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Linking people to coastal habitats: A meta-analysis of final ecosystem goods and services on the coast

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ABSTRACT

Coastal ecosystem goods and services (EGS) have steadily gained traction in the scientific literature over the last few decades, providing a wealth of information about underlying coastal habitat dependencies. This meta-analysis summarizes relationships between coastal habitats and final ecosystem goods and services (FEGS) users. Through a "weight of evidence" approach synthesizing information from published literature, we assessed habitat classes most relevant to coastal users. Approximately 2800 coastal EGS journal articles were identified by online search engines, of which 16% addressed linkages between specific coastal habitats and FEGS users, and were retained for subsequent analysis. Recreational (83%) and industrial (35%) users were most cited in literature, with experiential-users/hikers and commercial fishermen most prominent in each category, respectively. Recreational users were linked to the widest diversity of coastal habitat subclasses (i.e., 22 of 26). Whereas, mangroves and emergent wetlands were most relevant for property owners. We urge EGS studies to continue surveying local users and identifying habitat dependencies, as these steps are important precursors for developing appropriate coastal FEGS metrics and facilitating local valuation. In addition, understanding how habitats contribute to human well-being may assist communities in prioritizing restoration and evaluating development scenarios in the context of future ecosystem service delivery.

1. Introduction

The relatively recent (since the Millennium Ecosystem Assessment, MEA, 2005) boom in literature addressing ecosystem goods and services (EGS) underscores an important relationship between healthy, functioning ecosystems, and human well-being (Naeem, 2009). These associations are often exemplified in coastal regions where tourism, recreation, aesthetic amenities, property protection, and fisheries, each with a unique dependency on habitats, are large economic drivers (Barbier et al., 2011; Arkema et al., 2013; Rao et al., 2015). Coastal areas face several challenges related to balancing the needs of an ever-increasing population, while preserving habitats and functions that support continual EGS delivery (Moberg and Rönnbäck, 2003; Rönnbäck et al., 2007; Barbier et al., 2011; Rao et al., 2015). Given stressors such as flooding, hurricanes, tsunamis, and sea level rise that may disproportionately affect EGS in coastal communities (Scott et al., 2004; Adger et al., 2005; Costanza et al., 2008; Craft et al., 2009; Mattheus et al., 2010; Gosling, 2013; Hernández-Delgado, 2015; Neumann et al., 2015; Runting et al., 2016), factoring human beneficiaries and their associated habitat dependencies into the decision process for long-term resiliency planning efforts may ultimately lead to better conservation outcomes, more holistic coastal planning initiatives, and meaningful stakeholder engagement (Adger et al., 2005; Egoh et al., 2007; Daily et al., 2009; Munang et al., 2013; Luisetti et al., 2014; Arkema et al., 2015; Elliff and Kikuchi, 2015; Zaucha et al., 2016).

The inherent relationships between ecosystem properties (e.g., habitats) and human benefits have been understood for quite some time, and have served as the basis for valuing EGS at local and global scales (de Groot, 1987; Costanza et al., 1997, 2017; Kubiszewski et al., 2017). Numerous studies have specifically focused on mapping the spatial distribution or potential availability of EGS based on attributes of land-cover, ecosystems, and/or habitats (Schägner et al., 2013; Werner et al., 2014; Brown and Fagerholm, 2015; Le Clec'h et al., 2016; Martin et al., 2016). Given the growing number of studies linking EGS to coastal

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features (e.g., Barbier, 2012; Carollo et al., 2013; Cabral et al., 2015), our aim was to quantify the state of knowledge for the extent to which coastal habitats broadly contribute to EGS, based on EGS mapping studies and other publications documenting human use along the coast. We focused on specific user groups (i.e., people using the coastal environment in similar ways or to achieve the same overarching purpose, like recreational opportunities) to hone in on final ecosystem goods and services (FEGS), those goods and services directly affecting people. We view FEGS endpoints as a subset of all EGS endpoints identified in broader classification schemes (MEA, 2005; de Groot et al., 2010; TEEB, 2010; Costanza et al., 2017; Haines-Young and Potschin, 2018).

We conducted a meta-analysis of existing literature to provide a synopsis of common use:habitat linkages in coastal environments. Given the intensive data requirements and expertise needed for spatially-explicit EGS mapping studies, this overview of linkages can help coastal communities with limited resources begin to plan for FEGS resilience. Proactive land-use planning in coastal communities requires that we account for the array of potential human users in a given area, understand how they derive benefits from their environment (e.g., which FEGS they use), and evaluate how changes in coastal landscapes might affect the availability and/or delivery of priority FEGS, that will likely change in the context of community needs and values (de Groot et al., 2010). While this analysis should not be interpreted as an exhaustive tally of all possible use:habitat linkages, it does provide a snapshot of the current state of knowledge and highlights areas of more/less emphasis within the literature. We hope coastal communities can couple this information with localized knowledge (e.g., concerning landscape features and primary user groups) to more readily incorporate FEGS considerations into habitat management decisions and long-term resiliency planning. Whether results complement existing mapping resources (e.g., EnviroAtlas; Pickard et al., 2015), or form the basis for a new resource providing a preliminary assessment of how users could be affected by land use decisions, coastal communities will benefit from a basic understanding of use:habitat dependencies.

Over the last decade, several models and tools have been developed to help communities evaluate ecosystem service tradeoffs in the context of land-management decisions (Tallis and Polasky, 2009; Arkema et al., 2013; Bagstad et al., 2013; Martín-López et al., 2014; Villa et al., 2014; Cabral et al., 2015; Berg et al., 2016; Zank et al., 2016; Owuor et al., 2017). Mapping flows of EGS from ecosystems, and related habitats, to groups of human users can help build consensus within communities in the context of local priorities (Crossman et al., 2013; Carmen et al., 2018), and there are numerous methodologies. Value estimates can vary widely depending on scale, model assumptions, indicators selected, and the resolution and type of data available for a particular site (Hauck et al., 2013; Schägner et al., 2013; Sharps et al., 2017). In addition, many coastal communities lack the time, resources, and expertise to undertake detailed ecosystem service valuation studies, and the timeframe required to complete such studies often exceeds that in which decisions must be made. Interim approaches that aid coastal communities in quickly assessing FEGS, relationships to mappable habitat features, and potential vulnerabilities can lead to more informed land-use planning decisions.

It is important for coastal communities to consider how local users could be affected by land-use changes and/or habitat modifications. By first synthesizing evidence from literature, then summarizing linkages in a cohesive manner, we present a means for coastal community stakeholders to quickly assess or map potential FEGS vulnerabilities related to habitat (i.e., final services that could be diminished by habitat alterations or losses) and incorporate these considerations into land-use planning discussions. We investigated the evidence for users benefiting from different coastal habitats and explored how the strength of evidence varied over space and time. An online search was undertaken first to identify potential publications addressing coastal EGS. Next, we reviewed each resulting publication more thoroughly to determine which FEGS users and habitats were being addressed. Lines of evidence (i.e., user group deriving benefits from one or more habitats) were then scored using three criteria evaluating the strength of evidence. We then developed statistical models testing for significant differences in the amount of evidence among user groups and habitats. Lastly, we appraised the amount of evidence across biogeographic realms and over time to assess the potential effects of study location and the time period over which studies were completed. Given the range of users dependent on coastal habitats, this meta-analysis may serve as a first-step in understanding how to build FEGS resiliency by protecting and restoring habitats in coastal communities.

2. Materials and methods

2.1. Background

We implemented a “weight of evidence” (WOE) framework, historically used in risk assessment (Burton Jr et al., 2002; Weed, 2005; Linkov et al., 2009, 2011, 2015), to assess the amount of evidence linking FEGS users to coastal habitats. This approach begins with a primary question or hypothesis of interest (e.g., to what extent do coastal users depend on specific coastal habitats, in our case); synthesizes information from multiple lines of evidence based on the relevance, quality, and extent of the information; and culminates with a final appraisal of evidence supporting a meaningful conclusion related to the original question (Gough, 2007; Linkov et al., 2009). Utilizing a WOE approach allowed us to appraise the evidence for use:habitat linkages in a transparent, systematic review of coastal ecosystem services literature. Similar to studies that have developed matrices using expert opinion and/or estimated the strength of relationships between land cover classes and EGS delivery at more localized and regional scales (e.g., Burkhard et al., 2012; Carollo et al., 2013; Cabral et al., 2015; Jacobs et al., 2015; Maltby et al., 2017; Owuor et al., 2017), results can be used to populate a matrix with X and Y axes corresponding to user groups and habitats, respectively, and entries representing the collective WOE for each use:habitat linkage. In this study, we limited our analysis to nearshore coastal habitats and assessed linkages across a broad suite of potential human users to provide a more holistic summary of habitat dependencies over a spectrum of potential uses.

2.2. Source selection

A literature search of abstracts, titles, and keywords published from ~1989 through 3 March 2017 was conducted using the ScienceDirect online search engine (see Table 1) to identify potential peer-reviewed sources addressing use:habitat linkages. Each search included the terms “ecosystem good*” or “ecosystem service*” to ensure the potential link to ecosystem services was considered at some level. We also included common terms for broadly describing the coastal landscape (i.e., coast and nearshore) and the word “habitat” as an extra assurance that we captured EGS studies addressing the relationship between habitat and EGS availability. Studies that may have indeed addressed potential ecosystem service delivery and/or connections to habitat inadvertently (e.g., studies of commercial fish habitat requirements) were omitted

Table 1
Terms used to select relevant literature in Science Direct, a search engine with more than 14 million publications from over 3800 and 35000 journals and books, respectively.

Search terms used in selecting literature sources
• “ecosystem service[a]” AND “coast[a]”
• “ecosystem good[a]” AND “coast[a]”
• “ecosystem service[a]” AND “nearshore[a]”
• “ecosystem good[a]” AND “nearshore[a]”
• “ecosystem service[a]” AND “habitat[a]”
• “ecosystem good[a]” AND “habitat[a]”

[a] Denotes that terms were searched to include the plural versions of nouns.