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Valuing ecosystem services from blue forests: A systematic review of the valuation of salt marshes, sea grass beds and mangrove forests

Amber Himes-Cornell [a,*], Linwood Pendleton [a], Perla Atiyah [b]

[a] Université de Bretagne Occidentale AMURE/LABEX/IUEM, 12 rue de Kergoat – CS 93837, 29238 Brest Cedex 3, France
[b] Lebanese American University, School of Engineering, Byblos, Lebanon

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ABSTRACT

Coastal ecosystems provide a number of life-sustaining services, from which benefits to humans can be derived. They are often inhabited by aquatic vegetation, such as mangroves, sea grasses and salt marshes. Given their wide geographic distribution and coverage, there is need to prioritize conservation efforts. An understanding of the human importance of these ecosystems can help with that prioritization. Here, we summarize a literature review of ecosystem service valuation studies. We discuss (1) the degree to which current valuation information is sufficient to prioritize blue carbon habitat conservation and restoration, (2) the relevancy of available studies, and (3) what is missing from the literature that would be needed to effectively prioritize conservation. Given the recent focus on blue carbon ecosystems in the international conservation, there are a number of areas where research on blue forest ecosystem assessment and valuation could be improved, from enhancing available methodologies to increasing valuation of rarely studied ecosystem services and wider geographic coverage of valuation studies. This review highlights these gaps and calls for a focus on broadening the ecosystem services that are valued, the methods used, and increasing valuation in underrepresented regions.

Contents

* Corresponding author at: Fisheries Policy, Economics and Institutions Branch, Fisheries and Aquaculture Policy and Resources Division, Food and Agriculture Organisation of the United Nations (FAO), Rome, 00153, Italy. Tel.: +39 0657050079.
E-mail address: amber.himescornell@fao.org (A. Himes-Cornell).

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1. Introduction

Coastal zones are home to a wide range of ecological and economic activity. While only occupying about 4% of total land area and 11% of oceans, they are some of the planet's most productive ecosystems (Millennium Ecosystem Assessment, 2005). Coastal ecosystems provide a number of life-sustaining services, from which benefits to humans (and the monetary value associated with those benefits) can be derived (Barbier, 2011). Despite their importance, coastal zones are also among the most threatened ecosystems on earth: humans are degrading and destroying these ecosystems worldwide at an increasing rate, and subsequently jeopardizing the availability of these critical services (Halpern et al., 2008; Millennium Ecosystem Assessment, 2005). A better understanding of how these ecosystems function, the services they provide (in both ecological and economic terms), and what is at stake should we lose them is a necessary part of any coastal zone management plan (Fisher et al., 2009).

Coastal zones can begin up to 100 km inland and include ocean waters extending from the upper intertidal zone to 40 m in depth (Duarte et al., 2013). These areas where land meets sea are marked by the presence of aquatic vegetation, such as seagrasses, salt marshes and mangroves, with plants either fully or partially submerged. These habitats are often referred to as blue carbon ecosystems or blue forests, because they act as carbon sinks, similar to their terrestrial counterparts (Mcleod et al., 2011; Pendleton et al., 2012). By capturing and sequestering carbon from the atmosphere, blue forests have an important role in climate change mitigation. Blue forest ecosystems also provide several other ecosystem services, including the provision of nursery habitats, raw materials, coastal protection, and enhancing water quality, to name a few (Lau, 2013). Studies have indicated that vast amounts of these ecosystems have been and are currently being lost or degraded worldwide. Over the last 20–50 years, 50% of salt marshes, 35% of mangroves, and 29% of seagrasses have been lost (Barbier, 2012; Millennium Ecosystem Assessment, 2005; Mcleod et al., 2011; Waycott et al., 2009).

Researchers have increasingly used the results of ecosystem service valuation studies to argue for the conservation of coastal ecosystems, particularly blue forests (Barbier et al., 2011). Several review papers have recently summarized valuation studies that have been conducted for these habitats; however, many of the studies covered are based primarily on studies that are more than 10 years old (Barbier et al., 2011, 2016; Dewsbury et al., 2016; Torres and Hanley, 2016; Vegh et al., 2014). For example, Dewsbury et al. (2016) cites 32 published seagrass economic valuations; however, only 9 were conducted in the last 10 years; the remaining 23 studies were conducted between 1977 and 2006. Torres and Hanley (2016) provide a review of coastal and marine ecosystem valuation studies. Similarly, the vast majority of their cited studies that specifically provide values for blue forest ecosystem services are more than 10 years old. The prevalence of older, possibly outdated data is also seen in Barbier et al. (2011) Salem and Mercer (2012) and Vegh et al. (2014). Barbier et al. (2011) also provide a review of estuarine and coastal ecosystem service values. Their review only cited one estimate for seagrass services (fisheries); however, that estimate was published in 2006. Barbier et al. (2011) cite more values for salt marshes (N = 5); however, these studies too are older than 10 years and the more recent studies only provide values for wetlands in general. Similarly, for mangroves, they only cite three studies, all of which are 10 or more years old. Salem and Mercer (2012) conducted a meta-analysis of the economic value of mangroves citing 62 mangrove valuation studies, only 9 of which were published in the last 10 years with the majority published in the 1980s and 1990s. Lastly, Vegh et al. (2014) also provide a recent review of the mangrove ecosystem services valuation literature, citing 72 mangrove valuation studies. Only 29 of these studies were published after 2006 and many do not actually provide ecosystem service valuation estimates that are specific to mangroves; only 11 were published in the last 5 years and most do not rely on recently collected data. The present review highlights the challenge of outdated valuation research and compiles valuation studies that have been done more recently.

Furthermore, very few papers have critically examined the methods and particularly the assumptions that underlie such studies, the methods used to estimate values, or the gaps in valuation for blue carbon ecosystems. We take a step back to examine the methods and underlying assumptions used in the historical valuation of blue forest ecosystem services. We provide a review of the services provided by mangrove, seagrass and salt marsh ecosystems and the methods that have been used to calculate economic values of those ecosystem services to date. Our aim is to help direct the future valuation of blue ecosystems and the use of these valuation estimates in blue forest management.

There are many international efforts aimed at conserving blue forest ecosystems, but given the wide geographic distribution and coverage of mangroves, seagrasses and salt marshes, there is great need to prioritize the areas to focus conservation efforts. An understanding of the human importance of these ecosystems can help with that prioritization. Here, we review ecosystem service valuation studies that have been conducted for each of these ecosystems over the last 10 years (2007–2016). First, we start with a description of how we conducted our literature review. Second, we summarize the results of the review. Finally, we provide a discussion of (1) the degree to which current ecosystem service valuation information is sufficient to prioritize blue carbon habitat conservation and restoration, (2) the relevancy of available studies, and (3) what is missing from the valuation studies (ecosystem service valuation and threats) that have been done that would be needed to effectively prioritize conservation.

2. Background

2.1. Blue carbon ecosystems

Globally, blue carbon ecosystems occupy a significant portion of the coastline (Fig. 1, Table 1). Seagrasses are flowering plants that are fully submerged in shallow marine waters. Optimal conditions for seagrasses include low sunlight exposure, soft substrates (i.e., sand, mud) and wave-protected areas (Duarte, 2002). Seagrass meadows are principally found in North America (UNEP-WCMC, 2016). Salt marshes are intertidal grasslands that form along continental margins, bays, and estuaries. They are characterized by sharp zonation of plants and low species diversity, but very high primary and secondary production. Salt marshes are principally located in Europe and North America (Mcowen et al., 2017). Mangroves are coastal forests that have adapted to high salinity conditions and are mostly found in the tropics and subtropics (Barbier et al., 2011). Mangroves are found in highest abundance in the tropical latitudes of Africa, Asia and Central and South America (Giri et al., 2011). All three habitats are represented to some extent in all regions of the world with the exception of mangroves in Europe.

Despite the relatively small geographical space they occupy (Fig. 1), blue forests provide a number of ecosystem services (Lau, 2013). By reducing the impact of incoming waves and stabilize sediments, they provide coastal protection and erosion control for adjacent shorelines (Rao et al., 2015; Shepard et al., 2011). They act as natural filters by removing nutrients from the sediment,