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A META-ANALYSIS OF THE CARBON ECOSYSTEM SERVICE IN HUMAN-MANAGED COASTAL ENVIRONMENTS

Thesis in: Integrated Coastal Zone Management

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Abstract

Coastal wetlands sequester and bury substantial amounts of atmospheric carbon dioxide (CO_2) via photosynthesis. These blue carbon (BC) ecosystems play an essential role in climate change mitigation. Despite the key role that BC ecosystems play, they are increasingly threatened by land use changes (LUC). This may impact their carbon storage and sequestration ecosystem services. We used meta-analysis in ecology to study carbon storage and sequestration within natural and transformed salt marshes and mangroves, across a global scale. Articles published since 2000 on the Web of Science Core Collection, that contained experimental data on carbon storage and sequestration for natural and modified ecosystems, were selected. Case studies were integrated into a database, and standardised. Research on mangroves concentrated on Asia and Oceania, whilst salt marshes concentrated on North America, eastern Asia and Oceania. We found that LUC in BC coastal ecosystems decreased carbon storage and carbon sequestration rates at a global scale. Carbon storage in mangrove sediments significantly decreased from 520.49 ± 388.99 Mg C ha^{-1} (mean ± SD) in natural systems to 186.81 ± 234.02 Mg C ha^{-1} in modified settings. Carbon storage in salt marsh sediments also decreased from 97.80 ± 107.69 Mg C ha^{-1} in natural ecosystems, to 31.42 ± 33.47 Mg C ha^{-1} in human-managed environments. Biomass carbon storage (aboveground and belowground biomass) averaged 103.07 ± 198.86 Mg C ha^{-1} in natural mangroves, whereas carbon storage in modified mangroves yielded an average of 29.01 ± 47.40 Mg C ha^{-1}. Within natural salt marshes, biomass carbon stocks had an average value of 3.66 ± 5.24 Mg C ha^{-1}. Carbon sequestration rates, significantly decreased in modified in mangroves, but not in salt marshes, due to inter-site variability. We found that sampling depth may affect the measurement of organic carbon stocks. Conversion of natural coastal ecosystems may decrease their carbon storage capacity.

Key words

Land use change, salt marshes, mangroves, carbon storage, carbon sequestration

1. Introduction

1.1. Climate change mitigation

Climate change is one of the main scientific issues of our decade (Christianson et al., 2022). This phenomenon is the result of an increase in atmospheric greenhouse gasses (GHG) (He & Silliman, 2019; Tang et al., 2018). Two activities are known for their contribution to climate change: (1) large amounts of GHG released by industrial activity and (2) land use changes (LUC) (He & Silliman, 2019; Mcleod et al., 2011). Deforestation alone accounts for approximately 20% of global emissions (Nellemann et al., 2009). Consequences of climate change include weather extremes, shrinking sea ice and losses to marine ecosystems (Christianson et al., 2022).

There is a myriad of literature documenting climate change, its impacts, and the need for action towards its mitigation (Griscom *et al.*, 2017; Hodgson *et al.,* 2009; IPCC, 2019; Letcher, 2009). In this context, preserving ecosystem services of climatic regulation or carbon sequestration seems to be a viable long term option for climate change mitigation (Elum et al., 2017).

To keep warming below 1.5 °C, there is an urgent need to reduce anthropic GHG emissions (Christianson et al., 2022). Some mitigation strategies include accelerating energy efficiencies and investing in cleaner, more renewable energy. Nature based solutions, which includes protecting, restoring, and sustainably managing earth's natural ecosystems, are important for addressing the causes and consequences of climate change. Moreover, nature based solutions could allow for approximately 30% of cost effective climate change mitigation (Seddon et al., 2019).

Ecosystems are able to capture and efficiently store large amounts of carbon, thereby slowing global warming. They also act as a powerful defence against long term climate change hazards and impacts (Seddon et al., 2019). Nowadays, the role of blue carbon stored within earth's seas and oceans is being recognised for its climate mitigation properties as well (Nellemann et al., 2009).

1.2. Concepts of carbon sequestration and storage

Carbon capture and its long term storage away from the atmosphere is called carbon sequestration. This process involves removal of atmospheric CO_2 by photosynthesis and the storage of carbon in the biomass, and long term in the sediment (Ahmed et al., 2017; Martins et al., 2022). Carbon sequestration in coastal ecosystems is broadly categorised by high conversion rates of CO_2 into plant biomass, high trapping rates of particulate organic carbon from allochthonous and autochthonous sources and, by favourable conditions within sediments which prevent decomposition of organic matter, allowing for its long term storage (Banerjee et al., 2017).

Carbon sequestration depends on the balance of carbon inputs and outputs, with inputs comprising mainly senesced plant material from the ecosystem itself (autochthonous sources) or dissolved carbon flowing into the system from elsewhere (allochthonous sources) (Villa & Bernal, 2018). Carbon outputs relate to the flowing out of organic carbon, or during the process of decomposition when inorganic carbon i.e., CO_2 and methane is produced (Lolu et al., 2020; Villa & Bernal, 2018).

Carbon storage is the long-term confinement of carbon in plant materials or sediment, and occurs when the rate of carbon burial becomes slow, enabling organic carbon to build up. A part of biomass is incorporated into the sediment as detritus, where it is decomposed slowly under anaerobic conditions (Gulliver et al., 2020). The organic matter that is not remineralized remains stocked as organic carbon in the sediment (autochthonous carbon).

These ecosystems also trap organic matter exported from adjacent ecosystems (allochthonous carbon) both in tidal flows and in terrestrial runoff, which they continually accrete within their sediments over time. For example, carbon inputs from upstream due to agricultural or aquacultural practices increase carbon inputs to soils (Lolu et al., 2020). Carbon storage or stocks can be expressed as the CO_2 equivalent removed from the atmosphere (Luisetti et al., 2014).

1.3. The role of coastal wetlands in carbon storage and sequestration

The oceans and its ecosystems are fundamental in maintaining earth's climate. Oceans store and cycle around 93% of the CO_2 on our planet (Nellemann et al., 2009; Mcleod et al., 2011). At the interface of land and sea lie coastal wetlands, ecosystems which include seagrasses, coral reefs, estuaries, beaches, salt marshes and mangrove forests (Li et al., 2018b). Vegetated coastal ecosystems serve as hotspots for ecosystem function and act as carbon sinks, the latter being a pool which accumulates and stores carbon-containing chemical compounds (Ahmed et al., 2017).

Since wetlands are submerged in stagnant water for at least part of the year, vegetation here have specialised hydric roots. This provides an optimal milieu for carbon storage and sequestration (Lolu et al., 2020). The effectivity of the carbon sink function of wetlands depends on its location, and hydrogeomorphological functioning. Carbon is sequestered in the soil, but their actual capacity is determined by the net balance in carbon fluxes (Villa & Bernal, 2018).

Mangroves, seagrasses and salt marshes play an extremely important role in carbon storage in ocean sediment (50-71%) although they constitute half a percent of seabed space (Nellemann et al., 2009). These coastal wetlands sequester and bury substantial amounts of atmospheric CO_2, which appear to play a role in mitigating the effects of climate change (Mcleod et al., 2011). Carbon stocks within coastal wetlands can exceed those of their terrestrial counterparts by several times, with their sequestration capacity being roughly ten times that of land ecosystems (Pendleton et al., 2012; Tang et al., 2018).

The carbon stored within the biomass and sediments of mangroves, salt marshes and seagrasses, is called blue carbon (BC) (Mcleod et al., 2011). BC ecosystems, e.g., mangroves, salt marshes, seagrasses, turf algae and microbial mats, are efficient at trapping CO_2 in its sediments through the biological action of primary producers (Donato et al., 2011). Sediments in these ecosystems have low oxygen levels, along with high salinity, which slows the process of carbon remineralisation (O'Connor et al., 2020).

Globally, BC ecosystems have an area of about half a million square kilometres, most of which is seagrasses (319 000km^2), followed by mangroves (139 170km^2) and finally, salt marshes (51 000km^2). Together, they store 11.5 billion tons of BC. Despite its smaller areal extent, mangroves contain the greatest pool of BC (6.5 billion tons). Seagrasses and salt marshes each contain 3 and 2 billion tons, respectively (Ahmed et al., 2017). Over the short term, BC is sequestered in plant biomass and over longer time periods, in sediments (Mcleod et al., 2011).

1.3.1. Carbon sequestration in mangrove forests

Mangroves comprise a group of vascular plants which are salt tolerant (Ong & Gong, 2013). Their geographic extent covers 118 countries, although 15 countries host 75%

of total cover (Macreadie et al., 2019). Mangroves form at the upper intertidal zone of both tropical and subtropical regions and comprise about 70 species (Ong & Gong, 2013; Srikanth et al., 2016). These ecosystems are rendered as some of the most productive coastal habitats and provide numerous services such as stabilising shores, supporting fisheries or acting as habitat formers, providing storm protection, building materials. They also have medicinal properties and are important sinks for atmospheric CO_2 (Herbeck et al., 2020).

With their physiological, biochemical and anatomical adaptations, mangrove trees thrive in environments characteristic of humid weather, fluctuating salt concentrations, low oxygen levels and frequent inundation of seawater. As a result of these abiotic conditions and adaptations, mangrove roots can store and bury large amounts of carbon, acting as sinks in the long term (Srikanth et al., 2016).

Within natural mangrove forests, several elements are known to facilitate carbon storage potential. Amongst these are tree density and coverage, forest development history, species diversity, and richness (Rasquinha & Mishra, 2021). Abiotic factors also play a role, having their influence on how propagules grow, and thereafter disperse. Sunlight, salinity and temperature likewise control carbon ecosystem services (Rasquinha & Mishra, 2021).

Carbon stored in the biomass and soils of mangroves form pools, with biomass containing living matter, and soils, dead organic matter. Carbohydrates are formed from the uptake of atmospheric CO_2 during photosynthesis. The retention of CO_2 in the form of carbohydrates prevents its respiration back into the air (Jonsson & Hedman, 2019), although roughly half of all assimilated CO_2 is respired through mangrove biomass (Alongi, 2012).

Although mangroves may contain high storage, the relationship between carbon accumulation rates and stocks are not clearly understood. For example, an Indonesian mangrove ecosystem was found to have low carbon accumulation, whilst maintaining high stocks. The opposite also held true, especially in coastal areas where high inputs of allochthonous carbon was evident (Jennerjahn, 2020).

1.3.2. Carbon sequestration in salt marshes

Salt marshes occur in 99 countries (Almahasheer, 2021), mostly in temperate regions (Chmura, 2013). These intertidal grasslands, halophytes, or low shrubs (Almahasheer,

2021) emerge in low energy shorelines, producing distinct plant zonation's with high primary productivity rates (Barbier et al., 2011). Their adaptations to low oxygenated waters, along with fluctuating salt and heat levels make them thrive in the environment (Almahasheer, 2021).

The ecosystem services of salt marshes are varied and multifaceted. For example, humans harvest them for food, whilst they can also be used as feed for grazing livestock (Barbier et al., 2011). Moreover, their morphological traits make them efficient at trapping sediment, thus preventing erosion and reducing storm surges (Barbier et al., 2011). Salt marshes act as a habitat for wildlife and are stores for carbon (Keshta et al., 2020). They also purify water and are important for commercial fisheries (Almahasheer, 2021).

Salt marsh high productivity rates make them amongst the best carbon sequestering environments on earth (Barbier et al., 2011; Wang et al., 2016). With the tides, salt marshes promote the "out welling" of organic carbon, although the mechanisms behind this are not fully known (Wang et al., 2016). Factors which can decrease marsh productivity include reduced accretion and increased flood duration (Day et al., 2016). Salt marshes also carry nutrients to the aquatic food web (Almahasheer, 2021).

Within salt marshes, carbon storage by settling of organic matter is linked to root growth, deposition of litter, and trapping of sediment by vegetation. High salinities act to reduce sulphate, preventing methanogenesis in these ecosystems, although during periods of low tide, organic matter undergoes aerobic decomposition. High primary productivity rates foster salt marshes as efficient carbon sequestering ecosystems (Banerjee et al., 2017).

Through photosynthesis, atmospheric CO_2 is fixed and stored within the above and belowground biomass of salt marshes. As a result of the low oxygen levels in their habitats, organic matter is able to accumulate overtime (Wollenberg et al., 2018). Carbon is stored over the short term in salt marsh biomass, and over the long term, within sediments (Banerjee et al., 2017).

1.4. Mangrove and salt marsh conversion risks

Despite the valuable carbon ecosystem services that we obtain from coastal wetlands, such as coastal protection, food security, and habitat provisioning (Fourqurean et al., 2015), these ecosystems are increasingly threatened by LUC (Himes-Cornell et al., 2018). Some LUC include coastal development, aquaculture, pollution, eutrophication, harvesting and alterations to hydrological regimes (Himes-Cornell et al., 2018).

When coastal land is reclaimed, it can lead to adverse effects on coastal environments resulting in losses to marine habitats and water quality deterioration (Meng et al., 2017). Estimations of blue carbon habitat losses are in the region of 8 000km^2 per a year. In the next 100 years, all mangroves could be lost while tidal salt marsh losses could reach 30-40%. Economic impacts of these losses could range from US$6 - 42 billion annually (Ahmed et al., 2017).

Over 35% of mangrove forests have been lost mostly to clear cutting and converted to aquaculture uses since the 1980s (van Bijsterveldt et al., 2020). Other factors affecting mangroves are degradation, conversion, and coastline disturbance (Himes-Cornell et al., 2018). Carbon stocks found in mangrove biomass or sediments may be affected and part of the accumulated CO_2 may be released into the atmosphere (Rani et al., 2021).

Transformation of mangroves for aquaculture is a driving factor of conversion (Susetyo et al., 2020). When mangroves are converted into shrimp ponds, the carbon sink function of natural ecosystems can be reversed. However, there are large uncertainties around the magnitude of carbon losses, and implications for natural CO_2 carbon sinks (Elwin et al., 2019).

When salt marshes are lost or degraded, their function as carbon sinks is compromised. The alteration of abiotic factors such as changes to hydrology, and salinity due to marsh infilling, river channelization and dredging all have consequences on salt marsh functioning. Moreover, the threat of coastal squeeze because of development and increasing sea levels could lead to submersion of saltmarshes (Abbott et al., 2019).

Reclamation, pollution, and alien invasive species also affect salt marshes (Himes-Cornell et al., 2018). When these ecosystems are transformed or degraded, valuable ecosystem services are lost (Barbier et al., 2011). Degradation and conversion of salt marshes impede the capacity of these ecosystems to act as CO_2 sinks (Abbott et al., 2019). Therefore, characterising ecosystem change on a worldwide scale is imperative in determining how human activities impact natural ecosystems (Krumhansl et al., 2016).

1.5. The meta-analytic tool in ecology

In gauging the effects of human intervention on natural ecosystems, a way of inference can be through a meta-analysis. Gurevitch et al. (2001) defines a meta-analysis as "the statistical synthesis of the results of separate studies". This type of study can bridge the gap between many experiments investigating the same or similar research question, and thereby allow for generalisations to be made. A meta-analysis is statistically defensible and integrates the results of many studies in a quantitative way (Gurevitch et al., 2001).

Although meta-analytic techniques can assist in deductive reasoning, it does have several drawbacks. For example, important data could be missing from primary studies, or the failure to report on results which are not statistically significant could lead to partiality (Gurevitch et al., 2001). Despite these problems, a systematic review can overcome them and thus lead to key deductions which can be used in coastal management (Claudet & Fraschetti, 2010).

1.6. Sediment carbon in natural and transformed ecosystems

A carbon stock is considered as the amount of organic carbon (C_{org}) stored in a blue carbon ecosystem over a specified soil depth (Howard et al., 2014). As carbon content generally changes with depth (Donato et al., 2011; Kauffman et al., 2011), estimated values of sediment carbon stocks would be dependent of the depth at which sediments are sampled. In practice, the aims and conditions of the individual research studies varied, leading to a large diversity of sampling depths protocols (Meng et al., 2019). Therefore, the effect of sediment sampling depth must be considered when comparing carbon stock estimates from different research. Given that primary studies can measure carbon stored in sediments at different depths, this could affect carbon storage estimates.

Scope of the current research

Coastal BC ecosystems could play a vital role in climate change mitigation. However, LUC is constantly threatening these ecosystems globally. Impacts of LUC on carbon storage and sequestration in salt marshes and mangroves are still poorly understood, and a systematic approach at a global level, such as that provided through a meta-analysis, is lacking.

This research was aimed at qualitatively and quantitatively reviewing carbon storage (the confinement of carbon in plant materials or sediment, measured as a total weight of carbon stored, and expressed as Mg C ha^{-1}) and sequestration (the process atmospheric CO_2 capture through photosynthesis, and its long term storage into sediments, measured as a rate of carbon uptake per year, and expressed as Mg C ha^{-1} yr^{-1}) within transformed and natural salt marshes and mangroves, across a global scale.

We define altered ecosystems as vegetated habitats (mangroves and salt marshes) which were transformed into aquaculture, agriculture, urban development, and other uses. Using a systematic meta-analytic approach, scientific articles reporting on carbon storage and sequestration of these coastal habitats have been searched on the Web of Science Core Collection database.

Given a global context, conclusions from the meta-analysis will act to further guide management and aid decision-making for coastal environments. It is hypothesised that transformation of natural salt marshes and mangroves will modify the carbon ecosystem processes related to sequestration and storage, leading to a decreased ability of these habitats to sequester and store carbon.

2. Methods

2.1. Literature search

The Web of Science (WoS) Core Collection was chosen as the primary search system as it is compatible in providing evidence synthesis for systematic reviews (Gusenbauer & Haddaway, 2020). Where possible, relevant references from review and research articles were retrieved and collated in the same way as original texts.

Using the WoS database, a search was conducted on publications that described natural and modified tidal salt marshes and mangroves. Articles were filtered to contain results for the years 2000-2022. Using various key words, phrases relating to carbon sequestration and storage were searched within the topic field (table 2.1). Figure 2.1 shows the meta-analytic process used for selection and grouping of data, along with number of articles in each tier.

Threats to mangroves and salt marshes can be divided into two main categories. These are direct or indirect drivers of transformation and can be destructive or non-destructive in nature. Mangroves are at risk due to aquaculture (mainly shrimp farming), and agriculture (rice or other crops) and coastal developmental changes (Burford & Longmore, 2001; Sharma et al., 2020; van Bijsterveldt et al., 2020; Padhy et al., 2021). Salt marsh pressures include coastal squeeze, reclamation, agriculture, aquaculture, and salt works (Luisetti et al., 2014; Yang et al., 2016; Tan et al., 2021; Li et al., 2018a; Castillo et al., 2017).

For clarification purposes, biomass is either the carbon found in below- or above-ground pools, with BGB called belowground biomass and AGB, aboveground biomass. Care was taken to ensure these measures were a converted value of carbon, and not just the biomass value itself. Moreover, interface refers to the environmental compartment in which carbon measurements were taken, either biomass or sediment (representing a measure of sequestration or storage).

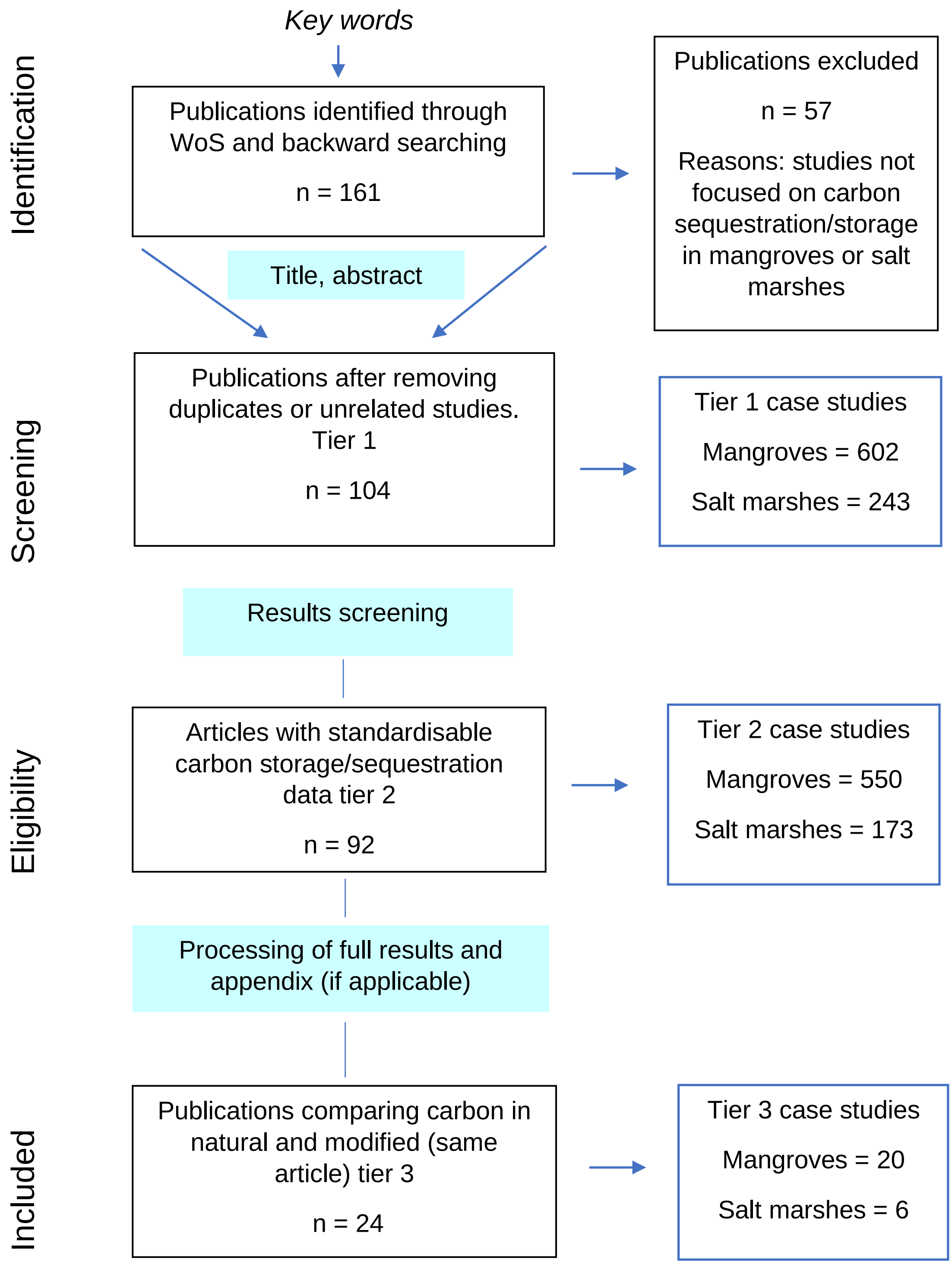

Figure 2.1. The process of meta-analysis used in the current study.

2.2. Article selection for the meta-analysis

To carry out the meta-analysis, we followed a structured procedure in three phases. In phase one of the literature review (tier one), all case studies pertaining to both ecosystems were pooled. In tier two, case studies specifically giving carbon sequestration and storage measurements in each ecosystem were standardised and analysed. Tier three included publications reporting on specific cases of transformation from natural to modified sites, along with the overall effects on carbon ecosystem services. Some articles were excluded from each tier, and the reasons are reported in table 2.

2.2.1. Identification and screening

The following key words were searched within the topic field of the WoS database to identify relevant articles: "blue carbon agriculture carbon sequestration storage". Again, using the same words, but replacing "agriculture" with "aquaculture" (table 2.1). Key words with a focus on mangroves, "mangrove rice field carbon sequestration storage". Using the same mangrove key words but replacing "rice field" with "shrimp farm" and then with "aquaculture".

Table 2.1. Key words used in the present meta-analyses.

Environment	Modification	Focus
Blue carbon	Agriculture	Carbon sequestration, storage
	Aquaculture	
Mangrove	Rice field	Carbon sequestration, storage
	Shrimp farm	
	Aquaculture	
Salt marsh	Aquaculture	Carbon sequestration, storage
	Salt pond	
	Salt works	
	Urban development	Carbon sequestration
	Sea walls	
	Reclamation	
	Saline blue carbon	Unspecified

For the ecosystem “salt marshes”, LUC relating to aquaculture and salt production were included in various forms (“salt pond, salt works”), with “carbon sequestration storage” concluding them. Key words relating to the effects of coastal squeeze on carbon sequestration were also included. These were “urban development salt marsh carbon sequestration”, “sea walls salt marsh carbon sequestration” and finally, “reclamation salt marsh carbon sequestration”. To end the synthesis, “salt marsh saline blue carbon”, was applied for an open-ended search (table 2.1).

161 studies were identified on WoS after inputting the key words. From these, article titles, abstracts, and results were screened, and included in a primary database, if they matched the search criteria. 59 articles were removed because of duplication or were unrelated to the current research. Remaining articles formed part of tier one and contained values on carbon storage and sequestration within sediments or biomass. Qualitative review articles relating to carbon ecosystem services in mangroves and or salt marshes were also included (for use in the discussion section). For a complete list of reasons for exclusion of case studies from each tier, see table 2.2. Figure 2.1 shows the process of meta-analysis used in the present study.

2.2.2. Article eligibility: tier one

Articles were eligible if they were based on the predetermined search criteria, i.e., they focused on mangroves, and/or salt marshes. Moreover, they were included if they had qualitative or quantitative data on carbon sequestration, or carbon storage. Information on various interfaces (biomass, sediment), were included in this search. Review data was included where possible, although these at times did not include values on carbon storage or sequestration. Relevant articles within reviews containing carbon data were searched and incorporated into the main database where possible. Repeat values were excluded.

2.2.3. Article inclusion for the meta-analysis: tier two

From tier one, all values in the dataset which could be standardised, were filtered, to create tier two. Carbon sequestration and storage values were grouped in one of two categories - natural or modified - for each ecosystem. Data here included quantitative results from different studies with varying levels of disturbance. Storage data were standardized to Mg C ha^{-1}, and sequestration to Mg C ha^{-1} yr^{-1}.

For each article selected, we defined a "case study" as each row of data on AGB, BGB, or sediment carbon storage or sequestration rate reported for a specific site. Therefore, one article may report a variable number of case studies (corresponding to each row of the data set in Table S5). In fact, some regional or national reviews provided a high number of case studies (see Table S5).

Biological invasion and pollution studies were considered since they are also human-driven impacts on natural ecosystems, changing the natural land use, and affecting the services we obtain from them. Carbon storage or sequestration values in restored or rehabilitating ecosystems were not included in tier two.

Table 2.2. Reasons for exclusion of case studies from each tier. Ecosystems: only mangroves and salt marshes. The scope of modified ecosystems in the current study was agriculture, aquaculture, salt works, deforestation, alien invasive species, pollution, and urban development. In tier 1, both quantitative and qualitative articles were included.

Tier 1	**Tier 2**	**Tier 3**
Studies specifically related to seagrass meadows or seaweeds, carbon fluxes or carbon accounting or ecosystem service evaluation.	Values for carbon storage and sequestration could not be standardised to Mg C ha^{-1}, and Mg C ha^{-1} yr^{-1}. E.g., area was not given.	For the biomass or sediment interface, comparable reference sites with carbon values for natural and modified ecosystems were not given.
Studies not related to mangroves or salt marshes.		
Studies not focused on natural or modified ecosystems.	Only quantitative cases were included (qualitative articles were excluded).	
Modified habitat categories were beyond the scope of the current study.	Rehabilitating or replanted ecosystem cases were omitted.	
Studies not focused on carbon storage or sequestration in natural or modified ecosystems.		

2.2.4. *Effects of land modification on carbon ecosystem services: tier three*

To further analyse tier two data, articles which measured carbon storage or sequestration before and after transformation in the same publication were filtered and rated according to the effect of LUC on carbon ecosystem services. Table 2.3 indicates how categories were assigned based on the percentage change of quantitative values in natural and transformed habitats. If more than one value was given for carbon storage or sequestration in the natural or modified land use, it was averaged across those categories.

Percentage change was calculated by the following formula:

$$\frac{(X1 - X2)}{X2} \, x \, 100$$

Where X_1 is the average value of carbon in the transformed environment and X_2, the average value of carbon in the natural ecosystem. Here, the value of carbon was either an averaged storage or sequestration value measured in the biomass or sediment interface of the transformed and natural ecosystem.

Table 2.3. Comparison of the change in carbon storage or sequestration, given as percentage difference in transformed versus natural habitats. Calculations with positive values indicated an increase in carbon ecosystem service (ES) following land use conversion and negative values, a decrease. All values were standardised to Mg C ha^{-1} yr^{-1} for sequestration and Mg C ha^{-1} for storage.

Percentage difference	Overall effect on carbon ES	Comments
>10-25%	Slight increase/decrease	Carbon storage or sequestration undergoes a small increase or decrease when land use changes.
26-75%	Increase/decrease	Carbon storage or sequestration increases or decreases when the habitat is transformed.
>75%	Intense increase/decrease	A strong increase or decrease in carbon storage or sequestration occurs when the habitat is transformed.

2.3. *Effect of sampling depth on carbon storage*

In order to test how carbon storage was affected by sediment sampling depth in both natural and modified ecosystems, those articles reporting specific sediment depth values at which cores were taken were selected from tier 2, along with corresponding carbon storage values. If primary articles contained several core depth intervals, for example 0-15cm, 15-30cm, 30-45cm, the exact measured depth of the last carbon storage value was used (e.g., core depths stipulating carbon storage values without a discreet sampling depth were not included). This was done for natural and modified ecosystems, for both salt marshes and mangroves.

Then, we plotted the carbon storage value against sediment sampling depth, to explore for correlation. Generalised Linear Model techniques (GLM; McCullagh & Nelder, 1989) were used to simultaneously test the effect of significance for sediment sampling depth and ecosystem status (natural vs. modified) in both salt marshes and mangroves. This class of models are widely used when the response variable is assumed to follow a nonlinear function, as it is in our case. The following independent variables (effects) were tested: ecosystem (natural vs modified), and sampling depth (m). According to the nature of our dependent variable, a Poisson Regression model with log link was used. R commander (Fox & Bouchet-Valat, 2021) was used to perform the analysis.

2.4. *Statistical analysis and software*

After testing for normality using the Shapiro–Wilk test, all data did not follow a normal distribution. Therefore, non-parametric Wilcoxon S-R tests were used to test significance between natural and modified environments in both salt marshes and mangroves (independent variables), across each dependent variable (carbon storage, sequestration). Data were analyzed with Microsoft Excel Version 2202 and Stata Statistics and Data Science (Standard Edition) Version 17, with level of significance set at $p < 0.05$ for the statistical analyses. Bar graphs are given as mean ± SD. For comparative reasons, carbon sediment storage depths were taken as a 1m depth. All tier 2 studies are reported in the Appendix (table S5).

3. Results

3.1. Primary data (tier one)

In total, 104 articles were found based on the predetermined search criteria, i.e., articles focused on carbon storage or sequestration in natural or modified mangroves, and or salt marshes (figure 2.1). 54 articles focused uniquely on mangroves, whilst 33 articles were based exclusively on salt marshes. 17 publications contained qualitative and quantitative information on both ecosystems, relating to carbon storage or sequestration.

From these articles, we analysed 848 case studies in tier one. Overall, the percentage of case studies corresponding to natural ecosystems was 84.91%. The rest studied modified systems, corresponding to the following categories of land use changes (in percentage): 2.48 (aquaculture), 2.48 (alien invasive species), 2.24 (reclamation), 2 (agriculture), 1.89 (pollution), 0.83 (salt production), 0.47 (general production), and 0.47% (other destructive change); 2.24% of cases did not mention a specific LUC. The number of case studies per article ranged between 1 and 117 (7.83 ± 13.85).

Mangroves and salt marshes accounted for 602 and 243 case studies respectively. Carbon storage in the biomass of natural mangroves had the most number of case studies (n = 293), followed by carbon storage in sediments (n = 231). Sediment carbon storage in natural tidal marshes also had a high number of cases (n = 164; table 3.1). Within tier 1, articles contained data relating to carbon sequestration and storage, and varying degrees of human disturbance (agriculture, aquaculture, production, alien invasive species, pollution, deforestation), or natural environments.

Table 3.1. Qualitative and quantitative case studies relating to both ecosystems across natural and modified categories, together with LUC or other interference (tier 1). Sediment and biomass interface data constitute sequestration and storage measurements. Other: any other destructive land uses. Uncategorised: these include review case studies, which did not measure carbon in any interface but contained qualitative information on mangrove or salt marshes relating to carbon ecosystem services.

Interface	**LUC**	**Mangrove**	**Tidal salt marshes**	**Grand Total**
Sediment	Natural	231	164	395
Sediment	Modified	37	40	77
Sediment	Agriculture	5	6	11
Sediment	Aquaculture	14	-	14
Sediment	Salt production	1	2	3
Sediment	Alien invasive species	9	2	11
Sediment	Production	2	-	2
Sediment	Pollution	4	10	14
Sediment	Reclamation	-	19	19
Sediment	Other	2	1	3
Biomass	Natural	293	26	319
Biomass	Modified	27	32	59
Biomass	Agriculture	6	-	6
Biomass	Aquaculture	7	-	7
Biomass	Alien invasive species	8	1	9
Biomass	Production	2	-	2
Biomass	Pollution	-	2	2
Biomass	Salt production	4	-	4
Uncategorised total		14	10	27
Grand Total		602	243	848

3.2. *Qualitative review on cases for the meta-analysis (tier two)*

After filtering all values in the tier one dataset which could be standardised, 92 articles were found, 35 for salt marshes, and 57 on mangroves. These values (35 and 57) were higher than the unique article number in each ecosystem from tier one because each ecosystem was analysed separately (remember 14 articles were based on both ecosystems). Altogether, 173 cases concentrated on salt marshes, and 550 for mangroves (table 3.2). Complete case study and article information used in the meta-analysis are given in table S5 of the Appendix.

Majority of research articles concentrated on Asia and Oceania for mangroves, and in north America, eastern Asia and Oceania for saltmarshes (figure 3.1). China and Australia in particular had the highest number of studies based on both ecosystems. South America and Africa also featured in mangrove research, though lacked in salt marsh publications. In general, salt marshes were represented by fewer countries (n = 10) than mangroves (n = 20).

Table 3.2. Number of case studies (n) used in the meta-analysis for each ecosystem, assessed as categories of carbon storage and sequestration (tier two). These didn't include rehabilitating or replanted salt marshes or mangroves. Values were standardised to Mg C ha^{-1} for storage and Mg C ha^{-1} yr^{-1} for sequestration. ES = ecosystem service.

Interface	Type of ecosystem	Carbon ES	Mangrove	Tidal salt marshes	Total
Biomass	Natural	Storage	263	19	282
Biomass	Modified	Storage	20	1	21
Sediment	Natural	Storage	200	50	250
Sediment	Modified	Storage	29	29	58
Sediment	Natural	Sequestration	33	67	78
Sediment	Modified	Sequestration	5	7	12
Total cases			550	173	723

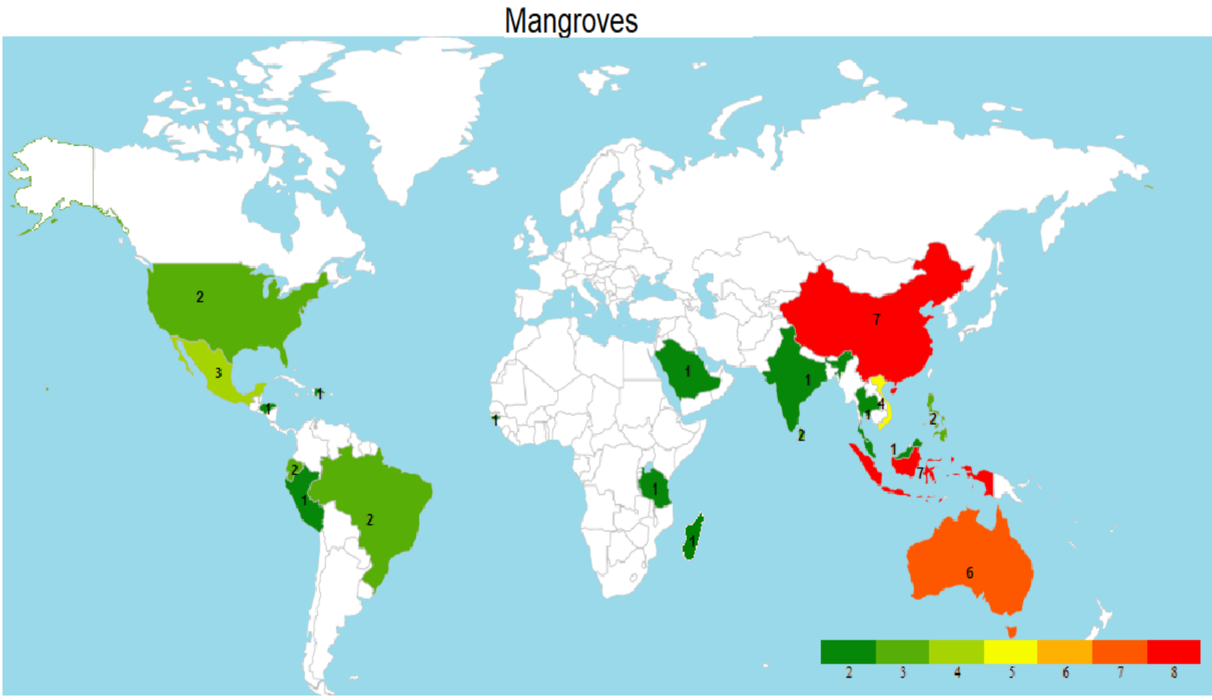

Figure 3.1a. Heat map showing number of articles for each country which contained standardisable data on mangroves and were used in tier two of the meta-analysis.

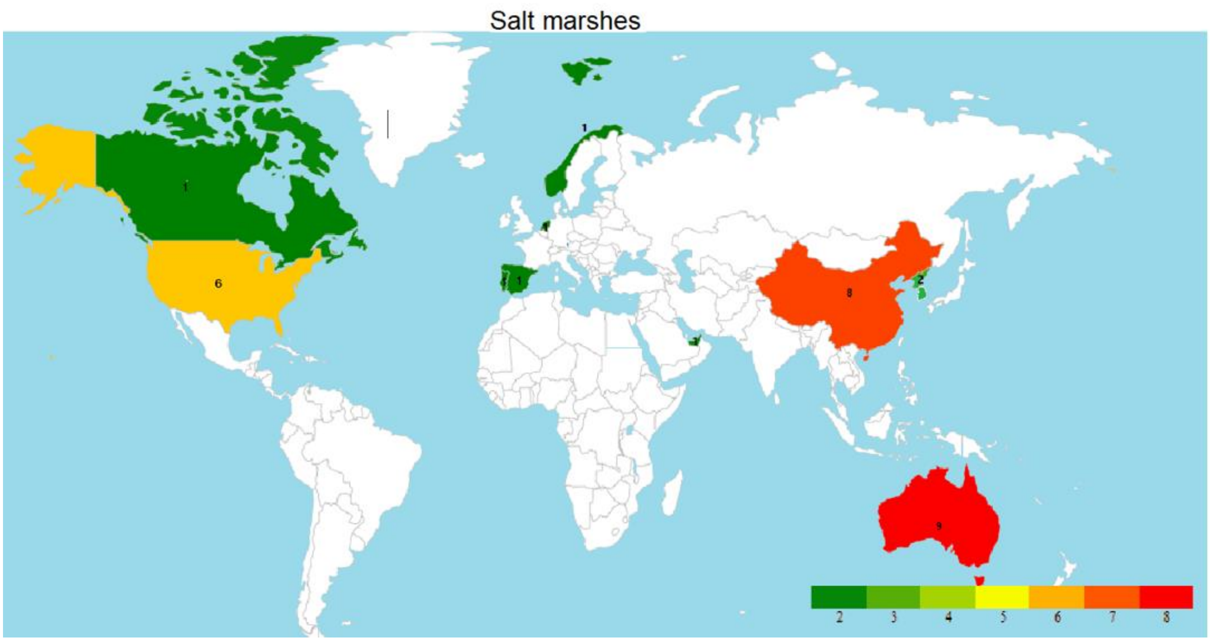

Figure 3.1b. Heat map showing number of articles for each country which contained standardisable data on salt marshes and were used in tier two of the meta-analysis.

3.3. Quantitative analysis of carbon storage and sequestration

3.3.1. Carbon storage in mangrove sediment

Sediment carbon storage in natural mangroves were significantly affected by LUC ($Z = 4.379$; $p < 0.01$). On average, natural mangroves stored more sediment carbon than modified ones, with carbon storage being 520.49 ± 388.99 (n = 200) and 186.81 ± 234.02 Mg C ha^{-1} (n = 29), respectively (figure 3.2a; table S1). Sediment carbon within transformed mangroves contained on average, highest values for salt production followed by aquaculture, clearing, invasive species, agriculture and pollution (figure 3.2b).

3.3.2. Carbon storage in mangrove biomass

Carbon stored in natural mangrove biomass (combined AGB and BGB) averaged 103.07 ± 198.86 Mg C ha^{-1} (n = 263) whereas carbon storage in modified mangroves yielded an average of 29.01 ± 47.40 Mg C ha^{-1} (n = 20; figure 3.2c). Mangrove biomass storage was significantly affected by LUC ($Z = 2.696$; $p = 0.0070$).

Four main land use changes resulted in a lower biomass carbon average in mangroves. These were agriculture, alien invasive species, production, and aquaculture (figure 3.2d). Most transformations into aquaculture resulted in decimating mangrove trees (n = 3), whilst some retained sparse tree coverage (n = 4). Production forests also had a very low biomass carbon storage (table S2).

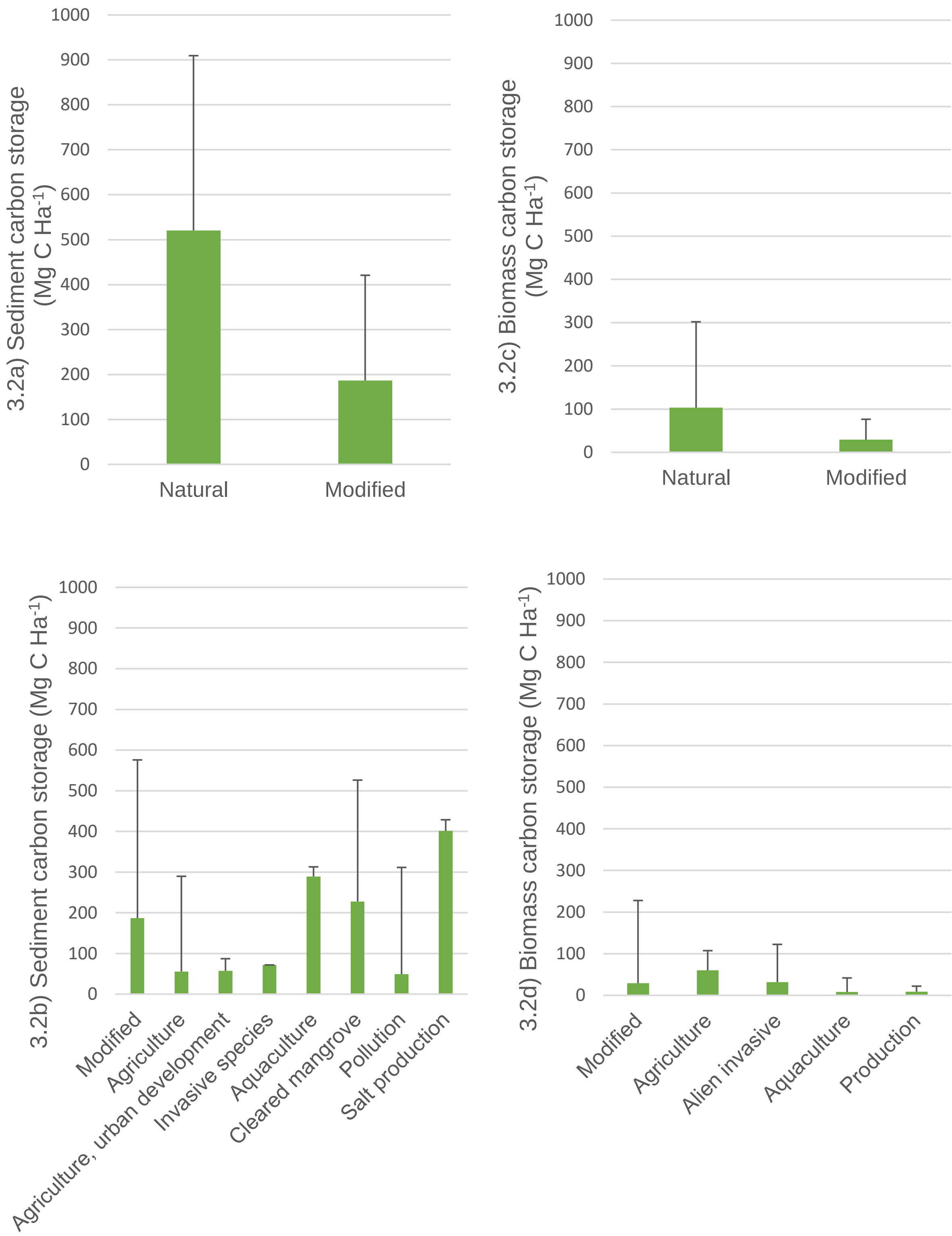

Figure 3.2. Carbon storage in mangrove sediment (3.2a and 3.2b) and biomass (3.2c and 3.2d) across natural and modified ecosystems. The mean carbon storage in modified habitats were averaged from all types of transformed mangroves.

3.3.3. Carbon storage in salt mash sediment and biomass

Carbon storage in salt marsh sediments was significantly affected by LUC ($Z = 3.946$; $p = 0.0001$). Natural salt marsh ecosystems stored nearly three times the amount of sediment carbon (97.8 ± 107.69 Mg C ha^{-1}) as transformed environments (31.42 ± 33.47 Mg C ha^{-1}; figure 3.3a). The combination of various modifications led to an overall decrease in sediment carbon storage within salt marshes. Aquaculture, reclamation, pollution and agriculture were some of the alterations leading to this decrease (figure 3.3b).

Information on biomass carbon storage within modified ecosystems were limited (one value for salt marshes). Therefore, biomass carbon storage data analysis was limited to natural ecosystems for salt marshes, and for this reason, the test for significance could not be carried out. Within natural salt marshes, biomass carbon stocks had an average value of 3.66 ± 5.24 Mg C ha^{-1} (figure 3.3c; table S3). Modification due to invasive species resulted in an increase in biomass carbon (although $n = 1$; figure 3.3d).

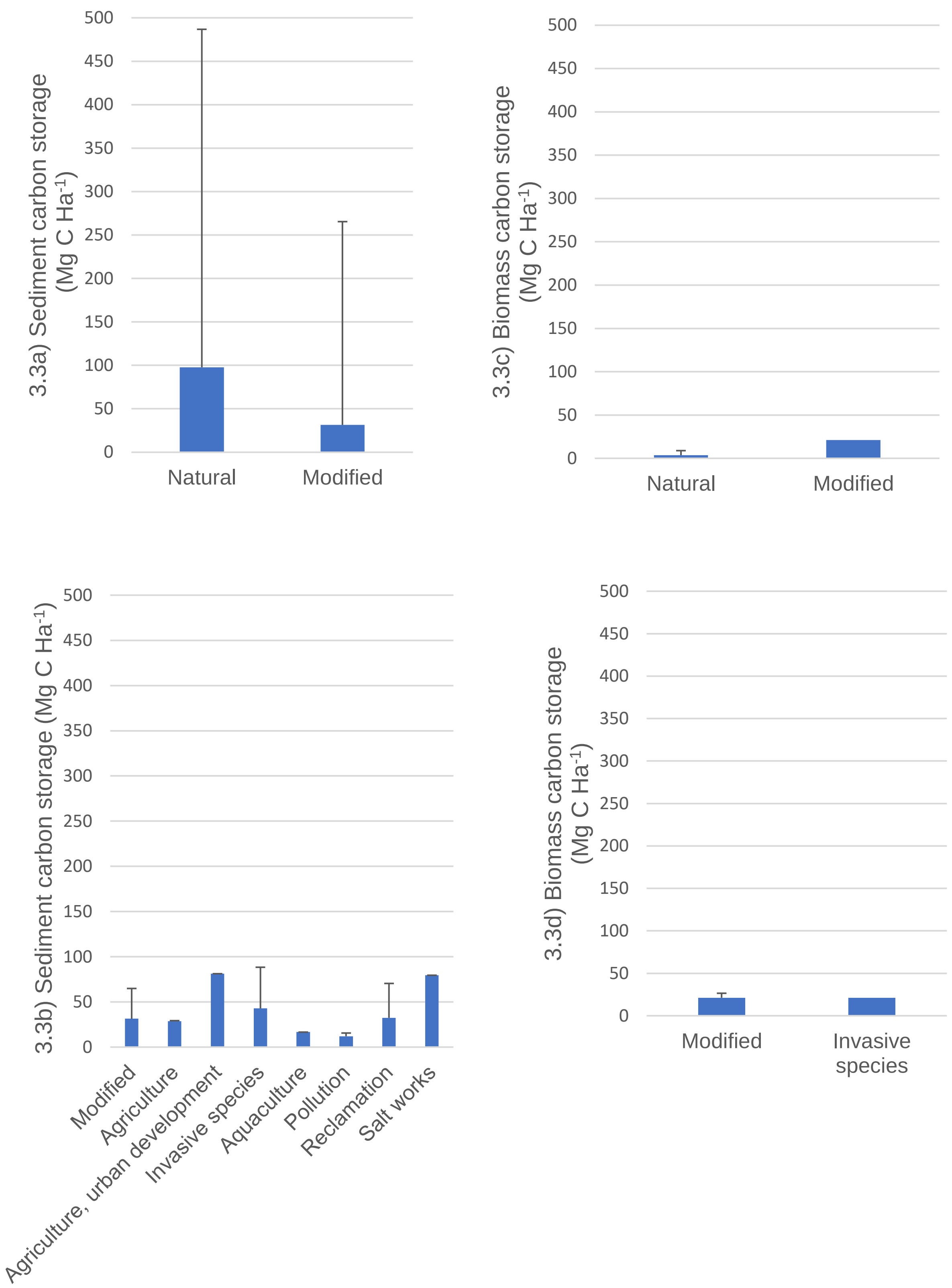

Figure 3.3. Carbon storage in salt marsh sediment (3.3a and 3.3b) and biomass (3.3c and 3.3d) across natural and modified ecosystems. The mean carbon storage in modified habitats were averaged from all types of transformed salt marshes.

3.3.4. *Sediment depth and carbon storage*

The sediment sampling depths for mangroves case studies (n = 159) ranged between 0.1 and 4 m (1.23 ± 0.88). For saltmarshes (n = 76), this ranged from 0.1 to 1.8 m (0.616 ± 0.420). Figure 3.4a shows the relationship between sediment sampling depth and carbon storage in mangroves. The carbon stored showed significant and positive increases in deeper sediment samples, although more sharped in natural mangroves than in modified ones.

Figure 3.4b shows a scatter plot of sediment sampling depth and carbon storage for salt marshes. In natural salt marshes, storage increased as sampling depth increased, whereas in modified salt marshes no increase in carbon stored in deeper sediment samples was observed.

After performing GLM analysis, both depth and type of ecosystem (natural or modified), were found to have significant effects on sediment carbon storage (table 3.3). Carbon storage significantly increased with sampling depth in salt marshes (p = 0.01249) and in mangroves (p<0.01). Moreover, differences on carbon content remain significant (higher content in natural than in modified ecosystems) in salt marshes (p = 0.00329) and mangroves (p<0.01), even when the effect of sampling depth was considered.

Table 3.3a. Results of the generalised linear model showing the effect of sampled sediment depth and natural/modified systems on carbon storage in mangroves.

Coefficients	Estimate	Standard error	z value	P value
Intercept	4.89724	0.01432	341.90	<0.01
Natural/modified	0.42710	0.01479	28.88	<0.01
Sampling depth	0.48610	0.00378	128.60	<0.01

Table 3.3b. Results of the generalised linear model showing the effect of sampled sediment depth and natural/modified systems on carbon storage in salt marshes.

Coefficients	Estimate	Standard error	z value	P value
Intercept	2.67651	0.04636	57.74	<0.01
Natural/modified	1.17120	0.03746	31.26	<0.01
Sampling depth	0.97420	0.03516	27.71	<0.01

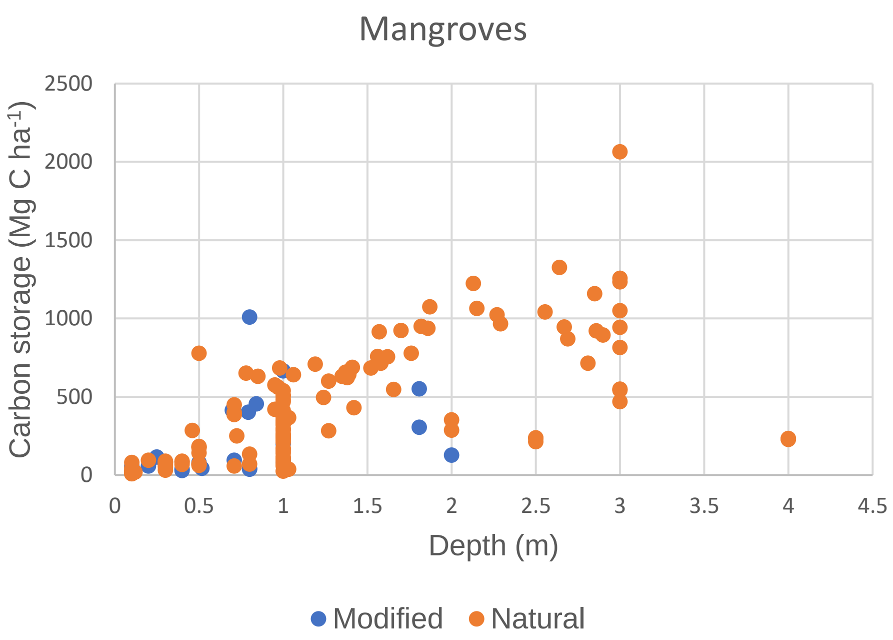

Figure 3.4a. Carbon storage in natural and transformed mangroves, given sediment sampling depth.

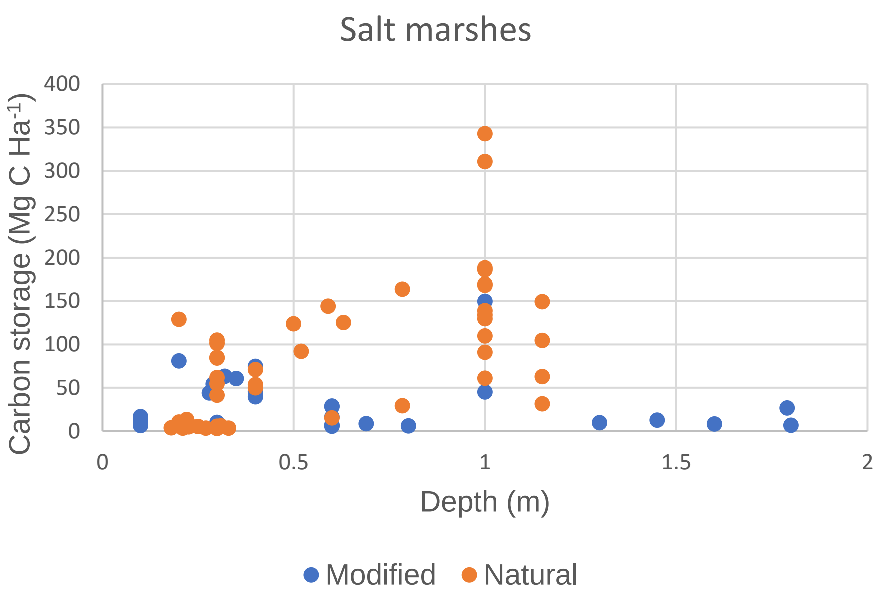

Figure 3.4b. Carbon storage in natural and transformed salt marshes, given sediment sampling depth.

3.3.5. Carbon sequestration rates in mangroves and salt marshes

Overall, transformed ecosystems had lower carbon sequestration rates than natural environments. Carbon sequestration rates were significantly affected by LUC in mangrove forests ($Z = -2.023$; $p = 0.0431$), although this was not the case for salt marshes ($Z = -0.169$; $p = 0.8658$). Mean sequestration rates in natural mangroves were 9.53 ± 30.24, whilst modified mangroves sequestered a lower 5.87 ± 4.61 Mg C ha^{-1} yr^{-1}. Natural salt marshes sequestered 3.16 ± 3.96 Mg C ha^{-1} annually, with sequestration decreasing to 1.31 ± 1.26 Mg C ha^{-1} yr^{-1} in modified settings, although these differences were not significant ($Z = -0.169$; $p = 0.8658$; table 3.4).

The decrease in mangrove carbon sequestration can be attributed to transformation for agricultural purposes, as well as the effects of alien invasive species and pollution. Alien invasive species showed the highest average carbon sequestration compared to pollution and agriculture. For salt marshes, alien invasive species had again the highest average carbon sequestration, followed by agriculture and pollution. Salt production resulted in a sequestration rate of zero.

Table 3.4. Mean carbon sequestration rates in impacted and natural ecosystems. Carbon sequestration values were standardised to Mg C ha^{-1} yr^{-1}. The mean carbon sequestration in modified ecosystems were averaged across all types of transformed systems. ES = ecosystem service. (-) not available.

Ecosystem	Carbon ES	Type of ecosystem	Mean	SD	n
Mangroves	Sequestration	Natural	9.53	30.24	33
Mangroves	Sequestration	Modified	5.87	4.61	5
Mangroves	Sequestration	Agriculture, urban development	1.05	-	1
Mangroves	Sequestration	Alien invasive	8.09	4.67	3
Mangroves	Sequestration	Pollution	4.03	-	1
Salt marsh	Sequestration	Natural	3.16	3.96	67
Salt marsh	Sequestration	Modified	1.31	1.26	7
Salt marsh	Sequestration	Agriculture, urban development	1.37	-	1
Salt marsh	Sequestration	Alien invasive	4.00	-	1
Salt marsh	Sequestration	Pollution	0.95	0.00	4
Salt marsh	Sequestration	Salt works	0.00	-	1

3.7. *Effects of land modification on carbon ecosystem services (tier three)*

Publications in table S4 reported the results of specific studies that analysed how land use changes have impacted carbon sequestration, or storage within natural salt marshes and mangrove forests. This table used a rating system comparing how carbon ecosystem services (ES) increased or decreased when habitat conversion occurs (see table 2.3 under Methods). Out of 26 case studies, 21 found a decrease in carbon ecosystem services following land use modification.

In mangroves, 90% of cases negatively impacted carbon storage, independent of the interface studied (figure 3.5a). Mangrove conversion to aquaculture, agriculture, and production (harvest and non-harvest) decreased carbon storage. On the other hand, pollution intensively increased carbon storage in mangrove sediments.

Carbon storage in salt marshes decreased by approximately 57% after land use changes or other impacts. Agriculture, invasive species and pollution were the main drivers of decreased carbon storage in marshes. Surprisingly, in 43% of cases, reclamation, agriculture, and invasive species, increased the carbon storage in salt marshes (figure 3.5b).

The impact of land use changes sometimes depends on the studied cases. For example, pollution in mangroves, or reclamation and invasive species in salt marshes, caused both an increase and decrease in carbon ecosystem services. Pooled agriculture/urban development and pollution resulted in decreases, whereas pooled agriculture/aquaculture increased carbon ecosystem services (table S4).

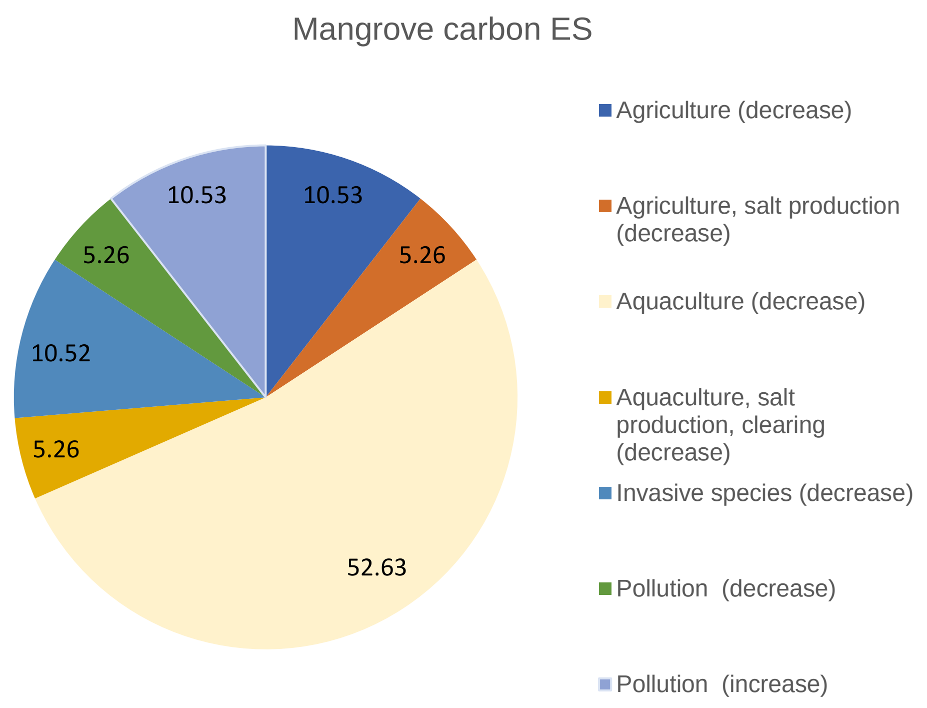

Figure 3.5a. Mangrove transformations leading to decreases and increases in overall carbon ecosystem services (ES).

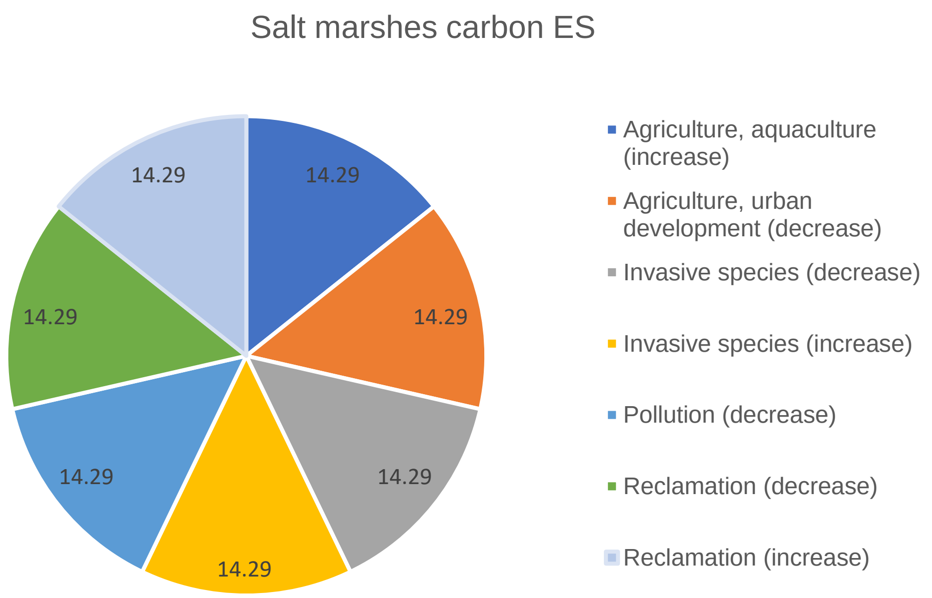

Figure 3.5b. Salt marsh modifications leading to an increase and decrease in carbon ES.

4. Discussion

We used a meta-analytic technique to study the effect of LUC on carbon ecosystem services (sequestration and storage) within mangroves and salt marshes. The results yielded an extensive literature on ecosystem services related to carbon storage and sequestration in coastal blue carbon ecosystems. Since 2000, more than 100 research articles have been devoted to this topic. Our focus was towards the evaluation of these services in natural and modified ecosystems, with those ecosystems that have been altered by human activities receiving less attention, as illustrated in the distribution of identified studies.

Mangroves in comparison with salt marshes received more attention as revealed by majority of the case studies, number of articles and a wider global representation. Mangrove research occurred in Asia, Africa, north and south America, Australia and Oceania. The higher number of studies may be attributed to the greater areal extent of this ecosystem (139 170km^2) compared to that of salt marshes (51 000km^2) (Ahmed et al., 2017). Mangroves are located in tropical and temperate regions where winter seawater isotherms are above 20°C, with the greatest percentage occurring between latitudes of 5°N and 5°S (Giri et al., 2011; Macreadie et al., 2019).

Publications based on salt marshes included north America, Europe, Australia and the middle east, representing 10 countries. These studies were based in the subtropics, temperate and Arctic landscapes (Macreadie et al., 2019), typical locations of salt marshes. In general, the geographical range of tidal marshes is slightly lower than that of mangroves, with occurrences in 99 countries, compared to 118 countries in which mangroves exist (Ahmed et al., 2017; Macreadie et al., 2019).

4.1. *Impacts of land use change on sediment and biomass carbon storage*

Our study revealed that transformation of coastal blue carbon ecosystems causes a decrease in carbon storage at a global level. Quantitative results from the meta-analysis (tier two) showed that sediment carbon storage in natural salt marshes (means hereafter 97.8 Mg C ha^{-1}) were about three times greater than impacted habitats (31.42 Mg C ha^{-1}). Sediment carbon storage in natural mangroves (520.49 Mg C ha^{-1}) were more than double that of transformed ecosystems (186.81 Mg C ha^{-1}). Both ecosystems showed significant differences in sediment carbon storage when impacted by LUC.

When coastal habitats are disturbed, their carbon storage capacity is lost and sedimentary carbon stores are said to be remineralised (Luisetti et al., 2019). We found that although sediment carbon stocks are reduced in transformed ecosystems, it did not result in complete mineralisation of soil organic carbon.

Studies on salt marshes have focused on soil carbon when these ecosystems are converted to agriculture or urban land, with rather different results (Yang et al., 2016). On conversion to agriculture, it could lead to a loss in ecosystem functioning of the salt marsh, if the net primary productivity drops below zero (Day et al., 2016). Carbon accumulation in converted salt marshes depends on the reclamation history, changes to hydrological regimes and intensity of the LUC (Yang et al., 2016).

A review by Sasmito et al. (2019) investigated LUC (including aquaculture and deforestation) within mangroves. They found that carbon soil stocks were reduced by just over 50%, and biomass losses were over 80%. Losses were dependent upon time since transformation, climate and geography of studied sites. In areas of mangrove conversion, when vegetation is cleared, this directly exposes soils to air, thereby inducing oxidation and releasing sequestered carbon (van Oudenhoven et al., 2015). However, belowground carbon could remain if settings are anoxic in nature and soils are left undisturbed (Krauss et al., 2018).

Degradation of mangrove forests is predominantly caused by transformation into aquaculture (Susetyo et al., 2020). Following the creation of shrimp ponds in mangrove ecosystems, reclamation impacts soil and water conditions (Bu et al., 2015; Elwin et al., 2019). This alters biophysical variables and affects the flux of CO_2 from soils. When mangroves are transformed for aquaculture, the top 1.5 or 2m of soil is excavated and tree coverage is lost, along with soil organic carbon. It is unclear exactly how much carbon can be lost on conversion, though this figure may be up to 50% of soil organic carbon (Elwin et al., 2019).

A study by Adame et al. (2021) looked at projected emissions from mangrove deforestation. Agriculture and aquaculture were the driving force of losses, followed by erosion, extreme climate events and clearing for other purposes. Global mangrove losses could result in high emissions if a “business as usual” approach continues.

We found that biomass carbon storage was greater in natural mangrove forests than modified environments. When mangroves are cleared, this leads to a loss of aboveground carbon stores (Krauss et al., 2018). A comparison of carbon stored in the biomass of salt marshes could not be carried out, because only one case study for modified marshes was found in the current search.

4.2. Effects of sediment sampling depth on carbon storage

We found significant correlations between sediment sampling depth and reported values of stored carbon, both in mangroves and saltmarshes. The differences in carbon storage remain significant after accounting for sampling depth, with higher values of carbon content in natural, unmodified ecosystems. The effect of sediment sampling on carbon storage was first demonstrated in terrestrial ecosystems (Franzluebbers, 2010; VandenBygaart et al., 2011). Our results support this statement also for blue carbon coastal ecosystems.

Organic rich soils within mangroves and salt marshes range between 10cm to more than 3m. This influences the organic carbon measurement; hence it is important to sample deeper in these coastal ecosystems. When soils are disturbed through drainage or oxidation, these are likely to impact deeper layers (Howard et al., 2014).

Sampling of sediment depths can be difficult due to the presence of extremely thick (>2.7m) soils, such as in the case of mangroves in Honduras (Bhomia et al., 2016b), or even due to minerogenic glacio-fluvial cobble found in Norwegian arctic salt marshes (Ward, 2020). Notwithstanding, a minimum depth of 1m has been proposed as a standard (Howard et al. 2014). The standardisation of sediment sampling and reporting of the maximum depth is imperative to increasing the accuracy and comparability of measured carbon stocks (Fest et al., 2022).

4.3. Effects of ecosystem conversion on carbon sequestration rates

Overall, sequestration rates were reduced if the area was impacted by agriculture, pollution, salt production, or invasive species, although there was considerable variability between case studies. Considering comparative case studies in tier three, conversion to agriculture/urban development (Howe et al., 2009) and exposure to pollution (Roughan et al., 2018) adversely affected carbon sequestration. Moreover, conversion of marshes to salt works restricts tidal flow, reducing sediment accretion, thus preventing carbon accumulation (Gulliver et al., 2020).

In terms of agriculture, the conversion of natural coastal ecosystems to crop farming can cause the depletion of soil organic carbon. This is due to a decrease in biomass carbon returns, variations in temperature and moisture, and the fact that soil in the upper surfaces are more prone to erosion (Lal et al., 2015). Depending on the geographic location, the effects of reclamation on coastal soils can modify or deteriorate, as in the case of Asia and Europe respectively (Li et al., 2014a).

Grazing of salt marshes by livestock may or may not have significant effects on carbon storage. For example, grazing was not found to affect carbon stock in the top 12cm of soil. However, this is site specific, and grazing benefits may be limited. Grazing could promote root growth of marshes and thereby counter potential carbon losses (Harvey et al., 2019). On the other hand, carbon sequestration can be affected by continual AGB removal and reduce plant productivity (Keshta et al., 2020). Grazing could also decrease enzymes essential in carbon cycling, possibly due to trampling or indirect redox chemistry effects (Mueller et al., 2017).

Gu et al. (2018) documented reclamation of salt marshes at a national level in China. In their review, they found that salt production in the 1950's, followed by agricultural conversion in the 1960's and '70s were dominating trends. Then, in the '80s and 90's, aquacultural ponds drove losses. In the late '90s, urban development became dominant. Alien invasive species and natural marsh composition increased salt marsh extent. Indeed, reclamation reduces the CO_2 sink of these ecosystems by reducing their areal extent and contributing to organic carbon emissions after disturbance.

Tian et al. (2019) reported on the effects of shrimp farm effluents which were discharged into a mangrove forest. They found that this pollution caused a significant decrease in soil total organic carbon, especially as discharge history increased. The natural reference site contained the highest mean value of soil organic carbon compared to impacted sites of ages 8 and 14 years.

4.4. Carbon storage and sequestration in natural ecosystems

In the current research, carbon storage for natural mangroves ranged between 7.24 to 1009 Mg C ha^{-1}, and 3.44 to 149.6 Mg C ha^{-1} in natural salt marshes. These ranges differ from those in the literature, such as those reported by Li et al., 2018a. Global estimations of carbon storage within a metre of sediment ranged between 90 - 540 Mg ha^{-1} in salt marshes and 289 - 551 Mg ha^{-1} in mangrove forests (Li et al., 2018a). These differences could be attributed to sediment sampling depth, as in our study, we included literature with varying sampling depths.

Donato et al. (2011) reported much higher mangrove carbon storage occurring in a region within the tropics, at 1,023 Mg ha-1. In the current study, articles with carbon storage measurements were based worldwide, and the effect of natural climates and availability of growing substrates would also affect carbon stored (e.g., Alongi, 2012).

In this study, mean sequestration rates in natural mangroves and salt marshes were 9.53 and 3.16 Mg C ha^{-1} yr^{-1} respectively. Mcleod et al. (2011) calculated the global average carbon burial rate across 34 mangrove and 96 salt marsh sites to be 2.26 and 2.18 Mg C ha^{-1} yr^{-1} respectively. Carbon sequestration fluctuates greatly in blue carbon ecosystems (Li et al., 2018b).

Globally, average mangrove carbon sequestration rates have been estimated at 2.42 and 2.10 Mg ha^{-1} C yr^{-1} in salt marshes (IUCN, 2021). Differences between ecosystems may be attributed to the perennial character of salt marshes, leading to a higher carbon burial by root decomposition. On the other hand, mangroves take a longer time for root turnover (Ouyang et al., 2017).

Reasons for the high carbon storage within mangrove soils can be explained by recalcitrance of roots, and inhibition of the enzyme phenoloxidase (Kida & Fujitake, 2020). Moreover, the concentration of reactive iron controls organic carbon in mangrove soils because binding of organic matter with iron repels degradation. Roughly 15% of organic carbon in sediments is bound directly with reactive iron (Dicen et al., 2019). Saturation of carbon within sediments does not occur within these ecosystems, given that sediments are able to accrete vertically (Mcleod et al., 2011).

Several abiotic factors control how soil organic carbon accumulates. A study on mangroves, salt marshes and fresh marshes in the US showed that precipitation, temperature, salinity, and catchment elevation played a role in carbon accumulation. Temperature affects organic matter decomposition. Latitude and the number of frost days also affected accumulation (Hinson et al., 2019).

4.5. Sustainable management of modified ecosystems

Most studies which compared carbon ES before and after transformation showed that that storage and sequestration deteriorated following modification of natural BC habitats (tier three). Mangrove degradation is primarily caused by aquaculture (Susetyo et al., 2020). 12 case studies based on conversion of mangroves to aquaculture showed decreases in carbon storage and sequestration. Conversion of mangroves for aquaculture and reclamation of salt marshes in general will be the focus for sustainable practices.

If managed correctly, aquaculture can provide long term benefits such as allowing for wild fish stocks to recover, whilst providing seafood (Custódio et al., 2019). In the 1980s and '90s, however, shrimp farming caused a rapid increase in mangrove deforestation. This "blue revolution" of aquaculture also led to debates on adverse consequences for environmental, social, and economic fronts (Ahmed et al., 2017).

Nowadays, the REDD+ (Reducing Emissions from Deforestation and Degradation) programme aims to reduce mangrove losses by preventing further destruction to these important ecosystems. To further address the degradation caused by aquaculture ponds, shrimp culturing can be translocated offshore to Integrated Multi-Trophic Aquaculture – IMTA farms. These IMTA farms involve farming species from different trophic levels together (Ahmed et al., 2017).

Another approach is by using the "organic aquaculture" concept. Organic aquaculture involves shrimp farming within a mangrove, provided that not more than 50% of the whole farm area is destroyed. If mangroves were previously destroyed, they should be reforested to a minimum of 50% of the farm area within a period of five years (Ahmed et al., 2018).

Traditionally, drainage of salt marshes was done by building sea defences or constructing ditches, and restricting tidal flow (Fernández et al., 2010). Reclamation of salt marshes by drainage changes the natural anaerobic conditions to aerobic, facilitating the remineralisation of organic carbon stored within its sediments (Bu et al., 2015; Fernández et al., 2010; Powell et al., 2020).

Knowledge on the ecological value of salt marshes, have invoked efforts to restore these important ecosystems, since rehabilitated salt marshes can provide a sustained sink for atmospheric carbon (Burden et al., 2013; Santín et al., 2009). Reclamation of salt marshes is a long known human activity, especially for agriculture. With the effects of coastal squeeze and expected sea level rise, salt marshes are threatened from both sides. The ecological restoration of salt marshes on a global scale is being introduced (Burden et al., 2013).

Construction of low levees in areas with highly armoured seawalls along coastlines may facilitate the colonisation of salt marshes, though this depends on hydrodynamic and morphodynamic site conditions (Li et al., 2018b). Alternatively, managed realignment, which is the planned breaching or breakdown of coastal defence structures, can allow for the creation of new intertidal area (Esteves, 2014). This progressive type of coastal management involves restoring flooding to agricultural marshes (Chmura, 2009).

When *Spartina* was introduced to invoke coastal reclamation in the 1930's, little was known about its invasive properties. Now, resource managers in Australia are looking for a sustainable trade-off to deal with its ability to outcompete native species, whilst also considering its resilience to rising sea levels and carbon sequestration potential. Management will entail drawing up a comprehensive cost benefit analysis of the invasive marsh's ecosystem services (Kennedy et al., 2018).

4.6. Management of salt marsh and mangrove ecosystems

Salt marshes in many regions are protected from dredging and infilling, although indirect influences continue to have impacts (Chmura, 2009). In light of this, management of salt marshes should consider those activities which affect water discharge, sediment and nutrient inputs (Chmura, 2009; Lu et al., 2018). For example, reduction in freshwater flows promote hypersaline environments. Moreover, impacts from effluent outflows upstream urban or agricultural fields can adversely impact marsh sustainability (Chmura, 2009).

Some management strategies to enhance the carbon sink of salt marshes include creating buffer zones. This will allow for marshes to migrate inland when sea level rise occurs. Land around and within salt marshes should be protected from development, this could also be accomplished by implementing buffers. Restoring natural marshes and reinstating the flow of tides will further promote carbon storage (Chmura, 2009). The idea of working with nature is increasingly recognised by coastal managers to promote soft engineering and maintain natural dynamics (Perkins et al., 2015).

Research on the conservation of mangroves go beyond that of monitoring. It should consider socioeconomic factors on a local scale which could drive losses or even promote conservation. The intactness of mangrove forests depend on the type of people living in them, and their community resource-based management. A move to forest conservation may be met with resistance from the locals (Espinoza-Tenorio et al., 2019) since the latter replaces bottom-up management.

Research into changes on mangrove area over specific time scales can yield varying results. In a highly populated estuary in China, analysis of satellite images of mangrove cover between 1990 – 2018 revealed losses in the first ten years of that time period, mainly due to aquaculture ponds and urban development. However, from 2000 onwards, estuarine mangrove exceeded cover that before 1990 by 6.8 km^2 (previously 11.5 km^2) owing to restoration efforts (Wang et al., 2021).

Restoration of coastal wetlands is recognised as the primary way to conserve these vital habitats. Primary to this aim is to reduce physical stressors or limit competition between salt marshes and mangroves. Although these may be important, management should consider other species interactions and integrate bottom-up and top-down controls. The introduction of biotic regimes which increase species richness can improve restoration efforts (Renzi et al., 2019).

Wetland delineation based on sound scientific approaches can promote the conservation of coastal ecosystems and facilitate better planning of the coastal zone. Monitoring through remote sensing promotes assessments of coastal ecosystems. Governance and policies also play an important role in how and why ecosystems are managed as such. Complexity relating to management from government to local level should be reduced to improve wetland conservation nationally (Rogers et al., 2016).

Good management of mangrove ecosystems can be impeded by unsustainable uses (e.g., aquaculture or timber extraction), as well as pollution from agricultural runoff and urban settlements. Moreover, natural impacts like storms and waves can cause losses to these ecosystems. A lack of government regulation for protecting and promoting sustainable development is another factor that should be considered. Although these factors may be documented by a study in Vietnam (Veettil et al., 2019) their implications are far and wide.

4.7. Study limitations

Some limitations were observed in the development of this work, such as (1) the absence of standardised depths of sediment organic carbon reported within primary studies. Although the Blue Carbon Manuals (Howard et al., 2014; IUCN, 2021) recommend measuring organic carbon in the first meter of sediment, it is not always possible (for example, due to reaching parent rock material beforehand, limits to manual removal of cores, and type of core used for sampling). Funding and technical expertise also has its own limitations. (2) Moreover, not all studies measured above- or below-ground biomass, along with soil organic carbon. (3) Finally, studies on carbon storage and sequestration in transformed ecosystems were low in comparison with studies on natural mangrove forest and salt marshes, limiting the statistical analysis.

4.8. Blue carbon ecosystem services conservation and management

The conservation, maintenance and restoration of blue carbon ecosystems is imperative in climate change mitigation strategies (Tang et al., 2018). Our study demonstrates that the change of use in coastal ecosystems may considerably impact their capacity to mitigate carbon emissions. Reclamation of these key ecosystems results in adverse effects on their carbon sequestration capacity. Therefore, restoration and regulation of reclamation activities are important tools in enhancing blue carbon habitats (Tang et al., 2018).

The implications of mangrove and salt marsh conversion are not only limited to losses of the carbon regulating ecosystem service. Losing valuable ecosystem goods and services hinder the ability of communities to meet basic needs. For example, fisheries are dependent upon the rich feeding grounds found in mangroves (Ong & Gong, 2013). Mangroves and salt marshes alike support the life cycle of marine fish and fisheries (Barbier, 2017). Well flushed estuaries containing mangroves may also provide a place for sustainable aquaculture (Ong & Gong, 2013).

Human benefits derived from salt marshes include fishing, nursery provisioning, nutrient removal, and storm protection. Despite knowledge of these goods and services, managers continue to exploit valuable coastal land, transforming the ecosystem for upstream uses. When the focus is only on one ecosystem service, for example increased land area by reclamation, it results in the net loss of ecosystem services (Gedan et al., 2009).

De Groot et al. (2010) documented that multifunctional uses of natural or semi-natural systems tend to be more economically viable than transformed landscapes. Moreover, intact wetlands accumulate greater benefits than converted ecosystems. Conversion of natural ecosystems may have short term profitability for a few but is at the expense of many in the long-term.

Ecosystem managers should use the precautionary principle to guide decision-making. It's imperative to recognise that humans drive change within natural ecosystems, and that these changes result in transformations of ecosystem function. Ecosystem based management will allow for adaptive management in light of humans driving ecosystem change (Curtin & Prellezo, 2010).

Natural blue carbon ecosystems should be protected from conversion, since their services go beyond those of carbon storage and sequestration alone. Ecosystem management should be based on protecting and maintaining ecological integrity, parallel to allowing the ecosystem to produce societal benefits.

5. Conclusions

The promotion, maintenance and exploration of blue carbon ecosystems is essential in the strategies for climate change mitigation. Reclamation of these key ecosystems results in adverse effects on their carbon sequestration capacity. This study shows that conversion of natural blue carbon ecosystems has resulted in a reduction of carbon storage and sequestration capacities within these ecosystems at a global level. The revision of more than 100 scientific articles through the procedure of the meta-analysis showed that sediment carbon storage in natural mangroves are nearly 3x that of transformed habitats.

Salt marshes showed a similar trend, with natural ecosystems storing about 3x that of modified ones. Carbon storage in mangrove above- and belowground biomass was on average 3.5x that of transformed ecosystems. Carbon sequestration rates also decreased in modified mangroves and saltmarshes, although there was a high variability among case studies. Moreover, most studies which compared carbon ES before and after transformation showed that storage and sequestration deteriorated following modification of natural BC habitats.

This study also showed that sediment sampling depths affected the measurement of change of carbon storage within mangroves and salt marshes (natural and modified). Standardising sediment sampling depth and reporting maximum sediment depth is critical for increasing accuracy and comparability of measured sediment carbon stocks. To enhance the storage and sequestration capacities of coastal blue carbon habitats, management practices should encourage their conservation and restoration. This could be vital in the mitigation of global climate change.

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Asterisks (*) indicate qualitative articles taken from tier 1.

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7. Appendix

Table S1. Carbon storage in natural and modified mangrove sediments, along with number of case studies (n). The mean carbon storage in modified mangrove sediment was averaged from all types of transformed mangroves. Carbon storage values were standardised to Mg C ha^{-1}. ES = ecosystem service. (-) not available.

Ecosystem	Interface	Type of ecosystem	Carbon ES	Mean	SD	n
Mangroves	Sediment	Natural	Storage	520.49	388.99	200
Mangroves	Sediment	Modified	Storage	186.81	234.02	29
Mangroves	Sediment	Agriculture	Storage	55.67	29.85	3
Mangroves	Sediment	Agriculture, urban development	Storage	57.31	-	1
Mangroves	Sediment	Invasive species	Storage	71.85	23.85	6
Mangroves	Sediment	Aquaculture	Storage	289.07	298.42	13
Mangroves	Sediment	Cleared mangrove	Storage	227.71	262.36	2
Mangroves	Sediment	Pollution	Storage	49.15	27.47	3
Mangroves	Sediment	Salt production	Storage	401.18	-	1

Table S2. Carbon storage in natural and modified mangrove biomass, along with number of case studies. The mean carbon storage in modified mangrove sediment was averaged from all types of transformed mangroves. Carbon storage values were standardised to Mg C ha^{-1}. ES = ecosystem service. (-) not available.

Ecosystem	Interface	Type of ecosystem	Carbon ES	Mean	SD	n
Mangroves	Biomass	Natural	Storage	103.07	198.86	263
Mangroves	Biomass	Modified	Storage	29.01	47.40	20
Mangroves	Biomass	Agriculture	Storage	59.99	90.61	4
Mangroves	Biomass	Alien invasive	Storage	31.79	33.82	8
Mangroves	Biomass	Aquaculture	Storage	7.98	13.05	7
Mangroves	Biomass	Production - harvest	Storage	9.00	-	1

Table S3. Carbon sediment and biomass storage in modified and natural salt marshes, along with number of case studies. The mean carbon storage in modified salt marshes was averaged from all types of transformed mangroves. Carbon storage values were standardised to Mg C ha^{-1}. ES = ecosystem service. (-) not available.

Ecosystem	Interface	Type of ecosystem	Carbon ES	Mean	SD	n
Salt marsh	Sediment	Natural	Storage	97.80	107.69	50
Salt marsh	Sediment	Modified	Storage	31.42	33.47	29
Salt marsh	Sediment	Agriculture	Storage	28.70	0.57	2
Salt marsh	Sediment	Agriculture, urban development	Storage	81.21	-	1
Salt marsh	Sediment	Alien invasive	Storage	42.74	45.62	2
Salt marsh	Sediment	Aquaculture	Storage	16.60		1
Salt marsh	Sediment	Pollution	Storage	12.03	3.54	6
Salt marsh	Sediment	Reclamation	Storage	32.42	38.00	16
Salt marsh	Sediment	Salt works	Storage	79.51	-	1
Salt marsh	Biomass	Natural	Storage	3.66	5.24	19
Salt marsh	Biomass	Modified	Storage	21.26	-	1
Salt marsh	Biomass	Alien invasive	Storage	21.26		

Table S4. Overall effects of land use change on carbon ecosystem services (ES) at each ecosystem, including interface at which the measurement was taken. Studies have comparable reference sites (tier 3). Values were standardised to Mg C ha^{-1} yr^{-1} for sequestration and Mg C ha^{-1} for storage. ES = ecosystem service.

Habitat	Conversion	Interface	Effect on ES	Reference
Mangrove	Agriculture	Sediment	Decrease	Andreetta et al., 2016
Mangrove	Aquaculture	Sediment	Decrease	Bhomia et al., 2016b
Mangrove	Agriculture, salt production	Biomass (BGB)	Decrease	Bournazel et al., 2015
Mangrove	Aquaculture	Sediment	Slight decrease	Cameron et al., 2018
Mangrove	Aquaculture, salt production, clearing	Sediment	Decrease	Castillo et al., 2017a
Mangrove	Aquaculture	Biomass (AGB)	Intense decrease	Castillo et al., 2018
Mangrove	Agriculture	Biomass (AGB & BGB)	Intense decrease	Castillo et al., 2018
Mangrove	Aquaculture	Sediment	Decrease	Eid et al., 2019
Mangrove	Aquaculture	Biomass (AGB & BGB)	Decrease	Elwin et al., 2019
Mangrove	Aquaculture	Sediment	Decrease	Elwin et al., 2019
Mangrove	Aquaculture	Sediment	Intense decrease	Kauffman et al, 2014
Mangrove	Aquaculture	Biomass (AGB & BGB)	Intense decrease	Kauffman et al, 2014
Mangrove	Aquaculture	Sediment	Decrease	Merecí-Guamán et al., 2021
Mangrove	Aquaculture	Sediment	Decrease	Mutiatari et al., 2018
Mangrove	Pollution	Sediment	Intense increase	Pérez et al., 2020
Mangrove	Pollution	Sediment	Decrease	Suárez-Abelenda et al., 2014
Mangrove	Pollution	Sediment	Slight increase	Tian et al., 2019
Mangrove	Invasive species	Biomass (AGB)	Decrease	Yu et al., 2020
Mangrove	Invasive species	Biomass (BGB)	Decrease	Yu et al., 2020
Tidal marsh	Agriculture, urban development	Sediment	Decrease	Howe et al., 2009
Tidal marsh	Reclamation	Sediment	Slight increase	Lewis et al., 2019
Tidal marsh	Agriculture, aquaculture	Sediment	Increase	Li et al., 2018a
Tidal marsh	Pollution	Sediment	Slight decrease	Roughan et al., 2018
Tidal marsh	Reclamation	Sediment	Decrease	van de Broek et al., 2019
Tidal marsh	Invasive species	Sediment	Slight decrease	Xia et al., 2021
Tidal marsh	Invasive species	Sediment	Intense increase	Li et al, 2014b

Table S5. Studies used in the meta-analysis (tier 2) showing country, type of ecosystem (natural or modified), and interface. Carbon sequestration, and storage are standardised to Mg C ha^{-1} yr^{-1}, and Mg Cha^{-1} respectively.

Reference	**Country**	**Ecosystem**	**Interface**	**Parameter measured**	**Land use simplified**	**Standardised value**	**Units**
Adame et al., 2013	Mexico	Mangrove	Biota AGB	Storage	Natural	84.58	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota AGB	Storage	Natural	69.55	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota AGB	Storage	Natural	50.40	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota AGB	Storage	Natural	54.82	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota AGB	Storage	Natural	1.44	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota AGB	Storage	Natural	3.41	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota AGB	Storage	Natural	2.54	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota BGB	Storage	Natural	61.07	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota BGB	Storage	Natural	57.41	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota BGB	Storage	Natural	30.42	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota BGB	Storage	Natural	27.69	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota BGB	Storage	Natural	3.39	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota BGB	Storage	Natural	7.41	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Biota BGB	Storage	Natural	4.76	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Sediment	Storage	Natural	1166.00	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Sediment	Storage	Natural	508.00	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Sediment	Storage	Natural	577.00	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Sediment	Storage	Natural	496.00	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Sediment	Storage	Natural	407.00	Mg C ha^{-1}
Adame et al., 2013	Mexico	Mangrove	Sediment	Storage	Natural	286.00	Mg C ha^{-1}

Adame et al., 2013	Mexico	Mangrove	Sediment	Storage	Natural	426.00	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota AGB	Storage	Natural	184.13	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota AGB	Storage	Natural	164.35	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota AGB	Storage	Natural	187.97	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota AGB	Storage	Natural	298.22	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota AGB	Storage	Natural	95.42	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota AGB	Storage	Natural	145.68	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota AGB	Storage	Natural	339.17	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota BGB	Storage	Natural	49.88	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota BGB	Storage	Natural	46.14	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota BGB	Storage	Natural	54.60	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota BGB	Storage	Natural	79.17	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota BGB	Storage	Natural	36.62	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota BGB	Storage	Natural	49.84	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Biota BGB	Storage	Natural	104.79	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Sediment	Storage	Natural	505.90	Mg C ha^{-1}
Adame et al., 2015	Mexico	Mangrove	Sediment	Sequestration	Natural	1.00	Mg C ha^{-1} y^{-1}
Adame et al., 2015	Mexico	Mangrove	Sediment	Sequestration	Natural	1.40	Mg C ha^{-1} y^{-1}
Adame et al., 2015	Mexico	Mangrove	Sediment	Sequestration	Natural	1.70	Mg C ha^{-1} y^{-1}
Adame et al., 2015	Mexico	Mangrove	Sediment	Sequestration	Natural	1.80	Mg C ha^{-1} y^{-1}
Adame et al., 2015	Mexico	Mangrove	Sediment	Sequestration	Natural	1.30	Mg C ha^{-1} y^{-1}
Adame et al., 2015	Mexico	Mangrove	Sediment	Sequestration	Natural	1.50	Mg C ha^{-1} y^{-1}
Adame et al., 2015	Mexico	Mangrove	Sediment	Sequestration	Natural	0.40	Mg C ha^{-1} y^{-1}
Ahmed et al., 2017	Global	Mangrove	Biota	Sequestration	Natural	1.15	Mg C ha^{-1} y^{-1}
Ahmed et al., 2017	Global	Mangrove	Biota	Sequestration	Natural	1.39	Mg C ha^{-1} y^{-1}

Alongi, 2012	Malaysia	Mangrove	Biota AGB	Storage	Natural	312.00	Mg C ha^{-1}
Alongi, 2012	Malaysia	Mangrove	Biota AGB	Storage	Natural	193.00	Mg C ha^{-1}
Alongi, 2012	Malaysia	Mangrove	Biota AGB	Storage	Natural	87.00	Mg C ha^{-1}
Alongi, 2012	Vietnam	Mangrove	Biota AGB	Storage	Natural	54.00	Mg C ha^{-1}
Alongi, 2012	Vietnam	Mangrove	Biota AGB	Storage	Natural	72.00	Mg C ha^{-1}
Alongi, 2012	Vietnam	Mangrove	Biota AGB	Storage	Natural	153.00	Mg C ha^{-1}
Alongi, 2012	China	Mangrove	Biota AGB	Storage	Natural	64.00	Mg C ha^{-1}
Alongi, 2012	China	Mangrove	Biota AGB	Storage	Natural	43.00	Mg C ha^{-1}
Alongi, 2012	China	Mangrove	Biota AGB	Storage	Natural	7.00	Mg C ha^{-1}
Alongi, 2012	Indonesia	Mangrove	Biota AGB	Storage	Natural	24.00	Mg C ha^{-1}
Alongi, 2012	Indonesia	Mangrove	Biota AGB	Storage	Natural	19.00	Mg C ha^{-1}
Alongi, 2012	Indonesia	Mangrove	Biota AGB	Storage	Natural	28.00	Mg C ha^{-1}
Alongi, 2012	Thailand	Mangrove	Biota AGB	Storage	Natural	138.00	Mg C ha^{-1}
Alongi, 2012	Thailand	Mangrove	Biota AGB	Storage	Natural	20.00	Mg C ha^{-1}
Alongi, 2012	Thailand	Mangrove	Biota AGB	Storage	Natural	29.00	Mg C ha^{-1}
Alongi, 2012	Australia	Mangrove	Biota AGB	Storage	Natural	115.00	Mg C ha^{-1}
Alongi, 2012	Australia	Mangrove	Biota AGB	Storage	Natural	55.00	Mg C ha^{-1}
Alongi, 2012	Australia	Mangrove	Biota AGB	Storage	Natural	297.00	Mg C ha^{-1}
Alongi, 2012	Malaysia	Mangrove	Biota BGB + soil	Storage	Natural	1893.00	Mg C ha^{-1}
Alongi, 2012	Malaysia	Mangrove	Biota BGB + soil	Storage	Natural	924.00	Mg C ha^{-1}
Alongi, 2012	Malaysia	Mangrove	Biota BGB + soil	Storage	Natural	392.00	Mg C ha^{-1}
Alongi, 2012	Vietnam	Mangrove	Biota BGB + soil	Storage	Natural	1125.00	Mg C ha^{-1}
Alongi, 2012	Vietnam	Mangrove	Biota BGB + soil	Storage	Natural	907.00	Mg C ha^{-1}
Alongi, 2012	Vietnam	Mangrove	Biota BGB + soil	Storage	Natural	1752.00	Mg C ha^{-1}
Alongi, 2012	China	Mangrove	Biota BGB + soil	Storage	Natural	555.00	Mg C ha^{-1}
Alongi, 2012	China	Mangrove	Biota BGB + soil	Storage	Natural	348.00	Mg C ha^{-1}

Alongi, 2012	China	Mangrove	Biota BGB + soil	Storage	Natural	325.00	Mg C ha^{-1}
Alongi, 2012	Indonesia	Mangrove	Biota BGB + soil	Storage	Natural	413.00	Mg C ha^{-1}
Alongi, 2012	Indonesia	Mangrove	Biota BGB + soil	Storage	Natural	684.00	Mg C ha^{-1}
Alongi, 2012	Indonesia	Mangrove	Biota BGB + soil	Storage	Natural	626.00	Mg C ha^{-1}
Alongi, 2012	Thailand	Mangrove	Biota BGB + soil	Storage	Natural	670.00	Mg C ha^{-1}
Alongi, 2012	Thailand	Mangrove	Biota BGB + soil	Storage	Natural	559.00	Mg C ha^{-1}
Alongi, 2012	Thailand	Mangrove	Biota BGB + soil	Storage	Natural	571.00	Mg C ha^{-1}
Alongi, 2012	Australia	Mangrove	Biota BGB + soil	Storage	Natural	621.00	Mg C ha^{-1}
Alongi, 2012	Australia	Mangrove	Biota BGB + soil	Storage	Natural	515.00	Mg C ha^{-1}
Alongi, 2012	Australia	Mangrove	Biota BGB + soil	Storage	Natural	1842.00	Mg C ha^{-1}
Alongi, 2012	China	Mangrove	Sediment	Storage	Natural	425.00	Mg C ha^{-1}
Alongi, 2012	China	Mangrove	Sediment	Storage	Natural	254.00	Mg C ha^{-1}
Alongi, 2012	China	Mangrove	Sediment	Storage	Natural	317.00	Mg C ha^{-1}
Alongi, 2012	Thailand	Mangrove	Sediment	Storage	Natural	528.00	Mg C ha^{-1}
Alongi, 2012	Thailand	Mangrove	Sediment	Storage	Natural	502.00	Mg C ha^{-1}
Alongi, 2012	Thailand	Mangrove	Sediment	Storage	Natural	444.00	Mg C ha^{-1}
Alongi, 2012	Australia	Mangrove	Sediment	Storage	Natural	621.00	Mg C ha^{-1}
Alongi, 2012	Australia	Mangrove	Sediment	Storage	Natural	515.00	Mg C ha^{-1}
Alongi, 2012	Australia	Mangrove	Sediment	Storage	Natural	1530.00	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	24.30	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	18.20	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	117.10	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	30.00	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	311.80	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	18.80	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	159.10	Mg C ha^{-1}

Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	159.50	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	111.90	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	213.80	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	338.40	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	282.90	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota AGB	Storage	Natural	171.00	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	3.10	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	404.00	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	18.20	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	8.20	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	27.90	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	2.50	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	14.20	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	21.30	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	14.90	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	36.70	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	43.60	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	27.20	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Biota BGB	Storage	Natural	40.00	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	174.80	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	1169.30	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	18.80	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	777.40	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	979.50	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	571.60	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	620.90	Mg C ha^{-1}

Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	1059.20	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	811.70	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	660.50	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	1014.80	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	965.10	Mg C ha^{-1}
Alongi et al., 2016	Indonesia	Mangrove	Sediment	Storage	Natural	290.00	Mg C ha^{-1}
Andreetta et al., 2016	Guinea-Bissau	Mangrove	Sediment	Storage	Natural	132.33	Mg C ha^{-1}
Andreetta et al., 2016	Guinea-Bissau	Mangrove	Sediment	Storage	Natural	68.61	Mg C ha^{-1}
Andreetta et al., 2016	Guinea-Bissau	Mangrove	Sediment	Storage	Agriculture	41.24	Mg C ha^{-1}
Andreetta et al., 2016	Guinea-Bissau	Mangrove	Sediment	Storage	Agriculture	35.78	Mg C ha^{-1}
Benson et al., 2017	Madagascar	Mangrove	Biota AGB + BGB	Storage	Natural	73.90	Mg C ha^{-1}
Benson et al., 2017	Madagascar	Mangrove	Biota AGB + BGB	Storage	Natural	46.23	Mg C ha^{-1}
Benson et al., 2017	Madagascar	Mangrove	Sediment	Storage	Natural	381.02	Mg C ha^{-1}
Benson et al., 2017	Madagascar	Mangrove	Sediment	Storage	Natural	294.63	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Biota AGB	Storage	Natural	15.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Biota AGB	Storage	Natural	54.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Biota AGB	Storage	Natural	179.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	537.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	411.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	322.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	667.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	352.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	427.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Biota AGB	Storage	Natural	70.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Biota AGB	Storage	Natural	196.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Biota AGB	Storage	Natural	52.00	Mg C ha^{-1}

Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	258.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	381.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	468.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	242.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	481.00	Mg C ha^{-1}
Bhomia et al., 2016a	Honduras	Mangrove	Sediment	Storage	Natural	492.00	Mg C ha^{-1}
Bhomia et al., 2016b	India	Mangrove	Biota AGB + BGB	Storage	Aquaculture	0.00	Mg C ha^{-1}
Bhomia et al., 2016b	India	Mangrove	Biota AGB + BGB	Storage	Natural	100.00	Mg C ha^{-1}
Bhomia et al., 2016b	India	Mangrove	Sediment	Storage	Aquaculture	61.00	Mg C ha^{-1}
Bhomia et al., 2016b	India	Mangrove	Sediment	Storage	Natural	134.00	Mg C ha^{-1}
Bournazel et al., 2015	Sri Lanka	Mangrove	Biota BGB	Storage	Natural	199.18	Mg C ha^{-1}
Bournazel et al., 2015	Sri Lanka	Mangrove	Biota BGB	Storage	Agriculture	34.15	Mg C ha^{-1}
Bournazel et al., 2015	Sri Lanka	Mangrove	Biota AGB	Storage	Agriculture	194.40	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Sediment	Sequestration	Natural	49.20	Mg C ha^{-1} y^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Sediment	Sequestration	Natural	167.80	Mg C ha^{-1} y^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Sediment	Sequestration	Natural	1.10	Mg C ha^{-1} y^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Sediment	Storage	Natural	575.00	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Sediment	Storage	Natural	418.40	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Sediment	Storage	Natural	504.80	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Sediment	Storage	Natural	509.50	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Biota AGB	Storage	Natural	33.20	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Biota AGB	Storage	Natural	12.10	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Biota AGB	Storage	Natural	91.50	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Biota AGB	Storage	Natural	68.70	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Biota AGB	Storage	Natural	182.20	Mg C ha^{-1}

Cameron et al., 2018	Indonesia	Mangrove	Biota BGB	Storage	Natural	7.20	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Biota BGB	Storage	Natural	2.70	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Biota BGB	Storage	Natural	31.00	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Biota BGB	Storage	Natural	13.80	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Biota BGB	Storage	Natural	70.80	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Sediment	Storage	Aquaculture	114.00	Mg C ha^{-1}
Cameron et al., 2018	Indonesia	Mangrove	Sediment	Storage	Aquaculture	665.00	Mg C ha^{-1}
Castillo et al., 2017	Philippines	Mangrove	Sediment	Storage	Natural	1040.21	Mg C ha^{-1}
Castillo et al., 2017	Philippines	Mangrove	Sediment	Storage	Natural	640.00	Mg C ha^{-1}
Castillo et al., 2017	Philippines	Mangrove	Sediment	Storage	Aquaculture	453.65	Mg C ha^{-1}
Castillo et al., 2017	Philippines	Mangrove	Sediment	Storage	Salt works	401.18	Mg C ha^{-1}
Castillo et al., 2017	Philippines	Mangrove	Sediment	Storage	Cleared	413.22	Mg C ha^{-1}
Castillo et al., 2017	Philippines	Mangrove	Sediment	Storage	Cleared	42.19	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota AGB	Storage	Natural	45.17	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota AGB	Storage	Natural	13.36	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota AGB + BGB	Storage	Agriculture	5.70	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota AGB	Storage	Aquaculture	0.12	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota AGB + BGB	Storage	Natural	71.70	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota AGB + BGB	Storage	Natural	22.50	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota AGB + BGB	Storage	Agriculture	5.70	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota AGB	Storage	Aquaculture	0.00	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota AGB	Storage	Aquaculture	0.04	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota BGB	Storage	Natural	19.36	Mg C ha^{-1}
Castillo et al., 2018	Philippines	Mangrove	Biota BGB	Storage	Natural	5.72	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Biota AGB	Storage	Natural	12.75	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Biota AGB	Storage	Natural	28.85	Mg C ha^{-1}

Cleyndert et al., 2020	Tanzania	Mangrove	Sediment	Storage	Natural	483.63	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Sediment	Storage	Natural	327.52	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Sediment	Storage	Natural	241.89	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Sediment	Storage	Natural	153.73	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Biota AGB	Storage	Natural	10.86	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Biota AGB	Storage	Natural	54.90	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Biota BGB	Storage	Natural	13.71	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Biota BGB	Storage	Natural	24.30	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Biota BGB	Storage	Natural	10.35	Mg C ha^{-1}
Cleyndert et al., 2020	Tanzania	Mangrove	Biota BGB	Storage	Natural	43.30	Mg C ha^{-1}
DelVecchia et al., 2014	Ecuador	Mangrove	Sediment	Storage	Natural	58.00	Mg C ha^{-1}
DelVecchia et al., 2014	Ecuador	Mangrove	Sediment	Storage	Natural	448.00	Mg C ha^{-1}
DelVecchia et al., 2014	Ecuador	Mangrove	Sediment	Storage	Natural	387.00	Mg C ha^{-1}
DelVecchia et al., 2014	Ecuador	Mangrove	Sediment	Storage	Natural	386.00	Mg C ha^{-1}
DelVecchia et al., 2014	Ecuador	Mangrove	Sediment	Storage	Natural	399.00	Mg C ha^{-1}
DelVecchia et al., 2014	Ecuador	Mangrove	Sediment	Storage	Natural	70.00	Mg C ha^{-1}
DelVecchia et al., 2014	Ecuador	Mangrove	Sediment	Storage	Natural	193.00	Mg C ha^{-1}
DelVecchia et al., 2014	Ecuador	Mangrove	Sediment	Storage	Natural	39.00	Mg C ha^{-1}
DelVecchia et al., 2014	Ecuador	Mangrove	Sediment	Storage	Natural	93.30	Mg C ha^{-1}
Donato et al., 2012	Yap island	Mangrove	Biota AGB	Storage	Natural	249.00	Mg C ha^{-1}
Donato et al., 2012	Yap island	Mangrove	Biota AGB	Storage	Natural	101.00	Mg C ha^{-1}
Donato et al., 2012	Yap island	Mangrove	Biota BGB	Storage	Natural	203.00	Mg C ha^{-1}
Donato et al., 2012	Yap island	Mangrove	Biota BGB	Storage	Natural	68.00	Mg C ha^{-1}
Donato et al., 2012	Yap island	Mangrove	Sediment	Storage	Natural	754.00	Mg C ha^{-1}
Donato et al., 2012	Yap island	Mangrove	Sediment	Storage	Natural	631.00	Mg C ha^{-1}

Donato et al., 2011	Indo-Pacific region	Mangrove	Biota AGB	Storage	Natural	435.00	Mg C ha^{-1}
Donato et al., 2011	Indo-Pacific region	Mangrove	Biota AGB	Storage	Natural	159.00	Mg C ha^{-1}
Donato et al., 2011	Global	Mangrove	Biota	Storage	Natural	32.60	Mg C ha^{-1}
Donato et al., 2011	Global	Mangrove	Sediment	Storage	Natural	256.00	Mg C ha^{-1}
Donato et al., 2011	Global	Mangrove	Sediment	Storage	Natural	501.00	Mg C ha^{-1}
Donato et al., 2011	Global	Mangrove	Sediment	Storage	Natural	813.00	Mg C ha^{-1}
Donato et al., 2011	Indo-Pacific	Mangrove	Biota BGB + soil	Storage	Natural	762.54	Mg C ha^{-1}
Donato et al., 2011	Indo-Pacific	Mangrove	Biota BGB + soil	Storage	Natural	1052.52	Mg C ha^{-1}
Donato et al., 2011	Indo-Pacific	Mangrove	Biota BGB + soil	Storage	Natural	485.10	Mg C ha^{-1}
Donato et al., 2011	Indo-Pacific	Mangrove	Biota BGB + soil	Storage	Natural	891.00	Mg C ha^{-1}
Dung et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	102.00	Mg C ha^{-1}
Dung et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	298.10	Mg C ha^{-1}
Dung et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	243.60	Mg C ha^{-1}
Dung et al., 2016	Vietnam	Mangrove	Sediment	Storage	Natural	636.30	Mg C ha^{-1}
Dung et al., 2016	Vietnam	Mangrove	Sediment	Storage	Natural	675.60	Mg C ha^{-1}
Dung et al., 2016	Vietnam	Mangrove	Sediment	Storage	Natural	690.30	Mg C ha^{-1}
Dung et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	689.90	Mg C ha^{-1}
Dung et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	696.20	Mg C ha^{-1}
Dung et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	703.20	Mg C ha^{-1}
Eid et al., 2019	Saudi Arabia	Mangrove	Sediment	Storage	Natural	292.00	Mg C ha^{-1}
Eid et al., 2019	Saudi Arabia	Mangrove	Sediment	Storage	Aquaculture	199.00	Mg C ha^{-1}
Elwin et al., 2019	Thailand	Mangrove	Biota AGB	Storage	Natural	84.76	Mg C ha^{-1}
Elwin et al., 2019	Thailand	Mangrove	Biota AGB + BGB	Storage	Aquaculture	17.22	Mg C ha^{-1}
Elwin et al., 2019	Thailand	Mangrove	Biota AGB + BGB	Storage	Aquaculture	30.61	Mg C ha^{-1}
Elwin et al., 2019	Thailand	Mangrove	Biota AGB + BGB	Storage	Natural	34.31	Mg C ha^{-1}

Elwin et al., 2019	Thailand	Mangrove	Sediment	Storage	Natural	944.72	Mg C ha^{-1}
Elwin et al., 2019	Thailand	Mangrove	Sediment	Storage	Aquaculture	550.78	Mg C ha^{-1}
Elwin et al., 2019	Thailand	Mangrove	Sediment	Storage	Aquaculture	303.99	Mg C ha^{-1}
Howe et al., 2009	Australia	Mangrove	Sediment	Storage	Agriculture, development	57.31	Mg C ha^{-1}
Howe et al., 2009	Australia	Mangrove	Sediment	Sequestration	Agriculture, development	1.05	Mg C ha^{-1} y^{-1}
Howe et al., 2009	Australia	Mangrove	Sediment	Storage	Natural	94.20	Mg C ha^{-1}
Howe et al., 2009	Australia	Mangrove	Sediment	Sequestration	Natural	0.89	Mg C ha^{-1} y^{-1}
IPCC, 2013	Global	Mangrove	Sediment	Storage	Natural	55.00	Mg C ha^{-1}
IPCC, 2013	Global	Mangrove	Sediment	Storage	Natural	1376.00	Mg C ha^{-1}
Jin et al., 2013	China	Mangrove	Biota	Sequestration	Natural	18.51	Mg C ha^{-1} y^{-1}
Jin et al., 2013	China	Mangrove	Biota	Sequestration	Natural	7.01	Mg C ha^{-1} y^{-1}
Jonsson & Hedman, 2019	Sri Lanka	Mangrove	Sediment	Storage	Aquaculture	1009.00	Mg C ha^{-1}
Jonsson & Hedman, 2019	Sri Lanka	Mangrove	AGB	Storage	Production (small scale)	9.00	Mg C ha^{-1}
Jonsson & Hedman, 2019	Sri Lanka	Mangrove	Sediment	Storage	Natural	17.00	Mg C ha^{-1}
Kauffman et al., 2014	Dominican Republic	Mangrove	Sediment	Storage	Natural	1084.00	Mg C ha^{-1}
Kauffman et al., 2014	Dominican Republic	Mangrove	Sediment	Storage	Natural	713.00	Mg C ha^{-1}
Kauffman et al., 2014	Dominican Republic	Mangrove	Sediment	Storage	Aquaculture	95.00	Mg C ha^{-1}
Kauffman et al., 2014	Dominican Republic	Mangrove	Biota AGB + BGB	Storage	Natural	161.00	Mg C ha^{-1}
Kauffman et al., 2014	Dominican Republic	Mangrove	Biota AGB + BGB	Storage	Natural	47.00	Mg C ha^{-1}
Kauffman et al., 2014	Dominican Republic	Mangrove	Biota AGB + BGB	Storage	Natural	10.00	Mg C ha^{-1}

Kauffman et al., 2014	Dominican Republic	Mangrove	Biota AGB + BGB	Storage	Aquaculture	0.00	Mg C ha^{-1}
Kauffman et al., 2014	Dominican Republic	Mangrove	Sediment	Storage	Natural	546.00	Mg C ha^{-1}
Kroeger et al., 2017	Global	Mangrove	Biota	Sequestration	Natural	1.62	Mg C ha^{-1} y^{-1}
Lewis et al., 2018	Australia	Mangrove	Sediment	Storage	Natural	62.60	Mg C ha^{-1}
Lewis et al., 2018	Australia	Mangrove	Sediment	Storage	Natural	84.30	Mg C ha^{-1}
Lewis et al., 2018	Australia	Mangrove	Sediment	Storage	Natural	50.70	Mg C ha^{-1}
Lewis et al., 2018	Australia	Mangrove	Sediment	Storage	Natural	31.48	Mg C ha^{-1}
Lovelock et al., 2014	Australia	Mangrove	Sediment	Sequestration	Natural	0.76	Mg C ha^{-1} y^{-1}
Mcleod et al., 2011	Global	Mangrove	Sediment	Sequestration	Natural	0.20	Mg C ha^{-1} y^{-1}
Mcleod et al., 2011	Global	Mangrove	Sediment	Sequestration	Natural	9.49	Mg C ha^{-1} y^{-1}
Meng et al., 2019	China	Mangrove	Sediment	Storage	Natural	344.67	Mg C ha^{-1}
Meng et al., 2019	China	Mangrove	Sediment	Sequestration	Natural	2.26	Mg C ha^{-1} y^{-1}
Meng et al., 2019	China	Mangrove	Biota AGB	Storage	Natural	253.98	Mg C ha^{-1}
Meng et al., 2019	China	Mangrove	Biota BGB	Storage	Natural	83.96	Mg C ha^{-1}
Merecí-Guamán et al., 2021	Ecuador	Mangrove	Biota AGB	Storage	Natural	73.62	Mg C ha^{-1}
Merecí-Guamán et al., 2021	Ecuador	Mangrove	Biota AGB	Storage	Natural	192.20	Mg C ha^{-1}
Merecí-Guamán et al., 2021	Ecuador	Mangrove	Sediment	Storage	Natural	220.57	Mg C ha^{-1}
Merecí-Guamán et al., 2021	Ecuador	Mangrove	Sediment	Storage	Natural	352.51	Mg C ha^{-1}
Merecí-Guamán et al., 2021	Ecuador	Mangrove	Sediment	Storage	Natural	168.19	Mg C ha^{-1}
Merecí-Guamán et al., 2021	Ecuador	Mangrove	Sediment	Storage	Natural	286.39	Mg C ha^{-1}
Merecí-Guamán et al., 2021	Ecuador	Mangrove	Sediment	Storage	Aquaculture	81.91	Mg C ha^{-1}

Merecí-Guamán et al., 2021	Ecuador	Mangrove	Sediment	Storage	Aquaculture	126.98	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	778.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	1223.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	936.70	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	1074.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	914.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	948.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	430.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	713.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	657.40	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	622.50	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	684.10	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	643.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	495.50	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	642.40	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	600.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	943.50	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	813.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	1049.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	1234.50	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	1255.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	283.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	560.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	629.40	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	2063.70	Mg C ha^{-1}

Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	682.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	650.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	706.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	687.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	282.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	965.10	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	1064.70	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	920.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	1324.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	894.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	869.70	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	922.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	756.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	1157.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Sediment	Storage	Natural	1023.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	383.50	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	279.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	418.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	255.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	219.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	245.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	1.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	12.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	152.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	113.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	68.40	Mg C ha^{-1}

Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	38.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	133.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	189.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	248.70	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	70.70	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	169.40	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	207.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	86.50	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	170.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	33.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	48.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	60.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	109.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	58.50	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	105.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	292.10	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	313.10	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	110.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	69.10	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	317.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	436.10	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	306.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	279.40	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	278.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	146.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	266.20	Mg C ha^{-1}

Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	147.50	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota AGB	Storage	Natural	460.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	33.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	2707.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	30.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	29.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	24.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	21.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	0.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	4.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	9.40	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	18.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	12.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	5.10	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	15.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	15.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	23.70	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	10.40	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	10.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	21.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	23.50	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	40.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	5.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	4.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	29.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	12.50	Mg C ha^{-1}

Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	26.70	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	10.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	60.00	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	42.80	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	26.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	17.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	25.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	73.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	35.30	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	51.60	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	32.20	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	28.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	42.10	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	8.90	Mg C ha^{-1}
Murdiyarso et al., 2015	Indonesia	Mangrove	Biota BGB	Storage	Natural	28.70	Mg C ha^{-1}
Mutiatari et al., 2018	Indonesia	Mangrove	Sediment	Storage	Natural	79.60	Mg C ha^{-1}
Mutiatari et al., 2018	Indonesia	Mangrove	Sediment	Storage	Aquaculture	57.66	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	71.80	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	34.20	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	59.00	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	47.30	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	102.00	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	53.90	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	74.70	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	82.90	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	73.30	Mg C ha^{-1}

Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	42.60	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	22.80	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	210.70	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	13.40	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	40.70	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota AGB	Storage	Natural	60.50	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	4.90	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	6.90	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	17.30	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	3.50	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	15.10	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	4.40	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	9.50	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	12.60	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	9.00	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	15.20	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	5.60	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	20.70	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	3.40	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	7.20	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Biota BGB	Storage	Natural	14.20	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Sediment	Storage	Natural	467.72	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Sediment	Storage	Natural	548.62	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Sediment	Storage	Natural	541.15	Mg C ha^{-1}
Nam et al., 2016	Vietnam	Mangrove	Sediment	Storage	Natural	169.73	Mg C ha^{-1}
Owers et al., 2013	Australia	Mangrove	Sediment	Storage	Natural	88.50	Mg C ha^{-1}

Owers et al., 2013	Australia	Mangrove	Sediment	Storage	Natural	79.20	Mg C ha^{-1}
Owers et al., 2013	Australia	Mangrove	Sediment	Storage	Natural	74.50	Mg C ha^{-1}
Perez et al, 2018	Global	Mangrove	Sediment	Sequestration	Natural	9.00	Mg C ha^{-1} y^{-1}
Pérez et al., 2020	Peru	Mangrove	Sediment	Sequestration	Natural	1.93	Mg C ha^{-1} y^{-1}
Pérez et al., 2020	Peru	Mangrove	Sediment	Sequestration	Pollution	4.03	Mg C ha^{-1} y^{-1}
Rovai et al., 2021	Brazil	Mangrove	Biota AGB	Storage	Natural	75.30	Mg C ha^{-1}
Rovai et al., 2021	Brazil	Mangrove	Biota BGB	Storage	Natural	81.90	Mg C ha^{-1}
Rovai et al., 2021	Brazil	Mangrove	Sediment	Storage	Natural	248.80	Mg C ha^{-1}
Rovai et al., 2021	Brazil	Mangrove	Biota AGB	Sequestration	Natural	4.64	Mg C ha^{-1} y^{-1}
Rovai et al., 2021	Brazil	Mangrove	Biota AGB	Storage	Natural	30.20	Mg C ha^{-1}
Rovai et al., 2021	Brazil	Mangrove	Biota BGB	Storage	Natural	32.80	Mg C ha^{-1}
Rovai et al., 2021	Brazil	Mangrove	Sediment	Sequestration	Natural	2.64	Mg C ha^{-1} y^{-1}
Rovai et al., 2021	Brazil	Mangrove	Sediment	Sequestration	Natural	3.02	Mg C ha^{-1} y^{-1}
Saintilan et al., 2013	Australia	Mangrove	Sediment	Storage	Natural	343.00	Mg C ha^{-1}
Saintilan et al., 2013	Australia	Mangrove	Sediment	Storage	Natural	285.00	Mg C ha^{-1}
Saintilan et al., 2013	Australia	Mangrove	Sediment	Storage	Natural	261.00	Mg C ha^{-1}
Saintilan et al., 2013	Australia	Mangrove	Sediment	Storage	Natural	241.00	Mg C ha^{-1}
Saintilan et al., 2013	Australia	Mangrove	Sediment	Storage	Natural	25.20	Mg C ha^{-1}
Saptoka & White, 2020	Global	Mangrove	Sediment	Sequestration	Natural	1.72	Mg C ha^{-1} y^{-1}
Sasmito et al., 2020a	Indonesia	Mangrove	Sediment	Storage	Natural	179.00	Mg C ha^{-1}
Sasmito et al., 2020a	Indonesia	Mangrove	Sediment	Storage	Natural	68.00	Mg C ha^{-1}
Sasmito et al., 2020a	Indonesia	Mangrove	Sediment	Sequestration	Natural	0.50	Mg C ha^{-1} y^{-1}
Sasmito et al., 2020a	Indonesia	Mangrove	Sediment	Sequestration	Natural	0.90	Mg C ha^{-1} y^{-1}
Sasmito et al., 2020b	Indonesia	Mangrove	Biota AGB	Storage	Natural	96.00	Mg C ha^{-1}
Sasmito et al., 2020b	Indonesia	Mangrove	Biota BGB	Storage	Natural	17.00	Mg C ha^{-1}

Schile et al., 2017	UAE	Mangrove	Sediment	Storage	Natural	36.70	Mg C ha^{-1}
Schile et al., 2017	UAE	Mangrove	Sediment	Storage	Natural	367.00	Mg C ha^{-1}
Schile et al., 2017	UAE	Mangrove	Biota AGB	Storage	Natural	3.50	Mg C ha^{-1}
Schile et al., 2017	UAE	Mangrove	Biota AGB	Storage	Natural	116.90	Mg C ha^{-1}
Schile et al., 2017	UAE	Mangrove	Biota BGB	Storage	Natural	3.80	Mg C ha^{-1}
Schile et al., 2017	UAE	Mangrove	Biota BGB	Storage	Natural	51.10	Mg C ha^{-1}
Schile et al., 2017	UAE	Tidal salt marshes	Sediment	Storage	Natural	29.50	Mg C ha^{-1}
Schile et al., 2017	UAE	Tidal salt marshes	Sediment	Storage	Natural	163.70	Mg C ha^{-1}
Schile et al., 2017	UAE	Tidal salt marshes	Biota AGB	Storage	Natural	1.00	Mg C ha^{-1}
Schile et al., 2017	UAE	Tidal salt marshes	Biota AGB	Storage	Natural	3.80	Mg C ha^{-1}
Schile et al., 2017	UAE	Tidal salt marshes	Biota BGB	Storage	Natural	0.90	Mg C ha^{-1}
Schile et al., 2017	UAE	Tidal salt marshes	Biota BGB	Storage	Natural	3.40	Mg C ha^{-1}
Serrano et al., 2019	Australia	Mangrove	Sediment	Sequestration	Natural	1.26	Mg C ha^{-1} y^{-1}
Serrano et al., 2019	Australia	Mangrove	Sediment	Storage	Natural	251.00	Mg C ha^{-1}
Serrano et al., 2019	Australia	Mangrove	Sediment	Storage	Natural	168.00	Mg C ha^{-1}
Serrano et al., 2019	Australia	Mangrove	Biota AGB	Storage	Natural	125.00	Mg C ha^{-1}
Simpson et al., 2019	USA	Mangrove	Biota AGB	Storage	Natural	85.10	Mg C ha^{-1}
Simpson et al., 2019	USA	Mangrove	Biota BGB	Storage	Natural	114.00	Mg C ha^{-1}
Simpson et al., 2019	USA	Mangrove	Sediment	Storage	Natural	182.00	Mg C ha^{-1}
Simpson et al., 2019	USA	Mangrove	Biota AGB	Storage	Natural	62.30	Mg C ha^{-1}
Simpson et al., 2019	USA	Mangrove	Biota BGB	Storage	Natural	84.90	Mg C ha^{-1}
Simpson et al., 2019	USA	Mangrove	Sediment	Storage	Natural	141.00	Mg C ha^{-1}

Suárez-Abelenda et al., 2014	Brazil	Mangrove	Sediment	Storage	Natural	81.00	Mg C ha^{-1}
Suárez-Abelenda et al., 2014	Brazil	Mangrove	Sediment	Storage	Natural	67.00	Mg C ha^{-1}
Suárez-Abelenda et al., 2014	Brazil	Mangrove	Sediment	Storage	Natural	87.00	Mg C ha^{-1}
Suárez-Abelenda et al., 2014	Brazil	Mangrove	Sediment	Storage	Pollution	38.00	Mg C ha^{-1}
Suárez-Abelenda et al., 2014	Brazil	Mangrove	Sediment	Storage	Pollution	29.00	Mg C ha^{-1}
Tian et al., 2019	China	Mangrove	Sediment	Storage	Natural	70.75	Mg C ha^{-1}
Tian et al., 2019	China	Mangrove	Sediment	Storage	Pollution	80.44	Mg C ha^{-1}
Tinh et al., 2020	Vietnam	Mangrove	Sediment	Storage	Natural	300.68	Mg C ha^{-1}
Tinh et al., 2020	Vietnam	Mangrove	Sediment	Storage	Natural	289.75	Mg C ha^{-1}
Tinh et al., 2020	Vietnam	Mangrove	Sediment	Storage	Natural	255.67	Mg C ha^{-1}
Tinh et al., 2020	Vietnam	Mangrove	Sediment	Storage	Natural	278.15	Mg C ha^{-1}
Tinh et al., 2020	Vietnam	Mangrove	Sediment	Storage	Natural	174.04	Mg C ha^{-1}
Tinh et al., 2020	Vietnam	Mangrove	Sediment	Storage	Natural	323.89	Mg C ha^{-1}
Tinh et al., 2020	Vietnam	Mangrove	Sediment	Storage	Natural	201.42	Mg C ha^{-1}
Tinh et al., 2020	Vietnam	Mangrove	Sediment	Storage	Natural	249.81	Mg C ha^{-1}
Tinh et al., 2020	Vietnam	Mangrove	Sediment	Storage	Natural	178.98	Mg C ha^{-1}
Tue et al., 2014	Vietnam	Mangrove	Sediment	Storage	Natural	584.20	Mg C ha^{-1}
Tue et al., 2014	Vietnam	Mangrove	Sediment	Storage	Natural	655.60	Mg C ha^{-1}
Tue et al., 2014	Vietnam	Mangrove	Biota BGB	Storage	Natural	44.90	Mg C ha^{-1}
Tue et al., 2014	Vietnam	Mangrove	Biota BGB	Storage	Natural	27.10	Mg C ha^{-1}
Tue et al., 2014	Vietnam	Mangrove	Biota BGB	Storage	Natural	32.00	Mg C ha^{-1}
Tue et al., 2014	Vietnam	Mangrove	Biota AGB	Storage	Natural	90.20	Mg C ha^{-1}
Tue et al., 2014	Vietnam	Mangrove	Biota AGB	Storage	Natural	109.20	Mg C ha^{-1}

Tue et al., 2014	Vietnam	Mangrove	Biota AGB	Storage	Natural	115.20	Mg C ha^{-1}
Tue et al., 2014	Vietnam	Mangrove	Sediment	Storage	Natural	629.00	Mg C ha^{-1}
van Oudenhoven et al., 2015	Indonesia	Mangrove	Sediment, biota	Storage	Agriculture	90.00	Mg C ha^{-1}
van Oudenhoven et al., 2015	Indonesia	Mangrove	Sediment, biota	Storage	Aquaculture	40.00	Mg C ha^{-1}
Wang et al., 2021	China	Mangrove	Sediment	Storage	Natural	8.80	Mg C ha^{-1}
Wang et al., 2021	China	Mangrove	Sediment	Storage	Natural	16.15	Mg C ha^{-1}
Wang et al., 2021	China	Mangrove	Sediment	Storage	Natural	7.24	Mg C ha^{-1}
Wang et al., 2021	China	Mangrove	Sediment	Storage	Natural	21.94	Mg C ha^{-1}
Wang et al., 2021	China	Mangrove	Sediment	Storage	Natural	27.01	Mg C ha^{-1}
Wang et al., 2021	China	Mangrove	Sediment	Storage	Natural	19.01	Mg C ha^{-1}
Wang et al., 2021	China	Mangrove	Sediment	Storage	Natural	43.31	Mg C ha^{-1}
Watson & Corona, 2017	Mexico	Mangrove	Sediment	Sequestration	Natural	0.73	Mg C ha^{-1} y^{-1}
Yando et al., 2016	USA	Mangrove	Biota AGB	Storage	Natural	63.87	Mg C ha^{-1}
Yando et al., 2016	USA	Mangrove	Biota AGB	Storage	Natural	14.76	Mg C ha^{-1}
Yando et al., 2016	USA	Mangrove	Biota AGB	Storage	Natural	13.05	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Biota AGB	Storage	Alien invasive	0.59	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Biota AGB	Storage	Alien invasive	44.40	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Biota AGB	Storage	Alien invasive	69.29	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Biota AGB	Storage	Alien invasive	92.17	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Biota AGB	Storage	Natural	91.24	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Biota BGB	Storage	Alien invasive	0.06	Mg C ha^{-1}

Yu et al., 2020	China	Mangrove	Biota BGB	Storage	Alien invasive	9.83	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Biota BGB	Storage	Alien invasive	17.04	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Biota BGB	Storage	Alien invasive	20.96	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Biota BGB	Storage	Natural	24.40	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Sediment	Storage	Alien invasive	77.09	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Sediment	Storage	Alien invasive	81.62	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Sediment	Storage	Alien invasive	85.20	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Sediment	Storage	Alien invasive	101.20	Mg C ha^{-1}
Yu et al., 2020	China	Mangrove	Sediment	Sequestration	Alien invasive	13.41	Mg C ha^{-1} y^{-1}
Yu et al., 2020	China	Mangrove	Sediment	Sequestration	Alien invasive	6.14	Mg C ha^{-1} y^{-1}
Yu et al., 2020	China	Mangrove	Sediment	Sequestration	Alien invasive	4.71	Mg C ha^{-1} y^{-1}
Zhang et al., 2013	China	Mangrove	Biota	Sequestration	Natural	2.09	Mg C ha^{-1} y^{-1}
Zhang et al., 2013	China	Mangrove	Biota	Sequestration	Natural	6.61	Mg C ha^{-1} y^{-1}
Duarte et al., 2013	Global	Mangrove	Biota	Sequestration	Natural	1.63	Mg C ha^{-1} y^{-1}
Duarte et al., 2013	Global	Mangrove	Sediment	Storage	Natural	255.00	Mg C ha^{-1}
Abbott et al., 2019	USA	Tidal salt marshes	Sediment	Sequestration	Natural	2.34	Mg C ha^{-1} y^{-1}
González-Alcaraz et al., 2012	Spain	Tidal salt marshes	Sediment	Storage	Pollution	11.00	Mg C ha^{-1}
González-Alcaraz et al., 2012	Spain	Tidal salt marshes	Sediment	Storage	Pollution	14.30	Mg C ha^{-1}
González-Alcaraz et al., 2012	Spain	Tidal salt marshes	Sediment	Storage	Pollution	6.80	Mg C ha^{-1}

González-Alcaraz et al., 2012	Spain	Tidal salt marshes	Sediment	Storage	Pollution	13.20	Mg C ha^{-1}
González-Alcaraz et al., 2012	Spain	Tidal salt marshes	Sediment	Storage	Pollution	16.90	Mg C ha^{-1}
González-Alcaraz et al., 2012	Spain	Tidal salt marshes	Sediment	Storage	Pollution	10.00	Mg C ha^{-1}
Gulliver et al., 2020	Australia	Tidal salt marshes	Sediment	Storage	Salt works	79.51	Mg C ha^{-1}
Gulliver et al., 2020	Australia	Tidal salt marshes	Sediment	Sequestration	Salt works	0.00	Mg C ha^{-1} y^{-1}
Howe et al., 2009	Australia	Tidal salt marshes	Sediment	Storage	Agriculture, development	81.21	Mg C ha^{-1}
Howe et al., 2009	Australia	Tidal salt marshes	Sediment	Sequestration	Agriculture, development	1.37	Mg C ha^{-1} y^{-1}
Howe et al., 2009	Australia	Tidal salt marshes	Sediment	Storage	Natural	129.20	Mg C ha^{-1}
Howe et al., 2009	Australia	Tidal salt marshes	Sediment	Sequestration	Natural	0.64	Mg C ha^{-1} y^{-1}
IPCC, 2013	Global	Tidal salt marshes	Sediment	Storage	Natural	16.00	Mg C ha^{-1}
IPCC, 2013	Global	Tidal salt marshes	Sediment	Storage	Natural	623.00	Mg C ha^{-1}
Kroeger et al., 2017	Global	Tidal salt marshes	Biota	Sequestration	Natural	0.91	Mg C ha^{-1} y^{-1}
Lewis et al., 2019	Australia	Tidal salt marshes	Sediment	Storage	Natural	104.80	Mg C ha^{-1}
Lewis et al., 2019	Australia	Tidal salt marshes	Sediment	Storage	Natural	63.17	Mg C ha^{-1}
Lewis et al., 2019	Australia	Tidal salt marshes	Sediment	Storage	Natural	31.90	Mg C ha^{-1}
Lewis et al., 2019	Australia	Tidal salt marshes	Sediment	Storage	Reclamation	45.50	Mg C ha^{-1}
Lewis et al., 2019	Australia	Tidal salt marshes	Sediment	Storage	Reclamation	149.60	Mg C ha^{-1}

Lewis et al., 2019	Australia	Tidal salt marshes	Sediment	Storage	Natural	149.19	Mg C ha^{-1}
Lewis et al., 2018	Australia	Tidal salt marshes	Sediment	Storage	Natural	84.44	Mg C ha^{-1}
Lewis et al., 2018	Australia	Tidal salt marshes	Sediment	Storage	Natural	85.18	Mg C ha^{-1}
Lewis et al., 2018	Australia	Tidal salt marshes	Sediment	Storage	Natural	104.95	Mg C ha^{-1}
Lewis et al., 2018	Australia	Tidal salt marshes	Sediment	Storage	Natural	62.02	Mg C ha^{-1}
Lewis et al., 2018	Australia	Tidal salt marshes	Sediment	Storage	Natural	101.59	Mg C ha^{-1}
Li et al., 2018	China	Tidal salt marshes	Sediment	Storage	Agriculture	29.10	Mg C ha^{-1}
Li et al., 2018	China	Tidal salt marshes	Sediment	Storage	Natural	15.60	Mg C ha^{-1}
Li et al., 2018	China	Tidal salt marshes	Sediment	Storage	Agriculture	28.30	Mg C ha^{-1}
Li et al., 2018	China	Tidal salt marshes	Sediment	Storage	Aquaculture	16.60	Mg C ha^{-1}
Li et al., 2014	China	Tidal salt marshes	Sediment	Storage	Natural	3.44	Mg C ha^{-1}
Li et al., 2014	China	Tidal salt marshes	Sediment	Storage	Alien invasive	10.49	Mg C ha^{-1}
Li et al., 2014	China	Tidal salt marshes	Sediment	Storage	Natural	5.83	Mg C ha^{-1}
Li et al., 2014	China	Tidal salt marshes	Biota AGB	Storage	Natural	3.06	Mg C ha^{-1}
Li et al., 2014	China	Tidal salt marshes	Biota AGB	Storage	Alien invasive	21.26	Mg C ha^{-1}
Li et al., 2014	China	Tidal salt marshes	Biota AGB	Storage	Natural	21.34	Mg C ha^{-1}
Lovelock et al., 2014	Australia	Tidal salt marshes	Sediment	Sequestration	Natural	0.09	Mg C ha^{-1} y^{-1}

Macreadie et al., 2017	Australia	Tidal salt marshes	Sediment	Storage	Natural	188.30	Mg C ha^{-1}
Macreadie et al., 2017	Australia	Tidal salt marshes	Sediment	Storage	Natural	186.26	Mg C ha^{-1}
Macreadie et al., 2017	Australia	Tidal salt marshes	Sediment	Storage	Natural	169.78	Mg C ha^{-1}
Macreadie et al., 2017	Australia	Tidal salt marshes	Sediment	Storage	Natural	139.06	Mg C ha^{-1}
Macreadie et al., 2017	Australia	Tidal salt marshes	Sediment	Storage	Natural	91.25	Mg C ha^{-1}
Macreadie et al., 2017	Australia	Tidal salt marshes	Sediment	Sequestration	Natural	0.55	Mg C ha^{-1} y^{-1}
Mcleod et al., 2011	Global	Tidal salt marshes	Sediment	Sequestration	Natural	0.18	Mg C ha^{-1} y^{-1}
Mcleod et al., 2011	Global	Tidal salt marshes	Sediment	Sequestration	Natural	17.13	Mg C ha^{-1} y^{-1}
Meng et al., 2019	China	Tidal salt marshes	Sediment	Storage	Natural	134.37	Mg C ha^{-1}
Meng et al., 2019	China	Tidal salt marshes	Sediment	Sequestration	Natural	2.18	Mg C ha^{-1} y^{-1}
Meng et al., 2019	China	Tidal salt marshes	Biota AGB	Storage	Natural	8.82	Mg C ha^{-1}
Meng et al., 2019	China	Tidal salt marshes	Biota BGB	Storage	Natural	9.95	Mg C ha^{-1}
Owers et al., 2013	Australia	Tidal salt marshes	Sediment	Storage	Natural	41.70	Mg C ha^{-1}
Owers et al., 2013	Australia	Tidal salt marshes	Sediment	Storage	Natural	55.10	Mg C ha^{-1}
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	0.58	Mg C ha^{-1} y^{-1}
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	0.59	Mg C ha^{-1} y^{-1}
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	0.69	Mg C ha^{-1} y^{-1}

Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	0.19	$Mg\ C\ ha^{-1}\ y^{-1}$
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	0.45	$Mg\ C\ ha^{-1}\ y^{-1}$
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	0.42	$Mg\ C\ ha^{-1}\ y^{-1}$
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	0.43	$Mg\ C\ ha^{-1}\ y^{-1}$
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	1.60	$Mg\ C\ ha^{-1}\ y^{-1}$
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	1.50	$Mg\ C\ ha^{-1}\ y^{-1}$
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	1.20	$Mg\ C\ ha^{-1}\ y^{-1}$
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	1.60	$Mg\ C\ ha^{-1}\ y^{-1}$
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	1.30	$Mg\ C\ ha^{-1}\ y^{-1}$
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	0.94	$Mg\ C\ ha^{-1}\ y^{-1}$
Peck et al., 2020	USA	Tidal salt marshes	Sediment	Sequestration	Natural	0.60	$Mg\ C\ ha^{-1}\ y^{-1}$
Ridge et al., 2019	USA	Tidal salt marshes	Sediment	Storage	Natural	125.00	$Mg\ C\ ha^{-1}$
Ridge et al., 2019	USA	Tidal salt marshes	Sediment	Storage	Natural	3.82	$Mg\ C\ ha^{-1}$
Ridge et al., 2019	USA	Tidal salt marshes	Sediment	Storage	Natural	97.20	$Mg\ C\ ha^{-1}$
Roughan et al., 2018	Canada	Tidal salt marshes	Sediment	Sequestration	Pollution	0.95	$Mg\ C\ ha^{-1}\ y^{-1}$
Roughan et al., 2018	Canada	Tidal salt marshes	Sediment	Sequestration	Pollution	0.95	$Mg\ C\ ha^{-1}\ y^{-1}$
Roughan et al., 2018	Canada	Tidal salt marshes	Sediment	Sequestration	Pollution	0.95	$Mg\ C\ ha^{-1}\ y^{-1}$

Roughan et al., 2018	Canada	Tidal salt marshes	Sediment	Sequestration	Pollution	0.95	Mg C ha^{-1} y^{-1}
Roughan et al., 2018	Canada	Tidal salt marshes	Sediment	Sequestration	Natural	1.02	Mg C ha^{-1} y^{-1}
Saintilan et al., 2013	Australia	Tidal salt marshes	Sediment	Storage	Natural	343.00	Mg C ha^{-1}
Saintilan et al., 2013	Australia	Tidal salt marshes	Sediment	Storage	Natural	311.00	Mg C ha^{-1}
Saintilan et al., 2013	Australia	Tidal salt marshes	Sediment	Storage	Natural	130.00	Mg C ha^{-1}
Saintilan et al., 2013	Australia	Tidal salt marshes	Sediment	Storage	Natural	110.00	Mg C ha^{-1}
Saintilan et al., 2013	Australia	Tidal salt marshes	Sediment	Storage	Natural	61.20	Mg C ha^{-1}
Saptoka & White, 2020	Global	Tidal salt marshes	Biota	Sequestration	Natural	2.18	Mg C ha^{-1} y^{-1}
Serrano et al., 2019	Australia	Tidal salt marshes	Sediment	Sequestration	Natural	0.39	Mg C ha^{-1} y^{-1}
Serrano et al., 2019	Australia	Tidal salt marshes	Biota AGB	Storage	Natural	7.50	Mg C ha^{-1}
Simpson et al., 2019	USA	Tidal salt marshes	Sediment	Storage	Natural	124.00	Mg C ha^{-1}
Simpson et al., 2019	USA	Tidal salt marshes	Biota AGB	Storage	Natural	2.06	Mg C ha^{-1}
Simpson et al., 2019	USA	Tidal salt marshes	Biota BGB	Storage	Natural	0.00	Mg C ha^{-1}
Smith, 2012	USA	Tidal salt marshes	Sediment	Sequestration	Natural	1.08	Mg C ha^{-1} y^{-1}
Sondak & Chung, 2015	Korea	Tidal salt marshes	Sediment	Sequestration	Natural	1.51	Mg C ha^{-1} y^{-1}
Sousa et al., 2017	Portugal	Tidal salt marshes	Sediment	Sequestration	Natural	1.20	Mg C ha^{-1} y^{-1}
Sousa et al., 2017	Portugal	Tidal salt marshes	Sediment	Sequestration	Natural	1.33	Mg C ha^{-1} y^{-1}

Sousa et al., 2017	Portugal	Tidal salt marshes	Sediment	Sequestration	Natural	1.57	Mg C ha^{-1} y^{-1}
Sousa et al., 2017	Portugal	Tidal salt marshes	Sediment	Sequestration	Natural	1.52	Mg C ha^{-1} y^{-1}
Sousa et al., 2017	Portugal	Tidal salt marshes	Sediment	Sequestration	Natural	1.83	Mg C ha^{-1} y^{-1}
Sousa et al., 2017	Portugal	Tidal salt marshes	Biota AGB + BGB	Storage	Natural	0.13	Mg C ha^{-1}
Sousa et al., 2017	Portugal	Tidal salt marshes	Biota AGB + BGB	Storage	Natural	0.48	Mg C ha^{-1}
Sousa et al., 2017	Portugal	Tidal salt marshes	Biota AGB + BGB	Storage	Natural	0.44	Mg C ha^{-1}
Sousa et al., 2017	Portugal	Tidal salt marshes	Biota AGB + BGB	Storage	Natural	0.35	Mg C ha^{-1}
Sousa et al., 2017	Portugal	Tidal salt marshes	Biota AGB + BGB	Storage	Natural	0.36	Mg C ha^{-1}
van de Broek et al., 2019	Netherlands	Tidal salt marshes	Sediment	Storage	Natural	147.60	Mg C ha^{-1}
van de Broek et al., 2019	Netherlands	Tidal salt marshes	Sediment	Storage	Natural	92.30	Mg C ha^{-1}
van de Broek et al., 2019	Netherlands	Tidal salt marshes	Sediment	Storage	Natural	144.10	Mg C ha^{-1}
van de Broek et al., 2019	Netherlands	Tidal salt marshes	Sediment	Storage	Natural	125.40	Mg C ha^{-1}
van de Broek et al., 2019	Netherlands	Tidal salt marshes	Sediment	Storage	Reclamation	61.00	Mg C ha^{-1}
van de Broek et al., 2019	Netherlands	Tidal salt marshes	Sediment	Storage	Reclamation	44.10	Mg C ha^{-1}
van de Broek et al., 2019	Netherlands	Tidal salt marshes	Sediment	Storage	Reclamation	54.50	Mg C ha^{-1}
van de Broek et al., 2019	Netherlands	Tidal salt marshes	Sediment	Storage	Reclamation	63.40	Mg C ha^{-1}
Wang et al., 2014	China	Tidal salt marshes	Biota	Sequestration	Natural	10.20	Mg C ha^{-1} y^{-1}

Wang et al., 2014	China	Tidal salt marshes	Biota	Sequestration	Natural	13.20	Mg C ha^{-1} y^{-1}
Wang et al., 2014	China	Tidal salt marshes	Biota	Sequestration	Natural	3.30	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	0.17	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	0.46	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	4.50	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.26	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	0.56	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	9.73	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	13.37	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	5.40	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.74	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.78	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	0.13	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	0.22	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	5.93	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.40	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	0.63	Mg C ha^{-1} y^{-1}

Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	12.77	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	15.69	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.72	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.89	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	8.56	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Storage	Natural	3.74	Mg C ha^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Storage	Natural	3.67	Mg C ha^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Storage	Natural	6.29	Mg C ha^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Storage	Natural	5.15	Mg C ha^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Storage	Natural	10.53	Mg C ha^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Storage	Natural	3.96	Mg C ha^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Storage	Natural	6.31	Mg C ha^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Storage	Natural	13.79	Mg C ha^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Storage	Natural	5.68	Mg C ha^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Storage	Natural	3.82	Mg C ha^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	0.19	Mg C ha^{-1} y^{-1}
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	0.22	Mg C ha^{-1} y^{-1}

Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.60	$Mg\ C\ ha^{-1}\ y^{-1}$
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.21	$Mg\ C\ ha^{-1}\ y^{-1}$
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	0.49	$Mg\ C\ ha^{-1}\ y^{-1}$
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	6.03	$Mg\ C\ ha^{-1}\ y^{-1}$
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.90	$Mg\ C\ ha^{-1}\ y^{-1}$
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.40	$Mg\ C\ ha^{-1}\ y^{-1}$
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	3.68	$Mg\ C\ ha^{-1}\ y^{-1}$
Ward, 2020	Norway	Tidal salt marshes	Sediment	Sequestration	Natural	1.59	$Mg\ C\ ha^{-1}\ y^{-1}$
Xia et al., 2021	China	Tidal salt marshes	Sediment	Storage	Natural	71.00	$Mg\ C\ ha^{-1}$
Xia et al., 2021	China	Tidal salt marshes	Sediment	Storage	Invasive species	75.00	$Mg\ C\ ha^{-1}$
Xia et al., 2021	China	Tidal salt marshes	Sediment	Storage	Natural	54.00	$Mg\ C\ ha^{-1}$
Xia et al., 2021	China	Tidal salt marshes	Sediment	Storage	Invasive species	40.00	$Mg\ C\ ha^{-1}$
Xia et al., 2021	China	Tidal salt marshes	Sediment	Storage	Natural	50.00	$Mg\ C\ ha^{-1}$
Xia et al., 2021	China	Tidal salt marshes	Sediment	Storage	Invasive species	46.00	$Mg\ C\ ha^{-1}$
Yando et al., 2016	USA	Tidal salt marshes	Biota AGB	Storage	Natural	2.36	$Mg\ C\ ha^{-1}$
Yando et al., 2016	USA	Tidal salt marshes	Biota AGB	Storage	Natural	3.40	$Mg\ C\ ha^{-1}$
Yando et al., 2016	USA	Tidal salt marshes	Biota AGB	Storage	Natural	0.11	$Mg\ C\ ha^{-1}$

Yim et al., 2018	China, North & South Korea	Tidal salt marshes	Sediment	Storage	Reclamation	6.48	Mg C ha^{-1}
Yim et al., 2018	China, North & South Korea	Tidal salt marshes	Sediment	Storage	Reclamation	6.22	Mg C ha^{-1}
Yim et al., 2018	China, North & South Korea	Tidal salt marshes	Sediment	Storage	Reclamation	9.81	Mg C ha^{-1}
Yim et al., 2018	China, North & South Korea	Tidal salt marshes	Sediment	Storage	Reclamation	13.02	Mg C ha^{-1}
Yim et al., 2018	China, North & South Korea	Tidal salt marshes	Sediment	Storage	Reclamation	8.81	Mg C ha^{-1}
Yim et al., 2018	China, North & South Korea	Tidal salt marshes	Sediment	Storage	Reclamation	26.98	Mg C ha^{-1}
Yim et al., 2018	China, North & South Korea	Tidal salt marshes	Sediment	Storage	Reclamation	8.78	Mg C ha^{-1}
Yim et al., 2018	China, North & South Korea	Tidal salt marshes	Sediment	Storage	Reclamation	7.14	Mg C ha^{-1}
Yim et al., 2018	China, North & South Korea	Tidal salt marshes	Sediment	Storage	Reclamation	7.51	Mg C ha^{-1}
Yim et al., 2018	China, North & South Korea	Tidal salt marshes	Sediment	Storage	Reclamation	5.87	Mg C ha^{-1}
Zhang et al., 2021	China	Tidal salt marshes	Sediment	Sequestration	Invasive species	4.00	Mg C ha^{-1} y^{-1}
Zhang et al., 2012	China	Tidal salt marshes	Biota	Sequestration	Natural	7.00	Mg C ha^{-1} y^{-1}
Duarte et al., 2013	Global	Tidal salt marshes	Biota	Sequestration	Natural	2.18	Mg C ha^{-1} y^{-1}
Duarte et al., 2013	Global	Tidal salt marshes	Sediment	Storage	Natural	162.00	Mg C ha^{-1}

8. References for appendix (tier two)

Asterisks (*) indicate comparative quantitative articles used in tier three.

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