Global patterns of the varying degree of functional redundancy in mangrove ecosystem services: A geospatial analysis.

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Being such a widespread diverse and social-ecological system, the mangrove forest supports and contribute to a multitude of ecosystem processes and functions which in turn produce a substantial line-up of ecosystem goods and services (Dahdouh-Guebas *et al.*, 2020). For these, the definitions we use are those introduced by (Costanza *et al.*, 2017) and (Dahdouh-Guebas *et al.*, 2020) i.e.: "Ecosystem processes and functions contribute to ecosystem services, but they are not synonymous. Ecosystem processes and functions describe biophysical relationships that exist regardless of whether or not humans' benefit. By contrast, ecosystem goods and services are those processes and functions that benefit people, consciously or un-consciously, directly or indirectly". Mangroves provide services to us by being sources of food nutrition, places for near and offshore commercial fisheries, harvesting forestry products for fuel and construction and eco- tourism (Curnick *et al.*, 2019; zu Ermgassen *et al.*, 2020). Coastal protection through wave attenuation is one of their key functions. Mangroves serve as the first line of defence during coastal flooding. They can reduce the wave energy by almost 66% with only the first 100m of their forest width (Menéndez *et al.*,2020). By being large carbon sequestration sinks, mangrove ecosystems are among the most productive ecosystems. For example, in the tropics, these carbon sinks account for 49-98% of carbon storage (Donato *et al.*, 2011). Despite all these benefits, they have been severely influenced by degradation, deforestation and anthropogenic pressures, to such an extent that 20-30% of global mangrove cover has been lost in just half a century (Duke *et al.*, 2007 Goldberg *et al.*, 2020). Anthropogenic factors like overexploitation, land-use change, and pollution are among the leading causes of their depletion and destruction, endangering species in different parts of the world (Polidoro *et al.*, 2010; Saenger *et al.*, 2019). In eastern Africa, the out of control extraction of wood for construction work led to a huge loss in mangrove area, threatening the Rhizopora, Bruguiera and Ceriops species (Saenger *et al.*, 2019). This reduction in species number could also alter the strength of ecosystem functions and services (Worthington *et al.*, 2020). The loss of functions is seen to be a bigger threat to ecosystem processes and services than that of species, however not much is known about what this depletion in mangrove biodiversity does to their ecological and socio-ecological functioning (Mouillot *et al.*, 2014). Chong (2019) investigated biological trait compositions of different mangrove forests from all over the world to establish an understanding between mangrove resilience and their ecological functioning. Tree diameter, root type, absolute maximum height and seed mass were among the eighteen traits explored. Here, the trait compositions were found to be more similar than species compositions, hence indicating that globally most mangrove forests are functionally similar and species redundancy is prominent (Chong, 2019). A study done by Aubry (2021, Un monde sans mangrove: déclin global des services écosystémiques dans une ère de pression anthropique croissante, Université Libre de Bruxelles - ULB, Brussels, Belgium) examines similar relationships between the species redundancy and socio-ecological functioning of the forest. In our ongoing study, we will further examine this relationship, globally map the findings of Chong (2019) and Aubry (2021) and perform geospatial analyses using geographic information systems. Significant differences in the species and trait compositions for regions with available datasets, in the Indo-West Pacific (116 datasets) and Atlantic East Pacific (85) distribution, will be subsampled more since some regions have been found to show more trait diversity than species diversity (Chong, 2019). The input data that we will use exist under the form of tabulated data with ecosystem processes and functions and with ecosystem goods and services which will be merged. As the redundancy of keystone species seems to play an integral role in mangrove resilience against disturbances, it is important to map out global patterns on these varying degrees of redundancy in processes and functions on one hand and goods and services on the other. Further serving as an early warning map highlighting where they are at risk. In turn, the study can serve

as a basis to establish a Red List of Mangrove Ecosystems using a social-ecological systems approach (Rodríguez *et al.*, 2012).

Keywords: Mangrove ecosystem; Processes and functions; Good and services; Global mangrove cover; Species redundancy; Spatial analysis; Trait diversity; IUCN Red List of Ecosystems