangroves provide a variety of provisioning (e.g. timber, medicines and multiple-use fisheries; (Bandaranayake 1999; Walters et al. 2008; Aburto-Oropeza et al. 2008), regulation (e.g. storm protection, erosion control, climate (Donato et al. 2011; Das and Crépin 2013; E. Barbier et al. 2011); support (e.g. nutrient cycling; (Hussain and Badola 2008; Feller et al. 2003) and cultural services (recreational, aesthetic and spiritual; (Queiroz et al. 2017) which support both adjacent ecosystems (Harborne et al. 2006) and coastal communities (Walters et al. 2008). Despite their ecological, social and economic significance however mangrove loss is occurring at rates that exceed the losses of tropical rainforests and coral reefs (Valiela, Bowen, and York 2001). Globally, mangroves are becoming increasingly threatened by human encroachment and associated anthropogenic pressures (Lugo 2002; Thomas et al. 2017). The primary threats facing these forests are mass conversion to alternative land uses (e.g. for aquaculture, agriculture, coastal development) and the unsustainable use of their resources (Alongi 2002; Polidoro et al. 2010; Thomas et al. 2017). These threats are further added to by increasing anthropocentric pressures and potential effects of climate-change (Ward et al. 2016; Krauss et al. 2014).

‘Undervaluation’, or our failure to recognize the true value of mangroves or is thought to be an underlying driver of their decline (Dixon, Miller, and Hamilton 1989; Huxham, Emerton, and Kairo 2015; Rönnbäck 1999; E. B. Barbier et al. 2008). The services mangroves provide, are often considered to be “public goods” which are characterised by (1) the inability to exclude stakeholders from their benefits and (2) that use of said benefits by one stakeholder does not reduce the benefits received by the next (de Groot et al. 2012; Brander et al. 2012). Development decisions are often made within a financial framework, using tools such as cost-benefit analyses (CBA) that look to maximise net-(economic) benefit (Farley 2008). Public goods possess values that exist outside of this framework, inconsistent with the valuation norms used in traditional markets (Costanza et al. 1997; TEEB 2010). Public good characteristics thus present problems for mangroves when they are being compared to land-use alternatives as these values are often ignored or forgotten in public decision making (Costanza et al. 1997; E. Barbier 2007; J. Ruitenbeek 1994; Hoang Tri, Adger, and Kelly 1998). This leaves ecosystems like mangroves unfairly represented, and thus undervalued against opportunities that promise the more tangible prospect of economic gain (Costanza et al. 1997; TEEB 2010). As a result, mangroves become vulnerable to conversion to land use alternatives such as shrimp farms, agricultural lands or coastal development (E. Barbier 2007; Rönnbäck 1999).

Discussions of undervaluation as a driver of ecosystem decline has prompted response by economists to develop a suite of techniques with which to assign monetary values to ES (Spaninks and Beukering 1997; Chee 2004; Costanza et al. 2014; Daily 1997), an approach called the “monetary or economic valuation of ecosystem services” (MVES). The tool (MVES) finds justification in that the translation of ES value into monetary terms could aid in communicating their importance to society and thus foster proper accounting for ecosystem loss and help in better allocation of management resources (Farley 2008, 2012; Daily et al. 2009; de Groot et al. 2012). An extension of the ESC, this tool and the ESC framework both gained considerable momentum following an attempt Costanza et al. (1997) to derive a global value of ES. causing a surge of interest in ESV and attempts by many to develop and refine the concept and associated techniques (Chee 2004; Vo et al. 2012). Typically, the economic valuation of ecosystems is carried out using a total economic valuation framework (TEV) where the direct and indirect use values of ecosystem services are calculated, along with and the non-use values of said system and aggregated to give an overarching monetary value (Spaninks and Beukering 1997; de Groot et al. 2012; Chee 2004). Use values are those that have an instrumental value to beneficiaries, and are separated into those that are directly consumed by stakeholders (e.g. food, fuelwood etc.) and those that indirectly benefit stakeholders (e.g. storm protection of communities as a function of its existence on shores)(Spaninks and Beukering 1997; Malik, Fensholt, and Mertz 2015). Direct use values are typically measured using the Market price (MP) method, where their monetary value is determined based on their total revenue or worth in the market (Salem and Mercer 2012; Chee 2004). The indirect values of ES are harder to assess as they do not have existing markets (Spaninks and Van Beukering 1997; Sukhdev 2008). The production function (PF) approach derives the value of a service by considering it a factor input to resource production, and using the value of changes in production that arise in its presence or lack thereof, as an indicator of its economic worth (E. Barbier 2007; Salem and Mercer 2012). The replacement cost method (RC) measures the value of an ecosystem service by calculating the expected costs of its substitution with man-made alternatives (e.g. storm, protection vs storm barrier) (Spaninks and Beukering 1997; Chee 2004; Salem and Mercer 2012). The damage-cost avoided method (DA) works by a similar theory but instead calculates the economic value of what could be lost if the service were not available (Salem and Mercer 2012; Chee 2004). At present, the Contingent valuation method (CVM), is the only technique in place to value non-use values, and involves asking stakeholders about their willingness-to-pay (WTP) or willingness-to-accept (WTA) to maintain services (Fisher, Turner, and Morling 2009; Salem and Mercer 2012). Travel cost (TC) looks at recreation value of ecosystems by looking at amount people spend on visiting ecosystems, or how much is lost when that ecosystem is no more (Salem and Mercer 2012). Finally, the benefit transfer (BT) method uses values derived in studies and applying them to other ecosystems (Chee 2004; Spaninks and Van Beukering 1997).

The use of MVES as a tool in measuring the values of ecosystems has attracted significant criticism (Lele et al. 2013; Schröter et al. 2014; McCauley 2006). Many authors have expressed concerns regarding the tools potential to lead way for the privatization/commodification of nature (Kosoy and Corbera 2010; Lele et al. 2013; Gómez-Baggethun et al. 2010; Gomez-Baggethun and Ruiz-Perez 2011; McCauley 2006), some question the accuracy of the techniques used (Chee 2004; Schmidt, Manceur, and Seppelt 2016; Spangenberg and Settele 2010), and others point out only a small portion of the values offered by ecosystems can be represented in monetary terms (Christie et al. 2012; Kelemen et al. 2014; Small, Munday, and Durance 2017). Several papers have been produced with regards to the different economic values of mangrove services and this study aims to review the literature in light of the aforementioned criticisms. Several studies have derived economic values for single services (e.g. wind attenuation)(see for example: Aburto-Oropeza et al. 2008; Das and Crépin 2013), others have attempted to derive monetary values for entire mangrove forests (see for example: Hema and Devi 2015; Bennett and Reynolds 1993). A study by Malik, Fensholt and Mertz, (2015) directly compared the net-benefit of a mangrove to a shrimp pond as a demonstration of MVES in a cost-benefit analyses context. At present, three other studies have provided large-scale, summative reviews of the mangrove valuation literature; Brander *et al.*, (2012) completed a meta-analysis and benefit transfer to estimate the economic value of mangrove services in Southeast Asia; Salem and Mercer, (2012) also used meta-regression analysis, investigating instead from a global perspective, examining possible interactions between the values of different mangrove service type. The most recent publication by Mukherjee, Sutherland, Dicks, *et al.*, (2014) employed expert based participatory approach to examine how mangrove services of reportedly high economic values, matched up to their values as determined by expert opinion.

2.2 Aims and Objectives

The aim of paper is to review all literature reporting economic values of mangrove services as a means of updating our knowledge of MVES use in mangrove systems, identifying potential trends or gaps in the literature and examining use of this tool in mangroves in light of current discourse surrounding the topic.

2.3 Methodology

Data collection and analysis

The data used in this study was collected using a bibliometric search with search engines, ISI web of knowledge and Google scholar. Literature searches were conducted using the following keywords, “mangrove”, “forest”, “system”, “ecosystem”, “services”, “economic”, “monetary”, “value” and “valuation” in all possible combinations. Initial searches revealed two pre-existing databases of collaborated literature concerning ecosystem service: “The TEEB valuation database” (TEEB 2010) and the MESP database” (http://www.marineecosystemservices.org/databases). The TEEB valuation database was developed alongside the TEEB-project by UNEP and contains a total of 1350 ecosystem valuations from over 300 case studies pertaining to a variety of different ecosystems. The mangrove valuations in this database displayed a range of publishing years of 1982 to 2009 (TEEB 2010). The MESP database, is a collection of marine service valuations available online and represents an extension of the TEEB database. Literature from the MESP database added mangrove service valuation studies of publishing years up to 2015. Mangrove valuation reports published outside of these ranges were identified by the bibliometric search as were several additional studies not included in the databases. Publications from both the peer-review and ‘grey’ literature (i.e. policy documents, working papers, management reports) were considered for inclusion in this study. Publications were selected for inclusion in the study if they contained primary reports of an economic pertaining to mangrove services or a mangrove ecosystem specifically and met the following criteria:

.

a. Value was originally derived in the paper
b. Value was reported in monetary units,
c. Value was derived using monetary valuation techniques
d. Study was concerning mangrove ecosystems or mangrove ecosystem services
e. Value was designated to mangroves or mangrove services as a single entity, independently of any other adjacent ecosystems.

Any publications reporting the monetary values of mangrove services that did not fit said criterion were excluded and considered beyond the scope of this study. Attempts were made to find all primary studies and was not considered if not. Within these several studies were not clear with regards to where the study was carried out or what methods were used, these were removed. The list of studies included can be found in the supplementary material. The data collected was analysed at the various levels described in the following:

Temporal distribution

Both types of literature were analysed with regards to year published. The range of years in the data was 1982 until 2017. The data was plotted in a stacked bar chart by year with grey and peer-reviewed literature plotted separately. No literature was excluded for this analysis so a total of 92 was used.

Geographical distribution

All literature was organised with regards to country of study site and mapped using QGIS as means of investigating whether global distribution of studies was in line with mangrove cover. The global distribution of mangrove valuation studies was analysed at two levels. First, the global distribution of the literature was analysed from the perspective of the two biogeographically defined regions of mangrove growth the Indo-west pacific (IWP) and the Atlantic East Pacific (AEP). Then, the literature was analysed at the regional level. The regions chosen were grouped as follows: Asia (Asia, Middle east) Africa (Continental Africa and Madagascar), Americas (North, South, central and the Caribbean) and Oceania (Australia, New Zealand and the east pacific islands). Studies reporting global values or values derived by meta-analysis were excluded from this stage of analysis meaning a total of 75 studies were included.

Mangrove services reported

Mangrove services reported in the literature were examined at three levels; Service category, value type and service type. The service categories examined were those defined by the MEA; provisioning, supporting, regulatory and cultural (full definitions of these can be found chapter 1). The literature was the examined by all service types reportedly offered by mangrove systems (See list). Inconsistencies with regards to service descriptions were prevalent throughout the literature. Several publications reported values for services using alternative terminology (e.g. Subsistence fisheries, capture fisheries, on-shore fisheries) so these were aggregated under a single descriptor. Other publications reported values of aggregated services (e.g. Fishery service: combined value of all fishery benefits at the site), so all publications reporting a similar service were aggregated into an overarching service. Papers reporting values of non-fish forestry products and raw materials (e.g. honey, timber, charcoal) were grouped into “Forestry product”. Publications reporting values related to subsistence fisheries or small capture fisheries that provided livelihoods to coastal communities were grouped under the “subsistence fishery” service. Any values reported with regards to a service category that did not specify the component services measured to derive the value were grouped under the related service category as provisioning services were groups as “Unspecified”. Papers reporting values concerning the indirect benefits of habitat, refuge or nursery service were grouped into “Nursery function”. Studies reporting measurements pertaining to option values of natural resources were grouped under “Biodiversity” whereas any reporting stakeholder will to aid in conserving biodiversity were grouped into the “conservation” group. Papers reporting the economic values of mangrove services related to nutrient cycling grouped under “soil quality”. Papers reporting values with regards to the protective capacity mangroves against wave energy, wind, hurricanes, tsunamis or generalised extreme events were grouped at “storm protection”. Studies reporting values as to pollution regulation or sediment trapping were grouped into the “Water quality” service. The “Carbon sequestration” service category pertained to any valuation studies reporting the economic value of a carbon stock in mangrove forests. Papers reporting any non-monetary values or alternative measurements of mangrove carbon stocks were considered beyond the scope of this study and therefore not included. Any papers reporting valuations of the contributions of mangrove forests to academic spheres were grouped as “Research and education”. Finally, studies reporting economic contributions of mangroves to the tourism sector were grouped under “Tourism and recreation”. The aim of this part of the analysis was determine which services were most prevalent in the valuation literature so any studies reporting a TEV were deconstructed by service and those that could not be were excluded as were the meta-analytic studies. In total 89 of the overall 92 studies were used in this part of the analysis.

Methods of assessment

In order to assess the use of ESV in the mangrove literature, the publications collected were analysed at two levels. First, the literature was examined with regards to the valuation techniques used in the study. Individual reports or observations were thus plotted with regards to the technique used. In addition to this, the studies collected were organised with regards to their use of MVES and an interdisciplinary tool. Papers were organised with regards to whether the tool was used exclusively or conjunction with tools from other disciplines. Publications using MVES independently of other methods were grouped under “Ec”. Publications using MVES in conjunction with social surveying methods were grouped under “EcS”, biological surveying methods under “EcB” and those using a combination of both were grouped as “EcBS”. In this study, social surveying methods were considered as those using approaches such as focus groups, ranking systems to evaluate the social value of the mangrove services being examined. In this context, biological methods were considered as those that assessed mangrove coverage delivering the ecosystem services being studied. A total of 75 publications were involved in this part of the analysis.

2.4 Results

Collection of literature using the described criterion, compiled a total of 92 papers. 50 of these were considered peer-revered and 42 were considered grey literature.

Temporal effects

A clear increasing trend in the amount of literature concerning the monetary valuation of mangrove services is present from 1982 through 2017. Primary literature has been showing a marked increase since 2008 (Figure 2.1). 54.3% of the total literature collected in the study was considered peer-reviewed literature and the remaining 45.7% was considered “grey” literature. When analysed separately, the peer-reviewed literature (blue) exhibits a more a gradual increase in amount published by year, peaking markedly in 2013, 2015, and 2017. In contrast, the amount of grey literature (red) published annually remains relatively stable over time, reaching highest around 1998, 1999 and 2002 (figure 2.1).

Global distribution of sites studied in the literature

Cartographic representation of the countries in which mangrove valuation studies have occurred (Figure 2.2) demonstrates a notable gap in the literature with regards to where these studies have been carried out. A marked difference can be seen with regards to the quantity of publications released concerning mangrove forests of the AEP when compared to those of the IWP region; the differences in which are inconsistent with the differences in mangrove cover amongst these regions. Of the literature analysed in this part of the review, a total of 62 studies were found to report mangrove values concerning the mangroves of the IWP region, compared to just 13 studies featuring mangrove ecosystems of the AEP region. This means that MVES studies concerning the mangroves of the IWP region account for 82.6% of the total literature, highlighting a significant deficit. When analysed at the regional level, Figure 2.2 demonstrates further disparity with regards to the continental regions present in the literature. The large majority of studies within this data set were found to pertain to mangrove inhabited countries in Asia and in total these studies accounted 68% of the total literature examined. Of studies pertaining to Asia as a region, 65% of these were found to have reported values in Southeast Asia. The Americas region was found to have hosted the second greatest quantity of mangrove valuation studies, however studies in the region accounted for a significantly lower proportion of the literature with a total of 12 publications (16%). Studies reporting monetary values of mangrove services in Africa and Oceania thus account for 12.5% of the total literature. The literature bias toward Southeast Asia does not reflect global distribution of mangrove cover as several continents deemed underrepresented by this review house some of the world's most extensive mangrove forests; this inconsistency will be detailed further in the discussion. This gap is also demonstrated at the country level. Studies concerning the mangroves in Thailand account for a greater proportion of the literature than any other, despite other countries in Southeast Asia (Indonesia, Malaysia, Burma) and in other regions (Australia, Brazil, Mexico) hosting considerably greater extents of mangrove forest. (Figure 2.2). Despite also hosting a large proportion of the studies examined, the number of valuation studies carried out in Indonesia, Malaysia and the Philippines are significantly less than those carried out in Thailand. Studies concerning mangroves in Brazil constitute the total literature originating from South America, and although Brazil houses considerably more mangroves than its neighbouring countries, the fact remains that the other South American countries and the majority of the Caribbean (with their varied uses, threats and ecological conditions) remain unrepresented.

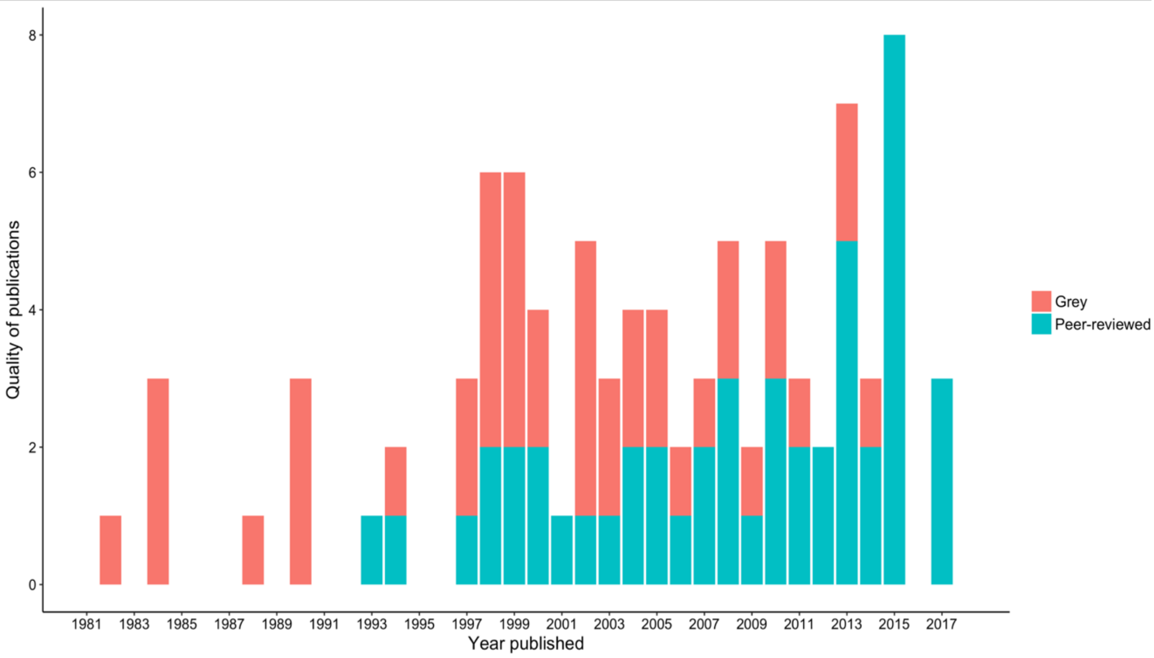

Figure 2.1 Quantity of publications reporting a monetary value for mangrove ecosystem services per year (n=92). Here, the data is separated by type of literature into 'grey' literature (red) and Peer-reviewed literature (blue).

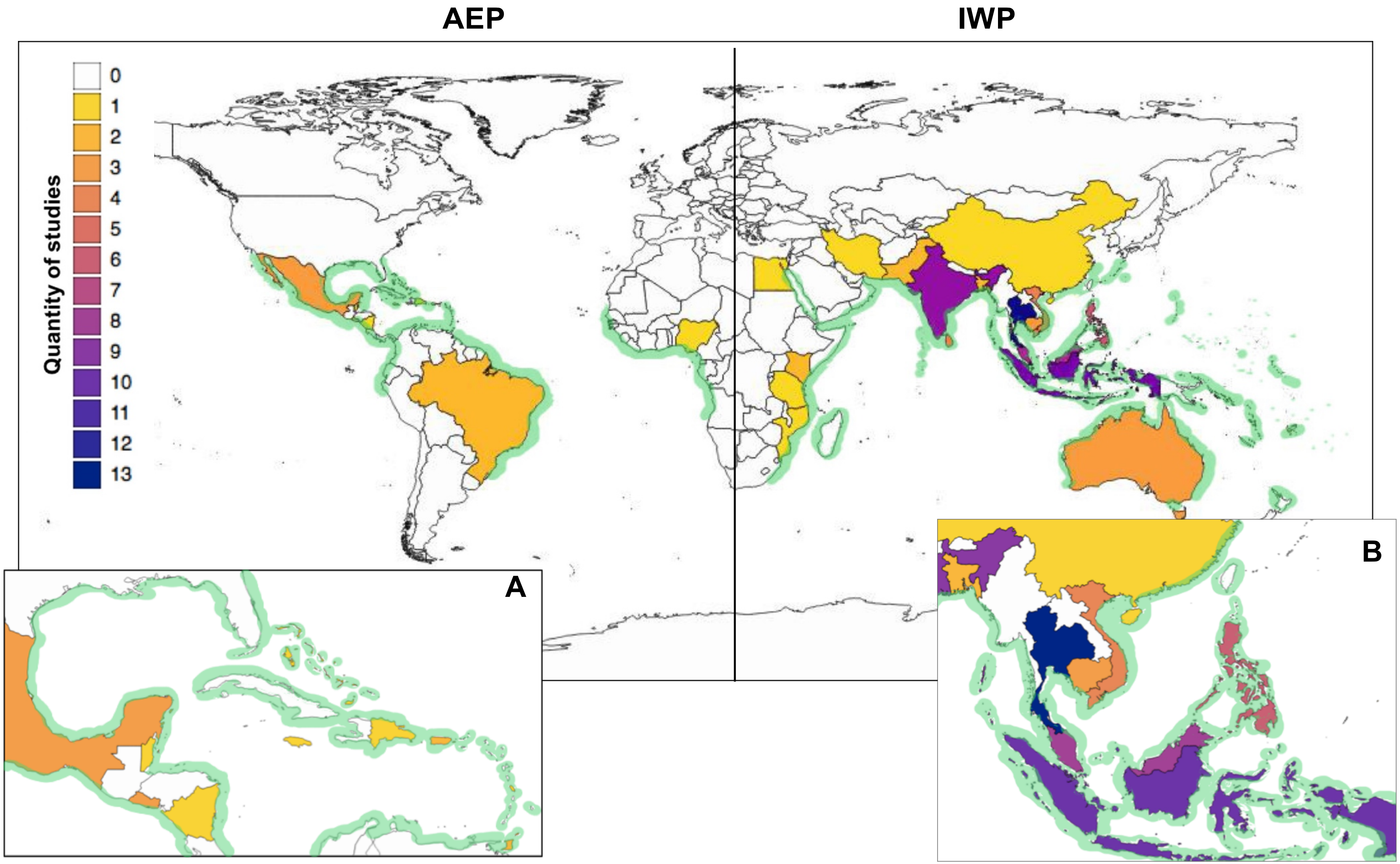

Figure 2.2 Global distribution of reported monetary valuation studies concerning mangrove forests or mangrove ecosystem services (n=75) throughout the AEP and IWP regions of mangrove distribution (green). Figures 21:A and 2.1B demonstrate value distribution across the Caribbean and Southeast Asia respectively, scaled up for clarity.

The most significant gap however appears to be that that concerning the countries in the African continent, where country coastlines to the West of continent are largely unreported.

Distribution of different service types valued in the literature

Of the four ecosystem service categories, the majority of values reported were those of the provisioning service category, followed by the supporting services, regulating service and the cultural services (Figure 2.3). In total, 81 observations were made with regards to mangrove provisioning services. Reports pertaining to the supporting and regulatory service categories were less prevalent in the literature, with 48 observations being reported in the supporting category and 52 in the regulatory category. Considerably fewer observation were made with regards to the cultural services of mangrove forests, with a total of 37 observations reported.

With regards to the individual service type reported, the forest product service was the most widely featured in the literature, followed by the nursery function service, subsistence fishery service and then the shoreline protection service. Of the cultural service category, the majority of observations were made in relation to tourism and recreation values. Reports of the nutrient cycling, water quality and education services were limited. In relation to these valuation reports of the biodiversity service and conservation were prevalent however in comparison to those most widely studies these services are underrepresented.

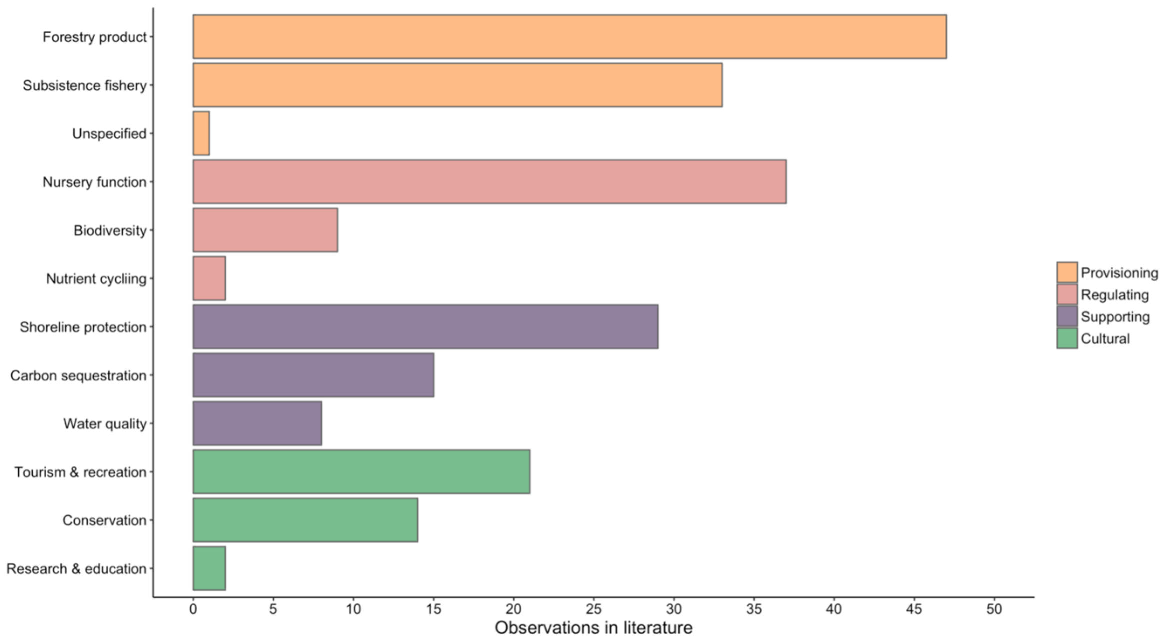

Figure 2.3 Quantity of observations as to the monetary values of different mangrove services in the literature (n=281). Observations were divided amongst service categories: Provisioning (orange) regulating (pink), supporting (purple) and cultural (green). The category accounting for the greatest proportion of the observations was the provisioning category. The individual service types found most widely reported in the literature were the forestry product, subsistence fishery, nursery function and storm protection services.

Assessment method - Valuation techniques

The results indicate variation in use of the different valuation techniques throughout the mangrove valuation literature (Figure 2.4). The market pricing (MP) method was the valuation technique used throughout the studies examined and accounted for a total of 53 observations. In comparison, the travel cost method (TC) was used the least throughout the literature and contributed toward just 3 observations. Uses of the Replacement cost (RC) and Production function (PF) approaches were also prevalent throughout the literature, contributing 24 and 23 observations respectively, however reports using these methods were considerably less populous than those using the MP method. Equal amounts of reports were found to have used the Contingent valuation method (CVM) and the Benefit transfer method (BT). A total of 13 valuations were reported using the Damage-cost avoided (DA). Disregarding the extremes shown in the use of MP and TC, reports using the remaining methods are demonstrate a relatively even distribution across the different techniques. valuation methods used demonstrate a relatively even spread with regards to their use throughout the literature. These results indicate that a total of 99 value observations within the mangrove literature have been derived using methods applied in an indirect manner, compared to 53 that involved the direct application of monetary units.

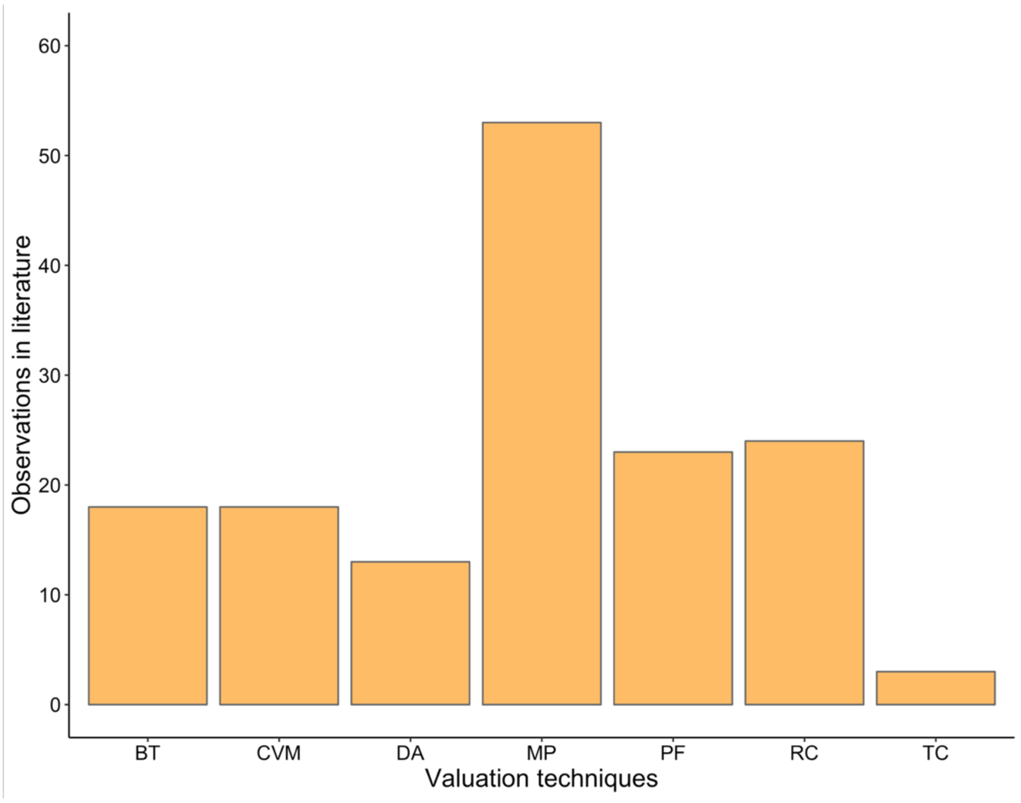

Figure 2.4 Number of value reports with regards to the MVES methodology used in the literature (n=281). Market pricing (MP) is used to directly measure the economic worth of a good or service whereas the Replacement cost (RC), Production function (PF), Damage-costs avoided (DA) Contingent valuation (CVM), travel cost (TC) and Benefit transfer (BT) methods use an indirect approach.

Assessment method – Mode of employ

Analysis of the literature with regards to how MVES was used in mangrove systems demonstrated that throughout the total literature MVES was more commonly employed in conjunction with alternative methods, than it was as an independent methods (Ec) (Figure 2.5). A combination of MVES and social surveying methods (EcS) was used in 58% of the literature examined and was thus the most prevalent mode of employ. EcS was used in 74% of the grey literature examined and 45% peer-reviewed literature. The Ec method was the second most popular mode of employ but was used considerably less than EcS, contributing to 21% of the total literature, 16% of the grey literature and 25% of the peer-reviewed literature. When analysed by region of study, Ec use in the peer-reviewed literature is exclusive to studies carried out in Asia, whereas it has been used more broadly in the grey literature. Use of EcBS was less prevalent than the use of Ec in the literature, with studies using this mode of employ contributing to 13% of the total publications examined, and was found to be more prevalent in the peer-reviewed literature where it contributed 16% of the literature than in the grey literature where it contributed to 10% of the studies examined. Finally, EcB was the least popular mode of employ in the literature examined, contributing to 8% of the total literature. Interestingly, EcB use accounts for 17% of the peer-reviewed literature examined but is not present in the grey literature.

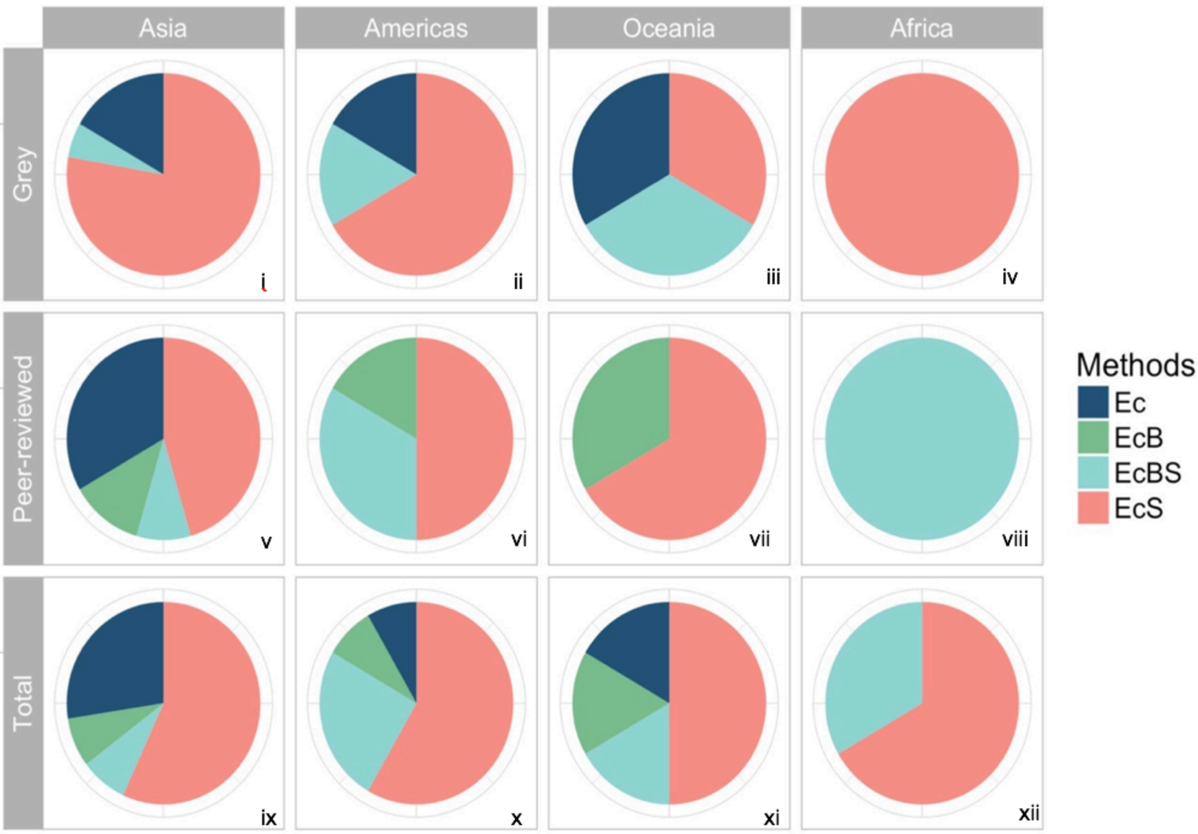

Figure 2.5 Demonstration of MVES throughout the gray literature from Asia (i, n=18), Americas (ii, n=6). Oceania (iii, n=3) and Africa (iv, n =4), the peer-reviewed literature concerning Asia (v, n=33), Americas (vi, n=6). Oceania (vii, n=3) and Africa (viii, n=2) and the total of these in Asia (ix, n=51), Americas (x, n=12). Oceania (xi, n=6) and Africa (xii, n=6). MVES use as an independent method (Ec-Dark blue) was found less popular than MVES use in conjunction with other surveying methods. Use in conjunction social surveying methods (EcS-pink) was the most popular mode of employ, followed by Ec, then MVES in conjunction with biological monitoring methods and social surveying methods combined (EcBS-light blue). Use of MVES in conjunction with biological monitoring methods alone (EcB-green) was the least popular mode of employ.

2.5 Discussion

Temporal effects

Review of the literature in relation to year of publication has demonstrated a clear increasing trend regarding the quantity of studies employing ESV as a means of measuring mangrove service values in recent decades. The earliest report of economic values pertaining to mangrove services identified by this review was published in published in 1982. The valuation study Christensen (1982) was a publication pertaining to the grey literature group of this study and formed a component part of an FAO report concerning the uses and management of mangroves in Asia and the Pacific. The first use of ESV identified in the peer-reviewed literature was that by Bennett and Reynolds (1993) in which researchers valued the Sarawak Mangrove reserve in Malaysia. In the years prior to this peer-reviewed study however, several reports of monetary mangrove values were published in the grey literature. This result implies, that the application of economic values as an approach to measure mangrove resources is not a novel one and was already being employed by conservation practitioners several years before its emergence in the peer-reviewed literature. This finding is corroborated by commented others (Raum 2017; Ingram, Redford, and Watson 2012) who have indicated that MVES is not a new concept with regards to forest management but has previously been referred to using different terminology. Publication of the first peer-reviewed paper using MVES in a mangrove system is concurrent with the emergence of the natural capital concept (P. Ehrlich and Ehrlich 1992; Costanza and Daily 1992; Cornell 2011) and it is likely that this study was thus was influenced by the contemporary discourse. The prevalence of MVES in both the peer-reviewed and grey literature is shown to increase as of 1998 where additional interest is likely to have been driven by the release of certain key papers (Daily 1997; Costanza et al. 1997). The release of said key publications, in combination with discourse surrounding concepts of greening the economy (Pearce 1996) prevalent at the time (Cornell 2011) are thought to have contributed to the momentum with which the tool was adopted by the academic community (Lele et al. 2013; Cornell 2011; Costanza et al. 2014; Raum 2017). In the years to follow, interest in MVES would have been further fuelled by the integration of the ESC framework into the Millennium Ecosystem assessment (MEA 2005) which was launched in 2000 (Lele et al. 2013; Costanza et al. 2014). The ESC and associated MVES were key components of the MEA (2005), which involved 1300 scientists and was implemented as a facilitating greater integration of environmental concerns into policy making (Costanza et al. 2014; Lele et al. 2013). The MEA (2005) was eventually published in 2005, bringing ESV and ESC to the attention of policy-makers (Costanza et al. 2014; Lele et al. 2013). The increasing trend found here is consistent with that observed by others who have reported the rise of mentions of the ESC in peer-reviewed literature (Vo et al. 2012; Farley 2012; Braat and de Groot 2012). Reports utilizing MVES demonstrate a surge in numbers as of 2008 (Figure 2.1). This increase is concurrent with the release of TEEB or “The economics of ecosystems and biodiversity” initiative created by the United Nations Environment Program (TEEB 2010). TEEB (2010) was released in an attempt to standardize MVES efforts in order to aid the tools integration into decision –making and ultimately facilitate better accounting of ecosystem loss (Costanza et al. 2014). This report brought the ESC and ESV to a wider audience and further attracted the attention of ecologists, economists, politicians and practitioners. Overall, reports in the grey literature remain relatively stable from 2002, which is likely a result of funding and capacity limitations experienced by conservation organisations. Reports in the peer-reviewed literature however, continue to increase gradually before experiencing a surge in interest in 2013 and 2015 (Figure 2.1). These are consistent with increasing interesting in interdisciplinary information and reports of the carbon sequestration capabilities of mangroves (Donato et al. 2011; Pendleton et al. 2012) making them important subjects of UNEP's blue carbon initiative (Nellemann et al. 2009) that is currently gaining momentum.

Spatial effects

Mapping of the study sites visited in the mangrove valuation literature revealed several notable and significant geographic gaps in the literature. We have demonstrated a significant deficit of literature concerning mangrove forests in the AEP region in comparison to those in the IWP region. In addition, the literature concerning mangroves in the IWP region represents a strong bias toward countries in Southeast Asia, meaning that the other mangrove-inhabited countries in the IWP remain largely unrepresented. Mangrove forests inhabit 123 countries worldwide (Carter, Schmidt, and Hirons 2015); Asia is known to possess the greatest extent of mangrove coverage, accounting for 42% of global forests, followed by the Americas which possesses 26%, Africa with 20% and Oceania with 12% (Giri et al. 2011). A study by Giri et al. (2011) however, listed the 15 in possession of the greatest mangrove extent worldwide, the top 5 of which were evenly distributed amongst the regions analysed. The literature bias toward the IWP region and the mangroves of Southeast Asia is thus inconsistent with the distribution of mangrove cover and must be addressed accordingly. The bias towards Southeast Asia appears to be in large part accountable for the literature deficit concerning the AEP. Review of the literature revealed multiple, compounding factors that may have been causal in designating Southeast Asia as priority region for research and management. One overarching, factor is likely to have been the extensive degree of mangrove deforestation experienced in this region (FAO 2007; Polidoro et al. 2010; Valiela, Bowen, and York 2001). Southeast Asia is believed to have lost more than 1/3 of its total mangrove cover in just a decade, between the 1980s and 1990s (Valiela, Bowen, and York 2001; Polidoro et al. 2010; Richards and Friess 2016; Brander et al. 2012). A study by Richards and Friess (2016) estimates that between 2000 – 2012 additional losses upward of 4,600,000ha may have occurred in Southeast Asia. Until recently this loss has been largely attributed to the rapid expansion of shrimp aquaculture (Valiela, Bowen, and York 2001; Jurgenne H. Primavera 2005; J. H. Primavera 2000; E. Barbier et al. 2011), however results by Richards and Friess (2016) indicate that although aquaculture was a main driver, the primary threats were country-dependent and palm oil also played a significant role. Although aquaculture can proceed with minimal damage if practised sustainably, the attractive incentive of foreign exchange brought about wide scale exploitation of mangroves in Southeast Asia, and this was largely encouraged by governments (E. Barbier, Strand, and Sathirathai 2002; E. Barbier and Sathirathai 2004). Southeast Asia is believed to possess one of the largest mangrove-dependent populations in the world (Mimura 2008; UNEP 2014; Orchard et al., 2016) meaning that detrimental socio-economic effects of mangrove loss would have been experienced at a broad scale (J. Primavera 1997). Expropriation and the privatisation of mangroves meant a decline in food security and threatened livelihoods for coastal communities (Primavera 1997). This elicited a suite of valuation studies to contribute to the resource management debate, done in attempts to demonstrate that the social costs of destroying mangroves far outweighed the short-term benefits arising from shrimp farms (Gunawardena and Rowan 2005;

Salem and Mercer 2012), an explanation further evidenced by extensive use of the Ec method in Asia (Figure 2.5). Other publications concerning the mangroves in Asia have used MVES to communicate the value of mangroves as natural storm barriers, in countries such as Vietnam and Thailand that have experienced devastating cyclones and tsunamis in recent years (Hoang Tri, Adger, and Kelly 1998; Lee et al. 2014; Das and Crépin 2013; Zhang et al. 2012). The widespread deforestation experienced by the region was of added significance as several countries are considered biodiversity hotspots and have the highest diversity of mangrove species in the world (Mark Spalding 2010). This meant that the deforestation in Asia contributed to placement of 16% of global mangrove species onto the threatened list (Polidoro et al. 2010; Richards and Friess 2016), in turn, this led to the designation of Ramsar and world Heritage sites under the UNESCO convention, which will have attracted international interest to the region. From a methodological perspective, sites in these countries may have been of additional interest to researchers due to their well-established histories of mangrove management (Carter, Schmidt, and Hirons 2015). Sites such as the Sundarbans in Bangladesh and the Matang forest in Malaysia which are also where some of the earliest recorded cases of mangrove management are documented (Carter, Schmidt, and Hirons 2015). For example, the Sundarbans has been managed from 1890 and Sundarbans Matang forest as of the late 19th century (Richards and Friess 2016; Carter, Schmidt, and Hirons 2015) and both sites are prevalent in the literature (DasGupta and Shaw 2017; Ahmad 2009; Uddin et al. 2013). This bias toward mangrove in South-east Asia presents an issue as for the most part the information collected cannot be extrapolated for use in management in other mangrove inhabited countries. Mangrove forests are ecosystems that experience extensive degrees of stakeholder engagement meaning that mangrove stakeholders are of particular relevance of mangrove services. The socio-cultural climates in the countries of Southeast Asia are unique and are not representative of other Asian countries, not to mention the countries outside of this region, meaning extrapolation of ES values could give rise to conflict if implemented in management schemes. Instead, gaps in the literature must be addressed. Mangrove inhabited countries in Africa are of particular significance as after Asia, Africa holds the second largest mangrove dependent population (UNEP 2014; Nibedita Mukherjee et al. 2014) yet relatively little is known with regards to their coastal ecosystems (Chevallier 2013). FAO (2007), states that mangroves in Africa occupy 33 countries (Chevallier 2013), however there is little mention of their ecosystem services and the importance to local people from Africa (See: (Walters et al. 2008; Satyanarayana et al. 2012; Chevallier 2013). Studies by Crow and Carney (2013; Lau and Scales, (2016) report the social significance of oyster fisheries in Gambian mangroves by women, where Satyanarayana et al. (2012) reviewed mangrove forest resources. In addition, James et al. (2011) demonstrated social significance of mangroves to communities in the Niger Delta. These publications indicate potential for mangrove management schemes based around coastal communities and MVES studies could facilitate interest by governments and the public. The Caribbean represents another area of interest as this region is heavily dependent on the Mesoamerican barrier reef (Harborne, Afzal, and Andrews 2001), a system greatly contributed to and supported by mangrove forests on the shores of its surrounded countries (Nagelkerken et al. 2008; Mumby et al. 2004). The marine systems in the Caribbean support livelihoods of approximately two million people, supporting fisheries of commercial importance like the Caribbean spiny lobster (*Panulirus argus*) and snapper (*Lutjanidae*) (Box and Canty 2010) and providing the foundations for the regions tourism industry (Doiron and Weissenberger 2014). The importance of mangroves to people in these regions suggests potential for integration of valuation approaches to facilitate more integrated approaches to mangrove management through inclusion of local stakeholders.

Service types reported

Review of the literature with regards to category and type of service valued found that, of the four service categories defined by the MEA, the greatest number of observations pertained to the provisioning category. Valuations of both the forest product and the direct fishery services from this category were the most prevalent in the literature, with the forestry product service having the most observations of all examined. These results were in accordance with observations by Salem and Mercer (2012), Brander et al. (2012), Mukherjee, Sutherland, Dicks, et al. (2014) and were consistent with the extensive use of the market pricing method demonstrated in Figure 2.4. The bias toward the provisioning category and its component services is likely to be a result of the widely acknowledged importance of said services to mangrove-dependent coastal communities. Additionally, this bias is indicative of the relative 'ease' with which market price valuations can be carried out (Abson and Termansen 2010; Small, Munday, and Durance 2017). Valuation reports of the nursery and shoreline protection services were also prevalent in the literature. These results were as expected, as nursery and shoreline protection represent two of the more celebrated mangrove services, and were consistent with observations by Salem and Mercer (2012), Brander et al. (2012), Mukherjee, Sutherland, Dicks, et al. (2014). Mangroves have long been recognized for their role in supporting on- and off-shore fisheries by providing habitat and nursery services to many species of significant ecological and commercial importance (Box and Canty 2010; Aburto-Oropeza et al. 2008). Loss of this service would have detrimental effects on the fishery industry and in turn various local and national economies (Carter, Schmidt, and Hirons 2015), a concern that has likely fuelled significant discourse around the service. Studies such as those by Mumby et al. (2004) and Nagelkerken et al. (2008) have provided evidence as to the link between mangroves and offshore fishery population which was key to this discussion. These papers have inspired efforts by others to develop and refine nursery associated valuation techniques, as well as to repeat research elsewhere (Anneboina and Kavi Kumar 2017). The nursery service has gained considerable interest from NGOs and other practitioners (Hutchison, Spalding, and Ermgassen 2014; Carter, Schmidt, and Hirons 2015; Peter Saenger, Gartside, and Funge-Smith 2013). Similar can be said for the shoreline protection service; despite the storm projection service of mangroves has been widely acknowledged, the degree to which mangroves are capable of reducing the impacts of catastrophic ocean events has been heavily debated in the literature (Lee et al. 2014). In countries that have been impacted by such events in recent years (e.g. Thailand, Vietnam) this service has gained attention from NGOs and Governments, becoming a focus of risk management discussion and attracting funding for associated management schemes (Spalding et al. 2014; Saenger and Siddiqi 1993). This study, in addition to other reviews, demonstrates a bias in the mangrove valuation literature toward indirect service with high, economic benefits. It is important to appreciate that the majority of these valuations are being derived through the use of indirect methods. This means that a large proportion of error is introduced in these studies which will impact accuracy and reliability of results (Schmidt, Manceur, and Seppelt 2016; Spangenberg and Settele 2010). If economic valuations of ecosystem services are to be implemented into management they are likely to be used in cost-benefit analyses where small differences in assigned values could be very influential on final land use decisions. Several of the techniques used in MVES have been criticised due to concerns regarding lacking reliability (See: Schmidt, Manceur, and Seppelt 2016; Spangenberg and Settele 2010; Chee 2004). Concerns over uncertainty and error are particularly prevalent in discussions surrounding the use of the benefit transfer (BT) method (see (Plummer 2009; Schmidt, Manceur, and Seppelt 2016) for discussion). This application of this method was found to be relatively popular in the mangrove valuation literature (Figure 1.4), contributing to further ambiguity as to the reliability of the mangrove service values available. The limitations regarding the BT method discussed in the wider valuation literature makes it somewhat concerning that of all the literature reviewed in this study, all reports of the biodiversity services of mangroves were derived using this method. What is perhaps more concerning is that the majority of these reports transferred values from a single paper (Ruitenbeek 1994). This result implies that in fact we know very little of the biodiversity values of mangrove forests, a deficit in knowledge representative of concerns as to the neglect of ecological values being discussed in the wider valuation literature (Laurila-Pant et al. 2015; Gómez-Baggethun et al. 2014).

Critics of MVES have raised concerns as to the relative one-dimensionality of the tool, an issue that has led to calls for value plurism in ecosystem valuations and one that is further demonstrated by the deficit in cultural service valuations found by this review (Martín-López et al. 2012; Kenter et al. 2015; Kelemen et al. 2014; Small, Munday, and Durance 2017). The cultural service category was demonstrative of a significant literature deficit as all observations were tourism; there were no observations of, for example, spiritual or aesthetic cultural services. This deficit is corroborative of concerns by many that cultural services and the non-material benefits of ecosystems remain underrepresented by the literature (Plieninger et al. 2013; Satz et al. 2013; Gee and Burkhard 2010; Milcu et al. 2013) and is reflective of the ongoing debate as to the viability of this category in ecosystem valuation (Winthrop 2014; Small, Munday, and Durance 2017; K. M. A. Chan et al. 2011; K. Chan et al. 2012). Cultural services are described by the MEA (2005) as “the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences”. Despite the breadth of this definition however, ESV valuations of cultural services are often limited to valuation of the more tangible aspects such as tourism and recreation (Milcu et al. 2013), a trend demonstrated in this study. This is in large part a result of the difficulty involved with quantifying and measuring non-material benefits that are intangible by nature (Schröter et al. 2014; Satz et al. 2013; Daniel et al. 2012). It is however becoming widely acknowledged that these nonmaterial benefits can act as important drivers of environmental changes (Small, Munday, and Durance 2017). Field observations by Gabb (unpublished data), are in agreement with these idea with regards to mangroves, as cultural and heritage values were found to be important in mangrove-dependent communities in Honduras. Here, it was found that primarily indirect mangrove beneficiaries felt a strong heritage based connection to the forests, with mangroves featuring heavily in childhood memories and many describing various mental health benefits derived from forest presence. It is important that we understand how people connect to the non-material benefits of ecosystems as such information could help us inspire better environmentally friendly behaviours and inform us as to how we can better engineer conservation programs. Thus, if we want to understand the value of ecosystems we need to explore these types of value, however hard to quantify they may be. A step towards achieving this could be the use of more mixed-methods approaches that use both qualitative and quantitative data to investigate information that may not otherwise be readily quantifiable. An example of one such method would be choice experiments, for example Best-worst scaling methods.

Finally, the number of papers found to value carbon stocks in mangroves did not meet background expectations. Carbon storage schemes have become a hot topic with blue carbon being a recent and very popular addition to the conversation. There is an established carbon market making monetary valuation of stocks simple and tangible. It was thus expected that there would be more papers valuing this service, however the review found only 15 valuation papers concerning the mangrove carbon sequestration service. It is likely that this is a result of the search parameters used in this study as there a wealth of literature on mangrove carbon quantification but much of this has never been translated into monetary values. Papers reporting any non-monetary values or quantities were not included during the data collection process as they were considered beyond the scope of this study. The lack of monetary valuing in carbon sequestration literature provides food for thought. PES and carbon schemes represent some of the more tangible on the ground applications of monetary valuation so if anything was to be prevalent in the literature one would expect it to be carbon values. This suggests that monetary valuation in carbon question is considered a secondary priority or perhaps even unnecessary by the related academic spheres. Perhaps this is suggestive that entities engaging in PES carbon that ES projects put more weighting to the underlying biological measurements and monitoring involved in said schemes than the end value. Pagiola

Assessment methods

This review has discussed several limitations pertaining to MVES as a tool in measuring the value of mangrove ecosystem services, many of which are likely to have contributed to the patterns observed regarding use of the tool (Figure 2.5). Investigation as to the use of MVES in the mangrove valuation literature revealed that the tool was more commonly employed alongside alternative methods from other disciplines that it was as an independent method (Ec). Four patterns of ESV use were identified: MVES use as an independent method (Ec), MVES was that in conjunction with social methods (EcS), MVES use in conjunction with biological methods (EcB) and finally, MVES use in conjunction with both social and biological methods (EcBS). Overall, examination at this level revealed that MVES was more commonly employed in conjunction with social surveying methods (EcS) than it was as an independent method. This was the case in both the peer-reviewed and the grey literature and may suggest that the information derived from ESV is more useful in combination with socio-cultural context. This finding supports the discourse mentioned prior as to the tools one-dimensionality as it would stand to reason that users of the tool are looking to alternative methods to collect the full breadth of value information requited. Perhaps the most surprising result however was the lack of biological surveying methods present in the grey valuation literature. This finding is consistent with current discourse surrounding concerns as to the relatively limited integration of primary, ecological information into management schemes and the extent research utility gap between researchers and managers (Cvitanovic et al. 2014; Pullin et al. 2004; Sutherland et al. 2004).

2.6 Conclusion

This purpose of this paper was to review the tool, monetary valuation of ecosystem service (MVES) regards to its application to mangrove ecosystem services, ultimately providing an update as to the current state of the literature. The review examined and reported extant trends concerning prevalence of the tool in mangrove literature, geographic locations of related studies, the types of services represented and the relevant techniques and approaches used to assess them. This study has identified a gap in the mangrove valuation literature with regards to mangrove inhabited countries in Africa and Latin America as well as with regards to the cultural services and non-material benefits provided by mangroves. This study has contributed to discourse on several concerns as to the limitations of MVES all of which highlight the necessity to move towards value plurism in valuation, which in turn could aid in facilitating integrated approaches to mangrove conservation. We acknowledge that the values offered by ecosystems have multiple dimensions, many of which cannot be accounted for in monetary terms. We do however, believe that in developing countries, where conservation is not high in governmental priority, the purpose of MVES as a communication tool is still very valid. Use of MVES in this way could be effective in raising awareness of decision makers and local stakeholders as to the importance of mangrove services. The effectiveness of this use of MVES however has not been widely proven thus examining the success of MVES as a communicatory tool for conserving mangrove forests could be worthwhile. At present, MVES studies account for much of the peer-reviewed literature specifically categorising and reporting mangrove services at different sites. An issue thus remains as to the significant literature deficits with regards to the mangrove services in Africa and Latin America. Future research should thus attempt to fill these gaps and build upon the efforts MVES to examine a range of value types in the mangroves of these regions.

2.7 Bibliography

Abdullah, Kamariah, Abdullah Mohamad Said, and Dasimah Omar. 2014. "Community-Based Conservation in Managing Mangrove Rehabilitation in Perak and Selangor." *Procedia - Social and Behavioral Sciences* 153 (October): 121–31. doi:10.1016/j.sbspro.2014.10.047.

Abson, D, and M Termansen. 2010. "Valuing Ecosystem Services in Terms of Ecological Risks and Returns." *Conservation Biology* 25 (2).

Aburto-Oropeza, O., E. Ezcurra, G. Danemann, V. Valdez, J. Murray, and E. Sala. 2008. "Mangroves in the Gulf of California Increase Fishery Yields." *Proceedings of the National Academy of Sciences of the United States of America* 105 (30): 10456–10459.

Ahmad, S. 2009. "RECREATIONAL VALUES OF MANGROVE FOREST IN LARUT MATANG , PERAK." *Journal of Tropical Forest Science* 21 (2): 81–87.

Alho, C. 2008. "The Value of Biodiversity: Production Value." *Brazilian Journal of Biology* 68 (4). Instituto Internacional de Ecologia: 1115–18.

Alongi, Daniel M. 2002. "Present State and Future of the World's Mangrove Forests." *Environmental Conservation* 29 (3). Cambridge University Press: 331–49.

Anneboina, L., and K. Kavi Kumar. 2017. "Economic Analysis of Mangrove and Marine Fishery Linkages in India." *Ecosystem Services* 24: 114–23.

Bandaranayake, W M. 1999. "Traditional and Medicinal Uses of Mangroves." *Mangroves and Salt Marshes* 2 (3). Kluwer Academic Publishers: 133–48.

Barbier, E. 2007. "Valuing Ecosystem Services as Productive Inputs." *Economic Policy* 22 (49): 177–229.

Barbier, E., S. Hacker, C. Kennedy, E. Kock, A. Stier, and Brian R. 2011. "The Value of Estuarine and Coastal Ecosystem Services." *Ecological Monographs* 81 (2). Ecological Society of America: 169–93.

Barbier, E., and S. Sathirathai. 2004. "Shrimp Farming and Mangrove Loss in Thailand." *Wetlands* 24 (4). Edward Elgar: 913–913.

Barbier, E., I. Strand, and S. Sathirathai. 2002. "Do Open Access Conditions Affect the Valuation of an Externality? Estimating the Welfare Effects of Mangrove-Fishery Linkages in Thailand." *Environmental and Resource Economics* 21 (4). Kluwer Academic Publishers: 343–65.

Barbier, Edward B., Evamaria W. Koch, Brian R. Silliman, Sally D. Hacker, Eric Wolanski, Jurgenne Primavera, Elise F. Granek, et al. 2008. "Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values - Supporting Material." *Science (New York, N.Y.)* 319 (5861): 321–23. doi:10.1126/science.1150349.

Bennett, Elizabeth L., and Colin J. Reynolds. 1993. "The Value of a Mangrove Area in Sarawak." *Biodiversity and Conservation* 2 (4): 359–75. doi:10.1007/BF00114040.

Box, Stephen, and Steven Canty. 2010. "The Long and Short Term Economic Drivers of Overexploitation in Honduran Coral Reef Fisheries Due to Their Dependence on Export Markets." In *Proceedings of the 63rd Gulf and Caribbean Fisheries Institute*, 63:43–51.

Braat, L, and R de Groot. 2012. "The Ecosystem Services Agenda:bridging the Worlds of Natural

Science and Economics, Conservation and Development, and Public and Private Policy." *Ecosystem Services* 1 (1). Elsevier: 4–15.

Brander, L., A. Wagtendonk, S. Hussain, A. McVittie, P. Verburg, R. de Groot, and S. van der Ploeg. 2012. "Ecosystem Service Values for Mangroves in Southeast Asia: A Meta-Analysis and Value Transfer Application." *Ecosystem Services* 1 (1). Elsevier: 62–69.

Carter, H., S. Schmidt, and A. Hirons. 2015. "An International Assessment of Mangrove Management: Incorporation in Integrated Coastal Zone Management." *Diversity* 7 (2): 74–104. Chan, K., A. Guerry, P. Balvanera, S. Klain, T. Satterfield, X. Basurto, A. Bostrom, et al. 2012. "Where Are Cultural and Social in Ecosystem Services? A Framework for Constructive Engagement."*BioScience* 62 (8). Oxford University PressAmerican Institute of Biological Sciences: 744–56. Chan, Kai M. A., Joshua Goldstein, Terre Satterfi, Neil Hannahs, Kekuewa Kikiloi, Robin Naidoo,

Nathan Vadeboncoeur, and Ulalia Woodside. 2011. "Cultural Services and Non-Use Values." In *Natural Capital: Theory and Practice of Mapping Ecosystem Services*, 206–28. Oxford University Press. doi:10.1093/acprof:oso/9780199588992.003.0012.

Chee, Y E. 2004. "An Ecological Perspective on the Valuation of Ecosystem Services." *Biological Conservation* 120 (4): 549–65. doi:10.1016/j.biocon.2004.03.028.

Chevallier, Romy. 2013. "Balancing Development and Coastal Conservation : Mangroves in Mozambique." *SAIIA Research Report*.

Christensen, B. 1982. "Management and Utilization of Mangroves in Asia and the Pacific." *Management and Utilization of Mangroves in Asia and the Pacific.*

Christie, M, I Fazey, R Cooper, T Hyde, and J Kenter. 2012. "An Evaluation of Monetary and Non-Monetary Techniques for Assessing the Importance of Biodiversity and Ecosystem Services to People in Countries with Developing Economies." *Ecological Economics* 83: 67–78.

Cornell, Sarah. 2011. "The Rise and Rise of Ecosystem Services: Is 'value' the Best Bridging Concept between Society and the Natural World?" *Procedia Environmental Sciences* 6. Elsevier: 88–95.

Costanza, R., R. D'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, et al. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* 387 (6630): 253–60.

Costanza, R., and H. Daily. 1992. "Natural Capital and Sustainable Development." *Society for Conservation Biology* 6 (1). WileySociety for Conservation Biology: 37–46.

Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S. Anderson, I. Kubiszewski, S. Farber, and R. Turner. 2014. "Changes in the Global Value of Ecosystem Services." *Global Environmental Change* 26: 152–58.

Crow, Britt, and Judith Carney. 2013. "Commercializing Nature: Mangrove Conservation and Female Oyster Collectors in The Gambia." *Antipode* 45 (2). Blackwell Publishing Ltd: 275–93. doi:10.1111/j.1467-8330.2012.01015.x.

Cvitanovic, C., C. J. Fulton, S. K. Wilson, L. van Kerkhoff, I. L. Cripps, and N. Muthiga. 2014. "Utility of Primary Scientific Literature to Environmental Managers: An International Case Study on Coral-Dominated Marine Protected Areas." *Ocean and Coastal Management* 102 (PA). Elsevier: 72–78.

Daily, Gretchen C. 1997. *Nature's Services: Societal Dependence on Natural Ecosystems*. Vol. 1. Island Press, Washington, DC.

Daily, Gretchen C, Stephen Polasky, Joshua Goldstein, Peter M Kareiva, Harold A Mooney, Liba Pejchar, Taylor H Ricketts, James Salzman, and Robert Shallenberger. 2009. “Ecosystem Services in Decision Making: Time to Deliver.” *Frontiers in Ecology and the Environment* 7 (1). Ecological Society of America: 21–28. doi:10.1890/080025.

Daniel, Terry C, A. Muhar, Arne Arnberger, Olivier Aznar, James W Boyd, Kai M A Chan, Robert Costanza, et al. 2012. “Contributions of Cultural Services to the Ecosystem Services Agenda.” *Proceedings of the National Academy of Sciences* 109 (23): 8812–19.

Das, S, and AS Crépin. 2013. “Mangroves Can Provide Protection against Wind Damage during Storms.” *Estuarine, Coastal and Shelf Science* 134 (1): 98–107.DasGupta, Rajarshi, and Rajib Shaw. 2017. “Participatory Mangrove Management in a Changing Climate : Perspectives from the Asia-Pacific.” In *Participatory Mangrove Management in a Changing Climate: Perspectives from the Asia-Pacific*, 31–57. doi:10.1007/978-4-431-56481- 2.

Dixon, John A., Glenys Owen Miller, and Lawrence S. Hamilton. 1989. “Mangrove Forests: An Undervalued Resource of the Land and of the Sea.” *Ocean Yearbook Online* 8 (1). Brill: 254–88. doi:10.1163/221160089X00146.

Doiron, S., and S. Weissenberger. 2014. “Sustainable Dive Tourism: Social and Environmental Impacts - The Case of Roatan, Honduras.” *Tourism Management Perspectives* 10: 19–26.

Donato, D., J. Kauffman, D. Murdiyarso, S. Kurnianto, M. Stidham, and M. Kanninen. 2011. “Mangroves among the Most Carbon-Rich Forests in the Tropics.” *Nature Geosci* 4 (5). Nature Publishing Group: 293–97.

Duke, N. 1992. *Tropical Mangrove Ecosystems*. Edited by A. I. Robertson and D. M. Alongi. Vol. 41. Coastal and Estuarine Studies. Washington, D. C.: American Geophysical Union. doi:10.1029/CE041.

Duke, N., M. Ball, and J. Ellison. 1998. “Factors Influencing Biodiversity and Distributional Gradients in Mangroves.” *Global Ecology and Biogeography Letters* 7 (1). Wiley: 27–47. doi:10.2307/2997695.

Ehrlich, P., and A. Ehrlich. 1992. “The Value of Biodiversity.” *Ambio* 21. Royal Swedish Academy of Sciences: 219–226.

Ehrlich, Paul R, and Harold A Mooney. 1983. “Extinction, Substitution, and Ecosystem Services.” *Source: BioScience* 33 (4): 248–54.

FAO. 2007. “The World’s Mangroves 1980-2005.” *FAO Forestry Paper*. Vol. 153.

Farley, Joshua. 2008. “The Role of Prices in Conserving Critical Natural Capital.” *Conservation Biology*.

———. 2012. “Ecosystem Services: The Economics Debate.” *Ecosystem Services* 1 (1): 40–49. doi:10.1016/j.ecoser.2012.07.002.

Feller, I., D. Whigham, K. McKee, and C. Lovelock. 2003. “Nitrogen Limitation of Growth and Nutrient Dynamics in a Disturbed Mangrove Forest, Indian River Lagoon, Florida.” *Oecologia* 134 (3): 405–14.

Fisher, Brendan, R. Kerry Turner, and Paul Morling. 2009. “Defining and Classifying Ecosystem Services for Decision Making.” *Ecological Economics* 68 (3): 643–53. doi:10.1016/j.ecolecon.2008.09.014.

Gee, Kira, and Benjamin Burkhard. 2010. “Cultural Ecosystem Services in the Context of Offshore Wind Farming: A Case Study from the West Coast of Schleswig-Holstein.” *Ecological*

Complexity 7: 349–58. doi:10.1016/j.ecocom.2010.02.008.

Giri, C., E. Ochieng, L. L. Tieszen, Z. Zhu, A. Singh, T. Loveland, J. Masek, and N. Duke. 2011. "Status and Distribution of Mangrove Forests of the World Using Earth Observation Satellite Data." *Global Ecology and Biogeography* 20 (1): 154–59.

Gómez-Baggethun, E., R. de Groot, P. Lomas, and C. Montes. 2010. "The History of Ecosystem Services in Economic Theory and Practice: From Early Notions to Markets and Payment Schemes." *Ecological Economics* 69 (6). Elsevier B.V.: 1209–18.

Gómez-Baggethun, E., B Martín-López, D Barton, L Braat, H Saarikoski, E Kelemen, M García-Llorente, et al. 2014. "State-of-the-Art Report on Integrated Valuation of Ecosystem Services." *European Commission FP7*.

Gomez-Baggethun, E., and M. Ruiz-Perez. 2011. "Economic Valuation and the Commodification of Ecosystem Services." *Progress in Physical Geography*, 1–16.

Groot, Rudolf de, Luke Brander, Sander van der Ploeg, Robert Costanza, Florence Bernard, Leon Braat, Mike Christie, et al. 2012. "Global Estimates of the Value of Ecosystems and Their Services in Monetary Units." *Ecosystem Services* 1 (1): 50–61.

Gunawardena, M., and J. S. Rowan. 2005. "Economic Valuation of a Mangrove Ecosystem Threatened by Shrimp Aquaculture in Sri Lanka." *Environmental Management* 36 (4): 535–50.

Harborne, A., D. Afzal, and M. Andrews. 2001. "Honduras: Caribbean Coast." *Marine Pollution Bulletin* 42 (12): 1221–35. doi:10.1016/S0025-326X(01)00239-9.

Harborne, A., P. Mumby, F. Micheli, C. Perry, C. Dahlgren, K. Holmes, and D. Brumbaugh. 2006. "The Functional Value of Caribbean Coral Reef, Seagrass and Mangrove Habitats to Ecosystem Processes" 50 (5): 57–189.

Hema, M, and PI Devi. 2015. "Economic Valuation of Mangrove Ecosystems of Kerala, India." *Journal of Environmental Professionals Sri Lanka*.

Hoang Tri, Nguyen, WN Adger, and PM Kelly. 1998. "Natural Resource Management in Mitigating Climate Impacts: The Example of Mangrove Restoration in Vietnam." *Global Environmental Change* 8 (1): 49–61. doi:10.1016/S0959-3780(97)00023-X.

Hogarth, Peter J. 2015. *The Biology of Mangroves and Seagrasses*. Oxford University Press.

Hussain, S., and R. Badola. 2008. "Valuing Mangrove Ecosystem Services: Linking Nutrient Retention Function of Mangrove Forests to Enhanced Agroecosystem Production." *Wetlands Ecology and Management* 16 (6): 441–50. doi:10.1007/s11273-008-9080-z.

———. 2010. "Valuing Mangrove Benefits: Contribution of Mangrove Forests to Local Livelihoods in Bhitarkanika Conservation Area, East Coast of India." *Wetlands Ecology and Management*.

Hutchison, James, Mark Spalding, and Philine zu Ermgassen. 2014. "The Role of Mangroves in Fisheris Enhancement." *The Nature Conservancy and Wetlands International.*, 1–54.

Huxham, M, L Emerton, and J Kairo. 2015. "Applying Climate Compatible Development and Economic Valuation to Coastal Management: A Case Study of Kenya's Mangrove Forests." *Journal of Environmental …*.

Ingram, Jane Carter, Kent H Redford, and James E.M. Watson. 2012. "Applying Ecosystem Services Approaches for Biodiversity Conservation: Benefits and Challenges." *SAPI EN. S. Surveys and Perspectives Integrating Environment and Society* 5 (1): 10. doi:VOL.5 / N°1.

James, Godstime K., Jimmy O. Adegoke, Ekechukwu Saba, Peter Nwilo, Joseph Akinyede, and Sylvester Osagie. 2011. "Economic Valuation of Mangroves in the Niger Delta." *World*

Fisheries: A Social Ecological Analysis, 265–80.

Kelemen, Eszter, Marina García-Llorente, György Pataki, Berta Martín-López, and Erik Gómez-Baggethun. 2014. “Non-Monetary Techniques for the Valuation of Ecosystem Services.” In *OpenNESS Reference Book.*, 1–4.

Kenter, J., L. O’Brien, N. Hockley, N. Ravenscroft, I. Fazey, K. Irvine, M. Reed, et al. 2015. “What Are Shared and Social Values of Ecosystems?” *Ecological Economics* 111: 86–99.

Kosoy, N., and E. Corbera. 2010. “Payments for Ecosystem Services as Commodity Fetishism.” *Ecological Economics* 69 (6). Elsevier: 1228–36.Krauss, K., K. McKee, C. Lovelock, D. Cahoon, N. Saintilan, R. Reef, and L. Chen. 2014. “How Mangrove Forests Adjust to Rising Sea Level.” *The New Phytologist* 202 (1): 19–34.

Kull, Christian A, Xavier Arnauld de Sartre, and Monica Castro-Larranaga. 2015. “The Political Ecology of Ecosystem Services.” *Geoforum* 61: 122–34.

Lau, Jacqueline D., and Ivan R. Scales. 2016. “Identity, Subjectivity and Natural Resource Use: How Ethnicity, Gender and Class Intersect to Influence Mangrove Oyster Harvesting in The Gambia.” *Geoforum* 69 (February): 136–46. doi:10.1016/j.geoforum.2016.01.002.

Laurila-Pant, Mirka, Annukka Lehikoinen, Laura Uusitalo, and Riikka Venesjärvi. 2015. “How to Value Biodiversity in Environmental Management?” *Ecological Indicators* 55 (August). Elsevier: 1–11.

Lee, S., J. Primavera, F. Dahdouh-Guebas, K. McKee, J. Bosire, S. Cannicci, K. Diele, et al. 2014. “Ecological Role and Services of Tropical Mangrove Ecosystems: A Reassessment.” *Global Ecology and Biogeography* 23 (7): 726–43.

Lele, S, O Springate-Baginski, R Lakerveld, D Deb, and P Dash. 2013. “Ecosystem Services: Origins, Contributions, Pitfalls, and Alternatives.” *Conservation and Society* 11 (4): 343–58.

Lo, E., N. Duke, and M. Sun. 2014. “Phylogeographic Pattern of Rhizophora (Rhizophoraceae) Reveals the Importance of Both Vicariance and Long-Distance Oceanic Dispersal to Modern Mangrove Distribution.” *BMC Evolutionary Biology* 14 (1). BioMed Central: 83.

Lugo, A. 2002. “Conserving Latin American and Caribbean Mangroves.” *Madera Y Bosques Número Especial,* 5–25.

Lugo, A., E. Medina, and K. McGinley. 2014. “Issues and Challenges of Mangrove Conservation in the Anthropocene.” *Madera Y Bosques* 20: 11–38.

Lugo, A., and S. Snedaker. 1974. “The Ecology of Mangroves.” *Annual Review of Ecology and Systematics*.

Malik, A, R Fensholt, and O Mertz. 2015. “Economic Valuation of Mangroves for Comparison with Commercial Aquaculture in South Sulawesi, Indonesia.” *Forests*.

Martín-López, B., I. Iniesta-Arandia, M. García-Llorente, I. Palomo, I. Casado-Arzuaga, D. Amo, E. Gómez-Baggethun, et al. 2012. “Uncovering Ecosystem Service Bundles through Social Preferences.” Edited by Kamal Bawa. *PLoS ONE* 7 (6). Public Library of Science: e38970.

McCauley, D. 2006. “Selling out on Nature.” *Nature* 443 (7107): 27–28. doi:10.1038/443027a.

MEA. 2005. “Ecosystems and Human Well-Being.” *Island Press, Washington, DC*. Vol. 5.

Milcu, A., J. Hanspach, D. Abson, and J. Fischer. 2013. “Cultural Ecosystem Services: A Literature Review and Prospects for Future Research.” *Ecology & Society* 18 (3). The Resilience Alliance: 44–88.

Mimura, Nobuo. 2008. *Asia-Pacific Coasts and Their Management : States of Environment*. Springer.

Mukherjee, N., W. Sutherland, M. Khan, U. Berger, N. Schmitz, F. Dahdouh-Guebas, N. Koedam, L. Dicks, and J. Hugé. 2014. “Ecosystem Service Valuations of Mangrove Ecosystems to Inform Decision Making and Future Valuation Exercises.” *PLoS ONE* 9 (9): e107706.

Mukherjee, Nibedita, William J. Sutherland, Md Nabiul I. Khan, Uta Berger, Nele Schmitz, Farid Dahdouh-Guebas, and Nico Koedam. 2014. “Using Expert Knowledge and Modeling to Define Mangrove Composition, Functioning, and Threats and Estimate Time Frame for Recovery.” *Ecology and Evolution* 4 (11): 2247–62.

Mumby, P., A. Edwards, A. Ernesto, K.. Lindeman, P. Blackwell, A. Gall, M. Gorczynska, et al. 2004. “Mangroves Enhance the Biomass of Coral Reef Fish Communities in the Caribbean.” *Nature* 427 (6974). Nature Publishing Group: 533–36.

Nagelkerken, I., S. Blaber, S. Bouillon, P. Green, M. Haywood, L. Kirton, J. Meynecke, et al. 2008. “The Habitat Function of Mangroves for Terrestrial and Marine Fauna: A Review.” *Aquatic Botany* 89 (2): 155–85.

Nellemann, C, E Corcoran, C Duarte, L Valdés, C De Young, L Fonseca, and G Grimsditch. 2009. *Blue Carbon - The Role of Healthy Oceans in Binding Carbon. Environment.* GRID-Arendal.

Orchard, S., L Stringer, and C Quinn. 2016. “Mangrove System Dynamics in Southeast Asia: Linking Livelihoods and Ecosystem Services in Vietnam.” *Regional Environmental Change* 16 (3): 865–79.

Pearce, D. 1996. *Blueprint 2: Greening the World Economy*. Earthscan Publications, in association with the London Environmental Economics Centre.

Pendleton, Linwood, Daniel C. Donato, Brian C. Murray, Stephen Crooks, W. Aaron Jenkins, Samantha Sifleet, Christopher Craft, et al. 2012. “Estimating Global ‘Blue Carbon’ Emissions from Conversion and Degradation of Vegetated Coastal Ecosystems.” Edited by Simon Thrush. *PLoS ONE* 7 (9). Public Library of Science: e43542.

Plieninger, Tobias, Sebastian Dijks, Elisa Oteros-Rozas, and Claudia Bieling. 2013. “Assessing, Mapping, and Quantifying Cultural Ecosystem Services at Community Level.” *Land Use Policy* 33. doi:10.1016/j.landusepol.2012.12.013.

Plummer, Mark L. 2009. “Assessing Benefit Transfer for the Valuation of Ecosystem Services.” *Frontiers in Ecology and the Environment*. Ecological Society of America. doi:10.1890/080091.

Polasky, Stephen, Heather Tallis, and Belinda Reyers. 2015. “Setting the Bar: Standards for Ecosystem Services.” *Proceedings of the National Academy of Sciences of the United States of America* 112 (24). National Academy of Sciences: 7356–61. doi:10.1073/pnas.1406490112.

Polidoro, B, K Carpenter, L Collins, N Duke, A Ellison, J Ellison, E Farnsworth, et al. 2010. “The Loss of Species: Mangrove Extinction Risk and Geographic Areas of Global Concern.” *PLoS ONE* 5 (4): 1–10. doi:10.1371/journal.pone.0010095.

Primavera, J. 1997. “Socio-Economic Impacts of Shrimp Culture.” *Aquaculture Research* 28 (10): 815–27.

Primavera, J. H. 2000. “Development and Conservation of Philippine Mangroves: Institutional Issues.” *Ecological Economics*.

Primavera, Jurgenne H. 2005. “Mangroves and Aquaculture in Southeast Asia.” *Report of the Regional Technical Consultation for the Development of Code of Practice for Responsible Aquaculture in Mangrove Ecosystems*, 25–37.

Pullin, Andrew S., Teri M. Knight, David A. Stone, and Kevin Charman. 2004. “Do Conservation

Managers Use Scientific Evidence to Support Their Decision-Making?" *Biological Conservation*. Elsevier.

Queiroz, Luciana de Souza, Sergio Rossi, Laura Calvet-Mir, Isabel Ruiz-Mallén, Sara García-Betorz, Júlia Salvà-Prat, and Antônio Jeovah de Andrade Meireles. 2017. "Neglected Ecosystem Services: Highlighting the Socio-Cultural Perception of Mangroves in Decision-Making Processes." *Ecosystem Services* 26 (August). Elsevier: 137–45. doi:10.1016/j.ecoser.2017.06.013.

Raum, Susanne. 2017. "The Ecosystem Approach, Ecosystem Services and Established Forestry Policy Approaches in the United Kingdom." *Land Use Policy* 64: 282–91.

Richards, D., and D. Friess. 2016. "Rates and Drivers of Mangrove Deforestation in Southeast Asia, 2000–2012." *Proceedings of the National Academy of Sciences* 113 (2): 344–49.

Rönnbäck, Patrik. 1999. "The Ecological Basis for Economic Value of Seafood Production Supported by Mangrove Ecosystems." *Ecological Economics* 29 (2): 235–52.

Ruitenbeek, H. J. 1994. "Modelling Economy-Ecology Linkages in Mangroves: Economic Evidence for Promoting Conservation in Bintuni Bay, Indonesia." *Ecological Economics* 10: 233–47. doi:10.1016/0921-8009(94)90111-2.

Ruitenbeek, J. 1994. "Modelling Economy-Ecology Linkages in Mangroves: Economic Evidence for Promoting Conservation in Bintuni Bay, Indonesia." *Ecological Economics* 10 (3): 233–47. doi:10.1016/0921-8009(94)90111-2.

Saenger, P., and N. Siddiqi. 1993. "Land from the Sea: The Mangrove Afforestation Program of Bangladesh." *Ocean and Coastal Management* 20 (1). Elsevier: 23–39.

Saenger, Peter, Donald Gartside, and S Funge-Smith. 2013. *A Review of Mangrove and Seagrass Ecosystems and Their Linkage to Fisheries and Fisheries Management*.

Salem, M., and D. Mercer. 2012. "The Economic Value of Mangroves: A Meta-Analysis." *Sustainability* 4 (3): 359–83.

Satyanarayana, Behara, Preetika Bhanderi, Mélanie Debry, Danae Maniatis, Franka Fore, Dawda Badgie, Kawsu Jammeh, et al. 2012. "A Socio-Ecological Assessment Aiming at Improved Forest Resource Management and Sustainable Ecotourism Development in the Mangroves of Tanbi Wetland National Park, the Gambia, West Africa." *Ambio* 41 (5). Springer: 513–26.

Satz, Debra, Rachelle K Gould, Kai M A Chan, Anne Guerry, Bryan Norton, Terre Satterfield, Benjamin S Halpern, et al. 2013. "The Challenges of Incorporating Cultural Ecosystem Services into Environmental Assessment." *Ambio* 42 (6). Springer: 675–84. doi:10.1007/s13280-013-0386-6.

Schmidt, Stefan, Ameur M. Manceur, and Ralf Seppelt. 2016. "Uncertainty of Monetary Valued Ecosystem Services - Value Transfer Functions for Global Mapping." Edited by Carlo Nike Bianchi. *PLoS ONE* 11 (3): e0148524. doi:10.1371/journal.pone.0148524.

Schröter, Matthias, Emma H. van der Zanden, Alexander P.E. E van Oudenhoven, Roy P. Remme, Hector M. Serna-Chavez, Rudolf S. de Groot, and Paul Opdam. 2014. "Ecosystem Services as a Contested Concept: A Synthesis of Critique and Counter-Arguments." *Conservation Letters* 7 (6): 514–23.

Small, N, M Munday, and I Durance. 2017. "The Challenge of Valuing Ecosystem Services That Have No Material Benefits." *Global Environmental Change* 44: 57–67.

Spalding, M, A McIvor, F Tonneijck, S Tol, and P Eijk. 2014. "Mangroves for Coastal Defence.

Guidelines for Coastal Managers & Policy Makers." *Wetlands International and The Nature Conservancy*, 42.

Spalding, Mark. 2010. *World Atlas of Mangroves*. Routledge.

Spangenberg, Joachim H., and Josef Settele. 2010. "Precisely Incorrect? Monetising the Value of Ecosystem Services." *Ecological Complexity* 7 (3). Elsevier: 327–37. doi:10.1016/j.ecocom.2010.04.007.

Spaninks, Frank, and Pieter Van Beukering. 1997. "Economic Valuation of Mangrove Ecosystems: Potential and Limitations." *CREED Working Paper*, no. 14.Spaninks, Frank, and Pieter Van Beukering. 1997. "Economic Valuation of Mangrove Ecosystems: Potential and Limitations," July.

Sukhdev, P. 2008. "The Economics of Ecosystems and Biodiversity: An Interim Report." In *European Communities*, edited by P. Kumar, 64. London and Washington. doi:10.1093/erae/jbr052.

Sutherland, William J., Andrew S. Pullin, Paul M. Dolman, and Teri M. Knight. 2004. "The Need for Evidence-Based Conservation." *Trends in Ecology and Evolution*. Elsevier Current Trends.

TEEB. 2010. "The Economics of Ecosystems and Biodiversity : Ecological and Economic Foundations." Earthscan.

Thomas, Nathan, Richard Lucas, Peter Bunting, Andrew Hardy, Ake Rosenqvist, and Marc Simard. 2017. "Distribution and Drivers of Global Mangrove Forest Change, 1996-2010." Edited by Shijo Joseph. *PLoS ONE* 12 (6). Food and Agriculture Organization of the United Nations: e0179302. doi:10.1371/journal.pone.0179302.

Tomlinson, PB. 1994. *The Botany of Mangroves*.

Uddin, Md Shams, E. de Ruyter van Steveninck, Mishka Stuip, and Mohammad Aminur Rahman Shah. 2013. "Economic Valuation of Provisioning and Cultural Services of a Protected Mangrove Ecosystem: A Case Study on Sundarbans Reserve Forest, Bangladesh." *Ecosystem Services* 5: 88–93.

UNEP. 2014. *The Importance of Mangroves to People: A Call to Action*. *United Nations Environment Programme World Conservation Monitoring Centre.*

Valiela, Ivan, Jennifer Bowen, and Joanna. York. 2001. "Mangrove Forests: One of the World's Threatened Major Tropical Environments." *BioScience*.

Vo, Quoc Tuan, C. Kuenzer, Quang Minh Vo, F. Moder, and N. Oppelt. 2012. "Review of Valuation Methods for Mangrove Ecosystem Services." *Ecological Indicators*.

Walters, B., P. Rönnbäck, J. Kovacs, B. Crona, S. Hussain, R. Badola, J. Primavera, E. Barbier, and F. Dahdouh-Guebas. 2008. "Ethnobiology, Socio-Economics and Management of Mangrove Forests: A Review." *Aquatic Botany* 89 (2): 220–36.

Ward, Raymond D., Daniel A. Friess, Richard H. Day, and Richard A. MacKenzie. 2016. "Impacts of Climate Change on Mangrove Ecosystems: A Region by Region Overview." *Ecosystem Health and Sustainability* 2 (4): 1–25.

Watson, Robert T, Thomas Rosswall, Achim Steiner, Klaus Töpfer, Salvatore Arico, and Peter Bridgewater. 2005. *Ecosystems and Human Well-Being*. Edited by Robert T Watson, Thomas Rosswall, Achim Steiner, Klaus Töpfer, Salvatore Arico, and Peter Bridgewater. *Millenium Assessments*. Vol. 5. Millenium Assessments. World Resources Institute. doi:10.1196/annals.1439.003.

Wilson, C, and Matthews. 1970. *Man's Impact on the Global Environment; Assessment and*

Recommendations for Action; Report. *Report of the Study of Critical Environment Problems (SCEP) 1970. Cambridge Massachusetts MIT Press 1970. 319 P*.

Winthrop, Robert H. 2014. “The Strange Case of Cultural Services: Limits of the Ecosystem Services Paradigm.” *Ecological Economics* 108: 208–14. doi:10.1016/j.ecolecon.2014.10.005.

Zhang, Keqi, Huiqing Liu, Yuepeng Li, Hongzhou Xu, Jian Shen, Jamie Rhome, and Thomas J. Smith. 2012. “The Role of Mangroves in Attenuating Storm Surges.” *Estuarine, Coastal and Shelf Science* 102–103 (May): 11–23.

Chapter 3

Stakeholder perceptions of the importance of mangrove ecosystem services in coastal communities on the Caribbean coast of Honduras

Abstract

Lessons learned from past conservation efforts have led to movement away from traditional, top-down approaches to ecosystem management and toward more integrated efforts, characterised by increased public participation and better communication across stakeholder types. Coastal ecosystems such as Mangrove forests are becoming increasingly incorporated into coastal zone management schemes centred around an integrated approach. The' Ecosystem Service Concept' and associated valuation methods have become popular means of attempting to facilitate better communication across stakeholder types, however focus on monetary valuation methods means that local communities remain excluded. We used a choice experiment in "Maximum Difference" (MaxDiff) to investigate social values of mangrove services to coastal communities at four sites along the Caribbean coast of Honduras, to demonstrate their significance in designing management schemes. We found that perceptions as to the relative importance of the nursery (high) and saltwater intrusion (low) services were consistent amongst sites. The majority of services however demonstrated variation amongst the sites. Some showing variation in attributed importance scores amongst sites maintained similar rankings of importance over the sites (biodiversity). Perceptions of others such as the storm protection, erosion limitation and tourism services were found to be affected by the relative geographies of the communities surveyed. The consistencies and differences shown in community perceptions here demonstrates the significance of capturing social values of ecosystem services as consistent perceptions offer potential for generalised, national management schemes and differences highlight the importance of considering site specifics to avoid conflict.

3.1 Introduction

The intertidal zone is amongst the most dynamic and harsh environments (D. Alongi 2008; Spalding 2010; Duke and Schmitt 2016). Characterized by high levels of salinity, strong winds, and anaerobic soils, among other fluctuating conditions, this space offers little to be desired in terms of the optimal conditions required for establishing plant communities (Duke and Schmitt 2016; Hogarth 2015; Kathiresan and Bingham 2001). Nevertheless, this environment offers the fundamental growth conditions for one of the earth's most productive ecosystems, mangrove forests (Kathiresan and Bingham 2001; Hogarth 2015; Gillis, Belshe, and Narayan 2017). Mangroves are defined as an assortment of woody salt-tolerant trees and shrubs which grow within estuaries and along coastlines in tropical and subtropical regions, primarily between 30^{o}N and 30^{o}S of the equator (Thomas et al. 2017; Hogarth 2015; Kathiresan and Bingham 2001; Giri et al. 2011; Tomlinson 1994; Duke 1992). Once thought to be unproductive wastelands (Lugo and Snedaker 1974; Gunawardena and Rowan 2005; J. H. Primavera 2000; Ic Feller and Sitnik 1996), mangrove ecosystems are gaining recognition for providing a variety of ecosystem services (Barbier 2007b; B. Walters et al. 2008; Friess and Thompson 2016). These services support adjacent ecosystems and are vital to the well-being of coastal communities (B. Walters et al. 2008; Hussain and Badola 2010; Duke and Schmitt 2014), providing benefits to local, national and even global scale economies (Spaninks and Van Beukering 1997; Salem and Mercer 2012; Thomas et al. 2017; Thompson, Primavera, and Friess 2017)

Ecosystem services (ES) is a term used to describe the processes and functions of ecosystems that support associated environments and help sustain human life (Costanza et al. 1997; Chapin et al. 2000). Use of ES terminology has gained considerable momentum as a means of raising awareness as to the importance of ecosystem, through communicating societal support by ecosystems (Lele et al. 2013; Daily 1997; Kull, de Sartre, and Castro-Larranaga 2015). Mangroves are becoming increasingly recognized as effective providers of multiple services which include: provisioning (e.g. timber, medicines and multiple-use fisheries; (W. M. Bandaranayake 1999; B. Walters et al. 2008; Aburto-Oropeza et al. 2008)); regulating (e.g. storm protection, erosion control, climate regulation; (Donato et al. 2011; S Das and Crépin 2013; Barbier et al. 2011)); supporting (e.g. nutrient cycling; (Hussain and Badola 2008; I. Feller et al. 2003)) and cultural services (recreational, aesthetic and spiritual; (Spaninks and Van Beukering 1997; Uddin et al. 2013)). Estimates suggest that today, over 220 million people live within 10km of mangrove forests, and the ES provided by these forests are of significant socio-economic importance to these communities (UNEP 2014).

Despite their social, economic and ecological significance, mangrove cover across the globe is declining at an alarming rate (Duke et al. 2007). The 20 years between 1980 - 2000 saw an estimated loss of 35% of global mangrove cover and decline is ongoing (Giri et al. 2011; Polidoro et al. 2010; Valiela, Bowen, and York 2001; Barbier et al. 2011) putting loss at 1% per year (Polidoro et al. 2010; FAO 2007; D. M. Alongi 2002). This means that mangrove loss is occurring at a rate which is faster than both tropical rainforests and of coral reefs (Valiela, Bowen, and York 2001; Polidoro et al. 2010) two ecosystems that have received considerably more international attention (Duarte et al. 2008). At present, the primary threats to mangrove habitats are the overexploitation of resources and mass clearing for alternative land uses (Valiela, Bowen, and York 2001; Polidoro et al. 2010; Carter, Schmidt, and Hirons 2015; Thomas et al. 2017). Clearing for aquaculture purposes for example, is commonplace in Southeast Asia, whereas countries in the Caribbean have removed large areas of mangrove forest for coastal tourism opportunities (Polidoro et al. 2010; D. M. Alongi 2002; Richards and Friess 2016; B. Walters et al. 2008; Barbier and Sathirathai 2004). Behaviours that threaten mangrove viability ultimately reduce ecosystem productivity and capacity to deliver vital services. For example, destruction of mangroves is believed to produce approximately 0.12 Giga Tonnes of CO_2 each year, an amount that accounts for roughly 0.3% of total anthropocentric emissions. Further compounding on this problem, clearance not only depletes these mangrove carbon storage stocks but also then prevents mangroves from sequestering and storing additional carbon in the future. Various anthropogenic pressures further add to the issues of clearing of clearing and overexploitation. For example, increasing levels of human encroachment often lead to problems such as pollution (e.g. agricultural runoff) and fragmentation (e.g. through construction of roads). These threats have varied knock on effects for services and their production. For example, the effects of pollution on water quality and the alterations to hydrology caused by human infrastructural encroachment not only affect connectivity and productivity, but also prove detrimental to the biodiversity and nursery services (Thomas et al. 2017; Valiela, Bowen, and York 2001; D. M. Alongi 2002; Jiao et al. 2015; Godoy and Lacerda 2015; Blanco-Libreros and Estrada-Urrea 2015).

In addition to the more directly anthropocentric threats described here, low-lying mangroves also face impending threats at hand of climate change and the resulting sea-level rise. If allowed to do so mangroves are capable of adapting to sea level rise through the accumulation of sediment, however the pace at which climate change is occurring, combined with human encroachment leaving the forests trapped at the shore line means that this is not guaranteed. Without these mangroves, human settlements nearby will not benefit from vital storm protection and erosion services in a time when extreme weather events are through to be become more frequent (Ward et al. 2016; Krauss et al. 2014).

Recent years have seen a shift in mangrove management, from central themes of exploitation and extraction towards those of preservation and conservation (Carter, Schmidt, and Hirons 2015; FAO 2007). The global extent of mangrove decline has resulted in protection efforts through international agreements such as the Ramsar convention (1974) and the UNESCO heritage program (Farnsworth and Ellison 1997; Polidoro et al. 2010; Carter, Schmidt, and Hirons 2015). On the ground, management has largely focused on the establishment of national parks (NPs) and marine protected areas (MPAs) to restrict human activity and limit anthropocentric pressures (Carter, Schmidt, and Hirons 2015). However, the effectiveness of such "top-down", preservationist approaches to conservation is becoming increasingly debated in the wider management literature (Bennett and Dearden 2014; Teixeira De Almeida et al. 2016). In many cases, implementation of MPAs and NPs has been found to be unsuccessful in preventing biodiversity loss in the environments they were designed to protect (Lugo, Medina, and McGinley 2014; Sarker et al. 2016). These so called 'paper-parks' often suffer due to lack of sufficient funds and resources for proper enforcement (Wilkinson et al. 2006; Terborgh 2002; Lugo, Medina, and McGinley 2014). Even in an ideal situation where funding, policing and management were successfully implemented, MPAs only offer a temporary solution. For one, sea level rise continues to threaten the forests in spite of protective legislation, but more so MPAs are vulnerable to legislative overhauls or funding cuts associated with changes in political parties, a very typical situation in developing countries. In addition, the high level of human interaction experienced by these ecosystems make it very difficult to prohibit use, meaning that prohibiting people from the mangroves would only be effective for a finite time period. PAs often face problems as a result of their exclusion of local communities (Bennett and Dearden 2014; Richmond and Kotowicz 2015; Blanco-Libreros and Estrada-Urrea 2015). Implementing PAs has been found to cause social conflict through the causing of detrimental socio-economic impacts such as inequality creation and the restriction or loss of livelihoods (Muhumuza and Balkwill 2013; Bavinck and Vivekanandan 2011; Bennett and Dearden 2014; Christie 2004). Such conflict can drastically impair the chances of successful conservation, and the success of conservation approaches can often be predicated by degree of local support (Bennett and Dearden 2014; J H Primavera and Esteban 2008; Blanco-Libreros and Estrada-Urrea 2015; Lugo, Medina, and McGinley 2014). Ecosystem decline and biodiversity loss are heavily influenced by socio-economic and political factors and preservationist approaches fail to account for these (Muhumuza and Balkwill 2013; Bennett, Peterson, and Gordon 2009; Christie 2004). Implementing successful PAs also faces limitations as a result of lacking communication amongst stakeholders. (Cvitanovic *et al.* (2014) and Sutherland *et al.*, (2004) for example, discuss concerns of the research-implementation gap between researchers and management practitioners, referencing the limited integration of primary research and scientific evidence (Knight et al. 2008; Pullin et al. 2004; Cook, Hockings, and Carter 2010). This causes problems as it means areas are managed with a lack of consideration of potential differences amongst sites and they may be treated as if all are the same (Cvitanovic et al. 2014). Although implementing PAs has undoubtedly contributed to safeguarding environments at risk, their lack of consideration to socio-economic factors is not compatible with combatting risks resulting from a growing population (Bennett and Dearden 2014). As a result, bottom up conservation approaches characterised by a greater focus on community level conservation have gained increasing attention (Wilkinson and Salvat 2012; Wilcock 1995; Gaymer et al. 2014; M. S. Reed, Fraser, and Dougill 2006; J. Reed et al. 2016) and it has become increasingly recognized that successful conservation requires movements toward integrated approaches (Likens and Lindenmayer 2012; Gaymer et al. 2014).

A characteristic element of the bottom-up approaches that feature heavily in integrated efforts is better integration of various stakeholders and effective collaboration amongst them (Wilkinson and Salvat 2012). Efforts to bridge the gaps and increase communication between practitioners and decision makers from within this framework has given rise to interdisciplinary tools such as monetary valuation of ecosystem services (MVES)(Laurans et al. 2013)(Gómez-Baggethun et al. 2010). Originally intended to communicate ecosystem values in terms more readily accessible by policy makers, ecosystem valuations have been heavily adopted into the mangrove service literature (Gómez-Baggethun et al. 2010)(Lele et al. 2013). Tidal marsh and mangrove ecosystem services (ES) have been valued at US\$194,000 ha^{-1} yr^{-1} by Costanza *et al.* (2014). Although MVES may help bridge gaps between managers and decision makers, it is lacking with regard to integrating direct resource users and local communities (Felipe-Lucia, Comín, and Escalera-Reyes 2014)(Locatelli et al. 2014)(Kelemen et al. 2014) . Social approaches to assessing importance of value to local people can help integrate their voices and perceptions (Felipe-Lucia, Comín, and Escalera-Reyes 2014; Small, Munday, and Durance 2017; Gómez-Baggethun et al. 2014). Mangroves are becoming increasingly included in integrated coastal zone management. ICZM aims to provide "a *balance* of development and conservation that ensures multi-sector planning, public participation, and conflict mediation" by incorporating government and community level participation in the process (Carter, Schmidt, and Hirons 2015). To help facilitate this we therefore need to look at how coastal, mangrove dependent communities value mangrove services and understand how these might influence their decision making.

The mangrove forests of Latin America and the Caribbean combined contribute to 26% of the global mangrove cover (Giri et al. 2011), however they remain largely underrepresented in the literature when compared to those in Southeast Asia. The Caribbean is believed to have lost 26% of its mangroves over the past 25 years, a loss second only to losses seen in Southeast Asia (FAO 2007; Polidoro et al. 2010). The Caribbean is home to the Mesoamerican Reef ecoregion, which includes Mexico, Belize, Guatemala and Honduras and holds the longest reef in the Western Hemisphere (Cahoon et al. 2003; Harborne, Afzal, and Andrews 2001). The Mesoamerican Barrier Reef (MAR) is considered to be of significant ecologically and socio-economic importance due to its wide-scale maintenance of associated ecosystems and support of livelihoods for people in bordering countries, approximately 2 million people (Mcfield and Kramer 2007). The ecoregion represents a considerable management challenge as it requires transboundary collaboration (Mcfield and Kramer 2007). The

Caribbean coastline of Honduras represents the Southern end of the MAR and stretches 753km (Harborne, Afzal, and Andrews 2001). The mangroves here contribute 14.7% of the total found in the MAR. The coastline offers a variety of marine habitats and a mixture of different mangrove systems both on-shore and off-shore (Harborne, Afzal, and Andrews 2001; Bhomia, Kauffman, and McFadden 2016), each of which exhibit varied levels of community dependency. Mangrove forest is thought to cover roughly 35,000ha in Honduras and is distributed relatively evenly between the country's Caribbean and pacific coasts (Canty, 2018). Coastal zone management is relatively novel to Honduras, however the existence of large-scale initiatives, dedicated NGOs and growing environmental consciousness in the country present an encouraging case for conservation here (Harborne, Afzal, and Andrews 2001).

3.2 Aims and objectives

The objective of this study was to examine perceptions of the relative importance of mangrove services that are held by coastal community members along the Caribbean coast of Honduras. Four mangrove-dependent communities were surveyed at four sites (two islands and two mainland) as a means of investigating potential variation across different systems. This study aims to build on existing knowledge of the mangrove services in this region, and to determine the degree of alignment between current economic valuation and local community priorities. This supports an ultimate aim of refining conservation priorities in Honduras and creating community crafted management projects.

3.3 Methodology

Ethics statement

This research project was conducted with full compliance of research ethics norms, and more specifically the codes and practices established by the University of Manchester Ethics Committee who approved this study prior to its commencement.

Study sites and data collection

The data used in this study was collected from communities at four different sites along the Honduran Caribbean coastline. The Caribbean Coast of Honduras represents the southern end of the Mesoamerican reef (MAR region) (Figure 3.1). The coastline stretches from Guatemala (15.43 ^{o}N; 88.13 ^{o}W) to Nicaragua (14.59 ^{o}N; 14.59 ^{o}W), measuring 735km, and includes The Bay Islands; Utila, Roatan and Guanaja (Figure 3.1) (Harborne, Afzal, and Andrews 2001; Bhomia, Kauffman, and McFadden 2016). The Caribbean coast of Honduras features a tropical wet climate, with temperatures ranging from a minimum of 20°C, to highs of 32°C, and the region experiences annual rainfall of approximately 2800–3000 mm (Harborne, Afzal, and Andrews 2001; Bhomia, Kauffman, and McFadden 2016). This region is host to multiple different marine habitats and variety of mangrove systems (i.e. riverine estuaries, lagoon, offshore) (Harborne, Afzal, and Andrews 2001; Ersión and Echa 2005). Mangrove species known to the region include two species of red mangrove (*Rhizopora mangle, R. harrisonii*), black mangrove (*Avicennia germinans*) and white mangrove (*Laguncularia racemosa*), and the associate mangrove species, buttonwood (*Conocarpus erectus*) (Ersión and Echa 2005). Reports suggest that the mangrove forests here face threats from mass clearing, pollution and unsustainable exploitation (Harborne, Afzal, and Andrews 2001). As a country, Honduras is believed to have lost over 85 000 ha of mangroves since 1980 (Lugo, Medina, and

McGinley 2014), losses that have been reported as results of the salt production and Shrimp farming industries (Ersión and Echa 2005; FAO 2007; Dewalt, Vergne, and Hardin 1996). Reports describing mangrove services in the context of the modern ecosystem service concept are scarce in this region. In Honduras, shifts in management toward the protection of marine environments originate around 1959 with establishment of the 'Ley de Pescar', established to make reefs protected areas (Harborne, Afzal, and Andrews 2001). In 1997, the countries of Central America collectively signed the 'Tulum declaration' to collaborate conservation efforts of the MAR (Harborne, Afzal, and Andrews 2001). Coastal zone management is thus relatively novel in Honduras, it has however gained considerable momentum through organisation of large-scale initiatives and the establishment of national, grass-roots NGOs (Harborne, Afzal, and Andrews 2001). The Forest Conservation Institution (ICF) is the governmental department responsible for management of mangroves, however, all day-to-day management of forests done by said local NGOs.

Data was collected from two island communities and two mainland communities. The island communities were inhabitants of the 'Islas de Bahia' or the Bay Islands, located between 30-50km off of the mainland coast (Korda, Hills, and Gray 2008). The Bay Islands are surrounded by a variety of coral reef systems that support a diversity of associated marine life that have led them to become central to the tourism and fishing industries (Harborne, Afzal, and Andrews 2001). Dive tourism and the associated infrastructure has proliferated in the Islands as several charismatic marine species such as whale sharks (*Rhincodon typus*), manta rays (*Manta birostris*) and green sea turtles (*Chelonia mydas*) frequent the surrounding reefs (Harborne, Afzal, and Andrews 2001; Doiron and Weissenberger 2014). Despite living amongst mangroves, the dependence of islands settlers on mangroves within the community was varied based on their social status. In comparison, community members at the mainland sites surveyed were fully dependent on their surrounding mangroves, which provided their livelihoods and were heavily integrated into their way of life. Much less has been reported with regards to the marine resources of the mainland (Harborne, Afzal, and Andrews 2001). The individuals surveyed on the mainland were members of artisanal fishing communities and experienced a much lower standard of living than their island counterparts (Harborne, Afzal, and Andrews 2001). Widespread destruction caused by Hurricane Mitch in 1998 (Cahoon et al. 2003) has prompted mass migration of poor and uneducated mainland inhabitants to the Bay Islands in search of employment in the tourism industry (Doiron and Weissenberger 2014; Stonich 1995; Canty 2007).

Roatan - Sandy Bay and West End communities

Roatan is the largest island of the Bay islands with an area of 133 km^2 (Figure 3.1) and is estimated to possess roughly 800ha of mangrove forests, most of which is located on the eastern side of the island (Cahoon et al. 2003; Doiron and Weissenberger 2014). The community sampled here inhabited the main residential zone of the Island, Sandy Bay, and a primary tourist zone, West end (Colwell 1998). The original settlers in Roatan are known as White Caracoles, people of Caymanian origin (West 2001; Harborne, Afzal, and Andrews 2001). Roatan tourism and real estate infrastructure, generated over US$180 million in 2006 from the tourist industry (Canty 2007). This tourism success has caused significant immigration to the area continuing a significant population of Garifuna and Latinos to the island (Stonich 1995). Community members include a mixture of service providers (e.g. manual labourers, plumbers) and those working in hospitality with the tourism industry. The area was designated a marine reserve (Colwell 1998) that was originally managed by a dive resort, which did create some tension due to loss of livelihoods, but management has now been taken over by the Bay Island Conservation Association (BICA), an NGO with greater community participation (Colwell 1998).

Utila - East harbour community

Utila is the smallest of the three Bay Islands is the island of Utila (Figure 3.1), and has mangroves along its northern coastline, interior areas and a few fragmented patches on the southern side along two lagoons (Jaxion-Harm et al. 2012; Bhomia, Kauffman, and McFadden 2016). The mangroves here are thought to cover roughly 66% of the island (Cahoon, 2003). Population here is mixture of white Utilans, white Cayans, Garifuna and Mezito Latinos (Korda, Hills, and Gray 2008). The primary settlement on the island is East Harbour. Tourism industry has transformed the island, turning it from fishing community to tourism destination, with the highest socio-economic position on the island possessed by those living in East Harbour (Korda, Hills, and Gray 2008). Development of the tourism industry has been extensive and Utila is now the fifth most affluent municipality of Honduras, due to the growth of dive tourism (Canty, 2007). The participants had similar occupations to those in Roatan. Mangroves here were managed by a separate branch of BICA-Utila.

Tela Bay - Miami community

The community surveyed in Tela (35°9'S, 80°59'W) were one of five Garifuna communities that inhabit the area (Loperena, 2012). The community here were a small artisanal fishing community surrounded by two national parks so were subsistence based mangrove users, with many people fishing to feed themselves and their families as well as for domestic trade. The community here live alongside the Laguna los Micos, a large mangrove lined lagoonal system that feeds into Tela bay. The lagoon is part of the Jeanette Kawas National Park, run and managed by a local NGO called PROLANSATE. The national park covers 781.68km^2 and boasts a variety of ecosystems, such a as mangroves, swamps, lagoons and river, however no estimates exist as to the specific mangrove coverage. The area is a hotspot for domestic tourism and tourism increased further with the Los Micos beach and golf resort project supported by the Inter-American Development Bank (IDB) and Tourism Ministry (Mollett 2014; Loperena 2012). In recent years the community experienced mass out-migration as a result of the projects failure and those that remain are involved in a preservation and tourism project to look like authentic traditional housing with thatched roofs.

La Ceiba - Cuero y Salado

The mangrove forest in Cuero y Salado (15.46°N, 87.07°W) was representative of a river estuarine system and is located 27km from the port city La Ceiba. Cuero y Salado was the first wetland in Honduras protected under the RAMSAR convention and is now one of 26 designated wildlife reserves in the country (Snarr 2005; Horochowski and Neil Moisey 1999; McCool and Moisey 2008). Although no official reports of mangrove coverage exist in the literature the park extends over more than 13,000 ha with a large proportion of this said to be occupied by mangroves. The area is managed by an organisation called Fundacion de Cuero y Salado (FUCSA) and has been managed in this way as of 1987 (Snarr 2005; Horochowski and Neil Moisey 1999). The participants surveyed in Cuero y Salado were an artisanal fishing community consisting predominately of

Mezito Latino settlers however, a small proportion of Garifuna live in the area (Horochowski and Neil Moisey 1999). The reserve receives tourists from La Ceiba, many of which come to engage in mangrove canal tours by kayak as this area hosts many charismatic species such as the Antillean Manatee (*Trichechus manatus*) (González-Socoloske, Taylor, and Thompson 2011). The area is under stress from the encroachment of agricultural land (palm plantations) in addition to illegal logging (Snarr, 2005).

The communities at the locations surveys were accessed by contacting the management practitioner's local to each area. Attempts were made to sample 30 people per site based on recommendations in the literature (Sawtooth Technical Paper 2013), however a small number of surveys had to be forgone. The total population sampled was 117. Individuals were using a simple random sampling method, via a door-to-door approach. Only those born on the island or having had lived on the island for 30+ years were asked to participate. Although a stratified random sampling method may have collected a more structured respondent population the small size of the communities interviewed meant that (after excluding foreigners and people under the age of 18) 30 respondents accounted for roughly 50-75% of site population, making a random sampling method equally as representative.

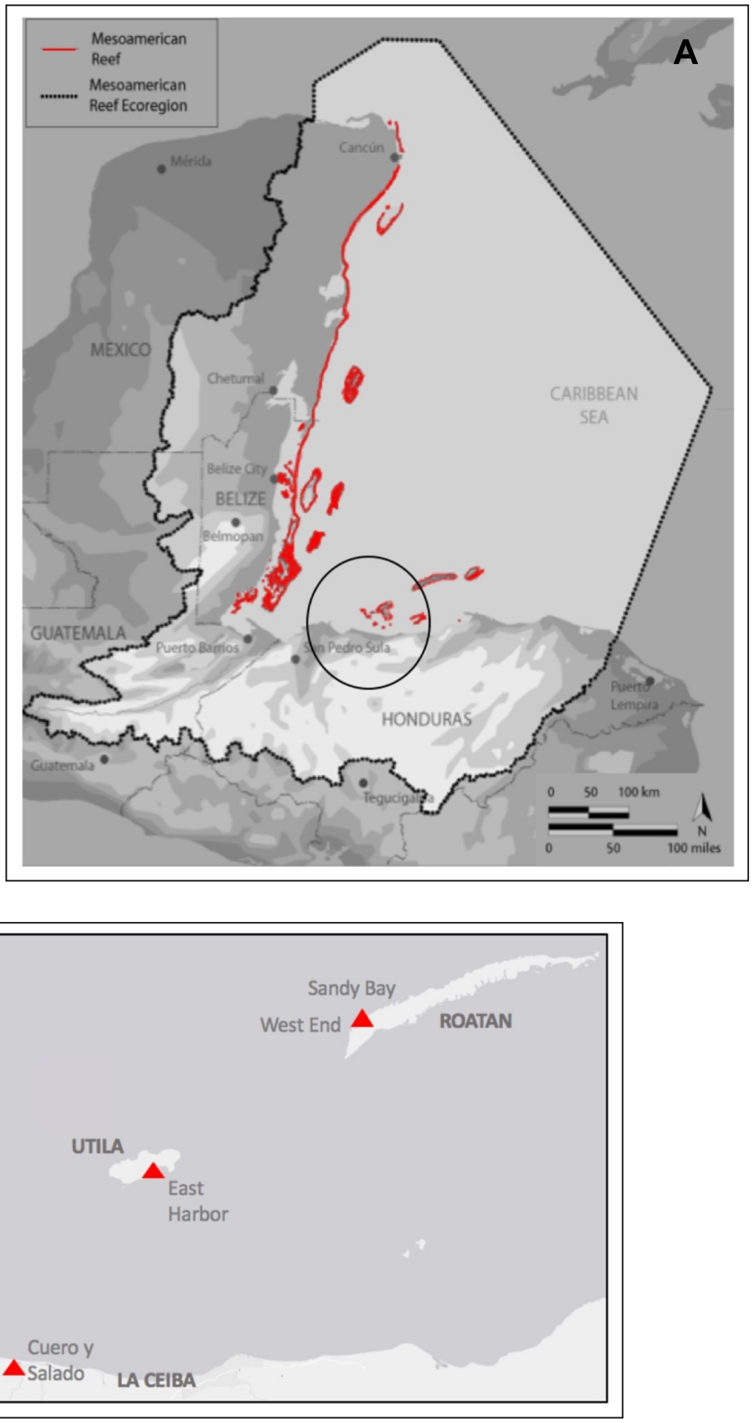

Figure 3.1 Map of the MAR ecoregion (A) and the study sites visited (B). Locations of the communities surveyed at each site are marked (triangles) and labelled. Mangrove cover in this region is represented in red. The map used in this figure was sourced and modified from: The Healthy Reefs for Healthy People Initiative (HRI; www.healthyreefs.org).

Best worst scaling technique

Stakeholder perceptions of mangrove services were surveyed using a choice experiment in "Maximum Difference" (MaxDiff) or 'best-worst scaling (BWS)' format. Initially introduced by Finn & Louviere (1992), BWS is often described as a sophisticated extension on Thurnstone's (1927) traditional method of paired comparisons (MPC) and a powerful variation on the standard rating scale (Flynn and Marley 2014; Erdem, Rigby, and Wossink 2012; Sawtooth Technical Paper 2013; Auger, Devinney, and Louviere 2007). BWS functions as a means of examining participant preferences; individuals trade-off amongst paired items from a pre-defined list (Erdem, Rigby, and Wossink 2012). As a result, this technique has become a popular approach to exploring the relative importance attributed to different things by individuals and groups (Nunes et al. 2016; Burke et al. 2013). Originally intended for examining consumer preferences in market research, BWS is becoming popular across a variety of different disciplines and is being used to explore subjects from medical care (Flynn et al. 2008; Wittenberg et al. 2016; Cheung et al. 2016), ethical issues (Auger, Devinney, and Louviere 2007), education (Burke et al. 2013) and even environmental policy and conservation science (Kreye et al. 2017; Greiner 2016; Soto, Adams, and Escobedo 2016). The popularity of BWS is likely owed to several advantages the approach has over traditional MPC (Erdem, Rigby, and Wossink 2012). One such advantage is BWS is particularly efficient in eliciting preference data, producing large quantities of utility information (at both a summative and at the attribute level) whilst asking relatively little of participants (Flynn et al. 2008; Erdem, Rigby, and Wossink 2012; Kreye et al. 2017; P. Saenger and Siddiqi 1993; Lancsar et al. 2013). BWS has also been praised for its ability to produce robust estimates using small sample sizes (Auger, Devinney, and Louviere 2007; Kreye et al. 2017). Here we adopt the BWS methodology to identify the relative importance of mangrove ES to stakeholders in each of our selected communities.

The choice experiment involves presenting participants with a series of choice sets. Each of these sets constitutes a subset of paired items or "attributes" taken from a master list and displayed in various combinations (Lee, Soutar, and Louviere 2007). Participants are then required to choose what they perceive to be the "best" and the "worst" or the "most", "least" attribute (in this case service) from each subset (Erdem, Rigby, and Wossink 2012; Sawtooth Technical Paper 2013; Lee, Soutar, and Louviere 2007). Multiple sets of varying item composition are generated, and participants are requested to repeat the choice task for each (Sawtooth Technical Paper 2013). In asking respondents to rate attributes in this way, they are forced to discriminate amongst them, revealing information regarding participant preference (Cohen 2009; Erdem, Rigby, and Wossink 2012; Sawtooth Technical Paper 2013). Finally, with participants only considering utility extremes rather than gaging preference strength, scale use bias is eliminated and cognitive load of the participant is reduced. BWS produces more reliable results by eliminating scale use bias and reducing cognitive load making for more reliable results (Auger, Devinney, and Louviere 2007; Flynn and Marley 2014; Kreye et al. 2017; Erdem, Rigby, and Wossink 2012).

Experimental design

The literature concerning mangrove ecosystem services in Honduras is limited. As a result, we provided a broad range of services in a pilot study, prior to the interviews with our stakeholders from our four communities. The pilot was conducted in a community called Peru, where a total of 30 community members were interviewed. The initial service list selected for piloting constitutes several mangrove goods and services, widely deemed important in the literature (Table 3.2). Importance in this case may be ecological, social or economic as well as any combination of these. The wider literature often groups or bundles of ecosystem services based on end function (Table 3.2: A). Selection of ES for the initial list involved deconstructing these groups in order to reduce ambiguity regarding specific services in the BWS experiment (Table 3.2: B). The pilot study highlighted the need to make amendments to the list of services chosen as some services needed aggregating, separating or removing. Attributes, “Non-timber product”, “charcoal”, “Pharmaceuticals” from raw materials and “aquaculture” from fisheries were removed as community members revealed they were not applicable to the region. The “carbon sequestration” and “Sediment trapping” services were removed due to difficulties explaining their relevance. The pilot also revealed issues with the use of technical phrasing with regards to the services. Technical terms such as “biodiversity” “nursery service” were understood and acknowledged to be important however they needed simplifying. All amendments were made and the services listed as they were used in the experiment can be, seen in Table 3.1.

Variable	Services as described in the best worst sets
Subsistence fishery	Fishing for food
Commercial fishery (small scale)	Fishing for money
Raw materials for construction	Materials for building houses
Forestry product for fuel	Fuel wood
Storm protection	Provide protection against storms
Flooding control	Reduce flooding
Saltwater intrusion	Stop salt water from getting into soil
Erosion	Protect against erosion
Water purification	Filter and purify water
Biodiversity	Have lots of plant and animal types
Nursery	Provide nurseries and habits for fish
Tourism	Provide tourism and recreation opportunities

Table 3.1 Final list of attributes (services) used in the direct and indirect BWS models. The second column shows the language changes undergone as a result of the pilot study.

(A) Service groups	(B) Pilot Services	References
Timber and Forest product	Building materials	(Traynor and Hill 2008; Dahdouh-Guebas et al. 2000; Kaplowitz 2001)
	Non-timber product*	(Sathirathai 1998; Hussain and Badola 2008; J. H. Primavera 2000)
	Pharmaceuticals*	(Semesi 1992; W. M. Bandaranayake 1999; W. Bandaranayake 2002)
	Fuelwood/charcoal*	(B. Walters et al. 2008; Kaplowitz 2001; Rönnbäck, Crona, and Ingwall 2007)
Fisheries	Subsistence	(Rönnbäck 1999; Samonte-Tan et al. 2007; Glaser and Diele 2004; Islam and Ikejima 2010)
	Aquaculture*	(Jurgenne H. Primavera 2005; Rönnbäck 1999)
	Commercial	(Aburto-Oropeza et al. 2008; Anneboina and Kavi Kumar 2017)
	Nursery	(Mumby et al. 2004; Nagelkerken et al. 2001; Serafy et al. 2015)
Coastal protection	Storm	(Hussain and Badola 2005; S Das and Crépin 2013; D. Alongi 2008; Barbier 2015; Mazda et al. 1997; Barbier 2007a, 2006; Saudamini Das and Vincent 2009)
	Flood control	(Sheng, Lapetina, and Ma 2012; Sheng and Zou 2017; Krauss et al. 2009; Mcivor et al. 2012; Zhang et al. 2012)
Shoreline stabilization	Erosion limitation	(Thampanya et al. 2006; Mazda et al. 2002; Kathiresan 2012; Hawkins 2011)
	Sediment trapping/build*	(Victor et al. 2005; Kathiresan 2003; Thampanya et al. 2006; Mcivor et al. 2012)
Water quality maintenance	Filtration*	(Wang et al. 2010)
	Salt water intrusion	(White and Kaplan 2017; Möller et al. 2014; M. S. Koch et al. 2015)
Cultural	Tourism	(Uddin et al. 2013; Wielgus et al. 2010; Cooper, Burke, and Bood 2009; Samonte-Tan et al. 2007)
	Biodiversity	(Ruitenbeek 1994)
Climate regulation	Carbon*	(Donato et al. 2011; Suratman 2008; Pendleton et al. 2012; Locatelli et al. 2014)

Table 3.2 Table of mangrove services assessed during the pilot study. All services chosen were deemed of social, ecological and economic importance in the literature. Services marked with * were removed from the experiment following the pilot study.

The direct and indirect services selected from the pilot study were modelled in separate experiments. Indirect and direct services were modelled separately in accordance with the exploratory nature of the study. Due to the lack of information concerning mangrove ecosystem service uses and values in Honduras it was decided that we wanted to investigate which services were considered the most important both the direct and indirect groupings. In the direct service experiment, participants were shown 4 sets, each consisting of 3 of the total 4 attributes (services). In the indirect service experiment participants were shown 6 sets each consisting of 4 of the total 8 attributes. Both experiments were designed following suggestions in the literature. Erdem, Rigby and Wossink (2012) suggest that the number of attributes per set must not exceed 5 items as this has been shown to result in heightened confusion in participants.

Sawtooth Software, (2013) recommends that in order to produce individual-level scores, each attribute must be shown a minimum of 3 times during the experiment. Both models were designed to satisfy the optimal experimental design criteria described by Sawtooth Software, (2013) achieving frequency balance, orthogonality connectivity amongst items and positional balance (Erdem, Rigby, and Wossink 2012; Sawtooth Technical Paper 2013). Figure 3.2 demonstrates an example choice set from the survey.

The mangroves in your area are known to provide various services...

Considering only these 4 mangrove services, which is the Most Important and which is the Least Important to you?

(1 of 6)

Most Important	Mangroves...	Least Important
☒	Protect against erosion	☐
☐	Reduce Flooding	☐
☐	Provide tourism and recreation activities	☒
☐	Stop salt water from getting into the soil	☐

Figure 3.2 Example choice set from the best MaxDiff choice experiment carried out in this study.

Experimental Model

The choices made by participants in the BWS experiment can be examined according to Thurstone's random utility theory (RUT) (1927) to derive relative importance scores for each service based on participant preferences for alternatives (Soufiani, Parkes, and Xia 2012; Erdem, Rigby, and Wossink 2012). RUT assumes all individuals are "rational decision makers" and when asked to choose amongst paired items they will choose those that represent the "maximum difference" in importance/attractiveness/preference as they will try and maximise their utility (Thurstone 1927; Cascetta 2009; Soufiani, Parkes, and Xia 2012; Erdem, Rigby, and Wossink

2012). Utility can thus be used as a measure of preference. In each set, participants will choose the pair of items with the greatest difference in utility, allowing for the derivation of probability-based information (Thurstone 1927; Cascetta 2009).

The formula for the random utility model is as follows (Erdem, Rigby, and Wossink 2012; Kreye et al. 2017):

$$U_{ijt} = V_{ijt} + \varepsilon_{ijt} \tag{1}$$

Where U_{ijt} describes the utility that respondent i derives from attribute j in choice set $t = \quad z\{1, 2, \ldots T\}$, and then V_{ijr} and ε_{ijt} function as deterministic and stochastic components respectively (Erdem, Rigby, and Wossink 2012). The stochastic component of equation 1, ε_{ijt}, allows the researcher to make probability-based comments regarding stakeholder behaviors (Erdem, Rigby, and Wossink 2012; Sawtooth Technical Paper 2013).

This study asks stakeholders about which mangrove services they deem the most and least important. From this information, we use choice modelling to derive the allocations of relative importance made by respondents amongst these services (Erdem, Rigby, and Wossink 2012).

Based on the assumption that decision makers will maximize utility by selecting attribute pairs with the maximum utility difference between them (Walker and Ben-Akiva 2002)(Erdem, Rigby, and Wossink 2012) (Sawtooth Technical Paper 2013). Scores can then be derived under the logit rule which specifies that that the probability of the participant choosing the i^{th} item as "best (or most important) from a set containing i through j items is equal to:

Pr (j is chosen best and k is chosen worst)

$$= \frac{exp(V_{ijt} - V_{ikt})}{\sum_{l}^{J}=_1 \sum_{m}^{J}=_1 exp(V_{ilt} - V_{imt}) - J} \tag{3}$$

(Walker and Ben-Akiva 2002; Sawtooth Technical Paper 2013; Erdem, Rigby, and Wossink 2012) For a detailed description as to the calculations used in calculating BWS importance scores please see the Sawtooth Technical paper (2013) and Erdem et al. (2012)

3.4 Analysis

Analysis of the choice data was carried by using hierarchical Bayes (HB) modelling. HB modelling allows for the derivation of individual level scores. The data is processed using a probability-based rescaling procedure, which involves arbitrary rescaling of the scores to sum to 100 (Erdem, Rigby, and Wossink 2012; Sawtooth Technical Paper 2013). The rescaling of raw choice data to a 0-100-point scale is carried out using the following equation(Sawtooth Technical Paper 2013; Erdem, Rigby, and Wossink 2012):

$$\frac{e^{Ui}}{(e^{ui} + a - 1)} \tag{4}$$

Here U_i is equal to the zero-centred raw logit weights for item i, e^{Ui} is the anti-log of U_i and a is equal to the number of items shown per set (Sawtooth Technical Paper 2013; Erdem, Rigby, and Wossink 2012). These rescaled weights are then transformed to ratio-scaled information allowing for accessible scores comparable against one another (Erdem, Rigby, and Wossink 2012; Sawtooth Technical Paper 2013). Tests for significance were carried out with regards to the differences observed between services and amongst sites. Significance of differences between services was tested for using an ANOVA and then significance of differences amongst sites was tested for using a Tukey post-hoc test. A Bonferroni correction was used to counteract the problem of multiple comparisons.

3.5 Results

A total of 117 participants were surveyed, a population within which the gender distribution amongst participants 38% Female 62% Male participants. The average age of participants was 42 years. Of the direct services analysed, the subsistence fishery service was consistently considered to be the most important (1st) service to the community members across all sites. Perceptions of the importance (Ui) of the subsistence fishery service was found to be significantly different across all sites ($F_{3,113} = 51.8$, $P < 0.001$). The highest importance score allocated to this service was that by community members in Roatan (66.1), followed by Utila (59.9), Cuero y Salado (47.2) and Tela (18.2). The perceived importance of this service by members in Roatan was significantly higher than that by members at Cuero y Salado ($P < 0.001$), and Tela ($P <0.001$), but not Utila ($P > 0.05$). All other pairwise comparisons were significant differences. The commercial fishery service was thus deemed to be of secondary importance to the subsistence fishery service by all communities with the exception of Tela, where instead building materials were identified as the second most important direct service. Perceptions of the importance of the commercial fishery service were also found to be significant different amongst communities at the sites surveyed ($F_{3,113} = 16.4$, $P < 0.001$). The highest importance score allocated to the commercial fishery service was that by members at Cuero y Salado (41.4) followed by Utila (29.0), Roatan (25.88) then Tela (18.2).

	Cuero y Salado	**Tela**	**Roatan**	**Utila**
Relative importance	Subsistence fishery	Subsistence fishery	Subsistence fishery	Subsistence fishery
	Commercial fishery	Building materials	Commercial fishery	Commercial fishery
	Building materials	Commercial fishery	Fuelwood	Building materials
	Fuelwood	Fuelwood	Building materials	Fuelwood

Table 3.3 Indirect services displayed by order of decreasing relative importance

Perceptions of importance with regards to the commercial fishery service in Cuero y Salado were significantly higher than those at Utila ($P <0.001$), Roatan ($P <0.001$) and Tela ($P <0.001$). The differences amongst communities at Tela and Utila were also significant, whereas difference amongst Roatan Utila and Tela were not. The perceptions of the material service were also significantly different across sites ($F_{3,113} = 57.5$, $P < 0.001$). Community members at Tela (34.4) considered the importance of the materials service to be significantly higher than communities at

Cuero y Salado (10.3), Utila (6.3) and Roatan (2.6) where they were generally considered of much less importance. Perceptions of the fuel service ($F_{3,113}$ = 14.6, P < 0.001) were also significantly different across the sites although this service was general considered to be of low importance. The highest score allocated to this service was that by Tela (10.3) followed by Roatan (5.4), Utila (4.6) and Cuero y Salado (1.5). Perceptions of importance with regards to the fuel service were significantly higher at Tela than at any other site.

Relative importance

Cuero y Salado	**Tela**	**Roatan**	**Utila**
Biodiversity	Nursery	Storm protection	Storm protection
Nursery	Biodiversity	Nursery	Nursery
Tourism	Tourism	Biodiversity	Biodiversity
Flood prevention	Storm protection	Water purification	Erosion
Water quality	Water quality	Erosion	Water purification
Salt-water intrusion	Flood prevention	Tourism	Salt-water intrusion
Storm protection	Salt-water intrusion	Flood prevention	Flood prevention
Erosion	Erosion	Salt water intrusion	Tourism

Table 3.4 Indirect services displayed in order of decreasing relative importance as designated by the different communities.

Of the eight indirect services examined in this study, no one service was unanimously allocated as either the most or least important across all sites studied (Table 4). When analysed, the differences in perceived importance of the different services were significant with the exception of two services. The nursery service was allocated consistently high importance scores ($F_{3,113}$ = 2.5, P > 0.05) whereas the salt water intrusion service was consistently low ($F_{3,113}$ = 2.2, P > 0.05). The nursery service was allocated the highest importance score in Tela (27.5) and was considered the most important service by the community here (1st). The second highest importance score allocated to nursery services was that by the community members in Cuero y Salado (24.3) which was considered of secondary importance to the Biodiversity service, followed by Roatan (23.3) and Utila (21.9) which both considered nursery service to be of secondary importance to the storm protection service. The salt water intrusion service was allocated the highest importance score by community members in Cuero y Salado (6.5) where it was ranked 6th, followed by Utila (6.1) where it also ranked 6th, then Tela (6.3) where it was ranked 7th and finally Roatan (3.2) where it was ranked the least important service to this community (8th). The remaining services demonstrated significant variation in their perceived importance by communities at the sites visited. Several services demonstrated stark differences in perception with regards to whether the site visited was a mainland or islands site. The storm protection service for example was significantly different across the sites surveyed ($F_{3,113}$ = 67.6, P > 0.01) and was allocated high importance scores by Utila (30.1) Roatan (23.3) in contrast to low scores by Cuero y Salado (5.6) and Tela (11.2). In both Utila and Roatan the storm protection service was considered the most important service (1st) overall, however in Roatan it was considered roughly equal to nursery service which ranked 2nd by a marginal difference. In comparison, the storm protection services ranked 4th and 7th in Tela and Cuero y Salado respectively. A similar pattern was seen with regards to the erosion service.

Perceptions of the importance of the erosion service were significantly different amongst all sites ($F_{3,113}$ = 17.3, P > 0.01) however it was considered more important by communities at the islands sites than by the community members at the mainland sites. The highest importance score allocated to the erosion service was that by Utila (11.9) where it was ranked 4th, followed by Roatan (10.1) where it was ranked 5th. The importance scores allocated for this service by community members in Utila were significantly higher than those by members in Roatan (P < 0.05) and perceptions at both were significantly higher at both than at Cuero y Salado (3.5) and Tela (3.2), where the service was considered the least important services (8th). The converse was seen with regards to the tourism service. Perceptions of the tourism service were significantly different across sites ($F_{3,113}$ = 8.03, P > 0.01) however the members of the mainland communities considered the service to be of significantly higher importance than those at the island sites. The highest importance score was allocated to the service by members in Tela (15.9) followed by members at Cuero y Salado (14.6) with the service ranking 3rd at both. The scores allocated for the tourism service at Roatan (8.0) and Utila (5.2) were significantly lower where the service was ranked 6th and 8th respectively. Perceptions of the biodiversity ($F_{3,113}$ = 23.5, P > 0.01), water purification ($F_{3,113}$ = 5.60, P > 0.01) and flood limitation ($F_{3,113}$ = 5.50, P > 0.01) services were also found to be significantly different amongst all sites however these represented less of a difference in between the islands and mainland sites. The biodiversity service was allocated the highest importance score by community members in Cuero y Salado (25.7) where it was considered the most important service (1st) but of roughly equal importance to the nursery service (2nd). Perceptions of the biodiversity service in Cuero y Salado were significantly different to those at Tela (P <0.01), Roatan (P <0.01) and Utila (P <0.01) where the biodiversity was ranked 3rd and, 4th and 4th respectively. Perceptions between Tela and Utila (P <0.01) however other pair wise comparisons were not. The water purification service was allocated the highest importance score by community members in Roatan (13.1) where it was ranked the 4th most important service, followed by Tela (9.2) Cuero y Salado (7.9) and Utila (6.9) where it was ranked as 5th unanimously. The differences in perceptions between Roatan significantly different to those seen in Cuero y Salado and Utila but not Tela. The Flood limitation service was allocated the highest importance score by community members in Cuero y Salado (12.0) where it was ranked 4th, followed by Tela (8.2), Utila (5.9) and Roatan (5.4) where it was ranked 6th, 7th and 7th respectively. Only perceptions of significant differences with regards to this service were those between Cuero y Salado and both Roatan (P<0.01) and Utila (P <0.01).

A Bonferroni correction was carried out to adjust for the number of pairwise comparisons made. The Bonferroni adjusted p value for the main analysis of variants is 0.00025 and 0.0063 for the direct and indirect services respectively. This means that the correction does not change the conclusion of any of the main ANOVAs which were found to be significant with uncorrected p values.

3.4 Discussion

The objective of this study was to examine the perceived importance of several mangrove services to coastal communities in Honduras in order to derive information as to their relative importance to said communities, and to see if stakeholder perceptions varied across communities. The different communities surveyed were found to rank the mangrove services differently with regards to their importance. Also, perceptions regarding the degree to which most services were considered important were found to differ between mainland and island communities in addition to amongst communities within those geographies. There were however a small proportion of services that demonstrated consistency in perceived importance to the different communities.

Direct services

Perceptions as to the relative importance of the subsistence fishery service were consistent across sites and it was ranked as the most important direct service by every community. Importance of subsistence fisheries to coastal communities is heavily reported in the literature (B. Walters et al. 2008; Anneboina and Kavi Kumar 2017; Peter Saenger, Gartside, and Funge-Smith 2013). Here we found that allocations of importance (Ui) to the subsistence fishery service differed significantly among sites meaning that although it was considered the most valued direct service relative to the other services, communities perceived it to be of differing degrees of absolute importance. The Community members at the island sites, Utila and Roatan, shared similar perceptions as to the importance (Ui) of the subsistence fishery service, with both communities allocating subsistence fisheries high importance scores (Ui). Tela and Cuero y Salado also allocated high relative scores to subsistence fisheries, however the importance (Ui) scores were significantly lower than those of the island sites and significantly different from one another, with Tela having the lowest importance score. This is likely representative of the variation in ways that community members benefitted from subsistence fisheries at the different sites and It would stand to reason that the difference observed between the island and mainland communities is representative of differences in resource access and livelihood opportunities. Despite living amongst mangroves, the dependence of individuals on mangroves within the communities varied based on their social status. The island communities demonstrated a range of mangrove dependency among their members however, for the most part they were considerably more economically developed and most users engaged less with mangrove resources. In contrast, the majority of individuals in the mainland communities were heavily dependent on mangrove resources. Although this might lead one to believe that the mainland communities would prescribe more importance to the subsistence service, the difference observed is a result of a wider and more even distribution of importance across the services by mainland community members. A greater proportion of island community members were not heavily dependent or dependent at all on the other direct services so for island communities the trade-off was easy. Community members at Cuero y Salado were almost exclusively fishermen who fished collectively as a community to feed themselves and their families, which is reflective in their allocation of almost equal importance levels (Ui) to the subsistence and commercial fishery services. Participants from Tela instead distributed importance between the subsistence and material services and allocated a significantly lower importance score to the commercial fishery service than Cuero y Salado. The differences in relative importance in Cuero and Tela will be related to community specific variation in uses of the mangrove. Although community members in Tela were also predominately fishermen, this community predominately earns income from domestic tourism, much of this primarily associated with showcasing of artisanal huts made of mangrove product (Loperena 2012). With the exception of Tela's use for artisanal construction materials, the mangrove materials service was generally considered of little importance by mangrove stakeholders on the Caribbean coast of Honduras, which contrasts to what is seen elsewhere globally and even in the Southern part of the country (Dewalt, Vergne, and Hardin 1996; Stonich 1995). This may be explained by local laws which prohibit destructive use of mangroves (Windevoxhel, Rodríguez, and Lahmann 1999) and the prevalence of better alternatives (e.g. buttonwood, Gabb, unpublished data). The same was seen with regards to perceptions regarding the use of mangrove wood as fuel. While globally there is a high reported use of mangroves as fuel for cooking and charcoal making (B. B. Walters 2005; Dahdouh-Guebas et al. 2000) none of the communities in this study used mangroves as cooking fuel and interpreted the questions as an inquiry as to mangrove wood use as fuel for campfires (i.e. recreational use, Gabb, unpublished data). Communities on the islands had access to electricity and gas whereas mainland participants used either petroleum or portable gas stoves for cooking.

Given the responses and the importance scores with regards to the subsistence and commercial fishery mangrove services, management approaches in these areas could focus on the importance of mangrove fisheries. Consideration of mangrove use for fuel or materials would not likely have a significant impact on management for these communities. However, as for all management, site specific factors, such as Tela's use of mangrove materials for tourism construction, must be considered.

Indirect services

Overall, perceptions of the relative importance of each indirect service varied significantly by site. No one community ranked the services in the same order as another. However, some perceptions of individual mangrove services were shown to be consistent across all sites. Community members at all four sites had similar perceptions as to the degree to which they perceived the nursery and saltwater intrusion services as important (both relative and Ui) and the differences in importance scores allocated at each were found not to be significantly different. The nursery service was consistently allocated high importance scores and as a result was considered as either the most or second most important service at every site. The mangrove nursery service has been heavily reported in the literature and is widely acknowledged to have significant ecological, economic and socio-cultural importance (Aburto-Oropeza et al. 2008; Anneboina and Kavi Kumar 2017; Mukherjee et al. 2014). Several publications have documented the crucial support of adjacent ecosystems by mangroves as they act in sheltering juveniles that go on to restock populations in seagrass meadows and coral reefs (Nagelkerken et al. 2000, 2008; Mumby et al. 2004). With regards to the economic importance of mangrove nurseries, many publications have used valuation techniques to derive the utility of this ecosystem function to the fishery industry (Barbier 2007; Anneboina and Kavi Kumar 2017; Aburto-Oropeza et al. 2008). The socio-cultural relevance of this nursery service however, is often mentioned as significant (Anneboina and Kavi Kumar 2017; Peter Saenger, Gartside, and Funge-Smith 2013; Glaser 2003) yet there have been no studies actually documenting or meausing this. Consistency in perceptions of this service are interesting because they means that in this region, not only do expert opinions match that of local people (Mukherjee et al. 2014) but perceptions of local people are consistent with the high monetary values attributed to this service by economic valuation studies (Salem and Mercer 2012; Brander et al. 2012). While there is often little agreement among social, economic and ecological valuations of ecosystem services, mangrove fisheries seem to stand out as a consistent agreement and should therefore be an important target, and unique opportunity, for novel management approaches and incentive schemes.

The widely perceived importance of the nursery service throughout the communities was likely contributed to by an awareness of the majority of individuals surveyed as to the links between functional mangrove forest function and offshore fisheries. Existence of this awareness is indicative of successful efforts by the local NGOs, present in each of the communities, to educate stakeholders. Perceptions of the saltwater intrusion service were representative of an opposite trend however, as it was consistently considered of very little importance by members of each community. Mangroves aid in preventing saltwater intrusion into soils and further onto land, whilst essentially acting as the last line of defence for adjacent ecosystems (White and Kaplan 2017; Möller et al. 2014; M. S. Koch et al. 2015). The Saltwater Intrusion protection service has been deemed import by experts opinion (Mukherjee et al. 2014) however, as highlighted by Mukherjee et al. (2014), the service has not been the subject of any economic valuation studies and as an individual ecosystem service it has not been widely been studied. It could be that this service was generally considered unimportant however it is more likely that this perception is a result of limits in the understanding of stakeholders. This is evidenced by comments of islands participants who said it would not matter if salt water contaminated their ground water as the islands plants were accustomed to high salinity (Gabb, unpublished data), which is incorrect and shows failure to appreciate the detrimental effects of water table contamination. Similarly, the flooding and water purification services generally had low scores but in contrast did not show any clear pattern among the communities.

It is worth noting that stakeholder understanding of ES is a highly influential variable in BWS. During data collection for this study it became evident that a lack of understanding by participants could introduce bias into the experiment. For example, if participant understanding of a particular service is incomplete the participant may assume that the service is unimportant, or on the contrary, participants may assume that the service is very complex and thus important. Lacking understanding could lead participants to choose a service over another they deem more important or even completely ignore the service. From a wider perspective, this issue highlights a more general flaw in the ES and valuation frameworks. The entire premise of these concepts is that ES and valuation are meant to create communication between stakeholders at all levels, yet this study shows that in general direct users of ES will most likely have incomplete understanding of the ES their ecosystems will provide. This implies that education programs and public outreach are an important first step that should be implemented long before there is any need for valuation. In light of this, the researcher suggests that any future applications of BWS as a means investigating attribution of importance to ES by stakeholders must take additional steps to ensure complete understanding by stakeholders. The researcher's suggestions of best practise to achieve this goal would to use preliminary interviews in a focus group setting to first test stakeholder understanding, then hold a short workshop on the relative services and finally carry out the choice experiment. In addition to eliminating bias, this process would generate useful information regarding community understanding that could help guide education projects by local NGOs. Execution of this method was not feasible for this study however it is earmarked for use in future studies by the researcher.

Perceptions of the storm protection, erosion and tourism services were found to differ significantly between the island and mainland communities. Perhaps the most notable example of this trend is the variation in perceived importance of the storm protection service. The storm protection service was considered significantly more important by members of the island communities than it was by members of the mainland communities. This difference is representative of variation in how coastal communities benefit from mangrove services as an effect of their geographical positioning and resulting exposure to environmental conditions. The Caribbean is vulnerable to hurricanes and the last one to hit Honduras was hurricane Mitch. Hurricane Mitch caused extensive destruction throughout Honduras, killing thousands (Cahoon et al. 2003). The third Bay Island, Guanaja was hit hard and virtually all of its mangrove forest was destroyed (Cahoon et al. 2003). Cuero y Salado on the mainland, would have been more sheltered, which was likely to have affected their perceptions of this service however, the communities in Tela attributed storm protection low importance scores as well. When asked about this service many participants commented that although they realised the importance of the storm protection service, storms were a rare occasion and that they considered the consistent provision of other services to be more important. These results are indicative of the potential for perceptions of ecosystem services to very spatially and temporally, variation that is a necessary consideration if we are to implement social valuation into management (Koch et al. 2009). Interestingly, although Guanaja was heavily impacted by Hurricane Mitch, Roatan and Utila experienced significantly lesser degrees of damage than the mainland, although the storm did have longstanding impacts on water provision after the event. Community members at the islands sites however, felt strongly about the importance of storm protection service, many referring to the destruction that happened on Guanaja and highlighting the greater deficit of mangroves in their own communities. It would stand to reason that these results are thus indicative of the power of experience and even second-hand experience to alter perceptions in stakeholders and social similarities among island communities may cause idea transference of the danger experienced by other islands. There is also the possibility that in major incidences like hurricanes rescue efforts and relief may be provided far faster to mainland communities and thus they may feel less effected by storms, for example with regards to hurricane Mitch, the Bay Islands were without running water for 3 days post storm (Harborne, Afzal, and Andrews 2001)

Perceptions of the erosion limitation service of mangroves showed a similar trend. Again, island community members perceived this to be more important than those in mainland communities. With regards to the communities surveyed in this study, this difference appears to be largely a result of experience as described with the storm protection service, but also influenced by the importance of tourism as the primary industry of the islands. Island communities referred to situations where mangrove forests have been cleared in the past resulting in the loss of popular tourist beaches due to erosion. Participants made comments regarding how “there was only so much island you could lose” (Gabb, unpublished data). Similar perceptions were expected on Tela for the same reason however the mangrove system here is lagoonal and is positioned off shore behind local housing (and thus offers little erosion protection to those houses).

Perceptions of the tourism service were also found to differ between the island and mainland sites, however with this service the trend was reversed. The tourism service was perceived to be more important by members of the mainland communities than it was members of the island communities. This is likely a result of the different tourism industries at the sites visited. Utila and Roatan are international tourist destinations heavily involved in the reef diving market, Roatan providing up-market, leisure opportunities and Utila being an international backpacking hotspot (Canty 2007). Although mangroves will maintain these industries indirectly through the maintenance of reefs and beaches, tourism specifically related to mangroves, such as wildlife tours, were scarce and of secondary importance. Both islands offered mangrove tours however these were not close to the island communities surveyed and not the primary source of tourism these community members were accustomed to. The mainland sites on the other hand had a mangrove related tourism infrastructure, in which many community members had constituent roles. Tela bay is primarily a tourism hotspot for domestic tourists and is surrounded by national parks (Loperena 2012; Mollett 2014). The site thus offers a variety of natural ecosystems for tourists to visit and organises mangroves tours by kayak for visitors to travel through the forests and visit the surrounding national parks (Jeannette Kawas and Izopo National Parks). Thus, mangroves here provide an additional source of income for community members that otherwise fish. Cuero y Salado are primarily a fishing village (McCool and Moisey 2008) that live amongst mangroves but also provide ecotourism destination for small number of tourists. Cuero y Salado was the first protected reserve established by Ramsar in Honduras and is a designated wildlife refuge (Snarr 2005). Mangrove tours to see various monkey and bird specieswere popular here and the site also offers occasional opportunities to see manatees (Snarr 2005; González-Socoloske, Taylor, and Thompson 2011). Both mainland communities provide nature and environmental themed tourism and this is likely to be a driver in the difference seen between the mainland and islands communities with regards to the tourism service.

Differing perceptions as to the importance of biodiversity between the island and mainland sites were also likely a result of the presence of eco-tourism infrastructure. In the wider, economic valuation literature valuations of the biodiversity service of mangroves is limited (Salem and Mercer 2012). This is likely due to the complexity of the concept and the term itself (Laurila-Pant et al. 2015). Economic valuations that have attempted to assign monetary values to the biodiversity service of mangroves have largely focused on the goods and resources that the service can provide (i.e. potential pharmaceuticals or technologies). In contrast, this study attempted to examine the biodiversity service of mangroves from non-material perspective, instead describing biodiversity as an aesthetic benefit, as an opportunity to see “different plants and animals”. Interestingly, although allocations of importance (Ui) varied across the sites, the service was consistently ranked within the top 4 services at each site, being deemed the most important service to community members in Cuero y Salado, second most to members in Tela, then 3rd for both Roatan and Utila. Although perceptions of the importance of the biodiversity service examined in this study are likely to have been influenced by tourism at the sites (as evidenced by the higher scores at Cuero y Salado and Tela), community members at all four sites expressed strong feelings with regards to this service. Many participants described positive effects related to being able to see various species associated with the mangroves. Participants in Utila for example described positive experiences associated with seeing an endemic species of mangrove dwelling Iguana, with which participants had strong cultural connections (Gabb, unpublished data). Participants in Roatan described the relaxing effects of being close to nature in the mangroves and seeing many of the associated bird species. Mainland participants made comments as to the need to respect mangrove associated species as they shared a home. From a wider perspective, these findings concur with opinions in the valuation literature that believe it is important to look social values and include non-material benefits in valuation (Small, Munday, and Durance 2017; Kelemen et al. 2014; Gómez-Baggethun et al. 2014).

3.5 Summary

The management of marine ecosystems such as mangroves is shifting towards integrated approaches inclusive of different stakeholder types (Carter, Schmidt, and Hirons 2015). For integration to function however we need to further our understanding of how people perceive ecosystem services and how said perceptions can change amongst communities and stakeholder types. Overall these results indicate that the importance attributed to mangrove services can differ among communities and be affected by the relative geographies of communities. They also indicate how diverse mangrove stakeholders are (Small, Munday, and Durance 2017) and suggest that we need to successfully type and consider them all (Hicks, Graham, and Cinner 2013; Small, Munday, and Durance 2017; Gómez-Baggethun et al. 2014). Dwindling fishery resources have seen calls by fishermen for stricter protection regulations (Korda, Hills, and Gray 2008), however issues caused by lacking capacity for protection (Lugo, Medina, and McGinley 2014) mean that making regulations stricter is unlikely to elicit significant change. Overall, the communities interviewed generally showedgood understanding of the importance of mangroves (similar observations by (Korda, Hills, and Gray 2008)) indicating the Caribbean coast of Honduras could have potential for community-based conservation initiatives. Consistency in perceptions with regards to the nursery service is could indicate promising foundations for incentive schemes central to fisheries maintenance by fishermen. The lack of understanding of certain services (e.g. salt water inundation service) show that local NGOs could benefit from instigating addition education campaigns to facilitate better community participation and raise public awareness, ultimately increasing changes of successful management programs (Carter, Schmidt, and Hirons 2015).

3.6 Conclusion

This aim of this study was to examine how different communities value mangrove services and to investigate potential variation in perceptions of mangrove service importance at the community level. The main finding of this study was that consistencies do exist between mangrove services considered highly economically important and those considered highly important from a social perspective. The study has demonstrated that ecosystem services in mangroves do have socio-cultural value that thus compound upon their ecological and economic values. This study has also clearly shown that although perceptions of certain services may be consistent across communities, perceptions as to the importance of others can change amongst communities and is also affected by the relative geographies of those communities. These findings suggest the potential for broad national marine management schemes in Honduras, centred around the services that are consistently valued across communities (i.e. fishery related). The results do however highlight the significance of considering site specifics in ecosystem management and thus suggest the importance of within management efforts as a means of limit conflicts and loss of livelihoods to ultimately increase changes of success.

3.7 Bibliography

Aburto-Oropeza, O., E. Ezcurra, G. Danemann, V. Valdez, J. Murray, and E. Sala. 2008. “Mangroves in the Gulf of California Increase Fishery Yields.” *Proceedings of the National Academy of Sciences of the United States of America* 105 (30): 10456–10459.

Alongi, D. 2008. “Mangrove Forests: Resilience, Protection from Tsunamis, and Responses to Global Climate Change.” *Estuarine, Coastal and Shelf Science* 76 (1): 1–13.

Alongi, Daniel M. 2002. “Present State and Future of the World’s Mangrove Forests.” *Environmental Conservation* 29 (3). Cambridge University Press: 331–49.

Anneboina, L., and K. Kavi Kumar. 2017. “Economic Analysis of Mangrove and Marine Fishery Linkages in India.” *Ecosystem Services* 24: 114–23.

Auger, Pat, Timothy M. Devinney, and Jordan J. Louviere. 2007. “Using Best-Worst Scaling Methodology to Investigate Consumer Ethical Beliefs across Countries.” *Journal of Business Ethics* 70 (3). Springer Netherlands: 299–326.

Bandaranayake, W. 2002. “Bioactivities, Bioactive Compounds and Chemical Constituents of Mangrove Plants.” *Wetlands Ecology and Management*.

Bandaranayake, W M. 1999. “Traditional and Medicinal Uses of Mangroves.” *Mangroves and Salt Marshes* 2 (3). Kluwer Academic Publishers: 133–48.

Barbier, E. 2006. “Natural Barriers to Natural Disasters: Replanting Mangroves after the Tsunami.” *Frontiers in Ecology and the Environment* 4 (3): 124–31.

———. 2007a. “In the Wake of Tsunami: Lessons Learned from the Household Decision to Replant Mangroves in Thailand.” *Resource and Energy Economics* 30 (2): 229–49.

———. 2007b. “Valuing Ecosystem Services as Productive Inputs.” *Economic Policy* 22 (49): 177–229.

———. 2015. “Valuing the Storm Protection Service of Estuarine and Coastal Ecosystems.” *Ecosystem Services* 11: 32–38. doi:10.1016/j.ecoser.2014.06.010.

Barbier, E., S. Hacker, C. Kennedy, E. Kock, A. Stier, and Brian R. 2011. “The Value of Estuarine and Coastal Ecosystem Services.” *Ecological Monographs* 81 (2). Ecological Society of America: 169–93.

Barbier, E., and S. Sathirathai. 2004. “Shrimp Farming and Mangrove Loss in Thailand.” *Wetlands* 24 (4). Edward Elgar: 913–913.

Bavinck, M., and V. Vivekanandan. 2011. “Conservation, Conflict and the Governance of Fisher Wellbeing: Analysis of the Establishment of the Gulf of Mannar National Park and Biosphere Reserve.” *Environmental Management* 47 (4): 593–602.

Bennett, E., and P. Dearden. 2014. “Why Local People Do Not Support Conservation: Community Perceptions of Marine Protected Area Livelihood Impacts, Governance and Management in Thailand.” *Marine Policy* 44: 107–16.

Bennett, E., G. Peterson, and L. Gordon. 2009. “Understanding Relationships among Multiple Ecosystem Services.” *Ecology Letters* 12 (12): 1394–1404.

Bhomia, R., J. Kauffman, and T.. McFadden. 2016. “Ecosystem Carbon Stocks of Mangrove Forests along the Pacific and Caribbean Coasts of Honduras.” *Wetlands Ecology and Management* 24 (2). Springer Netherlands: 187–201.

Blanco-Libreros, J., and E. Estrada-Urrea. 2015. “Mangroves on the Edge: Anthrome-Dependent

Fragmentation Influences Ecological Condition (Turbo, Colombia, Southern Caribbean).” *Diversity* 7 (3). Multidisciplinary Digital Publishing Institute: 206–28.

Brander, L., A. Wagtendonk, S. Hussain, A. McVittie, P. Verburg, R. de Groot, and S. van der Ploeg. 2012. “Ecosystem Service Values for Mangroves in Southeast Asia: A Meta-Analysis and Value Transfer Application.” *Ecosystem Services* 1 (1). Elsevier: 62–69.

Burke, P., S. Schuck, P. Aubusson, J. Buchanan, J. Louviere, and A. Prescott. 2013. “Why Do Early Career Teachers Choose to Remain in the Profession? The Use of Best-Worst Scaling to Quantify Key Factors.” *International Journal of Educational Research* 62: 259–68.

Cahoon, D., P. Hensel, J. Rybczyk, K. McKee, C. Proffitt, and B. Perez. 2003. “Mass Tree Mortality Leads to Mangrove Peat Collapse at Bay Islands, Honduras after Hurricane Mitch.” *Journal of Ecology* 91 (6). Blackwell Science Ltd: 1093–1105.

Canty, Steve. 2007. “Positive and Negative Impacts of Dive Tourism: The Case Study of Utila, Honduras” 46: 1–41.

Carter, H., S. Schmidt, and A. Hirons. 2015. “An International Assessment of Mangrove Management: Incorporation in Integrated Coastal Zone Management.” *Diversity* 7 (2): 74–104.

Cascetta, Ennio. 2009. “Random Utility Theory.” In *Transportation Systems Analysis. Models Ans Applications*, 89–167. Springer, Boston, MA.

Chapin, F., E. Zavaleta, V. Eviner, R. Naylor, P. Vitousek, H. Reynolds, D. Hooper, et al. 2000. “Consequences of Changing Biodiversity.” *Nature* 405 (6783): 234–42.

Cheung, K., B. Wijnen, I. Hollin, E. Janssen, J. Bridges, S. Evers, and M. Hiligsmann. 2016. “Using Best–Worst Scaling to Investigate Preferences in Health Care.” *PharmacoEconomics*. Springer.

Christie, P. 2004. “Marine Protected Areas as Biological Successes and Social Failures in Southeast Asia.” *American Fisheries Society* 42: 155–64.

Cohen, E. 2009. “Applying Best-Worst Scaling to Wine Marketing.” *International Journal of Wine Business Research* 21 (1). Emerald Group Publishing Limited: 8–23.

Colwell, S. 1998. “Dive-Tourism and Private Stewardship of Small-Scale Coral Reef Marine Protected Areas.” *ITMEMS 1998 Proceedings*, 217–21.

Cook, C., M. Hockings, and R. Carter. 2010. “Conservation in the Dark? The Information Used to Support Management Decisions.” *Frontiers in Ecology and the Environment* 8 (4). Ecological Society of America: 181–88.

Cooper, E., L. Burke, and N. Bood. 2009. “Coastal Capital: Economic Contribution of Coral Reefs and Mangroves to Belize.” *World Resources Institute, Washington, DC.*, 53.

Costanza, R., R. D’Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, et al. 1997. “The Value of the World’s Ecosystem Services and Natural Capital.” *Nature* 387 (6630): 253–60.

Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S. Anderson, I. Kubiszewski, S. Farber, and R. Turner. 2014. “Changes in the Global Value of Ecosystem Services.” *Global Environmental Change* 26: 152–58.

Cvitanovic, C., C. J. Fulton, S. K. Wilson, L. van Kerkhoff, I. L. Cripps, and N. Muthiga. 2014. “Utility of Primary Scientific Literature to Environmental Managers: An International Case Study on Coral-Dominated Marine Protected Areas.” *Ocean and Coastal Management* 102

(PA). Elsevier: 72–78.

Dahdouh-Guebas, F., C. Mathenge, J. G. Kairo, and N. Koedam. 2000. “Utilization of Mangrove Wood Products around Mida Creek ‘Kenya’ amongst Subsistence and Commercial Users.” *Economic Botany* 54 (4). Springer-Verlag: 513–27.

Daily, Gretchen C. 1997. *Nature’s Services: Societal Dependence on Natural Ecosystems*. Vol. 1. Island Press, Washington, DC.

Das, S, and AS Crépin. 2013. “Mangroves Can Provide Protection against Wind Damage during Storms.” *Estuarine, Coastal and Shelf Science* 134 (1): 98–107.

Das, Saudamini, and Jeffrey R Vincent. 2009. “Mangroves Protected Villages and Reduced Death Toll during Indian Super Cyclone.” *Proceedings of the National Academy of Sciences* 106 (18). National Academy of Sciences: 7357–60.

Dewalt, B., P. Vergne, and M. Hardin. 1996. “Shrimp Aquaculture Development and the Environment: People, Mangroves and Fisheries on the Gulf of Fonseca, Honduras.” *World Development* 24 (7). Pergamon: 1193–1208.

Doiron, S., and S. Weissenberger. 2014. “Sustainable Dive Tourism: Social and Environmental Impacts - The Case of Roatan, Honduras.” *Tourism Management Perspectives* 10: 19–26.

Donato, D., J. Kauffman, D. Murdiyarso, S. Kurnianto, M. Stidham, and M. Kanninen. 2011. “Mangroves among the Most Carbon-Rich Forests in the Tropics.” *Nature Geosci* 4 (5). Nature Publishing Group: 293–97.

Duarte, C., W. Dennison, Robert J. Orth, and T. Carruthers. 2008. “The Charisma of Coastal Ecosystems: Addressing the Imbalance.” *Estuaries and Coasts* 31 (2). Springer-Verlag: 233–38.

Duke, N. 1992. “Mangrove Floristics and Biogeography.” *Tropical Mangrove Systems* 41: 63–100.

Duke, N., J. Meynecke, S. Dittmann, A. Ellison, K. Anger, U. Berger, S. Cannicci, et al. 2007. “A World Without Mangroves ?” *Science* 317: 41–43.

Duke, N., and K. Schmitt. 2014. “Tropical Forestry Handbook,” 1–24.

———. 2016. “Mangroves: Unusual Forests at the Seas’ Edge.” In *Tropical Forestry Handbook, Second Edition*, 2:1693–1724. Berlin, Heidelberg: Springer Berlin Heidelberg.

Erdem, S., D. Rigby, and A. Wossink. 2012. “Using Best-Worst Scaling to Explore Perceptions of Relative Responsibility for Ensuring Food Safety.” *Food Policy* 37 (6): 661–70.

Ersión, V, and F Echa. 2005. “Estudio Tematico Sobre Manglares Honduras.”

FAO. 2007. “The World’s Mangroves 1980-2005.” *FAO Forestry Paper*. Vol. 153.

Farnsworth, Elizabeth J, and Aaron M Ellison. 1997. “The Global Conservation Status of Mangroves.” *Ambio*.

Felipe-Lucia, María R., Francisco A. Comín, and Javier Escalera-Reyes. 2014. “A Framework for the Social Valuation of Ecosystem Services.” *Ambio* 44 (4). Springer Netherlands: 308–18. doi:10.1007/s13280-014-0555-2.

Feller, I., D. Whigham, K. McKee, and C. Lovelock. 2003. “Nitrogen Limitation of Growth and Nutrient Dynamics in a Disturbed Mangrove Forest, Indian River Lagoon, Florida.” *Oecologia* 134 (3): 405–14.

Feller, Ic, and M Sitnik. 1996. “Mangrove Ecology: A Manual for a Field Course.” *Smithsonian Institution, Washington, DC*, 1–135.

Finn, Adam, and Jordan J Louviere. 1992. “Determing the Appropriate Response to Evidence of

Public Concern: The Case of Food Safety.” *Journal of Public Policy & Marketing*. American Marketing Association.

Flynn, T., J. Louviere, T. Peters, and J. Coast. 2008. “Estimating Preferences for a Dermatology Consultation Using Best-Worst Scaling: Comparison of Various Methods of Analysis.” *BMC Medical Research Methodology* 8 (1). BioMed Central: 76.

Flynn, T., and A. Marley. 2014. “Best Worst Scaling: Theory and Methods.” *Handbook of Choice Modelling*, 178–201.

Friess, D., and B. Thompson. 2016. “Mangrove Payments for Ecosystem Services (PES): A Viable Funding Mechanism for Disaster Risk Reduction?” In *Advances in Natural and Technological Hazards Research*, 42:75–98. Springer International Publishing.

Gaymer, C., A. Stadel, N. Ban, P. Carcamo, J. Ierna, and L. Lieberknecht. 2014. “Merging Top-down and Bottom-up Approaches in Marine Protected Areas Planning: Experiences from around the Globe.” *Aquatic Conservation: Marine and Freshwater Ecosystems* 24 (S2): 128–44.

Gillis, L., E. Belshe, and G. Narayan. 2017. “Deforested Mangroves Affect the Potential for Carbon Linkages between Connected Ecosystems.” *Estuaries and Coasts* 40 (4). Springer US: 1207–13.

Giri, C., E. Ochieng, L. L. Tieszen, Z. Zhu, A. Singh, T. Loveland, J. Masek, and N. Duke. 2011. “Status and Distribution of Mangrove Forests of the World Using Earth Observation Satellite Data.” *Global Ecology and Biogeography* 20 (1): 154–59.

Glaser, Marion. 2003. “Interrelations between Mangrove Ecosystem, Local Economy and Social Sustainability in Caeté Estuary, North Brazil.” *Wetlands Ecology and Management* 11 (4). Kluwer Academic Publishers: 265–72.

Glaser, Marion, and Karen Diele. 2004. “Asymmetric Outcomes: Assessing Central Aspects of the Biological, Economic and Social Sustainability of a Mangrove Crab Fishery, Ucides Cordatus (Ocypodidae), in North Brazil.” *Ecological Economics* 49 (3): 361–73. doi:10.1016/j.ecolecon.2004.01.017.

Godoy, Mario D.P., and Luiz D. de Lacerda. 2015. “Mangroves Response to Climate Change: A Review of Recent Findings on Mangrove Extension and Distribution.” *Anais Da Academia Brasileira de Ciências* 87 (2). Academia Brasileira de Ciências: 651–67.

Gómez-Baggethun, E., R. de Groot, P. Lomas, and C. Montes. 2010. “The History of Ecosystem Services in Economic Theory and Practice: From Early Notions to Markets and Payment Schemes.” *Ecological Economics* 69 (6). Elsevier B.V.: 1209–18.

Gómez-Baggethun, E., B Martín-López, D Barton, L Braat, H Saarikoski, E Kelemen, M García-Llorente, et al. 2014. “State-of-the-Art Report on Integrated Valuation of Ecosystem Services.” *European Commission FP7*.

González-Socoloske, D, C. Taylor, and O. Thompson. 2011. “Latin American Journal of Aquatic Mammals Distribution and Conservation Status of the Antillean Manatee (Trichechus Manatus Manatus) in Honduras.” *Latin American Journal of Aquatic Mammals* 9 (2): 123–31.

Greiner, Romy. 2016. “Factors Influencing Farmers’ Participation in Contractual Biodiversity Conservation: A Choice Experiment with Northern Australian Pastoralists.” *Australian Journal of Agricultural and Resource Economics* 60 (1): 1–21. doi:10.1111/1467-8489.12098.

Gunawardena, M., and J. S. Rowan. 2005. “Economic Valuation of a Mangrove Ecosystem

Threatened by Shrimp Aquaculture in Sri Lanka." *Environmental Management* 36 (4): 535–50.

Harborne, A., D. Afzal, and M. Andrews. 2001. "Honduras: Caribbean Coast." *Marine Pollution Bulletin* 42 (12): 1221–35. doi:10.1016/S0025-326X(01)00239-9.

Hawkins, Slayde. 2011. "Katoomba Issue Brief. Payments for Ecosystem Services in Vietnam's Mangrove Forests," 1–4.

Hicks, Christina C., Nicholas A.J. Graham, and Joshua E. Cinner. 2013. "Synergies and Tradeoffs in How Managers, Scientists, and Fishers Value Coral Reef Ecosystem Services." *Global Environmental Change* 23 (6). Pergamon: 1444–53.

Hogarth, Peter J. 2015. *The Biology of Mangroves and Seagrasses*. Oxford University Press.

Horochowski, Katerina, and R. Neil Moisey. 1999. "The Role of Environmental NGOs in Sustainable Tourism Development: A Case Study in Northern Honduras." *Tourism Recreation Research* 24 (2): 19–29. doi:10.1080/02508281.1999.11014872.

Hussain, S., and R. Badola. 2005. "Valuing Ecosystem Functions: An Empirical Study on the Storm Protection Function of Bhitarkanika Mangrove Ecosystem, India." *Environmental Conservation* 32 (1): 85–92. doi:10.1017/S0376892905001967.

———. 2008. "Valuing Mangrove Ecosystem Services: Linking Nutrient Retention Function of Mangrove Forests to Enhanced Agroecosystem Production." *Wetlands Ecology and Management* 16 (6): 441–50. doi:10.1007/s11273-008-9080-z.

———. 2010. "Valuing Mangrove Benefits: Contribution of Mangrove Forests to Local Livelihoods in Bhitarkanika Conservation Area, East Coast of India." *Wetlands Ecology and Management*.

Islam, M. S., and K. Ikejima. 2010. "Gear Type, Species Composition and Economic Value of Fisheries in the Mangroves of Pak Phanang, Thailand." *Wetlands Ecology and Management* 18 (1): 27–36. doi:10.1007/s11273-009-9145-7.

Jiao, Nian-Zhi, Da-Ke Chen, Yong-Ming Luo, Xiao-Ping Huang, Rui Zhang, Hai-Bo Zhang, Zhi-Jian Jiang, and Fei Zhang. 2015. "Climate Change and Anthropogenic Impacts on Marine Ecosystems and Countermeasures in China." *Advances in Climate Change Research* 6 (2). Elsevier: 118–25. doi:10.1016/j.accre.2015.09.010.

Kaplowitz, Michael D. 2001. "Assessing Mangrove Products and Services at the Local Level: The Use of Focus Groups and Individual Interviews." *Landscape and Urban Planning* 56 (1–2). Elsevier: 53–60. doi:10.1016/S0169-2046(01)00170-0.

Kathiresan, K. 2003. "How Do Mangrove Forests Induce Sedimentation?" *Revista de Biologia Tropical* 51 (2): 355–59.

Kathiresan, K. 2012. "Importance of Mangrove Ecosystem." *International Journal of Marine Science*.

Kathiresan, K., and B.L. Bingham. 2001. "Biology of Mangroves and Mangrove Ecosystems." *Advances in Marine Biology* 40: 81–251.

Kelemen, Eszter, Marina García-Llorente, György Pataki, Berta Martín-López, and Erik Gómez-Baggethun. 2014. "Non-Monetary Techniques for the Valuation of Ecosystem Services." In *OpenNESS Reference Book.*, 1–4.

Knight, Andrew T., Richard M. Cowling, Mathieu Rouget, Andrew Balmford, Amanda T. Lombard, and Bruce M. Campbell. 2008. "Knowing but Not Doing: Selecting Priority Conservation Areas and the Research-Implementation Gap." *Conservation Biology*. doi:10.1111/j.1523-

1739.2008.00914.x.

Koch, EW, EB Barbier, BR Siliman, DJ Reed, GME Perillo, SD Hacker, EF Granek, et al. 2009. “Non-Linearity in Ecosystem Services : Temporal and Spatial Variability in Coastal Protection.” *Frontiers in Ecology and the Environment* 7 (1): 29–37. doi:10.1890/080126.

Koch, M. S., C. Coronado, M. W. Miller, D. T. Rudnick, E. Stabenau, R. B. Halley, and F. H. Sklar. 2015. “Climate Change Projected Effects on Coastal Foundation Communities of the Greater Everglades Using a 2060 Scenario: Need for a New Management Paradigm.” *Environmental Management* 55 (4). Springer US: 857–75.

Korda, Rc, Jm Hills, and Ts Gray. 2008. “Fishery Decline in Utila: Disentangling the Web of Governance.” *Marine Policy* 32 (6): 968–79. doi:10.1016/j.marpol.2008.02.009.

Krauss, Ken W., Terry J. Doyle, Thomas W. Doyle, Christopher M. Swarzenski, Andrew S. From, Richard H. Day, and William H. Conner. 2009. “Water Level Observations in Mangrove Swamps during Two Hurricanes in Florida.” *Wetlands* 29 (1). Springer Netherlands: 142–49. doi:10.1672/07-232.1.

Krauss, Ken W., Karen L. McKee, Catherine E. Lovelock, Donald R. Cahoon, Neil Saintilan, Ruth Reef, and Luzhen Chen. 2014. “How Mangrove Forests Adjust to Rising Sea Level.” *The New Phytologist* 202 (1): 19–34. doi:10.1111/nph.12605.

Kreye, Melissa M, Elizabeth F Pienaar, José R Soto, and Damian C Adams. 2017. “Creating Voluntary Payment Programs: Effective Program Design and Ranchers’ Willingness to Conserve Florida Panther Habitat.” *Land Economics* 93 (3): 459–80. doi:10.3368/le.93.3.459.

Kull, Christian A, Xavier Arnauld de Sartre, and Monica Castro-Larranaga. 2015. “The Political Ecology of Ecosystem Services.” *Geoforum* 61: 122–34.

Lancsar, Emily, Jordan Louviere, Cam Donaldson, Gillian Currie, and Leonie Burgess. 2013. “Best Worst Discrete Choice Experiments in Health: Methods and an Application.” *Social Science & Medicine* 76 (1): 74–82. doi:10.1016/j.socscimed.2012.10.007.

Laurans, Y., A. Rankovic, R. Billé, R. Pirard, and L. Mermet. 2013. “Use of Ecosystem Services Economic Valuation for Decision Making: Questioning a Literature Blindspot.” *Journal of Environmental Management* 119: 208–19.

Laurila-Pant, Mirka, Annukka Lehikoinen, Laura Uusitalo, and Riikka Venesjärvi. 2015. “How to Value Biodiversity in Environmental Management?” *Ecological Indicators* 55 (August). Elsevier: 1–11.

Lee, Julie Anne, Geoffrey N. Soutar, and Jordan Louviere. 2007. “Measuring Values Using Best-Worst Scaling: The LOV Example.” *Psychology and Marketing* 24 (12). Wiley Subscription Services, Inc., A Wiley Company: 1043–58. doi:10.1002/mar.20197.

Lele, S, O Springate-Baginski, R Lakerveld, D Deb, and P Dash. 2013. “Ecosystem Services: Origins, Contributions, Pitfalls, and Alternatives.” *Conservation and Society* 11 (4): 343–58.

Likens, Gene E., and David B. Lindenmayer. 2012. “Integrating Approaches Leads to More Effective Conservation of Biodiversity.” *Biodiversity and Conservation* 21 (13). Springer Netherlands: 3323–41. doi:10.1007/s10531-012-0364-5.

Locatelli, Tommaso, Thomas Binet, James Gitundu Kairo, Lesley King, Sarah Madden, Genevieve Patenaude, Caroline Upton, and Mark Huxham. 2014. “Turning the Tide: How Blue Carbon and Payments for Ecosystem Services (PES) Might Help Save Mangrove Forests.” *Ambio*. doi:10.1007/s13280-014-0530-y.

Loperena, Christopher Anthony. 2012. “A Fragmented Paradise : The Politics of Development and Land Use on the Caribbean Coast of Honduras.” University of Texas – Austin.

Lugo, A., E. Medina, and K. McGinley. 2014. “Issues and Challenges of Mangrove Conservation in the Anthropocene.” *Madera Y Bosques* 20: 11–38.

Lugo, A., and S. Snedaker. 1974. “The Ecology of Mangroves.” *Annual Review of Ecology and Systematics*.

Mazda, Y., M. Magi, M. Kogo, and P. Hong. 1997. “Mangroves as Coastal Protection from Waves in the Tong King Delta, Vietnam.” *Mangroves and Salt Marshes*. Kluwer Academic Publishers.

Mazda, Y., M. Magi, H. Nanao, M. Kogo, T. Miyagi, N. Kanazawa, and D. Kobashi. 2002. “Coastal Erosion due to Long-Term Human Impact on Mangrove Forests.” *Wetlands Ecology and Management* 10 (1). Kluwer Academic Publishers: 1–9.

McCool, Stephen F., and R. Neil. Moisey. 2008. *Tourism, Recreation and Sustainability: Linking Culture and the Environment*. CABI Pub. doi:10.1079/9781845934705.0000.

Mcfield, Melanie, and Patricia Kramer. 2007. “Healthy Reefs for Healthy People: A Guide to Indicators of Reef Health and Social Well-Being in the Mesoamerican Reef Region.” *Healthy Reefs for Healthy People Initiative*, 1–208.

Mcivor, Anna, Tom Spencer, Iris Möller, and Mark Spalding. 2012. “Storm Surge Reduction by Mangroves. Natural Coastal Protection Series: Report 2. Cambridge Coastal Research Unit Working Paper 41.” *Natural Coastal Protection Series*, 35.

Möller, I., M. Kudella, F. Rupprecht, T. Spencer, M. Paul, B. van Wesenbeeck, G. Wolters, et al. 2014. “Wave Attenuation over Coastal Salt Marshes under Storm Surge Conditions.” *Nature Geoscience* 7 (10). Nature Research: 727–31.

Mollett, S. 2014. “A Modern Paradise: Garifuna Land, Labor, and Displacement-in-Place.” *Latin American Perspectives* 41 (6): 27–45.

Muhumuza, Moses, and Kevin Balkwill. 2013. “Factors Affecting the Success of Conserving Biodiversity in National Parks: A Review of Case Studies from Africa.” *International Journal of Biodiversity* 2013. Hindawi Publishing Corporation: 1–20.

Mukherjee, Nibedita, William J. Sutherland, Md Nabiul I. Khan, Uta Berger, Nele Schmitz, Farid Dahdouh-Guebas, and Nico Koedam. 2014. “Using Expert Knowledge and Modeling to Define Mangrove Composition, Functioning, and Threats and Estimate Time Frame for Recovery.” *Ecology and Evolution* 4 (11): 2247–62.

Mumby, P., A. Edwards, A. Ernesto, K.. Lindeman, P. Blackwell, A. Gall, M. Gorczynska, et al. 2004. “Mangroves Enhance the Biomass of Coral Reef Fish Communities in the Caribbean.” *Nature* 427 (6974). Nature Publishing Group: 533–36.

Nagelkerken, I., S. Blaber, S. Bouillon, P. Green, M. Haywood, L. Kirton, J. Meynecke, et al. 2008. “The Habitat Function of Mangroves for Terrestrial and Marine Fauna: A Review.” *Aquatic Botany* 89 (2): 155–85.

Nagelkerken, I., G. van der Velde, M.W. Gorissen, G.J. Meijer, T. Van’t Hof, and C. den Hartog. 2000. “Importance of Mangroves, Seagrass Beds and the Shallow Coral Reef as a Nursery for Important Coral Reef Fishes, Using a Visual Census Technique.” *Estuarine, Coastal and Shelf Science* 51 (1): 31–44.

Nagelkerken, I, S Kleijnen, T Klop, R. A.C.J. Van Den Brand, E. Cocheret De La Morinière, and G.

Van Der Velde. 2001. “Dependence of Caribbean Reef Fishes on Mangroves and Seagrass Beds as Nursery Habitats: A Comparison of Fish Faunas between Bays with and without Mangroves/seagrass Beds.” *Marine Ecology Progress Series* 214 (April): 225–35.

Nunes, Fernando, Teresa Madureira, José Vidal Oliveira, and Helena Madureira. 2016. “The Consumer Trail: Applying Best-Worst Scaling to Classical Wine Attributes.” *Wine Economics and Policy* 5: 78–86. doi:10.1016/j.wep.2016.10.002.

Pendleton, Linwood, Daniel C. Donato, Brian C. Murray, Stephen Crooks, W. Aaron Jenkins, Samantha Sifleet, Christopher Craft, et al. 2012. “Estimating Global ‘Blue Carbon’ Emissions from Conversion and Degradation of Vegetated Coastal Ecosystems.” Edited by Simon Thrush. *PLoS ONE* 7 (9). Public Library of Science: e43542. doi:10.1371/journal.pone.0043542.

Polidoro, B, K Carpenter, L Collins, N Duke, A Ellison, J Ellison, E Farnsworth, et al. 2010. “The Loss of Species: Mangrove Extinction Risk and Geographic Areas of Global Concern.” *PLoS ONE* 5 (4): 1–10. doi:10.1371/journal.pone.0010095.

Primavera, J. H. 2000. “Development and Conservation of Philippine Mangroves: Institutional Issues.” *Ecological Economics*.

Primavera, J H, and J. M.A. Esteban. 2008. “A Review of Mangrove Rehabilitation in the Philippines: Successes, Failures and Future Prospects.” *Wetlands Ecology and Management*. doi:10.1007/s11273-008-9101-y.

Primavera, Jurgenne H. 2005. “Mangroves and Aquaculture in Southeast Asia.” *Report of the Regional Technical Consultation for the Development of Code of Practice for Responsible Aquaculture in Mangrove Ecosystems*, 25–37.

Pullin, Andrew S., Teri M. Knight, David A. Stone, and Kevin Charman. 2004. “Do Conservation Managers Use Scientific Evidence to Support Their Decision-Making?” *Biological Conservation*. Elsevier.

Reed, J., J. Van Vianen, E. Deakin, J. Barlow, and T. Sunderland. 2016. “Integrated Landscape Approaches to Managing Social and Environmental Issues in the Tropics: Learning from the Past to Guide the Future.” *Global Change Biology* 22 (7): 2540–54.

Reed, Mark S, Evan D G Fraser, and Andrew J Dougill. 2006. “An Adaptive Learning Process for Developing and Applying Sustainability Indicators with Local Communities.” *Ecological Economics* 59 (4): 406–18. doi:10.1016/j.ecolecon.2005.11.008.

Richards, D., and D. Friess. 2016. “Rates and Drivers of Mangrove Deforestation in Southeast Asia, 2000–2012.” *Proceedings of the National Academy of Sciences* 113 (2): 344–49.

Richmond, Laurie, and Dawn Kotowicz. 2015. “Equity and Access in Marine Protected Areas: The History and Future of ‘Traditional Indigenous Fishing’ in the Marianas Trench Marine National Monument.” *Applied Geography* 59 (May). Pergamon: 117–24. doi:10.1016/j.apgeog.2014.11.007.

Rönnbäck, Patrik. 1999. “The Ecological Basis for Economic Value of Seafood Production Supported by Mangrove Ecosystems.” *Ecological Economics* 29 (2): 235–52.

Rönnbäck, Patrik, Beatrice Crona, and Lisa Ingwall. 2007. “The Return of Ecosystem Goods and Services in Replanted Mangrove Forests: Perspectives from Local Communities in Kenya.” *Environmental Conservation* 34 (4): 2007. doi:10.1017/S0376892907004225.

Ruitenbeek, H. J. 1994. “Modelling Economy-Ecology Linkages in Mangroves: Economic Evidence for Promoting Conservation in Bintuni Bay, Indonesia.” *Ecological Economics* 10: 233–47. doi:10.1016/0921-8009(94)90111-2.

Saenger, P., and N. Siddiqi. 1993. “Land from the Sea: The Mangrove Afforestation Program of Bangladesh.” *Ocean and Coastal Management* 20 (1). Elsevier: 23–39.

Saenger, Peter, Donald Gartside, and S Funge-Smith. 2013. *A Review of Mangrove and Seagrass Ecosystems and Their Linkage to Fisheries and Fisheries Management*.

Salem, M., and D. Mercer. 2012. “The Economic Value of Mangroves: A Meta-Analysis.” *Sustainability* 4 (3): 359–83.

Samonte-Tan, Giselle P. B., Alan T. White, Mary Ann Tercero, John Diviva, Esperanza Tabara, and Ciemon Caballes. 2007. “Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines.” *Coastal Management* 35 (2–3): 319–38. doi:10.1080/08920750601169634.

Sarker, Swapan K., Richard Reeve, Jill Thompson, Nirmal K. Paul, and Jason Matthiopoulos. 2016. “Are We Failing to Protect Threatened Mangroves in the Sundarbans World Heritage Ecosystem?” *Scientific Reports* 6 (1). Nature Publishing Group: 1–12.

Sathirathai, Suthawan. 1998. “ECONOMY AND ENVIRONMENT PROGRAM FOR SOUTHEAST ASIA Economic Valuation of Mangroves and the Roles of Local Communities in the Conservation of Natural Resources : Case Study of Surat Thani , South of Thailand.”

Sawtooth Technical Paper. 2013. “MaxDiff System/Web Technical Paper.” *Design* 8 (360): 0–26.

Semesi, Adelaida K. 1992. “Developing Management Plans for the Mangrove Forest Reserves of Mainland Tanzania.” *Hydrobiologia* 247 (1–3): 1–10. doi:10.1007/BF00008199.

Serafy, Joseph E, Geoffrey S Shideler, Rafael J Araújo, and Ivan Nagelkerken. 2015. “Mangroves Enhance Reef Fish Abundance at the Caribbean Regional Scale.” *PLoS ONE* 10 (11). Public Library of Science: e0142022. doi:10.1371/journal.pone.0142022.

Sheng, Y. Peter, and Ruizhi Zou. 2017. “Assessing the Role of Mangrove Forest in Reducing Coastal Inundation during Major Hurricanes.” *Hydrobiologia*. doi:10.1007/s10750-017-3201-8.

Sheng, Y Peter, Andrew Lapetina, and Gangfeng Ma. 2012. “The Reduction of Storm Surge by Vegetation Canopies: Three-Dimensional Simulations.” *Geophysical Research Letters* 39 (20). doi:10.1029/2012GL053577.

Small, N, M Munday, and I Durance. 2017. “The Challenge of Valuing Ecosystem Services That Have No Material Benefits.” *Global Environmental Change* 44: 57–67.

Snarr, Kymberley Anne. 2005. “Seismic Activity Response as Observed in Mantled Howlers (Alouatta Palliata), Cuero Y Salado Wildlife Refuge, Honduras.” *Primates* 46 (4): 281–85. doi:10.1007/s10329-005-0151-y.

Soto, José R., Damian C. Adams, and Francisco J. Escobedo. 2016. “Landowner Attitudes and Willingness to Accept Compensation from Forest Carbon Offsets: Application of Best-Worst Choice Modeling in Florida USA.” *Forest Policy and Economics* 63 (February): 35–42. doi:10.1016/j.forpol.2015.12.004.

Soufiani, Hossein Azari, David C Parkes, and Lirong Xia. 2012. “Random Utility Theory for Social Choice.” *25th Annual Conference on Neural Information Processing Systems*, no. 1: 126–34.

Spalding, Mark. 2010. *World Atlas of Mangroves*. Routledge.

Spaninks, Frank, and Pieter Van Beukering. 1997. “Economic Valuation of Mangrove Ecosystems: Potential and Limitations,” July.

Stonich, Susan C. 1995. “The Environmental Quality and Social Justice Implications of Shrimp Mariculture Development in Honduras.” *Human Ecology* 23 (2). Kluwer Academic Publishers-Plenum Publishers: 143–68. doi:10.1007/BF01191647.

Suratman, Mohd Nazip. 2008. “Carbon Sequestration Potential of Mangroves in Southeast Asia.” In *Managing Forest Ecosystems: The Challenge of Climate Change*, edited by Felipe Bravo, Robert Jandl, Valerie LeMay, and Klaus Gadow, 297–315. Springer Science + Business Media B.V. doi:10.1007/978-1-4020-8343-3_17.

Sutherland, William J., Andrew S. Pullin, Paul M. Dolman, and Teri M. Knight. 2004. “The Need for Evidence-Based Conservation.” *Trends in Ecology and Evolution*. Elsevier Current Trends.

Teixeira De Almeida, Luiza, Jo ~ Ao, Luís Sampaio Olímpio, Ana Fl Avia Pantalena, Beatriz Soares De Almeida, Marcelo De, and Oliveira Soares. 2016. “Evaluating Ten Years of Management Effectiveness in a Mangrove Protected Area.” doi:10.1016/j.ocecoaman.2016.03.008.

Terborgh, John. 2002. *Making Parks Work : Strategies for Preserving Tropical Nature*. Island Press.

Thampanya, U., J. E. Vermaat, S. Sinsakul, and N. Panapitukkul. 2006. “Coastal Erosion and Mangrove Progradation of Southern Thailand.” *Estuarine, Coastal and Shelf Science* 68 (1): 75–85. doi:10.1016/j.ecss.2006.01.011.

Thomas, Nathan, Richard Lucas, Peter Bunting, Andrew Hardy, Ake Rosenqvist, and Marc Simard. 2017. “Distribution and Drivers of Global Mangrove Forest Change, 1996-2010.” Edited by Shijo Joseph. *PLoS ONE* 12 (6). Food and Agriculture Organization of the United Nations: e0179302. doi:10.1371/journal.pone.0179302.

Thompson, Benjamin S., Jurgenne H. Primavera, and Daniel A. Friess. 2017. “Governance and Implementation Challenges for Mangrove Forest Payments for Ecosystem Services (PES): Empirical Evidence from the Philippines.” *Ecosystem Services* 23: 146–55. doi:10.1016/j.ecoser.2016.12.007.

Thurstone, L. L. 1927. “A Law of Comparative Judgment.” *Psychological Review* 34 (4): 273–86. doi:10.1037/h0070288.

Tomlinson, PB. 1994. *The Botany of Mangroves*.

Traynor, Catherine Helen, and Trevor Hill. 2008. “Mangrove Utilisation and Implications for Participatory Forest Management, South Africa.” *Conservation and Society* 6 (2): 109–16.

Uddin, Md Shams, E. de Ruyter van Steveninck, Mishka Stuip, and Mohammad Aminur Rahman Shah. 2013. “Economic Valuation of Provisioning and Cultural Services of a Protected Mangrove Ecosystem: A Case Study on Sundarbans Reserve Forest, Bangladesh.” *Ecosystem Services* 5: 88–93.

UNEP. 2014. *The Importance of Mangroves to People: A Call to Action. United Nations Environment Programme World Conservation Monitoring Centre.*

Valiela, Ivan, Jennifer Bowen, and Joanna. York. 2001. “Mangrove Forests: One of the World’s Threatened Major Tropical Environments.” *BioScience*.

Victor, S, Y Golbuu, E Wolanski, and R H Richmond. 2005. “Fine Sediment Trapping in Two Mangrove-Fringed Estuaries Exposed to Contrasting Land-Use Intensity, Palau, Micronesia.” *Wetlands Ecology and Management* 12 (4): 277–83. doi:10.1007/s11273-005-8319-1.

Walker, Joan, and Moshe Ben-Akiva. 2002. “Generalized Random Utility Model.” *Mathematical Social Sciences* 43 (3): 303–43. doi:10.1016/S0165-4896(02)00023-9.

Walters, B., P. Rönnbäck, J. Kovacs, B. Crona, S. Hussain, R. Badola, J. Primavera, E. Barbier, and F. Dahdouh-Guebas. 2008. “Ethnobiology, Socio-Economics and Management of Mangrove Forests: A Review.” *Aquatic Botany* 89 (2): 220–36.

Walters, Bradley B. 2005. “Patterns of Local Wood Use and Cutting of Philippine Mangrove Forests.” *Economic Botany* 59 (1): 66–76. doi:10.1663/0013-0001(2005)059[0066:POLWUA]2.0.CO;2.

Wang, Mao, Jinhan Zhang, Zhigang Tu, Xueqin Gao, and Wenqing Wang. 2010. “Maintenance of Estuarine Water Quality by Mangroves Occurs during Flood Periods: A Case Study of a Subtropical Mangrove Wetland.” *Marine Pollution Bulletin* 60 (11): 2154–60.

Ward, Raymond D., Daniel A. Friess, Richard H. Day, and Richard A. MacKenzie. 2016. “Impacts of Climate Change on Mangrove Ecosystems: A Region by Region Overview.” *Ecosystem Health and Sustainability* 2 (4): 1–25.

West, P. 2001. “Endangered Peoples of Southeast and East Asia: Struggles to Survive and Thrive.” *The Journal of Asian Studies* 60 (3). Greenwood Press: 829–30.

White, Elliott, and David Kaplan. 2017. “Restore or Retreat? Saltwater Intrusion and Water Management in Coastal Wetlands.” *Ecosystem Health and Sustainability* 3 (1): e01258. doi:10.1002/ehs2.1258.

Wielgus, Jeffrey, Emily Cooper, Ruben Torres, and Lauretta Burke. 2010. “Coastal Capital : Dominican Republic: Case Studies on the Economic Value of Coastal Ecosystems in the Dominican Republic.” *World*, no. April: 42.

Wilcock, D. 1995. “Top-down and Bottom-up Approaches to Nature Conservation and Countryside Management in Northern Ireland.” *Area* 27 (3): 252–60.

Wilkinson, Clive, Anne Caillaud, Lyndon Devantier, and Robin South. 2006. “Strategies to Reverse the Decline in Valuable and Diverse Coral Reefs, Mangroves and Fisheries: The Bottom of the J-Curve in Southeast Asia?” *Ocean & Coastal Management* 49: 764–78. doi:10.1016/j.ocecoaman.2006.06.014.

Wilkinson, Clive, and Bernard Salvat. 2012. “Coastal Resource Degradation in the Tropics: Does the Tragedy of the Commons Apply for Coral Reefs, Mangrove Forests and Seagrass Beds.” *Marine Pollution Bulletin* 64: 1096–1105. doi:10.1016/j.marpolbul.2012.01.041.

Windevoxhel, N., J. Rodríguez, and E. Lahmann. 1999. “Situation of Integrated Coastal Zone Management in Central America: Experiences of the IUCN Wetlands and Coastal Zone Conservation Program.” *Ocean and Coastal Management* 42 (2–4). Elsevier: 257–82.

Wittenberg, Eve, Monica Bharel, John F.P. Bridges, Zachary Ward, and Linda Weinreb. 2016. “Using Best-Worst Scaling to Understand Patient Priorities: A Case Example of Papanicolaou Tests for Homeless Women.” *Annals of Family Medicine* 14 (4). American Academy of Family Physicians: 359–64.

Zhang, Keqi, Huiqing Liu, Yuepeng Li, Hongzhou Xu, Jian Shen, Jamie Rhome, and Thomas J. Smith. 2012. “The Role of Mangroves in Attenuating Storm Surges.” *Estuarine, Coastal and Shelf Science* 102–103 (May): 11–23.

Chapter 4

General discussion

4.1 Summary

As human populations continue to rise, increasing demands are being made of global ecosystems for their natural resources, and unsustainable use is causing widespread degradation. Lessons from past conservation efforts have highlighted the necessity for movements away from traditional, top down efforts following the preservationist approach (e.g. National Parks and Marine Protected Areas), and move toward more integrated, bottom up approaches (Bennett and Dearden 2014; Muhumuza and Balkwill 2013; Meyer and Carleton 2016; Gaymer et al. 2014). Integrated approaches to environmental management are typically characterised by public participation and multi-sector collaboration, aligning efforts of conservation with development rather than against it (Johnson, Poulin, and Graham 2003; Carter, Schmidt, and Hirons 2015; Reed et al. 2016). Transitions towards increased integration in management has given rise to concepts such as the "Ecosystem Service Concept" (ESC), to serve as a central framework (MEA 2005). The ESC involves the utilitarian framing of ecosystem functions as 'services' in order to better represent societal dependence on ecosystems and thus create a common reasoning toward ecosystem conservation amongst different types stakeholders (Chapin et al. 2000; Costanza et al. 2014; Abson and Termansen 2010; B. Fisher and Kerry Turner 2008; Braat and de Groot 2012). Attempts to facilitate better communication amongst the different stakeholder groups involved in environmental management has given rise to an ESC associated tool referred to as the valuation of ecosystem services (Cornell 2011; Lele et al. 2013; Costanza et al. 2014; Norgaard 2010). Thus far, development of methods for ecosystem service valuation have primarily focused on the application of monetary units to ES, an approach called the monetary valuation of ES (MVES) (Norgaard 2010; Costanza et al. 2014; Gómez-Baggethun et al. 2010). MVES involves the designation of hypothetical prices to ES as a means of demonstrating their true values to decision makers in a language readily applied to land-use decisions, thus closing a gap between managers, ecologists and decision makers. This tool has gained significant momentum following seminal works by Costanza, (1997) and Daily (1997) and has since been widely adopted into academic circles (Lele et al. 2013; Cornell 2011). Unfortunately, despite successfully bridging significant communication gaps between managers and decision makers, use of the ESC alongside MVES is characteristic of a top-down approach, as it excludes local stakeholders, thus ultimately failing the objectives of integration. This has led to criticism regarding its relative one-dimensionality (Gómez-Baggethun et al. 2014), which has in turn brought about efforts to develop social or non-monetary valuation frameworks greater value plurism in valuation (Kelemen et al. 2014; Kenter et al. 2015; Christie et al. 2012; Chan et al. 2012). Use of said methods increases public participation and allows the opinions and knowledge of local stakeholders to be voiced and considered. At present, significant discourse remains as to how to effectively use ESC and valuation in conservation management to limit value conflicts and increase chances of successful implementation (Seppelt et al. 2011; J. Fisher and Brown 2014; Laurans et al. 2013; Small, Munday, and Durance 2017; de Groot et al. 2010). In light of current discourse, we believe that suggestions by Gómez-Baggethun et al. (2014) of an integrated value framework to consider a diversity of values have serious potential in conservation management.

Mangrove forests are an ecosystem that exhibit extensive degrees of stakeholder engagement, providing local communities with subsistence and livelihood opportunities (Walters et al. 2008; Hussain and Badola 2010) as well as supporting local and regional economics (Aburto-Oropeza et al. 2008; Anneboina and Kavi Kumar 2017) and adjacent ecosystems (Mumby et al. 2004; Nagelkerken et al. 2008), and thus provide ES with plural values to a diversity of stakeholders and varying levels. These forests provide an exemplary system of the need to consider the different types of value if this framework is to be used in integrated approaches to forest management. The objective of this study was thus to explore the use of the ESC framework and valuation in mangrove systems, in light of the contemporary discourse surrounding it's potential and limitations in the wider literature.

Chapter 2 examined the use of MVES in mangrove systems by providing an extensive literature review of all reported monetary values assigned to mangrove forests or their services. The primary objective of this part of the study was to provide an investigation and an update as to trends of MVES use in the mangrove literature and to supplement findings in prior reviews by Brander *et al.*, (2012), Salem and Mercer, (2012) and Mukherjee *et al.*, (2014). The trends and gaps revealed in this review were then examined in light of the aforementioned discourse, aiding in supplementing the extent literature by taking a closer look at the issues that must be addressed before ESC and valuation can be used in mangrove management. Overall, review of the literature revealed that, with regards to mangrove ecosystems, MVES use is primarily of a communicatory nature, which many comment is the way the MVES was intended (Norgaard 2010). In a review of the wider scope of MVES, Laurans *et al.*, (2013) defined three categories of MVES use: decisive, technical, and informative use. Laurens (2013) described decisive use of MVES in aiding in decision making, assisting trade-offs, in addition to use as an environmental monitoring unit and as a negotiation tool. Technical use in design of a management instruments is defined as price-setting and determining damage compensation (Laurens, 2013). Informative use as described by Laurens (2013) involved raising awareness and as measurements for justification and support. Review of the literature demonstrated use of MVES with regards to mangroves is primarily informative. We would argue that due to the location of the majority of mangrove forests in lesser developed countries where conservation is not a top government priority, use of the tool in this way is valid. However, the limitations to implementation of MVES are not applicable to use of the tool in this way. The other modes of use described by Laurens are representative of true integration into management, where the issues described in this thesis act as to limit the effectiveness of MVES. Said limitations were reflected in the results of chapter 2, the more notable being the lack of representation of cultural values and non-material benefits, value conflicts between services of low economic value but high social value (e.g. building materials and subsistence fisheries), and vice versa, as well as the deficit concerning ecological values and proper utilisation of ecological research. These limitations are central to discussions regarding the relative one-dimensionality of MVES, in which concerns are raised as to the capacity for studies to capture all types of value in monetary units. Chapter 2 thus demonstrates support for calls in the wider literature as to the necessity of value plurism in ecosystem service valuation if the tool is to be used in mangrove management. An additional significant finding made in this part of the study was that there is a notable deficit with regards to valuation studies concerning mangroves of the AEP region when compared to the IWP region (specifically Africa, Latin America and the Caribbean), a deficit further demonstrated with regards to the mangrove inhabited countries in the IWP region that are not Southeast Asian. In light of the discussions here as to the limitations of valuation, this gap may seem insignificant. It is the case however that in reviewing this literature it has become clear that MVES studies of mangroves such as those examined in this study make up the majority of peer-reviewed reports concerning the different services that mangroves are providing worldwide. It is thus vital that we fill the gaps pertaining to Africa, Latin America and the Caribbean though perhaps future studies would benefit from using a variety of valuation methods in a truly interdisciplinary approach for capturing plural values.

The study in Chapter 3 we attempted to employ non-monetary methods in order to examine the ways in which local stakeholders valued mangrove services. Participants from mangrove dependent communities at four different sites on the Caribbean coast of Honduras were asked to complete a choice experiment in MaxDiff format. The experiment involved selecting which mangrove services they deemed the most and least important to themselves from a list of predetermined services. Analysis of these choice sets derived a ratio-scaled importance score for each of the services examined, providing (1) information as how important the services were considered in relation to one another (2) how these perceptions differed amongst the communities surveyed. One overarching, particularly significant finding from this part of was that (with the exception of the nursery and saltwater intrusion prevent services), perceptions as to the importance (or socio-cultural value) of services were shown to vary amongst sites, in addition to being affected by the relative geographies of the communities (island vs. mainland). The study found that mangrove users with higher levels of mangrove dependence (based on relative social status) demonstrated a more even distribution of importance across direct mangrove services. The consistencies observed with regards to perceptions of the nursery service were particularly interesting as this service can thus be considered one of high social, economic and ecological value offering potential as the base for valuation focused management schemes as all values are consistent. In addition, despite showing variation amongst the sites importance scores for the subsistence and commercial fishery services were consistently high which could indicate potential for fishery-based community management schemes. Although this study reports consistencies in the nursery service, the variation in perceptions amongst communities as to the other services examined demonstrates that consideration of site-specificity is crucial in implementing management schemes. The results pertaining to the high importance scores for the building material services attributed by community members in Tela are particularly demonstrative of this point. Use of the non-monetary methods in this study allowed us to capture high values pertaining to a service that may have otherwise been overlooked due to its low market value. Failure to recognize and consider site-specific values held by local stakeholders such as those by Tela, provide opportunity for value conflict and thus reduce overall chances of conservation success. These comments are further evidenced by the clear variation between perceptions held by island communities compared to mainland communities that indicate effects of community geography on community perceptions. In cases such as that of the storm protection service, island community members considered this service to be highly valuable whereas mainland community members did not. Storm protection is heavily reported as important in the literature however implementing a management schemes focused around this service would allow for value conflicts as members at the mainland sites would fail to understand and appreciate the value of the service. Similar can be said with regards to perceptions of the biodiversity service in this study. In this context biodiversity was defined as an opportunity to observe nature, one that many participants expressed strong positive feelings towards. Values such as these cannot be captured in monetary units however it is clear that in this case biodiversity in this context was very important to stakeholders (consistently ranked within the top 4 most important services). Overall, use of non-monetary methods in this study have demonstrated the existence of values outside of the economic paradigm and demonstrated that the importance of services to stakeholders can vary amongst communities and affected by the relative geographies of said communities. It would stand to reason that the results of this study indicate strong potential for a national mangrove management scheme in Honduras (perhaps based around fisheries) however flexibility within this would be needed to accommodate different stakeholders.

4.2 Conclusion

This thesis explored the use of ESV in assessing the importance of mangrove ecosystem services, first reviewing the existing literature concerning their monetary valuation in chapter 2, followed by experimental use of a non-monetary technique for their valuation in chapter 3. The review in chapter 2 demonstrated an increasing prevalence of monetary valuation use in mangrove service studies, in addition to highlighting various biases present in said literature. More specifically, chapter 2 revealed strong biases with regards to world regions studied, services valued and consequently, methods used. These trends imply that other than perhaps introducing previously unvalued mangrove systems to the academic arena, said monetary studies are only adding to what we already know of mangrove service values and offering limited insight into the values of other, less tangible services. Valuations of mangrove storm protection and fisheries for example have been exhausted whereas various cultural services or the biodiversity service remain underrepresented. The underrepresentation of such services in the literature is a result of their inherently intangible nature, making them difficult to fit within the economic paradigm. It is the case however that in neglecting to study and report their values, whilst actively choosing to continue reporting on the monetary value of others, we are providing an incomplete picture of mangrove ecosystem worth. Not only that but we are also perpetuating the idea that these services with more inherently social values are insignificant when in reality, social perspectives tend to be strong underlying drivers of both positive and negative environmental behaviours and thus can be key to the success of conservation schemes. For this reason, we chose to explore the values of several mangrove services from a social perspective in chapter 3. The main finding in chapter 3 was that consistencies between economic and social values do exist. Services such as the nursery and storm protection services were considered highly important across all sites, although the order by which differed with community. These results were to be expected however interestingly, the biodiversity service was also consistently thought to be highly important. These results demonstrate the importance of site-specific management plans rather than national blanket regulations but also confirms that monetary valuation alone cannot offer a complete picture of mangrove values. Overall the results of this thesis support the idea that we cannot rely solely on monetary valuation to demonstrate the worth of an ecosystem. If we are to continue using ESV in mangroves we need to develop a multi-value framework that looks at biological, social and economic values of ecosystems rather than continuing to report new monetary mangrove values. Although one could argue that revisiting the monetary value of well-studied services in previously unstudied sites could help attract attention of governmental bodies specific to the relative areas, we have to consider whether doing so represents the best and most efficient use of limited conservation resources. Several authors have critiqued monetary valuation methods and expressed concern regarding their accuracy and reliability. This in combination with the limitations discussed here suggests that if we do want to attract governmental attention perhaps we could just use benefit transfer methods to derive values from similar, previously valued mangrove systems. It is also worth considering whether focussing on valuation as a whole is worth the effort. Ultimately with a perfect framework we will still just be placing a value on a system, one that won't be attainable in any way by local, ground-level stakeholders. The problem here is that in doing this valuation remains a top down approach rather than the integrated tool it had hoped to be. We need to consider if rather than focusing on a framework for placing values we should instead be looking at how valuation methods, monetary, social or biological can derive information about how people values ecosystems that can be used to aid management through the creation and engineering of problem, site and community specific management schemes and education programs. Future work may look at how cultural services compare to economically important ones and look at how choice experiments exploring social values can better help managers.

4.3 Bibliography

Abson, D, and M Termansen. 2010. “Valuing Ecosystem Services in Terms of Ecological Risks and Returns.” *Conservation Biology* 25 (2).

Aburto-Oropeza, O., E. Ezcurra, G. Danemann, V. Valdez, J. Murray, and E. Sala. 2008. “Mangroves in the Gulf of California Increase Fishery Yields.” *Proceedings of the National Academy of Sciences of the United States of America* 105 (30): 10456–10459.

Anneboina, L., and K. Kavi Kumar. 2017. “Economic Analysis of Mangrove and Marine Fishery Linkages in India.” *Ecosystem Services* 24: 114–23.

Bennett, E., and P. Dearden. 2014. “Why Local People Do Not Support Conservation: Community Perceptions of Marine Protected Area Livelihood Impacts, Governance and Management in Thailand.” *Marine Policy* 44: 107–16.

Braat, L, and R de Groot. 2012. “The Ecosystem Services Agenda:bridging the Worlds of Natural Science and Economics, Conservation and Development, and Public and Private Policy.” *Ecosystem Services* 1 (1). Elsevier: 4–15.

Brander, L., A. Wagtendonk, S. Hussain, A. McVittie, P. Verburg, R. de Groot, and S. van der Ploeg. 2012. “Ecosystem Service Values for Mangroves in Southeast Asia: A Meta-Analysis and Value Transfer Application.” *Ecosystem Services* 1 (1). Elsevier: 62–69.

Carter, H., S. Schmidt, and A. Hirons. 2015. “An International Assessment of Mangrove Management: Incorporation in Integrated Coastal Zone Management.” *Diversity* 7 (2): 74–104.

Chan, K., A. Guerry, P. Balvanera, S. Klain, T. Satterfield, X. Basurto, A. Bostrom, et al. 2012. “Where Are Cultural and Social in Ecosystem Services? A Framework for Constructive Engagement.” *BioScience* 62 (8). Oxford University PressAmerican Institute of Biological Sciences: 744–56.

Chapin, F., E. Zavaleta, V. Eviner, R. Naylor, P. Vitousek, H. Reynolds, D. Hooper, et al. 2000. “Consequences of Changing Biodiversity.” *Nature* 405 (6783): 234–42.

Christie, M, I Fazey, R Cooper, T Hyde, and J Kenter. 2012. “An Evaluation of Monetary and Non-Monetary Techniques for Assessing the Importance of Biodiversity and Ecosystem Services to People in Countries with Developing Economies.” *Ecological Economics* 83: 67–78.

Cornell, Sarah. 2011. “The Rise and Rise of Ecosystem Services: Is ‘value’ the Best Bridging Concept between Society and the Natural World?” *Procedia Environmental Sciences* 6. Elsevier: 88–95.

Costanza, R., R. de Groot, P. Sutton, S. van der Ploeg, S. Anderson, I. Kubiszewski, S. Farber, and R. Turner. 2014. “Changes in the Global Value of Ecosystem Services.” *Global Environmental Change* 26: 152–58.

Daily, Gretchen C. 1997. *Nature’s Services: Societal Dependence on Natural Ecosystems*. Vol. 1. Island Press, Washington, DC.

Fisher, Brendan, and R. Kerry Turner. 2008. “Ecosystem Services: Classification for Valuation.” *Biological Conservation*.

Fisher, J, and K Brown. 2014. “Ecosystem Services Concepts and Approaches in Conservation: Just a Rhetorical Tool?” *Ecological Economics* 108 (December). Elsevier: 257–65.

Gaymer, C., A. Stadel, N. Ban, P. Carcamo, J. Ierna, and L. Lieberknecht. 2014. “Merging Top-down and Bottom-up Approaches in Marine Protected Areas Planning: Experiences from around the Globe.” *Aquatic Conservation: Marine and Freshwater Ecosystems* 24 (S2): 128–44.

Gómez-Baggethun, E., R. de Groot, P. Lomas, and C. Montes. 2010. “The History of Ecosystem Services in Economic Theory and Practice: From Early Notions to Markets and Payment Schemes.” *Ecological Economics* 69 (6). Elsevier B.V.: 1209–18.

Gómez-Baggethun, E., B Martín-López, D Barton, L Braat, H Saarikoski, E Kelemen, M García-Llorente, et al. 2014. “State-of-the-Art Report on Integrated Valuation of Ecosystem Services.” *European Commission FP7*.

Groot, R de, R Alkemade, L Braat, L Hein, and L Willemen. 2010. “Challenges in Integrating the Concept of Ecosystem Services and Values in Landscape Planning, Management and Decision Making.” *Ecological Complexity* 7 (3): 260–72.

Hussain, S., and R. Badola. 2010. “Valuing Mangrove Benefits: Contribution of Mangrove Forests to Local Livelihoods in Bhitarkanika Conservation Area, East Coast of India.” *Wetlands Ecology and Management*.

Johnson, M C, M Poulin, and M Graham. 2003. “Towards an Integrated Approach to the Conservation and Sustainable Use of Biodiversity: Lessons Learned from the Rideau River Biodiversity Project.” *Human Ecology Forum* 10 (1): 40–55.

Kelemen, Eszter, Marina García-Llorente, György Pataki, Berta Martín-López, and Erik Gómez-Baggethun. 2014. “Non-Monetary Techniques for the Valuation of Ecosystem Services.” In *OpenNESS Reference Book.*, 1–4.

Kenter, J., L. O’Brien, N. Hockley, N. Ravenscroft, I. Fazey, K. Irvine, M. Reed, et al. 2015. “What Are Shared and Social Values of Ecosystems?” *Ecological Economics* 111: 86–99.

Laurans, Y., A. Rankovic, R. Billé, R. Pirard, and L. Mermet. 2013. “Use of Ecosystem Services Economic Valuation for Decision Making: Questioning a Literature Blindspot.” *Journal of Environmental Management* 119: 208–19.

Lele, S, O Springate-Baginski, R Lakerveld, D Deb, and P Dash. 2013. “Ecosystem Services: Origins, Contributions, Pitfalls, and Alternatives.” *Conservation and Society* 11 (4): 343–58.

MEA. 2005. “Ecosystems and Human Well-Being.” *Island Press, Washington, DC*. Vol. 5.

Meyer, Cameron, and Shorb Carleton. 2016. “Relative Efficacy of Efforts to Reduce Bushmeat Poaching in the Democratic Republic of the Congo.” *Undergraduate Journal of Humanistic Studies* 3: 1–7.

Muhumuza, Moses, and Kevin Balkwill. 2013. “Factors Affecting the Success of Conserving Biodiversity in National Parks: A Review of Case Studies from Africa.” *International Journal of Biodiversity* 2013. Hindawi Publishing Corporation: 1–20.

Mukherjee, N., W. Sutherland, M. Khan, U. Berger, N. Schmitz, F. Dahdouh-Guebas, N. Koedam, L. Dicks, and J. Hugé. 2014. “Ecosystem Service Valuations of Mangrove Ecosystems to Inform Decision Making and Future Valuation Exercises.” *PLoS ONE* 9 (9): e107706.

Mumby, P., A. Edwards, A. Ernesto, K.. Lindeman, P. Blackwell, A. Gall, M. Gorczynska, et al. 2004. “Mangroves Enhance the Biomass of Coral Reef Fish Communities in the Caribbean.” *Nature* 427 (6974). Nature Publishing Group: 533–36.

Nagelkerken, I., S. Blaber, S. Bouillon, P. Green, M. Haywood, L. Kirton, J. Meynecke, et al. 2008. “The Habitat Function of Mangroves for Terrestrial and Marine Fauna: A Review.” *Aquatic*

Botany 89 (2): 155–85.

Norgaard, R. 2010. “Ecosystem Services: From Eye-Opening Metaphor to Complexity Blinder.” *Ecological Economics* 69 (6): 1219–27.

Reed, J., J. Van Vianen, E. Deakin, J. Barlow, and T. Sunderland. 2016. “Integrated Landscape Approaches to Managing Social and Environmental Issues in the Tropics: Learning from the Past to Guide the Future.” *Global Change Biology* 22 (7): 2540–54.

Salem, M., and D. Mercer. 2012. “The Economic Value of Mangroves: A Meta-Analysis.” *Sustainability* 4 (3): 359–83.

Seppelt, R, C Dormann, F Eppink, S Lautenbach, and S Schmidt. 2011. “A Quantitative Review of Ecosystem Service Studies: Approaches, Shortcomings and the Road Ahead.” *Journal of Applied Ecology* 48 (3). Blackwell Publishing Ltd: 630–36.

Small, N, M Munday, and I Durance. 2017. “The Challenge of Valuing Ecosystem Services That Have No Material Benefits.” *Global Environmental Change* 44: 57–67.

Walters, B., P. Rönnbäck, J. Kovacs, B. Crona, S. Hussain, R. Badola, J. Primavera, E. Barbier, and F. Dahdouh-Guebas. 2008. “Ethnobiology, Socio-Economics and Management of Mangrove Forests: A Review.” *Aquatic Botany* 89 (2): 220–36.