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A review of seagrass economic valuations: Gaps and progress in valuation approaches

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ABSTRACT

Multiple studies have documented the ecologically important role that seagrasses play in estuarine and marine ecosystems. Unfortunately, economic valuations of these systems have not been as widespread. To date, most techniques rely on mechanisms that do not incorporate the actual ecological drivers behind the economic service, but rather rely on proxy measures to derive value. In this manuscript we review the many values that seagrasses have that result in economic services, and the valuation techniques used to estimate their monetary value. We present a conceptual framework linking seagrass ecosystems to the economic services they provide, showing the areas where novel valuation approaches are most lacking. We conclude that indirect methods used to valuate seagrass ecosystems underestimate the economic value of their services, and that more derivative-based models linking ecological structure and function to all associated economic services are essential for accurate estimations of their dollar value.

Contents

1. Introduction

Seagrasses are marine angiosperms that inhabit coastal ecosystems worldwide. While the taxonomic diversity of seagrass is

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low, its acreage typically extends to hundreds of thousands of kilometers of the coastline (Short et al., 2007; Orth et al., 2006). Seagrasses provide many ecosystem services (Fonseca et al., 2002; Emmett Duffy, 2006). These ecosystem services may be permanently tethered to local economies, meaning that quality of life in some coastal communities might depend on the state of the seagrass meadows. (Anderson, 1989; Spurgeon, 1999; Unsworth et al., 2010). Unlike other primary producers in the marine environment, seagrasses have a broad latitudinal range, inhabiting all but polar ecosystems (Orth et al., 2006). This means that the economic services provided by seagrass ecosystems occur at multiple spatial scales. The nature of some of these services and the proximity of seagrass ecosystems to densely populated areas however, exposes them to a wide variety of activities that negatively impact it (Orth et al., 2006; Duarte, 2002).

Recent studies have reported a perpetual worldwide decline in seagrass abundance (Orth et al., 2006). The causes of these declines vary spatially and temporally. Heavy dredging from marine construction is a well-documented negative impact activity on seagrass beds (reviewed in (Erftemeijer and Robin Lewis, 2006)). Shallow seagrass beds are especially prone to scouring from vessel grounding and scarring from the propellers of motorized boats (Zieman, 1976). These injuries not only remove the aboveground biomass, but excavate the rhizomes and sediment sometimes creating blowholes. Marine fauna can then create further damage by excoriating the adjacent rhizome thus causing neighboring beds to collapse (Patriquin, 1975). Near shore seagrass beds are also vulnerable to allocthonous nutrient inputs as effluent from human activities (Harlin and Thorne-Miller, 1981) or from groundwater (Reide Corbett et al., 1999). These nutrient increases can result in an ecological shift to faster growing micro and macroalgae both of which outcompete seagrasses for light, and are physiologically better equipped to proliferate in a high nutrient environment (den Hartog, 1994; Harlin, 1975; Silberstein et al., 1986). Overfishing can also spur cascading effects that have negative effects on seagrasses in a couple of ways. Firstly, the removal of large predators releases the consumer pressure on smaller predators who feed on epibenthic fauna in seagrass ecosystems. Epibenthic fauna feed on epiphytic algae that accumulate on the blades of seagrasses. When epibenthic fauna is removed from the system, the accumulation of epiphytes on seagrass leaves can prevent seagrasses from accessing much needed light for photosynthetic activity (Heck and Valentine, 2006). Secondly, the removal of large predators allows herbivores to feed unimpeded on seagrass beds (Myers et al., 2007).

Most of the negative impacts on seagrass beds reflect the reality that coastal ecosystems are by-and-large common use areas. High volumes of commercial, recreational and tourist activities ensure a large amount of boat and human traffic within a few miles from the shoreline resulting in direct impact on seagrass beds. In addition, 40% of the world's population live within 60 km of the coastline (Organization, 2005), meaning that coastal communities are more likely to suffer from negative externalities associated with population increase.

There have been many calls for stricter management policies to aid in the preservation and restoration of existing seagrass beds (Fonseca et al., 1998). While many of these requests cite the economic value of seagrass ecosystems, there have been only a few studies that provide dollar estimates of the value of these systems. A main reason for this is that seagrass itself does not have much direct market value. Therefore, economic assessments of their worth rely on indirect values derived from the services these systems provide. Since some of these services result in social benefit, traditional market methods may be insufficient for deducing actual economic value. Additionally, the specific ecological relationship between seagrasses and some of its benefits have only been relatively recently documented, and therefore efforts to translate certain ecosystem functions into economic terms are still in its infancy.

There is a clear need for greater progress to be made on seagrass valuation. As humans increasingly populate coastal cities, greater pressure is being applied to coastal ecosystems to satisfy local demands for space, food, and other resources. Chief among the potential impacts to the coastal ecosystem by burgeoning populations is the decrease in water quality due to runoff, dredging and other human activities (Waycott et al., 2009; Grech et al., 2012). The varying ability of seagrass meadows to mitigate these effects, means that local communities bear the negative economic effects of destroyed meadows. Where communities rely heavily on the ecosystem services seagrasses provide, wellbeing suffers much more disproportionately when compared to communities that draw from a variety of ecosystem services (Grech et al., 2012). To create greater awareness among policymakers and the general public of the need to protect seagrasses, and to convince politicians to commit resources to do so, a clearer economic argument for seagrass ecosystem preservation needs to be made. Commercial stakeholders tend to have an easier time demonstrating the economic value of their projects. Income from property taxes, corporate taxes and tourist revenue has visible and tangible benefits for the local economy. These linear economic relationships make it easier for these stakeholders to enlist the support of managers and politicians, even if the enactment of these projects produces long-term harm to coastal ecosystems. Environmental managers however have a more difficult time demonstrating the economic contribution of non-commercial ecosystem uses.

In this paper, we review the different values of seagrass ecosystems and the valuation techniques used to estimate seagrass value around the world. We indicate here the strengths and weaknesses of each approach, and discuss the areas where the field can be advanced. We believe that recent literature on seagrass ecology has uncovered new ecosystem services (Unsworth and Cullen-Unsworth, 2014), and therefore, existing economic valuation studies may be incomplete.

We first discuss the theoretical economic valuation framework that guides the review of this issue. Second, we highlight the list of current attempts at valuation of seagrass ecosystems, pointing out the gaps in their approaches. Finally we present a conceptual model (Seagrass Ecosystem Valuation [SEV] model) that provides a framework to valuate and aggregate the multiple ecosystem services of seagrass ecosystems, discussing ways in which it can be used by managers and future stakeholders in local systems.

2. Methods

We used ISI web of knowledge and searched for valuation papers using the terms ‘SEAGRASS VALUATION’, ‘SEAGRASS ECONOMIC VALUE’ and ‘SEAGRASS VALUATION METHODS’. We culled the papers for all examples where valuation attempts were used to ascribe an economic value to seagrass beds. We also collected papers that originally described the ecological relationship that seagrass beds have with each of its ecosystem services. We then classified the studies into groups based on whether they addressed one or more of direct use values, indirect use values, and non-use values. This classification allowed us to identify any gaps on the seagrass value spectrum.

3. Seagrass value

Total Economic Value (TEV) is an aggregate estimation of the function-based value that an ecosystem provides a local